A REVIEW OF THE FOSSIL FISHES OF CHINA, THEIR STRATIGRAPHICAL AND GEOGRAPHICAL DISTRIBUTION.

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ABSTRACT. A summary of the present knowledge of fossil fishes in China. After a brief review of the historical development of research on fossil fishes, all known forms are enumerated in stratigraphical order. Their geographical distribution is made clear by a map showing all the main sites described in the text. A simplified systematic review is given at the end of the paper.

Contents:

1. INTRODUCTION.

THE study of fossil vertebrates in China was begun with the description of mammalian teeth of Cenozoic and Psychozoic age, purchased from the druggists or indirectly collected from other sources. The early descriptions of fossil mammals of China by Koken, Owen, Schlosser and others were based on material of such origin. During this time no fossil fish was recorded.

Even in the time of Anderson's and Zdansky's field work in China, and Andrews' expedition in northern China (Mongolia), attention was chiefly paid to the discovery of other vertebrates, mainly reptiles and mammals. Some occasional finds of fossil fishes can only be regarded as a sort of by-product.

Nevertheless, a number of fossil fish localities were discovered during this time which yielded many interesting forms, such as *Sinamia zdanskyi*, described by Stensiö, the fossil fish in Taiku described by Tchang, and the fossil remains from Suiyuan described by Hussakof, etc. During the last fifteen years great progress has been made in the discovery of fish remains. For the first time, we have made a real excavation for collecting fishes only, at the so-called Locality 14 near Choukoutien.

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This locality has yielded several thousands of fish remains. In Shanwang, eastern Shantung, we have discovered a rich fish level. More recently, discovery of Devonian placoderms was made through a number of geologists while working in southern China.

From all these facts, we begin to have a fairly good idea concerning the fish fauna of China. Since the described literature of fossil fishes is so scattered, and a great number of fish specimens secured by the Geological Survey of China are not yet described, it is desirable to give a short account of our knowledge of fossil fishes in China, especially concerning the stratigraphical and geographical distribution.

2. HISTORICAL REVIEW.

Fossil fishes have been known to the Chinese for many centuries. The genus *Lycoptera*, and fishes of similar kinds from various provinces in northern China, were collected by natives and sold to curio-dealers. They were prepared and framed by those dealers and considered as treasures. A short account of this has been published by H. T. Chang (1921, pp. 240-243) in his monograph entitled "Lapidarium sinicum."

In the early days of the field activities of the Geological Survey of China, fish remains were found by many geologists from a number of provinces, chiefly in northern China. With the exception of *Lycoptera*, they are represented only by isolated scales and fragmentary parts of the skeleton. Most of these remains belong to ganoids. They were sent to England for determination, but the results are not yet published.

The fish remains from China discovered by the Central Asiatic Expedition were determined by Hussakof (1932), and those collected by Tan and Zdansky were described, Stensiö (1935), (probably only a part of the collection included in this memoir). A part of the fish remains from Sinkiang discovered by P. L. Yuan, of the Sino-Swedish Expedition, were described by Yuan and Koh (1936). The collection of fossil fishes recently made by the National Geological Survey of China is mostly not yet studied. The first announcement of the discovery of Devonian fishes was made by the late Mr. Y. S. Chi (1940), and some others were collected by the writer.

In view of the richness of the fossil fish fauna in China, further collection and proper study of them are of outstanding importance both for stratigraphy and vertebrate paleontology.

3. IMPORTANT FISH-BEARING HORIZONS.

We shall now enumerate the known fish-bearing horizons in China, from old to young, stratigraphically. (cf. Table I.)

1. *Lower Devonian from Yunnan with Cephalaspis indet.* The presence of *Cephalaspis* remains has been known for many years through the findings of members of the Geological Survey of China. A fine specimen was presented to Doctor Grabau who briefly mentioned it in his Stratigraphy of China. This specimen is still kept by him in Peiping. But quite recently a rich *Cephalaspis*-bearing level has been discovered in Chuting, eastern Yunnan, by Y. C. Sun of the Southwestern Union University and by members of the Bureau of Mine Prospects under C. Y. Hsieh. I recently had the opportunity of examining the specimens of Sun and am convinced that they belong to the Cephalaspidae. The collection consists of several well preserved skulls and dermal plates of the trunk and tails. By careful collection, it is hoped entire skeletons will be found.

