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THE NATURAL HISTORY SECRETARY.

"It will flourish, if naturalists, chemists, antiquaries, philologers, and men of science in different parts of *Asia*, will commit their observations to writing, and send them to the Asiatic Society at Calcutta. It will languish, if such communications shall be long intermitted; and it will die away, if they shall entirely cease." SIR WM. JONES.

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No. III.—Containing pp. 135—180, with Plates VII—XI, was issued on December 14th, 1880.

No. IV.—Containing pp. 181—250, with Plates II, III, VI and XIII, was issued on March 7th, 1881.

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II. } III. } Indian, Burmese and Andaman Mollusca.

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ERRATA AND ADDENDA.

p. 14. Bones of fishes from the Trias of Tibet referred to under the head "Cretaceous," should have been mentioned in the preceding paragraph.

p. 24. At the time of writing the notice of Siwalik Carnivoras I had not seen the paper by Mr. Bose on that subject,* and consequently was not aware that *Felis grandicristata* and *Canis cautleyi* are merely provisional species. It should also have been mentioned in treating of the genus *Ursus*, that there is in the collection of the Indian Museum, a canine-tooth from the Irawadi Siwaliks probably belonging to this genus.

p. 31. In treating of the Pleistocene Proboscidia it should have been mentioned that the first described teeth of *Mastodon pandionis* are said to have been obtained

ADDITIONAL ERRATA.

Page 182, line 27 from top, *for* Five *read* Two.
„ 186, „ 8 from top, „ "*angulata-lunaris*" *read* "*angulato-lunaris.*"
„ „ „ 2 from bottom, *omit* "it is figured here".
„ 190, „ 19 from top, *for* "*contingens*" *read* "*contingentibus*".
„ 191, lines 24 and 26 from top and in footnote, *for* "*Situla*" *read* "*Sitala*".
„ 192, bottom line, *for* "*ponsa*" *read* "*pansa*".
„ 216, line 4 from top, *for* "specimen" *read* "specimens".
„ 221, „ 4 from top, *for* "I have described the species" *read* "I have *never* described the species."

The mistakes on pp. 182 and 221 are important.

.... + 0·020194 R_1 = 0·275 R_1

Should read

Diff.

.... + 0·020194 R_1 = 0 275 R_1

* Q. J. G. S. Vol. XXXVI, p. 119.

JOURNAL

OF THE

ASIATIC SOCIETY OF BENGAL.

Part II.—PHYSICAL SCIENCE.

No. I.—1880.

I.—*On a Simple Method of using an insignificant Fraction of the Main Current produced by a Dynamo-Electric Machine for Telegraph Purposes.*—*By* Louis Schwendler, M. Inst. C. E. &c.

(Received 29th October; read November 5th, 1879.)

The currents which a dynamo-electric machine is able to generate through a small external resistance, are so enormously strong and also so constant and exceedingly cheap, that I have always thought it would be of technical as well as of economical importance to use them for signalling purposes. The difficulty only was how to solve the problem practically. Manifestly, the currents could not be produced through the telegraph lines, in the ordinary manner of applying dynamo-electric machines, for, in the first place, telegraph lines offer high resistance, and, in the second place, the use of *the closed-circuit system* would become imperative. However, some time ago a very simple method occurred to me which appears to contain the germs of practical success, and, having lately made some experiments on the subject, I do not hesitate to communicate the result.

Suppose we have a dynamo-electric machine, the two terminals of which are connected by a resistance r through which any kind of *useful work* is to be performed by the current.

For instance, during the night, r may consist of an electric arc, and the useful work done by the current is given out as *light* for the *signalling office;* or during the day-time r may consist of another dynamo-electric machine which acts as an ordinary electromagnetic engine, performing some useful mechanical work, *i. e.*, pulling the punkhas, lifting messages, producing a draught of cool air, &c.; or the current may be made to pass through a galvanoplastic apparatus in connection perhaps with the Surveyor General's Office, &c.

Now connecting the *negative pole** of such a dynamo-electric machine to earth, the positive pole to *all* the lines terminating in a telegraph office, while the two poles are permanently connected by the resistance *r* through which the current produces the useful work above-mentioned, then it will be clear, without demonstration, that *all* the lines so connected can be provided with signalling currents (which are exceedingly weak as compared with the strong main current) by simply *tapping* the main current, and that without perceptibly reducing it, *i. e.*, without affecting the *useful work* performed by the main current through *r*. Supposing that the useful work performed by the main current repays all the expenses connected with the erection and working of the dynamo-electric machine, then obviously this would be a method which would supply the signalling currents for nothing. This might be an inducement for telegraph-administrations to introduce the electric light, since they would get the signalling currents into the bargain, and the costly and cumbersome galvanic apparatus might be dispensed with.

An example will show this more clearly. A Siemens dynamo-electric machine of medium size can easily be made to produce through an electric arc a current of 30,000 milli-oerstedts, of which not more than 3 milli-oerstedts are required to work the Siemens's polarized relay with engineering safety. Suppose that the sent current is made equal to twice the current which is required to arrive, we have the following calculation for Calcutta office :—14 long lines terminate at Calcutta, hence 14 × 6 = 84 milli-oerstedts would (as a maximum) have to be tapped off from the main current of 30,000 milli-oerstedts. This represents a loss of only 0·28°/₀ ,—which is so small that not even the most sensitive eye would be able to detect any variation in the light.

Hence in this case we would feed the Telegraph lines with currents which actually cost nothing, as the electric light alone would repay all expenses.

During my recent light experiments in London, it was experimentally established that the current in milli-oerstedts which a dynamo-electric machine is able to produce, can be expressed as follows :—

$$C = E \left\{ \frac{1 - e^{-K\left(\frac{v}{r+m}\right)^2}}{r+m} \right\} \times 1000$$

* In India we use positive signalling currents.

E and K are two *constants* for any dynamo-electric machine. E is an electromotive force in volts; K is of such dimensions that $v \sqrt{K}$ represents an electrical resistance; *m* is the internal resistance of the dynamo-electric machine; *r* is the external resistance through which the useful work by the main current has to be performed.

m and *r* are to be expressed in ohms. The resistance of the leading wires has been supposed *nil.*

If we call R the resistance of a telegraph line, which we wish to feed from the main current, then the signalling current passing into that line when the main current is tapped would be

$$\frac{Cr}{R + r} = E \left\{ \frac{1 - e^{-K\left(\frac{v}{r + m}\right)^2}}{r + m} \right\} \times \frac{1000\, r}{R + r}$$

and this current, in the case of the Indian lines, should not be less than 6 milli-oerstedts. Hence we have the following equation:—

$$E \left\{ \frac{1 - e^{-K\left(\frac{v}{r + m}\right)^2}}{r + m} \right\} \times \frac{1000\, r}{R + r} = 6$$

from which *r* can be calculated, since E, K, *m*, *v* and R are known.

I need scarcely point out, that as R is invariably so large that *r* can be neglected in comparison with it; the current in *one* line only depends on the resistance of that line, and not on the resistance of the other lines in connection with the dynamo-electric machine. Hence the signalling through one line is not influenced by the signalling on other lines; and in this respect the method is on a par with signalling through different lines by separate batteries.

We will take a special case.—For a Siemens's medium machine, making $r = 3$, we have a main current of about 17,710 milli-oerstedts, and the current passing into a line of 8000 resistance (800 miles of $5\frac{1}{2}$ wire) would be 6·6 milli-oerstedts. Supposing that all the 14 lines at Calcutta office are to be supplied with 6·6 milli-oerstedts each, the current carried off would be $6{\cdot}6 \times 14 = 92{\cdot}4$ milli-oerstedts, or 0·5 °/₀ of the main current.

It is best to make all the lines equal in resistance by adding to the shorter lines some artificial resistance. This measure would prevent a dead earth (occurring on one of the lines and close to Calcutta) from having any effect on the working of the other lines. In Europe, where the lines are much shorter, the signalling currents supplied by a given dynamo-electric machine, working through a given resistance *r*, could be much greater than 6·6 milli-oerstedts.

For any given R (resistance of the line) the currents can be increased by selecting a dynamo-electric machine with the right internal resistance.

The advantages of the method appeared to me sufficiently great to justify a practical trial :—

Experiment, October 11, 1879. With a Siemens's dynamo-electric machine (medium size) I produced a powerful electric light; and between the poles of the dynamo-electric machine I connected up four artificial lines, each of 10,000 units resistance, with relays ranging between 500 to 1000 units. These four parallel circuits worked very well, singly and simultaneously. No variation of the electric light during telegraphing could be noticed, even when the line resistance was reduced to 1000 units. Further, the resistance of one line was increased to 20,000, and the signalling currents were still sufficiently strong (1·6 milli-oerstedts).

Experiment, October 14, 1879. Same as above; but a branch current was conveyed by the store-yard line (from the store-yard where the dynamo-electric machine with its electric light was put up) to Calcutta signalling-office (4 miles), and one of the Agra lines (850 miles in length) worked by this current.

The sent current, measured at Calcutta, was 9·6 milli-oerstedts; the received current, measured at Agra, 1·85. The great loss was due to the exceedingly low insulation of the line near Calcutta. It is now the breaking up of the monsoons, when the climate in lower Bengal represents almost a hot vapour bath.

Several messages were sent to Agra, but no variation in the electric light could be observed.

II.—*On the Occurrence of the Musk-Deer in Tibet.*

By R. LYDEKKER, B. A.

(Received November 17th, 1879.)

Some degree of doubt seems, hitherto, to have prevailed among naturalists whether the Musk-Deer *(Moschus)* occurs on the Tibetan plateau, or whether it is confined to the wooded districts of the Alpine Himalaya. Thus in a paper contributed by Mr. W. T. Blanford to the 'Proceedings of the Zoological Society of London,'* the author says that he has grave doubts whether the Musk-Deer occurs anywhere on the Tibetan plateau. In a paper published by myself in the Society's Journal,† I mentioned that, from having seen skins in Ladák, as well as from the fact of the Ladákis

* 1867, p. 634. † 1877, Pt. II, pp. 287-8.

having a name for the animal, I was of opinion that the Musk-Deer must occur somewhere in Tibet, though I had at that time no positive proofs to offer. Lately, however, I have obtained such evidence as seems to leave no doubt that this animal should be reckoned among the fauna of Tibet.

Firstly, it will, I think, be generally admitted that the musk-pods of the Musk-Deer are an important article of export from Tibet to India.* Although this affords *primâ facie* evidence that the Musk-Deer occurs in Tibet, yet it might be objected that this musk was first taken from China to Tibet, and thence exported through Nepál or Ladák to India; I, therefore, now proceed to bring forward the more direct proofs of the occurrence of the animal in Tibet proper.

The earliest evidence which I have to notice, is that of the great traveller Marco Polo.† That writer mentions the occurrence of the Musk-Deer at a place which he calls Ergiul, which Colonel Yule locates to the north of Tibet, and south of the great Gobi desert, in latitude 40°. From Marco Polo's description, there can be no doubt of the identity of the animal referred to with the Musk-Deer, though he commits the error of mentioning a pair of lower as well as upper tusks. Again, the same traveller‡ mentions the occurrence of the same animal in eastern Tibet, probably somewhere near the longitude of Lhása, and also that the Tibetans call the animal Gureri.

A later traveller, Mr. Bogle, the envoy of Warren Hastings, describes§ most circumstantially the hunting and capture of a Musk-Deer (or, as he calls it, Musk-Goat) at Rinjaitzay, which is situated north of the Tsánpú river near Shigâtze in Tibet. Mr. Bogle describes the animal as being hornless, coated with stiff hair, and with tusks depending from the upper jaw of the male: he also mentions that the Tibetan Musk-Deer is of a lighter colour than the Musk-Deer of Bhútán. This description leaves no possible doubt as to the animal referred to.

General Cunningham‖ mentions that the Musk-Deer (known to the Ladákis as Lá) is found in Tibet as well as in Kashmir.

During the past summer, I met in Lahúl with a Tibetan who had formerly occupied a high official position at Lhása, and who informed me,

* Markham, 'Tibet.' Int. p. cxxii, p. 197.
Hodgson 'Trade of Nepál.'
Cunningham. 'Ladák,' p. 242.

† Yule's 'Marco Polo,' Vol. I, p. 267.

‡ Yule, loc. cit., Vol. II, p. 37.

§ Markham, loc. cit., p. 114.

‖ Loc. cit., p. 202.

that the Musk-Deer was of common occurrence on the Tsánpú river in the neighbourhood of Lhása.

Mr. W. H. Johnson, the Governor of Ladák, informs me that the Musk-Deer is found in the country below and to the east of Lhása, along the course of the Tsánpú river. The musk brought from this district, Mr. Johnson says, has wrongly acquired the name of Khoten musk; this seems to have originated from the fact that when Khoten was a large Buddhist city, and important trading place, the musk was carried there from Lhása, and thence to India. Mr. Johnson also observes that the Musk-Deer occurs only where the birch tree grows.

The whole of this evidence taken together appears to me to afford abundant evidence as to the occurrence of a species of *Moschus* in Tibet, though I have no means of knowing whether it be the same as *M. moschiferus*. The Musk-Deer is of common occurrence in Bhútán, and it appears to me to be probable that it extends north of that district in most of the open countries up to Tibet, and thence across, or round, the Gobi desert into Siberia.

The occurrence of the Musk-Deer far in on the Tibet plateau is a fact of considerable importance, as it is the only instance of any of the large mammals of the forest clad Alpine Himalaya extending its range into the dry and desert regions to the north.

In my former paper, quoted above, I thought it probable that the Musk-Deer occurred in Ládák; this, however, I now find is not the case; I can find no evidence of the animal occurring anywhere in the upper Indus valley.

III.—*Note on some Ladák Mammals.—By* R. Lydekker, B. A.

Otter.—In his report on the Mammalia of the second Yarkand Mission* (p. 32), Mr. W. T. Blanford mentions that the late Dr. Stoliczka, in his notes, referred to the occurrence of a small species of otter *(Lutra)* in the Indus at Leh, but was unable to procure a specimen.

During the past summer I purchased at Leh a flat skin of an otter, said to have been obtained from the Indus at Shushot, near Leh. This skin is of very dark colour superiorly, and the length of the body-part is about 30 inches; the tips of the hairs are paler. Unfortunately, neither the skull nor the claws remain in my specimen, so that specific determination is quite impossible. The skin, however, seems to be very like that of the European

* 'Scientific Results of the Second Yarkand Expedition,' Mammalia, by W. T. Blanford. Calcutta, 1879.

otter (*L. vulgaris*), and the animal, therefore, may very possibly belong to the same species as a skin obtained by Major Biddulph in Gilgit (? from the Indus), and which Mr. Blanford, in the above-quoted note, thinks is very like *L. vulgaris.*

I learn from Mr. Elias, the British Joint-Commissioner at Leh, that otters are said to be of common occurrence at the bridge which spans the Indus below Leh; these otters live in the stone-work piers of the bridge. I may add that Mr. Elias has promised to endeavour to procure a specimen of the skin and skull of one of these animals.

Dr. Stoliczka speaks of the Leh otter as being a small species; since, however, he never procured a specimen, and as my specimen is a large skin, it is probable that Stoliczka's estimate of size was not exact.

Marmots.—I cannot quite agree with Mr. Blanford* in calling the Red Marmot (*Arctomys caudatus*) the common marmot of Ladák, as it appears to me that the species is only found on the outskirts of that region. I have procured specimens of that species on the range between Kashmir and Tilel (Kishenganga valley), on the pass between Tilel and Drás, and on both sides of the Zoji-Lá, separating the latter place from Kashmir. I have, however, never seen this species in the more interior parts of Ladák, where it appears to me to be replaced by *Arctomys himalayanus*, or the Yellow Marmot, which appears to me to be entitled to be called the "Ladák Marmot" *par excellence.* I have seen or procured specimens of the latter species, from the mountains above Khalchi, on the Indus; on the pass separating the Markha river from the Gia river, to the south of Leh; and, still further south, on Kiang-Chu Maidân, in Rúpsú; to the north of the Indus in Ladák, on the Chang and Kai passes, forming the watershed of the Indus and Shyok rivers; around the Pangong lake; and in the Chang-Chenmo valley. *Arctomys caudatus* seems to me to be confined to the country on the confines of the rainless districts, while *A. himalayanus* occurs only in the inner, and thoroughly Tibetan, districts.

In the field, the two species can be at once distinguished by their respective cries. The cry of the Red Marmot is a peculiar long screaming whistle of great shrillness: the Yellow Marmot on the other hand utters a short chirping bark. It is not easy to convey an idea of the two sounds to the reader, but when they have been once heard in the field, they never can be mistaken for one another.

I should be much inclined to doubt the suggestion of Mr. Blanford† that the marmot said by Dr. Stoliczka to range up to a height of 17,000 feet in Ladák is *A. caudatus*; it is much more likely to be *A. himalayanus*, which I have killed above 18,000 feet; the former I have never seen above 14,000 feet (Drás and Tilel pass).

* Loc. cit. p. 37.

† Loc. cit. p. 39.

IV.—*A Sketch of the History of the Fossil Vertebrata of India.*—*By* R. Lydekker, B. A.

(Received January 6th; read February 4th, 1880.)

As far as I am aware, there has not hitherto been written a complete history of the whole Fossil Vertebrate Fauna of India, as far as it is at present known to us, and I have, therefore, thought that it may interest many members of this Society, as well as others, to know something of the extent and affinities of this fauna, without the labour of wading through the various works in which its history is recorded. The history of the Fossil Vertebrata of India is, indeed, intimately connected with this ancient Society, since some of the earliest workers in this branch of enquiry were formerly among its members, and many of the results of their labours are to be found scattered through its earlier records. Pre-eminent among those workers will always stand out the names of Baker, Durand, Cautley, Colvin, Falconer, Hislop, M'Clelland, and Spilsbury. And it must always be remembered, to their honour, that these workers in this most interesting department of palæontology were solely amateurs, and that in their time the study of vertebrate palæontology in this country was encumbered with difficulties of which we, at the present day, can have no adequate conception. The labours of Mr. Hislop were mainly expended in searching the Gondwána rocks of the Central Provinces, from which he obtained many interesting remains of reptiles, batrachians, and fishes; Col. Sykes' collections were chiefly made among the fossil fishes of the Deccan; while the field of labour of the other workers lay mostly among the mammaliferous beds of Northern India, and the Narbada (Nerbudda) valley.

I very much regret to say that since these illustrious workers, no amateurs in India seem to have entered upon this interesting field of research, and during the five years which I have been upon the staff of the Geological Survey of India, we have not, I believe, received, in the Indian Museum, a single fragment of a fossil vertebrate from a non-professional worker. It is partly in the hope that this paper may reach the eye of amateurs interested in natural science, and especially of those who lead a wandering life in India, and induce them to endeavour to collect specimens of vertebrate fossils for the Indian Museum, that it has been penned.

Apart from members of the Geological Survey of India, to whom I shall refer presently, there are other workers who, though not members of this Society, have contributed largely to the history of the extinct vertebrate life of India. Noticeable among these are the names of Buckland, Crawfurd, and Clift. Crawfurd, on his return from his mission to the court of Ava in 1826, brought back some Tertiary mammalian remains from the valley of the Irawadi, which were among the first obtained in Asia by Europeans,and which were subsequently described by the late Mr. Clift in the 'Transactions of the Geological Society of London.'* In the same volume of the 'Transactions,' a memoir was also published by the late Dr. Buckland on the Ava bones. Another memoir also appeared in the same volume by Mr. Pentland, on certain mammalian remains from the Siwaliks of Sylhet, collected by Sir T. Colebrooke. As you are doubtless aware, the fossil vertebrate fauna of the Siwaliks and the newer Narbadas, were subsequently fully illustrated, and in part described, by our former illustrious associates, Falconer and Cautley, the results of whose labours are abundantly dispersed through our Society's publications, and displayed in that now classic work the 'Fauna Antiqua Sivalensis.'

Dr. Charles Murchison, the editor of the 'Palæontological Memoirs' of Dr. Falconer, has rendered one of the most important services to the cause of vertebrate palæontology in this country, by collecting and publishing the scattered notes and memoirs of that distinguished palæontologist. Professors Owen and Huxley have contributed largely to our knowledge of the fossil Reptilia and Batrachia of India; while the fossil fish have been enriched either by the discoveries or the writings of Messrs. Egerton, Miall, Sykes, and Walker.

A valuable memoir on the extinct Siwalik genus *Sivatherium* was contributed to the 'Geological Magazine' by Dr. Murie; another on *Bramatherium*, by Mr. Bettington and Professor Owen, to the 'Journal of the Royal Asiatic Society.' A few Siwalik fossils collected by the Messrs. Schlagintweit were described in the German 'Palæontographica' by the late H. von Meyer. The late Dr. J. E. Gray also determined a few of the Indian fossil reptiles. Professor A. Milne-Edwards determined some Siwalik bird-bones. Some mammal-bones from the Tibet Tertiaries were determined by Mr. Waterhouse.

Among the later contributors to our knowledge of the fossil vertebrata of India must be mentioned Professor Rütimeyer, who has afforded valuable information on the Siwalik ruminants in the British Museum; and Mr. P. N. Bose, who has described some of the fossil Siwalik Carnivora in the same collection. Mr. Davies, of the British Museum, has also contributed to the 'Geological Magazine' a valuable paper on Siwalik birds. Professor Leith Adams has published some notes on *Elephas namadicus* in the Palæontographical Society's publications.

The above names are only the chief among the workers in Indian

* Ser. 2, Vol. II.

vertebrate palæontology who are unconnected with the Geological Survey of India. Of the former or present officers of that department, I must mention, among discoverers, the names of Messrs. W. T. and H. F. Blanford, Fedden, Foote, Hacket, Hughes, Medlicott, Theobald, Tween, and Wynne, and, among writers, Messrs. W. T. and H. F. Blanford, Foote, Oldham, Stoliczka, Theobald, Waagen, and, lastly, myself.

