44. The Limestone Caves of Burma and the Malay Peninsula.*

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(Plates XVIII – XXII.)

INTRODUCTION.

The caves of the Oriental Region do not possess the interest of those of some parts of Europe and America. As a rule they are not of vast size or impressive interior; few or none of them contain streams or lakes; their fauna does not appear to be a highly specialized one, and no palaeontological deposits of importance have been discovered in them; they have not, so far as we know, been the home of races whose civilization is extinct. It is, however, no less necessary to study what is ordinary than what is striking; indeed, the former is in many cases the more important from a scientific point of view. Comparatively little attention has yet been directed to the structure and fauna of the limestone caves of Burma and the adjacent countries, and it has seemed worth while, if only in order to stimulate further study, to gather together the scattered and often somewhat inaccessible references in literature, and to add the results, imperfect as they are, of our own several investigations in the Shan States, Tenasserim, the Siamese and the Federated Malay States.

Although the caves are scattered over an area of great extent—it extends from western China in the north to Borneo

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in the south—and are often separated one from another by long distances, they are in many respects remarkably uniform. The formations in which they occur are probably of similar if not identical origin in the different localities, and the manner in which they themselves have been formed is the same: the great sheet of limestone that once covered the country has been partly dissolved and low isolated hills alone remain to represent it. These hills, which often have fantastic forms and rise conspicuous in flat land devoted to or suitable for agriculture, most commonly contain the caves, eaten out of their centres by the action of water. Sometimes the mouths are at the base of the hills, sometimes they open on the face of precipitous cliffs, which may have almost the appearance of white marble, or may be almost black on account of weathering.

A large proportion of the caves are mere recesses which do not penetrate sufficiently far to be at any point beyond the reach of daylight, but some consist of long passages and great chambers within the hill. In many cases there are several series of passages and caverns, the latter of considerable diameter, of great height and usually of circular form with a domed roof. The passages, which are as a rule less lofty than the inner caverns but often of considerable width, wind about from chamber to chamber, often ascending or descending as they do so and in some cases attaining a total length of many hundred yards. It is very common for there to be a small aperture like a skylight in the roof of the larger chambers and sometimes the roof has collapsed more or less completely, leaving the chamber open to the sky and with its floor encumbered with debris. It is apparently owing to this penetration and subsequent destruction of the roofs of caves which occupied the interior of hollow hills that the strange amphitheatres occasionally seen in limestone districts in Burma and Malaya are due.

At a few places the hills in which the caves occur form islands, as in the great lagoon in the north-east of the Malay Peninsula, so like the Chilka Lake of Orissa in many respects, which is marked in some English maps as Senggora Lake, is called by the Siamese simply the "Great Lake" (*Talé Sap*) and is known to the Malays as *Laut Dalam*, the "Inner Sea."

In the islands of this lake and in some of those that lie in the northern part of the Straits of Malacca off the coast of the State of Trang, the caves are a source of revenue to the Siamese Government as nesting-places of one or other of the swifts of the genus *Collocalia* that produce the edible nests of Chinese trade. At nesting-time these caves are zealously protected against poachers, and the right to collect the nests is a strictly preserved state monopoly farmed out at high rent.

A commoner commercial asset of the caves is bat-dung

manure, which, both in Burma and in Siamese territory, is collected annually in many of them. The subject, so far as Burma is concerned, is discussed by Mr. I. H. Burkill in a pamphlet issued as No. 1 in the *Agricultural Ledger* (Calcutta), for 1911.

The earliest description of any of the caves appears to be that given by Capt. W. Foley in his "Notes on the Geology, etc. of the Country in the Neighbourhood of Maulamyeng (vulg. Moulmein)" published in the Journal of this Society for 1836 (Vol. V, pp. 269-281, pl. VII). He mentions as the principal caverns of the district those at Yêtsêy, Tyokhla, Joe-ka-beng, Damatha, Nyown-beng-zeite, Phabia, and describes the Buddha-cave at Dhammathat (or Damatha) and also a small cave a little further to the south near the summit of the hill which had (in 1836) "been but lately selected by the Phúngi, for the better concealment of a quantity of manuscripts written in the *Thalian* or *Burmah* character, and secreted in the upper part of the *Damatha* cavern at a time that the country was invaded by *Tshan* (Siamese)." Some of these manuscripts he procured for presentation to the Asiatic Society.[1] It is evident from his map that the Nyown-beng-zeite[2] caves to which he refers are those now known under the name of Khayon or "Farm Caves."

Another cave near Moulmein which Capt. Foley mentions is situated at *Phabowng Thowng*, a limestone hill on the banks of the Atbaran; this cave has a stream running through it.

The next Burmese cave to be described, was that of Shwe Male (Yule's "*Narrative of the Mission to the Court of Ava in 1855*," London, 1858, pp. 177-83). This cave is in crystalline limestone belonging to the Moyok series.

The caves of the Atbaran River and at Thonzoo (the Three Pagodas) are referred to by Tickell and Parish (*Journ. As. Soc. Bengal*, XXVIII, 1859, pp. 425 and 465-8), the latter author being interested particularly in the vegetation of the hills containing them. The limestone hills near Moulmein were described in 1871 by Stoliczа (also in the Journal of this Society) with special reference to their molluscan fauna; he pointed out how the isolation of these rocks admitted of the development of certain persistent peculiarities of the animals of different localities; but he did not describe the caves. Theobald, another member of the Geological Survey of India, mentions them in his "Geology of Pegu" (*Mems. Geo. Surv. Ind.*, X [2], p 139) but does not add greatly to our knowledge

1 It is probable that these are still in the Society's possession, but our Burmese MSS. have not yet been adequately catalogued.

2 Nyaungbinzeik (or Nyown beng zeite) is a village on the banks of the Ataran River. There is a ferry there on the road from Moulmein to the caves, and it is the only village on the journey.

of the caverns themselves, although he makes an important contribution to the geology of the rocks containing them.

Fea appears to have been the first zoologist to describe the interior of any of the caves. He visited those near Moulmein and, in an interesting letter [1] published by the Geological Society of Italy (*Bull. Soc. Geogr. Ital.*, 1888) dealt with their peculiarities and his collecting in them. The zoological results of his journey are published in the *Ann. Civ. Mus. Stor. Nat.*, 1869–1897; many cave-haunting species are described by specialists in this important series of papers.

The Batu caves near Kuala Lumpur in the Malay State of Selangor were investigated by Ridley at the request of the British Association, in whose Report for 1898 (pp. 572-582) he published the results of his researches. Four caves are carefully described and diagrams of two of them are given; the animals inhabiting their darker parts are recorded with notes on their habits.

In 1899 the members of the Skeat Expedition to the Malay Peninsula visited the caves near Biserat in the Siamese State of Jalor, which had not previously been investigated. In these they discovered several new cavern-haunting species (described in Reports on the Expedition, mostly in the *Proceedings of the Zoological Society of London*, 1900-1903), closely allied to those found by Fea in the Farm Caves. In June, July, October and November, 1902, the Jalor caves were visited again by Robinson and Annandale; their collections have been described in *Fasciculi Malayenses* (Liverpool, 1903-1905), in the supplement ("Itinerary") to which notes on the caves themselves will be found (pp. vi and xxv-xxviii).

The caves of the islands in the Talé Sap are described by Skeat in his report to the British Association (1900); also by Warrington Smythe in his *Five Years in Siam*. Annandale has given certain particulars about those on the coast of Trang in the Supplement to *Fasciculi Malayenses* (p. xv) and in the anthropological part of that work (vol. I, p. 63).

Ancient clay tablets found in caves in Trang and Kedah are described in the following papers:—"Short Notes on a Buddhist Votive Tablet" by C. O. Blagden (*Journ. Straits Branch Roy. As. Soc*, 1903, p. 205); "Clay Tablets from Caves in Siamese Malaya" by A. Steffen with notes by Nelson Annandale (*Man*, vol. II, No. 125, pl. M, 1902); "Notes on Clay Tablets from the Malay Peninsula" by Rakhaldas Banerji, with an Introductory Note by N. Annandale (*Journ. As. Soc. Bengal*, [n. s.] vol. III, p. 459, 1907).

The date of the tablets from Trang appears to be about the 8th to the 11th century A.D. Professor Kern of Leyden

[1] Fea's more detailed account of his wanderings ("*Quatro Anni i Birmaine et le Tribu Limitri*") is unfortunately not available in Calcutta.

(who had, however, seen only a photograph) attributed one from Kedah to the 10th century; but Babu Binod Bihari Bidyabinod of the Indian Museum, who has examined this and other specimens from Kedah which Dr. R. Hanitsch, Director of the Raffles Museum, Singapore, has been kind enough to lend us, informs us that they must be considerably older. He is of the opinion, on palaeographic grounds, that they belong to the 7th century; his note is printed in the appendix to this paper (p. 423). In any case their script (pl. XVIII) is North Indian, as is also that of the Trang tablets.

