

CRETACEOUS FOSSILS FROM SHANTUNG.

BY A. W. GRABAU

(With two plates and seven text-figures)

The material collected by Mr. H. C. T'an of the Survey in the Cretaceous beds of Shantung, as described by him in a preceding paper, includes a number of distinct faunas. So far each locality and each horizon has furnished species peculiar to itself and not found at any other locality. Nor, excepting some Mêngyin species, are there any localities known elsewhere where the same species are found again. It is true the paper-shales of the Trans-Baikal region in Siberia, are similar to those of Laiyang. With, however, the possible exception of *Estheria middendorfi*, which in our beds is represented by a form half the size of the Siberian form, there are no species in common, though it can not be denied that *Lycoptera sinensis*, the characteristic fish of our beds, is a close relation of *L. middendorfi* of the Siberian paper-shales. Both shales were no doubt deposited under similar conditions, which were evidently those of playa lakes occasionally flooded by intermittent streams, and both are most probably of the same age.

The Siberian beds have been variously assigned to horizons ranging from the Jurassic to the Miocene. Reis*, summarizing the discussion of the age indicated by the faunas and floras of these beds, says:

“So erscheinen nach allem doch die Kennzeichen, welche für ein jung-jurassisches-alteretacisches Alter der Turgaschiefer sprechen, das Uebergewicht für sich zu beanspruchen”.

The flora of the Laiyang beds, described in a preceding paper by Mr. Chow, seems to me to have a decided Lower Cretaceous aspect, nothing like it being known from the Upper Jurassic or older formations of Asia. Moreover many forms agree with, or closely represent, species found in the Lower Cretaceous of western Europe, or in the Potomac formation of eastern North America. The insect fauna too, is wholly distinct from the Jurassic insect fauna found in the Ust Balai Basin of Siberia and referred to the Jurassic on the basis of the associated plants.

* Otto M. Reis, Die Binnenfauna der Fischechiefer in Transbaikalien. Explor. Géol. et Minières le long du Chemin-de-fer de Sibérie. Liv. XXIX pp 1-68.

The occurrence of *Proteroscarabæus* in our shales, a true representative of the SCARABÆIDÆ further suggests the post-Jurassic age of these beds, since no undoubted member of this family has been found in strata older than the Eocene (see discussion under the genus). The highly specialized character of the species too, indicates a relatively young age, for even if some of the Upper Jurassic species should turn out to be truly referable to this family, they are all less specialized than the form obtained from our beds.

The age of the lower Mêngyin beds is confidently referred to the Lower Cretaceous (Wealden), for the leading species of *Unio* are of Wealden types and correspond to species obtained from equivalent strata in Szechuan and described by Frech.

The lower Chingshan formation may also be of Lower Cretaceous age, though the common and only pelecypod of the fauna has a decided Laramie aspect.

The Wangshih series is unhesitatingly referred to the Upper Cretaceous, because of the abundance of *Pisidium*- and *Sphærium*-like pelecypods, and the general resemblance of the fauna to that of the North American Laramie formation.

The stratigraphy of the several formations may be briefly summarized here, the reader being referred for details to Mr. T'an's paper in an earlier part of this bulletin, from which these summaries are derived.

A. Generalized Section in Lai-Yang-Hsien, Eastern Shantung.
(After H. C. T'an)

In descending order:

II. CRETACEOUS FORMATIONS

3. *Wangshih Formation* (Upper Cretaceous). Chiefly red clay with some conglomerates and with reptilian bones at two horizons near the middle. Red clay and gray coarse sands and conglomerates in the lower part.

Thickness about2,000 meters

Disconformity.

2. *Chingshan Formation* (Lower? Cretaceous). Brown tuff-conglomerates, with some layers of red clay near the top, and with red-brownish clay and conglomerate containing reptilian bones; green clayey shale with pelecypods; violet-brown clay shale and yellow and reddish sandstone in the basal portion.

Thickness about..... 1,200 meters

From the green shale, between the basal brown shales and the reptile-bearing beds, the following species have been obtained (Loc. 219).

PELECYPODA: *Leptesthes chingshanense* Grabau

PLANTÆ: Indeterminable plant remains.

Disconformity (?)

1. *Laiyang Formation* (Lower Cretaceous). Shales and sandstones of various colors, mostly yellow and green, sometimes calcareous, alternating with beds of yellow sandstone. Red beds scarce or absent. Near the middle a series of grayish paper-shales weathering yellow, at two levels separated by sandstone, and containing a rich flora, and a fauna of *Estheria*, insects, and fish. (Loc. 218). Basal part conglomeratic and with some indeterminable plants.

Thickness about..... 700 meters

The following species have been described from these beds. The plant descriptions by Mr. Chow are given in the preceding paper.

PLANTÆ: *Brachyphyllum obesum* Heer; *B. magnum* Chow; *B. multiramosum* Chow; *Sphenolepis elegans* Chow; *S. arborescens* Chow; *Pagiophyllum* sp.; *Palæocypris* cf. *flexuosa* Sap.; *Auracarites* sp.; *Baiera* cf. *australis* McCoy; *Zamites* sp.; *Thinnfeldia* sp. PHYL-

LOPODA: *Estheria* cf. *middendorfi* R. Jones. IN-

SECTA: *Sinoblatta laiyangensis* Grabau; *Laiyangia paradoxiforme* Grabau; *Proteroscarabæus yeni* Grabau; *Samarura? gregaria* Grabau. PISCES: *Lycoptera sinensis* Woodw.; *Lycoptera ferox* Grabau.

Great Unconformity.

I. ARCHEAN GNEISS.

B. *Generalized Section at Chiao-Hsien, Eastern Shantung.*

II. CRETACEOUS FORMATIONS.

3. *Wangshih Formation* (Upper Cretaceous). Chiefly red clay with conglomerate and sand at the top, and at various horizons. A conglomeratic bed with reptile bones above the middle, and green clay and some conglomerate about 700 meters above the base, the clay containing pelecypods and gastropods (Loc. 220).

Thickness about.....2,000 meters.

From the green clay about 700 meters above the base, the following species have been obtained:

PELECYPODA: *Cyrena (Sphærium?) tani* Grabau; *Cyrena (Pisidium) shantungense* Grabau; *Cyrena (Pisidium?) wangshihense* Grabau; *Cyrena (Pisidium) retrorostrum* Grabau; *Cyrena (Pisidium) altiformis* Grabau. GASTROPODA; *Limnæus? sp.* *Cyclophorus? sp.*

Disconformity.

2. *Chingshan Formation* (Lower Cretaceous?). Brown tuff-conglomerate and tuff with lava, no fossils.

Thickness about.....1,200 meters

Disconformity?

1. *Laiyang Formation* (Lower Cretaceous). Chiefly sandstones of yellowish and greenish color, alternating with

shales. Near the middle a bed of shale with plant-remains; no fish or insects have been found here.

Thickness about.....900 meters

Great Unconformity.

I. ALGONKIAN GNEISS.

C. *Mêng-Yin Valley Section*

This section is incomplete, being bounded by faults. For details see Mr. T'an's paper.

From the shales of this formation at Ning-Chia-Kou a number of fossils have been obtained and sent to the survey by Pater Alfred Kassel. These include: PELECYPODS: *Unio (Lampsila?) johannböhmii* Frech; *Unio cf. menkii* Dunker; *Mycetopus mengyinensis* Grabau. GASTROPODS: *Bithinia mengyinensis* Grabau; *Valvata suturalis* Grabau.

The first two species of pelecypods have been described by Frech from beds referred by him to the Wealden in Szechuan province (Richthofen, Vol. V). The Mêngyin beds yielding these fossils are referred to the same horizon.

DESCRIPTION OF SPECIES.

PELECYPODA

Genus *LEPTESTHES* Meek

Leptesthes chingshanense Grabau (sp. nov.)

(Text - Fig. 1.)

This shell belongs to the Corbiculoid group of the *Cyrenidae*, and although its internal structure is only partially preserved, it appears to belong to the above genus which is characteristic of the Laramic group of the western United States.

Shell thin except at the hinge-line, where it is much thickened; transverse; the length and height about as 1.5:1 (ranging from 1.4:1 to

1.6:1) with the beak about 2/5 the distance from the front of the shell in the adult; somewhat nearer 2/3 the distance from the front in the young. Greatest convexity of valves in umbonal region, nearly flat in lower half and gently convex in both anterior and posterior parts. Anterior end broadly

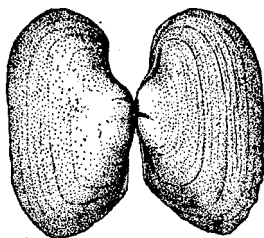


Fig. 1.

Leptesthes chingshanense Grabau. Type with both valves in contact, nat. size.

rounded; posterior end obliquely truncated with the posterior angle rounded. A faint angulation may sometimes be seen extending from the umbonal region to the posterior ventral margin, delimiting the truncated region, but this is never very sharp. The posterior region is flattened for some distance above the truncated end. The anterior dorsal slope is slightly concave.

Surface of shell marked by many faint growth-lines, and by occasional stronger ones, indicating periodic modification in growth. Because of the tenuity of the shell neither muscular impressions nor pallial line are sufficiently marked to make a pronounced impression on the internal mold except in rare cases. The former appear to be subequal in size, the anterior adductor being elongate and lying a short distance in front of the beak. Pallial line without sinus.

The lateral teeth are rather strong, those posterior to the beak forming a pronounced impression on the internal mold. There is one strong lateral tooth in the right, and two fainter ones in the left valve behind the beak, those extending within a short distance of the posterior dorsal margin. The teeth show a faint cross striation or transverse notching as in species of *Corbicula* generally but this is never strongly marked. The anterior teeth are heavy, but not well preserved.

Escutcheon well-marked, having a maximum width of 2.5 mm. where the length is about 18 mm.

The following measurements show but slight variations in the adult.

