Critical Observations Upon Siwalik Mammals

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Article VII.—CRITICAL OBSERVATIONS UPON SIWALIK MAMMALS

(Exclusive of Proboscidea)

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I. INTRODUCTION

During the winter of 1926–27 I spent six weeks at the Indian Museum in Calcutta and two months at the British Museum (Natural History) in London making a critical re-examination of the type collections of the Siwalik Fauna preserved in those two institutions. The object of this study was to check up in the light of modern palæontological evidence the classic researches and descriptions of Falconer and Cautley and of Lydekker, and the admirable later work of Pilgrim, as a basis for researches and description of the collections obtained for the American Museum by Mr. Barnum Brown in 1921–1923. The expenses of making this study were defrayed from funds provided by Mrs. Henry Clay Frick, as a part of her gifts to the American Museum for Siwalik collecting, preparation and research work.

To the President and Trustees of the American Museum I desire to

express my high appreciation of the opportunity and privilege of making this research, involving release from Museum duties over a period of several months. I am likewise deeply indebted to the friendly aid of Director Pascoe, Superintendent Pilgrim and others of the staff of the Geological Survey of India, to Doctor Bather and Mr. A. T. Hopwood and other good friends at the British Museum, who placed the collections wholly at my disposal for study and comparison, provided every facility for examining the specimens and referring to the published literature and the museum records, and aided and enlightened me upon various obscure points.

The accompanying series of notes and criticisms are by no means to be regarded as final conclusions. They represent principally an attempt to verify, revise and supplement the type descriptions with the aid of subsequent palæontological knowledge, to point out doubtful or erroneous identifications or conclusions as to the affinities of certain types, and to reconsider the correlation of the Siwalik faunas with those of Europe and America. The views here expressed upon the affinities of various Siwalik mammals, and especially upon the faunal correlation, will call for a further and more careful criticism when the monographic researches upon Mr. Brown's collections have been completed. They represent the present personal viewpoint of the author, and no attempt is made at this stage to bring them into conformity with the conclusions of Professor Osborn based upon his proboscidean researches, or those of Doctor Pilgrim based upon his extensive and detailed studies of the stratigraphy and faunas of the Siwalik region.

II. CORRELATION OF THE SIWALIK FAUNAS

The fundamental necessity in any discussion of correlation is to have some definite and fixed standard of comparison. This standard is of necessity the stratigraphic and faunal succession in Europe, as the terms in universal use are of European origin and were applied primarily to European formations and faunas. Unfortunately the current usage of terms and correlation by European authorities is not wholly settled or consistent. The classic faunas of Pikermi, Samos and Eppelsheim are referred by some authorities to the Pliocene, by others to the Miocene. The equally classic fauna of Val d'Arno, formerly regarded as Pliocene, is considered by some of the best modern Italian and French authorities as early Pleistocene contemporary with the beginnings of Pleistocene glaciation; and with it are closely associated other important mammal faunas, Senèze and Perrier in France and the Red Crag of England. I do not

profess to have sufficient knowledge of the stratigraphy of these European formations to decide such problems on their merits, and have thought better to adopt as a standard the results of the Tertiary correlation studies made by Dr. T. W. Vaughan and his associates and published in the Bulletin of the Geological Society of America in December, 1924, and Haug's Treatise on Geology. In correlating European with American mammal faunas I pointed out in the G. S. A. Bulletin, above cited, certain relations which make it necessary either to revise the American succession downward, or the European succession upward. Accepting in that paper the older standards for the European faunas, it seemed necessary to suggest that the commencement of American glaciation would have to be placed in the Pliocene. If, however, the upper Val d'Arno and equivalent formations containing the first *Equus* fauna also represent, as do the Sheridan and other corresponding beds in the Plains region of America, the outwash of early glaciation, the renewed activity in erosion and sedimentation conditioned by the same combination of elevation and increased rainfall that brought about the glaciation of the higher and more northerly lands, then it would seem in every way suitable to place them both at the beginning of the Pleistocene. The appearance of the *Equus* fauna in the United States and in Europe marks a great migration movement, its center of dispersal apparently the more northerly regions of Eastern Asia and North America. This migration is due presumably to a change in climate, conditioned no doubt by diastrophic movements, and would naturally coincide with the onset of glaciation in more northerly centers and the mountain regions, as well as with a renewal of erosional activity and sedimentation.

If these relations are verified by more intensive stratigraphic and faunal studies, it would seem that they provide an acceptable line of division between Pliocene and Pleistocene, at the expense of shifting into the Pleistocene certain classic European faunas which have generally been regarded as Upper Pliocene. The alternative would seem to involve placing not only the "*Equus* Fauna" but also a part of the glacial period in the Pliocene.

The appearance of *Equus*, with its very characteristic associated fauna, in the United States, in Western and Southern Europe, Southwestern Asia, India and China, is taken therefore as the beginning of the Pleistocene in the faunal succession, as the onset of glaciation in the regions to the north of these marks the beginning of the Pleistocene in the geologic record. Whether the term be thus limited or not it appears that

the faunal, climatic and diastrophic changes were associated and dependent the first upon the second, the second upon the third.[1]

The boundary between Miocene and Pliocene is an equally difficult one to standardize. While I follow Dr. Vaughan in his reference of the Pontian to the Miocene, it is not by any means clear that the *Hipparion* fauna of the Old World occurs in the Pontian proper. On the contrary it seems that the appearance of *Hipparion* in the Old World, distinctly and unmistakably an invading type of American origin, is a proper and convenient indication of Pliocene age. Again the question of whether it is *called* Pliocene or not seems less important than the fact that it marks another great migration movement, due to change in climate, dependent in turn upon diastrophic movements.

Without therefore undertaking to decide whether the first appearance of *Equus* and of *Hipparion* in the Old World faunas coincides exactly with the opening of Pleistocene and of Pliocene time respectively, according to this or that usage or definition, I think they accord approximately, and that they mark well-defined faunal changes that are a logical base for epochal divisions as they are conditioned by major geologic changes of widespread extent and world-wide influence.