Other clay tablets, apparently of much more recent date, are commonly found in caves in Jalor and Pahang. These tablets probably date from the 18th century A.D. Many of them bear the image of a Buddha seated beneath a seven-headed cobra with expanded hood (pl. XIX). According to Rakhaldas Banerji (*op. cit.*, p. 469) this is the divine Buddha Amoghasiddhi; but Temple (*The Indian Antiquary*, vol. xxii, p. 339), referring to similar images from Burma, regards them as representing Buddha Gotama and suggests their Siamese origin. In one of the caves near Biserat there is a gigantic recumbent figure with a many-headed cobra shielding the head with its hood. This statue, which is said to have been erected by a Siamese nobleman in the eighteenth century, certainly represents the last earthly Buddha, and there can be no doubt that modern Siamese iconography differs from that of ancient India in the use of the protecting many-headed cobra as an emblem.

Archæological descriptions of limestone caves in the Amherst district of Tenasserim are given by Taw Sein Ko in *The Indian Antiquary*, vol. XXI, p. 377 (1892), and by Temple in vol. XXII, p. 327 (1893), of the same publication. Photographs and plans of the Farm Caves and others in the same district, and figures of comparatively recent clay tablets from them are reproduced by the latter author. None of the remains appear to be ancient.

In Tenasserim and Jalor many limestone caves are still used as Buddhist temples, while in Trang and other Siamese States, and also in Yünnan (pl. XXI), they serve the same purpose for Chinese worship.

In parts of both the British and the Siamese Malay States small caves are occupied temporarily as habitations by jungle-tribes (see Skeat and Blagden, *Pagan Races of the Malay Peninsula*, pp. 168, 173), while on the coast of Trang a single large cavern was, until it was desecrated by Chinese pepper-planters in search of bat-guano, the tribal burial-place of the *Orang Laut Kappir* or Pagan Sea-Gypsies (Annandale, *Fascic. Malay., Anthrop*, vol. I, p. 63).

The folklore of the caves in Burma and Malaya is probably very extensive, as they are universally regarded with

superstitious respect. Very little information is, however, available on this point. It is believed in the British States and also in Trang that the clay tablets found in the caves are made by spirits, which the Malays call *orang Perai* (Peri folk) and the Siamese *pi*. These spirits resemble the Scotch fairies in appearence and habits, being little folk of small size and great beauty, extremely fond of festivities and processions, which they conduct from cave to cave at night with lights and dancing. The cave-bats in Jalor are called spirit-birds (*burong hantu*), a name more frequently conferred on owls; it is believed that their droppings falling on the human skin cause an unpleasant disease. In the Jalor caves a strong wind blows outwards towards the entrance at certain times of the day, and inwards from it at others. This is believed by the Malays and Siamese of the district to be the actual Cave-Spirit (*Hantu Goah*).

We hope that these notes may prove useful to those who may have fuller opportunity for investigating the caves of Burma and Malaya than has fallen to our lot.

PART I.—GEOLOGY.

The well-known caves of Moulmein are situated in a series of limestones which is probably continuous with the "Plateau" and associated limestones of the Northern Shan States. These formations are known to occur far to the south in the Southern Shan States and in Karenni, but the intervening areas have not as yet been geologically explored.

To the south of Moulmein the limestones continue through Tenasserim, but here again they have only been described from small isolated exposures, since no detailed survey of the district has been attempted. The first information regarding the occurrence of a fauna of carboniferous age in Tenasserim was given by Dr. T. Oldham in 1856.[1] He divided the rocks which cover so large a portion of the southernmost divisions in Burma into a lower group, which was termed the "Mergui Series," and an upper one to which the name "Moulmein Series" was given. The former is well developed in the south, while the latter obtains its maximum development towards the north. The most conspicuous member of the Moulmein series is the massive limestone which forms so important a feature of the landscape around Moulmein, and in the higher parts of the Salween valley. The thickness of the two divisions was stated to be about 9,000 feet, and the

[1] *Records of the Government of India, Home Dept.*, No. X, 1856, reprinted in "Papers on Burma," No. 25. Notes on the Coal-fields and Tin-Stone Deposits of the Tenasserim Provinces, pp. 375–405

age of the whole given as Palaeozoic, the Moulmein beds being provisionally placed in the "lower carboniferous group of European geologists."

In 1863 W. Theobald from the evidence of a few fossils procured from Zwah-ga-byn, a limestone hill which forms a prominent landmark above Moulmein, and is popularly known as the "Duke of York's nose," pronounced the age of the limestone as equivalent to the carboniferous limestone of Europe. He also regarded it as probable that the limestone met with in the Mergui Archipelago belonged to the same formation.[1]

To quote from Theobald's Memoir:—

> "The most marked feature of this limestone is its mode of occurrence in steeply scarped hills, the sides of which overhang, as may be seen in the case of the hills near Moulmein, which rise abruptly from the low inundated plains between the Gaine and the Attaran rivers, and exhibit the precise appearance of what they undoubtedly were at no remote geological period—sea-girt rocks, such as still stud the Mergui Archipelago, and which from their position in low-lying alluvial plains even now, during the rains, are approachable only by boats, through a mimic freshwater sea."

Theobald also speaks of the existence of other extensive caves to the north-east beyond Toungoo.

It is not known what became of the fossils mentioned both by Oldham and Theobald. They are not in the collection of the Geological Survey of India and were never described in detail. Fortunately, some years later, a further small series of foraminifera, corals, brachiopoda and gastropoda was obtained by P. N. Bose from the limestone hills near Therabwin in Tenasserim.

The following species were determined by F. Noetling[2] who pronounced them to be of carboniferous (probably upper carboniferous) age.

Schwagerina oldhami, Noetl.
Lonsdaleia salinaria, Waag. and Wentz.
Lithostrotion, spec. nov.
Araepora cf *ramosa*, Waag and Wentz.
Polypora cf. *biarmica*, Keyserl.
Productus cf. *sumatrensis*, F. Roemer.
Athyris, sp.
Spirifer, sp.
Bellerophon, sp.

1 W. Theobald, On the Geology of Pegu. *Mem. Geol. Surv. India*, Vol. X, p. 138.

2 F. Noetling, Carboniferous Fossils from Tenasserim. *Rec. Geol. Surv. India*, Vol. XXVI, Pt. 3, pp. 96—100.

Pleurotomaria aff. *durga*, Waag.
Murchisonia, sp.

This fauna is one in which Indian and Sumatran types are mixed and it is probably of the same age as that from Zwah-ga-byn hill.

It is in every degree probable that similar limestones of anthracolithic age extend to the far south through the Malay Peninsula, and that the caves of that area are in identical formations.[1]

In the state of Pahang (F. M. S.), an extensive calcareous series consisting chiefly of limestones exists. It has been termed the Raub Series by J. B. Scrivenor who writes[2]:—

> "The big limestone hills form a picturesque feature in the landscape wherever they occur, similar to those on the west of the Main Range. Gunong Sinyum, with its huge caves, is perhaps the most striking of them, although not the largest. In Sarawak and Kinta there is clear evidence that the steep cliffs of the limestone hills coincide with fault planes, and it might be expected that the same explanation of the formation of these precipices would be found in Pahang. It has not been possible, however, to prove this, and in the absence of clear evidence we must regard the Pahang limestone hills as having been formed by the processes of denudation acting unequally on masses of strongly jointed and tilted beds of limestones. The caves found in the hills are as beautiful as caves elsewhere in limestone country, but present no special feature."

Fossils have been found in a few localities. From the Mill Gully and Gua Sah exposures, obscure coral, crinoidal, and other structures have been reported, as well as some fairly good remains of Cephalopoda which C. C. Crick believes belong to the genera *Orthoceras*

Cyrtoceras
Gyroceras
and *Solenocheilus*,

pointing to a carboniferous age for the rocks.

From Lubok Sukum imperfect casts and impressions have been obtained which Messrs. Newton and Crick think may be of permian age. They consist of circular or elliptical forms resembling Waagen's *Xenodiscus*, straight tube-like bodies which appear to be closely allied to *Dentalium herculea* of De Koninck and a number of other organisms, too obscure for

[1] Caves in the Malay Peninsula. *Brit. Assoc. Repts.*, 1898, p. 571.
[2] J. B. Scrivenor, The Geology and Mining Industries of Ulu Pahang, 1911, p. 33.

determination, among them being an Aviculopectinoid impression and some possible Brachiopod remains.[1]

J. M. Maclaren is of the opinion that the Raub Series will prove to resemble the limestones and shales of the Southern Shan States described by C. S. Middlemiss.[2]

W. W. Skeat, observing the occurrence of fossils on some of the images of Buddha in the north-eastern part of the Malay Peninsula, was led to search for the quarry from which the rock was obtained out of which the images were carved, and it was at length found on the western flank of the great central axis of the Peninsula.[3]

From the fossiliferous limestone so obtained Prof. T. Mckenny Hughes determined a trilobite (*Proetus*), encrinite stems and arms, and several species of lamellibranchs and brachiopods, including at least one *Chonetes*. "There is a well-preserved and highly ornamented *Pleurotomaria* and a Cephalopod, which by its horse-shoe lobes confirms what is suggested by the general facies, namely, that the deposit belongs to the highest beds of the Carboniferous, or rather, perhaps, to beds intermediate between the Carboniferous and the overlying system to which the compromise name of Permo-Carboniferous has been applied."