Minor contributions, in the way both of specimens and papers, have been made by other gentlemen, all of whose names it would be both tedious and difficult to bring together, but for whose exertions the workers in this branch of enquiry have, none the less, good cause to be grateful. Among these names I may mention, Bell, Dr. (Ichthyolite from Kach); Blyth, E. (Siwalik Mammals); Burney, Col. (Ava Vertebrates); Burt, Lieut. (Jamna Bones); Cantor, T. (Siwalik fish-skull); Carter, Dr.; Colebrooke, Sir T. (Tibet Tertiary Mammals); Dawe, W. (Tertiary Vertebrates); Dean, E. (Jamna Mammals); Everest, Rev. R. (Siwalik Vertebrates); Felix, Major, (Narbada Mammals); Foley, Capt. (*Diodon* from Ramri Island); Frazer, Capt. (Narbada Mammals); Fulljames, Capt. (Perim Mammals); Godwin-Austen, Col. (Siwalik Mammals); Gowan, Major (*Archegosaurus* from Bijori); Hügel, Baron (Perim Fossils); Ewer, W. (Siwalik Vertebrates); Lush, Dr. (Perim Vertebrates); Ousely, Col. (Narbada Mammals); Pepper, Miss (Perim Mammals); Phayre, Sir A. (Ava Mammals); Prinsep, J. (Tertiary Mammals); Rivett-Carnac, H. (*Archegosaurus* from Bijori); Royle, (Siwalik Mammals); Sim, Lieut. (*Archegosaurus* from Bijori); Smith, Capt. E. (Jamna Mammals); Strachey, Genl. (Tibet Tertiary Mammals); Trail, Dr. (Tibet Tertiary Mammals); and Verchere, Dr. (Siwalik Mammals).

The extinct vertebrate fauna of India, with the noticeable exception of the mammalian upper Tertiary fauna, is generally remarkable for its extreme poverty; a poverty which may be due in some cases to the want of adequate research, and in others to the small number of fossils preserved in the different strata. Only here and there, in the great Gondwâna series of India—which, as far as regards its higher and fossiliferous part, in serial position, in mineralogical composition, and in its fresh-water character, seems to correspond very closely with the Trias-Jura of the Connecticut valley in America,—do we find fossils locally abundant, as the reptiles of the Panchet group, and the fish and reptiles of the Kota-Maleri and neighbouring groups. With the exception of a few Cretaceous reptiles, the fossils from the above-mentioned groups, which are really very few, are the only representatives of the Pre-Tertiary land and fresh-water vertebrate fauna of which we have any traces in India.

In place of the numerous and gigantic dinosaurs of the secondary lands of Europe and America, we have in India only here and there a few bones, indicating the former existence of a small number of species; while of the more specialized and bird-like dinosaurs of those countries, we have as yet no trace in India; neither of the toothed birds, which present so remarkable a feature in the secondary epoch of America, are there any vestiges in India. The numerous species of the volant and toothed pterodactyls of Europe, and of their toothless representatives in America, are also totally unknown from Indian strata.

Of the gigantic estuarine or marine saurians, so characteristic of the secondaries of Europe and America, Indian strata have hitherto only yielded a few remains of a single *Ichthyosaurus* and *Plesiosaurus*. Of the lower batrachians, only a few species are known from the (probably) Triassic rocks of India, and the great number of species so characteristic of the Carboniferous and Trias of Europe are almost totally unrepresented in this country. The marine fish fauna is likewise remarkable for its general poverty.*

It must, however, be observed that many of the vertebrates which do occur are only known by a single skull, or a tooth, or a few bones or scutes, and it, therefore, seems probable that many other species must have left similarly scattered remains through the strata of India, which from their extremely local distribution have hitherto escaped detection.

No distinctly recognizable traces of mammals have been as yet detected in India below the Nummulitic rocks, and in the latter only by a few generically undeterminable bones; indeed, we meet with no well-developed mammalian fauna till the period of the Upper Miocene and Lower Pliocene, when we suddenly come upon the evidence of the former existence of a vast and varied fauna which is, probably as numerically abundant in its species and genera as any known fossil fauna in the world. Previous to the Tertiary, the whole history of mammalian life in India is a complete blank. The bird-fauna of India, with a few exceptions, is almost totally unknown previously to the present epoch.

The above remarks have an important negative bearing on evolution. We know that the greater part of the peninsula of India has existed as land for an incalculable period of geological time,—at all events from the Triassic epoch, and we further know that in other regions mammals have existed on the globe since the Triassic, and birds since the Jurassic, period. As regards the above two groups of vertebrates, India throws not a single ray of light on their origin. We have not a trace of any one of the curious generalized forms of the Eocene mammals of North America in the strata of India, and yet we cannot think that ancient India was almost without mammalian life till the upper Miocene. It is indeed probable that the lost

* Marine rocks are absent over most parts of peninsular India, though present in force in Trichinopoli, Kach, Sind, and the Himalaya.

mammals of Secondary and early Tertiary India may have filled many a puzzling gap in the animal series.

It is the same with the reptiles, which were doubtless the dominant forms during the epoch of the Trias-Jura, and which have only here and there left a trace of their former existence in this country. Why may not many forms of those half-birds, half-reptiles have inhabited Secondary India of whose existence we have ample proofs in other countries; and why may not many of such Indian forms have still more closely bridged the gap which even yet exists between birds and reptiles? Great and numerous as are the advancements in uniting the scattered links of the broken chain of vertebrate evolution, it must ever be borne in mind that, while we have evidence of a large Secondary land-surface like India, which has hitherto yielded scarcely any links to this wondrous chain; we must never despair if we find that other countries are still of themselves unable to make the chain extend across all the gaps, owing to the want of a few links. Who shall say that such missing links never inhabited Secondary India, where their remains either still lie buried, or have been for ever lost beyond recovery? I, indeed, imagine that early India must have teemed with reptiles, and perhaps with higher forms of life, for it is inconceivable that this country was once mainly a mere forest of plants, of the existence of which we have such ample evidence in the Trias-Jura, unenlivened, except in one or two small spots, by vertebrate life.

I now proceed to sketch what is known of the fossil vertebrates of India, commencing with the lowest class, and tracing it through the various formations from the lowest in which it occurs to the highest; and similarly with the higher classes. I must premise that very many of the Indian fossil vertebrates are only known by extremely scanty remains, and that their affinities are consequently obscure. Of others, again, only very slight preliminary descriptions, without figures, have yet been published, and consequently foreign palæontologists have not yet had the opportunity of comparing them with other species, by which their affinities might be more fully illustrated.

Fossil Fishes.

Carboniferous.—The earliest fishes of which we have at present any record in India are only known by some few teeth and fin-spines, collected by Dr. Waagen and Mr. Wynne of the Geological Survey, in the Salt-Range of the Punjáb, and described by the former writer in the 'Palæontologia Indica.'* These fish remains were obtained from strata termed by Dr. Waagen the "Productus-Limestone," corresponding in the main to the Carboniferous. *Sigmodus dubius* is a fish belonging to a new genus founded upon a single tooth; this tooth is of an elongated conical form, and much resem-

* Ser. XIII, parts 1 and 2, 1879-80; the latter part in the press.

bles the teeth of some saurians; it is referred by Dr. Waagen to the ganoids. Another tooth, referred provisionally by Dr. Waagen to the genus *Poecilodus*, under the name of *P. paradoxus*, is of the flattened cestraciont type. *Psephodus indicus* is a species formed upon the evidence of another tooth. Both these genera belong to the *Cochliodontidæ*, which Dr. Waagen classes among the Dipnoi, though they are more generally referred to the Elasmobranchii. Of the undoubted Elasmobranchii (Selachii), Dr. Waagen describes four species, belonging to three genera, from teeth, and four species, belonging to two genera, from fin-spines (ichthyodorulites). Of the teeth, two are referred to a genus (*Helodopsis*) allied to *Helodus*, under the names of *H. elongata* and *H. abbreviata*. A fragment of a tooth is referred, without specific determination, to the European genus *Psammodus*, characteristic of the Carboniferous. A fourth tooth is referred to the European genus *Petalorhyncus*, with the specific name of *P. indicus*: it is extremely doubtful whether *Petalorhynchus* is really distinct from *Petalodus* of the Carboniferous. Of the spines, or "ichthyodorulites," three specimens are referred to the American Carboniferous genus *Xystracanthus*, under the names of *X. gracilis* and *X. major* and *X. giganteus*. If I rightly understand Dr. Waagen's notes, he thinks it possible that these spines may belong to *Helodopsis*. A third spine is referred to a new genus under the name of *Thaumatacanthus blanfordi*.

As far as the evidence of these fishes goes, we find that the cestraciont-toothed sharks were the dominant forms in the Indian, as well as in the European and American Carboniferous.

Trias-Jura.—In the upper part of the great Gondwána system of India, which, as I have said, probably corresponds as a whole to the Trias-Jura of other countries, remains of fishes have been found in some abundance, all of which, as far as determined, are of fresh-water types, and belong to the Ganoidei and Dipnoi, no traces of the more modern Teleostei having yet been found in these rocks. The earliest groups of rocks in the Gondwána system in which fish remains have been detected are the Mangli and Srípermatúr groups; but these remains have not yet been even generically identified. In the Kota-Maleri* group there occur nine species of Ganoids and three of Dipnoi; the former from the Kota beds have been described under the genera *Dapedius*, *Lepidotus*, and *Tetragonolepis* by Messrs. Egerton and Sykes;† many of them show Liassic affinities: the three genera

* Mr. King has lately shown a distinction between the Kota and Maleri beds; confirming the original distinction as to the Liassic affinities of the fossils of the former, and the Rhæto-triassic of those of the latter.

† Quar. Jour. Geol. Soc. of London, Vols. VII, IX, X. Palæontologia Indica, Ser. IV, part 2.

have a united range in Europe from the Lias to the Eocene: *Lepidotus* is very characteristic of the Wealden of England. Of the Maleri Dipnoi, teeth of four species of the living Queensland genus *Ceratodus* were named by the late Dr. Oldham, three of which have lately been figured by Professor Miall,* who does not admit the fourth species, *C. oblongus.*

Cretaceous.—A few fish-remains have been obtained from the Lameta rocks (of middle Cretaceous age), but are not yet determined. The next group of rocks in which fish-remains have been obtained are the upper and middle Cretaceous rocks of Trichinopoli; these remains have been described by the late Dr. Stoliczka† and Sir Philip Egerton.‡ They comprehend seventeen species of elasmobranchs, ranged under the genera *Corax*, *Enchodus*, *Lamna*, *Odontaspis*, *Otodus*, *Oxyrhina*, *Ptychodus*, and *Sphærodus*, and one ganoid doubtfully referred to *Pycnodus.* No Teleostei have been described, which is very probably owing to the less facility with which their remains are preserved; it being almost certain that they must have been represented in the Indian Cretaceous seas. The above-named genera are mainly characteristic of the Cretaceous rocks of Europe: two species are common to Europe and India. Bones, apparently of fishes, have been lately obtained by Mr. Griesbach from the Trias of Tibet. Mr. Griesbach tells me that these bones are not uncommon in the Trias limestone, but that he has not yet been able to extract any specimens in a determinable condition.

Eocene.—From the probably Nummulitic rocks of Port Blair, in the Andamans, and Rámri Island, off the Arakan coast, there have been obtained the oral teeth of a large species of *Diodon*, which I have lately provisionally called *Diodon foleyi*, after Captain Foley, the discoverer of the Rámri Island specimen.§ The living *Diodon hystrix* is now abundant off the coasts of the Andamans and Arakán, where the genus has doubtless lived since the Eocene. From Nummulitic rocks in the neighbourhood of Thyatmyo, cycloid fish-scales have been obtained,|| but are not generically determined.

From the Nummulitics of the Punjáb, some fish-scales and the dental plate of a species of ray *(Myliobatis)* have been obtained by Mr. Wynne.¶ From strata immediately overlying the Nummulitics of Kohát, Mr. Wynne has obtained the incisor of a sparoid fish belonging to the genus *Capitodus*, which has been recently described by myself as *C. indicus*;** the genus

* Palæontologia Indica, Ser. IV, part 2.
† Ibid., Cretaceous Fauna of S. India, Vol. IV.
‡ Quar. Jour. Geol. Soc. Lon. Vol. VII.
§ R. G. S. I. Vol. XIII, part I.
|| Manual of Geology of India, p. 716.
¶ R. G. S. I. Vol. X, p. 43.
** Ibid. Vol. XIII, part I.

Capitodus was previously only known from the Miocene of Vienna and Silesia, and is allied to the living genus *Sargus.*

Mio-Pliocene.—From the Siwalik rocks there were, I believe, a considerable number of fish-remains procured by Falconer and Cautley, but these were never described: the collection of fossil fish-remains from the Siwaliks in the Indian Museum is but small. Among the Teleostei, we have the siluroids represented by a very perfect skull, originally described in the Society's Journal* by Dr. Cantor as the skull of a huge frog: subsequently this skull was referred by M'Clelland† to the siluroid fishes. The latter writer describes the skull as being remarkable for its great breadth, and as carrying teeth on the jaws, but not on the palate: M'Clelland also thought that the skull might belong to a species of *Pimelodus:* this determination is, I think, certainly erroneous, because the latter genus, with one African exception, is entirely West Indian, and it is unlikely that a fresh-water genus of fishes should be found in the Pliocene of India, and now only in Africa and the West Indies. Many of the living Indian siluroids (*Clarius*, *Heterobranchus*, *Silurus*, *Silurichthys*) have palatal teeth, and the fossil cannot, therefore, belong to any of those genera. The Indian genus *Chaca*, on the other hand, is characterized, according to Dr. Günther,‡ by its exceedingly broad and depressed head, and absence of palatal teeth, and I think, therefore, it is not improbable that the fossil may belong to that genus, though, in the absence of specimens for comparison, I cannot be sure. Detached vertebræ, from the Siwaliks, also indicate the existence of teleostean and, probably, fresh water fishes, but of what group is uncertain. Of the Elasmobranchii, a few teeth indicate the former existence of a Siwalik *Lamna*, which probably inhabited the larger rivers: a single tooth from the mammaliferous beds of the Irawadi belongs to a species of *Carcharias*, and large squaline vertebræ have been obtained from Perim Island. From the Siwaliks of Sind and the Punjáb, we have some crushing palatal teeth of an undescribed fish, which I have lately sent home for determination.

Scales of teleostean fishes have been obtained by Col. Godwin-Austen from the Tertiaries or post-Tertiaries of Kashmir; they are not, however, determined.

The above notes indicate the extreme poverty of the fossil fish-fauna of India—a poverty, I think, in great part due to the want of sufficient search.

* Vol. VI, p. 583.

† Calc. Jour. Nat. Hist. Vol. IV, p. 83.

‡ Brit. Mus. Cat. of Fishes, Vol. V, p. 29.

Fossil Batrachians.

Trias-Jura.—We now come to the history of the fossil Batrachia (Amphibia), where we shall find an equal poverty of species and genera; such as are known being merely, in all probability, a few relics left from a large fauna. The oldest Indian batrachians, like their European and American contemporaries, belong to the labyrinthodont order, characterized by the peculiarly infolded structure of their teeth. The oldest form of the order in India is only known from an undescribed skeleton obtained from a group of the Gondwána system at Bijori, hence named by Mr. Medlicott the Bijori group.* This skull was originally exhibited before our Society in 1864, and commented upon by Mr. H. F. Blanford, who thought that it should be referred either to *Archegosaurus* or *Labyrinthodon*,† adducing some evidence to shew that it belonged to the former genus. Subsequently, the specimen was alluded to as a true *Archegosaurus* by the late Dr. Oldham,‡ and still later by Mr. Medlicott.§ I cannot discover what has become of this most interesting fossil, which is certainly not in the collection of the Indian Museum, where it is only represented by a cast. Judging from this cast, I think it not improbable that the specimen really does belong to *Archegosaurus*: it much resembles a skull of that genus from the European Carboniferous figured by H. von Meyer.|| The European species being from the Carboniferous rocks does not at all preclude the Indian species from being of Triassic age, since there is considerable difference in the range in time of the Pre-Tertiary land faunas and floras of the two countries; genera having very frequently survived to a later period in India than in Europe.

From the Panchet group of the Gondwánas, we have two labyrinthodonts, to which the generic names *Pachygonia* and *Gonioglyptus* have been applied by Professor Huxley;¶ these genera are only known by fragmentary skulls and jaws; they were slender-jawed forms and allied to the labyrinthodonts of the Keuper. They are classed by Professor Miall in the group Euglypta with *Mastodonsaurus* and *Capitosaurus*. The fossils on which the two above-named Indian genera were founded are in the collection of the Indian Museum. From the nearly contemporaneous Mangli group, we have another labyrinthodont, *Brachyops laticeps* of Owen, also belonging to a genus otherwise unknown, and allied to European Jurassic, and African

* M. G. S. I. Vol. X, p. 159, (art. II, 27.)

† J. A. S. B., Vol. XXXIII, p. 337.

‡ R. G. S. I. Vol. IV, p. 70.

§ Loc. cit.

|| Palæontographica, Vol. VI, pl. XI, fig. 5.

¶ Pal. Ind. Ser. IV. part 1.

and Australian (probably) Triassic forms. The skull on which the genus is founded was described by Professor Owen.* The European Jurassic genus to which it is allied is *Rhinosaurus*, the African (Triassic ?), *Micropholis*, and the Australian, *Bothriceps;* the genus seems to me to be also closely allied to *Tuditanus radiatus* of the American Carboniferous. *Brachyops* belongs to the short-jawed group of labyrinthodonts; and, with the first three above-mentioned genera, constitutes the group "Brachyopina" of Professor Miall. The skull of *Brachyops* is, I believe, in the collection of the Geological Society of London: it is represented by a plaster cast in the Indian Museum.

Tertiary.—From the Trias to the Tertiary is a long leap, but hitherto no batrachian remains have been found in India between these two formations. In the lower Tertiaries of the island of Bombay, there occur a large number of the remains of frogs belonging, apparently, to two species. The smaller of these two species was first described by Professor Owen† under the name of *Rana pusilla;* subsequently, however, Dr. Stoliczka,‡ from the absence of vomerine teeth and from the structure of the limbs, referred the species to the genus *Oxyglossus*, at the present time living in China and Siam, and, possibly, in India. A larger frog from the same beds, noticed by Professor Owen in the same paper, has not yet been generically determined. I believe that these Bombay frogs are the oldest representatives of the group.

Fossil Reptiles.

Trias-Jura.—The oldest members of the class Reptilia hitherto found in India belong to the orders Dinosauria and Dicynodontia (Anomodontia), and occur in the presumably Triassic rocks of Panchet near Ráníganj, in the horizon known as the "Panchet group." The *Dicynodon* was originally described by Professor Huxley§ under the name of *D. orientalis;* additional remains have subsequently been described by myself,|| which show that this species belonged to the sub-genus *Ptychognathus* of Professor Owen. Other remains noticed in the latter memoir, seem to indicate the former existence of a second and larger species of *Dicynodon*. This group of reptiles seems, on the whole, to be characteristic of the Trias of India, Russia, and Africa. The dinosaur has been named *Ankistrodon indicus* by Professor Huxley,¶ and is the only known representative of the

* Q. J. G. S. L. Vol. XI, p. 37.
† Ibid. Vol. V, p. 173.
‡ M. G. S. I. Vol. VI, p. 387.
§ Pal. Ind. Ser. IV, Vol. I, part I.
|| Ibid. part 3.
¶ Loc. cit.

genus. The teeth of *Ankistrodon*, of which only two are known, have laterally compressed crowns, with serrated edges, like those of the dinosaurian *Megalosaurus* and the mammalian *Machærodus*, and are implanted in distinct sockets. The genus is allied to the Jurassic and Cretaceous *Megalosaurus*, and to various Triassic genera.

From the Denwa group of the Gondwána system, a large crocodilian scute has been obtained by Mr. Hughes,* which seems to belong to Professor Huxley's undescribed genus *Parasuchus*.

From the neighbouring Kota-Maleri group, we have the crocodilian *Parasuchus* and the lacertian *Hyperodapedon*. The genus *Parasuchus* has never been described, but only incidentally alluded to by Professor Huxley†; it was formed for the Kota-Maleri bones: it seems to have been closely allied to the Triassic *Belodon* and *Stagonolepis*. On labels attached to the bones of *Parasuchus*, now in the Indian Museum, there occurs the specific name of *hislopii*, in Professor Huxley's handwriting. *Hyperodapedon*‡ is closely allied to the living genus *Hatteria* (*Sphenodon*), represented by two species in the New Zealand Islands, and, according to Professor Huxley, to the Triassic *Rhynchosaurus*, though this is doubted by Professor Owen.

From the undoubtedly Jurassic rocks of Kach (Cachh), there has been obtained (Chári group) a vertebra which I think very probably belongs to *Parasuchus*, though I cannot be certain;§ and (Umia group) a fragment of a lower jaw of a *Plesiosaurus*, which I have named *P. indicus*:|| the specific affinities of the latter cannot be fully determined from the fragment.

Cretaceous.—From the Cretaceous rocks of India, we have, among the Dinosauria, a species of *Megalosaurus*, certainly from the Trichinopoli, and probably from the Lameta rocks (middle Cretaceous);¶ this genus is only known in India by detached teeth; in Europe, it ranges from the Jurassic to the lower Cretaceous (Wealden). From the Lameta rocks, there have also been obtained the remains of another gigantic genus of dinosaur, allied to the Wealden *Pelorosaurus* and the Jurassic *Cetiosaurus*, which I have named, from the great size of the bones, *Titanosaurus*;** from the evidence of the vertebræ, there appear to have been two species, *T. indicus* and *T.*

* Pal. Ind. Ser. IV. part 3.
† Q. J. G. S. L. Vol. XXVI, p. 49, XXXI, p. 427.
‡ Ibid. XXV, p. 151.
§ R. G. S. I. Vol. X, p. 35.
|| Pal. Ind. Ser. IV, part 3.
¶ Ibid.
** Ibid.

blanfordi. *Titanosaurus* was a gigantic and, probably, land reptile, but whether bipedal or quadrupedal is not known. Remains of another, but much smaller, reptile have been also obtained by Mr. Hughes from the Lameta rocks; the remains are, however, not sufficient for generic determination, but I think it not impossible that they may have belonged to a dinosaur.

