INVERTEBRATE FAUNA OF THE MORRISON FORMATION¹

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LISTS OF DESCRIBED SPECIES

When, in 1886, C. A. White² reviewed the invertebrate fauna of the formation now known as Morrison, he listed 21 species, as follows:

<i>Unio felchii</i> White	<i>Vorticifex stearnsii</i> White
<i>Unio toxonotus</i> White	<i>Valvata scabrada</i> M. and H.
<i>Unio macropisthus</i> White	<i>Viviparus gilli</i> M. and H.
<i>Unio iridoides</i> White	* <i>Lioplacodes veterinus</i> M. and H.
<i>Unio lapilloides</i> White	* <i>Neritina nebrascensis</i> M. and H.
<i>Unio stewardi</i> White	<i>Metacypris forbesi</i> Jones
<i>Unio nucalis</i> M. and H.	<i>Metacypris</i> sp.

¹ Contribution to the symposium held at the Philadelphia meeting December 30, 1914.

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² C. A. White: Fresh-water invertebrates of the North American Jurassic. U. S. Geol. Survey Bull. 29, 1886.

* The two species marked with an asterisk, from "near head of Wind River," probably belong to a later fauna.

Limnæa ativuncula White
Limnæa consortis White
Limnæa ? accelerata White
Planorbis veterinus M. and H.

Darwinula leguminella Forbes
Cypris purbeckensis (Forbes)
Cypris sp.

Of these, seven species are referred to *Unio*, three to *Limnæa*, one each to *Planorbis*, *Vorticifer*, *Valvata*, *Viviparus*, *Lioplacodes*, and *Neritina*, and five are ostracod crustaceans. All are of fresh-water habitat. More than half of them come from a single locality near Cañon City, Colorado. The others are reported from the Black Hills, from two localities in southern Wyoming, and from the head of Wind River, Wyoming, the stratigraphic position of the species from the last-named locality being doubtful. Logan³ has listed five species from the Freeze-out Hills, southern Wyoming, of which three species of *Unio* and a *Valvata* are described as new. The list is as follows:

Unio baileyi Logan
Unio knighti Logan
Unio willistoni Logan

Valvata leei Logan
Planorbis veterinus M. and H.

All from Freeze-out Hills.

Undescribed collections from Morrison, Colorado City, and Uncompaggre Valley, Colorado, from the Black Hills, from the neighborhood of Como, Wyoming, and of Jensen, Utah, and from the Great Falls and Lewistown areas in Montana, have added to the Morrison fauna without changing its essential characteristics until, as now known, it includes about 30 species, practically all of which are referred to living genera.

COMPARISON WITH OTHER NON-MARINE INVERTEBRATE FAUNAS

WEALDEN FAUNA

From the statement that the fauna consists of fresh-water Mollusca and Ostracoda belonging to modern genera, it is evident that it can offer little direct evidence on the exact age of the Morrison formation. Logan's argument for correlating the Morrison with the Wealden because, as he says, "four of the genera—*Unio*, *Valvata*, *Planorbis*, and *Viviparus*—which are represented in the two formations by species having practically the same degree of development are not known from older formations," is not valid because it does not agree with the facts of distribution as now known. *Unio*, *Planorbis*, and *Valvata* are all known from formations older than the Wealden, and the species of *Unio* from the Upper Triassic

³ W. N. Logan: The stratigraphy and invertebrate faunas of the Jurassic formation in the Freeze-out Hills of Wyoming. *Kansas Univ. Quarterly*, vol. 9, 1900, pp. 132-134.

of Texas and New Mexico appear to be as well developed as those from the Morrison. It can not be justly claimed that there is anything in the Morrison invertebrates themselves that precludes their reference to an earlier epoch than the Wealden. They do not offer any evidence on the correlation of the Morrison with the Potomac group which has been advocated on the basis of the vertebrate fauna.