	1	2	3	4 (young)
Total Length.....	29. mm.....	25.5 mm.....	34. mm.....	11. mm.
Length of anterior portion.....	12. mm.....	10. mm.....	13. mm.....	4. mm.

	1	2	3	4 (young)
Height.....	18. mm.....	18. mm.....	22. mm.....	7. mm.

This shell is smaller than the genotype *Leptesthes fracta* Meek§ of the Laramie of Wyoming, though the proportion of length and height are nearly the same. The type specimen of the American species figured by Meek shows a posterior truncation which is however less oblique than that of our species. Moreover, according to White (U. S. Geol. Surv. 3d Ann. Rep. p. 439), this is not normal for the species but a slight deformity of the type. It is not shown in the other specimens figured by White, though it is possible that these are not con-specific with the type. The convexity of our shell is also much less than that of the American species.

Horizon and Locality: This species is common in the gray shales which form the basal part of the Chingshan Formation which disconformably overlies the Laiyang Formation in the Laiyang Valley. It is the only identifiable invertebrate and is associated with some plant remains of indeterminate character. Reptilian remains have been found in somewhat higher strata. The shells usually occur either with the valves closed or widely spread, rarely with the valves separated. This shows that the species lived where found, being often still in the vertical position in which it was probably embedded in the mud.

Genus *Unio* Retzius.

Subgenus *Lampsilis* Rafinesque

Unio (Lampsilis) johan-böhmi Frech

(Figs. 2a-b)

1911. *Unio Joh-Böhmi* Frech—in Richthofen China, Vol. v. p. 223, pl. 31, figs. 3a-c, 4.

This species, originally described from the Lower Cretaceous (Wealden) beds 10 li N. of Yün-Yang-Hsien, near Kwei-Chou-Fu, province of Szechuan, appears to be abundantly represented in the middle part of the Méngying series at Ning-Chia-Kou, Shantung. A number of internal molds,

§ U. S. Geol. Surv. Territories Vol. IX, p. 161.

none of them preserving the shell intact, have been obtained here by Pater Alfred Kaschel and sent to the Survey.

These shells are much elongated, with the umbo about one fifth the length from the anterior end. The umbones are not very prominent and the beaks appear to be but moderately incurved. Dorsal margin gently arcuate or nearly straight for the greater part of the length behind the beak, curving abruptly, or passing rather sharply into the posterior subtruncate margin which meets the ventral margin in a regularly, and sometimes rather sharply rounded posterior end.

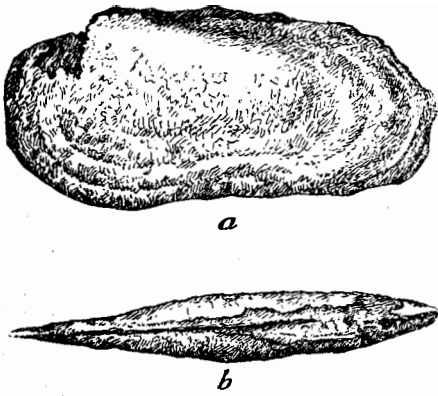


Fig. 2.

Unio (Lampsilis) johan-böhmii Frech; left (a) and dorsal (b) aspects of internal mold of a strongly compressed individual; nat. size.

Ventral margin nearly straight or even slightly concave in the greater part of its extent, curving upward posteriorly somewhat abruptly, and more sharply so anteriorly to form a rounded anterior end. In front of the beak, the internal molds are rather sharply depressed on the dorsal margin and indented by the pseudo-cardinal teeth. In the types figured by Frech, these are very strong but none of our specimens show more than their impression in the mold.

The posterior hinge-margin of the mold is marked by a moderate depression indicating a corresponding thickening of the hinge of the shell, this being, however, less pronounced than the anterior hinge impression.

In one of the molds there is a suggestion of a faint oblique angulation in the posterior portion of the shell, but this is not pronounced enough to form a definite feature. In spite of the rather imperfect character of the molds, I see no reason for considering this form other than the species described by Frech from Szechuan. The ventral concavity of the two specimens figured by Frech, is more pronounced than in our mold but a third specimen figured by him scarcely shows this at all. It is, however, quite noticeable in one of our specimens.

Only approximate measurements of the molds can be given, since they are imperfect and somewhat crushed. Some of these are as follows, those of No. 3 being of the most perfectly preserved mold.

	(1)	(2)	(3) (Figs. 2a-b.)
Length of shell.....	75 mm.....	65 mm. ±.....	58 mm.
Height at umbo.....	28 mm.....	22 mm.	26 mm.
Height in posterior fourth.....	28 mm.....	22 mm. ±	24 mm.
Greatest thickness.....	18 mm ±.....	15 mm. ±.....	9 mm.

This form resembles somewhat the modern *Unio distortus* Heude which lives in the headwaters of the Jao-tcheou river, south Kien-té and in the Ts'ing-yang district, vicinity of Nanking, in central China. § That form, however, has a more pronounced umbonal ridge, above which the shell is flattened or even faintly depressed. This feature is only faintly indicated in one of our molds, which agrees rather better with the young of the modern species than with the adult. On this account one might be tempted to regard the Cretaceous Shantung and Szechuan forms as ancestral to the species living today somewhat farther south and east, a view not incompatible with the persistence of uniform continental conditions in China from the Cretaceous to the present (See Stratigraphy of China, Cretaceous and Tertiary palæogeographic maps). On the other hand these similarities of characters may be due to parallelism in development.

Unio cf. menkii Dunker

(Fig. 3)

cfr. *Unio Menkei* Dunker; Frech in Richthofen China, Vol. V. 1911, pl. 31, Figs. 5a, b.

Frech has figured a less elongated and higher form of *Unio* from the Wealden of Osnabrück and Osterwald, Germany for the purpose of comparison with his *Unio johan-böhmi*. A single internal mold from the greenish tuffs of the Mêngyin formation of Ning-Chia-Kou, Shantung, also sent to us by Pater Kaschel, appears to agree with this form. The shell was apparently smooth, of moderate convexity, the height and length being as

§ Conchyliologie Fluviale de la Province de Nanking et de la Chine Centrale par le R. P. Heude S. J. Paris. 4th fascicle, pl. 62, figs. 122 a, 122b.

1:1.5, instead of 1:2.2 or even 1:2.7 as in the preceding species. In the specimen figured by Frech the proportions of height to length are as 1:1.65. The beaks are approximately one third the length of the shell from the front, and are not strongly pronounced or incurved. The ventral border is gently arcuate or nearly straight in the center, meeting the posterior border, which is also gently arcuate, in a rounded posterior-ventral margin. Anteriorly the ventral border curves more strongly, meeting the anterior dorsal border in a rather strong curve. There is a faint broad and rather ill-defined median depression on the mold of the right valve, but this may be a deformation. In the young (as shown by the growth-lines) the beak is nearer the center, being only slightly in front of the middle of the length of the shell.

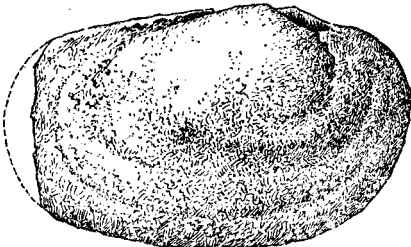


Fig. 3.

Unio cf. menkii Dunker, right side of internal mold, nat. size.

Among our modern Chinese species *Unio modestus* Heude¹ most nearly resembles this species in the rounded posterior end free from angulations, and in the general compressed character of the shell. The modern form, which is common in the upper parts of the rivers of Ning-Kouo-lsien in Anhui province, differs, however, from the fossil form in its proportionally somewhat greater length, being in this respect intermediate between the present form and *Unio johan-böhmi* which is associated with it in the same beds, the two species having been obtained from the same hand specimen. Frech reports some fragmentary specimens from Szechuan which may belong to this species.

Of the west American forms figured by White², *Unio priscus* Meek and Hayden from the Laramie formation, comes nearest to our form, agreeing with it in general form and proportions. The ventral border however is straighter in the American form and the beak somewhat nearer the anterior end.

The following measurements serve to compare the Shantung and the European specimens:

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1. Heude *loc. cit.* 2nd fascicle, pl. XIV, No. 29.
 2. 3d Ann. Rep. U. S. G. S. 1882, pl. 14, Fig. 1.

	Shantung Specimen (Fig. 3)	European specimen figured by Frech.
Length.....	48 mm. ±	66 mm.
Height at Umbo.....	32 mm.	40 mm.

Genus *MYCETOPUS* d'Orb.

These elongated odentulous fresh-water Naiadacea are represented by a number of species in the rivers of central China today, but have not been reported from older horizons so far as I am able to find out. It may be that the species here referred to this genus does not truly belong to it, but since the internal characters of our shell cannot be ascertained from the molds which alone represent this species, and since the external form agrees rather closely with that of young individuals of several of the modern species, it is placed in this genus for the present. More extensive collections may enable us to decide for or against its retention in this genus.

Mycetopus mengyinensis Grabau (sp. nov.)

(Figs. 4a, b. 5a-b.)

Shell small, greatly elongated, with nearly parallel dorsal and ventral margins. Hinge apparently edentulous. Valves equally convex, greatest convexity behind and somewhat below the umbones. Beaks about one-fifth the length from the anterior end. Just in front of them the internal mold is marked by the impression of a strong oblique subumbonal internal ridge or callosity, which extends to the rather pronounced anterior muscular impression. This feature is also recognizable, though less strongly marked, in modern Chinese species of this genus. The hinge-line of the mold extends in a straight line behind the beak for a distance equal to about three-fifths the length of the shell, and then curves into the posterior margin which is regularly rounded.

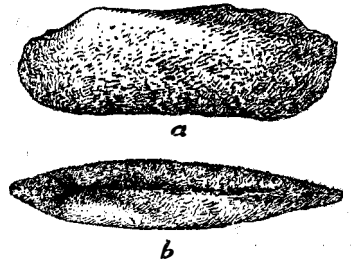


Fig. 4.

