圆尾鱼属(†*Cyclurus*，Amiidae，Pisces) 在中国的首次发现[1]

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摘要：记述了弓鳍鱼亚科一新种：†*Cyclurus orientalis*（东方圆尾鱼）,标本采集于中国湖南省湘乡市下湾铺早始新世至中始新世下湾铺组。化石因具有以下特征而被归入弓鳍鱼亚科(Amiinae)：尾前椎为双椎型；除第一尾椎和第一尾下骨外,其余尾椎和尾下骨均一对一愈合；无膜质尾骨；背鳍长。因其第一冠状骨上的牙齿顶端圆钝,而被归入 †*Cyclurus* 属。本新种与 †*Cyclurus* 属中其他种的区别在于：背鳍鳍条较少；身体短而高；脊椎和椎体较少。在始新世淡水鱼类的跨太平洋分布达到鼎盛时,由于弓鳍鱼亚科并非仅分布于太平洋两岸的类群,因此不能作为跨太平洋分布的指示类群。弓鳍鱼亚科在北半球的分布范围更广,与某些其他淡水鱼类群例如狗鱼科(Esocidae)和骨舌鱼科(Osteoglossidae)相似,这种现象只能用有别于形成跨太平洋分布的地质背景来解释。

关键词：东亚,始新世,弓鳍鱼亚科

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DISCOVERY OF †*CYCLURUS*（AMIINAE, AMIIDAE, AMIIFORMES, PISCES）FROM CHINA

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Abstract Described in this paper is a new amiine, †*Cyclurus orientalis*, collected from the early to middle Eocene Xiawanpu Formation of Xiawanpu, Xiangxiang City, Hunan Province, China. It is unquestionably an amiine because of the diplospondylous vertebrae of both the normal and alternating types in its preural caudal region, the one-to-one fusion between the ural centra, except the first one, and the hypurals, the absence of the urodermals in the caudal skeleton, and the long dorsal fin. It is referred to †*Cyclurus* because its first coronoid carries teeth with rounded tops. It is different from other species of †*Cyclurus* in having fewer dorsal fin rays, deeper and shorter body, and fewer vertebrae and centra. During the Eocene when the transpacific distribution pattern reached its maximum, amiines were not uniquely shared by both sides of the Pacific and thus cannot be taken as an indicator of the transpacific distribution. Their wider, northern hemisphere distribution, along with the similar distribution of some other fish groups such as Esocidae and Osteoglossidae, may call for an alternative explanation by other special geological backgrounds.

Key words East Asia, Eocene, Amiinae

1 Introduction

So far, very few fossils referable to the family Amiidae have been found from East Asia, although their closest endemic relatives from the Early Cretaceous, sinamiids, are fairly abundant and widely distributed in this area (Fig. 1). Since †*Sinamia zdanskyi* was described by Stensiö in 1935 from Mengyin, Shandong Province, the species has been unearthed from many localities of northern China, e. g. , Ordos, Nei Mongol; Guyuan, Ningxia Hui Autonomous Region; Wuqi, Shaanxi Province; and Huanxian and Lintao, Gansu Province (Liu et al. , 1963; Liu and Su, 1983). Additional species of the genus †*Sinamia* also have been reported. These are †*S. huananensis* (Su, 1973) from Shexian, Anhui Province and Pujiang, Shouchang and Chun'an, Zhejiang Province (Chang and Chou, 1977); †*S. chinhuaensis* (Wei, 1976) from Wuyi, Zhejiang Province; †*S. luozigouensis* (Li, 1984) from Wangqing, Jilin Province; and †*S. po-yangica* (Su and Li, 1990) from Yiyang, Jiangxi Province. A possible new species of †*Sinamia* from Yixian, Liaoning (Zhang, 2005) was reported recently, but without detailed description. Fossil remains referred to indeterminate species of †*Sinamia* were also uncovered from the Early Cretaceous Tetori Group of Kuwajima, southwest Honshu, central Japan (Yabumoto, 2005; Yabumoto et al. , 2006). In addition, another genus of the family, †*Ikechaoamia* with two new species, was discovered from Ordos, Nei Mongol, northern China (†*I. orientalis* Liu, 1961) and Jinyun, Zhejiang Province, southern China (†*I. meridionalis* Zhang and Zhang, 1980). More recently, a new genus and species, †*Siamamia naga*, referred to the †Sinamidae was added to this list (Cavin et al. , 2007) from Phu Phok, northeast Thailand. Although Yabumoto (1994) and Grande and Bemis (1998) called †*Nipponamia satoi* an "amiid", subfamily indeterminate, which was from the Early Cretaceous Wakino Subgroup of the Kwanmon Group of Kitakyushu, Japan, Yabumoto (1994) acknowledged that the fish was closer to †*Sinamia* and †*Ikechaoamia* than to other forms.
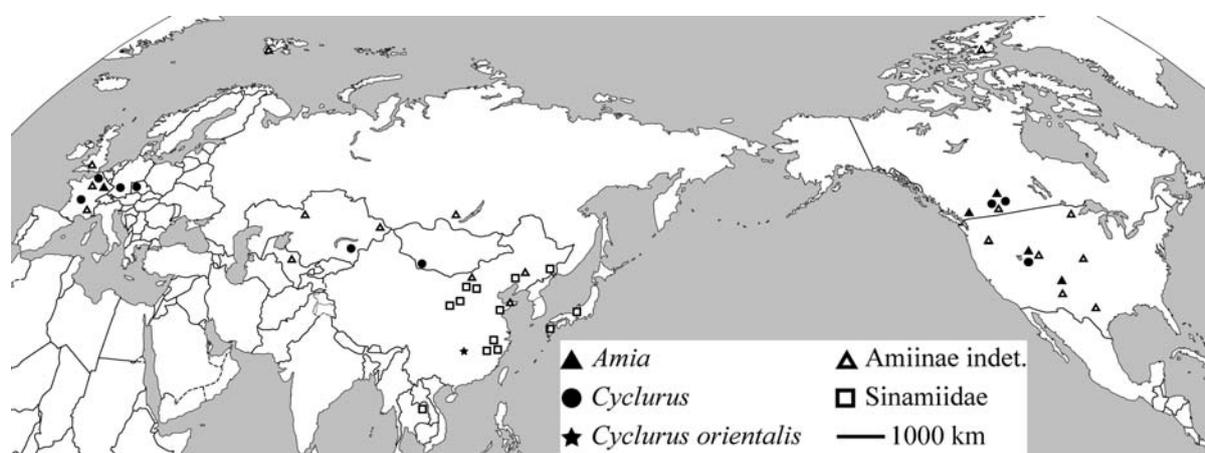