The line between Oligocene and Miocene I regard as similarly definable by the appearance of the *Anchitherium* fauna in the Old World and in the United States (the American "*Kalobatippus*" being equivalent to the early species of *Anchitherium* and very probably indistinguishable generically). This with other evidence tends to place the American John Day fauna at the base of the Miocene rather than the top of the Oligocene, a much more satisfactory arrangement, as its relations to the Lower Miocene faunas are much closer than to the Oligocene White River faunas. The European Aquitanian faunas, which have much in common with the John Day and Rosebud-Harrison faunas of America, are equally well marked in distinction from the Oligocene (Stampian) mammal faunas.

Older Tertiary mammal faunas are not known from India, but in Burma the Pondaung Eocene is fortunately so related to the marine Yaw series that its age is not open to question. The Irawaddy series in Burma has yielded a number of fragmentary remains which would indicate that it covers a considerable period, Miocene to early Pleistocene, but further study is needed before any exact correlations can be made.

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[1]Berry, in his able philosophic discussion of correlation, appears to me unduly skeptical of the value of diastrophism. It is not, in my mind, satisfactory as directly observable in special regional work. But indirectly, in its influence upon erosion and sedimentation, climate and faunal migration and extinction, it appears to me not merely a fundamental cause but a very practical and necessary explanation in interpreting these phenomena.

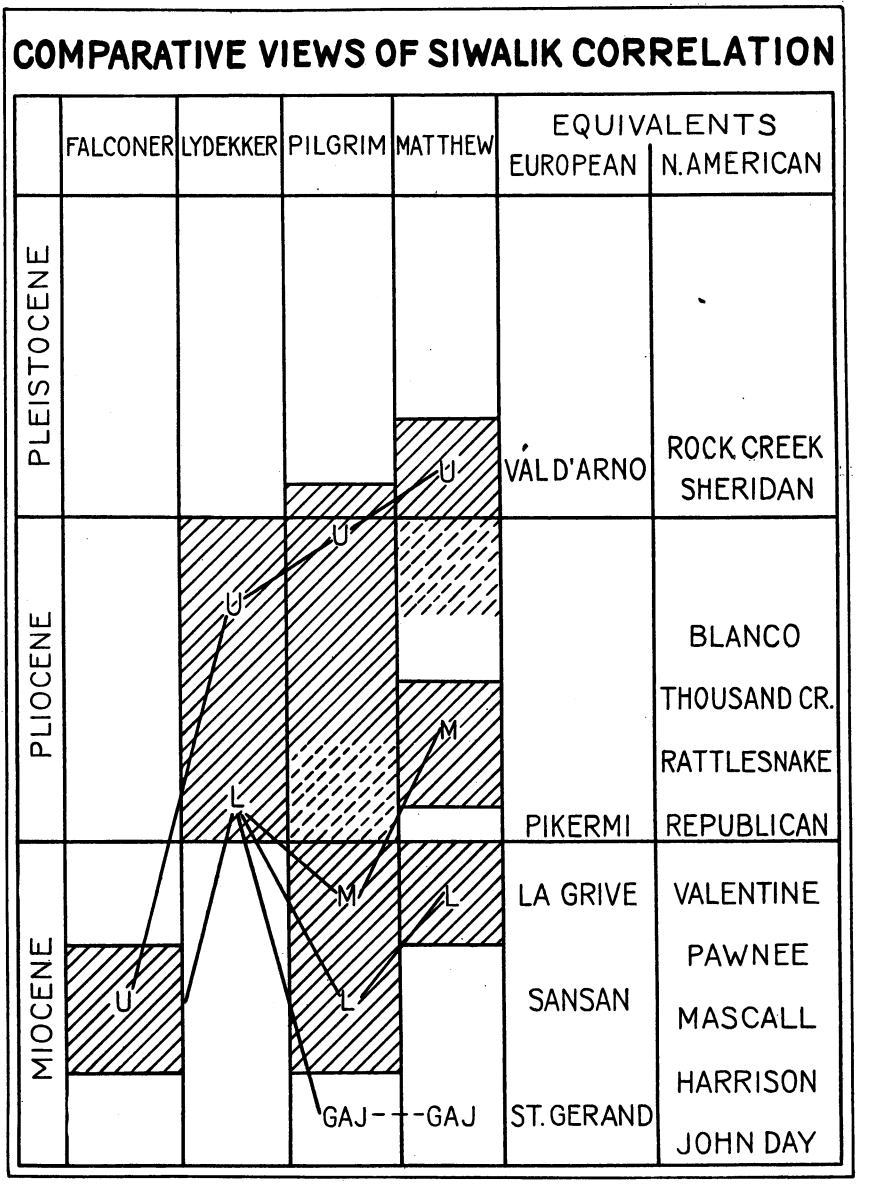

Fig. 1. Comparative Views of Siwalik Correlation.

The terrestrial "bone-beds" of Java, outcropping on both sides of a long east-west anticline and immediately overlying Pliocene marine marls, have yielded fossil mammals at many points, but the collections are mostly undescribed or inadequately described, except for those made by the Selenka expedition at and near Trinil on the Solo River. These, in the opinion of the German geologists, are Lower Pleistocene, although regarded by Dubois and by some other Dutch authorities as Upper Pliocene. The fauna has considerable resemblance to the Upper Siwalik fauna of India, and this resemblance is closer in some undescribed collections than in those obtained at Trinil. It may be that the "bone-beds" are not everywhere of the same geological age, although their relations to the anticlinal uplift are apparently identical. More field study and collecting and study of the mammals at various localities are necessary to decide.