Mycetopus mengyinensis Grabau, left (a) and dorsal (b) aspects of internal mold; nat. size.

There is no depression in the hinge-line, showing that the valves met internally with edentulous and unthickened hinge margins. Anterior to the beak, the mold is depressed, and characterized by the impressions of the two oblique callosities already referred to, but so far as can be ascertained from the two specimens now in our possession, there is no dentition.

The anterior end of the mold appears somewhat nasute, because of the dorsal depressions, rounding regularly into the ventral margin which is straight for the greater length of the shell, except for a very gentle median concavity. Posterior muscle scar situated close to the posterior-dorsal margin, this and the anterior one being disposed much as in modern species of the genus *Mycetopus*.

	(1)	(2)
Length.....	44 mm.....	36 mm.
Height at umbo.....	15 mm.....	14 mm.
Height at corresponding distance from posterior end.....	15 mm.....	14 mm.
Thickness of mold.....	9 mm.....	8 mm.

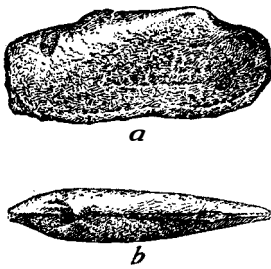


Fig. 5.

Mycetopus mengyinensis
Grabau, right (a) and dorsal
(b) aspects of a smaller internal
mold showing impressions of subumbonal ridges;
nat. size.

Among modern Chinese forms a young of *Mycetopus oleivorus* Heude¹ comes nearest to our form, though the former is many times larger. With a length of 98 mm. the umbonal height of the type specimen of that form is 19 mm., while the height of the posterior end is 10.5 mm., and the beak is about 1/4th the length of the shell from the front. This gives a proportion of height to length as 1:5. In a young stage of this shell, however, where the length is 39 mm. the umbonal height is 11.5 mm., giving a proportion of 1:3.4 which is only slightly greater than that of our fossil species. The adult *M. oleivorus* reaches a length of 190 mm.; and an umbonal height of 35 mm., and has a much more pronounced umbonal ridge and obliquely subtruncate posterior end.

1. loc. cit. pl. XXIII, fig. 48.

It would at first glance seem that the specimens in question are the young of *Unio johan-böhmi* with which they are associated, but the apparent edentulous character of the hinge speaks against this. Moreover the young of *U. johan-böhmi* are less elongate in proportion, with the dorsal and ventral margins arched and not parallel. The present form is therefore regarded as distinct. Of American fossil forms *Anodonta parallela* White¹ from the Laramie formation, approaches very closely to our form, though it is larger. With a length of 61 mm. and an umbonal as well as posterior height of 19 mm., the proportion of height to length are as 1:3.2 which is very little larger than in our forms. The posterior end of the American form is somewhat more sharply rounded and the ventral margin shows no concavity. Otherwise the two might be considered co-specific.

This species is at present known only from the Mêngyin formation at Ning Chia-Kou where two specimens were obtained by Pater Kashel.

Genus *CYRENA* Lam. (*sens. lat.*)

The shells here placed provisionally under this generic term, used in its comprehensive sense, are small and mostly preserved with the two valves in conjunction, but it has not been possible to obtain any specimens showing the character of the hinge. In the only case where the interior of the shell was exposed the hinge teeth appear to be absent or at best very feebly developed, and not sufficiently definite to enable me to determine their character. This is in part due no doubt to their being broken.

In form some of the shells suggest *Pisidium* and others appear to be so nearly equilateral as to suggest the genus *Sphaerium*. The former genus has, however, been regarded as absent from strata older than Eocene, though White has described a species from the Laramie. *Sphaerium* has, however, been obtained from strata of Upper Cretaceous age, several species being described by White from the Laramie. These genera have been separated from the Cyrenidæ by Dall who created for them the family Sphæriidæ, because of their small size, feeble and short ligament, simple pallial line and absence of hinge-plate. The cardinal teeth are variable, thin and often defective, but the laterals are distinct.

1. 3d Ann. Report U. S. G. S. pl. 19, fig. 5.

Cyrena (Sphaerium?) tani Grabau (sp. nov.)

(Figs. 6a, b.)

Shell small moderately convex equivalve, though by pressure the beak of one valve may appear above that of the other; subcircular, with the length somewhat in excess of the height, though sometimes nearly equaling it. Beak about two fifths the length of the shell from the anterior end. Shell slightly depressed in front of the beak and with a short ligamental area behind. Anterior end regularly rounded, posterior end formed of three successive gentle curvatures meeting in a more abrupt curve, and giving the shell a subtruncate appearance behind.

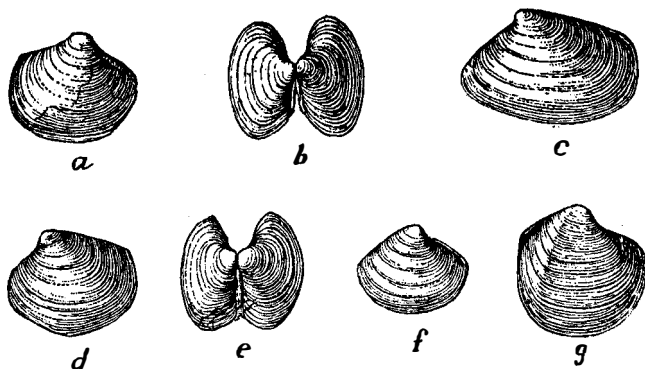


Fig. 6.

Cretaceous *Cyrenas*, all enlarged three times *a*, *Cyrena (Sphaerium) tani* Gr. right valve; *b*, the same, two valves in conjunction, partly opened, viewed from above; *c*, *Cyrena (Pisidium) shantungense* Gr. left valve; *d*, *Cyrena (Pisidium?) wangshihense* Gr. left valve; *e*, the same with the valves conjoined, and partly open; *f*, *Cyrena (Pisidium) retrostrum* Gr. right valve; *g*, *Cyrena (Pisidium) altiformis* Gr. right valve. *Pisidium* beds of Wangshih Formation (Upper Cretaceous) Chiao-Hsien, Shantung.

Surface smooth except for fine lines of growth and coarser lines of growth-pauses at subregular intervals.

Measurements:

The following are the measurements of [three characteristic specimens.

	1	2	3
Length	7.5 mm.	5.0 mm.	6.0 mm.
Height	7.3 mm.	4.3 mm.	4.5 mm.
Distance of beak from anterior end	3.0 mm.	2.0 mm.	2.5 mm.

No. 1 is a typical form (Fig. 6a) with the valves in conjunction and slightly compressed so as to bring the beak of one valve over the other. No. 2 is a more convex form with the valves spread (Fig. 6b), and probably represents the dimensions more correctly. No. 3. is like No. 1 but smaller.

Horizon and Locality: Fairly common in the gray shales in the lower part of the Wangshih series of Chiao-Hsien, east Shantung, (loc. 220) Coll. H. C. T'an, after whom the species is named. The horizon is Upper Cretaceous.

Cyrena (Pisidium?) shantungense Grabau (sp. nov.)

(Fig. 6c.)

Shell small, elongate, wider than high, with the beak in the anterior third. Convexity moderate, not inflated. Beaks small, slightly incurved, with a slight depression in front, and a straight but sloping hinge line behind, which extends for nearly four-fifths the distance from the beak to the posterior end into which it curves abruptly. Posterior end regularly rounded and broader than the anterior. Ventral margin gently arcuate.

Greatest convexity of the shell a little above the middle. Surface marked by fine growth-lines and by regular equi-distant, and rather pronounced strong concentric lines marking periodic interruptions of growth, these sometimes giving the shell the appearance of being marked by regular concentric wrinkles.

Measurements. Two characteristic specimens give the following measurements:

	(1) (Fig. 6c)	(2)
Length.....	8 mm	7 mm.
Height.....	5 mm.....	5 mm.
Distance beak to ant. end.....	3 mm.....	2 mm.

This shell is readily distinguished from the preceding species by its elongate form, long sloping hinge line, and anteriorly placed beaks as well as by the strong concentric growth-interruptions. From *C. (Pisidium?) wangshihense* it is distinguished by its proportionately greater length, sloping

hinge-line, and the absence of an incipient umbonal ridge or angulation.

From the fact that many specimens occur in a somewhat crushed condition, the characters do not always appear clearly, and it may not always be readily possible to distinguish this from the next species. In normal specimens however the distinctions are readily seen.

Horizon and Locality: In the Wang-shih formation of Chiao-Hsien, east Shantung (loc. 220) associated with the preceding species. Fairly common.

Cyrena (Pisidium?) wangshihense Grabau (sp. nov.)

(Fig. 6d,e)

Shell small, elongate, wider than high, with the beak in the anterior third, inflated. Beaks rather strongly incurved, with a pronounced depression in front and a long straight hinge-line behind, which slopes much less than in the preceding species. Posterior end broadly arched or subtruncate, the posterior dorsal portion of the shell separated from the lateral parts by a faint, though evident umbonal ridge, which extends obliquely across the shell from the beak to the posterior ventral border. Ventral margin gently arcuate joining the posterior margin rather abruptly, but curving regularly into the frontal margin which is more narrowly and strongly rounded than the posterior. Surface marked by fine lines of growth, and occasionally stronger growth-cessations which are, however, irregularly spaced.

Dimensions:

Length.....	6 mm.
Height.....	4.5 mm.
Beak to front.....	2 mm.
Thickness abt.....	4 mm.

This shell is readily distinguished from the preceding species by the faint umbonal ridge, sub-truncate posterior end, stronger convexity, and slightly different proportions.

Horizon and Locality: Associated with the preceding species, but less common.

Cyrena (Pisidium) retrorostrum Grabau (sp. nov.)

(Fig. 6f.)