Fig. 1   Distribution of the †Sinamiidae and Amiinae in northern hemisphere

Up to now, however, fossil amiids were described only from two closely situated localities in East Asia. They are †*Cyclurus efremovi* (Sychevskaya, 1981, originally named as *Amia efremovi*, then changed to †*Cyclurus* by Grande and Bemis, 1998) from the upper Paleocene of southern Mongolia and †"*Pappichthys*" *mongoliensis* (Hussakof, 1932, referred to the genus *Amia* by several other authors) from the Eocene of Shara Murun, Nei Mongol, China. †"*Pappichthys*" *mongoliensis* was considered by Grande and Bemis (1998) as an indeterminate genus and species of the subfamily Amiinae (Fig. 1). Besides, fragmentary materials were described from some localities of the Central Asia. They are †*Cyclurus* "*chinzhalensis*" (Sychevskaya,

1986, originally named as *Amia chinzhalensis*) from the middle or upper Eocene of southeast Kazakhstan, suggested by Grande and Bemis (1998) as an undiagnosable species (*nomen dubium*) of the genus †*Cyclurus*; "*Amia*" *furiosa* and "*Amia*" *strigasa* (Sychevskaya, 1986), from the early Oligocene of eastern Kazakhstan; "*Amia*" *limosa* and "? *Amia*" *semimarina* (Nessov, 1985), from the Late Cretaceous of Uzbekhistan.

During our field work of the last few decades, we have discovered *Amia*-like fossil materials from a few more localities in China, e. g., the middle Eocene Huadian Formation, Huadian, Jilin Province (Chang and Zhou, 1993); the late Paleocene or early Eocene Huangxian Formation, Longkou, Shandong Province; and the middle Eocene Xiawanpu Formation, Xiangxiang, Hunan Province (Fig. 1). They were not yet studied because the materials consist mainly of disarticulated bones and are difficult to diagnose. In this paper, we describe two nearly complete specimens from Xiawanpu.

2   Materials and methods

The materials described in this paper consist of two complete specimens preserved in oil shale. Unfortunately, the bones of the head region have been severely damaged by poor preparation before we received the specimens, and the outline of a number of bones from the head region cannot be observed clearly. The parts of the specimens spared by the earlier poor preparation were later prepared carefully under a binocular microscope using fine needles. Material for comparison is a head skeleton of *Amia calva* IVPP OP 342. All specimens are stored in the collections of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Beijing, China. Line-drawings were done based on photos, aided by constant examinations of the specimens under a binocular microscope Wild M5. Terminology and method of measurements used in this study follow Grande and Bemis (1998).

3   Systematic paleontology

Division Halicostomi Regan, 1923 (*sensu* Patterson, 1973)
Subdivision Halecomorphi Cope, 1872 (*sensu* Patterson, 1973)
Order Amiiformes Hay, 1929 (*sensu* Grande & Bemis, 1998)
Superfamily Amioidea Bonaparte, 1838 (*sensu* Grande & Bemis, 1998)
Family Amiidae Bonaparte, 1838 (*sensu* Grande & Bemis, 1998)
Subfamily Amiinae Bonaparte, 1838 (*sensu* Grande & Bemis, 1998)
†*Cyclurus* Agassiz, 1844 (*sensu* Grande & Bemis, 1998)
†*Cyclurus orientalis* sp. nov.

Diagnosis   †*Cyclurus* with the fewest dorsal fin rays among amiines, containing two rudimentary and 35 segmented rays (ii, 35), compared with 36−39 segmented rays in †*C. kehreri*, 39 in †*C. oligocenicus*, 39−40 proximal radials in †*C. macrocephalus*, 41 in †*C. efremovi*, 44 in †*C. valenciennesi*, 44−46 in †*C. gurlei*, and 45−53 in *Amia* (except †"*A.*" *hesperia*, in which dorsal fin rays are about 40, but the status of the species is uncertain); marginal teeth on premaxilla and dentary with distinct groove along length of their labial surface; and with the following combination of characters: body deeper and shorter (BL/SL 37%) than in most other species of the genus †*Cyclurus* (19% ~32%) but falling in the range of that of †*C. gurleri* (35% ~42%); total number of vertebrae (52+3) and centra (65+3) fewer than in most other species of †*Cyclurus* (55−59 vertebrae and 70−79 centra in †*C. gurleri*, 59 vertebrae and 76 centra in †*C. efremovi*, 60−63 vertebrae and 79−81 centra in †*C. valenciennesi*, 56 vertebrae and 71 centra in †*C. ignotus*, 55 vertebrae and 70 centra in †*C. macrocephalus*), except †*C.*

kehreri, in which the numbers are similar（52－54 vertebrae and 65－69 centra）.

Holotype IVPP V 16284, a complete skeleton with scale cover, only with tips of a few longest caudal fin rays missing.

Paratype IVPP V 16285, a complete skeleton with scale cover, bent in the middle with convexity towards the ventral side, head preserved in dorso-ventrally depressed position, showing the dorsal face of the skull, body remaining in laterally compressed situation.

Etymology orient-, Latin, meaning east.

Type Locality and horizon Xiawanpu, Xiangxiang City, Hunan Province, China; Xiawanpu Formation, early to middle Eocene（Editorial Committee of "Stratigraphical Lexicon of China", 1999）.

Associated fauna and flora Several groups of fishes: a catostomid（†*Amyzon hunanensis*）, two percoids（†*Tungtingichthys hsiawanpuensis*, †*T. gracilis*）, and a catfish（†*Aoria lacus*）（Cheng, 1962; Chang and Liu, 1998; Chang et al. , 2001）; concostracans *Paraleptesthria menglaensis*; ostracods *Candona abrupta*, *Cyprois xiangxiangensis*; and plants *Palibinia laxifolia*, *P. korowinii*, *Cinnamomum lanceolatum*, *Chamaecyparis* sp. , *Sabina* sp. , *Zelkova ungeri*, *Comptonia anderssonii*, *Salix bienensis*（Li and Zheng, 1995）.