The Siwalik fauna was regarded by early writers as Miocene, and it so appears in all the older text-books. Lydekker in his studies of 1876–1884 regarded it as Pliocene, but indicated that it was not a unit fauna. Pilgrim, as a result of extensive field work and intensive studies of the collections, separated it into three major divisions, Lower, Middle and Upper, with a series of subordinate local unit faunas. The Upper Siwalik he regarded as Pliocene, the Middle as Upper Miocene, the Lower as Middle Miocene.

Nearly all of the Siwalik fauna as known to Falconer and other earlier writers was the Upper Siwalik fauna as now known. A few genera (*Hyænarctos, Hipparion, Bramatherium*) came from what is now known as Middle Siwalik. Lydekker made considerable additions to the Middle Siwalik fauna and partly recognized it as representing an older fauna, which he called Lower Siwalik; with this he also placed a few fragments from what is now known as Lower Siwalik and some specimens from the Gaj fauna. Pilgrim was the first to make clear distinctions between the successive faunas, and added very largely to the faunas, Lower Siwalik (Chinji) and Gaj (Bugti) faunas. Cooper made considerable further additions to the Gaj or Bugti fauna from collections in Baluchistan.

In venturing to modify the results of Doctor Pilgrim's very thorough studies I am guided by the following considerations:

1. The appearance of new invading elements in a fauna is a safer guide to its correlation than the disappearance of old elements or the average composition of the fauna as a whole. The appearance of these new elements must be interpreted in the light of what is known of their origin and dispersal. When this is as directly recorded and fully docu-

mented as it is in the case of Tertiary Equidæ or Camelidæ, the evidence appears not open to any effective challenge. But more often the appearance of new elements in a fauna may be explained in several ways, the relative probability of which is not easy to test.

2. India and the Oriental region generally are today characterized by the survival of many primitive types of mammals as well as by the absence, scarcity, or recent appearance of some of the most progressive and specialized mammals. It compares in these respects with West Africa and tropical America. While it does not necessarily follow that this was true during the later Tertiary, yet it should be so considered until evidence proves the contrary; and so far from proving the contrary I believe that all of the evidence conforms with this assumption and much of it is difficult to explain in any other way. It should be added that the faunas of the Siwalik hills, of Burma, and of Java, should on this assumption contain progressively more and more of these relict elements or primitive survivors from earlier northern faunas, and that the indications that these fossil faunas were archaic, not ancient, should in the same sequence be progressively more marked.

A. THE UPPER SIWALIK, FAUNAL LIST AND COMMENTS

Pilgrim in his correlation paper lists a large fauna as from the Boulder Conglomerate. This is practically the Siwalik Fauna of the earlier writers, only a few types withdrawn which are known or inferred to come from the Middle Siwaliks. In recent work Pilgrim has, however, regarded this great fauna as coming from the Pinjor zone.

FAUNAL LIST: MAMMALS

Simia satyrus.
Semnopithecus palæindicus.
Papio falconeri.
Fragmentary and rare, but appear to be nearly related to modern Primates.

**Ursus theobaldi.* Battered skull, probably related to modern sloth bear, *Melursus*, of India.

Hyænarctos sivalensis.[1] A Pliocene genus, but doubtfully from Upper Siwalik.

**Mellivora sivalensis.* More primitive than modern ratel, more progressive than *Eomellivora* of Chinese Pliocene.

**Lutra palæindica.* More primitive than modern otters.

**Enhydriodon sivalensis*[2]. Horizon uncertain.

†*Vulpes curvipalata.* Related to *V. bengalensis.*

†*Canis cautleyi.* Related to Indian wolf.

**Viverra bakerii.* Related to *V. civetta* and *genetta.*

**Viverra durandi.*

[1]The matrix is not like that of the known Upper Siwalik fossils, but a peculiar chocolate brown.

[2]Reported by Pilgrim from Middle Siwalik; but the matrix of the typical specimens is characteristically like that of many known Upper Siwalik specimens. Much more specialized than *E. bamboli* of ? Miocene (probably Pliocene) of Italy.

†*Hyæna bosei*[1]. Near *H. striata.*
**Hyæna colvini* Lydekker.
†**Hyæna sivalensis* Falconer.[2] Near *H. spelæa,* etc., *sinensis.*
†*Meganthereon falconeri* Pomel.[3] Cf. *M. meganthereon,* Perrier, Val d'Arno.
**Meganthereon palæindicus.*
**Felis cristata.* Cf. *F. tigris,* Pleistocene and recent.
†*Cynælurus brachygnatha, ? = C. pleistocænicus,* Pleistocene, China.
Felis subhimalayana.
Nesokia cf. *hardwickii.*
Hystrix sp. Near *H. leucurus.* Distinct from *H. sivalensis.*
Rhizomys sp. Cf. *R. troglodytes,* Pleistocene, China.
Caprolagus sivalensis.
**Stegodon ganesa.* Syn. *S. insignis. S. sinensis,* Pleistocene, China, *S. airawana* of Java said to be more specialized.
Elephas planifrons. Of Pliocene type, but only in Lower Pinjor.
**Elephas hysudricus.* Cf. *E. meridionalis,* Val d'Arno, etc.
Dicerorhinus platyrhinus. Cf. *R. etruscus* of Val d'Arno, etc.
**Rhinoceros sivalensis.* } Doubtfully separable. Related to modern Oriental
**Rhinoceros palæindicus.* } rhinoceroses but also to Pliocene species.
†*Equus sivalensis*[4]. Syn. *E. namadicus,* doubtfully separable. Cf. *E. stenonis* of Val d'Arno and Pleistocene Holarctic species.
†*Chalicotherium sivalense.* Cf. *C. sinense,* Pleistocene, China.
Sus falconeri.
Potamochærus hysudricus.
Potamochærus giganteus.
Potamochærus magnus.
*†*Hexaprotodon sivalensis.* More primitive than Pleistocene hippopotami of Europe.
†*Camelus sivalensis.* Syn. *C. antiquus,* doubtfully separable. Typical *Camelus,* more advanced than Pliocene American Camelidæ.
Moschus sp. Inadequate type.
Cervus sivalensis.
Cervus.
†*Giraffa sivalensis.*
**Sivatherium giganteum.* Syn. *Indratherium majori.*
Hemitragus sivalensis. Pleistocene and recent.
Bucapra daviesi.
Boselaphus sp. Pleistocene and recent.[5]

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[1] = *H. sivalensis* Bose (not Falconer). See notes.
[2] = *H. felina* Bose. See notes.
[3] = *Machærodus sivalensis* Falconer and Cautley. See notes.
[4] *Equus* first appears in North America in the Pleistocene.
[5] Cf. also *Duboisia,* Pleistocene of Java.