Of the Cretaceous Crocodilia, we only know of one species by some amphicoelian vertebra and scutes obtained by Mr. W. T. Blanford from the upper Cretaceous rocks of Sind.* As far as I can judge, from these imperfect remains, they appear to indicate an animal allied to *Suchosaurus* of the Wealden of England.

The Chelonia are only known to have existed in India during the Cretaceous period by the evidence of some broken plates, in the collection of the Indian Museum, obtained from the Lameta group, from the intra-Trappeans of Rajamahendri (Rajamundry), and from the upper Cretaceous rocks of Sind. These remains are in far too imperfect condition for even generic determination.

A large species of *Ichthyosaurus*, which I have called *I. indicus*,† is known solely by a few vertebræ collected by Mr. Foote in the middle Cretaceous rocks of Trichinopoli. *Ichthyosaurus*, in England, ranges from the Lias to the Chalk.

Eocene.—The only specifically known Eocene Indian reptile with which I am acquainted, has been referred by the late Dr. Gray‡ to the genus *Hydraspis* belonging to the family Emydidæ. The specimen on which the determination rests is a carapace, from the intra-Trappean rocks of Bombay, originally named by Mr. Carter *Testudo leithii.* The genus *Hydraspis* is now found living exclusively in Tropical America. From the Nummulitics of the Punjáb, remains of Crocodilia have been obtained by Messrs. Theobald and Wynne, of the Geological Survey, but are not generically determined.

Mio-Pliocene and Pleistocene.—From the Mio-Pliocene Siwaliks and from the Pleistocene Narbadas, a considerable number of reptilian remains have been obtained, but, in many cases, have not yet been described. Remains of Crocodilia have been obtained in considerable numbers from the Sub-Himalayan Siwaliks and from the corresponding rocks of Burma, Perim Island, and Sind; and many of them have been named by Falconer. Of the genus *Crocodilus*, a Siwalik species has been identified with the living *C. palustris* (*bombifrons*, Gray).§ Remains of a crocodilian have

* Pal. Ind. Ser. IV. part 3.

† Ibid.

‡ Ann. Mag. Nat. Hist. Ser. IV, Vol. VIII, p. 339.

§ Cat. Foss. Vert. A. S. B. p. 200. The cranium there named *C. palæindicus* seems to belong to *C. palustris.*

also been obtained from the Irawadi and the Narbada, but their specific determination is difficult. Of the genus *Gharialis* (*Leptorhynchus*), one Siwalik species has been identified with the living *G. gangeticus;* a gharial from the Manchhars of Sind also belongs to this species. Another long-jawed Siwalik crocodile with slender teeth has been named *Gharialis leptodus;* and another with much shorter jaws and teeth, *G. crassidens;* the latter has been obtained from the Siwaliks and from Sind.

Of the order Lacertilia, only one Siwalik representative is known, belonging to the genus *Varanus*, and named by Falconer *V. sivalensis.** This determination was made on the evidence of a distal extremity of the humerus, now in the British Museum.

The Ophidia are only known by some vertebræ, much like those of the genus *Python*, obtained from the Siwaliks of the Punjáb and Sind: these vertebræ have not yet been generically determined.

The Chelonia are known by a considerable number of Siwalik, and two Narbada, species. Of the land tortoises, we have, firstly, the gigantic extinct species, *Colossochelys atlas* of Falconer and Cautley, from the Siwaliks and the Irawadi. Falconer says that the fossil species is mainly distinguished from the living genus *Testudo* by the thickening of the anterior (episternal) portion of the plastron; this character was considered to be only of subgeneric value, and I think the species might well be named *Testudo atlas*. The length of the carapace, according to Falconer's restoration, is 12 feet 3 inches, and of the entire animal, with the head and tail extended, 22 feet. In addition to *Colossochelys*, there is good evidence of the former existence of other gigantic tortoises in the Siwalik period. In the Indian Museum, there are several specimens of the ankylosed episternals of tortoises belonging to two distinct species. These bones are as thick, but not so elongated, as the episternals of *Colossochelys;* they have diverging but shorter extremities than in the latter genus. The animals to which these bones belonged must have been, I think, two-thirds as large as *Colossochelys*, and may not improbably have belonged to *Testudo*. A broken episternal indicates a third, but smaller species. A fourth species is indicated by three episternals, which are not bifurcated at their free extremities: these bones indicate a smaller animal The episternal bones, from their solidity, seem more frequently preserved than any others. A single carapace of a small tortoise in the Indian Museum, from the Siwaliks, seems to belong to the genus *Testudo*. Among the hard-shelled emydine tortoises, we have, from the Siwaliks, a species of *Bellia* described by Mr.

* Pal. Mem. Vol. I, pl. XXXII, figs. 4-7.

Theobald* under the name of *B. sivalensis*. This species, according to Mr. Theobald, is very closely allied to *B. crassicollis*, which, according to the same writer,† inhabits Tenasserim, Siam, and Sumátra. The other living species *(B. nuchalis)* inhabits Jáva. Another carapace of a Siwalik emydine, in the Indian Museum, seems to belong to a second species of *Bellia*. In labels on the casts of Siwalik fossils from the British Museum, a three-ridged carapace of an emydine bears the name of *Emys hamiltonoides* (Falc. and Caut.): this name was doubtless given from the resemblance of this carapace to that of the living *Damonia (Emys) hamiltonii*, now inhabiting Lower Bengál: the generic name of the fossil should probably be *Damonia*. An imperfect carapace, collected by Mr. Theobald in the Siwaliks of the Punjáb, and now in the collection of the Indian Museum, seems to belong to *Emys* proper. Mr. Theobald has lately described,‡ under the name of *Cautleya annuliger*, a gigantic Siwalik emydine, from the evidence of a single marginal bone; the genus is said to be distinguished from all other emydines by the cartilaginous, in place of osseous, union of the marginal with the adjoining bones. In the family *Bataguridæ*, Dr. Falconer determined the identity of a Siwalik emydine with *Pangshura (Emys) tectum* of Bell§; subsequently, the species was shown by Dr. Stoliczka‖ to occur in the newer Narbada deposits also: *Pangshura tectum* now inhabits Lower Bengál. Of the genus *Batagur*, a part of a plastron from the Narbada has been thought by Dr. Stoliczka¶ to belong very probably to *B. dhongoka*, now found living in the Narbada. Remains of a large *Batagur*, from the Siwaliks, are contained in the collection of the Indian Museum, but have not yet been specifically determined. A small carapace, with a ridge on the vertebral plates, lately presented by the Rúrki Museum to the Indian Museum, very probably belongs also to *Batagur*. Of the soft-shelled river-tortoises, a *Trionyx* from the Narbada has been thought by Dr. Stoliczka** to be not improbably identical with the living *T. gangeticus*. Plates of an undetermined *Trionyx* have been obtained in considerable numbers from the Sub-Himalayan Siwaliks, and from those of Burma and Perim Island. A carapace of an *Emyda* in the British Museum, from the Siwaliks, has been identified by Dr. Gray with the living *Emyda vittata* (*ceylonensis*, Gray). This species, according to Mr. Theobald, inha-

* R. G. S. I. Vol. X, p. 43.

† Catalogue of Reptiles of India, p. 10.

‡ R. G. S. I. Vol. XII, p. 186.

§ Pal. Mem. Vol. I, p. 382.

‖ R. G. S. I. Vol II, p. 39.

¶ Loc. cit.

** Loc. cit.

bits Central and Southern India and Ceylon. In the Indian Museum there are numerous remains of *Emyda* from the Siwaliks of the Punjáb, Burma, and Perim Island, which may or may not belong to the last-named species.

General Remarks.—The foregoing notes will show that the fossil reptiles of India are noticeable for the extreme paucity of species known, and for the fragmentary remains of the known species. The Mesozoic Reptilia belong, as far as described, to extinct genera: the one known Eocene reptile (*Hydraspis*) belongs to a living genus, but one which is now far removed from India. The Siwalik (Mio-Pliocene) reptiles appear in great part to belong to living Indian genera, and in many cases to living species; the modern representatives are, however, in most cases, found no longer in the Sub-Himalayan distiets, but are now confined to Southern India. The Narbada fossil reptiles, in all probability, belong altogether to living species, and probably to species inhabiting the same district.

Fossil Birds.

Mio-Pliocene.—Fossil remains of birds have hitherto been found in India only in the Sub-Himalayan Siwaliks, and there only in comparatively small numbers. Some of their remains are in the Indian Museum, and have been partly described by myself,* while others are in the British Museum, and have been lately described by Mr. Davies.† Among the carinate birds, a tarso-metatarsus is considered by Mr. Davies to belong to a cormorant, possibly of the genus *Graculus.*‡ A species of pelican (*Pelecanus cautleyi*) is indicated by a fragment of an ulna; this bird, according to Mr. Davies, must have been somewhat smaller than the living Indian *P. mitratus.* Another part of an ulna has been referred to a new species (*Pelecanus sivalensis*) by Mr. Davies, with a reservation as to the generic determination. A gigantic wader has been described by myself, under the name of *Megaloscelornis sivalensis*, from the evidence of a sternum and tibio-tarsus. A distal extremity of a large bird humerus in the Indian Museum, collected by Mr. Fedden in Sind, has a diameter of 2 inches across the condyles: I cannot at present identify this bone with the humerus of any living genus of bird: from its size it might belong to *Megaloscelornis*; it makes some approach to the humerus of *Ploteus.* A species of adjutant has been named by Milne-Edwards *Argala falconeri.*§

* R. G. S. I. Vol. XII, p. 52.

† Geol. Mag. January 1880, p. 18.

‡ This bone was doubtfully referred by M. Edwards to *Phaëton.*

§ The bone in the British Museum referred to by myself on page 56 of the above quoted paper belongs to this species.

There are also two small undetermined bird bones in the Indian Museum. The Struthioid or Ratitian modification of bird structure appears to have been represented by three Siwalik species; *viz.*, an ostrich *(Struthio asiaticus)* indicated by some of the bones of the lower leg and foot and by vertebra: an emeu *(Dromæus sivalensis)*, by bones of the foot: and, according to Mr. Davies, a three-toed bird, intermediate between these two genera, by a single phalangeal bone. The living ostrich is confined to the African continent, and the emeu to New-Holland; the occurrence of fossil species of these genera in the higher Tertiaries of India, probably points to a late land connection between these countries.

FOSSIL MAMMALS.

Eocene.—No traces of mammals have hitherto been detected in India below the Eocene, and in the latter formation only some fragmentary bones have been obtained by Mr. Wynne in the Nummulitics of the Punjáb. The only determinable bones consist of the distal portion of the femur and metatarsals of a probably perissodactyle animal, and the astragalus of an artiodactyle.* The femur was obtained from the Nummulitic (Subáthú) zone of the Punjáb, while the astragalus was obtained immediately above the Nummulitic clays of Fatehjang in the Punjáb, which are probably of upper Eocene age. The astragalus seems certainly to be that of a ruminant, as it belonged to an animal in which the navicular and cuboid bones were united. If this determination be correct, ruminants existed in the upper Eocene period.

Mio-Pliocene.—The Tertiary ossiferous rocks of Perim Island, Sind, the Punjab, the Sub-Himalayan Siwaliks, Sylhet, Tibet, and the valley of the Irawadi, have yielded a large number of mammalian and other vertebrate fossils, many of which are represented in the collection of the Society, now transferred to the Indian Museum. The fossils of the Irawadi valley were first brought to notice by Crawfurd and Clift, while those of the typical Siwaliks were rendered classic by the labours of Falconer and Cautley, and other former members of this Society. Some of these fossiliferous beds are of Miocene, and others of Pliocene age, and an admirable *resumé* of their distribution and relations are given in the 'Manual of the Geology of India,' to which work I must refer my readers desirous of further information on this subject.

The Siwalik Primates are at present known merely by a few fragments of upper and lower jaws and teeth, and it is probable that more species remain to be discovered. The known forms comprehend a large anthropoid ape, which has been named *Palæopithecus sivalensis*;† this

* R. G. S. I. Vol. IX, p. 92. In that passage the words "*mammaliferous* clays," should be "*nummuliferous* clays."

† R. G. S. I. Vol. XII, p. 38.

species is known by the palate of a female and the canine of a male, and seems to have been allied to the living orang of Borneo, but is distinguished by the form of its premolars; two species of (probably) *Semnopithecus* and two of *Macacus** have also been determined.

Among the Carnivora, we have a large tiger *(Felis cristata)*† characterized by its large sagittal crest; a second species has lately been described by Mr. P. N. Bose under the name of *F. grandicristata*,‡ with a still larger crest; while a third and much smaller species is indicated by a lower jaw in the Indian Museum. Of the genus *Machairodus* (*Machærodus*), there is *M. sivalensis* of Falconer and Cautley, said by Mr. Bose to be equal in size to the jaguar, and a larger species described by the same writer under the name of *M. palæindicus*. The genus *Pseudælurus*, distinguished from *Felis* by the presence of an additional lower premolar, is known by one lower jaw, which I have referred to a new species under the name of *P. sivalensis*.§ Among the civet-like animals, we have *Viverra bakeri* of Mr. Bose, said to be closely allied to the living civet, and *Ictitherium sivalense* described by myself from a lower jaw.|| The hyænas are represented by *Hyæna sivalensis* of Falconer and Cautley, said by Mr. Bose to present relationship both to the Indian *H. striata* and the African *H. crocuta;* and *H. felina* of Mr. Bose, distinguished by the absence of the first upper premolar. The dogs, according to the same writer, are represented by two species of *Canis (C. curvipalatus* and *C. cautleyi)*, the latter closely allied to the wolf; there is a specimen of the palate of a *Canis* in the Indian Museum, but I am at present unable to say whether it belongs to either of the above species. The genus *Amphicyon*, distinguished from *Canis* by the presence of an additional upper molar, is represented by *A. palæindicus*,¶ remains of which have been obtained from Sind and the Punjáb. The bears are known by a single undescribed cranium of *Ursus* in the Indian Museum, and by the remarkable genus *Hyænarctos*, of which two species are known: *H. sivalensis*** was the original species on which the genus was founded, and has the upper molars with quadrangular crowns; a tooth apparently belonging to this species has been described by Professor Flower from the newer Pliocene (Red Crag) of

* R. G. S. I. Vol. XII. p. 92.

† Pal. Mem. Vol. I, p. 315. In manuscript the name of *Felis palæotigris* occurs.

‡ Of this and five other species of Siwalik Carnivora, described by the same writer, I have only seen the notice given in 'Nature,' Jan. 1st, 1880.

§ R. G. S. I. Vol. X, p. 83.

|| Ibid. p. 32.

¶ Pal. Ind. Ser. X, Vol. I, p. 84. *Megalotis (Otocyon)* normally agrees with *Amphicyon* in having three upper true molars: it may, however, according to Prof. Flower, have four of these teeth.

** F. A. S. pl. O.

England: the second species, named by myself *H. palæindicus*,* is known only by an upper jaw, not yet figured; the upper molars of this species have triangularly shaped crowns, somewhat like those of *Amphicyon*. Of the subursoid Carnivora, we have the living Indian and African genus *Mellivora*, represented by *M. sivalensis*,† apparently very closely allied to the living Indian species. A species of badger *(Meles)* is indicated by one lower jaw collected by Mr. Theobald.‡ Of the otters, one species of *Lutra* (*L. palæindica*) has been named by Falconer and Cautley from a skull and lower jaw§; another lower jaw in the Indian Museum, collected by Mr. Theobald, not improbably belongs to a second Siwalik species. *Enhydriodon*|| is a genus peculiar to the Siwaliks, and is allied to the living sea-otter *(Enhydris)* now inhabiting the shores of the North Pacific; the Siwalik genus was not improbably a river-dwelling form.

Of the Proboscidia, now represented only by the Indian and African elephants, there were a large number of Siwalik species, belonging to the genera *Elephas*, *Mastodon*, and *Dinotherium*. Of the first-named genus, there were three sub-genera living in Siwalik times, *viz*., *Euelephas*, *Loxodon*, and *Stegodon*. *Euelephas* was represented by *E. hysudricus*, provided with simpler molars than the living representative of the sub-genus; *Loxodon* was represented by *L. planifrons*, remarkable for being the only species of elephant in which premolars are known to have been developed. The sub-genus *Stegodon* is peculiar to South-Eastern Asia, and was represented by four species in the Sub-Himalayan and other Indian Siwaliks: these species are named *S. ganesa*, *S. insignis*, *S. bombifrons*, and *S. cliftii*. The molars of the two first are more complex than those of either of the other two, and are indistinguishable from each other; the skull of the first species is distinguished by its enormously developed tusks. The intermediate molars of *S. cliftii* have not more than six ridges each. From (probably) Pliocene deposits in China, two stegodons have been described by Professor Owen under the names of *S. sinensis* and *S. orientalis*, which appear to be respectively the same as *S. cliftii* and *S. insignis*.¶ Of the mastodons, five species, *M. sivalensis*, *M. latidens*, *M. perimensis*, *M. pandionis*, and *M. falconeri*, have been described from the Mio-Pliocene of India: the three first-named species belong to the tetralophodont, and the two last to the trilophodont, sub-division of the genus: the two first-named species have a tendency to a pentalophodont molar formula. Of the European

* R. G. S. I. Vol. XI, p. 103.

† Ibid. p. 102: named in 'F. A. S.' *Ursitaxus*.

‡ R. G. S. I. Vol. XI, p. 102.

§ F. A. S. supl. pl. Pl.

|| Ibid.

¶ Pal. Ind. Ser. X. Vol. I. pt. 5 (in the press.)

Miocene genus *Dinotherium*, three species, *D. indicum*, *D. pentapotamiæ*, and *D. sindiense*, have been described from the Indian Mio-Pliocene: the last species presents a remarkable approximation to the mastodons in the form of its mandible.*

The perissodactyle modification of the great order Ungulata is well represented, both in genera and species, in the Indian Mio-Pliocene. Of *Rhinoceros* there are four named species, *R. iravadicus*, *R. sivalensis*, *R. palæindicus*, and *R. platyrhinus*;† the molars of the two first are constructed on the type of those of *R. sumatrensis*; those of the last on the type of those of *R. indicus; R. sivalensis* and *R. palæindicus* were unicorn, and *R. platyrhinus* was bicorn. Bones of one species have also been obtained from Tibet. The hornless rhinoceroses were represented by *Acerotherium perimense*, of which there is a fine undescribed skull from the Punjáb in the Indian Museum.‡ It is doubtful if the genus *Tapirus* is represented in the fossil state in India; a symphysis of a mandible has been figured in the second volume of the second series of the 'Transactions of the Geological Society of London' by the late Mr. Clift, and referred to *Tapirus*, but I think the determination is at least open to doubt. Molars of *Listriodon* were described in MSS. by Falconer under the name of *Tapirus* and so published in the 'Palæontological Memoirs.'§ The genus *Listriodon*|| is represented by two species, *L. pentapotamiæ* and *L. theobaldi*. The genus *Chalicotherium* is represented by one species (*C. sivalense*),¶ presenting some peculiar points in its dentition: this genus has till lately been classed with *Anoplotherium* among the Artiodactyla, but Professor Cope has lately come to the conclusion that it is a perissodactyle allied to *Palaeotherium*. The horses are represented by the genera *Equus* and *Hippotherium* (*Hipparion*). *Equus* is known by a Siwalik species (*E. sivalensis*),** never fully described, and by one from the Tibetan

* For figures and descriptions of the Indian fossil Proboscidia, see F. A. S. and Pal. Ind. Ser. X, Vol. I, pt. 5 (in the press): a jaw of *D. pentapotamiæ* was described as *Antoletherium* by Falconer.

† F. A. S. and Pal. Ind. Ser. X, Vol. I.

‡ Some molars of this species were described by myself under the name of *Rhinoceros planidens*. *R. Sivalensis* has lately been made the type of a new genus *Zalabis* by Prof. Cope, but on insufficient grounds.

§ Vol. I, p. 415.

|| Pal. Ind. Ser. X, Vol. I. and R. G. S. I. Vol. XI, p. 98 I have followed Professor Cope in classing this genus with the tapirs; Kowalewsky was inclined to place it among the artiodactyles.

¶ Pal. Mem. Vol. I, pl. XVII.

** Professor Huxley (Q. J. G. S. L. 1870, Presid. Address) remarks that *some* of the Siwalik horses show traces of a "larmial" cavity on the skull. I do not know whether this remark applies to the Siwalik or Narbada horse, but probably the former as the older.

Tertiaries: of *Hippotherium*, there are two Siwalik species, *H. antilopinum* and *H. theobaldi**: remains of the genus have also been obtained from Tibet. M. Gaudry remarks† that the Siwalik *Hippotheria* have no lateral digits; this may possibly be the case with *H. antilopinum*, but it is certainly not so with the larger *H. theobaldi*, of which there is a nearly complete tridactyle foot in the Indian Museum. *H. theobaldi* has not yet been fully described; it is very like *H. gracile*, to which species some Siwalik molars were referred by H. von Meyer‡ under the name of *Equus primigenius*.