Shell minute, transverse, with anterior end slightly longer than the posterior, a feature characteristic of typical *Pisidium*. Beaks incurved and pointing forward, with a rather pronounced depression in the cardinal margin in front of the beak. Hinge-line short; greatest convexity in umbonal region; anterior end rather sharply rounded, posterior end broader; posterior ventral border faintly subtruncate, ventral border broadly rounded.

Surface with subregularly spaced coarse growth-wrinkles and fine growth-lines.

There is some variation in the forms included under this species, this being chiefly in the relative length of the anterior and posterior ends, and in the proportion of length to height. The measurements of the type are: Length 5. mm., length anterior end 2.75 mm., height 4. mm.

Horizon and Locality. In the Wangshih formation of the Upper Cretaceous of Chioa-Hsien, east Shantung, associated with the preceding species; rare. Coll. H. C. T'an.

Cyrena (Pisidium) altiformis Grabau (sp. nov.)

(Fig. 6g.)

Shell with height and length nearly equal, and with beak in the posterior third. Beaks elevated and moderately incurved, with a very pronounced depression in front of the beak. Anterior end regularly rounded into basal margin.

Hinge-line short; posterior end subtruncate, with a rather pronounced umbonal ridge extending from the beak to the posterior ventral margin, the posterior portion of the shell bounded by it being depressed-convex or flat. Surface with fine growth-lines and at subregular intervals with somewhat more pronounced lines, but no marked wrinkles.

Dimensions of type: length 6 mm.; height 5.8 mm.; length of posterior end 2 mm.; of anterior end 4 mm.

This shell is readily distinguished from the others described, by the subequal length and height, the pronouncedly posterior position of the beak,

the rather strong umbonal ridge, and the subtruncate posterior end. The growth lines are also more regular than in most of the other species.

Horizon and Locality: In the Wangshih formation of Upper Cretaceous age. Chioa-Hsien, east Shantung, associated with the preceding; rare. H. C. T'an Coll.

GASTROPODA

Genus *BITHINIA* Gray.

Bithinia mengyinense Grabau (sp. nov.)

(Figs. 7a-d)

This species is at present known only from internal molds to which thin layers of the shell adhere. The height of the largest specimen was probably not much over 12 mm, the height of the mold being 11 mm. with a maximum diameter of the last whorl of 9.5 mm. The apex is not preserved in the mold, but the apical termination of the mold indicates the existence of an apical septum. Whether the apical whorls were decollated in the shell or not can not be determined. The original number of volutions may have been between 5 and 6, but only four remain in the mold. These enlarge rapidly but uniformly, until the diameter of the tube of the final whorl is 4.5 mm. The amount of embracing is comparatively small, being considerably below the ambitus of the whorl, and thus producing deep sutures. The final whorl embraces about one third of the preceding one. The whorls are uniformly and regularly rounded, the apertural end of the mold being circular in the largest specimen, but somewhat ovoid in a smaller one. The umbilicus is narrow and apparently covered by a thickening of the inner lip. The apical angle in the large mold is 60°, in the smaller about 54°, the height of the latter is 8 mm. and the maximum diameter of the shell at the last whorl about 5.5 mm., the greatest apertural diameter of the whorl itself being 4 mm. Surface, so far as preserved, smooth, with growth-lines very fine.

This shell resembles the internal molds described by O. Reis from the fish beds of Transbaikalia under the name *Paludina pura* Eichwald. Our species, however, cannot be placed in the genus *Paludina*, the enlargement

of the whorls being too regular, the last whorl having a less proportional diameter, and the amount of embracing being much less than in species of that genus. The apical angle of our shell is wider than that of the Siberian form, and the final whorl proportionately smaller. Of modern Chinese species *B. umbilicaris* Möllendorf comes perhaps nearest to our form in size, rate of increase of whorls, and apical angle.

Horizon and Locality: In the Mêngyin formation of Ning-Chia-Kou, Shantung, Lower Cretaceous. (Coll. P. Kachel.)

Genus *VALVATA* Müller

Valvata suturalis Grabau (sp. nov.)

(Figs. 7e-g.)

Shell smooth low-spired, round-whorled, and broadly umbilicated; represented by internal molds to which only a part of the shell adheres.

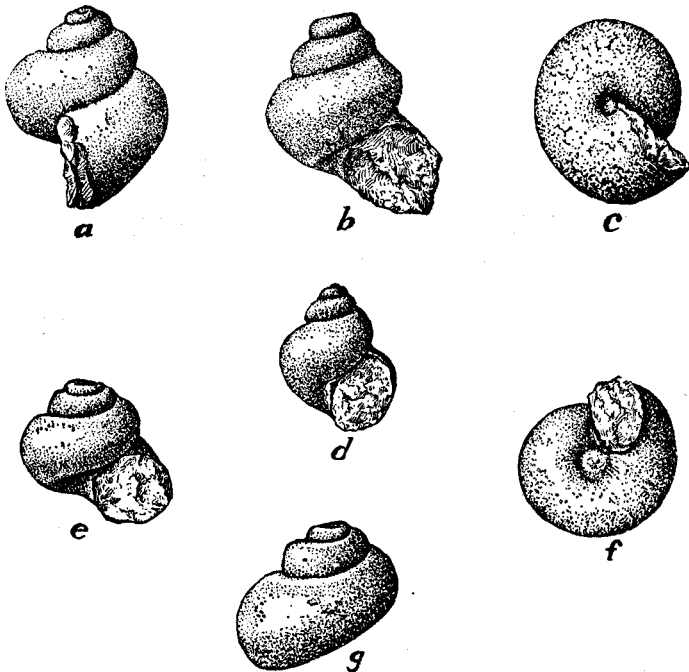


Fig. 7.

Lower Cretaceous Gastropoda from Shantung; all enlarged $2\frac{1}{2}$ times. a-c, *Bithinia mengyinense* Grabau, a lateral, b apertural, c umbilical views of the type, an internal mold; the umbilicus in c is covered by the inner lip in the perfect shell; d the same species, another smaller individual retaining part of the shell at the inner lip which extends over the umbilical region. e-g *Valvata suturalis* Grabau; e apertural, f umbilical, g lateral views of the type, an internal mold. f. shows the relatively large umbilicus. Mêngyin Formation, Ning-Chia-Kou, Shantung.

Whorls few, rather rapidly and regularly increasing, with comparatively slight embracing in the later whorls, producing a well-marked suture. Apical whorls not preserved, there being an indication, in the mold, of the existence of an apical septum. Earlier whorls more strongly embraced than the later, producing a lower apical spire. The original number of whorls appears to have been four, but only three are preserved in the largest mold. Aperture broadly ovoid, more broadly rounded below than above, and with the longest diameter oblique to the axis of the shell. Umbilicus of moderate size, not covered by the inner lip which is continuous with the outer one.

This shell resembles somewhat closely *Valvata piscinalis* Möll. of the fresh-water Miocene of Transylvania, but the spire is somewhat more elevated; the apical angle is nearly the same, being somewhat greater than 90°. Our species is also somewhat larger. The height of our largest mold is 8.5 mm., greatest diameter of shell in last whorl 9 mm., diameter of aperture 4.7 mm., diameter of umbilicus about 2.5 mm.

This shell might be mistaken for a broader form of the preceding species, except for the wide umbilicus which is a characteristic feature and on which account it is referred to *Valvata*, in spite of the rather strongly elevated spire. The shell was apparently smooth with occasional stronger growth-lines, the direction of which coincided with the axis of the spire.

Horizon and Locality: Represented by a number of internal molds in the collection of Father Kachel from the Mêngyin formation at Ning-Chia-Kou, Shantung, where it is associated with the preceding. Lower Cretaceous.

Genus *LIMNAEUS* Cuvier

Limnaeus? sp.

Several crushed shells from the *Cyrena* shales of the Wangshih series of Chiao Hsien, East Shantung (loc. 220) appear to belong to this genus of fresh water shells. They are too imperfect for precise determination.

Genus *CYCLOPHORUS* Montf.

Cyclophorus? sp.

A number of crushed, round-whorled, thin-shelled and low-spined gastropods with well-marked umbilicus, appear to belong to this or a related

genus of terrestrial mollusks. They were obtained from the *Cyrena* shales of the Wangshih formation at Chiao-Hsien, East Shantung.

CRUSTACEA.

Genus *ESTHERIA* Ruppel

Estheria cf. *middendorfi* R. Jones

- 1862 *Estheria Middendorfi* Rupert Jones, Fossil Estheriæ, Palæontographical Society Monographs, Vol. XIV, pp. 111-114, pl. IV, figs. 12-22, text fig. 11.
- 1865 *Estheria Middendorfi* Jones, Eichwald, Lathæa Rossica, Vol. II, pt. 2, pp. 1181-1183.
- 1865 *Estheria orientalis* Eichwald, Lathæa Rossica *ibid.*
- 1910 *Estheria Middendorfi* R. Jones, Reis, Die Binnenfauna der Fischschiefer in Transbaikalien—Explor. Géol. et Minières le long du Chemin-de-Fer de Sibérie. Liv. XXIX, pp. 40-41, pl. II, figs. 24-25, pl. IV, figs. 19, 20, 23.

Original description: "Carapace-valves thin, suboblong, straight on the dorsal margin, nearly the whole of which is occupied by the hinge-line; umbo forward, not preserved in the many specimens seen; ends well rounded, and nearly equal; ventral margin gently and nearly symmetrically curved. Ridges distinct, about twenty-four, sometimes more numerous, and crowded towards the ventral edge; interspaces bearing an open, irregular reticulation, often passing into thin, transverse, somewhat irregular riblets; the irregularly hexagonal areas of the reticulation when highly magnified, are seen to be delicately punctured."