It is interesting to note that Messrs. Newton and Crick consider their fossils younger than the ones referred to above; but according to Dr. Annandale the limestone from which Skeat's fossils were obtained was very different in structure

[1] *Loc. cit.*, p. 34.

Since the above account was written, J. B. Scrivenor has published a summary of his ten years' work in an illuminating report entitled, The Geological History of the Malay Peninsula. (*Quart. Journ. Geol. Soc.*, Vol. 69, 1913, pp. 343 371). In this it is stated that he is not prepared to accept the scanty palaeontological evidence regarding the age of the Raub Series without qualification. To quote.—"The fossils found so far, in fact, have done no more than give a hint as to the age of the rocks; they may be carboniferous or permo-carboniferous. Other evidence unknown at the time when the fossils were described, makes it improbable that they are permian" (p. 353)

This evidence depends upon the discovery in Perak, immediately above the Raub Series, of glacial clays, which Scrivenor correlates with the Talchirs of the Indian Peninsula. It would be too far from the purpose of the present paper to enter into the question of the exact age of the Gondwana boulder beds here, but it may be mentioned that in the course of the discussion on Scrivenor's paper, La Touche argued that the Malayan Glacial Beds belong to a later period of glaciation than that represented by the Talchirs. He expressed the opinion, however, that the Raub Series was apparently a southward extension of a portion of the dolomitic limestones of the Burmese Shan States, probably representing their upper parts and pointing to the transgression of the carboniferous sea southwards, followed by an eastward retreat of the coast of Gondwanaland.

[2] Gold; its Geological Occurrence and Geographical Distribution, 1908, p. 287.

[3] Natural History and Ethnography of the Malay Peninsula. *Brit. Assoc. Repts.*, 1901, p. 414.

and appearance from that which formed the walls of caves in the neighbourhood.

In Siam, the whole of the great range on the west which extends almost unbroken from the extreme south of the kingdom to the most northerly point above Chieng Sen on the Mekong, and thence northwards through the British trans-Salween Shan States into China, appears to consist largely of enormously thick limestone beds, probably of carboniferous age in part, lying upon metamorphic and schistose formations. These limestone beds are found throughout the Malayan Provinces and in the Ratburi district. The Chieng Mai district and the series of hill ranges across northern Siam from Chieng Sen down to Pitsanulock are said to present much the same geological features. In Eastern Siam, limestone hills are found towards the north and west, and where the Mekong turns from east to south they again appear as a barrier of ever-decreasing height between the river and the basin of Eastern Siam. At the junction of the Nam Mun and the main river the great masses of limestone which form the southern boundary of the eastern part of the country come in, and running westwards as far as the Dong Phaya Yen mountains, overlook the plains of Central Siam. Limestone pinnacles are found piercing the alluvium of Central Siam, as at Chainat, Prabat, and Kabin.[1]

Permo-Carboniferous limestones are known to occur in Sumatra, Toba-landan, Timor and Rotti.[2] In Western Borneo they contain caves which are very similar to the Burmese and Malayan ones.[3]

Further to the east in Tongking and the Laos, limestones of the same age have been identified.

To the north of the Moulmein, Amherst and Thaton districts the limestones stretch through Karenni into the Shan States. Caves are found in them along the edge of the hills bordering on the Shan States and dividing them from the broad plains of the Irrawaddy valley. These caves are well known as they yield large quantities of bat guano.[4] In the Southern Shan States the limestones which often contain caves, as for example in the neighbourhood of Kalaw, have been well described by C. S. Middlemiss who writes as follows:—

> "The dark-grey limestone frequently weathers almost black into sharp-edged honeycombed masses, into pinnacled crags, weather-beaten towers and walls into deep basins and swallow holes (often as regular and circular as

[1] W. A. Graham, Siam, London, 1912, pp. 86-93.
[2] See literature quoted by J. B. Scrivenor *loc. cit.*, p. 48.
[3] *Brit. Assoc. Repts.*, 1898, p. 581.
[4] I. H. Burkhill, Guano in India, *The Agricultural Ledger*, 1911, No. 1, p. 7.

a gigantic amphitheatre, but sometimes funnel-shaped): into strange valley systems, without connection one with the other, and that often end mysteriously either as underground passages down which streams precipitate themselves and become lost, or as marshes and lakes where evaporation helped out no doubt by subterranean percolation causes a disappearance of the waters: into innumerable caves and passages beneath the ground, some now high and dry from the waters that caused them and which are locally mined for the nitrates that have accumulated upon the floors from the decomposition of cave animal deposits, others used as show places and temples; others again unknown to fame and rich in their virgin beauty of stalactitic growths."[1]

In the Northern Shan States these limestones are well known, and have been described in various papers appearing in the publications of the Geological Survey of India by T. D. La Touche.[2] Wherever they have been examined in this area by myself, depressions appearing on the surface of the ground which they underlay have always been a striking feature, as has also been the fact that their drainage very often disappears underground. La Touche has noted how these depressions vary in size from "pipes" a few feet in diameter to "swallow-holes" and funnel-shaped "punch-bowls," of which the latter are by far the most common, and from these to enclosed valleys several miles in length and breadth, traversed by running streams. These phenomena are due to underground dissolution of the rock and the consequent settling down of the roof of a cavity or cavern, too weak to support its own weight. Owing to the crushed condition of the limestones in the Northern Shan States, as a result of the tectonic stresses induced by the great earth movements which took place after their formation, large open caverns such as occur near Moulmein and further south are of rare occurrence. In the Southern Shan States caverns are known to exist and it is believed that systematic searching would reveal the presence of many others.

C. Deiner has described rich collections of anthracolithic fossils collected by La Touche and Middlemiss in the Northern and Southern Shan States. His opinion regarding their ages is quoted below:—

"In brief the anthracolithic faunas of Burma and of the Indian region (Salt Range-Himalayas), so closely situated

[1] C. S. Middlemiss, Report on a Geological Reconnaissance in parts of the Southern Shan States and Karenni. *General Rept., Geol. Surv. India*, 1899-1900, pp. 130-131.

[2] See especially T. H. D. La Touche, Geology of the Northern Shan States. *Mem. Geol. Surv. India*, Vol. XXIX, Pt. II.

geographically, must be considered as belonging to the same zoogeographical province. Their similarity may be interpreted as due both to their proximity in geographical position, and to their stratigraphical homotaxis. This correlation places the anthracolithic faunas of the Shan States on the same level as the middle and upper Productus limestone of the Salt Range or of exotic block of Chitichun No. 1." [1]

Although somewhat beyond the region treated of in this paper mention may be made of the fact that both devonian and anthracolithic limestones attain a considerable development in the Chinese province of Yünnan, and that in the western parts of the province small caverns are sometimes found in the rocks of the latter group. As an example of these a photograph of the Ta-shih-wo cave near the edge of the Yung-ch'ang fu plain is appended. (Pl. XXI).

It is probable that in many of the caves of Burma and the Malay Peninsula, deposits of recent or approximately recent fossil or sub-fossil remains will be found; but no such deposits have as yet been investigated. The teeth of a large tiger and a skull of the Bamboo-Rat (*Rhizomys sumatrensis*) have, however, been forwarded to Calcutta for examination, with the information that they were found in a small cave near Mogok, Ruby Mines District, and in some of the Jalor caves there are large beds of freshwater shells and mammalian bones.

PART II.—THE FAUNA OF THE CAVES.

The following list of the animals that have been recorded from the limestone caves of Burma and Malaya, or are represented therefrom by authentically named specimens in the Indian Museum, is compiled for the most part from Ridley's "Account of caves in the Malay Peninsula" in the *Rep. Brit. As.* for 1898; from the papers on the zoological results of the Skeat Expedition to the Malay Peninsula, published mostly in the *Proc. Zool Soc. London* between 1900-1903; from the zoological parts of Annandale and Robinson's *Fasciculi Malayenses*, and from papers on the late Signor Fea's Burmese collection in the *Ann. Civ. Mus. Genova* (1889-1897).

We have added obeservations of our own, more particularly on the Orthoptera and Pedipalpi.

[1] C. Diener, Anthracolithic Fossils of the Shan States. *Pal. Ind.*, New Series, Vol. III, Mem. No. 4.

Name.	Cave Locality.	Remarks.
Mammalia.		
Carnivora.		
Felis tigris, L.	Batu Caves ..	Commonly rests in caves near Kuala Lumpur.
Insectivora.		
Scriculus nigrescens (Gray)	Near Biserat ..	A specimen was trapped by the Skeat Expedition in the entrance to one of the larger caves.
Chiroptera.		
Cynopterus, sp.	Batu Caves .	Found by Ridley in large numbers in one cave.
Xantharpyia amplexicaudata (Geoff.) ..		
Eonycteris spelaea (Dobson)	Farm Caves ..	Only known from the Farm Caves.
Rhinolophus affinis, Horsf.		
,, *minor*, Horsf.		
Hipposiderus armiger (Hodgs.)		
,, *diadema* (Geoff.)		Common cave-haunting species of wide distribution. Several of the species have been or will doubtless be divided at least into local races.
,, *larvatus* (Horsf.) ..		
,, *bicolor* (Temm.)		
Taphozous longimanus, Hardw.		
,, *saccolaemus*, Temm.		
Rhinopoma microphyllum, Geoff. ..	Dhammathat ..	Found in large numbers, to apparently[1] the exclusion of other species, in the long, dark, tunnel-like cave.
Nyctinomus plicatus (Buchn.) ..		A common cave-haunting species.