Bubalis palæindicus.	Pleistocene and recent.
Hippotragus sivalensis.	Pleistocene and recent.
Cobus patulicornis.	These genera and species need revision. They are mostly comparable to Pleistocene and recent species; some compare with the Upper Val d'Arno species.
Cobus palæindicus.	
Cobus gyricornis.	
Hemibos antilopinus.	
Hemibos triquetricornis.	
?Amphibos acuticornis.	
Buffelus palæindicus.	
Buffelus platyceros.	
†*Bos acutifrons.*	
†*Bos planifrons.*	
Bos platyrhinus.	
Bison sivalensis.	

*Hard gray sandstone matrix, black enamel, bone dark or black, specimens often badly chipped, rolled, or battered.

†Soft, light, sandy matrix, teeth and bones light-colored.

In reviewing the above list I can find no valid reasons for referring the Upper Siwalik fauna to the Pliocene. Some of the species are nearly related to those of the Val d'Arno; but, as already noted, the Pliocene age of the Val d'Arno fauna is doubtful. *Hyænarctos* is certainly a Pliocene genus, but it appears doubtful whether the Indian species is really from the Upper Siwalik beds; if it is, it would have to be regarded as a survival, in view of the general character of the fauna. The Siwalik *Stegodon* appears to be a more primitive type than the Pleistocene species from China and Java. This, if verified, might be similarly explained, and would parallel the relations of the Indian elephant to the mammoths of late Pleistocene. *Elephas planifrons* is a primitive species, but occurs only in the base of the Upper Siwaliks (auct. Pilgrim).

On the other hand most of the fauna belongs to modern genera unknown in the Tertiary, and the species are related to modern species about as one would expect in an early Pleistocene fauna. The occurrence of *Equus* and *Camelus* appears to me very convincing evidence of Pleistocene age. For the Equidæ occur in the Old World only as invading types—*Hyracotherium, Anchitherium, Hipparion, Equus,* in no case leading up from one to another through intermediate types. On the other hand, the American Tertiaries record a long series of intermediate stages leading insensibly from one to another (as has been elsewhere described) and this series has in recent years been so perfected through new material discovered in the later Tertiary (noticed and partly described, especially by Childs Frick and myself), that there seems to be no reasonable doubt of the evolution of *Equus* in North America and its

dispersal thence into the Old World and South America. But true *Equus* is not fully developed in North America until the beginning of the Pleistocene. The Upper Pliocene species are transitional. It could not appear in India before it had evolved in North America; and this holds true equally of Italy. Pilgrim has suggested, following an older view of my own, that the dispersal center of *Equus* was in northern Asia, and that it reached India before it appeared in North America. But there is no evidence to support this hypothesis and the abundant fossil record is wholly against it. My own suggestion was based upon an uncritical acceptance of the Pliocene age of *Equus stenonis;* and subsequent discoveries have piled up overwhelming contrary evidence. Abel has maintained that the Old World *Equus* is derived from *Hipparion* and the New World *Equus* ("*Neohippus*") from *Pliohippus*. But this view, also based upon the supposed Pliocene age of the Old World species of *Equus*, seems even less defensible. For there is no intermediate series between *Hipparion* and *Equus* in the Old World; on the contrary, the Old World species are all more or less aberrantly specialized, as shown by Pavlow. And the Old World and New World species of *Equus* are quite too much alike in every detail of their underlying structure to be the results of convergent evolution. If they were so, the Old World species would certainly inherit in common certain characters of *Hipparion*, the New World species certain characters of *Pliohippus* and *Plesippus*, that would upon careful study become apparent, and serve to distinguish the one group from the other. The history of the past, as Dollo has observed, is never wholly obliterated in the structure of animals, and the evidence of diverse ancestry could certainly be detected. Abel and Antonius have not adduced any such proof of their theory, nor have I been able to find any. *Equus* seems to me very certainly a unit genus, derived from a single source, although it is quite possible that its ancestor may have been related to certain *North American* species of *Hipparion* of the *H. whitneyi-occidentalis* group, as well as to *Pliohippus* and *Plesippus*. And I cannot regard it as other than North American in origin.

Camelus affords equally strong evidence for Pleistocene age of the Upper Siwalik beds. The Camelidæ are generally recognized as a group of North American origin and dispersal, and as regards the later Tertiary this is hardly open to any question. *Camelus* itself is not certainly recognized in America; Gidley has reported it from Alaska, Wortman from Nebraska, but in neither case is the evidence conclusive. The Pleistocene genera in North America are *Camelops* and "*Lama*," equivalent to *Camelus* in the progressive reduction of the teeth, and *Eschatius*, slightly further

advanced. In the Pliocene no camel has got beyond the "*Pliauchenia*" stage; in the Miocene all are in more primitive stages in tooth reduction and specialization—*Oxydactylus* in the Lower Miocene, *Protolabis* in the Middle, *Procamelus* in the Upper, with early "*Pliauchenia*" stages appearing just at the end of the Miocene. Now the Siwalik *Camelus* is not a primitive species, but it represents a stage of evolution in the dentition which was attained in North America only at the beginning of the Pleistocene. It is not credible that this stage of camelid evolution could have reached India in the Pliocene before it evolved in North America. This is not a conclusion based merely upon a count of premolar teeth. The entire character and degree of specialization of teeth and skull support it fully.