4　Description

General appearance The holotype（IVPP V 16284）is a comparatively well preserved, laterally compressed specimen, showing its right lateral side（Fig. 2A, B）. Most part of the body is covered with scales, only the caudal portion of the vertebral column and related neural, haemal arches and spines and the caudal skeleton are exposed. Its total length measures slightly more than 212 mm, and the standard length is 175 mm. Its maximum body depth is situated at the origin of the dorsal fin and is 65 mm. Its body depth（37% of the standard length）is deeper and shorter than most species of the genus †*Cyclurus*（19% ~ 32%）except †*C. gurleri*, in which the BD/SL is 35% ~ 42%. The head length is 54 mm and 30% of the standard length. With a depth of 42 mm, the head is longer than deep. The orbit, as in other amiids, is situated anteriorly, i. e. , the snout is much shorter than the distance between the posterior rim of the orbit to the posterior margin of the opercle. As in all other amiines, the fish has a long dorsal fin, though the shortest among the members of the subfamily. The paratype is much smaller, with an estimated total length of 94 mm. Since the specimen is bent, other measurements could only be approximate. Although the very tips of a few longest caudal fin rays are missing, we can still see that the fin is rounded. For measurements and meristics see Table 1.

Skull Despite the relatively well shown outline of the skull in the holotype（Fig. 3A, B）, most of the bones at the lateral surface of the skull were damaged by improper preparation prior to our possession of the specimens. Many bones are incomplete and broken. The external surface layers of most cheek bones were scraped off and the boundaries between the bones are impossible to detect. In this specimen, the right side of the skull is shifted somewhat downwards and the left side upwards. The left frontal is the only relatively well-preserved bone from the skull roof, whereas the surface part of the right frontal is mostly gone, with only the basal layer left, showing the contour of the bone. The bone is rectangular, with its anterior two thirds narrower than the posterior part, and with grooves and ridges on the surface, radiating from the center of ossification. The parietals are missing. Only bits of the basal parts of the bones from the occipital and ethmoid regions are shown and they are difficult to distinguish. In the paratype, a fish with an estimated total length less than half of the holotype, the skull is dorso-ventrally compressed, with its dorsal surface up（Fig. 4A, B）. Although most bones of the skull roof are exposed, the sutures between them are indistinct. We could roughly trace the general
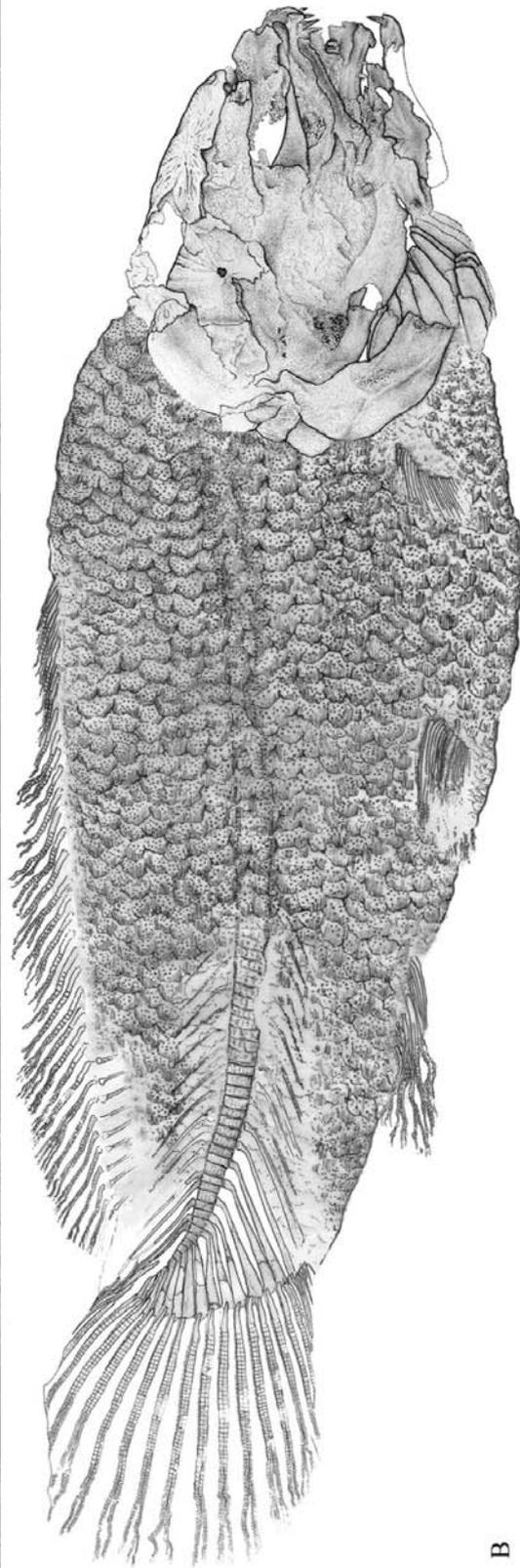
Fig. 2　†*Cyclurus orientalis* sp. nov., holotype IVPP V 16284 in right lateral view

A. photograph, B. line-drawing, anterior facing right; scale bar = 10 mm

Table 1 Measurements and meristics of †*Cyclurus orientalis* sp. nov. （mm）

Specimens	IVPP V 16284	IVPP V 16285
Total length	≥212	~94，estimated
Standard length	175	~77，estimated
Body depth	65	~22，estimated
Head length	54	~28，estimated
Head depth	42	~18
Mandibular length	~28，estimated	~18
Prepectoral length	57	
Prepelvic length	93	
Predorsal length	77	
Preanal length	125	
Caudal fin length	≥37	17
Caudal peduncle length	42	23
Caudal peduncle depth	28	9
Dorsal fin base	90	31
Anal fin base	16	5
Dorsal margin length between dorsal fin and caudal fin	8	
Body depth as % of SL	37	~28
Head length as % of SL	30	~36
Mandibular length as % of HL	52	~64
Prepectoral length as % of SL	32	
Prepelvic length as % of SL	53	
Predorsal length as % of SL	44	
Preanal length as % of SL	71	
Caudal fin length as % of SL	21	~22
Caudal peduncle length as % of SL	24	~30
Caudal peduncle depth as % of SL	16	~12
Dorsal fin base as % of SL	51	~40
Anal fin base as % of SL	9	~6
Number of vertebrae	52+3	
Number of centra	65+3	>63
Ural centra	10	10
Hypurals	12	12
Epurals	3	
Dorsal rays	ii, 35	
Anal rays	~8	~8
Pectoral fin rays	~17	~17
Caudal rays	ii, 19, iii	ii, 19, v

outlines of the nasals, frontals, parietals, dermopterotics and the lateral parts of the extrascapulars from the blurry sutures around the bones, and from the thickened posterior margin of the parietals. The course of the supraorbital sensory canals traversing the frontals longitudinally and backwards entering the dermopterotics (supratemporal sensory canal), then turning medially into the lateral parts of the extrascapulars (parts of occipital sensory canal) could also be detected.