POTOMAC FAUNA

The five species of invertebrates which W. B. Clark⁴ has named from the Potomac are apparently all distinct from Morrison species, but an examination of the published figures shows that they are all so imperfectly preserved that even their generic reference is very doubtful. The forms described are as follows:

Unio patapscoensis Clark
Cyrena marylandica Clark

Viviparus arlingtonensis Clark
Bythinia arundelensis Clark

All are from the Arundel formation except the *Unio*, which is from the Patapsco.

Further comparison of the Morrison invertebrates shows that specifically and as a fauna they are decidedly distinct from all other fresh-water faunas that are found geographically or stratigraphically near them. The faunas which deserve mention in this connection are those of the Kootenai, the Bear River, and the Dakota.

KOOTENAI FAUNA

In Montana the coal-bearing Kootenai formation has yielded non-marine invertebrates at many localities, but they have not been thoroughly collected nor fully described. From a locality about 7 miles southeast of Harlowton I have described⁵ the following six species:

Unio farri
Unio douglassi
Viviparus montanaensis

Goniobasis ? silberlingi
Goniobasis ? ortmanni
Campeloma harlowtonensis

When these species were described their exact stratigraphic position was not known, but it has since been determined that they came from the Kootenai formation, which in the Great Falls field has yielded similar forms, though not so well preserved, together with a *Neritina* and some other species. The so-called Dakota fossils of the Yellowstone National

⁴W. B. Clark: Lower Cretaceous, Maryland Geol. Survey, 1911, pp. 211-213.

⁵T. W. Stanton: A new fresh-water molluscan fauna from the Cretaceous of Montana. Proc. Am. Philos. Soc., vol. 43, 1903, pp. 188-199.

Park probably also belong in this fauna. The only species that suggests a Morrison form is the *Viviparus*. The other gastropods, and the *Unios* especially, are very distinct from those of the Morrison. The evidence of the invertebrates, therefore, is opposed to Professor Berry's⁶ suggestion "that this general horizon in the Rocky Mountain area has been regarded as Morrison where it contains vertebrate remains and Kootenai where it contains plant remains."

It is still questionable whether Fisher and Calvert were justified in identifying the Morrison beneath the Kootenai in Montana, and it may be that the beds which they so identified really form a basal member of the Kootenai, as Fisher suggested. The dinosaur bones collected from this part of the section were not well enough preserved for even generic identification, and fragments of bone were found at different horizons throughout the overlying Kootenai formation. In this connection I call the attention of vertebrate paleontologists to the fact that the Carnegie Museum at Pittsburgh has a collection of dinosaur bones obtained by Hatcher from supposed Kootenai at the locality near Harlowton, Montana, which yielded the invertebrates here listed, and it may be that there is another collection of them at Princeton University. Possibly these are good enough for determining whether or not they are distinct from Morrison forms. That post-Morrison formations do contain dinosaurs related to those of the Morrison is shown by the occurrence of *Hoplitosaurus* and *Camptosaurus* in the Lakota near Buffalo Gap, South Dakota, as recorded by Gilmore.⁷ For this reason the finding of a bone of an unidentified sauropod dinosaur in the Comanche series of Oklahoma has never seemed to me very strong evidence that the Morrison is of Comanche age. If some groups of Morrison dinosaurs ranged into later formations, the sauropods also may have had a greater vertical range.

BEAR RIVER FAUNA

The Bear River fauna occurs in a thick formation at the base of the Upper Cretaceous in southwestern Wyoming. It is a large and greatly varied fresh-water fauna, with a few brackish-water species, which has been fully described by C. A. White.⁸ It shows no relationship with the Morrison fauna other than a few common genera, and its resemblance to the Kootenai fauna is but little closer.

⁶ E. W. Berry: Lower Cretaceous, Maryland Geol. Survey, 1911, p. 164.

⁷ C. W. Gilmore: Proc. U. S. National Museum, vol. 36, 1909, p. 300.

⁸ C. A. White: The Bear River formation and its characteristic fauna. U. S. Geol. Survey Bull. 128, 1895.