I cannot therefore regard *Equus* and *Camelus* in the Upper Siwalik as any older than Lower Pleistocene. The associated species of other genera differ so much from their nearest modern relatives that I could not regard the fauna as any later, if indeed it be a unit fauna.

It should be observed, however, that the Upper Siwalik types which I have examined in the British Museum show two diverse types of fossilization. In one group, to which *Equus* and *Camelus* belong, and others marked with a dagger (†), the matrix is soft and the teeth and bone light-colored and not very hard. It is significant that most of the modern types (nearly all the larger bovids) are in this type of preservation. On the other hand, a second group, marked with an asterisk (*), shows a very different preservation, flinty, hard and black, in a hard gray sandstone, and very often rolled and battered. There are some suggestions that these may belong to an older horizon; on the other hand the records show that the *Camelus* specimens were obtained in the vicinity of Moginand, and came from the upper part of the Pinjor exposures. Possibly this is true of most or all of the similarly preserved material, and if so the evidence would not preclude referring the group of types marked (*) to an older horizon, perhaps Pliocene. This would bring into conformity the proboscidean evidence which seems to indicate that some at least of the Proboscidea are Pliocene and decidedly older than the early Pleistocene of Java, China, etc. However, I do not see any sufficient evidence to warrant making such a division at present. It might be verified or disproved by field work; but experience shows that hasty splitting up of faunas upon such insufficient evidence is quite likely to be largely or entirely in error, and has been the basis of a great deal of entirely worthless phylogenetic speculation. It is better to play safe, to keep an open mind on doubtful points, but not attempt to decide them without sufficient evidence.

B.—THE MIDDLE SIWALIK, FAUNAL LIST AND COMMENTS

Nearly all this fauna is from Dhok Pathan and Hasnot. It is the fauna discovered by Theobald in the Siwaliks of the Punjab, and described by Lydekker.

Faunal List

Palæopithecus sivalensis.	
Semnopithecus hasnoti.	
Macacus sivalensis.	
Indarctos punjabiensis.	Cf. *I. oregonensis*, Rattlesnake, Oregon. *I. lagrelii* of Chinese Pontian decidedly more primitive.
Syn. *I. salmontanus.*	
Hyænarctos palæindicus.	
Amphicyon lydekkeri.	One upper molar. Specialized; doubtfully *Amphicyon.*
Potamotherium hasnoti.	I have not seen these types. No good descriptions or figures.
Enhydriodon cf. *sivalensis.*	
Mellivora punjabiensis.	No evidence that this belongs to *Mellivora.* See notes.
Mellivorodon palæindicus.	More probably feline than mustelid. Quite indeterminate.
Lutra bathygnathus.	Genus indeterminable.
Palhyæna sivalensis.	Cf. *hipparionum* of Pikermi.
Palhyæna hipparionum.	
Palhyæna indica.	
Hyæna macrostoma.	Cf. *H. chæretis, eximia.*
Hyæna cf. *eximia.*	
Hyæna gigantea.	
Machærodus cf. *schlosseri.*	Two jaws, one of which is near to *M. schlosseri* of Pikermi; the other is a feline.
Machærodus sp.	
Æluropsis annectens.	Practically indeterminate feline.
Felis sp.	Not described or figured, and I have not seen the specimens.
Felis sp.	
Rhizomys sivalensis.	Smaller than the species from the Pleistocene of China, but otherwise similar.
Hystrix sivalensis.	Appears to be intermediate between the Pikermi species and the Pleistocene *Hystrix;* see notes.
Dinotherium indicum.	List as given by Pilgrim.
Tetrabelodon corrugatus.	
Tetrabelodon punjabiensis.	
Mastodon hasnoti.	
Mastodon latidens.	
Mastodon aff. *latidens.*	
Stegodon cliftii.	
Stegodon bombifrons.	
Hipparion antelopinum.	Near to the larger and smaller types of Pikermi and Samos, but appear somewhat more specialized. See notes.
Syn. *H. punjabiense.*	
H. chisholmi.	
Hipparion theobaldi.	

Aceratherium lydekkeri. } Not *Aceratherium.* Probably related to *Chilo-*
Aceratherium sp. } *therium* Ringström.
Teleoceras sp. Not *Teleoceras.* May be *Chilotherium.*
Rhinoceros aff. *sivalensis.* See notes.
Chalicotherium ? sp. Not found.
Tetraconodon magnus.
Sus punjabiensis.
Potamochœrus titan.
Potamochœrus.
Listriodon sp.
Microbunodon silistrense.
Merycopotamus cf. *dissimilis.*
Merycopotamus sp.
Hippopotamus iravaticus.
Dorcatherium majus. Inadequate type of no correlation value.
Cervus simplicidens. } Inadequate type of no correlation value.
Cervus triplicidens. }
Hydaspitherium megacephalum.
Syn. *Helladotherium grande* Pilgrim, non Lydekker.
Hydaspitherium grande Lydekker, non Pilgrim.
?Syn. *H. magnum* Pilgrim.
Giraffa punjabiensis. See notes.
Tragocerus indicus. } Compared by Pilgrim with *T. amaltheus* Pikermi,
Tragocerus sp. } but differs very considerably in the teeth.
Strepsicerine antelope, n.g.
(——— *latidens* Lydekker).
?*Boselaphus lydekkeri.*
Palæoryx sp.
Gazella sp.
Proleptobos birmanicus.

PRIMATES.—With few exceptions, every specimen of an anthropoid primate found in the Siwaliks or other Tertiary formations has been made the type of a new species. Genera are equally abundant in proportion. While this excessive splitting may be desirable in view of the important status of such documents in discussions of the origin of man, the very scanty material has no great weight as correlation evidence, in spite of the imposing array of names.