Otoliths A small (less than 1.5 mm in diameter), compressed, rounded element was found under the anterior parts of the frontals (Fig. 3C). It is white in color and seems to consist of pure calcareous substance (calcite or aragonite). Very few otoliths have been found in fossil
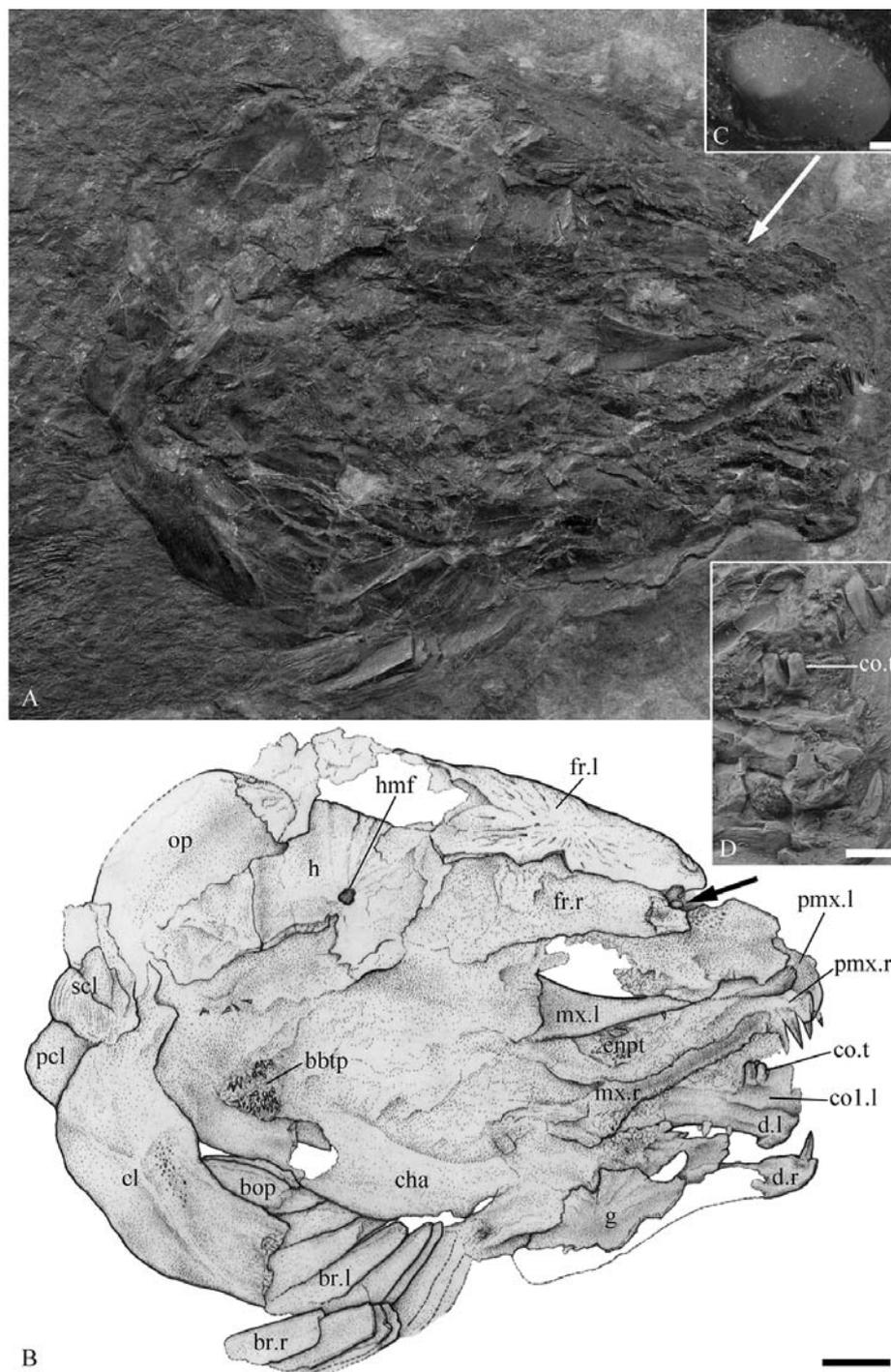
Fig. 3　†*Cyclurus orientalis* sp. nov. , holotype

A−B. photograph (A) and line-drawing (B) of skull in right lateral view, scale bar = 5 mm; C. otolith, scale bar = 0. 2 mm; D. jaw region, scale bar = 2 mm; the arrow points to the otolith

Abbreviations：bbtp. basibranchial tooth patch 基鳃骨齿板；bop. branchiopercle 鳃鳃盖骨；br. l, br. r. branchiostegal rays of left and right side 左右鳃条骨；cha. anterior ceratohyal 前角舌骨；cl. cleithrum 匙骨；co1. l. left coronoid 1 左冠状骨 1；co. t. coronoid teeth 冠状骨齿；enpt. entopterygoid 内翼骨；d. l, d. r. left and right dentary 左右齿骨；fr. l, fr. r. left and right frontal 左右额骨；g. gular 喉板骨；h. hyomandibular 舌颌骨；hmf. foramen for hyomandibular branch of cranial nerve VII 面神经舌颌支孔；mx. l, mx. r. left and right maxilla 左右上颌骨；op. opercle 鳃盖骨；pcl. postcleithrum 后匙骨；pmx. l, pmx. r. left and right premaxilla 左右前上颌骨；scl. supracleithrum 上匙骨

amiids. Nolf (1985) in his monograph on fossil otoliths reported that there had not been otolith-based fossil record of the Amiiformes. Even up to now, the only finds of otoliths are documented by Jerzmanska (1977) in †*Cyclurus kehreri*, a utricular otolith in † "*Amia*" *hesperia*, and two small possible otoliths in †*Amiopsis woodwardi* reported by Grande and Bemis (1998). Since there are no similar structures of the kind found in the matrix (oil shale) around the fossil fish, we suggest that it may belong to the fish and most probably is an otolith, though it is not exactly *in situ*. And we think it is worth of mentioning here.