So far as our rather poorly preserved specimens permit us to judge, they agree in all essentials with the above description except size, and I have little hesitation in referring them to the same species. The length of a left valve of a large specimen is 10 mm. while the umbo is about 2 mm. from the anterior end; the height of this specimen is 5.5 mm. A right valve measuring about 8.5 mm. in length has a height of 4.5 mm., while the hinge-line is about 5.5 mm. long. A typical specimen figured by Jones as of natural size has a length of nearly 21 mm. and a height of 13 mm. One

figured by Reis has a length of 22 mm. and a height of 14 mm. It thus appears that our specimens are only about half the size of the Siberian forms, nevertheless I shall for the present refer them to this species, though further collections may produce material to show that our form is distinct.

The details of sculpture described by Jones and Reis are not recognizable in our specimens.

Horizon and Locality: In the paper-shales of the Laiyang formation, 1 li N. of Nan-Wu. Lai-Yang Hsien, Shantung (Loc. 221). Lower Cretaceous. H. C. T'an Coll. Geol. Surv. China. Cat. No. 429. Associated with plants and *Lycoptera ferox* Gr. and *L. sinensis* Woodw.

INSECTA

Few fossil insects have so far been described from eastern Asia and every addition to the insect fauna, however fragmentary, is of interest. This is especially true of the Mesozoic insect fauna, for during this era the Asiatic continent was not only as large as, but larger than it is today. It thus most probably included a variety of habitats, and hence the insect fauna may be expected to be a varied one. Moreover, as eastern Asia is one of the few northern lands of great extent on which Cretaceous strata are largely represented by continental deposits, we may expect to find here the record of a fauna so far largely unknown, and represented elsewhere by a gap in the faunal succession of insect life.

The only insect faunas heretofore known from the Mesozoic of eastern Asia were obtained from Siberia and described in the Russian literature*. One of these is from the Ust Balei Basin in the Irkutsk region, the deposits of which, from the associated plant remains, have been described as belonging to the Middle Jurassic. Among the insects described from these strata are the following**.

* As this literature is at present only in part available, full citation and comparison can not be made; this it is hoped, can be made before the fuller descriptions and illustrations of these forms appear in the *Palæontologia Sinica*.

** Brauer, Redtenbacher, and Ganglbauer, Fossile Insekten der Jura-formation Ostsibiriens. *Mém. de l'Acad. Imp. des Sciences de St. Petersburg*, VII ser., vol. XXXVI, No. 15, 1886.

Order ORTHOPTERA

Family LOCUSTOPSIDÆ Handl.

Parapleurites gracilis Br. Redt. & Gangl.

Family LOCUSTIDÆ

Pseudohumbertiella grandis (Br. Redt. & Gangl.)

Order BLATTOIDEA

Family POROBLATTINIDÆ Handl.

Ophismoblatta sibirica (Br. Redt. & Gangl.)? *Ophismoblatta maculata* (Br. Redt. & Gangl.)

Order COLEOPTERA

Timarchopsis czekanowskii Br. Redt. & Gangl.*Carabocera prisca* Br. Redt. & Gangl.*Doggeria sibirica* Handl.*Memptus braueri* Handl.*Memptus redtenbacheri* Handl.*Coleopteron*—gen. & sp.?

Order PERLARIA (only in Siberia)

Mesonemura maaki Br. Redt. & Gangl.*Mesoleuctra gracilis* Br. Redt. & Gangl.*Platyperia platypoda* Br. Redt. & Gangl.

Order ODONATA

Palaophlebia synlestoides Br. Redt. & Gangl.*Samarura gigantea* Br. Redt. & Gangl.*Samarura minor* Br. Redt. & Gangl.*Samarura pulla* Br. Redt. & Gangl.*Samarura angustata* Br. Redt. & Gangl.*Samarura rotundata* Br. Redt. & Gangl.

Order PLECTOPTERA (Larvæ)

Mesobætis sibirica Br. Redt. & Gangl.*Mesoneta antiqua* Br. Redt. & Gangl.

Order PANORPATAE Brauer

Mesopanorpa hartungi (Br. Redt. & Gangl.)

Order LEPIDOPTERA

Phragmatoecites damesi Oppenheim*Palæocossus jurassicus* Oppenheim

Order DIPTERA

Mesopsychoda dasyptera Br. Redt. & Gangl.*Nematocera* Br. Redt. & Gangl.

Incertæ Sedis.

Baseopsis? *sibirica* Br. Redt. & Gangl.

Carabid larva. Br. Redt. & Gangl.

Colcoptera larva. Br. Redt. & Gangl.

From the Turga shales of the Turga river, the deposits which have furnished *Lycoptera middendorfi*, Reis§ records the following insects.

Phryganidarum gen. sp. (rare), *Ephemeropsis orientalis* Eichwald (common). Handlirsch* also records *Phacelobranthus braueri* Handle from Turga, basing this species on part of the material originally identified by Brauer, Redtenbacher and Ganglbauer as *E. orientalis* Eichw.

Ephemeropsis trisetalis Eichw. is recorded from these beds on the Towega River, Nertschinsk, E. Siberia, and *E. orientalis* Eichw. from Konduyewskaya on the Turga in Nertschinsk. From Byrka *Ephemeropsis middendorfi* Handl. is recorded, a species which Reis would unite with *E. orientalis*. From deposits of the same age on the Witim river the following insects are recorded by Reis: *Carabid* (gen. & sp. indet.), *Rhynchophoron* (gen. & sp. indet.), *Staphylinid* (gen. & sp. indet.), *Phryganid* (gen. & sp. indet.), *Libellulid* (gen. & sp. indet.). Finally from the corresponding beds near Irkutsk, Heer records a Coleopteron under the name *Elatoides sibiricus* Heer**. The age of the deposits on the Turga and Witim rivers is probably Lower Cretaceous.

§ O. M. Reis, Die Binnenfauna der Fisch-schiefer in Transbaikalien. Explor. Géol. Min. le long du Chemin-de-Fer de Sibérie, Liv. XXIX, 1910.

* Die Fossilen Insecten p. 604 pl. 46 fig. 33.

** Mem. Acad. Sci. St. Petersburg. XXII, no. 12, p. 41, pl. 27, fig. 9, 1876.

New Species from Shantung.

Order *Blattoidea*Genus *SINOBLATTA* Grabau (gen. nov.)

Among the material collected by Mr. T'an from the Laiyang shales is a specimen of a cockroach represented by both the crushed specimen and its counterpart. The animal exposes its ventral side and the wings are only partly shown. Hence it is not possible to relegate it to any of the genera whose diagnosis is based on wing structure. The form of the body and the large size of the head are unlike any other fossil form I have seen recorded, and since it can not be referred to any of the genera described, it is placed under a new generic name.

Only two species of *Blattoidea* have so far been recorded from Mesozoic rocks of Siberia, these are both referred by Handlirsch to his genus *Ophismoblatta* and are both from the Jurassic beds of Ust Balei, East Siberia. One *O. sibirica* (Br. Redt. & Gangl.), is represented by a wing, the other *O. maculata* (Br. Redt. & Gangl.) by a body fragment including parts of the thorax and abdomen. This is doubtfully referred to the same genus because of the association. As the genus *Ophismoblatta* is founded on the wing and as the body fragment is too imperfect to admit comparison with our specimen it has seemed best not to refer the latter to this Siberian genus.

The characters of the genus can at present not be separated from those of the species but the large oval head with the large eyes, the somewhat heart-shaped form of the prothorax, and the relatively long femur of the legs, may be taken as perhaps of generic significance. The scapular vein of the tegmina appears to be very strong since its course is apparently well marked in the impression.

Genotype and only known species: *Sinoblatta laiyangensis* Grabau (sp. nov.).

Horizon. At present only known from the Lower Cretaceous Laiyang formation of Shantung.

Sinoblatta laiyangensis Grabau (sp. nov.)

(Plate I, fig. a.)

The only specimen in our collection is nearly complete so far as the body is concerned but the individual lies upon its back and thus only the margins of the wings, which were apparently closed, are seen. These do not permit of the determination of the detail of the nervation and so the only characters that can be described are those of the ventral side of the body.

The head is unusually large for nymphæ of this group and in its compressed character on the shale surface shows a nearly oval form, 2 mm. long, and with the width half again as great as the length i. e. 3 mm., this being somewhat behind the middle; anterior end regularly rounded. On one side a large sub-oval impression is shown which appears to be an eye; its mate on the opposite side is not preserved. Two long slender antennæ are inserted, one on either side of the head just in front of the eye. They taper very gently from a basal width of about one-third of a millimeter, and one of them can be traced for a length of 7 mm., its original length being apparently much more than that. These antennæ are distinctly and sharply segmented, about 10 segments occurring in the space of 1 mm. A slightly projecting thickening on one side suggests the maxillary palp. The mouth parts are not distinguishable in the impressions.

The prothorax (prosternum) is large, somewhat wider than long. Anterior end regularly rounded with the head loosely articulated, posterior end subtriangular, the sides converging so as to form nearly a rectangle. Anterior pair of limbs appear inserted near the middle. Meso- and meta-thorax not differentiable. Of the second and third pair of legs the femur, tibia and tarsus are generally well preserved but the inner joints are not recognizable. The femur is swollen in the center and rather long. It appears to be smooth. The tarsus is comparatively long and thin but its joints can not be made out.

Only faint impressions of the wings are noticeable but the venation can not be definitely determined. In the right anterior wing or tegmen (left as seen from below in pl. I, fig. a.) the mediastinal and scapular veins are recognizable at their anterior portion while the branching veins of these

systems are also indicated, but the detail of arrangement can not be determined.

The abdomen is only partly preserved the posterior segments being wanting.

Total length of specimen to end of last preserved segment of abdomen about 17 mm. Total original length perhaps 20 mm. Length of head 2 mm., width of same 3 mm., length of prothorax 5 mm. Greatest width 6 mm.; other parts in proportion.