2. *Upper Devonian of Hunan and Yunnan with Bothriolepis sinensis.* The rich fish-bearing locality of Tiomachien, southwest of Changsha, Hunan province, was first discovered by Chi and Yeh. Later M. N. Bien and the writer made additional collections from the same spot. The late Chi, in a preliminary study, identified the remains as *Bothriolepis sinensis*, a form closely related to *B. canadensis*. The presence of apparently the same species from the same stratigraphical horizon was recorded later in several localities in Yunnan province. One of the localities is situated in the district Kungyang and others east of Kunming. They were discovered by P. S. Shiung and the late T. Y. Hsue respectively. Now both in the Geological Survey of China and in the Geological Institute of the Southwestern Union University in Kunming, there is a series of these specimens waiting for final study.

3. *Carboniferous fish bed in Sinkiang.* P. L. Yuan has discovered two main fish-bearing levels in the vicinity of Tihua in Sinkiang, the lower one of which belongs to Carboniferous age. Yuan (1935). The fish remains of the lower beds are, however, not yet described.

4. *The Sinosemionotus level in Sinkiang, middle Triassic.* This is the upper fish level of Yuan. Part of the remains were described by him and Koh as *Sinosemionotus urumchii* (1936). Recently, the latter author has found additional specimens from Sinkiang, probably derived from the same horizon.

TABLE I.

Geologic age	Fish remains	Locality	Remarks
Pleistocene	*Ctenopharyngodon idellus*	Loc. 3 Choukoutien	
Upper Pliocene	Cyprinidae indet.		
	Ctenopharyngodon sp.	Sanmen, Shansi	
	Hypophthalmichthys sp.		
	Carassius aaratus	Taiku, Shansi	
Lower Pliocene	Cyprinidae indet.	Ertemte, Suiyuan, Nanning, Kwangsi etc.	
	Barbus szechuanensis	Loc. 14 Choukoutien	
	Barbus brevicephalus		
Miocene	*Leuciscus miocenicus*		
	Barbus linchuensis	Shanwang, Shantung	
	Barbus scotti		
	Pseudorasbora macrocephala		
	Rhineastes grangeri	Tung Gur, Suiyuan	
	Cyprinidae indet.	Hsiawanpu, Hunan, etc.	Not yet published
Early Tertiary	Teleostei indet.	Wusu and Kusha, Sinkiang, Hengyang, Hunan etc.	Not published
	Pappichthys mongoliensis	Shara Murun etc.	
	Catostomus sp.		
	Cyprinidae indet.		
Cretaceous	*Lycoptera* sp.	Jehol	
	Lycoptera ferox	Shantung, Jehol	
	Lycoptera sinensis		
	Lycoptera fragilis	Ondai Sair, Mongolia	
	Sinamia zdanskyi	Mengyin, Shantung	
	Mesoclupea showchangensis	Showchang, Chekiang	
	Mesoclupea globicephala		
Jurassic	*Lepidotus* sp. nov.	Weiyuan, Szechuan	Not published
	Ganoids indet.	Junghsien, Szechuan	
	Ganoids indet.	Central Kansu	
	Ganoids indet.	N. Shensi	Not published
	Ganoids indet.	N. Manchuria	
	Hybodus sp.	Yungteng, Kansu	
	Ceratodus szechuanensis	Weiyuan, Kuanyuan, Szechuan	
Upper Triassic	*Hybodus houtienensis*	Anning, Yunnan	
Middle Triassic	*Sinosemionotus urumchii*	Urumchi, Sinkiang	
Carboniferous	Fish remains	Urumchi, Sinkiang	Not published
Upper Devonian	*Bothriolepis sinensis* and other similar forms	Tiomachien, Hunan, Kunyang, Central Yunnan etc.	Not yet published Mostly not published
Lower Devonian	Cephalaspis indet.	Chueting, E. Yunnan	Not published

5. *The upper Triassic fish horizon from Yunnan.* The other Triassic fish level was made known by the finding of a spine of *Hybodus* from Anning, Yunnan. It has been described by me recently (1941). Indications of the presence of fragmentary fish remains from the same period were located in several other places.