Of the artiodactyle modification of the Ungulata, there is a still longer list in the Indian Mio-Pliocene. In the bunodont sub-division, we have *Hippopotamus* represented by two species (*H. iravadicus* and *H. sivalensis*), both belonging to the hexaprotodont sub-genus. A Siwalik bunodont (*Tetraconodon magnum*)§ is noticeable for its enormous conical premolars; this genus is probably related to *Entelodon* (*Elotherium*) of the Tertiaries of Europe and America. The true pigs (*Sus*) are represented by three species, *S. giganteus*, *S. hysudricus*, and *S. punjabiensis;* the two former were named by Falconer and Cautley, while the last name was applied by myself.|| *Sanitherium* is a small suine animal, only known by the lower molars. *Hippohyus* is a genus of suine animals whose molars present a peculiar complexity of pattern, recalling that of the molars of the horse; the genus is peculiar to the Siwaliks, where it appears to have been represented by two species.¶ The European Miocene genus *Hyotherium* is represented in the Tertiaries of Sind and Perim Island by a species which I have provisionally named *H. sindiense*.** Of the suine animals with selenodont teeth, we have, among the forms with five cusps on the molars, a species of *Anthracotherium* (*A. silistrense*)†† from Sind, the Punjáb, and Sylhet, and a species of *Hyopotamus* (*H. sindiense*)‡‡ from Sind: among the forms characterized by having only four cusps on the molars, we have four genera, *Merycopotamus*, *Chæromeryx*, *Hemimeryx*, and *Sivameryx*,§§ all peculiar to the Sind and Punjáb Siwaliks, and each known only by a single species:|||| the two last genera are at present undescribed.

* Milk-molars of this species were at first referred to a new genus, *Sivalhippus*, by myself (R. G. S. I. vol. X. pp. 31. 82).

† "Animaux Fossiles and Geologie dè l'Attique" p. 231.

‡ Palæontographica, Vol. XV, p. 17.

§ Pal. Ind. Ser. X, Vol. I.

|| R. G. S. I. Vol. XI, p. 81. A suine animal has been named by myself *Hippopotamodon*, but I am now not certain of its generic distinctness.

¶ Ibid. p. 82. ** Ibid p. 77.

†† Ibid. p. 78, a jaw of this species was described by me as *A. punjabiense*.

‡‡ Ibid. Vol. X, p. 77. §§ Ibid. Vol. XI, pp. 78, 80.

|||| Falconer in a MS. note described some teeth of *Dorcatherium*, under the name of *Merycopotamus nanus*. (Pal. Ind. Ser. X, Vol. I.)

Among the true ruminants, we have the deer family represented by several species of *Cervus*, namely, *C. triplidens*, *C. simplicidens*, and *C. latidens;* the genus of the last being somewhat doubtful. A fourth undescribed species has been named *C. sivalensis.** The genus *Dorcatherium* is represented by the two species, *D. majus* and *D. minus.*† At least one of the Siwalik deer had branching antlers with a flattened beam, somewhat like those of the living *C. duvaucellii*. *Cervus triplidens* had a large accessary column in the molars, while *C. simplicidens* was a species as large as the Káshmir stag, with a much smaller accessory molar column. A single molar in the Indian Museum seems to indicate a Siwalik representative of the genus *Palæomeryx*. The giraffes were represented in India by probably two species, one of which has been named *Camelopardalis sivalensis.*‡ Of the family Sivatheriidæ, which, with the exception of *Helladotherium*§ from the Pikermi beds of Attica, is peculiar to India, we have four genera in the Mio-Pliocene. *Hydaspitherium* is represented by probably three species, *H. megacephalum* known by the skull, which carried a massive conjoint horn-base above the occiput; and *H. leptognathus* and *H. grande*, by lower jaws and teeth. *Bramatherium perimense* is known by the skull, teeth, and jaws; this species seems to have carried a pair of horns over the occiput and a large conjoint horn-base on the frontals. *Vishnutherium iravadicum* is at present only known definitely by a fragment of a lower jaw from Burma of much smaller size than any of the other genera: it is not impossible, however, that some nondescript upper molars, in the Indian Museum, from the Punjáb, may belong to this genus. *Sivatherium giganteum* was the first known of this group of animals, and was originally described in the Society's Journal‖ as a fossil elk: several skulls of this species are known; the male carried two pairs of horns, placed like those of the living Indian four-horned antelope (*Tetraceros*), while the female was hornless. An elaborate memoir on this interesting animal has been published by Dr. Murie.¶ The molar teeth seem to be nearest to those of the giraffes, and also approach those of *Cervus megaceros* and *Alces:* Dr. Murie comes to the conclusion that the horns of *Sivatherium* were intermediate in structure between the antlers of deer and the horns of the true cavicorn ruminants, and that they probably

* Pal. Ind. Ser. X, Vol. I, Preface (in the press).

† Ibid.

‡ Remains of this species were described under the names of *C. sivalensis* and *C. affinis* by Falconer. See R. G. S. I. Vol. XI, p. 83.

§ Pal. Ind. Ser. X, Vol. I, R. G. S. I. Vol. XI, p. 90. M. Gaudry in his work, 'Les Enchainements du Monde Animal,' mentions that *Helladotherium* occurs in India: I am unacquainted on what grounds.

‖ Vol. IV, p. 506.

¶ Geol. Mag. Vol. VIII, p. 438.

carried a deciduous sheath like those of the living American prong-buck (*Antilocapra*). Of the antelopes, several species have been described, the largest of which (*A. palæindica,*)* is supposed to have presented affinities to some African forms; *A. sivalensis*† is allied to the Indian blackbuck (*A. cervicapra*); while *A. patulicornis* and *A. acuticornis* do not appear to come close to any living forms. Other molar teeth belong to a species of *Portax*, now only represented by the living nilghai of India. Others again are like those of *Palæoryx*, a genus of antelopoid animals described from the Pikermi beds of Attica; this determination, owing to the absence of skulls and the great difficulty of precisely determining isolated ruminant teeth, is only provisional. The oxen are represented by five genera, among which *Hemibos* is represented by three species, *H. occipitalis*, *H. acuticornis*, and *H. antilopinus*:‡ this genus is peculiar to the Siwaliks, and connects the oxen and antelopes. *Leptobos falconeri* is another species of antelopoid oxen, known by some crania. The genus *Bubalus* is represented by *Bubalus platyceros*, a species with horns concave superiorly; and, in the highest Siwalik, by *B. palæindicus*, which is extremely close to the living wild buffalo of Assam. Of the genus *Bison*, there is only one species in the Siwaliks, which has been named *B. sivalensis*, and which seems to have been related to the extinct European *B. priscus*. Of the true oxen (*Bos*) there are three Siwalik species, namely, *Bos acutifrons* remarkable for its enormous horns and angulated forehead; *B. planifrons* with shorter horns and a flattened forehead, and allied to the gigantic *Bos primigenius* of Europe; and *Bos platyrhinus* only known by the lower half of a skull, and of which the generic affinities are doubtful. There seem to have been four species of goats in the Indian Tertiaries, most of which are probably of Pliocene age, *viz.*, an unnamed species with horn-cores very like those of the Himalayan *Capra falconeri* (markhor), and two named species, *C. sivalensis* and *C. perimensis*, both of which are only known by frontlets and horn-cores: the fourth species has been described by Professor Rütimeyer under the name of *Bucapra daviesii*. No remains of the genus *Ovis* have hitherto been described from the Sub-Himalayan or other Indian Siwaliks, but a cranium obtained from the presumably Siwalik strata of Tibet has been referred by the late Mr. Blyth to this genus. The genus *Camelus* is known by *C. sivalensis*, which presents a pe-

* Pal. Mem. Vol. I, pl. 23.

† Pal. Ind. Ser. X, Vol. I. Two species (*A. picta* and *A. gyricornis,*) were named in MSS. by Falconer.

‡ These three species have been also described under the generic names of *Probubalus*, *Amphibos*, and *Peribos*; the synonomy will be found in the first volume of the tenth series of the 'Palæontologia Indica,' where all the other Indian fossil ruminants are noticed. Part of this volume is still in the press.

culiarity in the lower molars, connecting it with the American auchenias, and distinguishing it from the other old-world camels.* The similarity of the lower molars of the Siwalik camel and *Auchenia* is very noteworthy, since America is supposed to have been the original home of the *Camelidæ:* this supposition is supported by the connection between the living American camels (*Auchenia*) and the Pliocene old-world camels.

The other orders of Mammalia are only represented by a few species of Rodentia and one of Edentata. Among the rodents, a rat (*Mus*) is mentioned by Falconer as a member of the Siwalik fauna. A species of bamboo-rat (*Rhizomys sivalensis*)† has been named by myself, from some lower jaws collected by Mr. Theobald in the Punjáb. A porcupine (*Hystrix sivalensis*) is known by a part of a cranium and a lower jaw.

The edentates are only known by one species of pangolin (*Manis sindiensis*), which has been named on the evidence of a solitary phalangeal bone from Sind.‡

The Mio-Plocene mammalian fauna of India, as a whole, is characterized by the great number of forms belonging to the orders including animals of large corporeal bulk, and also by the admixture of modern African and Miocene European genera with those now peculiar to India. The Proboscidia and the perissodactyle Ungulata, now so sparingly represented on the globe, were abundant in Mio-Pliocene India, and were probably the dominant forms: the ruminants have now diminished somewhat in numbers in several groups, but not to such a striking extent as the proboscidians. The selenodónt hogs, like *Merycopotamus* and *Anthracotherium*, belong to a group which has completely passed away, while their congener the hippopotamus is now confined to Africa. Of the larger mammals now inhabiting India, nearly all are generically represented in the Pliocene, while forms, like *Anoa* (the living representative of *Hemibos*), inhabiting neighbouring countries seem to have descended from Indian ancestors. The micro-mammalia are practically unrepresented in the Mio-Pliocene, but this is probably due to the smaller chance of their remains being preserved in a fossilized condition, or, if so preserved, of being discovered.

Pleistocene.

The mammals of the Pleistocene of India are as yet even less well known than those of the Mio-Pliocene, owing to the smaller areas in which

* A second species of Siwalik camel was named in MSS. *C. antiquus* by Falconer. This species cannot now be identified.

† For descriptions of this and other Siwalik rodents, see R. G. S. I. Vol. XI, p. 100. *Rhizomys* is probably the same as *Typhlodon* of Falconer.

‡ Pal. Ind. Ser. X, Vol. I.

they are found. It seems, however, even with our present knowledge, to be pretty safe to say that the numerical strength of species of the larger mammals so characteristic of the Mio-Pliocene had disappeared in the Pleistocene. From the older alluvium of the Jamna river, mammalian bones have been obtained in considerable quantities, but only two species have been satisfactorily determined; the remaining bones have only been generically named, and are, therefore, not referred to here, as it is in many cases impossible to say whether they belong to living or to extinct species. The presence of *Hippopotamus* remains in a stratum is pretty good evidence of such stratum being not newer than the Pleistocene. The discovery of a molar and canine of this genus in the alluvia of the Pemganga river, by Mr. Fedden, consequently shows that some of those deposits should be referred to the Pleistocene. In many cases, as in the delta of the Ganges, it is often most difficult, or impossible, to draw the line between the Pleistocene deposits and the Recent alluvium of the same area.

In the laterite of Madras, stone implements, and a human tibia have been found by Mr. Foote, and are assigned to the Pleistocene by Professor Boyd-Dawkins. Stone implements have likewise been obtained from the ossiferous beds of the Narbada valley, in association with the remains of extinct mammals. The mammalian fauna of the Narbada beds comprises, among the Carnivora, a species of bear *(Ursus namadicus)*, named by the authors of the 'Fauna Antiqua Sivalensis' on the evidence of a portion of the maxilla with the molar dentition: this specimen is now in the British Museum, presented by Captain Frazer.* Among the Proboscidia, we have the extinct *Euelephas namadicus*, characterized by the extraordinary ridge on the forehead; the molars of this species are very like those of the European *Elephas antiquus*, from which Professor Leith Adams has thought that the Indian and European forms might belong to the same species. *Stegodon* was represented by *S. ganesa* and, possibly, by *S. insignis*. Among the fossil perissodactyles of the Pleistocene, we have *Rhinoceros deccanensis*† of Mr. Foote from the Deccan, a species without permanent lower incisors, and shewing African affinities; and from the Narbada the living *R. indicus*, remains of which were at first named *R. namadicus*. A third species *(R. namadicus)* probably also existed in the Pleistocene. The horses are represented by *Equus namadicus*,‡ as yet not fully described. Among

* F. A. S. plate O. I have elsewhere mentioned a species of *Felis* from the Narbada beds, the determination having been made on the evidence of the olecranal portion of an ulna in the old collection of the Geological Survey; the history of the specimen is, however, unknown, and from its mineral condition I am by no means sure that it is from the Narbada.

† Pal. Ind. Ser. X, Vol. I.

‡ Faun. Ant. Siv. *E. palæonus* seems to be the young of *E. namadicus*.

the artiodactyles, we find two species of *Hippopotamus*, one of which (*H. namadicus*) belongs to the hexaprotodont type, while the other (*H. palæindicus*) is tetraprotodont, like the larger living species;* *H. palæindicus* has also been found in the older alluvia of the Jamna. The pigs seem to have been represented by *Sus giganteus*.† A species of stag was named by Falconer *Cervus namadicus*, but never described; a single molar from the Narbada in the Indian Museum is indistinguishable from the corresponding tooth of the living *C.* (*Rucervus*) *duvaucellii*. Three species of Narbada oxen have been described, *viz.*, *Bos namadicus* of Falconer and Cautley, a taurine ox showing some affinities to the living Asiatic genus *Bibos*, also occurring in the Pem-ganga alluvium and, possibly, in the Deccan; *Bubalus palæindicus* of the same authors, very closely allied to the living wild Indian buffalo, also found in the Jamna alluvium; and *Leptobos frazeri* of Professor Rütimeyer. A species of nilghai (*Portax*) has lately been described by the same writer from the Narbada rocks, under the name of *P. namadicus*; teeth of the same genus have also been obtained from the Pem-ganga alluvium.

The Pleistocene rodents are only represented by some incisors probably belonging to the genus *Mus*, obtained from the Narbada valley, and now in the Indian Museum.

Recent.

The Recent deposits have not yet, as I have said, in many cases been satisfactorily separated from the Pleistocene, and the very local occurrence of mammalian bones renders this point of doubt one not likely to be soon cleared up. Any alluvial deposits of bones from which *Hippopotamus* is absent, and which do not contain any other extinct animals, I should be disposed to class as Recent.

Human remains have been obtained in the alluvium of the plains in various localities, at considerable distances below the surface, but generally in very imperfect condition. Specimens of the teeth and jaws of *Macacus rhesus* are exhibited in the Indian Museum, obtained from the alluvia of Assam and Madras; those from the former locality are in a highly mineralised condition. Molars of the Indian elephant have been obtained in the alluvium of the plains of India, and in that of the delta of the Irawadi. A last upper molar of *Rhinoceros indicus* has been obtained by Mr. Foote in the alluvium of Madras: this specimen is very interesting as shewing the former range of that species far to the south of its present habitat, which Jerdon gives as "the Terai from Bhotan to Nepal." *Sus*

* The smaller Liberian hippopotamus (*Chæropsis*) has only two lower incisors.

† The authority for introducing this species in the Narbada fauna is the specimen drawn in plate LXX, fig. 8. of the F. A. S.

indicus has also been obtained by Mr. Foote in the same formation. *Antilope cervicapra* is represented by a fossil horn-core in the Indian Museum whose exact locality is uncertain. Antlers, horn-cores, and teeth of species of *Bos* and *Cervus* have been obtained from alluvia of various parts of the plains, and from raised beaches on the Kattiawar (Kattywar) coast; as, however, these specimens are not yet specifically determined, no more can be said about them.

List of the Fossil Vertebrata of India and Burma.

The following list exhibits in a systematic form all the well-established species of Indian and Burman fossil vertebrata, together with the best authenticated of the unnamed species with which I am acquainted. For the great divisions of geological times, the terms Anthropozoic (Age-of-Man), Theriozoic (Age-of-Mammals), Saurozoic (Age-of-Reptiles), and Ichthyozoic (Age-of-Fishes), have been employed in lieu of the old terms Post-Tertiary, Kainozoic, Mesozoic, and Palæozoic, as being more applicable to a chronology of vertebrate evolution, and as forming a series of symmetrical terms.

I. ANTHROPOZOIC (POST-TERTIARY).

1. Recent Alluvia.

MAMMALIA.	Primates.	Homo (sapiens ?). Plains.
		Macacus rhesus. Gúlpara and Madras.
	Proboscidia.	Euelephas indicus. India and Burma.
	Ungulata.	Rhinoceros indicus. Madras.
		Sus indicus. Madras.
		Cervus. Kattiawar.
		Antilope cervicapra. Ganges Valley. (?)
		Bos. sp. Kattiawar and Plains.
REPTILIA.	Chelonia.	? (plates) Calcutta.

Other undetermined remains of, probably, recent species.

2. Pleistocene.

MAMMALIA.	Primates.	Homo. sp. Narbada (weapons) and Madras (weapons and bones).
	Carnivora.	Ursus namadicus. (F. and C.) Narbada.
	Proboscidia.	Euelephas namadicus. (F. and C.) Narbada.
		Stegodon ganesa. (F. and C.) Narbada.
		——— ? insignis. (F. and C.) Narbada.
		? Mastodon pandionis. (Falc.) Deccan.
	Ungulata.	Rhinoceros deccanensis. (Foote.) Deccan.
		——— indicus. (Cuv.) Narbada.
		——— namadicus. (F. and C.) Narbada.
		Equus namadicus. (F. and C.) Narbada.

MAMMALIA.	UNGULATA.	Hippopotamus namadicus. (F. and C.) Narbada.
		——— palæindicus. (F. and C.) Nar. and J.
		——— sp. P: G.
		Sus giganteus. (F. and C.) Narbada.
		Cervus sp (? duvancellii) (Narbada).
		Bubalus palæindicus (F. and C.) Narbada and J.
		Bos namadicus. (F. and C.) Narbada. P: G. and (?) Deccan.
		Leptobos frazeri. (Rüt.) Narbada.
		Portax namadicus. (Rüt.) Narbada. and P: G.
	RODENTIA.	Mus. sp. Narbada.
REPTILIA.	CROCODILIA.	Crocodilus (?) sp. Narbada.
	CHELONIA.	Pangshura tectum. (Bell. sp.) Narbada.
		Batagur (? dhongoka) Narbada.
		Trionyx (? gangeticus.) Narbada.

II. THERIOZOIC (KAINOZOIC.)

1. PLIO-MIOCENE.

MAMMALIA.	PRIMATES.	Palæopithecus sivalensis. (Lyd.) S.
		Macacus sivalensis. (Lyd.) S.
		——— sp. S.
		Semnopithecus subhimalayanus. (Myr.) S.
		——— sp. S.
	CARNIVORA.	Felis cristata. (F. and C.) S.
		—— grandicristata. (Bose.) S.
		—— sp. S.
		Machairodus sivalensis. (F. and C.) S.
		——— palæindicus. (Bose) S.
		Pseudælurus sivalensis. (Lyd.) S.
		Ictitherium sivalense. (Lyd.) S.
		Viverra bakerii. (Bose.) S.
		Hyæna sivalensis. (F. and C.) S.
		——— felina. (Bose.) S.
		Canis curvipalatus. (Bose.) S.
		—— cautleyi. (Bose.) S.
		Amphicyon palæindicus. (Lyd.) S. Sd.
		Ursus. sp. S.
		—— sp. I.
		Hyænarctos sivalensis. (F. and C.) S. Sd.
		——— palæindicus. (Lyd.) S.
		Mellivora sivalensis. (F. and C.) S.
		Meles, sp. (Lyd.) S.

MAMMALIA. CARNIVORA. Lutra palæindica. (F. and C.) S.
Enhydriodon sivalensis. (F. and C.) S.

PROBOSCIDIA. Euelephas hysudricus. (F. and C.) S.
Loxodon planifrons. (F. and C.) S.
Stegodon ganesa. (F. and C.) S.
——— insignis. (F. and C.) S.
——— bombifrons. (F. and C.) S.
——— cliftii. (F. and C.) S.
Mastodon sivalensis. (F. and C.) S.
——— latidens. (F. and C.) S. I. Sd. P.
——— perimensis. (F. and C.) S. Sd. P.
——— pandionis. (F.) Sd. S. P.
——— falconeri. (Lyd.) Sd. S.
Dinotherium indicum. (Falc.) S. P.
——— pentapotamiæ. (Falc.) S.
——— sindiense. (Lyd.) Sd. S.

UNGULATA.

Perissodactyla.
Chalicotherium sivalense. S. Sd.
Rhinoceros iravadicus. (Lyd.) I.
——— palæindicus. (F. and C.) S.
——— platyrhinus. (F. and C.) S.
——— sivalensis. (F. and C.) S. Sd.
——— sp. Tibet.
Acerotherium perimense. (F. and C.) P. Sd. S. I.
Listriodon pentapotamiæ. (Falc. sp.)
——— theobaldi. (Lyd.) S.
(?) Tapirus, sp. (Clift.) I.
Equus sivalensis. (F. and C.) S.
——— sp. Tibet.
Hippotherium antilopinum. (F. and C.) S.
——— theobaldi. (Lyd.) P. S. Sd.
——— sp. Tibet.

Artiodactyla.
Hippopotamus iravadicus. (F. and C.) I.
——— sivalensis. (F. and C.) S.
Tetraconodon magnum. (Falc.) S.
Sus giganteus. (F. and C.) S.
— hysudricus. (F. and C.) S. P. Sd.
— punjabiensis. (Lyd.) S.
Hippohyus sivalensis. (F. and C.) S.
——— sp. S.
Sanitherium schlagintweitii (Myr.) S.
Hyotherium sindiense (Lyd.) Sd.
Anthracotherium silistrense. (Pent.) Sy. S. Sd.
Hyopotamus palæindicus. (Lyd.) Sd.

MAMMALIA. UNGULATA. Artiodactyla.