Horizon and Locality. In the Laiyang shales (fish beds) at Pa-Tzu, Lai-Yang Hsien, Shantung; 1 specimen (counterparts). Coll. H. C. T'an. (G. S. C. Mus. Cat. 425, 426.).

Order?

(Genus *LAIYANGIA* Grabau (gen. nov.)

Among the insects obtained from the Laiyang fish beds is one that presents a number of anomalous characters, which make it difficult to ascertain its true relationships. I confess myself entirely at a loss in attempting to refer it to any known order, much less described genus, though the lamentable fact that we are at present without adequate literature references may be in part responsible for this. Nevertheless a rather thorough examination of standard works on modern insects and of Handlirsch's "Die Fossilen Insekten", and a review of the orders of insects as there outlined, gives me no clue as to the systematic position of the form here to be described. It is of course true, that the strong vertical compression of the body has considerably altered its form, and the remarkable appearance of the thorax may be in part due to this. Yet it seems doubtful if mere compression could account for the marked character of this part of the body since the parts, as preserved, are extremely symmetrical. Under these circumstances I can only describe the fossil as carefully as the material permits, and leave the interpretation and systematic reference to the future. If the wings alone were preserved one would probably not hesitate to place the insect among the Blattoidea but the other characters of the body entirely forbid such a reference.

As only a single specimen of this form is known, the generic characters must be essentially those of the species. The chief of these may be summarized as follows:

Head oval, rather large, not transverse, and apparently loosely joined to the thorax. Antennæ and mouth-parts not determinable. Prothorax moderately large about as long as wide, and apparently distinct from the mesothorax to which it is only joined in the median portion. The combined mesothorax and metathorax large, forming together a truncated cone (as compressed on the rock surface) fully twice as wide behind as in front, and strongly lobed with oblique lobations; abruptly ending behind. Legs slender with long many-jointed tarsus. Two pairs of well developed wings approximately of equal length, the anterior about three times as long as wide, the posterior apparently wider. Veination simple, the principal veins all beginning far back. Costa marginal, sub-costa simple, meeting the wing margin near the mid-length. Radial simple, meeting the margin a little in front of the mid-length of the wing. Radial sector branching off near the base of the radial, and sending a number of branches to the front margin of the wing. Media also beginning far back, much branched, the branches extending to both the frontal and back margins of the wing, cubitus few-branched (about 4 in the genotype); anal field sharply outlined by a strong arcuate anal fold, which has a remarkable resemblance to that of the wings of the *Blattoidea*. Anal veins not preserved; cross veins not shown. Posterior wings with more complicated nervation, the subcosta (?) giving off a number of short branches to the frontal margin of the wing; cross-veins apparently well developed. Abdomen remarkable in that the anterior ring is much contracted as in many Hymenoptera, the next one abruptly widening again thus giving the insect a contracted "waist". Posterior part of abdomen not preserved.

Genotype: *Layangia paradoxiformis* Grabau (sp. nov.)

Horizon: Lower Cretaceous, Laiyang formation, Shantung.

In attempting to interpret the structure of this insect we might assume that the meso- and meta-thorax are very short and that the greater part of the triangular lobed structure here referred to the thorax might in reality be a part of the abdomen, the posterior part of which is abruptly

contracted and has an unknown terminal portion. In that case we must consider the sudden expansion of the body behind the contracted ring as illusory and only apparent, this appearance being brought about in some way by the crushing. While this would do away with the anomaly of a lobed thorax, it would still leave us with a form differing markedly in appearance and in wing structure from any known type. In such a form the posterior wings, which are evidently folded over the body, would project for almost half their length beyond the end of the abdomen. Moreover, there is a faint but not to be disregarded indication of a posterior leg which proceeds from a point that would fall upon the prolongation of the line separating the fourth and fifth lobes of the supposed thorax. This is shown in the figure somewhat more strongly than its actual appearance. Until better preserved material then shows the contrary, I shall regard the lobed conical portion of the body as forming the combined meso- and meta-thorax.

Laiyangia paradoxiformis Grabau (sp. nov.)

(Plate II, fig. b.)

The specimen appears to expose the ventral surface. Head of regular oval outline 2 mm. long, width 1.3 mm., with antennæ and mouth parts crushed and much distorted; loosely joined to the prothorax, with the appearance of a short thick neck between them.

Prothorax comparatively small, somewhat heart-shaped, with the greatest width in the anterior third. Length about 2.5 mm., greatest width about 2.25 mm. Anterior pair of legs not preserved. The prothorax seems to be distinct from the rest of the thorax and partly separated from it by posterior lateral indentations so that it is connected only in the central portion with the meso-thorax. Meso- and meta-thorax forming a truncated cone in outline, defined in front by the indentations which separate it from the prothorax and sharply contracted behind to the narrow "waist" which unites it with the abdomen. At the anterior end of the meso-thorax the width is 4 mm., at the posterior end of the meta-thorax it is 7.5 mm. The sides of the thorax converge forward in a regular manner, forming straight lines except for the lobation.

This part of the thorax is divided into five lobes on each side by

oblique lateral indentations which are continued by obliques lines towards the center. The lobes are rounded on the exterior and increase slightly in size from before backwards, the posterior pair being the largest. The posterior lateral borders of the thorax converge at the same angle as the lobe-lines, the constriction producing a waist 2.5 mm. in width. A median groove, about $1/3$ mm. wide and generally well-marked though shallow, extends along the entire center of the thorax including the prothorax.

So far as may be judged from the position of the wings the anterior two lobes of this part of the thorax belong to the meso-thorax and the posterior three to the meta-thorax. Thus identified the lobes of the meso-thorax are less distinct than those of the meta-thorax.

Of the second pair of legs one is partly preserved, the inner leg joints being apparently redoubled and more or less dissociated. The best preserved part seems to be the tarsus for it is made up of five distinct joints each provided with setæ distally, the last joint forming a long claw, which is however, not very distinct. The leg-joints themselves are slender and delicate.

Anterior pair of wings about 3 times as long as wide, the length being 12 mm. and the width a little less than 4 mm., with the end rather regularly rounded. Anal field large and well-defined by a strong anal furrow of sub-semicircular outline, and strikingly like that found in the tegmina of the Blattoidea; nervures only in part traceable. Subcosta simple, reaching the costal margin at about the middle of the wing-length and closely approaching the anal furrow at its proximal end. Radial simple, close to the subcostal at the proximal end, where it almost seems to merge with it, diverging from it distally and joining the costal margin some distance in front of the subcostal, leaving a somewhat wider space than that between the succeeding branches of the radial sectors. The junction of the latter with the radial is not clear but its divergence from it is pronounced and it can be traced for some distance. It gives rise to at least six subparallel branches which are convex outward, joining the costal wing margin at regularly spaced distances. The sixth of these branches appears to bifurcate not far from the center, the two divisions of this branch reaching the margin at about the same intervals as the preceding simple branches. The median can not be continuously

traced, but appears to have numerous branches (at least 12) which reach the outer margin of the wing.

The cubitus appears to be four-branched, the original two branches again bifurcating near the margin. This is however not very clear.

The nervures of the anal group are not preserved, the large field bounded by the anal furrow appearing blank in both wings except for a few faint and indefinite impressions. No cross-veins are seen in the specimen, they being either absent or so fine that they were not preserved.

One of the posterior wings is partially shown, but does not allow precise tracing of the nervures. The subcosta, however, appears to extend farther out on the wing than is the case in the tegmina, and also appears to send off short branches to the costal margin. The length of the posterior wings, so far as can be ascertained, is about the same as that of the anterior pair but they appear to be broader. However, too little of them is preserved to permit definite characterization. They appear, however, to retain numerous cross-veins. The abdomen is poorly preserved. All that can be determined, is that the anterior ring is much contracted, being in the compressed state only 2.5 mm. wide. The next ring is abruptly widened to about 6 mm. but the detailed character of this and the succeeding rings, if such existed, can not be determined. If the abdomen was long enough to extend to the end of the posterior wings when these were closed, its length was at least 8 mm. Length of specimen as preserved 17 mm. (The venation of the wing is indicated as follows: *C*, costa; *Sc*, Subcosta; *R*, radial; *Rs*, radial sector; *M*, media; *Cu*, cubitus; *A*, anal fold.)

Horizon and Locality. A single specimen was obtained from the thin gray shales which form the fish-beds of the Laiyang formation 2 li north of Po-Tzu in Lai-Yang-Hsien, Shantung Province. The horizon is regarded as Lower Cretaceous. Coll. H. C. Tan.

Order COLEOPTERA

Division LAMELLICORNIA

Family SCARABÆIDÆ

Genus *PROTEROSCARABÆUS* Grabau (gen. nov.)

As only a single specimen is known, the generic and specific charac-

ters can not readily be delimited; still certain striking characters may be regarded as of generic value.

Head triangular with converging sides and laterally placed eyes. Antennæ lamellicorn with seven (?) leaf-like appendages which could be spread fan-like. Head and prothorax intimately united, their sides nearly continuous. Prothorax (pronotum) widest behind the middle, in front of which the sides converge to the head with the sides of which they are continuous. Posterior portion more abruptly contracted thus sharply dividing the pro-thorax from the meso-thorax. Anterior pair of legs with broad tibia with serrate or notched outer margin, and without tarsi.

Meso-thorax and meta-thorax united; abdomen six ringed. Second and third pair of legs somewhat different, the latter with longer and stouter tarsus ending in a double spine. Distal end of tibia with two spines. Elytra subtruncate posteriorly not wholly covering the end of the abdomen; longitudinally marked by close-set rows of fine spots.

There can be no doubt that we have here a true Scarabæid. This is shown in the modification of the anterior pair of legs, where the tarsi have become obsolete while the tibia is expanded into a broad blade-like structure, with lateral spinose serrations and evidently adapted for digging purposes. These blades are much like those of the sacred scarab of the Mediterranean region (*Ateuchus sacer*) but are broader, and the notches more complicated. The scarabæoid character is also shown in the structure of the antennæ which show the characteristic leaf-like appendages of the *Lamellicornia*. Our genus differs from the sacred scarab in lacking the six-pointed coronal frontal margin, which instead is slightly nasute. The prothorax of our species is much more strongly contracted behind than is usually the case in the modern or even Tertiary beetles of this group.