URSIDÆ.—*Indarctos* points apparently to a later date for the Dhok Pathan than the Lower Pliocene of China, but about equal to the Rattlesnake of Oregon. The *Hyænarctos* might be ancestral to the supposed Upper Siwalik *H. sivalensis,* but is quite closely allied. It is *slightly* nearer to the Sansan and Santa Fé *Hemicyon,* from which the *Hyænarctos* group is in my opinion rather directly derived.

MUSTELIDÆ.—All the material that I have been able to examine is so fragmentary as to be valueless for correlation, and for the most part the generic attributions are doubtful at the best.

HYÆNIDÆ.—Two or three doubtful species of *Palhyæna*, all allied to *P. hipparionum* of the Pikermi-Samos fauna, but the material that I have seen is very fragmentary. *Hyæna* comprises, as at Pikermi and Samos, a number of species related to the modern *striata* and *crocuta* respectively, but less differentiated, the species more or less intermediate.

FELIDÆ.—The *Machærodus* and *Ælurictis* groups appear to be represented by fragmentary material allied to the Pikermi-Eppelsheim species, but insufficiently known to be of much use in correlation.

RODENTIA.—Too incomplete to be important in correlation; related to Pikermi and later Pliocene and Pleistocene species.

DINOTHERIUM.—Palmer has shown that *D. indicum* and *D. pentapotamiæ* and *D. giganteum* of Eppelsheim are doubtfully separable on present evidence. The genus certainly occurs in both Middle and Lower Siwaliks, and a more careful re-study of the material may bring to light valid distinctive characters in place of the erroneous ones predicated by Lydekker. The remaining Proboscidea I have not studied.

HIPPARION is abundant and characteristic in the Dhok Pathan. A number of skulls and articulated limbs have been obtained and the characters are thoroughly comparable with the Pikermi-Samos *Hipparions* as well as those of China. There are two distinct types, as at Pikermi and Samos, and, while there may be more, the supposed evidence upon which additional names have been based consists wholly of erroneous observations or interpretations. The larger, more robust *H. theobaldi* has a much larger and longer skull, heavier limbs and feet and relatively larger lateral digits than *H. gracile, mediterraneum* or *crassum* (if these be distinct species and not mere geographic races). The lateral digits are heavier than in any of the species of *Merychippus*, as well as any American *Hipparion;* the complication of the enamel on the lake borders is equally extreme. The same relations hold true when comparison is made with *H. richthofeni* of the Chinese Pliocene. All the Old World *Hipparions* belong to a single group with round to round-oval protocone, highly complex enamel, deep lacrymal pits, relatively large lateral digits with considerable facet for the inner cuneiform on the head of metatarsal III, and various other characters. These are carried to a maximum in the Indian species as compared with other well known species. *H. antelopinum* is smaller and slenderer than *theobaldi*, but belongs quite unmistakably to the same group. Certain American species, *H. mohavense, H. gratum*, show an approach toward this Old World *Hipparion* but are distinctly more primitive, especially *H. gratum.* The Florida species belong to an entirely distinct group, *Nannippus*, which I have elsewhere characterized.

The inference from this is that the Old World or typical group of *Hipparion* presents the following successive stages in specialization:

4. *Hipparion theobaldi; antelopinum.* Middle Siwalik, India.
3. *H. gracile* (Eppelsheim); *H. mediterraneum, H. matthewi H. proboscideum,* etc. (Pikermi-Samos); *H. crassum* (France); *H. richthofeni* (China).
2. *H. mohavense.* California. Ricardo formation.
1. *H. gratum.* Nebraska, etc. Valentine beds.

The later stages of this series are probably also represented by imperfectly known species in North America and Europe, etc., but the species cited are abundant and well known, so that their skull and foot structure can be compared. *Hipparion gratum* is in turn derivable from a certain group of species of *Merychippus* of the Mascall-Deep River-Pawnee Creek Miocene (*M. isonesus* group) through intermediate stages found in the Santa Fé of New Mexico and Barstow of California.

As *Hipparion* is distinctly an invading type everywhere in the Old World, while its ancestry is fully represented in the American succession, I can find no other explanation of the above relations than that the Middle Siwalik is distinctly later than the so-called Pontian fauna of Pikermi, Samos, Maragha and China, which in turn are later than the Ricardo and much later than the Valentine (commencement of the "*Hipparion* fauna" in America).

RHINOCEROSES.—The so-called Aceratheria from India were referred to *Aceratherium* by Lydekker on the quite arbitrary ground that they were hornless. They appear to me to be gigantic species of *Chilotherium,* and whether or not they are placed within that genus (the skull differences are considerable) they have nothing to do with the true *Aceratherium,* but belong in the Oriental rhinoceros group. To *Chilotherium* is more definitely referable the so-called *Teleoceras* of the Mid-Siwalik. It has nothing to do with the true *Teleoceras,* and probably no especial relations with *Brachypotherium* of the older Miocene of Europe. The species of the Middle Siwalik may be compared with certain species of Pikermi-Samos, and with most, if not all, of the Chinese "Pontian" rhinoceroses as described by Ringström. It is not apparent that the Mid-Siwalik species are any later than Pikermi, but they lack the African rhinoceros group, which did not appear until Upper Siwalik and then only one species,[1] *R. platyrhinus.*

SUIDÆ.—*Listriodon* is reported by Pilgrim upon very doubtful evidence as surviving in the Middle Siwalik. I have not seen it. The remaining Suidæ I have not studied.

[1] *R. deccanensis* and *karnulensis* of the Indian Pleistocene, referred to this group, are of somewhat doubtful position. See notes.

HIPPOPOTAMIDÆ.—*Merycopotamus* is chiefly found in the Middle Siwaliks, also in the Tatrot zone of the Upper Siwaliks. It represents the last survival of the anthracotheres, but is not ancestral to *Hippopotamus* as has been suggested. *Hippopotamus* is derived from the Suidæ.

TRAGULIDÆ AND CERVIDÆ.—The material is too inadequate to have any correlation value.