Merycopotamus dissimilis. (F. and C.) S.
Chæromeryx silistrensis. (Pom.) Sy.
Hemimeryx, sp. (Lyd.) Sd.
Sivameryx, sp. (Lyd.) Sd.
Cervus triplidens. (Lyd.) S.
——— sivalensis. (Lyd. Mss.) S.
——— simplicidens. (Lyd.) S.
——— (?) latidens. (Lyd.) S.
Dorcatherium majus. (Lyd.) S.
——— minus. (Lyd.) S.
Palæomeryx, sp. (Lyd.) S. Sd. (?)
Camelopardalis sivalensis. (F. and C.) S. P.
——— sp. S.
Hydaspitherium grande. (Lyd.) S.
——— leptognathus. (Lyd.) S.
——— megacephalum. (Lyd.) S.
Bramatherium perimense. (Falc.) P.
Sivatherium giganteum. (F. and C.) S.
Vishnutherium iravadicum (Lyd.) I. S. (?)
Antilope palæindica. (F. and C.) S.
——— patulicornis. (Lyd.) S.
——— porrecticornis. (Lyd.) S.
——— sivalensis. (Lyd.) S.
? Palæoryx, sp. (Lyd.) S.
Portax, sp. (Lyd.) S.
Hemibos occipitalis. (Falc. sp.) S.
——— acuticornis. (Falc. sp.) S.
——— antilopinus. (Falc. sp.) S.
Leptobos falconeri. (Rüt.) S.
Bubalus platyceros. (Lyd.) S.
——— palæindicus. (F. and C.) S.
Bison sivalensis. (Falc. MSS.) S.
Bos acutifrons. (Lyd.) S.
—— planifrons. (Lyd.) S.
—— platyrhinus. (Lyd.) S.
Bucapra daviesii. (Rüt.) S.
Capra perimensis. (Lyd.) P.
—— sivalensis. (Lyd.) S.
—— sp. (Lyd.) S.
? Ovis, sp. (Blyth.) S. T.
Camelus sivalensis. (F. and C.) S.

MAMMALIA.	RODENTIA.	Mus. sp. S.
		Rhizomys sivalensis. (Lyd.) S.
		Hystrix sivalensis. (Lyd.) S.
	EDENTATA.	Manis sindiensis. (Lyd.) Sd.
AVES.	CARINATÆ.	Graculus (?), sp. (Dav.) S.
		Pelecanus cautleyi. (Dav.) S.
		——— ? sivalensis. (Dav.) S.
		Megaloscelornis sivalensis (Lyd.)
		Megaloscelornis. (?) sp. Sd.
		Argala falconeri (M. Ed.) S.
	RATITÆ.	Struthio asiaticus. (M. Ed.) S.
		Dromæus sivalensis. (Lyd.) S.
		Gen. indet. (Brit. Mus. Col.) S.
REPTILIA.	CROCODILIA.	Crocodilus palustris (Less.) S. P.
		——— sp. I.
		Gharialis gangeticus (Gmel.) S. Sd. I.
		——— leptodus (F. and C.) S.
		——— crassidens. (F. and C.) S. Sd.
	LACERTILIA.	Varanus sivalensis. (Falc.) S.
	OPHIDIA.	Gen. indet. S. Sd.
	CHELONIA.	Colossochelys atlas. (F. and C.)
		Testudo (?), 5 sp. S.
		Bellia sivalensis. (Theo.) S.
		—— sp. S.
		Damonia hamiltonoides. (Falc. sp.) S.
		Emys, sp. S.
		Cautleya annuliger. (Theo.) S.
		Pangshura tectum. (Bell. sp.) S.
		Batagur, sp. S.
		Trionyx, sp. S. I. P.
		Emyda vittata. (Pet.) S.
		——— sp. S. I. P.
PISCES.	ELASMO-	Carcharias, sp. I.
	BRANCHII.	Lamna, sp. Sd.
		? (vertebræ.) P.
	?	? (palatal teeth) S. Sd.
	TELEOSTEI.	Chaca (?), sp. S.
		? (vertebræ.) S. Sd.

2. EOCENE (INTRATRAPPEAN AND NUMMULITIC).

MAMMALIA.	UNGULATA.	(perissodactyle femur). Punjáb.
		(artiodactyle astragalus) Punjáb.

REPTILIA.	CROCODILIA.	(teeth and vertebræ) Punjáb.
	CHELONIA.	Hydraspis leithii (Carter sp.) Bombay.
BATRACHIA.	ANOURA	Oxyglossus pusillus. (Owen. sp.) Bombay.
		——— (?) sp. Bombay.
PISCES.	ELASMOBRANCHII.	Myliobatis, sp. (Lyd.) Punjáb.
	TELEOSTEI.	Diodon foleyi, (Lyd.) Ramri I. and Pt. Blair.
		Capitodus indicus. (Lyd.) Punjáb.
		? (Cycloid scales) Nr. Thayetmyo.

III. SAUROZOIC (MESOZOIC).

1. CRETACEOUS SERIES.

REPTILIA.	DINOSAURIA.	Megalosaurus, sp. (Lameta and Trichinopoli)
		Titanosaurus blanfordi. (Lyd.) Lameta gp.
		——— indicus. (Lyd.) Lameta gp.
		? (unknown reptile.) Lameta gp.
	CROCODILIA.	(amphicælian sp.) (Lyd.) Sind.
	CHELONIA.	? (plates.) Lameta, Rajamahendri, and Sind.
	ICHTHYOSAURIA.	Ichthyosaurus indicus. (Lyd.) Trichinopoli.
PISCES.	ELASMOBRANCHII.	Corax incisus. (Eg.) Trichinopoli.
		—— pristodontus. (Ag.) Trichinopoli.
		Enchodus serratus. (Eg.) Trichinopoli.
		Lamna complanata. (Eg.) Trichinopoli.
		—— sigmoides. (Eg.) Trichinopoli.
		Odontaspis constrictus. (Eg.) Trichinopoli.
		——— oxypeion. (Eg.) Trichinopoli.
		Otodus basalis. (Eg.) Trichinopoli.
		——— divergens. (Eg.) Trichinopoli.
		——— marginatus. (Eg.) Trichinopoli.
		——— minutus. (Eg.) Trichinopoli.
		——— nanus. (Eg.) Trichinopoli.
		——— semiplicatus. (Eg.) Trichinopoli.
		Oxyrhina triangularis. (Eg.) Trichinopoli.
		——— sp. (Stol.) Trichinopoli.
		Ptychodus latissimus. (Ag.) Trichinopoli.
	GANOIDEI.	Pycnodus (?), sp. (Stol.) Trichinopoli.
	?	? (scales) Lameta.
	?	? (scales) Intratrappean. Rajamahendri.

2. JURA-TRIASSIC SERIES.

REPTILIA.	DINOSAURIA.	Ankistrodon indicus (Hux.) Panchet gp.
	CROCODILIA.	(amphicælian sp.) (Lyd.) Chari gp.

REPTILIA.	CROCODILIA.	Parasuchus, sp. (Hux.) (hislopii. MSS.) Maleri gp.
		—— ? sp. (Lyd.) Denwa gp.
	LACERTILIA.	Hyperodapedon, sp. (Hux.) Maleri gp.
	DICYNODONTIA.	Dicynodon orientalis. (Hux.) Panchet gp.
		———— sp. Panchet gp.
	PLESIOSAURIA.	Plesiosaurus indicus (Lyd.) Umia. gp.
BATRACHIA.	LABYRINTHODONTIA.	Brachyops laticeps. (Ow.) Mangli. gp.
		Gonioglyptus longrostris. (Hux.) Panchet gp.
		Pachygonia incurvata (Hux.) Panchet gp.
		Archegosaurus (?) Bijori gp.
PISCES.	DIPNOI.	Ceratodus hislopianus. (Old.) Maleri gp.
		———— hunterianus. (Old.) Maleri gp.
		———— virapa. (Old.) Maleri gp.
	GANOIDEI.	Dapedius egertoni. (Syk.) Kota gp.
		Lepidotus breviceps. (Eg.) Kota gp.
		———— calcaratus. (Eg.) Kota gp.
		———— deccanensis. (Eg.) Kota gp.
		———— longiceps. (Eg.) Kota gp.
		———— pachylepis. (Eg.) Kota gp.
		Tetragonolepis analis. (Eg.) Kota gp.
		———— oldhami. (Eg.) Kota gp.
		———— rugosus. (Eg.) Kota gp.
	?	? (Scales) Srípermatúr gp. Kota gp.

IV. ICHTHYOZOIC (PALÆOZOIC).

1. CARBONIFEROUS.

PISCES.	GANOIDEI.	Sigmodus dubius. (Waag.)	Salt-range.
	ELASMOBRANCHII.	Poecilodus paradoxus. (Waag.)	Salt range.
		Psephodus indicus. (Waag.)	do.
		Helodopsis elongata. (Waag.)	do.
		———— abbreviata. (Waag.)	do.
		Psammodus, sp.	do.
		Petalorhyncus indicus. (Waag.)	do.
		Xystracanthus gracilis. (Waag.)	do.
		———— major. (Waag.)	do.
		———— giganteus. (Waag.)	do.
		Thaumatacanthus blanfordi. (Waag)	do.

Abbreviations used in the above.

Ag. = Agassiz; Dav. = Davies; Eg. = Egerton; F. and C. = Falconer and Cautley; Gmel. = Gmelin; Hux. = Huxley; I. = Irawadi

(Irrawaddy) valley, Burma; J. = Jamna; Less. = Lesson; Lyd. = Lydekker; M. Ed. = Milne-Edwards; Myr. = Herman von Meyer; Old. = Oldham; Ow. = Owen; P. = Perim Island, gulf of Cambay; Pent. = Pentland; P: G. = Pem-ganga; Pet. = Peters; Pom. = Pomel; Rüt. = Rütimeyer; S. = Siwaliks (including Punjáb); Sd. = Sind; Stol. = Stoliczka; Sy. = Sylhet; Syk. = Sykes; T. = Tibet; Theo. = Theobald; Waag. = Waagen.

Conclusion.

In the foregoing sketch of the fossil vertebrata of India, but few new facts have been recorded, and, indeed, the main objects in penning it were the hope, firstly, of inducing persons interested in scientific enquiries to aid us in our endeavours to increase our knowledge of this interesting branch of science, and, secondly, of making one of those landmarks, so necessary in an ever-increasing subject like the present, from whence new advances can again be made. With regard to the first object, it may be observed that District Officers in India, and other officials, in the course of their periodical professional tours through the country, have far greater opportunities of collecting the larger and more conspicuous fossils than can possibly fall to the lot of the officers of the Geological Survey of India, who are few in number, and who, for years together, are not called upon to visit many parts of the country. To all who have opportunities of travelling through unfrequented parts of India likely to contain fossil remains, the appeal is here made for assistance in our endeavours to obtain a more complete knowledge of the fossil vertebrata of India. Any fossils sent to the Superintendent of the Geological Survey of India (Calcutta) will be most gratefully received, and, after comparison or description, either returned to their owners, or, if presented, carefully preserved in the collection of the Indian Museum.

Note.—Additions to this paper have been made while it was passing through the press, bringing it up to date.

V.—*Account of the Verification of some Standard Weights with considerations on Standard Weights in general.*—*By* Col. J. F. Tennant, R. E., F. R. S., *Master of Her Majesty's Mint.*

(Recd. Jan. 5th;—Read Feb. 4th, 1880.)

When I first contemplated the verification of a series of weights from a primary standard, I had little information as to procedure, and indeed I have till now had little as to details. I had intended in this paper to deal with the verification of a whole series of ounce weights; but circumstances beyond my control have delayed the latter portion, and I think that probably this shorter paper will be as much as the patience of my readers will stand: in it are described, with examples, all the cases I shall meet; while the explanations will, I trust, enable any one to follow my procedure and somehow to verify any other set of weights. This end being gained, the delay of the paper to add the numerical results of farther work, would add little to its popular, or even scientific value, and this circumstance has induced me to offer it in its present state to the Asiatic Society.

I am aware that I am open to the charge of excessive (factitious) accuracy, and I freely admit that I have used an excessive number of decimal places; but the number was originally fixed by the fact that it caused no trouble and saved thought. The difference between the trouble of dealing with 5 or 6 figures and 4 with an arithmometer is, in my case, more than compensated by the absence of the absolute necessity of watching the increase of the last figure: and too, I had not, till I had gone some way with these weighings, so clear an idea of the probable errors as I now have. The systematic calculation of these is, so far as I know, new: it has taught me much, and guided me where I might have gone wrong. I think that it should always be carried out; but of course, the foundation of the calculation—the estimation of the probable error of one comparison, will not commend itself to all men:—those who in other respects may follow my procedure may prefer a different course in this, and, when the system of weighment is different, this datum must be determined in a correspondingly different manner. Even then, I hope, that the conclusions I have come to may have their use, for the evidence they offer of the rapid accumulation of error in multiplying from a small primary standard, is quite independent of the amount ascribed to the error of one comparison.

I have added the Tables requisite in reducing the comparison of weights of varying density and in determining specific gravity. These are deduced from the same data precisely as those used in the British Standards Department, but I have employed Fahrenheit's thermometer, the English inch, and the English grain, because, to me, those units were more accessible (as they will be to most readers of the English language) and not because I prefer them. I have thought that it was more important to avoid conversions of the data before using them than to adhere to general considerations; just as (with the late Warden of the Standards) I have preferred uniformity of data for reduction; rather than a possible scientific accuracy, which is, after all, not demonstrably gained.

SECTION I.—*On Weights.*

In May 1879, I received from England a set of Bullion Weights of gilt bronze, with their errors on the Commercial Standard of England roughly given, and a Troy Ounce of Platinum-iridium, with its error in vacuo in terms of the Parliamentary Standard Pound P S. I at the same time received a set of Metric Weights of Platinum-iridium from 100 grammes to one milligram, with their errors in terms of the Kilogramme des Archives, which is the Normal Standard weight of France. My paper here will be confined to dealing with some of the Bullion Weights: and it will be necessary in order to understand the procedure I follow, and also the scientific principles of weighing, that I should give an account of the English system of weights.

Ordinary weights are made of brass, iron, or some other cheap metal, but all these are liable to oxidation, and thus none of these metals is suitable for a Standard. The metal chosen for the English Standard was platinum, which is nearly indestructible. Since then it has been found that, whereas platinum is soft, an alloy with iridium is hard, has the other advantages of platinum, and can be made with sufficient readiness for the purpose required: this alloy is used in my Primary Standards as it is in the European Standards now being made in Paris. The use of such substances for Standard Weights, however, leads to some complication: these metals are heavy; while the metals and alloys ordinarily used are comparatively light. Now the weight of a body in air is different from its weight in vacuo by the weight of the air displaced, and this varies with the state of the atmosphere: consequently the relative weight of a pound of brass and one of platinum, which are alike in vacuo, will, in air, be found to vary continually relatively to each other. In order to avoid the inconvenience of this, it has been found desirable that the Commercial Standard should be of brass or bronze; both of which, having nearly the same density as the metals used in ordinary weights, will show the same differences at all times and places, with sufficient accuracy for commercial purposes; and which, moreover, are cheap enough to allow of the weights of all sizes being made of them. For general Standard purposes, weights are now made of gilt bronze, the gilding preserving them to a great extent from changing by oxidation.

As the Parliamentary Standard of England P S. has its true weight in vacuo,* the first impression would be, that the Commercial Standard in ordinary air should weigh the same as P S. in vacuo: but this has not been the practical solution. When the Houses of Parliament were destroyed in 1834, the English standards were destroyed in them, and the new Standard was meant to be a restoration of the old one. Now the old Standard was a brass Troy Pound made in 1758, of which there were a variety of copies more or less accurate. On the evidence from these, and some other sources, was determined the difference between the lost pound and a piece of platinum, both taken in vacuo. Then (the Government of the day having determined that the new Standard should represent the Avoirdupois, and not the Troy Pound as before), a second piece of Platinum P S. was made which should weigh very nearly 7000 such grains as those of which the destroyed Pound (U) contained 5,760, both being taken in vacuo, and it is believed that the result was accurate to a very small fraction of a grain, thanks to the great labours of Professor Miller. In reverting to the Commercial Pound, that would be 7,000 grains of which U weighed 5,760, both taken in air, and then, as the density of the new commercial Pound was very close to that of U, all sensible uncertainty arising from the destruction of U and the impossibility of knowing its exact density would vanish.

Professor Miller found the Platinum Pound P S. to be 7000·00093 grains of U both weighed in vacuo, and by Act of Parliament, *this* was declared to be the true standard of weight, and that one grain should be a seven-thousandth part of it. The Commercial Pound W was an imaginary Pound, supposed to be made of brass of a density of 8·15034, which was what Professor Miller estimated as the density of the lost Pound U. Though the standard in vacuo was changed, as above, by a minute quantity, it would have been wrong to change the weight of W in air. In order then that its weight in vacuo should become that of the Pound P S., it became necessary to suppose that this weight in vacuo†, and consequently its density, were changed, and to ascribe to it a new density of 8·1430.

The present definition of the English Commercial Pound then is—

* I have followed the wording of my predecessors, but I should prefer to call the "*weight in vacuo*" the "*Mass,*" and restrict the term "*weight*" to the apparent force exercised. If this distinction were made, the questions involved would be much clearer. The Parliamentary Standard has been treated as one of *Mass;* hence two of the gilt secondary standards, each of the same Mass as P. S., will not have ordinarily the same *weight*, unless they have the same specific gravity.

† The weight in vacuo was 7000 grains of U, and in consequence of the Act of Parliament it became necessary that it should be the same as that of P S. or 7000·00093 grains of U.

The weight in standard air of a piece of brass whose weight in vacuo is the same as that of P S., and whose density, compared with that of water at its maximum density (the brass being at the freezing point), is 8·1430.

If we know the value of a weight in terms of P S., we shall be able to find its value in terms of W by adding the weight of air displaced by the same weight of brass similar to that of which W is supposed to be made, and deducting that actually displaced by the weight to be determined.

The Standard Platinum-Iridium ounce sent me is certified to weigh (in vacuo) 479·95979 grains in terms of P S., and the density has been assumed as 21·414, which is that of the 100 gramme weight. In English Standard Air its weight is given as 480·00502 grains, but that datum is useless for purposes of reference. It is called E I in the books of the Standards Office in London, and I propose to retain this name.

The ounce weight of the bullion set was certified to weigh 480·00145 grains in vacuo in terms of P S. and 480·00203 grains in English Standard Air in terms of W.

The following matter must be borne in mind in order that the procedure in my weighments may be understood:

The sign = means that the weights on each side of it are equal in vacuo.

The sign ≡ means that these are equal in air at the time; and, in the case of Commercial Weights, that they are sufficiently equal for practical purposes at all times.

The sign ≏ means that the weights on each side being in the respective pans of the balance there would be equilibrium. When no division of the scale is mentioned as the resting point, it is assumed to be 10 for Oertling No. 1 and 15 for Oertling No. 2.

O_n is one of the set of Gilt Bullion Weights—the subscript number denotes its nominal value in Troy ounces.

P_n is one of a set of grain weights which have been used for small quantities, and *n* is the number of grains nominally: all weights not less than 1 grain are of platinum and have been cleaned by incandescence in a spirit-lamp. The tenths of grains are of aluminum and the hundreths of uncertain material.

R_1 and R_2 are two riders (approxinately of one-tenth of a grain each) used with the balance Oertling No. 1.

The Tables I have used in my reductions have been calculated by myself to the units of the Barometer and Thermometer scales commonly used in England, and which it was most easy for me to refer to. That for the density of air, has been calculated from the formula given by Professor Miller, in his paper in the Philosophical Transactions, with the necessary changes for units, and for the position of Her Majesty's Mint at Calcutta. The density of water has been calculated from a formula similar to Professor Miller's; but with the constants deduced from the new Tables of the British Standards Office. The other Tables, for the expansion of metals, are deduced from the same data as those of Professor Miller, but the form makes them more compact and convenient without any loss of accuracy. All will be found at the end.

SECTION II.—*The Balances.*

Oertling No. 1 is a chemical balance by Oertling with a beam 365 m. m. (14·56 inches) between the extreme knife edges. The principal knife edge is 28 m. m. (1·1 inches) long and the smaller ones 16·5 m. m. or 0·65 inches; all are of agate resting on agate planes. The beam is divided for the use of riders, and I have satisfied myself that the divisions are sufficiently accurate for this purpose. The scale is placed on the lower part of the pillar, and is read by a long index attached to the centre of the beam: this is in my opinion, the best arrangement.

Oertling No. 2 is a balance whose beam carries knife edges 404 m. m (15·9 inches) apart. The central knife edge is 38·4 m. m ($1\frac{1}{2}$ inches) long and those at the ends, 22 m. m or 0·87 inches. They are all of agate and rest on agate planes. The beam is very strong, and divided with sufficient accuracy for the use of a rider. There is an index of soft iron at each end of the beam to read an ivory scale. The left scale had very fine graduations and appeared to me useless. I have substituted a better one and removed the right scale.

SECTION III.—*Density of O Set of Weights.*

In order to compare O_1 with EI it is necessary to have a density of O_1: I have determined that of O_3 and assumed it to be the same as that of O_1 and of the other O weights.

It appears from the papers received from the Standards Office that O_3 = 3 Troy ounces = 1440 grains with sufficient accuracy for this purpose, its exact value will be seen later.

On July 4th 1879, the balance Oertling No. 1 having been prepared for taking specific gravities, and a platinum hook, intended to support O_3 in water, having been hung by a fine wire of platinum so as to be immersed in distilled water; O_3 was placed in the pan in air, and counterbalanced with weights. O_3 being then placed in the hook, and all air bubbles carefully removed, it was found that; X being about 1490·2 grains:

$X \triangleq O_3$ in water (temp. = 84°. 1) + hook &c. in water + $(O_{\cdot 3} + O_{\cdot 04} + O_{\cdot 005} + O_{\cdot 004})$ in air + 4. $\frac{R_2}{10}$ at 10·02 divisions of the scale—

then, removing O_8 from water, carefully drying it, and placing it in the pan, I found after adding 180 minims of water

$$X \bumpeq O_8 \text{ in air} + \text{hook \&c. in water} + 2{\cdot}72\,\frac{R_2}{10} \text{ at } 10{\cdot}02 \text{ divisions.}$$

Hence the loss of weight apparently $= O_{\cdot 3} + O_{\cdot 04} + O_{\cdot 005} + O_{\cdot 004} + 1{\cdot}28\,\frac{R_2}{10}$.