Cheek bones   Almost all surface parts of the cheek bones in the holotype, including the opercular series and infraorbital series, are severely damaged, and individual bones are impossible to recognize. Merely the inner side of a large posterodorsal portion of the left opercle, an anterior part of a possible branchiopercle, and several branchiostegal rays are preserved. The left branchiostegals are still connected to the anterior ceratohyal and eight of them (including impressions) can be counted, whereas only four branchiostegals remain from the right side. In the posterior area of the lower jaw the central portion of the gular bone with broken peripheral parts was preserved (Fig. 3A, B). In the paratype, the opercular series is better revealed, the opercle, preopercle, subopercle, interopercle, and branchiopercle from the left side can all be seen as impressions. The right opercle shows fairly thick, radiating ridges. Eight left branchiostegals, most as impressions, are observed. No sign of supraorbitals is seen (Fig. 4A, B).

Jaws and palate   The holotype shows three large teeth and one impression of a tooth from the right premaxilla and part of the left premaxilla with one tooth on it. The incomplete impression of the right maxilla stretching from the premaxilla posteroventrally is also shown. The left maxilla with a broken tooth tip under its lower border is exposed in its inner view, shifted upwards and positioned horizontally through the middle of the orbit. The anterior part of the right dentary with one large anterior tooth and that of the left dentary with impressions of two teeth are also visible. The first left coronoid is also discovered attached to the lingual side of the left dentary. Two blunt and one broken teeth are shown on the bone (Fig. 3B, D). A tooth tip, pointing downwards, found in front of the coronoid teeth is possibly broken from the right maxilla situated just above it. From the bones of the palate, only the left entopterygoid with tooth patch can be seen in the lower part of the orbit. In the paratype, the anterior part of the left maxilla, the left dentary with several anterior teeth, angular, and impression of supraangular are observed (Fig. 4A, B). Other bones from the jaws and palate are not clear.

Hyoid and branchial arches   From the bones of the hyoid arch, the upper portion of the left hyomandibular, possibly with the foramen for the hyomandibular ramus of the facial nerve, is observed in the holotype. The left anterior ceratohyal connected with the branchiostegals is also seen (Fig. 3A, B). As most of the cheek bones were destroyed by the previous preparation, parts of branchial tooth plates and detached teeth are exposed. The basibranchial tooth patch, even if it was formed by small tooth plates, seems consolidated into a comparatively broad triangular piece clearly shown in the rear of the oral cavity (Fig. 3B). In the upper part of the oral cavity, small, detached teeth from the tooth patches of upper branchial arches or upper pharyngeal tooth patches are found. These elements are not frequently seen in fossil materials. The teeth on all tooth patches are conical, thin, long, and pointed.

Teeth   The marginal teeth on premaxilla and dentary are large, long, and pointed, with a distinct groove in the middle of the teeth, along the length of their labial surface. The groove makes the teeth look slightly labiolingually compressed than conical (Fig. 3D). As far as we can see from their tips, the teeth on maxilla are more conical. The teeth on the first coronoid are with rounded tops (Fig. 3D). The teeth on the tooth patches of the branchial arches are long and fine (Fig. 3B).

Pectoral girdle and paired fins   A large part of the right cleithrum with ornamentation,
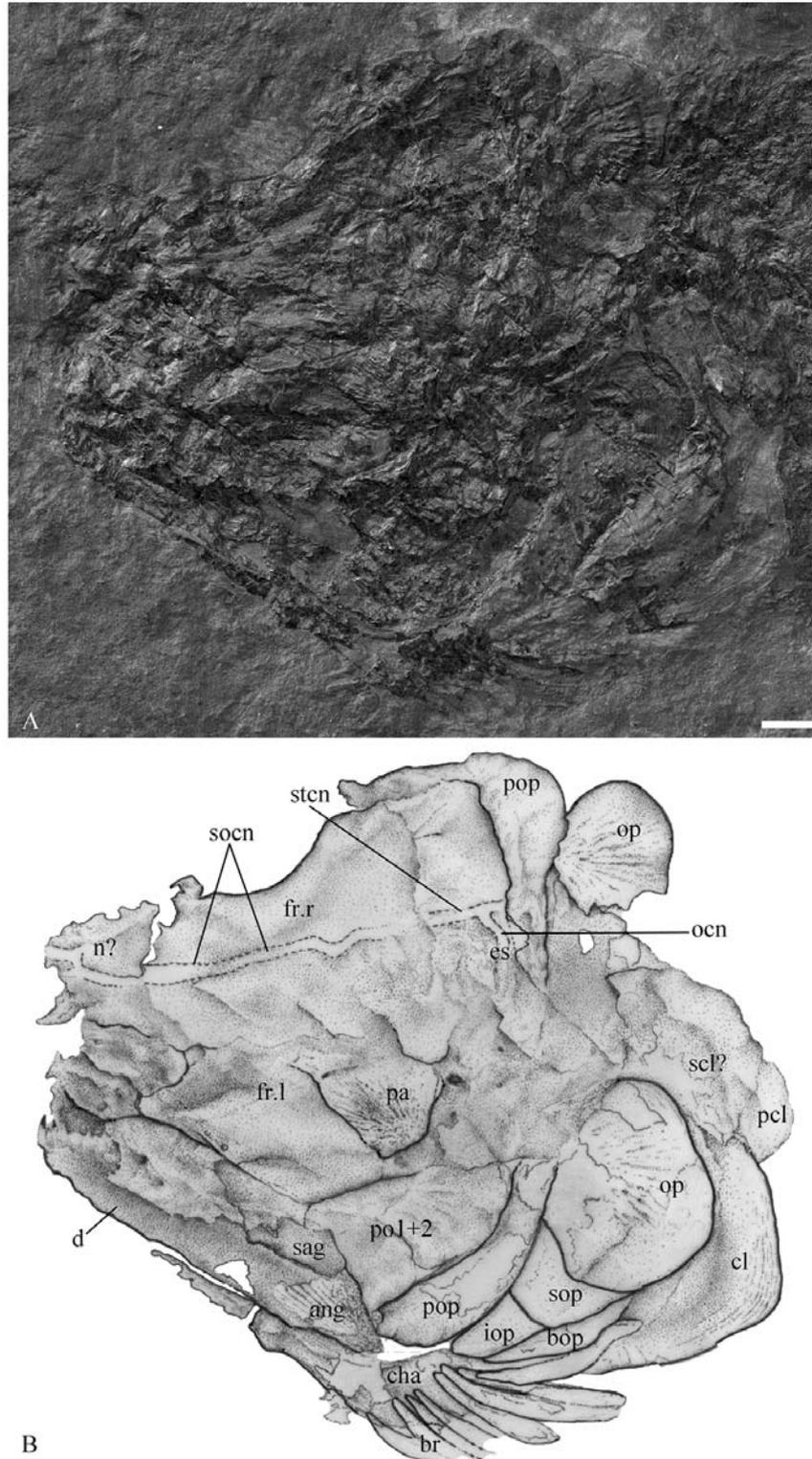
Fig. 4   †*Cyclurus orientalis* sp. nov., photograph (A) and line-drawing (B)
of IVPP V 16285 in left lateral view, anterior facing left, scale bar = 2 mm