No undoubted members of the family *Scarabæidæ* have heretofore been obtained from strata older than the Tertiary. Those Jurassic forms that have been placed here by various authors are considered by Handlirsch as either positively referable to other families, or as being so indefinite that they may with equal propriety be referred to any one of a number of families.

This Lower Cretaceous form therefore represents the oldest known member of the family, in fact the only pre-Tertiary form which definitely shows those characters which are readily recognizable as belonging to that family.

Genotype: Proteroscarabæus yeni Grabau

Horizon: Lower Cretaceous, Laiyang formation.

Locality: Lai-Yang Hsien, Shantung.

Proteroscarabæus yeni Grabau (sp. nov.)

(Plate II, fig. a.)

Head sunk into the prothorax and apparently closely united with it, there being only a faint line of demarkation between the two. Outline of head subtriangular, with the anterior end rounded and somewhat constricted laterally, so as to give it a slightly nasute appearance. There is a suggestion, on one side, of fine setæ or bristles, which margined this portion of the head but this is not very clear. Sides of the triangle somewhat lobate but not strongly notched, the most pronounced of the lobes marking the position of the eyes which are laterally placed and somewhat behind the middle. On one side of the head is preserved a part of one of the lamelliform feelers which, however, is somewhat crushed and apparently not in place. The joints are very short, their number not ascertainable but there appear very faint impressions of seven delicate leaf-like appendages of somewhat varying length but all wider than long and spread in an irregular fan-like manner. With one or two exceptions these leaf-like blades are not represented by chitinous (carbonized) films but are mere delicate impressions. The joints of the antenna however, are preserved in carbonized chitin.

Length of the head, as exposed, a little less than 3 mm., greatest width, near the junction with the pro-thorax, a little less than 4 mm.

Pro-thorax distinct and nearly free, the pronotum forming with the head an inverted heart-shaped outline. The anterior margin of the pronotum, where it joins the head, is gently concave while the sides for more than half the length are gently convex or nearly straight, sloping outwards to form the greatest width, which is a little posterior to the middle. Beyond this they are

more sharply rounded backwards and then abruptly converge backwards to the narrow connecting portion with the meso-thorax. The anterior width of the pronotum is nearly 4 mm., its greatest width 7.5 mm., and the width at the contracted posterior end about 3.75 mm. Its median length is about 4.8 mm. This measurement is, however, only approximate as both the anterior and posterior lines of demarkation are not very accurately determinable. The left one of the anterior pair of legs is well preserved, but the right one is only represented by a fragment. As compressed on the shale, the left leg shows the broad blade-like tibia without terminal coxal joints, a characteristic of the *Lamellicornia*, and more especially of the *Scarabæidæ*. The outer margin of this blade-like tibia, which has an exposed width of 1.5 mm., is marked by a series of short spines often hook-like. The posterior one is short and slightly recurved, the next anterior is blunt and broad. In front of this is a longer and rather sharp spine with a smaller slightly backward directed subsidiary spine on its posterior or outer margin. The fourth spine from behind is larger than the others and like them somewhat asymmetric. It also has a small secondary spine on its posterior or outer margin. The fifth spine from behind is the longest. It is slender with nearly parallel sides ending in an abruptly recurved pointed hook. Finally the last one shown is abruptly bent outwards at nearly right angles at the tip which thus forms a laterally projecting spine, behind which there is a second shorter and narrower laterally projecting secondary spine. This final portion of the modified tibia is, however, less clearly outlined. In its general character this tibia, evidently modified as in modern forms for digging, is like that found in recent genera of scarabs such as *Ateuchus*, but it is broader, and with the spines more varied, the posterior ones being proportionately shorter and the anterior proportionately longer.

Meso- and meta-thorax apparently united, their combined length about equal to that of the pro-thorax. Elytra well-marked, coriaceous, with regularly curving outer margin and subacute posterior end. When closed the posterior border appears subtruncate, with the last segment of the abdomen projecting beyond it. Surface of elytra marked by numerous very fine gently curving lines of fine spots or pustules, which in general are parallel to the

outer margins of the elytra but are not very readily visible. Posterior pair of wings not exposed.

The second pair of legs proceeds from the shoulder region of the meso-thorax; that on the right side is nearly complete as is also the third one, while the corresponding legs on the left side are crushed, and have their parts distorted and commingled. Only a small terminal portion of the femur of the second (meso-thoracic) leg is exposed, this being somewhat larger than the tibia. The latter is furnished with a row of backward-projecting spines or setæ on the inner margin and ends in a pair of strong spines, an outer and an inner, between which the tarsus articulates. The tarsus appears to be formed of five joints which have been somewhat crushed and disarranged. It terminates in a curved spine. Posterior (meta-thoracic) leg longer and more robust than the second, with a broad femur mostly hidden, and a broad gently curved tibia serrated on its inner side (and possibly also furnished with bristles or setæ) and likewise ending distally with two terminal spines. The tarsus is long but its elements can not be separated. It appears to be delicately fringed on the inside, and ends with two slender slightly curved spines. These are, however, only faintly shown.

Abdomen with six segments faintly visible through the elytra, the last segment rounded posteriorly and projecting beyond the distal margin of the elytra when closed.

Length of entire specimen 19.5 mm. Greatest width across elytra near posterior part of thorax 10.5 mm.

This beautiful and unique specimen of the oldest known scarab is named in honor of Dr. W. W. Yen, the noted Chinese scholar and statesman, and Minister of Agriculture and Commerce.

Horizon and Locality. A single specimen only was obtained from the Laiyang paper-shales, 1 li north of Man-Wu in Lai-Yang-Hsien, Shantung. Coll. H. C. Tan. (Cat. Chinese Geol. Survey 428).

Order ODONATA

Genus *SAMARURA* Brauer, Redtenbacher and Ganglbauer.

This generic name was proposed for larvæ of Odonata or dragon flies first obtained from the Middle? Jurassic beds of the Ust Balei basin, in

eastern Siberia. Their most characteristic feature is the possession of three leaf-like or petaloid terminal appendages. Handlirsch suggests that these forms belong to his suborder Anisozygoptera. Five species were described as listed above (p. 165) all of which are comparatively large.

A larva of this type is abundant on certain layers of the Laiyang paper-shales, but the specimens are generally imperfect, and especially the terminal portion of the abdomen is poorly preserved or wanting. Only a few specimens show the terminal appendages and these have the form of the species described from Ust Balei. Only two are however visible these being symmetrically disposed, but the apparent absence of a third may be an accident of preservation for, in the Ust Balei specimen only two of the three are sometimes visible, the third being covered. Though not identical with any of the species described from the more northern region, our forms appear to be congeneric with them, and here for the present I shall place them, although I recognize the fact, that the persistent appearance of only two terminal appendages in all the specimens which preserve this part of the body, points to a distinct generic type.

Samarura gregaria Grabau (sp. nov.)

(Plate I, figs. b-d)

This form is uniformly smaller than those described from Siberia and less slender; being proportionally about twice as wide as these more northern forms. Owing to the generally incomplete character of the specimens, it is difficult to ascertain the number of exposed abdominal segments but they are usually not over eight, including the terminal one. In an apparently complete form, the seventh seems to be followed by the terminal lobed segment. In a ventral aspect, however, the seventh sternum appears very long and may cover additional segments, though none have been observed in any of our specimens. The segments appear in most cases rectangular, but are really somewhat wider at the posterior than at the anterior end, the posterior lateral angles of each segment overhanging the anterior part of the segment behind it, in some cases being apparently prolonged into short spines. This is, however, as a rule only seen when the segments are in contact, but where, as is usual, they are slightly separated, the lateral slopes of the segments seem to be

aligned so as to form a continuous side line to the abdomen. The width of the abdominal rings or segments as flattened on the shale surface, range in a typical specimen, from 1 mm. at the front, to 0.5 mm. or slightly less in the seventh segment. The length of the first four segments is generally about 0.5 mm. each, but the posterior segments are longer, the ante-penultimate, with an anterior width of less than 1 mm., having a length of 0.7 mm. or more, and sometimes appearing quadrilateral. In another specimen, however, which also shows seven somites in addition to the terminal one, the sixth shows an anterior width of a trifle over a millimeter. The next segment visible is, however, short and less than 0.7 mm. in width. The width of the anterior somite in this specimen is nearly 1.5 mm. In life the maximum diameter of the abdominal rings was probably less than 1 mm. on the average.

The lobes of the terminal segment are circular, or nearly so, and so far I have not been able to determine positively that there are more than two, though in at least one specimen, there is a faint suggestion of a third flattened between the others. If it should develop that there are really only two such appendages this species will have to be referred to another genus.

Thorax of compressed specimens broader than abdomen. The thoracic rings appear to be short but are so much crushed that the details can not be made out.

The legs are long, the posterior or metatarsal pair, when extended, nearly or quite reaching the end of the body. The femur is always slightly swollen and broader than the tibia, and the tarsus appears to be rather long. There are no wings. The head is small, subcircular and two short antennæ are preserved in some specimens, these often appearing fimbriate*. Neither head nor thorax is sufficiently well preserved to show details.

These larvae are of nearly uniform size, measuring a trifle less than 8 mm. in length, exclusive of the antennæ. They are sometimes crowded together in great numbers on the thin paper-shales, but separate individuals are also found. They are not directly associated with the land-plants (conifers, etc.) preserved in these strata, but carbonized stems, apparently of

* This, I believe, is due to the mode of preservation and not an original feature. In fig. b. it is a little too strongly emphasized by the artist.

aquatic plants, are found with them in some cases.