[1] Anderson, in the Administration Report of the Marine Survey of India for the official year 1897-8, describes the emergence of *Nyctinomus plicatus* in a dense stream from a cave at Hpagat on the Salween, 26 miles above Moulmein. These bats were followed by small numbers of a much larger species, and it is possible that the *Rhinopoma* at Dhammathat may also have been associated with some scarcer species taking flight at a different hour.

Name.	Cave Locality.	Remarks.
Rodentia.		
Sciurus atridorsalis, (Gray.)	Farm Caves ..	A specimen was taken by Fea in one of these caves.
Mus surifer, Miller.	Jalor ..	Common in these caves but not peculiar to them.
Rhizomys sumatrensis (Raff.) ..	Mogok ..	A subfossil skull has been examined by Mr. E. Vredenburg.
Hystrix grotei, Gray.	Jalor ..	Apparently rests in large numbers in caves during the day.
Ruminantia.		
Nemorhaedus swettenhami, Butler ..	Jalor ..	See subsequent notes. The species (or race) is called *Capricornis sumatrensis swettenhami* by Lydekker,[1] in *Cat. Rum. Brit. Mus.*, p. 188 (1913).
Aves.		
Macrochires.		
Collocalia innominata, Hume ..	Talé Sap ..	Breeds in caves.
Reptilia.		
Lacertilia.		
Gymmodactylus pulchellus (Gray.) ..		Common in caves in different parts of the Malay Peninsula : also found in the jungle.
Lygosoma scotophilum, Boulenger ..	Batu Caves ..	Originally described from a cave but also found in the jungle,
Reptilia.		
Ophidia.		
Coluber taeniurus (Cope).	Batu Caves ; Jalor	pale phase (see below) is found in caves.
Batrachia.		
Ecaudata.		
Rana glandulosa, Boulenger	Batu Caves	By no means confined to caves.
,, *jerboa* (Gunther)	,,	
Bufo asper, Gravh.	,,	

MOLLUSCA.		
Gastropoda.		
Streptaxis sankeyi, Benson	Farm Caves ..	Recorded from several localities outside the caves.
Hypselostoma laidlawi, Collinge ..	Jalor	Only known from a cave.
Prosopeas tchehelense, de Morg. ..	,, ...	See below. A common species under cliffs as well as in caves.
Opeas innocens, Preston	Farm Caves ..	Only known from dead shells from a cave.
Ophisthostoma annandalei, Sykes ..	Jalor .. }	Only known from a cave.
Ditropsis cavernae, Sykes	,, .. }	
INSECTA.		
Thysanura.		
Japyx indicus, Oud	Farm Caves ..	Not uncommon also under logs of wood in the open.
Collembola.		
Neanura pudibunda, Imms	,, ..	Only known from caves; brilliantly coloured and with eyes.
Cyphoderus simulans, Imms	,, ..	Found with preceding species; blind and colourless.
Orthoptera.		
Chelisoches morio, Fabr.	Jalor	A common species outside caves in Malaya.
Periplaneta sp. (? *americana*, Linn.) ..	,,	
Spelaeoblatta gestroi, Bolivar ..	Karen country ..	Only found in a cave.
Rhaphiodophora, (? *brunneri*. Kirby) ..	Farm Caves ..	Identical with a species found in the jungle.
Diestrammena unicolor, Brunner ..	,, ..	Also recorded from northern China.
,, *annandalei*, Kirby ..	Jalor	Only known from the Jalor Caves.
,, sp.	Batu Caves ..	Not identified specifically.
Neuroptera.		
Myrmecaelurus, sp.	,, .	Recorded by Ridley.

[1] Two errors may be noticed in this author's statement as to the skin of the Malay Serow presented to the British Museum by Messrs. H. C. Robinson and N. Annandale. It is not the type, which was from the Larut Hills: and it came from the neighbourhood of Biserat in Jalor. So far as we are aware, there is no place in the Malay Peninsula called Bigerat, and Biserat is nowhere near the Larut Hills.

Name.	Cave Locality.	Remarks.
Hymenoptera.		
Ponera confinis, Roger var.	Farm Caves ..	Abundant in caves near Moulmein.
Lepidoptera.		
Pyralis fumipennis, Butler	Jalor	By no means confined to caves, in which, however, it apparently breeds.
Pyralis pictalis, Curt.	Farm Caves ..	Apparently breeds in the largest of these caves, to which it is not confined.
Crypsithyris spelaea, Meyrick ..	,, ..	Probably a true cavernicolous species.
Diptera.		
Sciara pallescens, Brunetti	,, ..	Perhaps a pale form of a species found in the open in Bengal (see below).
Nycteribosca amboinensis, Rondani *Raymondia pagodarum*, Speiser *Ascodipteron siamense*, Speiser	.. Jalor ..	.. Bat-parasites.
Myriapoda.		
Chilognatha.		
Platyrhachis malaccanus (Peters) ..	Jalor ..	.. Not a true cavernicolous species.
Doratonotus cavernicola, Sinclair ..	,,	.. Only known from a cave.
Cambalopsis calva (Pocock), var. ..	Farm Caves	.. The typical form of this species was not found in a cave.
Cambalamorpha jeae (Pocock) ..	,,	.. Perhaps a true cavernicolous species.
Schizotarsia.		
Scutigera longicornis (Fabr.)... ..	,,	.. See notes; probably not confined to caves.
,, *maculata*	,,	Probably not confined to caves.
,, *decipiens* (Verh.)	,,	
,, sp.	Batu Caves	
Arachnida.		
Scorpiones.		
Chaerilus, sp. nov.	Dark Cave	

Pedipalpi.			
Hypoctonus wood-masoni (Oates) ..	Farm Caves	}	Not confined to caves.
,, ? *formosus*, Oates ..	,,		
Schizomus (*s. str.*) *cavernicola*, Gravely ..	,,	..	Only known from these caves.
Stygophyrynus cavernicola (Thor.) ..	Tenasserim	..	Probably confined to the caves near Moulmein (see notes).
Stygophyrynus cerberus, Simon.	Jalor	..	Probably confined to the Jalor caves; closely related to last species.
Catagius pusillus, Thor.	Tenasserim	..	Only known from caves in the neighbourhood of Moulmein.
Araneae.			
Talanistes cavernicola, Thor.	Farm Caves		
Althepus pictus, Thor.	,,	}	Probably not true cavernicolous species.
Pholcus diopsis, Simon	Jalor		
Acari.			
Uropoda, sp.	Farm Caves		
CRUSTACEA.			
Isopoda.			
Armadillo infuscatus, Budde-Lund. ..	Jalor	..	Only known from a cave.
,, *intermixtus*	Batu Caves	..	Recorded by Ridley. We have not been able to discover the author of the species.[1]

[1] Mr. Collinge informs us that that no description of this species appears to have been published. He also tells us that an Isopod collected by Gravely from among pieces of decaying wood in the depths of the large Farm Cave is blind.

MAMMALIA.

Literature.

1876. Dobson, *Catalogue of the Chiroptera in the British Museum.*
1889 Thomas and Doria, *Ann. Mus. Civ. Genova* (2) VII, p. 92.
1888-1891. Blanford, *Fauna of British India, Mammalia.*
1900. Bonhote, *Proc. Zool. Soc. London*, 1400, p. 869.
1903. Bonhote, Report on the Mammals, *Fasciculi Malayenses* (Zool.) 1, p. 1.

The species recorded in our list are named for the most part on the authority of Dobson, who described one of the bats; of Oldfield Thomas and Doria, who worked out the collection of mammals made by Fea in Burma, or of Bonhote, who reported on those obtained by the Skeat Expedition and by Annandale and Robinson in the Malay Peninsula. *Rhizomys sumatrensis* is included on the evidence of a sub-fossil skull recently sent for identification, with the teeth of a large tiger, to the Geological Survey of India.

None of the mammals are cavernicolous in the sense of living in caves without ever abandoning them. The bats, of which only a small proportion of the cave-haunting species of Burma and Malaya have probably been recorded as yet from caves, merely use them as places of diurnal retreat, as is probably also the case with the porcupine; and although some species probably use caves for this purpose always, others are equally content with an overhanging rock or a hollow tree. Sometimes one species of bat appears to haunt a cave to the exclusion of all others; sometimes several or many species occur together.

The tiger and the Malayan Serow belong to a different category in that they only visit the caves occasionally, using them as places of shelter but probably never as permanent abodes. *Nemorhaedus swettenhami* also makes another use, in the neighbourhood of Jalor, of certain caves of which the roof has collapsed, frequenting them habitually for the purpose of dropping its dung. Apparently one such cavern or amphitheatre is set aside for the purpose in each of the little limestone hills of the district. A similar habit has been observed in other antelopes.