DAKOTA FAUNA

The Dakota fauna, as described⁹ and as represented in collections, is small but complex. Eliminating the Comanche species from the neighborhood of Salina, Kansas, which were described as Dakota by Meek, there remains a number of fresh-water species, some of which are related to those of the Bear River, and several brackish-water and marine mollusks which show relationship with the succeeding Benton fauna. None of the fresh-water species suggests derivation from Morrison forms.

TIME LIMITS OF THE MORRISON FORMATION AS DETERMINED BY ASSOCIATED MARINE FAUNAS

GENERAL DISCUSSION

The Morrison fauna then stands by itself, distinct from the few fresh-water invertebrates that preceded it in the Triassic and distinct from the non-marine Cretaceous faunas which followed it. Of course, there is no basis for comparison with the marine faunas which are nearest to it in time, but the study of these marine faunas serves to fix definitely the time limits within which the Morrison formation must fall.

SUNDANCE FAUNA

The lower limit is fixed by the age of the marine Jurassic Sundance formation on which the Morrison rests in southern Wyoming. The Sundance is classified as Upper Jurassic, and for that reason it has been assumed by some geologists that everything above the Sundance must be post-Jurassic. But a study of the fauna of the Sundance shows that it is by no means the latest Jurassic, but that it belongs in the *lower* part of the Upper Jurassic. It is characterized by *Cardioceras cordiforme* and other invertebrates, which indicate approximate correlation with the Oxfordian of the European Jurassic. In Europe the Oxfordian is followed by later Jurassic sediments, classified by De Lapparent as Sequanian, Kimmeridgian, and Portlandian (including Purbeckian). In Alaska also the fauna most closely related to the Sundance fauna occurs in beds which are overlain by several thousand feet of later Jurassic strata. There is ample room, therefore, for the Morrison within the Jurassic.

The incursion of the sea which resulted in the deposition of the Sundance formation and its equivalents in the Rocky Mountain region

⁹ F. B. Meek: U. S. Geol. Survey Terr., vol. 9, 1876.

C. A. White: Proc. U. S. National Museum, vol. 17, 1894, pp. 131-138.

was a comparatively brief episode in the long period covering a large part of the Mesozoic era during which continental conditions prevailed. If the retreat of this sea was immediately followed by a long period of uplift and erosion prior to Morrison time, the evidence of it seems to have been overlooked by geologists. There is evidence that there was erosion and baseleveling before the marine Jurassic was laid down. On the assumption that marine waters were finally withdrawn from the Sundance sea either by a slight general uplift or by the silting up of the shallow basin, it is not unreasonable to suppose that the formation of continental deposits like the Morrison might begin almost immediately over the same area and extend far beyond it. The alternative hypothesis requires a considerable interval between the Sundance and the Morrison apparently unrepresented by either deposits or erosion.

WASHITA FAUNA

It is not within my province to speak of the possible upper limit of the Morrison as determined by the age of the floras in the overlying Kootenai and Lakota formations of Montana and the Black Hills. The oldest overlying marine fauna is found above the southern extension of the Morrison in southeastern Colorado, northeastern New Mexico, and northwestern Oklahoma, where the Morrison, with its characteristic dinosaurs, is overlain by beds containing the fauna of the Washita group, which is the uppermost of the three groups forming the Comanche series. In America it has been customary to classify the Comanche series as Lower Cretaceous in contrast with the great Upper Cretaceous series beginning with the Dakota sandstone. A number of European paleontologists who have given some attention to the Washita fauna believe it to be of Cenomanian age, the Cenomanian being regarded as the base of the Upper Cretaceous in Europe. This determination being taken as the latest possible assignment of the overlying beds, the Morrison must be older than Cenomanian and probably younger than Oxfordian. That it represents all of this interval is not probable, but in my opinion the lithologic and stratigraphic evidence of a break in sedimentation is fully as great, if not greater, between the Morrison and the rocks of Washita age, where they are in contact as it is between the Morrison and the Sundance in the northern area where these two formations come together. So far as stratigraphy and invertebrate faunas are concerned, the Morrison is somewhat more likely to belong to the Jurassic portion of the interval just indicated than to the Cretaceous portion; but their evidence is not conclusive on this point.