My approximate calculations gave me the sum of the above four weights as 167·5400 grains, and the value of the rider is approximately $\frac{1}{10}$th of a grain, the difference from the true value being negligible. Hence the loss of weight between air and water was 167·5528 grains, and, though I did not observe the Barometer, it may be considered as 29·46, and the temperature 87°·5; this gives $\Delta\, O_8 = 8{\cdot}5649$.

Again on July 7th, I found in the same way.

(A) $X + 5\,\frac{R_1}{10} \bumpeq O_8$ in water + hook &c. in water $+ 167{\cdot}54$ grains $+ 3\,\frac{R_2}{10}$ at 13·30 Div.

(B) $X + 5\,\frac{R_1}{10} \bumpeq O_8$ in water + hook &c. in water $+ 167{\cdot}54$ grains $+ 6\,\frac{R_2}{10}$ at 4·72 Div.

} Temp. water 84·25 F.

and, after adding 169 minims of water.

(C) $X + 5\,\frac{R_1}{10} \bumpeq O_8$ in air + hook &c. in water $+ 7\,\frac{R_2}{10}$ at 14·80 Div.
Bar. 29°·445.

(D) $X + 5\,\frac{R_1}{10} \bumpeq O_8$ in air + hook &c. in water $+ 9\,\frac{R_2}{10}$ at 8·35 Div.
Temp. 85°·7 F.

Hence by interpolating between (A) and (B)

$$X + 5\,\frac{R_1}{10} \bumpeq O_8 \text{ in water} + \text{hook \&c. in water} + 167{\cdot}54 \text{ grs.} + 4{\cdot}14\,\frac{R_2}{10}$$

and from (C) and (D)

$$X + 5\,\frac{R_1}{10} \bumpeq O_8 + \text{hook \&c. in water} + 8{\cdot}49\,\frac{R_2}{10}$$

} Temperatures Water 84°·25F. Air 85·7; Bar. 29·445 in.

Thus the loss of weight was apparently 167·4965 grains, and $\Delta\, O_8 = 8{\cdot}5676$. Giving this last result triple weight, on account of better observing, we have as a mean; $\Delta\, O_8 = 8{\cdot}5669$: which may be considered the density for all the weights of this set; and which will not be altered by the true values of the weights used, being substituted for the approximate ones.

SECTION IV.—*System of Weighments.*

I have adopted a uniform system of weighment for comparing the weights. Some years ago I made a considerable number of experiments on the species of errors which occurred in practice, and the present system is the outcome: there have been minute deviations, but in all material points the procedure has been uniformly followed, and I think it has been successful in eliminating all progressive errors. The principal of these is the tendency of the arms of the balance to expand unequally with temperature, but there are others which have occasionally been found. I annex specimens of the form I have used in work.

The weights to be compared being placed in the pans, a preponderance is given to one side of the balance; so as to make the resting point, when the whole is in equilibrium, lie on one side of the centre point; yet so slightly, that the weight used to get the value of the scale, shall deflect the resting point to the other side. In the first example with Oertling No. 1, it will be seen, that with EI in the left pan and O_1 in the right, the Right Rider was placed at 1·2 of the beam scale; in this state the index had its resting point at 7·54 divisions (10 being the middle). Then the weight $P_{\cdot 01}$ was added to the left side and the resting point became 15·81 Div. Each resting point is deduced from 4 readings, two low l_1 and l_2, and two high h_1 and h_2. The beam having been carefully released, the first excursion outwards, and the return towards the scale centre, are neglected; and the next four readings of the extremes of oscillation taken. The first reading will thus usually be low, if the resting point be low; and high, if that be high: but, when signs of irregularity occur, this may not be the case, as I have always, in such cases, freely omitted readings till the oscillations have become regular. Then, supposing a low reading first, $\frac{l_1 + 2h_1 + l_2}{4}$ and $\frac{h_1 + 2l_2 + h_2}{4}$ would be readings of the resting points, and the sums in the numerators have been rapidly formed separately during the work, added, and divided by 8. This has been afterwards checked by $\frac{l_1 + h_2 + 3\ (l_2 + h_1)}{8}$: of course, when h comes first, the h's take the place of the l's in these formulæ, and *vice versâ.*

We thus have two "*partial weighments*"

$$EI \doteq O_1 + 1{\cdot}2\,\frac{R_2}{10} \text{ at } 7{\cdot}54 \text{ divisions and}$$

$$EI + P_{\cdot 01} \doteq O_1 + 1{\cdot}2\,\frac{R_2}{10} \text{ at } 15{\cdot}81 \text{ divisions}$$

from which I get, by interpolation, as a result of the "*weighment*"

$$EI \triangleq O_1 + 1{\cdot}2\,\frac{R_2}{10} - P_{\cdot 01}\cdot\frac{2{\cdot}46}{8{\cdot}27} \text{ or } O_1 + 1{\cdot}2\,\frac{R_2}{10} - 0{\cdot}297\,P_{\cdot 01}$$

The second weighment is made after the weights are interchanged in the pans and the result deduced the same way. These together make one "*comparison;*" and then a second comparison is made, every operation being followed, but precisely in the reverse order, to make a "*complete comparison.*" The result of the four equations when summed is

$$4\,EI \equiv 4\,O_1 + 0{\cdot}191\,P_{\cdot 01} \text{ or}$$
$$EI \equiv O_1 + 0{\cdot}04775\,P_{\cdot 01}$$

The interpolations are made with sufficient accuracy with a slide rule.

In all the comparisons of the O set and P set, except those of EI with O_1, which were made with the balance Oertling No. 1, I have used one of the riders (the right) to add a constant weight to one side and the other in variable positions. Assuming that the rider can be accurately placed on the divisions, and that these are sufficiently accurate, it seems to me that I may safely use the rider in this way, and that the error of determination of the weight of the rider will thus be of less importance than that of a small weight.

In the case of the very small weights I have added the weight P_{24} to one pan, and P^{*}_{24} to the other, in order to steady them, with great advantage.

Section V.—*Determination of O_1, in terms of the English Commercial Pound.*

I have before mentioned that I have received as a Standard a Troy ounce of Platinum-Iridium, whose weight in terms of the Parliamentary Standard Pound P S. is 479·95979 grains of P S.; and I have explained the relations between the English Standard Pound and the commercial Pound. In order that I may determine the errors of the Bullion set of Weights, it is necessary that I should determine O_1 in terms of the English Commercial Pound: I have it is true the determination made in London, but it is necessary to verify this, not only to make the standard of weight now, identical with that I should get again, but also because the gilt weights may have slightly changed in the long voyage.

The Barometer I have used is an Aneroid Barometer by Browning, which I have found give corrected Barometer readings without sensible error. I have, except in the first comparison, used two Thermometers which were examined for me some years ago at Kew, and whose zero point I have recently re-determined: these were suspended in the balance case of Oertling No. 1, so as to hang about half way between the pillar carrying the central plane, and the suspensions of the scale pans. The Humidity has been deduced from a new Masons Hygrometer: I have not the errors of its Thermometers, but they are modern, and not likely to have any producing sensible corrections to my result.

The following is a specimen of computation for the comparison of EI and O_1 which is entered in the type form; in it, v EI = volume of water at its greatest density which is displaced by EI at 32°. F.

$$\text{it therefore} = \frac{wt.\ \text{EI}}{\Delta\text{EI}} = \frac{479{\cdot}95979}{21{\cdot}414} = [1{\cdot}35051]$$

$$\text{similarly } v\ O_1 = \frac{479{\cdot}99760}{8{\cdot}5669} = [1{\cdot}74842]$$

May 24th, 1879 A. M.

Commenced at 6 h. 48 m. Ended at 7 h. 33 m.

Dry Bulb 85°·9 F.		Dry Bulb 85°·4	
Wet do. 81·0	Vapour Tension 0·993 in.	Wet do. 80·1	Vapour Tension 0·960 in.
Diff. 4·9		5·3	

Mean of Thermometers 85°·5 Mean Red. Barometer 29·605 in.

Correction 0·00 0·189(0·993 + 0·960) = 0·369

Mean Temperature 85·50 h. = 29·236 log — 1·46592

log A_t (Tab I.) 5·59005

7·05597	.... 7·05597
log v EI ...... 1·35051	log v O_1 ... 1·74842
(Tab. III.) log (1 + E P_t) 0·00035	(Tab. III.) log (1 + E B_t) ... 0·00066
Air displaced by EI = 0·025517 grs. } log = 8·40683	Air displaced by O_1 = 0·063834 grs. } log = 8·80505

		grains.
Weight EI in Vacuo	=	479·95979 of P S.
Air displaced	=	— 0·025517
EI	=	479·934273
Air displaced by O_1	= +	0·063834
O_1 = EI	—	0·000475*
O_1	=	479·997632

* In section IV, I found EI = O_1 + 0·4775 $P_{\cdot 01}$ and (Sec. VI) $P_{\cdot 01}$ = 0·009947 grains.

Abstract of Comparisons.

1879 May 24,	O_1 =	479·997632	P S. grain.
„ 28,	„	·997489	„
„ 30,	„	·996732	„
„ 31,	„	·997266	„
„ June 1,	„	·996911	„

Mean $O_1 = 479·997206 \pm 0·000115$ P S. grains.

I have received, from the Meteorological Reporter to the Government of Bengal, the following mean data for Calcutta which I take as the definition of Standard Air

Reduced Barometer,...	29·787 in.	whence $\Delta A_s = 7.06510$.
Temperature,............	79°·0 F.	
Humidity,...............	0·76 per cent.	

Hence I have weight of O_1 = 479·997206 grains of P S.
Deduct displaced Standard Air = — 0·065178
Add Standard Air for $\frac{480}{7000}$ W = + 0·068571

$O_1 \equiv$ 480·000599 grains of English Commercial Pound.

This value differs slightly from that sent me and which I have quoted before.

SECTION VI.—*On the determination of the errors of single weights.*

In the interval between O_1 and O_{10} there are, in all English bullion sets, weights O_5, O_4, O_3, and O_2; so between O_{10} and O_{100} come O_{20} O_{30} O_{40} and O_{50}, and so on.

Between these weights we may make comparisons giving the following equations:

$$O_{10} \equiv O_5 + O_4 + O_1 + x_1 \pm e \ (a)$$
$$\equiv O_5 + O_3 + O_2 + x'_1 \pm e \ (b)$$
$$\equiv O_4 + O_3 + O_2 + O_1 + x''_1 \pm e \ (c)$$
$$O_5 \equiv O_4 + O_1 + x_2 \pm e$$
$$O_5 \equiv O_3 + O_2 + x_3 \pm e$$
$$O_4 = O_3 + O_1 + x_4 \pm e$$
$$O_3 = O_2 + O_1 + x_5 \pm e$$

e being the *p. e.* of one comparison.

Hence we have $O_2 \equiv 2\,O_1 + x_4 - x_3 + x_2 \pm e\sqrt{3}$

$$O_3 \equiv 3\,O_1 + x_5 + x_4 - x_3 + x_2 \pm e\sqrt{4}$$
$$O_4 \equiv 4\,O_1 + x_5 + 2x_4 - x_3 + x_2 \pm e\sqrt{7}$$
$$O_5 \equiv 5\,O_1 + x_5 + 2x_4 - x_3 + 2x_2 \pm e\sqrt{10}$$

$$O_{10}\begin{cases} \equiv 10\,O_1 + 2x_5 + 4x_4 - 2x_3 + 3x_2 + x_1 \pm e\sqrt{34} \text{ from } (a) \\ \equiv 10\,O_1 + 2x_5 + 4x_4 - 3x_3 + 4x_2 + x_1' \pm e\sqrt{46} \text{ from } (b) \\ \equiv 10\,O_1 + 2x_5 + 4x_4 - 3x_3 + 3x_2 + x_1'' \pm e\sqrt{39} \text{ from } (c) \end{cases}$$

which equations give the ascending series; and it is important to note, that if the probable error of the observations be alike, there is a disadvantage in using any comparison but (*a*), and that even if (*b*) and (*c*) be observed as checks, they should not be used in computing, as they will lower the weight of O_{10}, on the accuracy of which we are dependent for continuing the upward series; thus the mean value of O_{10} from (*a*) and (*c*) will be

$$O_{10} \equiv 10\,O_1 + \tfrac{1}{2}\,(4x_5 + 4x_4 - 5x_3 + 6x_2 + x_1 + x_1'') \pm e\sqrt{\tfrac{143}{4}}$$

and if the series (*b*) had been involved the loss of probable accuracy would have been greater.

Next as to descending or decreasing series from W_{10}.

1st. Descending through (*a*)

$$O_5 \equiv \tfrac{5}{10}\,O_{10} + \frac{x_2 - x_1}{2} \pm e\sqrt{\tfrac{50}{10}}$$

$$O_4 \equiv \tfrac{4}{10}\,O_{10} + \tfrac{1}{10}\,(2x_5 + 4x_4 - 2x_3 - 2x_2 - 4x_1) \pm e\sqrt{\tfrac{44}{10}}$$

$$O_3 \equiv \tfrac{3}{10}\,O_{10} + \tfrac{1}{10}\,(4x_5 - 2x_4 - 4x_3 + x_2 - 3x_1) \pm e\sqrt{\tfrac{46}{10}}$$

$$O_2 \equiv \tfrac{2}{10}\,O_{10} - \tfrac{1}{10}\,(4x_5 - 2x_4 + 6x_3 - 4x_2 + 2x_1) \pm e\sqrt{\tfrac{76}{10}}$$

$$O_1 \equiv \tfrac{1}{10}\,O_{10} - \tfrac{1}{10}\,(2x_5 + 4x_4 - 2x_3 + 3x_2 + x_1) \pm e\sqrt{\tfrac{34}{10}}.$$

Again descending through (*b*)

$$O_5 \equiv \tfrac{5}{10}\,O_{10} + \tfrac{1}{2}\,(x_3 - x_1') \pm e\sqrt{\tfrac{50}{10}}$$

$$O_4 \equiv \tfrac{4}{10}\,O_{10} + \tfrac{1}{10}\,(2x_5 + 4x_4 + 2x_3 - 6x_2 - 4x_1') \pm e\sqrt{\tfrac{70}{10}}$$

$$O_3 \equiv \tfrac{3}{10}\,O_{10} + \tfrac{1}{10}\,(4x_5 - 2x_4 - x_3 - 2x_2 - 3x_1') \pm e\sqrt{\tfrac{34}{10}}$$

$$O_2 \equiv \tfrac{2}{10}\,O_{10} - \tfrac{1}{10}\,(4x_5 - 2x_4 + 4x_3 - 2x_2 + 2x_1') \pm e\sqrt{\tfrac{38}{10}}$$

$$O_1 \equiv \tfrac{1}{10}\,O_{10} - \tfrac{1}{10}\,(2x_5 + 4x_4 - 3x_3 + 4x_2 + x_1') \pm e\sqrt{\tfrac{46}{10}}.$$

Also descending through (*c*)

$$O_5 \equiv \tfrac{5}{10}\,O_{10} + \frac{x_3 + x_2 - x_1''}{2} \pm e\sqrt{\tfrac{75}{10}}$$

$$O_4 \equiv \tfrac{4}{10}\,O_{10} + \tfrac{1}{10}\,(2x_5 + 4x_4 + 2x_3 - 2x_2 - 4x_1'') \pm e\sqrt{\tfrac{32}{10}}$$

$$O_3 \equiv \tfrac{3}{10}\,O_{10} + \tfrac{1}{10}\,(4x_5 - 2x_4 - x_3 + x_2 - 3x_1'') \pm e\sqrt{\tfrac{23}{10}}$$

$$O_2 \equiv \tfrac{2}{10}\,O_{10} - \tfrac{1}{10}\,(4x_5 - 2x_4 + 4x_3 - 4x_2 + 2x_1'') \pm e\sqrt{\tfrac{56}{10}}$$

$$O_1 \equiv \tfrac{1}{10}\,O_{10} - \tfrac{1}{10}\,(2x_5 + 4x_4 - 3x_3 + 3x_2 + x_1'') \pm e\sqrt{\tfrac{39}{10}}.$$

If we were to be guided here by the same consideration as before, we should absolutely prefer the use of series (*a*) alone, but it is easy to see, that as the probable error of O_1 involves only $\tfrac{1}{10}$ of that of O_{10}; the determination of its weight will be almost entirely dependent on the error generated in the comparisons of the group* of the series, and not on that derived from the starting weight: this renders the choice less important.

As a matter of fact I have worked both through (*a*) and (*b*) taking the mean result and in this case.

$$O_5 \equiv \tfrac{5}{10} O_{10} + \tfrac{1}{4} (x_3 + x_2 + x_1 + x_1') \pm e \sqrt{\tfrac{25}{10}}$$
$$O_4 \equiv \tfrac{4}{10} O_{10} + \tfrac{1}{20} (4x_5 + 8x_4 - 8x_2 - 4x_1 - 4x_1') \pm e \sqrt{\tfrac{44}{10}}$$
$$O_3 \equiv \tfrac{3}{10} O_{10} + \tfrac{1}{20} (8x_5 - 4x_4 - 5x_3 - x_2 - 3x_1 - 3x_1') \pm e \sqrt{\tfrac{31}{10}}$$
$$O_2 \equiv \tfrac{2}{10} O_{10} - \tfrac{1}{20} (8x_5 - 4x_4 + 10x_3 - 6x_2 + 2x_1 + 2x_1') \pm e \sqrt{\tfrac{50}{10}}$$
$$O_1 \equiv \tfrac{1}{10} O_{10} - \tfrac{1}{20} (4x_5 + 8x_4 - 5x_3 + 7x_2 + x_1 + x_1') \pm e \sqrt{\tfrac{39}{10}}.$$

My choice was a matter of accident, but it turns out that the sum of the squares of the probable errors of all the deduced weights is less than for any one of the single series.

The other system of weights, which I have in this paper slightly to deal with, is what I shall call the "*English grain system.*" In it the weights interpolated between 10 and 1 are 6, 3 and 2. Thus starting from either end of the decad there are four weights to be derived; but among these weights alone, only three equations can be obtained.

$$\begin{aligned} P_{10} &= P_6 + P_3 + P_1 + x_1 \\ P_6 &= P_3 + P_2 + P_1 + x_2 \\ P_3 &= P_2 + P_1 \qquad + x_3. \end{aligned}$$

To make a definite resect the best plan is to use a second P_1 called P_1': $P._1 + P._3 + P._1$ from the next lower decad height be used but the equations would not be independent for the separate decads.

$$P_2 = P_1 + P_1' + x_4 \text{ and } P_1 = P_1' + x_5$$

and we now have 5 equations to determine 5 quantities, and the result is definite. Of course by substituting P'_1 for P_1, we can get 3 more equations like the first three, but the labour would be increased, and the result would still be definite, though slightly more accurate, especially as regards the spare weight P_1'.

From the equations we have; *in ascending (increasing weights)*

$$\begin{aligned} P_1' &= P_1 - x_5 \pm e. \\ P_2 &= 2\,P_1 - x_5 + x_4 \pm e \sqrt{2} \\ P_3 &= 3\,P_1 - x_5 + x_4 + x_3 \pm e \sqrt{3} \end{aligned}$$

* I use the term *decad* to include the weights from 0·1 to 1, or from 1 to 10, &c., the last being ten times the first; and a *group* of equations consists of those connecting the weights of a *decad.*

$$P_6 = 6\,P_1 - 2x_5 + 2x_4 + x_3 + x_2 \pm e\sqrt{10}$$

$$P_{10} = 10\,P_1 - 3x_5 + 3x_4 + 2x_3 + x_2 + x_1 \pm e\sqrt{24}.$$

While *descending*, we have

$$P_6 = \tfrac{6}{10}\,P_{10} - \tfrac{1}{10}\,(2x_5 - 2x_4 + 2x_3 - 4x_2 + 6x_1) \pm e\sqrt{\tfrac{84}{10}}$$

$$P_3 = \tfrac{3}{10}\,P_{10} - \tfrac{1}{10}\,(x_5 - x_4 - 4x_3 + 3x_2 + 3x_1) \pm e\sqrt{\tfrac{36}{10}}$$

$$P_2 = \tfrac{2}{10}\,P_{10} - \tfrac{1}{10}\,(4x_5 - 4x_4 + 4x_3 + 2x_2 + 2x_1) \pm e\sqrt{\tfrac{56}{10}}$$

$$P_1 = \tfrac{1}{10}\,P_{10} + \tfrac{1}{10}\,(3x_5 - 3x_4 - 2x_3 - x_2 - x_1) \pm e\sqrt{\tfrac{24}{10}}$$

$$P_1' = \tfrac{1}{10}\,P_{10} - \tfrac{1}{10}\,(7x_5 + 3x_4 + 2x_3 + x_2 + x_1) \pm e\sqrt{\tfrac{64}{10}}.$$

Section VII.

I now proceed to the determination of the actual values of the weights below O_1, and of the P set, in commercial grains. The equations have all been determined in terms of the rider R_1, in the balance Oertling No. 1, and they are given in this way. Of course the whole of the computations were made with this unknown factor, but it has been determined (see page 56) and the value has been substituted in the results to save repetition. The differences between the two determinations of the constant term in each equation are given, and from them is derived a probable error of one equation. I had intended that the observations in each decad should be separately valued, but when that is done the results are so nearly alike that it seems unnecessary to adhere to this. The mode of determining the probable error of each weight is the subject of the next section, but the values are given in this.

Value of Weights of W set below W_1 with Balance Oertling No. 1.