Animals such as *Mus surifer* belong to a third category, for it is probable that certain individuals of the species take up a permanent abode in caves, in which they find the greater part or the whole of their food. Most individuals of the species are, however, not cavernicolous.

None of the cave-haunting mammals of Burma or Malaya, to what ver category they belong, appear to be modified structurally in accordance with this habit. Most of the species

have a fairly wide distribution outside caves, but *Eonycteris spelaea* has only been taken in the Farm Caves, and in any case it is impossible at present to be sure of the range of any of the smaller Burmo-Malayan mammals, owing to the intensive study of the Oriental species now in progress in European and American museums.

BIRDS.

Literature.

1895. Blanford, *Fauna of British India, Birds* III.
1901. Bonhote, *Proc. Zool. Soc. London*, p. 68.

It is probable that many species of birds occasionally nest in the mouths of caves, but only one species can be asserted definitely to breed in the interior of the limestone caves of Malaya or Burma, namely *Collocalia innominata*, Hume, specimens of which were taken by members of the Skeat Expedition off the islands of the Talé Sap from which edible nests are collected for commercial purposes. Possibly it is the nests of this species also that are collected in the caves of limestone islands off the northern part of the west coast of the Malay Peninsula, but Blanford stated in 1895 (*op. cit.*, p. 178) that the edible birds' nests of commerce were obtained only, so far as was then known, from *C. francica* (Gmel.), which is found in Tenasserim, the Andaman and the Nicobar Is., as well as in the Malay Archipelago on the one hand and Arrakan on the other. *C. innominata* is known from the Andamans and from Tenasserim as well as the Malay Peninsula.

REPTILES and BATRACHIA.

Literature.

1898. Ridley, *Rep. Brit. Ass.*, p. 572.
1903. Boulenger, "Report on the Reptiles." *Fasciculi Malayenses* (Zool.) I, p. 133.
1903, 1904. Butler, *Jour. Bombay Nat. Hist. Soc.* XV, pp. 193 387.
1912. Boulenger, *Fauna of the Malay Peninsula, Reptiles and Batrachia.*

No blind or colourless reptile or batrachian is known from the caves of Burma and Malaya, and no species of either group appears to be confined to them. The snake *Coluber taeniurus* (plate XXII), however, provides interesting evidence as to the effects of the cave-dwelling habit on the colouration of the individual.

Pale individuals (fig. B) were first discovered in the Batu Caves and were accepted as the types of a new variety (*ridleyi*, Boulenge), no normally coloured examples of the species then being known from the Malay Peninsula. The same phase was found later in the Jalor Caves, and dark individuals of the

typical form have been discovered sparingly in different parts of the Malay Peninsula, in which the species (except in caves) is apparently much scarcer than it is in other parts of its range. This is wide, extending from Malaya into Burma and the neighbouring countries, the Eastern Himalayas and Northern China. No very young individual has yet been found in caves, but the smallest yet obtained in them—it was captured by Annandale in 1899 near Kuala Lumpur—approached the typical form in colouration much more closely than did larger examples from the same cave. The snake is naturally retiring in habits; several specimens were dug up in the course of road-making in the Abor country during the recent expedition. The cave-phase, owing chiefly to the loss of brown and reddish pigment, has the anterior part of the body (except for a black line through the eye) nearly white, while the posterior part bears conspicuous black longitudinal stripes on an almost white ground. Ridley has pointed out that, lying as the snake commonly does on narrow ledges in the white walls of caves, this type of colouration aids in concealing it by torchlight; but torchlight is not a natural feature of the caves.

It may be stated with some confidence that *Coluber taeniurus* is not, as a species, cavernicolous, but usually leads a more or less nocturnal life in the open, hiding by day in holes, under logs and in other such positions. Certain individuals, however, enter the caves; these find a plentiful food-supply in the bats and so grow to their full size without emerging. This mode of life has a peculiar effect on their pigmentation, apparently destroying brown and reddish pigments without affecting black to the same extent; some black markings, however, disappear, as is clearly shown in the figures of the two phases (pl. XXII).

The lizard *Gymnodactylus pulchellus* is a species occasionally found on tree-trunks in the jungle far from caves. It also is nocturnal in habits and, curiously enough, is also striped with black and white, but transversely instead of longitudinally. No difference exists in this (or in any other) respect between cavernicolous and arboreal individuals. Many individuals have adopted a cavernicolous life and the species has been found in caves in widely separated parts of the Malay Peninsula. Although the species is reported to occur in Tenasserim, it has not yet been found in any Burmese cave.

The other lizard on our list (*Lygosoma scotophilum*), although it was originally captured in the inner parts of one of the Batu Caves, has no striking peculiarity of colouration and has since been taken in the jungle.

A third species of this suborder might perhaps be added to the list, namely *Gonotodes affinis* (Stoliczka), specimens of which have recently been collected in the Batu Caves. As a rule it haunts either rocks at the edge of streams or else tree-

trunks in which, owing to the coalesence of the buttresses characteristic of some jungle trees, pools of water accumulate. It is sometimes almost amphibious in habits.

The Batrachia recorded from the Batu Caves are nocturnal species that also occur in the jungle and have no particular spelaeological interest.

MOLLUSCA.

Literature.

1871. Stoliczka, *Journ. As. Soc. Bengal*, XL (2), pp. 143, 217.
1902. Collinge, *Journ. Malac.* IX, p. 71.
1903. Sykes, *Proc. Zool. Soc. London*, vol. I, p. 194.
1908. Blanford and Godwin-Austen, *Faun. Brit. Ind., Mollusca*, I.
1910. Preston, *Rec. Ind. Mus.*, V, p. 33.

In addition to the species of Mollusca included in our list there are others that have been found occasionally in caves; for some land-snails occurring only on the limestone cliffs of the Siamese Malay States and Tenasserim, and also others of less restricted range (*e.g.* several species of *Rhiostoma* and *Cyclophorus*), occasionally make their way into caverns, while floods not infrequently wash in the shells of water-snails such as *Ampullaria* and *Vivipara*. Some of the terrestrial species described by Stoliczka from the cliffs at the Farm Caves and at Dhammathat might possibly find a place among cavernicolous forms with equal justice to *Streptaxis sankeyi*, Bsn., and *Prosopeas tchehelense*, de Morg., both of which have been found in the open. We have, however, attempted to restrict the list so far as possible to species which, to our knowledge, are either strictly cavernicolous or else habitually enter caves for purposes of protection or to seek food. The *Streptaxis* is so common in the Farm Caves that we see no reason to think that it does not do so, while the *Prosopeas* occurs not infrequently in enormous numbers in the darkest part of the Jalor and Selangor Caves, apparently feeding on bats' dung. *Opeas innocens*, Preston, is only known from the Farm Caves, in which, however, only dead shells were found.

The case of *P. tchehelense* is interesting, for the shell would appear at first sight to be specially modified for a cavernicolous life. It was originally described as being "*fusca*", but in specimens from at any rate one of the Jalor caves both the shell and the body of the animal are as a rule totally devoid of pigment. The eye, however, is not only pigmented but, as is shown by sections, perfectly normal in structure. The species has a wide range in the Malay Peninsula. Large swarms are often found under overhanging cliffs as well as in caves.

The other molluscs, the names of which are given in the

list, are minute colourless species found as yet only on the floor of caves. They are probably cavernicolous in a strict sense, but nothing is known of their habits or anatomy.

INSECTS.

Literature.

Collembola.

1912. Imms, *Proc. Zool. Soc. London*, p. 80.

Orthoptera.

1888. Brunner von Wattenwyl, *Verh. K. K. Zool. Bot. Gesells. Wien.* XXXVIII, p. 229.
1893. Brunner von Wattenwyl, *Ann Civ. Mus. Genova* (2) XIII (XXXIII), p. 193.
1897. Bolivar, *Ann. Civ. Mus. Genova* (2) XVIII (XXXVIII), p. 32.
1900. Annandale, *Ent. Record*, XII, p. 75.
1908. Kirby, *Rec. Ind. Mus.*, II, p. 43.

Hymenoptera.

1913. Wheeler, *Rec. Ind. Mus.* VIII, p. 233.

Lepidoptera.

1903. Swinhoe, "Report on the Moths", *Fascic. Malay. Zool.*, I, p. 99.
1909. Meyrick, *Rec. Ind. Mus.*, II, p. 399.

Diptera.

1903. Speiser, "Report on the Diptera Pupipara". *Fascic. Malay.* (Zool.) sp.
1912. Brunnetti, *Faun. Brit. Ind.*, *Dipt. Nemocera.*

A noteworthy feature of our list of the insects of the Burmese and Malayan caves is the total absence of the names of beetles. Many species of the order must actually occur, but although both Ridley in Selangor and Gravely in Tenasserim obtained specimens that can be assigned to well-known families, it has not been possible to arrange for their precise identification. This is also the case with the few Rhynchota that have been collected.