Abbreviations：ang. angular 隅骨；es. extrascapula 外肩胛骨；iop. interopercle 间鳃盖骨；n?. nasal？鼻骨；ocn. occipital sensory canal 枕感觉管；pa. parietal 顶骨；po1+2. postorbital 眶后骨1+2；pop. preopercle 前鳃盖骨；sag. supraangular 上隅骨；socn. supraorbital sensory canal 眶上感觉管；sop. subopercle 下鳃盖骨；stcn. supratemporal sensory canal 上颞感觉管；for the rest see Fig. 3
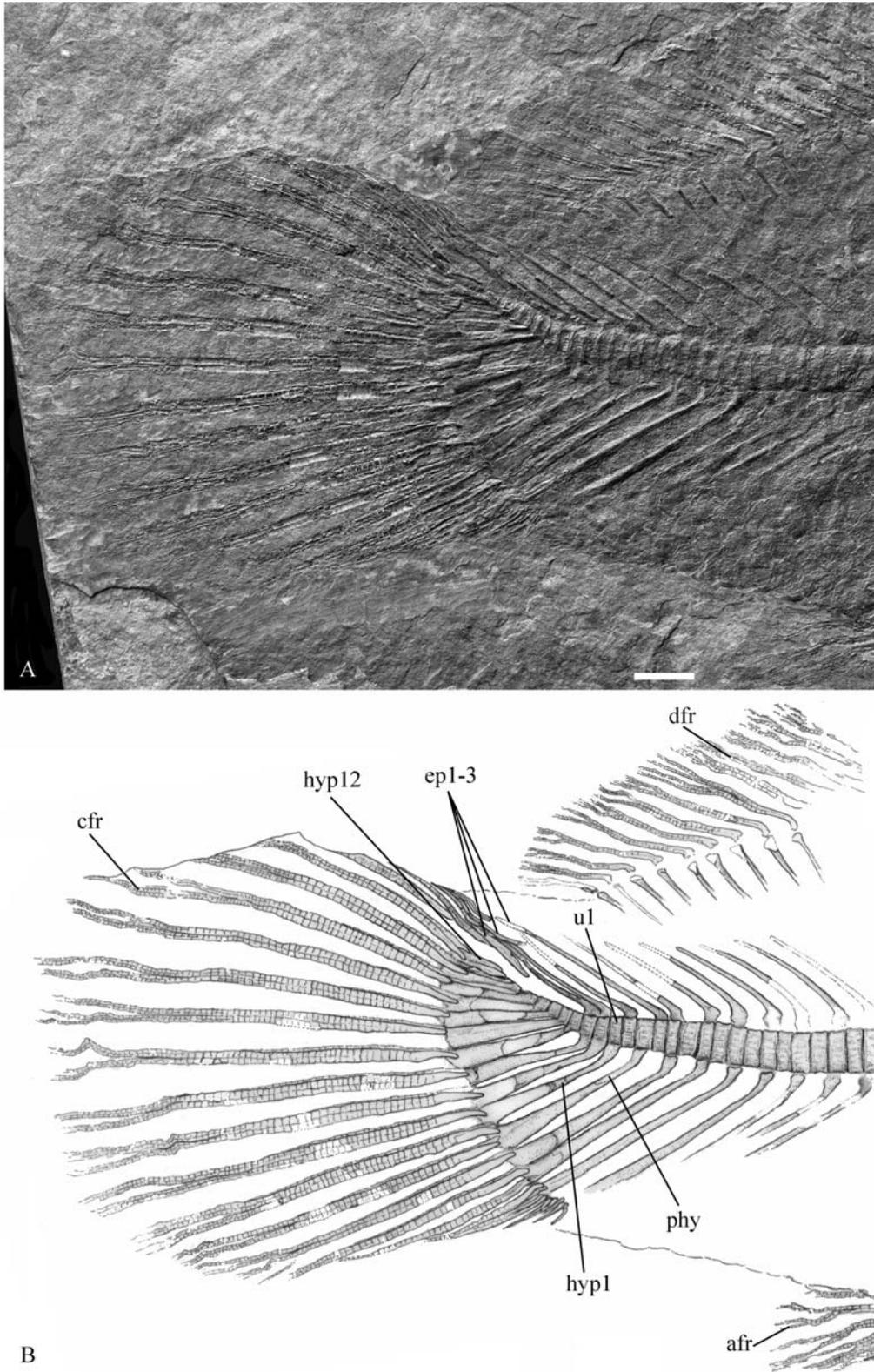
Fig. 5 †*Cyclurus orientalis* sp. nov., photograph（A）and line-drawing（B）
of caudal part of holotype in right lateral view，anterior facing right，scale bar = 5 mm
Abbreviations：afr. anal fin ray 臀鳍条；cfr. caudal fin ray 尾鳍条；dfr. dorsal fin ray 背鳍条；ep1–3.
epural 尾上骨 1–3；hyp1. hypural 尾下骨 1；hyp12. hypural 尾下骨 12；phy. parhypural 副尾下骨；u1.
ural centrum 末端尾椎 1

a right postcleithrum, and part of the right supracleithrum, are observed in the holotype (Fig. 3A, B), whereas impressions of the left cleithrum, supracleithrum, and the postcleithrum itself can be seen in the paratype (Fig. 4A, B). The pectoral fin contains about 17 fin rays, and in the pelvic about 8 fin rays in both holotype and paratype could be counted.