Horizon and Locality. Lower Cretaceous Laiyang paper-shales, 1 li N. of Pa-Tsu, Lai-Yang-Hsien, Shantung. H. C. T'an Coll. (Geol. Surv. China. Cat. 423, 424, etc.).

PISCES.

Genus *LYOPTERA* J. Müller.

Lycoptera sinensis Smith-Woodward.

1901.—*Lycoptera sinensis* Smith-Woodward. Catalogue of the Fossil Fishes of the British Museum, Pt. IV., p. 3, text-fig. 1.

Woodward's description: "Length of head with opercular apparatus slightly less than the maximum depth of the trunk, and occupying scarcely more than one quarter of the total length to the base of the caudal fin. Vertebrae about 45 in number, 20 being caudal. Pectoral fins when adpressed, scarcely reaching more than halfway to the origin of the pelvic pair; other fins apparently as in the type species".—

In the majority of individuals, the length of the head is much less than one-fourth the length of the body to the base of the caudal fin, the ratio in a typical adult specimen, where the length is 100 mm., being as 1:3.57, and less in younger specimens. The position of the dorsal fin is in front of the anal, whereas in *L. middendorfi* it is behind. There are 13, and in exceptional cases, 14 axonosts in the anal fin of the adult, but only 12 in the younger specimens. In like manner there are 12 principal rays in the outer part of the anal fin (basiosts) of the smaller individuals, this number increasing to 13 or even 14 in the adult, while splitting of some of the rays still further increases their number. Preceding the principal rays there are 3 shorter or fulcral rays. The dorsal fin has 11 axonosts or ray supports, and 10 principal rays in the outer part (basiosts), preceded by at least 2 fulcral rays (4 in some specimens).

The details of arrangement of the rays of the anal fin are also characteristic.

The species will be fully described and illustrated in a paper on the Lower Cretaceous Fishes from North China to be published in *Palæontologia Sinica*, Series C. Vol. III.

Horizon and Localities: Common in the Laiyang shales in Lai-Yang Hsien, Shantung (Loc. 218, 1 Li NE of P'o-Tzu; 221, 1 Li N. of Nan-Wu; 222, 2 li N. of Po'Tzu; etc.) Coll. H. C. T'an.

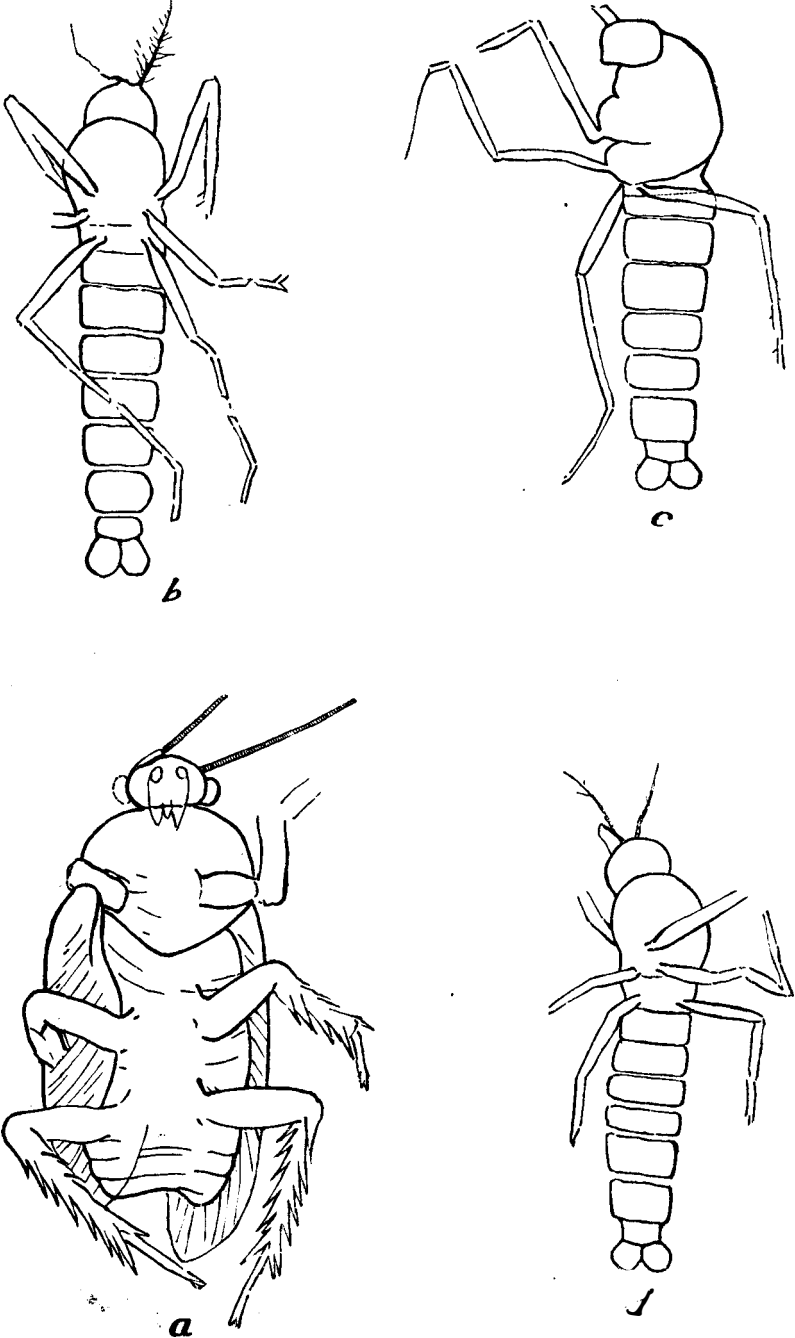
Lycoptera ferox Grabau (sp. nov.)

Slender, with the body scarcely or not at all increasing in height behind the head, which is generally as high as the body. The length, exclusive of the tail rays, is about 5 times the height, or six times that, when the entire length is taken. The ratio of the length of the head to the length of the body ranges from 1:3.70 to 1:3.85 when the caudal rays are omitted, or, when the entire length is taken, it is as 1:4.70. The dorsal fin lies in front of the anal, and the pectoral fin reaches to about four fifths the distance to the front of the pelvic carrier. The arrangement of the rays in the caudal fin is peculiar, in that the ventral lobe is shifted forward more than in the other species of the genus.

The appearance of the head is the most distinctive feature, the front being abruptly rounded and truncate in the lower part from the forward shifting of the frontal and ethmoid bones. The mouth thus appears more ventral than in *L. sinensis*, where it forms the forward pointing end. The gape is short but wide, giving the animal a rather ferocious appearance.

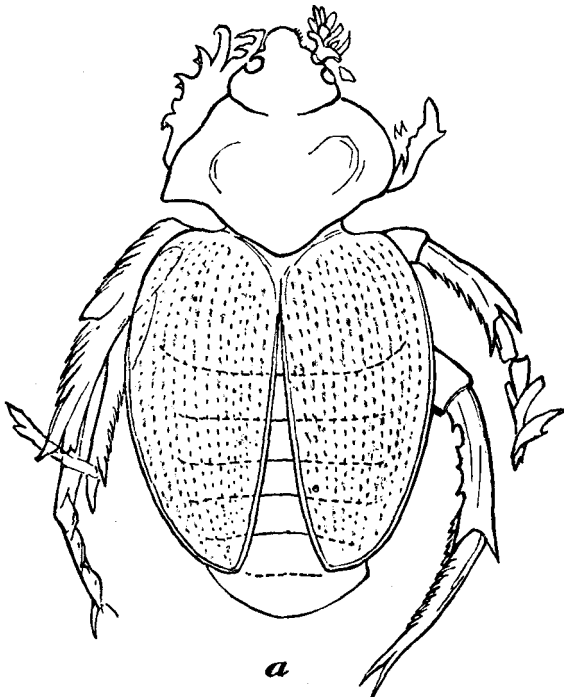
This fish will be described in detail with the others in *Palæontologia Sinica*, Ser. C. Vol. III.

Horizon and Localities: Associated with the preceding species in the Laiyang shales of Lai-Yang Hsien, Shantung (Loc's. 218, 221, 222). H. C. T'an Coll.

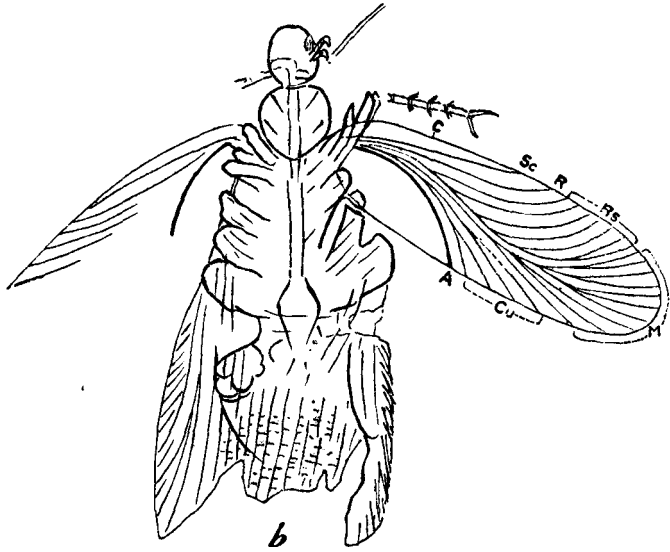


Lower Cretaceous Insects.

a *Sinoblatta laiyangensis* Grabau (enlarged 3 times); b-d *Samarura gregaria* Grabau, three larvæ in different attitudes (enlarged 8½ times). Laiyang Formation, Lai-Yang-Hsien, Shantung.



a



b

Lower Cretaceous Insects.

- a. *Proteroscarabæus yeni* Grabau (enlarged 4 times).
 - b. *Laiyangia paradoxiformis* Grabau (enlarged 4 times).
- Laiyang Formation, Lai-Yang-Hsien, Shantung.

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