Of the two Collembola (*Neanura pudibunda* and *Cyphoderus simulans*) described by Imms from the Farm Caves, one (the *Cyphoderus*) is regarded by him as strictly cavernicolous, apparently because it is colourless and blind; but other species of the genus precisely similar in these respects are found in

ants' or termites' nests and even under stones at the edge of water (see Carpenter, *Journ. As. Soc. Bengal*, 1913, p. 215). *Neanura pudibunda* is of a bright red colour and possesses eyes. The two species occur together.

Among the Orthoptera of the caves the most interesting are the wingless grasshoppers of the subfamily Stenopelmatinae, of which three species have been recorded from them, one from the Farm Caves (*Diestrammena unicolor*, Brunner), one from those of Jalor (*D. annandalei*, Kirby), and one from the Batu Caves (*Diestrammena*, sp.). A fourth was discovered by Gravely in the Farm Caves, but its specific identification is a little doubtful. It belongs to the genus *Rhaphidophora* and is identical with one (probably *R. brunneri*, Kirby) that occurs in the jungles of the same district. Unlike the species of *Diestrammena*, which live as a rule on the cave-walls and on rocks rising from the ground, it inhabits burrows in the soil of the floor. The species of *Diestrammena* may be considered separately, as although not always cavernicolous they are very characteristic of the fauna of caves.

D. unicolor is reported to occur in northern China (Vladivostok and Pekin) as well in the Farm Caves, but in Tenasserim has only been taken in them and in those at Dhammathat in the same district. In the caves it is extremely abundant. It exhibits considerable individual variation in colour, and the young, instead of being almost unicolourous, are distinctly mottled. When disturbed it is extremely active; it seems to be more sensitive to the smell (? or heat) of a torch than to the light of an acetylene lamp. The antennæ are much longer than those of the *Rhaphidophora* and appear, to judge from the basal part, to be (like those of many other Locustidae) asymmetrical. In none of our specimens are both antennae complete, but in those from the Farm Caves the basal joint of the right antenna is usually larger than that of the left, while the converse is usually the case in those we have examined from Dhammathat.

D. annandalei has only been taken in the Jalor Caves, in all of which it is extremely abundant, both on the walls and on the floor. It apparently feeds on bats' dung and is itself the prey of the large scorpion-spider *Stygophrynus cerberus*. The antennæ appear to have slightly different functions, the longer one being held out straight in front of the body when the animal is at rest, while the shorter one moves round nearly in a circle. Doubtless this enables the insect to appreciate the approach of an enemy, living as it does in the dark.

The species of *Diestrammena* that occurs in the Selangor caves has not been identified, and may be the same as one of the preceding two. Ridley, however, states that it utters at times a feeble chirp, whereas the species from Tenasserim and Jalor have not been observed to do so.

Most of the other Orthoptera in the list (including the

earwig *Chelisoches morio*) are nocturnal species which probably leave the caves at night. The cockroach *Spelæoblatta gestroi* may, however, be strictly cavernicolous. It was found by Fea in a cave in the Karen country; but nothing definite seems to be known about its habits.

Ants are not uncommon in some of the caves, but the only species as yet identified is one from the large Farm Cave, in which it is abundant. Professor Wheeler has been kind enough to examine specimens, which he assigns to an undescribed variety of *Ponera confinis*, Roger. There is nothing to prove that they are modified in correlation with a cavernicolous life; indeed, they are darker than the typical form of the species.

The three species of moths found in the caves belong to two genera both of which are represented by many non-cavernicolous species. Meyrick, who described the Microlepidopteron *Crypsithyris spelæa* from the Farm Caves, believes it to be especially modified in that it is colourless except for its eyes, which are, however, well pigmented. A similar moth occurs in the Jalor caves but has not been identified. The two species of the genus *Pyralis* that have been obtained in the caves are both well pigmented moths of rather conspicuous colouration, and have been taken in districts in which no limestone caves exist; yet it is probable that both breed in such caves when an opportunity occurs. *P. fumipennis* was found in large numbers on the walls of one of the largest of the Jalor caves at some distance from the entrance; on the floor of the same cave, amidst bats' dung, still larger numbers of little caterpillars were observed, each inhabiting and dragging with it a small bean-shaped case made partly of the remains of insects. There can be little doubt that these caterpillars were the larvae of the moth. Of *P. pictalis* a single specimen was taken in one of the Farm Caves. It was resting on the wall in the dark. Larvae similar to those taken in Jalor were also observed on the floor.

Of the four species of Diptera recorded from the caves three (*Nicteribosca amboinensis*, *Raymondia pagodarum* and *Ascodipteron siamense*) are bat-parasites and as such of no particular interest from a spelæological point of view. The fourth (*Sciara pallescens*, Brunetti) is a small fungus midge which is at any rate considerably paler than the majority of its congeners. Indeed, Brunetti is of the opinion that it is possibly no more than a pale phase of *S. fulvescens*, a form taken in the open in Bengal. Each nominal species is at present known from a single specimen. The type of *S. pallescens* was taken in the darkest part of the largest of the Farm Caves. Ridley records a small Chironomid midge as being abundant in one of the Batu Caves, but it has not been identified or described.

The insects actually identified and recorded from the caves probably represent only a small proportion of those that occur.

MYRIAPODA.

Literature.

1890, 1891, 1893. Pocock, *Ann. Civ. Mus. Genova* (2) X (XXX), pp. 384. 401, XIII (XXXIII), p. 390.
1898. Ridley, *Rep. Brit. As.*, p. 580.
1901. Sinclair, *Proc. Zool. Soc. London*, p. 517.

Millepedes are often common in the caves, which, in Jalor at any rate, are a favourite resort of large Polydesmidæ (such as *Platyrachis malaccanus*) by no means exclusively cavernicolous. It is probable, however, that some Oriental Myriapoda actually are so. This is possibly the case with *Cambalomorpha feae*,[1] a small whitish Julid very abundant in the Farm Caves, in which it has been obtained by ourselves as well as by others. The Polydesmid *Deratonotus cavernicola*, which is of a pale brown colour, may also be strictly cavernicolous, but this is more doubtful.

A particular interest attaches itself to the *Scutigerae*, which are often found in caves as well as under stones and logs in the open, for very little is yet known of the Oriental representatives of the family. Probably no species of this family on our list is strictly confined to caves, and all are strongly pigmented.

A peculiar habit, possibly correlated with life in the dark, was noted by Gravely in the large Farm Cave in the case of a *Scutigera* which Professor Silvestri has identified as *S. decipiens* (Verh.). Representatives of this species were not very numerous and, being extremely sensitive, were difficult to catch. Several were seen both on the walls of the cave and among the large stones on the floor. An individual seen on an overhanging ridge near the floor was hauled out in a net, on the outside of which it left one of its legs. A vigorous rhythmical contraction and expansion of the muscles of the severed leg took place, as a result of which a surprisingly loud creaking sound was emitted. It was produced by means of a stridulating organ, the structure of which was subsequently investigated. Near the base of the ventral side of the femur there is a minute transverse slit, the distal margin of which bears a row of outwardly directed hooks. The sound must be produced by these, but further investigation is needed, with fresh material, to show the surface against which the hooks rub when the muscles of the leg contract and expand, and the

1 Specimens of this species often become brown in spirit, but in life the animal is very nearly white.

manner in which so minute an organ produces so loud a sound. Although similar organs can be detected on the legs that still remain attached, it was not found possible to induce the animal to stridulate in such a way as to produce an audible sound. It must, therefore, be supposed that the sound is only produced by detached legs—they are very easily detached—and that as they leap about squeaking they distract an enemy's attention from their owner, which slips away silently in the dark. Ridley has noticed that another species of *Scutigera* (*S. maculata*) that occurs in the Batu Caves appears to be quite harmless and does not attempt to bite when captured. It apparently feeds on cockroaches and other insects.

We have to thank Professor Silvestri and Mr. A. S. Hirst for naming several of the Myriapoda mentioned in our list.

ARACHNIDA.

Literature

1889. Thorell, *Ann. Civ. Mus. Genova* (2) VII (XXVII).
1889 (1890). Oates, *Journ As. Soc. Bengal* LVIII, p. 4.
1898. Ridley, *Rep. Brit. As.*, p. 580.
1898. Thorell, *Ann. Civ. Mus. Genova* (2) XIX (XXXIX), p. 279.
1900. Pocock, *Faun. Brit. Ind.*, *Arachnida*.
1901. Simon, *Proc. Zool Soc. London*, p. 76.
1912. Gravely, *Rec. Ind. Mus.*, VII, p. 107.

Among the Arachnida of the caves the Pedipalpi, of which one of us has made a special study, are of particular interest. We propose therefore to deal with them family by family in considerable detail.

PEDIPALPI.

THELYPHONIDAE.

Hypoctonus wood-masoni (Oates).

Gravely obtained a number of specimens of this whip-scorpion under stones close to the rocks at Dhammathat, and several in the Buddha cave at the same place. He also obtained the species on the eastern slopes of the Dawna Hills, and beyond them at Myawadi on the Siamese frontier. It was originally described from Mount Mulai-yit, south of the Dawna Range, and has also been found at Mitan in the Haung-tha-raw Valley. It has thus a wide distribution outside the caves, probably the widest yet known for any member of its genus.