GIRAFFIDÆ.—The revised identifications of the Siwalik genera and species make a revised comparison with other Giraffidæ necessary. I find no evidence of *Helladotherium* or *Samotherium* in the Middle Siwalik, and *Hydaspitherium* and *Bramatherium* appear distinctly more advanced and specialized than anything found in Pikermi, Samos, Maragha or China, although much less specialized than *Sivatherium*+*Indratherium* of the Upper Siwalik. But these later stages do not appear to have been attained outside of India (unless Abel's *Sivatherium* from Adrianople is really of that genus). The more typical Giraffinæ are represented in Pikermi and supposed to be represented in India; but of this there is no certain evidence; the teeth of *"Orasius" attica* and those of *"O." punjabiensis* are not very much alike except in size, and no limb bones of giraffe proportions are recorded in the Dhok Pathan. True giraffes do apparently occur in the Upper Siwalik beds, but even there the evidence is fragmentary and not wholly conclusive.

ANTELOPES.—There is a considerable variety of genera and species, and their remains are the most abundant fossils in the Siwalik beds. They are referred to Pikermi and later Pliocene or Pleistocene genera, mostly on rather insufficient grounds. *Tragocerus indicus* is one of the few well-based types, and is similar in horn-type to the Pikermi *Tragocerus*, but the teeth are somewhat more hypsodont, anterior premolars with simpler pattern. The remaining genera recorded must all be regarded as provisionally identified, and until the antelopes are more carefully revised no correlations can safely be based upon them. When that is done, they should afford some of the best correlation evidence.

In general the evidence of the Dhok Pathan fauna appears to me to indicate an age somewhat later than Pikermi, Samos or the Chinese Lower Pliocene, and it may be as late as Middle Pliocene. But it appears to be related to the Palæarctic faunas in the same way as are the Pleistocene and modern faunas of the two regions, although not to the same degree. India was then, as it is now, a refuge where primitive types survived after they had disappeared from the northern world.

C. THE LOWER SIWALIK, FAUNAL LIST AND COMMENTS

This is the fauna of the Chinji Zone, first described by Pilgrim and practically unknown to earlier writers.

Faunal List

Dryopithecus indicus.

Dissopsalis carnifex.
Syn. *D. ruber.*
— A remarkably primitive type of creodont, in about Upper Eocene evolutionary stage.

Amphicyon cf. *giganteus.* — A single molar. Valueless for exact correlation.

Amphicyon palæindicus.
Amphicyon chinjiensis.
Haplogale sp.
— Undescribed. Not seen.

?Potamotherium sp. — Possibly the *Potamotherium* is the same as a very good otter jaw in the Brown Collection. If so, it is nearer to *Lutra* than to *Potamotherium.*

Progenetta proava.
Æluropsis chinjiensis.
Syn. *Sivælurus* Pilgrim.
Æluropsis sivalensis.
— The genus is close to *Ælurictis* (Miocene-Pliocene, Europe and North America). The type species is from the Middle Siwaliks.

Machærodus sp. — Not seen.

Dinotherium sp.
Dinotherium pentapotamiæ.
— Probably not separable from *D. giganteum.* See notes.

Trilophodon angustidens.
Trilophodon falconeri.
Trilophodon macrognathus.
— Not examined. All sorts of things have been referred to "*Mastodon angustidens.*"

?Chilotherium intermedium.
?Syn. *Aceratherium* aff. *tetradactylum.*
Syn. *Teleoceras* sp.
— These rhinoceroses belong to the modern Oriental group, and are most, if not all, referable to *Chilotherium.* They are certainly neither *Aceratherium* nor *Teleoceras.*

Phyllotillon sp. — The several Chinji chalicothere teeth that I have seen are certainly not *Phyllotillon* but *Chalicotherium* or *Macrotherium.*

Hyotherium cf. *sindiense.*
Sus sp.
Sanitherium schlagentweitii.
Listriodon pentapotamiæ. — Near to *L. splendens* of the later Miocene of Europe.
Listriodon sp.

Microbunodon silistrense.
Hemimeryx pusillus.
— Anthracotheres. The phylogeny of this group and identification of genera and species have been so bedevilled by hasty and incomplete studies that they are hardly usable for correlation.

Dorcabune sp.
Dorcatherium anthracotherioides.
Dorcatherium minus.
Dorcatherium sp.
Dorcatherium majus.
— The types are too fragmentary to be identifiable even generically. They are probably traguloids of the *Dorcatherium* group.

Dicrocerus sp.	Not seen.
Propalæomeryx sivalensis. ??Syn. "*Giraffa* sp."	Valueless for correlation. See notes.
Giraffokeryx punjabiensis.	A characteristic genus of four-horned primitive giraffids near to *Palæotragus* and *Palæomeryx* in many respects.
Protragocerus, 2 sp. Strepsicerine antelope. *Gazella* sp.	Antelopes of several genera related to the Pikermi-Samos antelopes are found in the Chinji, but have not been exactly studied.

The Chinji fauna cannot be adequately compared until it has been critically revised throughout. I was able to study a part of the type material in Calcutta and London, and have reviewed some of Mr. Brown's collections in New York, but can make only partial comparisons.

The above list is taken from Pilgrim, 1913, with some modifications based on his later publications and my own notes herewith. Many of the species are represented by very scanty and fragmentary material and their generic position is by no means certain. Some I have not seen, and Doctor Pilgrim has published no descriptions or even statements of the nature of the types.

PRIMATES.—Too rare and fragmentary to be safe guides in correlation.

CREODONTA.—*Dissopsalis* is a remarkable survival, much more primitive than the Oligocene *Hyænodon.*

CANIDÆ.—A few isolated teeth and jaw fragments referred to *Amphicyon* are the only representatives of this family. Similarly fragmentary amphicyonines found in the American Miocene and Pliocene would be quite indecisive for correlation. So far as I have seen, the material most resembles *A. giganteus* and *frendens*, the former being the genotype and associated with *Dinotherium;* but what the relations may be to the better known species, *A. major* of Sansan, *sinapius* of the American Middle Miocene and *Pliocyon gidleyi* and *mæandrinus* of the American Pliocene, can be determined only when better material is available.