6. *Jurassic Fishes.* In almost every level of the Jurassic deposits in China there are remains of fishes to be noticed. In most places, however, they are only represented by fragmentary specimens, apparently due to the rather primitive way of collecting. The following are the principal localities with ganoids and other fishes:

a. Ganoids from Manchuria.
b. Ganoids from northern Shensi.
c. Ganoids from Kansu.
d. Ganoids from Szechuan.
e. *Hybodus* sp. from Yungteng, Kansu and Kuangyuan in northern Szechuan.
f. *Ceratodus* from Weiyuan and Kuangyuan, Szechuan.

It should be noted that the ganoids from western Szechuan are represented by a number of well preserved specimens, at least one of them with even the detailed structure of the skull perfectly preserved. According to the determination of the late Y. S. Chi, it belongs to the genus *Lepidotus*, comparable with the species known from the Purbeck of England. The species is probably new. The untimely death of Chi interrupted the final description of the material which is now kept in the Cenozoic Laboratory of the Geological Survey of China.

7. *The Cretaceous fishes.* As noted above, the upper Jurassic or early Cretaceous fishes belong to the first-known fish remains in China. But even the best known form, *Lycoptera*, is not yet fully described. On the other hand, a thorough study of the member of the Amiidae, *Sinamia zdanskyi*, was published by Stensiö (1935). The lower Cretaceous *Lycoptera fragilis* was described by Cockerell (1924-1925), and Hussakof (1932). The Cretaceous fish fauna seems generally marked by the extinction of true ganoids and dominance of *Lycoptera* and other modern looking forms. The genus *Lycoptera* is known chiefly from north China, throughout Jehol, Shantung, Shensi and Kansu provinces, but some of them, such as the fish remains of Kienyang in western Shensi may

belong to Tertiary age and should be considered as Clupedae or Cyprinidae. In Chekiang, however, fishes of lower Cretaceous age were described by Ping and Yen (1933) as *Mesoclupea showchangensis* and *M. globicephala* which represent the oldest known Clupedae in China, if the determination is correct.

8. *Early Tertiary fishes.* In the early Tertiary deposits of China, remains of fishes are still more abundant than in those of the Cretaceous. Unfortunately these are generally in a fragmentary state of preservation, often represented only by isolated scales, vertebrae and other bones. Complete specimens are rarely known. Most of these are not yet properly described. A number of specimens have been collected by the Central Asiatic Expedition and described by Hussakof as *Pappichthys mongoliensis* and *Catostomus* sp. from Shara Murun and Ulan Shireh formations in Suiyuan. They belong to the Eocene age. The presence of fish remains, mostly very fragmentary, is recorded in the early Tertiary beds of Sinkiang, Kansu, Shensi, Shansi, Honan, Hunan, Yunnan and many other places.

9. *The Miocene fish fauna.* The Miocene of China, although insufficiently known, seems to be rich in fishes. Hussakof has described one of the Siluridae, *Rhineastes grangeri*, from the Tung Gur formation of Suiyuan (1932). In the upper Miocene of Shanwang, eastern Shantung, at least four species of fishes were known, viz., *Leuciscus miocenicus*, *Barbus linchuensis*, *Barbus scotti* and *Pseudorasbora macrocephala*, all Cyprinidae (Young and Tchang, 1936). From Hsiawanpu, Hsiangshiang, in Hunan, fishes of the family Cyprinidae are also recorded.

10. *Pliocene fishes.* In the Pliocene of China, a rich fish fauna occurred in the Locality 14 of Choukoutien. It is represented by thousands of well preserved individuals, but of only two species, *Barbus szechuanensis* and *Barbus brevicephalis* which were described by Chang (1937). From the Pliocene beds of Ertemte (Schlosser, 1924) and Nanning, etc., remains chiefly of Cyprinidae, in a rather fragmentary state, were reported.