The few immature specimens of *Hypoctonus* which were found in and around the Farm Caves probably belong to this species rather than to the Moulmein form, *H. formosus*, Butler; for conditions at the Farm Caves resemble those at Dhammathat

more closely than those at Moulmein, and the Farm Caves do not appear to be separated from Dhammathat more completely than is Dhammathat from the next rocks in the direction of Mulai-yit or the Dawna Range.

?Hypoctonus formosus, Butler.

This species is said by Thorell to have been found by Fea in the Farm Caves (*Ann. Civ Mus. Genova* [2] VII [XXVII], p. 526), but he does not appear to have seen Oates' paper (*Journ. As. Soc. Bengal*, LVIII, 1889, pp. 4–19, pl. 11), in which the differences between *formosus* and other Burmese species had been described; nor does he appear to have noticed any such differences himself. Moreover, it is impossible to tell from his paper whether the specimens he saw from the Farm Caves were sufficiently mature to admit of specific identification.

SCHIZOMIDAE.

Schizomus (*s. str.*) *cavernicola*, Gravely.

This species was described (*Rec. Ind. Mus.*, VII, 1912, p. 107) from specimens collected in the large Farm Cave, where they were found on moist soil with the Collembola on which they probably feed. Their antenniform legs are unusually long, but their eyes, which take the form of a pair of pale spots, are in no way remarkable. This is somewhat surprising as many non-cavernicolous forms are without recognizable eyes, while a species from Prome, on the other hand, has real eyes with a convex vitreous cornea.

One or two immature specimens of this family were seen under stones in a sheltered crevice of the rocks outside, but none of them were captured and we cannot say whether they belong to this species or not.

TARANTULIDAE.

The majority of the scorpion-spiders found in the caves belong to the interesting genus *Stygophrynus*, of which only two species have as yet been described. Both these species are cavernicolous; they are *S. cavernicola*, Thorell and *S. cerberus*, Simon. The former occurs in the caves of northern Tenasserim, the latter in those of Jalor.

The differences between the two species, though constant, are so small that in the absence of a good series of specimens of at least one of them their distinctness might well have been doubted. Consequently it is by no means improbable that the specimens from Saigon (*Bull. Mus. Hist. Nat. Paris*, 1901, p. 265) identified by Kraepelin as *S. cavernicola* before *S. cerberus* was known, will prove to belong either to the latter or to

a distinct species; for Saigon must be quite as completely separated from Khayon as Jalor is. Flower records the occurrence of "an animal allied to Phipson's Tarantula. ..far into the caves" at Batu near Selangor (*Journ. Straits As. Soc.* July 1901, p. 40); doubtless this is also a *Stygophrynus*. Mr. Moulton has sent for examination a specimen of Tarantulidae from Klingkang, a limestone mountain range in Borneo. The great length of the femora of its antenniform legs suggests that it inhabits caves like *Stygophrynus*. It differs, however, considerably in the structure of the hand from the two known species of *Stygophrynus*, and may have to be made the type of a new genus There are also specimens of an undescribed species of *Stygophrynus* from Mentawei and Java in the Hamburg Natural History Museum.

Stygophrynus cavernicola, Thorell.

Thorell described this species from specimens obtained by Fea in the Farm Caves (*Ann. Civ. Mus. Genova* (2) VII. (XXVII) 1889). It has since been obtained at the same place both by Annandale and by Gravely, while the latter found a few specimens also in dark corners of the small and well-lighted Buddha Cave at Dhammathat, but none in the long dark Guano Cave at the same place.

It lives chiefly on the walls of the darkest recesses and crevices of the caves, where it sits in the usual position adopted by members of its family when at rest, *i.e.* the body and walking legs lie flat against the support, the femora of the antenniform legs are folded over the back and directed inwards, while the distal parts of these legs are curled round above the walking legs. The femora of the arms ("pedipalps") are directed a little backwards and upwards, not directly outwards as in the genus *Phrynichus*.

This scorpion-spider, like *Phrynichus*, seems to regard its extreme flatness as its best protection against ordinary enemies, and on the approach of a collector with a light it only clings the closer to its rock. As soon as any part of it is touched, however, it darts away forwards, backwards or sideways, with such rapidity that its course is often hard to follow, and then crouches in some fresh place When once disturbed to this extent it becomes more suspicious, and usually keeps its antenniform legs extended for a time. In these respects it so closely resembles species of the nocturnal but non-cavernicolous genus *Phrynichus* that it seems unlikely that the eyes of the two genera differ greatly if at all in the extent to which they are functional, though the exceptional length of the antenniform legs in *Stygophrynus* has presumably been developed to meet a need for increased sensibility to touch This may be due to the fact that their cavernicolous life practically limits their food

supply to insects of the sub-family Stenopelmatinae, which have enormously long and very sensitive antennae.

No ovigerous specimens of *S. cavernicola* appear to have been found, although Gravely made a special search for them and obtained a number of specimens which appear to be mature.[1] Probably the species breeds during the rains, as do *Charinides bengalensis* in Calcutta and the species of *Phrynichus* indigenous in Ceylon.

Stygophrynus cerberus, Simon.

Simon described this species from specimens obtained in caves in the neighbourhood of Biserat in the Siamese State of Jalor (*Proc. Zool. Soc.*, 1901, p. 76).

It is much more abundant than the Moulmein species, and is larger, darker in colour, and more heavily built. It is known to breed in May and June, the female carrying her eggs in a sac covering the lower surface of the abdomen as in other species of Tarantulidae. It resembles the Tenasserim species in its habits; both sexes sit on the walls of the caves in total darkness, with the femora of the antenniform legs crossed over their backs; they feed on the Locustid *Diestrammena annandalei*, which they catch with their arms, in spite of the fact that the insect is very active and is constantly feeling for the approach of enemies with its enormously long antennae.

Sections of the eyes have shown them to be pigmented and apparently well developed, but it is uncertain whether they are sensitive to light or not.

Catagius pusillus, Thorell.

Fea obtained the type of this species in the Farm Caves (*Ann. Civ. Mus. Genova* [2a] VII [XXVII] 1889, p. 531). Gravely has since obtained other specimens from the same place and from the Buddha Cave at Dhammathat. They live under stones, especially in the large Farm Cave, at the end furthest from the entrance; one or two immature specimens were found under stones in a crevice on the outside of the rocks. No ovigerous specimens have as yet been seen.

The antenniform legs are unusually variable in length; as a rule their femora are about twice as long as the carapace is broad, as in non-cavernicolous species; but in one or two specimens they are about three times as long as the carapace is broad, *i.e.* very nearly as long, in proportion to the size of the body, as in *Stygophrynus cavernicola*.

In addition to the Pedipalpi, a species of scorpion of the genus *Chaerilus* (stated to be new but not described) is recorded by Ridley from the Batu Caves; while three kinds of appar-

[1] At least one of them contains ova, apparently ready for extrusion.

ently cavernicolous spiders are known from different localities in Burma and the Siamese Malay States.

One of the spiders (*Talanites cavernicola*, Thorell) belongs to the family Drassidae. Thorell described this species from a single mutilated specimen obtained by Fea in the Farm Caves, and we believe it to be the one common on the floor of the large Farm Cave and of the Guano Cave at Dhammathat.

The other two spiders are Pholcids and spin webs among rocks in the caves, but it is very doubtful whether either of them is strictly cavernicolous; indeed, one of the two, which lives on the walls in the Farm Caves, is also found in the Karen Cheba Hills; this is *Althepus pictus*, Thorell. The other species (*Pholcus diopsis*, Simon) is only known from the caves of Jalor.

Several mites were found on the bat *Rhinopoma microphyllum* from the Guano Cave in Dhammathat, one of which has been referred by Warburton to the genus *Uropoda*.

CRUSTACEA.

Literature.

1898. Ridley, *Rep. Brit. As*, p. 581.
1902. Budde-Lund in Lanchester, *Proc. Zool. Soc.*, p. 379.

The only Crustacea recorded from the caves are two wood-lice, one described from Jalor and one recorded from the Batu Caves near Selangor. It is noteworthy that although the former (*Armadillo infuscatus*, Budde-Lund) is paler in colour than some species of its genus, it is no paler than one (*A. pallidus*) found in the jungle in the same district A blind wood-louse lives in the large Farm Cave (see above, p. 407, footnote 1)

SOME CONSIDERATIONS ON THE FAUNA.

It will be clear from the foregoing notes that no animal that has reached the heights of specialization in relation to a cavernicolous existence, has as yet been recorded from any of the limestone caves of Burma and the Malay Peninsula. Many blind or pur blind species are included in their fauna, and several that are provided with enormously developed organs of touch; but in both cases the species belong to genera or larger groups in which similar peculiarities are well, if not so well, developed in non-cavernicolous species. The very long antennae of *Diestrammena unicolor* or the equally long antenniform legs of *Stygophrynus cavernicola* are not peculiar to species that live in caves but are characteristic features of the groups to which they belong. An animal that lives in holes in the ground, or under stones or logs, from which it does not emerge by daylight, lives almost as much in the dark, and has almost as great a need for well-developed "feelers," as one that occupies the darkest recesses of a cave. It is in relation to a

furtive existence in the open that the sensory peculiarities of the Tarantulidae and the Stenopelmatinae have probably originated.