Dorsal and anal fins　As in all other amiines, the dorsal fin is long, with two rudimentary rays and 34 or 35 segmented rays in the holotype (Fig. 2), whereas 35 segmented rays and 35 proximal radials are counted in the paratype. The number is the least in the genus †*Cyclurus* (36–46) and *Amia* (45–53). The number of the anal fin rays that could be counted from both the holotype and paratype is eight.

Vertebral column　Although most of the anterior part of the body in the holotype is covered with scales, the vertebral centra are shown faintly through the scale cover and the count of their number is more or less precise (Fig. 2A). The posterior part of the vertebral column is better exposed. There are 52 vertebrae, among which 13 are diplospondylous. Thus, the number of centra should be 65. In the same specimen, in front of the first vertebra, we were able to trace one neural spine and one faint impression of another neural spine. In this case, two or three vertebrae should be added to the number. The total number of the vertebrae must then be 54 (or 55) and the number of the centra — 67 (or 68). The total number of centra in the paratype is approximately 63. The better exposed impressions of vertebral centra in the paratype definitely show three or more ridges and pits on their side.

Caudal skeleton and caudal fin　Ten ural centra, each supporting a hypural, are observed. The first hypural is articulated with the first ural centrum, whereas the 2nd to 10th are fused with the centra. Two uppermost hypurals are not connected with any centrum. Thus, the total number of hypurals is 12. The hypurals, parhypural, and two or three posteriormost haemal spines are each connected with a caudal fin ray, except the few more anterior neural spines that are connected with more caudal fin rays. Three epurals are present in both holotype and paratype; the uppermost one in the holotype and all three in the paratype are preserved as impressions. The one under the last neural spine is rather long and broad, and the two above the neural spines are thinner and shorter. No urodermals are observed in either of the specimens. The caudal fin is rounded, containing 19 segmented, principal rays and two short, non-segmented epaxial and three hypaxial fin rays in the holotype (Fig. 5A, B). The number of the caudal fin rays in the paratype is ii, 19, v (Fig. 6A).
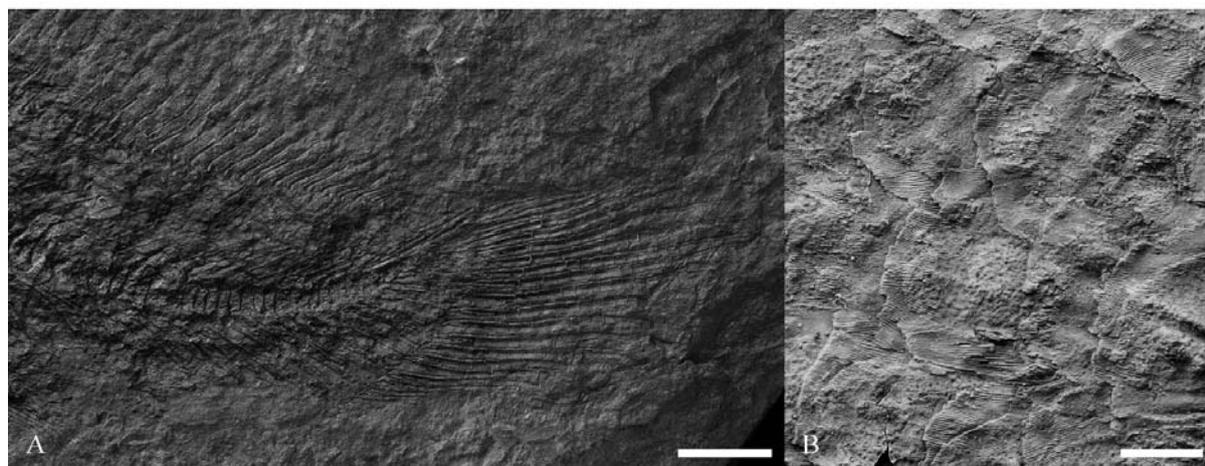

Fig. 6　†*Cyclurus orientalis* sp. nov.
A. photograph of caudal part of IVPP V 16285 in left lateral view, anterior facing left, scale bar = 5 mm;
B. photograph (coated with ammonia chloride) of flank scales of holotype, showing irregularly arranged tubercles and numerous fine, longitudinal ridges, scale bar = 2 mm

Scales In the holotype, the body is covered almost entirely with scales, but no complete scales are preserved. Only the posterior, unoverlapped areas of the scales are exposed, and all of them are with broken posterior margins (Fig. 6B). The anterior, middle part of the unoverlapped area is studded with irregularly arranged tubercles, whereas lateral and posterior to this area are numerous fine, longitudinal ridges, as in other amiids (Fig. 6B). The number of scales along the midline of the body can roughly be calculated as a few more than 50 and the number of scale rows across the body at the level of the origin of the dorsal fin is estimated as about 20. In the paratype, the scales are not well preserved.

5 Discussion

Phylogenetic position The fish described in this paper undoubtedly belongs to the Amiidae because it has diplospondylous vertebrae of both the normal and alternating types in its preural caudal region, and the vertebral centra show two or more ridges and alternating pits on their side. It is unquestionably an amiine also because of each of the ural centra (except the first one) fused with a hypural, the absence of the urodermals in the caudal skeleton, the long dorsal fin containing two unsegmented and 35 segmented fin rays, and the possible absence of the supraorbitals. The only character we are fortunate to have and can use to refer the fish to the genus †*Cyclurus* (*sensu* Grande and Bemis, 1998) is that the teeth on the first left coronoid are not pointed but with broad, rounded tops. A new species †*Cyclurus orientalis* is established on the basis of the combination of the following characters: the fewest segmented dorsal fin rays (35 versus 36–53 in other species of †*Cyclurus* and *Amia*); marginal teeth on premaxilla and dentary with distinct groove along length of their labial surface and thus slightly labiolingually compressed; body deeper and shorter (BL/SL 37%) than in most other species of the genus (19% ~32%), though falling in the range of †*C. gurleri* (35% ~42%); the total number of vertebrae (52+3) and centra (65+3) fewer than in most other species of †*Cyclurus* (55–63 vertebrae and 70–81 centra) except †*C. kehreri*, in which the numbers are similar (52–54 vertebrae and 65–69 centra). As mentioned by Grande and Bemis (1998), the species of the genus †*Cyclurus* are mainly based on measurements and meristic characters, and the intrarelationships within the genus is pending further study.