I have here the following equations:

O_1	$\equiv O_{.5}$	$+ O_{.4}$	$+ O_{.1}$	$-0{\cdot}213325\ R_1$	Difference	=	2600
O_1	$\equiv O_{.5}$	$+ O_{.3}$	$+ O_{.2}$	$-0{\cdot}238825$,,	,,	=	1450
$O_{.5}$	$\equiv O_{.4}$	$+ O_{.1}$		$-0{\cdot}001800$,,	,,	=	350
$O_{.5}$	$\equiv O_{.3}$	$+ O_{.2}$		$-0{\cdot}124325$,,	,,	=	500
$O_{.4}$	$\equiv O_{.3}$	$+ O_{.1}$		$-0{\cdot}002913$,,	,,	=	825
$O_{.3}$	$\equiv O_{.2}$	$+ O_{.1}$		$-0{\cdot}011113$,,	,,	=	275

$O_{.1}$	$\equiv O_{.05}$	$+ O_{.04}$	$+ O_{.01}$	$-0{\cdot}033200\ R_1$	Difference	=	200
$O_{.1}$	$\equiv O_{.05}$	$+ O_{.03}$	$+ O_{.02}$	$-0{\cdot}042213$,,	,,	=	2925
$O_{.05}$	$\equiv O_{.04}$	$+ O_{.01}$		$-0{\cdot}020938$,,	,,	=	475
$O_{.05}$	$\equiv O_{.03}$	$+ O_{.02}$		$-0{\cdot}032138$,,	,,	=	1475
$O_{.04}$	$\equiv O_{.03}$	$+ O_{.01}$		$-0{\cdot}030838$,,	,,	=	775
$O_{.03}$	$\equiv O_{.02}$	$+ O_{.01}$		$-0{\cdot}035763$,,	,,	=	475

$O._{01} = O._{005} + O._{004} + O._{001}$	$-0.012263\ R_1$	Difference =	425
$O._{01} = O._{005} + O._{003} + O._{002}$	-0.021500 „	„ =	150
$O._{005} = O._{004} + O._{001}$	-0.076963 „	„ =	1625
$O._{005} = O._{003} + O._{002}$	-0.015813 „	„ =	1725
$O._{004} = O._{003} + O._{001}$	-0.040638 „	„ =	675
$O._{003} = O._{002} + O._{001}$	-0.093775 „	„ =	100
$O._{025} = O._{02} + O._{005}$	$-0.016100\ R_1$	Difference =	200

From these equations I deduce

	grs.		grs.	
$O._5$	= 240·000300 + 0·056006 R_1	=	240·005927	*p. e.* = 0·000064
$O._4$	= 192·000240 + 0·127762 „	=	192·013076	„ 0·000060
$O._3$	= 144·000180 + 0·100631 „	=	144·010290	„ 0·000047
$O._2$	= 96·000120 + 0·081700 „	=	96·008328	„ 0·000048
$O._1$	= 48·000060 + 0·030044 „	=	48·003078	„ 0·000037
$O._{05}$	= 24·000030 + 0·020606 „	=	24·002100	„ 0·000033
$O._{04}$	= 19·200024 + 0·015988 „	=	19·201630	„ 0·000040
$O._{03}$	= 14·400018 + 0·021269 „	=	14·402155	„ 0·000033
$O._{02}$	= 9·600012 + 0·031475 „	=	9·603180	„ 0·000042
$O._{01}$	= 4·800006 + 0·025537 „	=	4·802574	„ 0·000035
$O._{005}$	= 2·400003 + 0·030932 „	=	2·403111	„ 0·000033
$O._{004}$	= 1·920002 + 0·065261 „	=	1·926559	„ 0·000040
$O._{003}$	= 1·440002 — 0·018011 „	=	1·438193	„ 0·000033
$O._{002}$	= 0·960001 + 0·033130 „	=	0·963329	„ 0·000042
$O._{001}$	= 0·480001 + 0·042634 „	=	0·484284	„ 0·000035
$O._{025}$	= 12·000015 + 0·036101 „	=	12·003642	„ 0·000077

The two largest weights P_{24} and P_{24}^{*} of the P set are each approximately equal to 24 grains and their sum is of course nearly = $O._1$ but they are of platinum while $O._1$ is of gilt bronze. Small as these are the errors cannot be neglected when accuracy is required. The purpose of the determination being mainly to get the values of the small weights of the P set with accuracy so that they may be used to determine differences, it is enough to correct the value above given of $O._1$ so that the deduced value of $P._{24} + P_{24}^{*}$ may be the same as if the comparison had been made in standard air. For all ordinary purposes the resulting values of these weights may be used without correction.

I have found that 48 grains of platinum would weigh less in my standard air than under the circumstances of the observation by 0.000063 grains. Also $O_1 = P_{24} + P_{24}^{*} + 0·050238\ R_1$.

grs.

The value of $O._1$ is = 48·000060 + 0·030044 R_1

∴ in actual air $P_{24} + P_{24}^{*}$ = 48·000060 — 0·020194 R_1

and the correction to standard air is — 0·000063

Hence in standard air $P_{24} + P_{24}^{*}$ = 47·999997 — 0·020194 R_1

I shall for convenience write M for 47·999997 grains and place the equations so far as ey are necessary to determine the weights down to P_1 in a form suitable for use thus—

		Diff.
$_{24} + P^*_{24}$	$- M + 0·020194\ R_1$	$= 0·275\ R_1$
$_{24} - P^*_{24}$	$- 0·006438$ „	$= 0·475$ „
$_{24} \quad - P_{16} - \quad P_6 \quad - P_2$	$- 0·012918$ „	$= 0·1125$ „
$P^*_{24} - P_{20} \quad - P_3 \quad - P_1$	$+ 0·000125$ „	$= 0.650$ „
$P_{20} - P_{16} \quad - P_3 \quad - P_1$	$+ 0·010138$ „	$= 0·900$ „
$P_{20} \quad - P_{10} - P_6 - P_3 \quad - P_1$	$- 0·008500$ „	$= 0·25$ „
$P_{16} - P_{10} - P_6$	$- 0.018400$ „	$= 0·1700$ „
$P_{10} - P_6 - P_3 \quad - P_1$	$- 0·004813$ „	$= 0·775$ „
$P_6 - P_3 - P_2 - P_1$	$+ 0·018908$ „	$= 0·375$ „
$P_3 - P_2 - P_1$	$+ 0·015463$ „	$= 0·1075$ „
$P_2 - P_1 - P'_1$	$+ 0·009388$ „	$= 0·1175$ „
$P_1 - P'_1$	$- 0·005838$ „	$= 0·1275$ „

I have tried various ways of dealing with these equations but, when the probable errors are wanted, the method of least squares is the easiest. I thus get—

	grs.		grs.	
P_{24}	$= 23·999999$	$- 0·006997\ R_1$	$= 23·999296$	*p. e.* $= 0·000042$
P^*_{24}	$= 23·999999$	$- 0·003185$ „	$= 23·998679$	„ $0·000042$
P_{20}	$= 19·999999$	$- 0·014515$ „	$= 19·998541$	„ $0·000050$
P_{16}	$= 15·999999$	$- 0·006007$ „	$= 15·999396$	„ $0·000049$
P_{10}	$= 9·999999$	$- 0·009026$ „	$= 9·999092$	„ $0·000043$
P_6	$= 6·000000$	$- 0·015531$ „	$= 5·998440$	„ $0·000013$
P_3	$= 3·000000$	$- 0·006360$ „	$= 2·999361$	„ $0·000035$
P_2	$= 2·000000$	$+ 0·001371$ „	$= 2·000137$	„ $0·000050$
P_1	$= 1·000000$	$+ 0·008077$ „	$= 1·000811$	„ $0·000039$
P'_1	$= 1·000000$	$+ 0·002461$ „	$= 1·000247$	„ $0·000043$

			Diff.
Further P_1	$= P._6 + P._3 + P._1$	$+ 0·000038\ R_1$	Diff. $725\ R_1$
$P._6$	$= P._3 + P._2 + P._1$	$+ 0·005525$ „	„ 0 „
$P._3$	$= P._2 + P._1$	$- 0·004675$ „	„ 500 „
$P._2$	$= P._1 + P'._1$	$+ 0·006963$ „	„ 1325 „
$P._1$	$= P'._1$	$+ 0·005813$ „	„ 525 „

			grs.	
Whence $P._6$	$= 0·600000$	$+ 0·002673\ R_1$	$= 0·600269$	*p. e.* $= 0·000056$
$P._3$	$= 0·300000$	$+ 0·005647$ „	$= 0·300567$	„ $0·000035$
$P._2$	$= 0·200000$	$+ 0·002832$ „	$= 0·200285$	„ $0·000042$
$P._1$	$= 0·100000$	$+ 0·000842$ „	$= 0·100085$	„ $0·000028$
$P'._1$	$= 0·100000$	$- 0·004971$ „	$= 0·099501$	„ $0·000045$

By weighing the riders against the nearly equal weight $P._1$ I have

$R_1 \equiv P._1 + 0{\cdot}003813\ R_2$ Diff. 425

$R_2 \equiv P._1 + 0{\cdot}000375\ R_1$ „ 600

Substituting successively for the value of R_1, of $P._1$, and of R_2 we get

	grs.		
$R_1 \equiv$	$0.1003814 + 0{\cdot}000847\ R_1 \equiv 0{\cdot}100466$ grs.	*p. e.* =	0·000062
$R_2 \equiv$	$0{\cdot}100000 + 0{\cdot}001217\ R_1 \equiv 0{\cdot}100122$ „	„ =	0·000062
Also—$P._1 \equiv$	$P._{06} + P._{03} + 0{\cdot}089038\ R_2$	Diff.	825
$P._{06} \equiv$	$P._{03} + P._{02} + 0{\cdot}104750$ „	„	1550
$P._{03} \equiv$	$P._{02} + 0{\cdot}105075$ „	„	900
$P._{01} \equiv$	$0{\cdot}099438$ „	„	137
Whence $P._{06} \equiv$	$\frac{3}{5} P._1 - 0{\cdot}059467\ R_2 \equiv 0{\cdot}060769$	*p. e.* =	0·000047
$P._{03} \equiv$	$\frac{1}{5} P._1 - 0{\cdot}029571$ „ $\equiv 0{\cdot}030400$	„	0·000034
$P._{02} \equiv$	$\frac{1}{5} P._1 - 0{\cdot}134646\ R_1 \equiv 0{\cdot}019881$	„	0·000047
$P._{01} \equiv$	0.099438 „ $\equiv 0{\cdot}009956$	„	0·000056

Section VIII.—*Determination of the probable errors of the values of the O and P sets.*

In Section VI, I have shown that if the probable error of the constant terms in the equations of a group be known, we can determine the probable errors of the determinations in the group, so far as they depend on it: and we have now to consider what may be taken as the probable error of one determination.

Each coefficient of R is derived in the preceding work from two determinations which rarely agree. The differences are noted in terms of the 6th decimal place of the coefficient. If we were certain that the true values of the constants lay between the determinations, then, calling the difference of the two $2a$, we should have $\frac{\Sigma a}{n}$ = the mean of errors and *p. e.* of an equation $= e = 0{\cdot}8454 \frac{\Sigma a}{n}$; but this value is clearly too small; because, if the occurrence of positive and negative errors be equally probable, then there is an even chance that a fourth of the values of $2a$ will be the difference and not the sum of the two actual errors.

I prefer therefore to use the formula

$$\text{mean of errors} = \frac{\Sigma v}{\sqrt{m\,(m-1)}}$$: m being the number of complete comparisons

$$\text{and probable error} = 0{\cdot}8454 \frac{\Sigma v}{\sqrt{m\,(m-1)}}$$

applying this to any one determination we shall have its probable error

$$= 0{\cdot}8454 \frac{2\,a}{\sqrt{2 \times 1}} = 0{\cdot}8454 \sqrt{2}\,a = 1{\cdot}1955\ a$$

Of course this is a very uncertain estimation, but we have a good many such equations, and the mean of the values may I think be taken as the fairest estimate. If then n be the number of equations, I take

$$p.\ e. \text{ of any one determination is } 1{\cdot}1955 \frac{\Sigma a}{n}$$

The group of equations determining the P weights would give the probable error from their residuals; but, there being only 12 equations to determine 10 quantities, I do not think this is so satisfactory as the above method; and I have used, for evaluating the errors in them, the weights of the results, deduced as usual, combined with the *p. e.* of an equation derived as above. Assuming that we may neglect the difference between the values of R_1 and R_2 in these differences, we have 41 values of $2\,a$; and it does not seem that there is any marked tendency to decrease with the weights: I therefore take the mean of all and I get

$$\frac{\Sigma a}{n} = 463{\cdot}53 \text{ R} \qquad p.\ e. = 554{\cdot}16 \text{ R} = 55{\cdot}651 = \text{e of Section VI}$$

$$\text{in which R is taken } 0{\cdot}100464 = \frac{36\,R_1 + 5\,R_2}{41}$$

Hence e^2 is $3097{\cdot}0$

The probable error of any determination as of that of $O._{02}$ for instance, depends:—

1st on the amount arising from its own group.

2nd probable error of the value assumed as known: in this case $O._1$

3rd on the probable error of the rider which was employed in taking the difference of weights in the pans.

Lastly O_1 itself has its probable error 0·000115 grains from the determinations; but there is also a portion dependent on $P._{01}$, which is involved in determining the difference between it and EI, the mean factor of $P._{01}$ being 0·0877. It is necessary, therefore, to start our evaluations with values of the probable errors of R_1 R_2 and $P._{01}$; and, fortunately, these are readily determined.

Let E be the *p. e.* of $P._1$ from all sources except R_1

e as before the *p. e.* of one determination

ϵ the *p. e.* of R_1

It will be seen from the table of deduction of probable errors that the value of E^2 is 758·2 and that it involves nothing unknown.

$$\begin{aligned} \text{Hence } (p.\ e.\ R_1)^2 &= \epsilon^2 \\ &= (1{\cdot}003813)^2\, E^2 + (0{\cdot}000842)^2\, \epsilon^2 + e^2 \\ &= 764{\cdot}0 + 0{\cdot}0000007\, \epsilon^2 + 3097{\cdot}0 = 3861{\cdot}0 \end{aligned}$$

$$\therefore \epsilon = 0{\cdot}000062 = \frac{1}{10^6}\sqrt{3861{\cdot}0}$$

again $p.\ e.\ R_2 = \sqrt{E^2 + e^2 + 0{\cdot}000375^2\ \epsilon^2} = \frac{1}{10^6}\sqrt{3861{\cdot}0} = 0{\cdot}000062$

$$p.\ e.\ P_{\cdot 01} = \sqrt{e^2 + 0{\cdot}099438^2\ (R_2)^2} = \sqrt{3135{\cdot}2} = 0{\cdot}000056$$

Determination of Probable Errors.

	Squares of Probable Errors (unit is 6th decimal place).						Probable error.
	From group.	From preceding groups.	From EI.	From R_1.	From $P_{\cdot 01}$.	Total.	
O_1	...	...	13225·0	...	24·1	13249·1	0·000115
$O_{\cdot 5}$	774·3	...	3306·2	12·1	6·0	4098·6	64
$O_{\cdot 4}$	1362·7	...	2116·0	64·2	3·9	3546·3	60
$O_{\cdot 3}$	960·1	...	1190·3	41·1	2·2	2193·7	47
$O_{\cdot 2}$	1734·3	...	529·0	25 7	1·0	2290·0	48
$O_{\cdot 1}$	1207·8	...	132·3	3·5	0·2	1343·8	37
$O_{\cdot 05}$	774·3	301·9	33·1	1·6	0·1	1111·0	33
$O_{\cdot 04}$	1362·7	193·2	21·2	1·0	„	1578·1	40
$O_{\cdot 03}$	960·1	108·7	11·9	1·7	„	1082·4	33
$O_{\cdot 02}$	1734·3	48·3	5·3	3·8	„	1791·7	42
$O_{\cdot 01}$	1207·8	12·1	1·3	2·5	„	1223·7	35
$O_{\cdot 005}$	774·3	305·0	0·3	3·7	„	1083·3	33
$O_{\cdot 004}$	1362·7	195·2	0·2	16·4	„	1574·5	40
$O_{\cdot 003}$	960·1	109·8	0·1	1·2	„	1071·2	33
$O_{\cdot 002}$	1734·3	48·8	0·1	4·2	„	1787·4	42
$O_{\cdot 001}$	1207·8	12·2	„	7·0	„	1227·0	35
$O_{\cdot 025}$	3097·0	2861·9	8·3	19·8	„	5987·0	77
P_{24}	1447·5	301·9	33·1	0·2	0·1	1782·8	42
P^*_{24}	1447·5	301·9	33·1	„	0·1	1782·6	42
P_{20}	2310·6	209·7	22·9	„	„	2543·2	50
P_{16}	2229·2	134·2	14·7	0·1	„	2378·2	49
P_{10}	1806·4	52·4	5·7	„	„	1864·5	43
P_6	148·1	18·9	0·9	0·5	„	168·4	13
P_3	1245·2	4·7	0·5	0·1	„	1250·5	35
P_2	2541·5	2·1	0·2	„	„	2543·8	50
P_1	1490 5	0·5	„	0·3	„	1491·3	39
P'_1	1836·0	0·5	„	„	„	1836·5	43
$P_{\cdot 6}$	2601·5	536·9	„	„	„	3138·4	56
$P_{\cdot 3}$	1114·9	134·2	„	„	„	1249·1	35
$P_{\cdot 2}$	1734·6	59·6	„	„	„	1794·2	42
$P_{\cdot 1}$	743·3	14·9	„	„	„	758·2	28
$P'_{\cdot 1}$	1982·1	14·9	„	„	„	1997·0	45

$$\text{Also } p.e.\, P_{\cdot 06} = \frac{1}{10^6}\sqrt{2064{\cdot}6+169{\cdot}5+13{\cdot}6} = \frac{1}{10^6}\sqrt{2247{\cdot}7} = 0{\cdot}000047$$

$$p.e.\, P_{\cdot 03} = \frac{1}{10^6}\sqrt{1032{\cdot}3 + 84{\cdot}2+13{\cdot}3} = \frac{1}{10^6}\sqrt{1129{\cdot}8} = 0{\cdot}000034$$

$$p.e.\, P_{\cdot 02} = \frac{1}{10^6}\sqrt{2064{\cdot}6 + 84{\cdot}2+70{\cdot}0} = \frac{1}{10^6}\sqrt{2218{\cdot}8} = 0{\cdot}000047$$

Section IX.—*Determinations of the Weights O_2 to O_{10} and also Prinsep's Bronze Troy Pound.*

The comparisons of the weights from O_2 to O_{10} have been made with the balance Oertling No. 2. Three complete comparisons were made in each case, and the weight $P_{\cdot 03}$ has been always used for valuing the scale. I have deduced the following equations of condition:—

grs.

$$O_3 \equiv O_2+O_1 \quad -0{\cdot}37200\, P_{\cdot 03} \equiv O_2+O_1 \quad 0{\cdot}000000-0{\cdot}37200\, P_{\cdot 03}$$
$$O_4 \equiv O_3+O_1+P_{\cdot 06}+0{\cdot}74542\, P_{\cdot 03} \equiv O_3+O_1+0{\cdot}060769+0{\cdot}74542\, P_{\cdot 03}$$
$$O_5 \equiv O_3+O_2+P_{\cdot 1} +0{\cdot}37867\, P_{\cdot 03} \equiv O_3+O_2+0{\cdot}100085+0{\cdot}37867\, P_{\cdot 03}$$
$$\equiv O_4+O_1+P_{\cdot 02}+0{\cdot}60467\, P_{\cdot 03} \equiv O_4+O_1+0{\cdot}019881+0{\cdot}60467\, P_{\cdot 03}$$
$$O_{10} \equiv O_5+O_4+O_1 - P_{\cdot 1} - P_{\cdot 06} + 0{\cdot}45742\, P_{\cdot 03} \equiv O_5 + O_4 + O_1 - 0{\cdot}160854 + 0{\cdot}45742\, P_{\cdot 03}$$

Whence I deduce by the Formulæ in Sec. VI.

$$O_2 \equiv 2\,O_1+ P_{\cdot 06} + P_{\cdot 02} - P_{\cdot 1} + 0{\cdot}97142\, P_{\cdot 03} \equiv 960{\cdot}011294 \text{ grs.} \quad p.e.=0{\cdot}000757 \text{ ,,}$$
$$O_3 \equiv 3\,O_1+ P_{\cdot 06} + P_{\cdot 02} - P_{\cdot 1} + 0{\cdot}59942 \text{ ,,} \equiv 1440{\cdot}000584 \text{ ,,} \quad p.e.=0{\cdot}000900 \text{ ,,}$$
$$O_4 \equiv 4\,O_1+2\,P_{\cdot 06} + P_{\cdot 02} - P_{\cdot 1} + 1{\cdot}34484 \text{ ,,} \equiv 1920{\cdot}084613 \text{ ,,} \quad p.e.=0{\cdot}001194 \text{ ,,}$$
$$O_5 \equiv 5\,O_1+2\,P_{\cdot 06} + 2\,P_{\cdot 02} - P_{\cdot 1} + 1{\cdot}94951 \text{ ,,} \equiv 2400{\cdot}123435 \text{ ,,} \quad p.e.=0{\cdot}001438 \text{ ,,}$$
$$O_{10} \equiv 10\,O_1+3\,P_{\cdot 06} + 3\,P_{\cdot 02} - 3\,P_{\cdot 1} + 3{\cdot}75167 \text{ ,,} \equiv 4800{\cdot}061736 \text{ ,,} \quad p.e.=0{\cdot}002795 \text{ ,,}$$

In the last Section, I have given a general formula for finding a probable error of observation. In this case, I have $\Sigma\,(o) = 3941{\cdot}2\,\frac{P_{\cdot 03}}{10^6}$, whence the probable error of one equation of condition will be

$$= 0{\cdot}8454\cdot\frac{3941{\cdot}2}{\sqrt{3{\cdot}2}}\cdot\frac{P_{\cdot 03}}{10^6} = 0{\cdot}000413{\cdot}5$$

The probable error of each determination of a weight depends—

1st, on its error derived from O_1 of which it is nearly a multiple,

2nd, on the error derived through the weights of the P set used to nearly counterbalance, 3rd, on the error due to the fraction of $P._{02}$ which is involved in its determination,

4th, on the error generated in the weighings of the series.