Nevertheless, a cavernicolous life is not in all respects identical with one spent in a small enclosed space, be it ever so dark. In a large cave conditions remain extremely equable throughout the seasons, there is room for active growth and movement, and those inhabitants of the cave which only frequent it by day (especially the bats) bring in with them from outside an abundant food-supply for animals that can flourish on the parts of their food indigestible to themselves. Thus the cavernicolous Orthoptera and Lepidoptera probably live, at one stage or another, largely on the remains of insects in the bats' droppings. These conditions encourage rapid multiplication on the part of the coprophils, and thus indirectly provide nourishment for actively predaceous animals such as *Stygophrynus*. It becomes the more necessary in the one case for the predator to possess organs of perception, in order that it may detect the presence of vigilant prey; in the other for the prey to possess similar organs whereby it may be warned of the approach of its enemy. Accordingly we find that in *Stygophrynus* and the cavernicolous species of *Diestrammena*, the striking peculiarities in the sensory organs possessed by their non-cavernicolous allies are exaggerated; for the antenniform legs of the Arachnid and the antennae of the insect are even longer and more delicate than is usually the case in their respective families.

The Pedipalp *Catagius pusillus* is of great interest from this point of view. Although adults have been found only inside the Farm Caves and the caves at Dhammathat, immature specimens have been taken under stones outside the former. The antenniform legs, moreover, although in some individuals nearly as long in proportion as those of *Stygophrynus cavernicola*, are as a rule much shorter, exhibiting a much greater variability in this respect than those of other species of the family. Unfortunately sufficient specimens have not been obtained to render a study of the exact nature of the variability possible.

As a general rule, among the groups represented in the Burmo-Malayan cave-fauna, colouration is more readily affected than structure by peculiar circumstances, and it is not surprising to find that this fauna includes a large proportion of unusually pale species or phases. In some cases (*e.g.* those of the moth *Crypsithyris spelaea* and the myriapod *Cambalamorpha feae*) it is probable that feebleness of pigmentation has become a specific character; while in others, especially in the cave-phase of the snake *Coluber taeniurus* and possibly in some strains of the mollusc *Prosopeas tchchelense*, paleness appears to be due to the direct effect on the individual of a

cavernicolous life. The question whether we are dealing here with two entirely different sets of phenomena, or merely with cases in some of which an individual peculiarity has become hereditary, can hardly be discussed without a consideration of the possibility of the inheritance of acquired characters. And sufficient evidence is not forthcoming.

In any case, there can be no danger in asserting that no species found in the caves of Burma and the Malay Peninsula is so highly specialized in correlation with this mode of life as are certain species found in the caves of Europe and North America. As a general rule the fauna of any given environment in a tropical country with an abundant rainfall is much richer in highly specialized forms than is that of a temperate climate. Why should the cave-fauna be an apparent exception to this rule? To answer this question it is necessary first to consider another, to wit, What cavernicolous forms are most highly specialized in the palaearctic zone? Many of them are aquatic species, *e.g.*, the Austrian salamander *Proteus* and the blind prawn of Kentucky, *Palaemonetes eigenmanni*. In these instances specialization mainly affects two features, colouration and the optic organs: the latter become degenerate or disappear, together with external pigmentation. It is improbable that any permanently aquatic animal occurs in any cave as yet investigated in Burma or Malaya. Other highly specialized (blind and colourless) cavernicolous animals are minute and inconspicuous and would only be found by more careful search than any that has yet been conducted in the caves of the Oriental Region.

In the great caves of Kentucky and Carniola, moreover, there are vast chambers separated by miles of total darkness from the light of day; these chambers and the passages that lead to and from them contain streams and lakes on which daylight never falls; whereas in the caves of Burma and Malaya there are no isolated waters, and long reaches of total darkness are of the greatest possible rarity; the holes produced by dripping water in the roofs of many of the largest caverns not only admit light but also provide a ready means of communication between the animals that have taken up their abode in the caves and their relatives that have continued to live a nocturnal and secretive life in the jungle on the surface of the hills. Opportunities for isolation are, therefore, of rare occurrence, and although isolation and specialization are not necessarily correlated, the former has undoubtedly played a very important part in the production of the peculiarities of faunas such as that of the Mammoth Cave.

Another interesting problem connected with the cave-fauna of the countries we are considering is that involved in the similarity of many of the species that occur in widely separated localities, but not, apparently, at any intermediate

point. Any statement as to this phenomenon must be qualified with an "apparently", for the invertebrates, which alone are concerned, of Burma and Malaya are still imperfectly known. But granted that it does occur even in a few instances, how has it come about? Why should *Stygophrynus cavernicola* be found only in the Farm Caves, at Dhammathat several miles away, and possibly in French Indo-China, many hundreds of miles away? Why should it be represented in the Jalor caves by another form hardly more than racially distinct? Are we to imagine that free intercourse took place between all these places at some previous geological epoch; or does it still take place, or has it been but recently interrupted, underground; or are we dealing not with real cases of specific identity but with instances of convergence? At present it is not possible to give a satisfactory answer to these questions.

APPENDIX.

1. *Note on clay tablets from a cave in Kedah.* (Plate XVIII).

The inscriptions on the fragments of the clay tablet are not sufficiently distinct to be read fully and their subject to be ascertained certainly. From the letters which form a word and render sense, and are identifiable without doubt, my idea is that they contain something more than the usual Buddhist creed, the "YE DHARMĀ," etc.

As regards the age of the inscription, its script pushes it down the later part of the 7th century A.D. The letters which I have identified without doubt are eight in the large fragment and eight in the small one. The eight letters: MĀ, HĀ, VO, DHI, forming the word "MAHĀVODHI"; the initial in fourth line; and TA, THĀ, GA, TO, forming the word "TATHĀGATO" placed towards the end of the tenth line of the large fragment, resemble MA, HA, VA, DHA, TA, THA, GA, in table IV, column XVIII, XIX of G. Buhler's "Grundriss der Indo Arischen Philologie und Altertumskunde." And this is also the case with the other eight. In the small fragment the four distinct letters DHA, MA, HA, TA, forming word "DHA (R) MA H (E) T (U)" in the beginning of the first line and TA, THĀ, GA, TO, forming the word "TATHĀGATO," in the fourth line appearing after the first letter, are similar to those of the large fragment. Dr. Buhler's letters in table IV and under columns XVIII and XIX are, according to his own statement, of 675 A.D., and belong to the alphabet of that period which is called the Kuṭila variety of the Magadha alphabet of the 7th century A.D. Consulting the facsimiles of the inscriptions of that period, I find that the letters I identified in the tablets are allied to those in the

inscriptions of Ādityasena and Jīvita Gupta II published by Dr. Fleet in his Corpus, Vol. III. The letters TA, THA, VA, GA, DHA, HA agree with those in Ādityasena's Aphsaḍ stone and Shapur image inscriptions; while the 'MA' agrees with that in Jīvita Gupta's Deo-Baranārk stone.

The rest of the characters, which I did not gather from the tablets as I could not make any sense of them, appear akin to the same inscription. For instance it may be noted that "YA", the first letter in the second line, "LA", the third letter counting from the right side in the sixth line of the large fragment, and VI, PU, LA, the three letters occurring after two letters in the second line of the small fragment, conform to those characters in the said inscription. Moreover the mode of affixing vowels to the consonants agrees throughout with that of the said inscriptions.

B. B. BIDYABINOD.

2. *Note on clay tablets from caves near Moulmein.*[1]

(Plate XX).

This representation of Gotama seems to be peculiar to the Burmese, the Shans and the Siamese. It is called in Burma a "Zabupade"; it always represents the Buddha in full regal dress; the head-dress is often, as in these tablets, a three-tiered crown surmounted by a pointed ornament; on both sides, attached to the crown, are appendages or wings; from the large holes in the lobes of the ears depend two ear ornaments the ends of which touch the shoulders, both arms have large armlets; the dress appears to be richly embroidered, with side ornaments at the shoulders.

It is called Zabupade (Pali: Jambupati) because, it is said, there was once in India a king, Jambupati by name, exceedingly proud and fond of rich dress; the Buddha, to curb his pride and vanity, assumed miraculously a regal dress in comparison with which the king's was simplicity itself, and preached to him a sermon on the vanity of the things of this world. It is to commemorate this event that the Buddha is thus represented.

From the general appearance of the figures, the tablets seem to be of Shan or Siamese origin. There have always been many Shans in this part of Burma, and wars between the Burmese and Siamese have been frequent; this would explain the presence of Shan or Siamese images in the Talaing country.

These tablets appear to be not earlier than the 18th century A.D.

C. DUROISELLE.

1 The specimen figured, which is now in the Indian Museum, is from the Buddha Cave at Dhammathat and not, as stated on the plate, from the Farm Caves. The specimen found in the Farm Caves bore the same design, but was broken in two and was more strongly weathered.