11. *Upper Pliocene fishes.* In the upper Pliocene (Nihowan) beds of Taiku, a modern looking fish, *Carassius auratus* was described by Chang (1933). In the upper Sanmenian (=Nihowan) series of Pinglu, southern Shansi, remains of *Ctenopharygodon* and *Hypophthalmichthys* were recorded by Bien (1934a). Those fish remains found in the lacustrine deposits

of the same age, Cyprinidae and other fishes, are chiefly represented by isolated vertebrae.

12. *The Pleistocene fishes.* The only known locality with fish remains of Pleistocene age is the Locality 3 of Choukoutien; these remains have been described by Bien as *Ctenopharynodon idellus* (1934).

GEOGRAPHICAL DISTRIBUTION.

On the accompanying map, I have plotted all the known localities with fossil fishes. This will give a general view of what we know about the fossil fishes in China. These localities are scattered widely throughout the vast country. It is, therefore, hoped that more localities will be found. As shown on the map, all the Palaeozoic fishes are restricted to south China, while all the fishes of later periods are much more widely distributed.

As I have mentioned above, most of the collections of fossil fishes are merely the by-products of other geological and palaeontological field explorations. With better understanding of the importance of the fossil fishes and by careful collecting, better specimens and new localities are surely going to be uncovered from time to time.

It is worth while to note that most of the fishes known in China are surprisingly similar to their equivalents in other countries. As examples I wish only to point out the close resemblance of *Bothriolepis sinensis* with *B. canadensis* and *Lepidotus* sp., with its equivalent of the Purbeck formation in England. Careful study of the fossil fishes of China will help us very much in a better understanding and correlation of the stratigraphy between China and other parts of the world.

5. SYSTEMATIC SUMMARY.

Up to now, as enumerated above, the following fishes are known in China:

Osteostraci.
- Cephalaspidae indet.

Antiarchi
- *Bothriolepis sinensis*

Selachii.
- Hybodontidae
- *Hybodus houtienensis*
- *Hybodus* sp.

General outline map of China showing the fossil fish-bearing districts in China. P, Devonian fish localities; H, localities with *Hybodus;* D, localities with *Ceratodus;* G, Ganoid localities; L, localities with *Lycoptera;* Ce, localities with remains chiefly of Cyprinidae of the early Tertiary age; Cl, localities with chiefly Cyprinidae and Clupedae of the late Cenozoic age. For detailed explanation see the text. A few sites with fishes, west of Tihua, are omitted.

Dipnoi.
  Ceratodontidae
    Ceratodus szechuanensis
    Ceratodus sp.
Ganoidei.
  Semionotidae
    Sinosemionotus urumchii
    Lepidotus sp. nov.
  Amiidae
    Sinamia zdanskyi
    Pappichthys mongoliensis
  Lycopteridae
    Lycoptera sinensis
    Lycoptera ferox
    Lycoptera sp.
Teleostei.
  Clupedae
    Mesoclupea showchangensis
    Mesoclupea globicephala
  Clupedae indet
  Cyprinidae
    Leuciscus miocenicus
    Barbus linchuensis
    Barbus scotti
    Barbus szechuanensis
    Barbus brevicephalus
    Pseudorasbora macrocephala
    Catostomus sp.
    Carassius aaratus
    Hypophthalmichthys sp.
    Ctenopharyngodon sp.
      etc. . . .

If we remember that before twenty years ago almost no fish remains were scientifically studied except *Lycoptera*, we can feel we have made good progress during the last two decades, but if we realize how few forms of the entire varied fish kingdom we have found up to now, we must say that we have only made a beginning. It is unnecessary to say that more work should be done to promote our knowledge of fishes in China.

6. CONCLUSIONS.

The above short account shows that we have now a better knowledge of the fish remains, especially those of the early horizons which are still mostly unknown, than when I attempted

to give a review of new vertebrate horizons in China eight years ago (1937). The discovery of the principal Paleozoic fishes was made since the outbreak of the war between China and Japan.

Concerning future prospects, it is sufficient to say that, just as with other vertebrate fossils, China is one of the most promising countries for fish remains. I wish only to note that in Kwangsi, Yunnan and Hunan the lower Paleozoic is partly developed as continental facies, so that we may hope to find more fish horizons in the Devonian as well as Silurian and older levels.

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