MUSTELIDÆ.—I do not know upon what evidence Doctor Pilgrim predicates *Haplogale* in the Chinji fauna. His *Potamotherium* I have not seen, but two jaws of otters in the Brown collection are better referred to *Lutra.* They are a large species with progressive teeth suggestive of *Aonyx.* I am equally unfamiliar with his *Progenetta.*

FELIDÆ.—*Sivælurus chinjiensis* appears to me to be a species of the *Æluractis* group, an archaic rather than primitive type, for it occurs in the American Pliocene, and probably the same genus as the type specimen of Lydekker's *Æluropsis sivalensis.* I have not seen any true *Machærodus*

in the Chinji, but it would be likely to occur. It is typical in the Eppelsheim and Pikermi faunas.

PROBOSCIDEA.—*Dinotherium* appears to be limited to the Lower Siwalik. The two described Indian species are very doubtfully separable either from each other or from *D. giganteum* of Eppelsheim. The "*Trilophodon*" I have not examined critically.

RHINOCEROTIDÆ.—Most of the Chinji rhinoceroses that I have seen could very well be referred to *Chilotherium* Ringström, but represent one or more somewhat primitive species. I do not see any particular affinities in this genus to the *Teleoceras* phylum; although the teeth maintain the rather primitive indifferent characters of the European members of that group (*Brachypotherium*), there is no indication in the Chinji of brachypodine rhinoceroses. The Chinji rhinoceroses may well be ancestral to those of the Middle Siwalik, and through *R. sivalensis* to the modern Indian and Sonda rhinoceroses, and through other intermediates to the Sumatran species. The Chinji species do not appear to include any of the atelodine group that appears in the Pikermi fauna, nor have I seen anything that suggests the true aceratheres of the European Miocene and early Pliocene. There is a small narrow-headed type with long nasals, small, brachydont, simple teeth that may be a primitive precursor of the Sumatran rhinoceros group and allied to "*Diceratherium*" of the Chinese Pliocene (which is certainly not true *Diceratherium*).

CHALICOTHERIIDÆ.—These are rare in the Chinji as in most Tertiary formations. Pilgrim reports *Phyllotillon*, but I do not know upon what evidence. The typical *Phyllotillon* is closely allied to *Moropus* of the American Lower Miocene. All the Chinji chalicotheres that I have seen belong to a different phylum, the *Macrotherium-Chalicotherium-Circotherium* series, and are small and rather primitive, comparable to the smaller species of *Macrotherium*, distinctly more primitive than *Chalicotherium* of Eppelsheim, much more so than *Circotherium*, which occurs in the Upper Siwalik and in the Pleistocene of China.

SUIDÆ.—*Listriodon* is the most characteristic genus, and the Chinji species is related to *L. splendens* of the Middle and Upper Miocene of Europe. Concerning the remaining Suidæ I am unable to formulate any views at present. Doctor Pilgrim has recently monographed the Indian Suidæ, but his methods appear to me to place too much weight upon one or two unsupported differentiation characters, allowing not enough for individual variation, and resulting in an extraordinarily complex arrangement which would be far more complex if the same methods were applied to *all* the Old and New World suillines, instead of only to the Indian groups.

ANTHRACOTHERIIDÆ.—Anthracotheres are not common in the Chinji, and appear to be all tetracuspid.

TRAGULOIDEA.—A number of small ruminants, probably related to *Dorcatherium* of Eppelsheim, but their exact position has not been determined.

GIRAFFIDÆ.—"*Propalæomeryx*," based upon a single upper molar, is at present not supported by any correctly referred specimens. It may be the same as certain short-crowned ? giraffids not yet studied. *Giraffokeryx* is the common and characteristic genus of the Chinji. A fine skull in the Brown collection shows that, while the teeth are primitive, the skull is a rather elongate four-horned type of probably aberrant character, quite distinct from *Palæotragus* with which Bohlin is disposed to identify the genus. It might conceivably stand ancestral to sivatheriines, ocapiines, samotheriines and giraffines, but very rapid and extensive diverse specializations would be necessary to bring about the changes, and there is hardly room between Lower and Middle Siwalik for so much diverse specialization. It appears more probable that the Chinji Giraffidæ included a considerable number of types with similar dentition, but with the earlier stages of diversification in skull and horn characters, and that the *Giraffokeryx* skull is a side line.

ANTELOPES.—There are several genera of antelopes in the Chinji, and jaws and teeth are the most abundant fossils there, but not much is known of the skulls. One type appears to be ancestral to *Tragocerus punjabiensis*, but the pertinence of that species to the Pikermi-Samos *Tragocerus* is open to question. I am unable to see much affinity to *Protragocerus* in any Chinji antelopes that I have examined; but certainly there are antelopes with the tragocerine and strepsicerine types of horn, as also small species that cannot be distinguished from *Gazella* by the scattered horn-cores, jaws and other fragmentary material.

The fauna has a distinctly Miocene aspect in such genera as *Listriodon*, the primitive stage of the antelopes, absence of large giraffids, of progressive rhinoceroses and chalicotheres, of several advanced types of Carnivora, but most especially in absence, save doubtfully near the top, of *Hipparion*. Negative characters are not the best indications, but I see nothing in the fauna to prevent its being regarded as Upper Miocene, equivalent to La Grive and associated faunas. I hardly think it can be much older, for it seems rather nearly related to the Hasnot fauna, and partly ancestral. Pikermi-Samos-Eppelsheim intervene as to age, but they are in many instances less closely related. In the *Tragocerus*, *Gazella*, *Macrotherium*, *Hydaspitherium*, "*Orasius*," *Rhinoceros*, *Lutra*,