Paleobiogeography and environment The family Amiidae, including both its living and fossil members, is widespread in all continents but Australia and Antarctica and from the Late Jurassic up to the present (Grande and Bemis, 1998), provided Kriwet's (2005) identification stands but Liu et al.'s (2002) identification of a Triassic amiid does not. Its sister group, the family †Sinamidae, however, is so far known to be only restricted to the Early Cretaceous of East Asia. Within the Amiidae, the subfamily Amiinae, with its two genera *Amia* and †*Cyclurus*, has an exclusive northern hemisphere distribution (Fig. 1), whereas the †Vidalamiinae the northern hemisphere to the southern hemisphere, and the distribution of the subfamilies †Amiopsinae and †Solnhofenamiinae is limited to small areas of West Europe (Grande and Bemis, 1998). Based on Boreske's (1974) review of amiids from North America, Patterson (1981) suggested that the distribution of the genus *Amia* (both living and fossil) indicates a closer relation between North America and Europe than between North America and Asia. This view was not accepted by Grande and Bemis (1998). Currently, the unequivocal species of the genus *Amia*, both living and fossil, have all been discovered from North America but one single exception, †*A.* "robusta", which is known from the Paleocene of France. However, their distribution range would probably expand were certain fossil amiines, now treated by Grande and Bemis (1998) as *nomina dubia*, finally to be elucidated by further research as belonging to the genus *Amia*. †*Cyclurus* has a wide distribution over North America, Europe, and Asia. Despite the fact that, up to now, only one definite †*Cyclurus* species, †*C. efremovi*, and one †*Cyclurus*

nomin dubium (†*C.* "*chinzhalensis*") have been described from East and Central Asia (Sychevskaya, 1986; Grande and Bemis, 1998), more discoveries of the members of the genus or even the subfamily from Asia are expected.

The †Sinamidae and most of its associates in the Early Cretaceous freshwater fish fauna (lampreys, primitive acipenseriforms, osteoglossomorphs, and others) have so far been found only from the area east to the Lake Baikal in Siberia, Bon-Chagan in Mongolia, and Yumen, Gansu Province in northern China (Chang and Miao, 2004). The endemism of the fish fauna of this area is understandable because the area, at that time, was isolated from North America by the Bering Strait in the east and from Europe by the Turgai Strait in the west (Sychevskaya, 1986; Chang and Chen, 2000; Chang and Miao, 2004). Members of the Early Cretaceous fish fauna endemic to East Asia started to appear in North America in the Late Cretaceous (MacAlpin, 1947; Estes and Berberian, 1969; Grande, 1986; Bryant, 1987; Grande and Bemis, 1991; Friedman et al., 2003) and this ended when a transpacific distribution pattern of the fauna emerged, which reached its maximum during the Eocene. The transpacific distribution pattern was mentioned by several paleoichthyologists (Grande, 1985, 1994; Sychevskaya, 1986; Chang and Chow, 1986; Chang and Zhou, 1993; Chang and Chen, 2000, 2008; Chang et al. 2001). The fish groups they studied or quoted to support their ideas include the Dasyatidae, Amiinae (*Amia* and forms previously referred to *Amia*, now to †*Cyclurus*), Osteoglossidae (†*Phareodus*, †*Musperia*, †*Phareoides*), Hiodontidae (†*Eohiodon*), †Paraclupeidae (†*Diplomystus*), Pellonulinae (†*Knightia*), Catostomidae (†*Amyzon*), and Esocidae (*Esox*). In a strict sense, only †*Eohiodon*, †*Diplomystus*, †*Knightia* and the Catostomidae (†*Amyzon*) among the aforementioned taxa are uniquely shared by both sides of the Pacific during the Eocene. Other groups of fishes had a much wider distribution at the time. The Dasyatidae inhabit worldwide marine water and only enter freshwater occasionally. The Eocene osteoglossids (†*Phareodus* and its close relatives), once thought as one of the indicators of the transpacific distribution (Grande, 1985), have recently been discovered from the Paleogene deposits of several localities in Europe and Asia. These include the marine lower Eocene of Denmark (Bonde, 2008), the freshwater Eocene of Belgium (Taverne et al., 2007), the freshwater Paleocene of India (Kumar et al., 2005), and possibly the freshwater Eocene of Pakistan (Murray and Thewissen, 2008). Although a new species of the genus †*Phareodus*, †*P. songziensis*, was described recently from Songzi, Hubei Province, China (Zhang, 2003), the holotype consists of only the posterior part of the body, and many features diagnostic for the genus cannot be clearly seen on the specimen. Additional specimens and detailed studies are needed to confirm the identification. The Amiinae and Esocidae are also widespread in northern hemisphere during the Eocene. We are unable to interpret their distribution until their phylogenies are sufficiently studied.

Further study on fossil fishes from East Asia is likely to add more taxa to the fauna list that shows a transpacific distribution pattern during the Eocene. The strict transpacific pattern of certain taxa of fishes and other animals during the Eocene has been considered as a result of particular geological events such as elevation of broad Bering land-bridge, low salinity of the Arctic Ocean and so on (Estes and Hutchison, 1980; Chang and Chen, 2000; McKenna, 2003). However, the widespread distribution patterns of other taxa (Amiinae, Esocidae, Osteoglossidae etc.) may call for an alternative interpretation based on other geological events. Thorough phylogenetic analyses of these groups, including *Amia* and †*Cyclurus*, in relation to their geographical occurrences would provide more useful information for resolving their biogeographical patterns and for further discussion of the geological events that have shaped the patterns.

The flora associated with †*Cyclurus orientalis* includes †*Palibinia laxifolia*, †*P. korowinii*, †*Cinnamomum lanceolatum*, *Chamaecyparis* sp., *Sabina* sp., *Zelkova ungeri*, †*Comptonia*

anderssonii, and *Salix bienensis*, and indicates a warm and arid climate（Li and Zheng，1995）.

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