The following Table shows the error from each source separately.

Weights.	Squares of Probable Errors from					Probable Error × 10^8.
	O_1	Equil. Weights.	$P._{02}$	Weighments of Series.	Total.	
O_2	52900	5225	1179	514116	573420	757
O_3	119025	5225	449	685488	810187	900
O_4	211600	11968	2259	1199600	1425427	1194
O_5	330625	18624	4747	1713720	2067716	1438
O_{10}	1922500	47022	47581	5826648	7813751	2795

In making these calculations, I have neglected to attend to the fact that the P weights used have a common origin; the sum of the squares of the probable errors given in the Table at the end of Section VIII is taken, and here (as will be seen by turning back) the error from their common origin $O._1$ is unfelt, but this is not always the case.

Among the weights in the Assay Office is a bronze Standard Troy Pound in a wooden case, on which case is stamped {J. FIELD Fecit}, and in ink is written

J. Prinsep. Std. 1 lb }

On the weight itself is engraved—

British Troy Pound.
= 5760 *grains.*
Royal Mint.

The surface of the weight is thinly oxidized, but it seems to be quite uninjured. I some time ago compared it, as well as I could, with the weights of the Gilt Troy set belonging to the Assay Office, which were supplied many years ago, and which were made by Bates in 1824. No record of any previous comparisons of these exists. The conclusion I came to was, that Prinsep's Troy Pound was about a mean of all the Gilt Pounds, the latter weights having sensible errors. I have then thought it worth while to determine the value of the Prinsep's Pound, and I find—

Prinsep's Pound $= O_{10} + O_2 + P_1 + P._{01} - 0{\cdot}487\ P._{02}$
$= 5760{\cdot}148354$ grains,

from a single complete comparison.

To find the probable error of this we must substitute in the above equation the symbolic values of $O_{10} + O_2$ and thus we have—

Prinsep's Pound $\equiv 12\,O_1 + P._{01} + 4\,P._{02} + 4\,P._{06} - 3\,P._1 + 4{\cdot}23606\,P._{03}$ from which the probable error will (when the errors generated in determining O_2 and O_{10}, and also in the single comparison of this weight are allowed for)

$$= \frac{1}{10^6}\sqrt{8878998} = 0{\cdot}002890$$

and we may consider Prinsep's Pound $\equiv 5760{\cdot}148 \pm 0{\cdot}003$ grains.

Section X.—***Considerations as to the Weights which should be made use of in a series.***

The only generally used decimal system of weights, is the metric, which is so largely diffused. In it the weights between W_1 and W_{10} are W_5, W_2 in duplicate, and W_1. When the system was adopted in England permissively, the intermediate weights chosen were W_5 W_3 and W_2. The other series in use, are those I have described before as the Bullion, and the English Grain Series. In making a series of weights of tolahs for the use of the Indian mints, I have therefore a choice; and it is worth considering which series is the best.

Commercially, the fewer weights required to make any weighment, the better. I think, too, that commercially it is undesirable to have duplicate weights, and of course none should be superfluous. In the strict *French Metric* system there are 3 weights required to weigh 9 and 8, while two are wanted for 7, 6, and 3, and the 2 is in duplicate; and in the *English modification* there are 3 weights wanted for 9 only, while 8, 7, 6, and 4 require two each, and there is no duplicate: I think then that the English modification is preferable to the original system.

In our *English Bullion* system there are never 3 weights wanted for any purpose; and 9, 8, 7, and 6 require two weights. But there are more weights than are wanted, there being 5 weights in each decad instead of 4.

In the *English Grain* system there are never 3 weights wanted; 9, 8, 7, 5. and 4 require two each, there are no duplicates, and none superfluous. I think then that the English Grain system is the best for commercial purposes.

Scientifically, the best system is that of which the values can be most accurately deduced from the standard Prototype. It is worthy of note, that neither of the Metric systems, nor the English Grain system, admit of the weights of a decad being completely determined without a second unit in each decad.

This is not an unmixed disadvantage. The 1, 10, &c., being necessary for this purpose only, and not used in common, may be kept separately, and referred to for verifications whenever desired, and by such use the errors of the weights of any decad, can be determined with comparatively little labour and without its being necessary to refer back to a primary weight. Thus, checking becomes much more manageable, and, by such a plan as I have adopted in dealing with the P set, one of the duplicates is far more accurately determined than the other, and can be laid aside for reference; the accuracy of the second being ordinarily sufficient.

The English Bullion system, as we have seen, contains the means of determining the values of all the weights without duplicates, and it is possible to have one weight practically unused, if we consent to make either 8 or 9 by three weights; this reference weight, however, is not so convenient for use as in the other cases.

The English Grain system has this advantage over all the others, that any weight from 1 to 10 requires at most two weights to make it. It has the disadvantage that 6 is not the half of ten, but, on the other hand, 3 is the half of 6; and I do not see the great gain of this relation, unless it be admitted that the system of division should be binary. In France, it was proposed that each multiple of a unit by ten, and each division by ten, should be a new unit. Some slight gain might have come if this had become a thoroughly practical procedure; but, in fact, one rarely hears of any but the kilogramme, gramme, and milligramme, and so of the other numbers of the series. I think, then, that the advantage of being able to have a single weight for half a hectogramme, &c. is dearly purchased, if there be a disadvantage in the determinations; and, in deciding on a system of weight, it is necessary to consider the probable errors of these determinations.

In each of these proposed systems, 5 comparisons, giving 5 equations, are enough to connect all the weights in a decad. If this number be alone used, then the probable errors of W_{10} derived from W_1 will be

English Grain System......	$e\sqrt{24}$	
„ Bullion	$e\sqrt{34}$	if the best equation be taken.
„ Metric	$e\sqrt{38}$	
Original Metric	$e\sqrt{26}$	

In this respect the English Grain system seems best, and the Modified Metric System the worst. The Original Metric system is nearly as good as the English Grain system, and it is possibly better if a good deal more labour be given to each; but I think—when it is considered that weighing by the English Grain system requires only two weights iu each decad, and that the standard system should coincide if possible with that in use—the palm will be assigned to the Grain system.

I think, too, that those who have gone with me so far, will feel as strongly as myself the great gain of a "large primary unit." It has always been considered necessary to have the primary unit very indestructible, and no doubt this is a very important point: the lead was taken in France, where the Normal Kilogramme was made of platinum; platinum was again used in England for the Standard Pound, and now standards of reference are made of a Platinum-iridium alloy. The cost of the mere metal is very heavy (a kilogramme is at present worth £60 for mere material), and the use of such a metal for large weights is of course out of the question. It seems to me doubtful whether equal accuracy could not be obtained by employing a large weight of gilt or nickelized bronze; from which copies could be made with far greater accuracy than they could be separately deduced from the small primary. It is possibly too late to change the material of Primary Standards now, but at all events the standard of Commercial Weight should be a large mass of gilt bronze.

Acting on these principles, I have nearly made a set of weights from 1000 tolahs to 0·001 tolah from these bullion weights. There will be several copies of the largest, carefully compared, some of which I trust Government will allow me to distribute. The individual weights are on what I have called the English Grain system: that is, there are—

1000 tolahs.	100 tolahs.	10 tolahs.	1· tolahs.	0·10 tolahs.	0·010 tolahs.
600 „	60 „	6 „	0·6 „	0·06 „	0·006 „
300 „	30 „	3 „	0·3 „	0·03 „	0·003 „
200 „	20 „	2 „	0·2 „	0·02 „	0·002 „
100 „	10 „	1 „	0·1 „	0·01 „	0·001 „

The final adjustments and deductions have yet to be made; but after what I have said, there will be little new in this. I have been very greatly assisted by Mr. Durham, Senior Assistant in the Assay Office, who has superintended all of the gilding; and to whom I owe devices which will allow the gilt weights to be made true almost to the accuracy of a single comparison by substitution.

Table I.

Logarithms for calculating the Weight of the Air adapted to Fahrenheit's Thermometer.

This Table gives 10 + the logarithm of the ratio which the weight of air at the temperature named and at Calcutta bears to that of the same volume of water when at its maximum density, the logarithm of the height of the barometer.

If B be the reading of the barometer reduced to freezing point; the temperature and V the elasticity of the vapour in the air

$$\text{then log sq. of air} = A_t + \log (B - 0{\cdot}238\ V).$$

The value of A_t at sea-level in latitude 45° can be got from these numbers by adding 0·000785·7 to each and thence the value for any other place.

Temp.	A_t	$\Delta^{(1)} A_t$	Temp.	A_t	$\Delta^{(1)} A_t$	Temp.	A_t	$\Delta^{(1)} A_t$
30°	5·6366164	8848	55°	5·6150200	8419	80°	5·5944469	8030
1	6357316	8830	6	6141781	8402	1	5936439	8015
32	6348486	8812	7	6133379	8387	2	5928424	8000
3	6339674	8794	8	6124992	8371	3	5920423	7985
4	6330880	8776	9	6116621	8354	4	5912438	7971
35	5·6322104	8759	60	5·6108267	8338	85	5·5904467	7957
6	6313345	8741	1	6099929	8323	6	5896510	7942
7	6304604	8724	2	6091606	8306	7	5888568	7927
8	6295380	8705	3	6083300	8291	8	5880641	7913
9	6287175	8689	4	6075009	8275	9	5872728	7899
40	5·6278486	8671	65	5·6066734	8258	90	5·5864829	7884
1	6269815	8654	6	6058476	8244	1	5856945	7870
2	6261161	8637	7	6050232	8227	2	5849075	7856
3	6252524	8619	8	6042005	8212	3	5841219	7841
4	6243905	8603	9	6033793	8197	4	5833378	7828
45	5·6235302	8585	70	5·6025596	8181	95	5·5825550	7813
6	6226717	8569	1	6017415	8166	6	5817737	7799
7	6218148	8552	2	6009249	8151	7	5809938	7785
8	6209596	8535	3	6001098	8135	8	5802153	7772
9	6201061	8518	4	5992963	8120	9	5794381	7757
50	5·6192543	8502	75	5·5984843	8105	100	5·5786624	
1	6184041	8485	6	5976738	8090			
2	6175556	8468	7	5968468	8074			
3	6167088	8452	8	5960514	8060			
4	6158636	8436	9	5952514	8045			

Table II.

Logarithm of the Ratio of the Density of Water to its Maximum Density for each degree of Fahrenheit's Thermometer.

This Table is founded on that given at page 66 &c. of the Report of the Warden of the Standards for 1871-72. Certain values of the Table there given, were taken and the constants found to express them in a series of the form A $(t - n_1)^2$ + B $(t - n_2)^3$, and, these having then been suitably modified to change the scale of the thermometer from Centigrade to Fahrenheit, the present Table was computed.

Temp.	Log. Ratio.	$\Delta^{(1)}$ R.	Temp.	Log. Ratio.	$\Delta^{(1)}$ R.	Temp.	Log. Ratio.	$\Delta^{(1)}$ R.
30°			55°	0·0002400	+302	80°	0·0014313	639
1			6	0002702	318	1	0·0014952	650
2	0·0000546	—143	7	0003020	335	2	0015602	659
3	0000404	—121	8	0003355	350	3	0016261	670
4	0000283	— 99	9	0003705	367	4	0016931	679
35	0·0000184	— 78	60	0·0004072	381	85	0·0017610	688
6	0000106	— 56	1	0004453	397	6	0018298	698
7	0000050	— 35	2	0004850	412	7	0018996	706
8	0000015	— 15	3	0005262	426	8	0018702	715
9	0000000	+ 06	4	0005688	441	9	0020417	723
40	0·0000006	+ 27	65	0·0006129	455	90	0·0021440	732
1	0000033	47	6	0006584	469	1	0021872	739
2	0000080	66	7	0007053	483	2	0022611	747
3	0000146	86	8	0007536	497	3	0023358	754
4	0000232	105	9	0008033	509	4	0024112	762
45	0·0000337	124	70	0·0008542	523	95	0·0024874	768
6	0000461	144	1	0009065	535	6	0025642	775
7	0000605	162	2	0009600	548	7	0026417	782
8	0000767	180	3	0010148	560	8	0027199	787
9	0000947	198	4	0010708	572	9	0027986	794
50	0·0001145	216	75	0·0011280	584	100	0 0028780	
1	0001361	234	6	0011864	596			
2	0001595	251	7	0012460	607			
3	0001846	269	8	0013067	617			
4	0002115	285	9	0013684	629			

Table III.

Logarithms for facilitating the Calculation of the Cubical Expansion of Metals.

Log. $(1 + EM_t.)$

	G = M Gold — 339·14	S = M Silver — 441·41	P = M Platinum — 208·32	B = M Baily's metal — 394·98.	Br = M Brass — 398·27
1	0 000010598	0·000013794	0 000006510	0·000012343	0·000012446
2	21196	27588	13020	24686	24892
3	31794	41382	19530	37029	37338
4	42392	55176	26040	49372	49784
5	52990	68970	32550	61715	62230
6	63588	82764	39060	74058	74676
7	74186	96558	45570	86401	87122
8	84784	110352	52080	98744	99568
9	95382	124046	58590	111087	112014

This table is founded on the supposition that up to 100° of Fahrenheit's Thermometer; log expansion for $n° = n \times$ log expansion for 1°; which is true sufficiently. The linear expansions of Gold and Silver have been taken from Vol. I of Professor Miller's Chemistry; the others from the paper in the 'Philosophical Transactions' on Standard Weights.

The argument of this Table is to be T — 32°; or T itself can be taken if the number at the head of the column be applied.

Thus for brass at 85·35° we have

Br 50°	0·000622·30	or Br 80°	0·000995·68
3	37·34	5	62·23
0·3	3·73	·3	3·73
0·05	0·62	·05	0·62
		Const.	— 398·27
	0·000663·99		0·000663·99

TYPE COMPARISON I.

May 24th, 1879. Oertling, No. 1.

Comparisons of EI with O_1.

Weight on left side.	Weight on right side.	Scale Readings. Low.	Scale Readings. High.	Deduced Mean.	Remarks.
EI	$O_1 + 1{\cdot}2 \frac{R_2}{10}$	5·7 6·1	9·5 9·2	7·54	Commenced at $6^{h.}48^{m.}$ A. M. A. Bar. $29{\cdot}60^{in.}$ Temp. 85°·0 F. Dry Bulb 85°·9. Wet Bulb 81°·0.
$EI + P_{\cdot 10}$	Do.	13·6 13·7	18·0 17·8	15·81	
$O_1 + P_{\cdot 01}$	$EI + 1{\cdot}2 \frac{R_2}{10}$	13·1 13·4	17·4 17·2	15 21	
O_1	Do.	3·4 3·8	10 7 10·3	6.95	
Do.	Do.	3·4 3·8	10·0 9·6	6·60	
$O_1 + P_{\cdot 01}$	Do.	13.3 13·6	16·6 16·3	15·03	
$EI + P_{\cdot 01}$	$O_1 + 1{\cdot}2 \frac{R_2}{10}$	12·8 13·3	18·9 18·5	15·99	
EI	Do.	3·0 3·6	11.9 11·4	7·61	Bar. $29{\cdot}61^{in.}$ Temp. 86°·0 F. Dry Bulb. 85°·4 Wet Bulb 80°·1. Ended at $7^{h.}33^{m.}$ A. M.

$$\text{Hence EI} \bumpeq O_1 + 1{\cdot}2 \frac{R_2}{10} - \frac{2{\cdot}46}{8{\cdot}27} P_{\cdot 01} \bumpeq O_1 + 1{\cdot}2 \frac{R_2}{10} - 0{\cdot}297\, P_{\cdot 01}.$$

$$EI \bumpeq O_1 - 1{\cdot}2 \frac{R_2}{10} + \frac{3{\cdot}05}{8{\cdot}26} P_{\cdot 01} \bumpeq O_1 - 1{\cdot}2 \frac{R_2}{10} + 0{\cdot}369\, P_{\cdot 01}.$$

$$EI \bumpeq O_1 - 1{\cdot}2 \frac{R_2}{10} + \frac{3{\cdot}40}{8{\cdot}43} P_{\cdot 01} \bumpeq O_1 - 1{\cdot}2 \frac{R_2}{10} + 0\,404\, P_{\cdot 01}.$$

$$EI \bumpeq O_1 + 1{\cdot}2 \frac{R_2}{10} - \frac{2{\cdot}39}{8{\cdot}38} P_{\cdot 01} \bumpeq O_1 + 1.2 \frac{R_2}{10} - 0{\cdot}285\, P_{\cdot 01}.$$

$$\therefore 4\ EI \equiv 4\ O_1 + 0{\cdot}191\, P_{\cdot 01} : \text{or } EI \equiv O_1 + 0{\cdot}04775\, P_{\cdot 01}.$$

Note.—In the original the succession of observations has been distinguished, but want of space rendered it necessary to give this up.

Type Comparison II.

June 5th, 1879. Oertling No. 1.

Comparisons of O_1 with $O._8 + O_4 + O._1 = S$.

Weight on left side.	Weight on right side.	Scale Readings. Low.	Scale Readings. High.	Deduced Mean.	Remarks.
$O_1 + 5\frac{R_1}{10}$	$S_1 + 4{\cdot}2\frac{R_2}{10}$	6·3 6·6	10·2 10·0	8.34	
$O_1 + 6\frac{R_1}{10}$	Do.	13·0 13·4	19·0 18·6	15·90	
$S + 0{\cdot}6\frac{R_1}{10}$	$O_1 + 4{\cdot}2\frac{R_2}{10}$	3·0 3·3	10·6 10·3	6·88	
$S + 1{\cdot}6\frac{R_1}{10}$	Do.	11·0 11·4	17·6 17·2	14·40	
Do.	Do.	9·9 10·4	19.4 18·8	14·49	
$S + 0{\cdot}6\frac{R_1}{10}$	Do.	4·1 4·4	9·7 9·4	6·98	
$O_1 + 6\frac{R_1}{10}$	$S + 4{\cdot}2\frac{R_2}{10}$	12·8 13·1	17·9 17·4	15·40	
$O_1 + 5\frac{R_1}{10}$	Do.	6·0 6·2	9·9 9·6	7·99	

Hence $O_1 \triangleq S + 4{\cdot}2\frac{R_2}{10} - \left(5{\cdot}0 + \frac{1{\cdot}66}{7{\cdot}56}\right)\frac{R_1}{10} \triangleq S + 4{\cdot}2\frac{R_2}{10} - 0{\cdot}5226\,R_1.$

$$O_1 \triangleq S - 4{\cdot}2\frac{R_2}{10} + \left(0{\cdot}6 + \frac{3{\cdot}12}{7{\cdot}52}\right)\frac{R_1}{10} \triangleq S - 4.2\frac{R_2}{10} + 0{\cdot}1015\,R_1.$$

$$O_1 \triangleq S - 4{\cdot}2\frac{R_2}{10} + \left(0{\cdot}6 + \frac{3{\cdot}02}{7{\cdot}51}\right)\frac{R_1}{10} \triangleq S - 4{\cdot}2\frac{R_2}{10} + 0{\cdot}.002\,R_1.$$

$$O_1 \triangleq S + 4{\cdot}2\frac{R_2}{10} - \left(5{\cdot}0 + \frac{2{\cdot}01}{7{\cdot}41}\right)\frac{R_1}{10} \triangleq S + 4{\cdot}2\frac{R_2}{10} - 0{\cdot}5272\,R_1.$$

$\therefore 4\,O_1 \equiv 4\,S - 0{\cdot}8481\,R_1$ or $O_1 \equiv O._8 + O._4 + O._1 - 0.212025\,R_1$

Type Comparison III.

October 22nd, 1879. Oertling No. 2.

Comparisons of O_5 with $O_1 + O_4 + P._{02} = S$.

Weight on left side.	Weight on right side.	Scale Readings. Low.	Scale Readings. High.	Deduced Mean.	Remarks.
S	O_5	9 5 9·9	14·1 13·8	11·91	
S + $P._{03}$	Do.	15·0 15·5	22·7 22·2	18·73	
O_5	S + $P._{03}$	12 0 12·2	14·6 14·3	13·34	
Do.	S	16·3 16·7	23·0 22·6	19·55	
Do.	Do.	16·1 16·6	23·3 22·8	19·58	
Do.	S + $P._{03}$	12·2 12·4	14·1 14·0	13·21	
S + $P._{03}$	O_5	15·4 15·7	21·0 20·7	18·13	
S	Do.	10·8 10·9	13·0 12·8	11·91	

Hence $O_5 \triangleq S + \frac{3·09}{6·82} P._{03} \triangleq S + 0·453\ P._{03}$.

$O_5 \triangleq S + \frac{4·55}{6·21} P._{03} \triangleq S + 0·732\ P._{03}$.

$O_5 \triangleq S + \frac{4·58}{6·21} P._{03} \triangleq S + 0·737\ P._{03}$.

$O_5 \triangleq S + \frac{3·09}{6·22} P._{03} \triangleq S + 0·497\ P._{03}$.

$\therefore 4\ O_5 \equiv 4\ S + 2·419\ P._{03}$ and $O_5 \equiv S + 0·60475\ P._{03}$.

$\equiv O_1 + O_4 + P._{02} + 0·64475 P._{03}$.

P. S. *June* 29*th*, 1880.—After the earlier part of this paper was drafted, I learnt that M. St. Claire Deville had proposed to make standards of the Commercial Kilogram in a new manner. The metal is to be the Platinum-iridium alloy so as to secure hardness and indestructibility, but, in order that the density may be nearly that of brass, it is to be hollow, the parts are to be soldered together by fusion so as to enclose a constant mass of air, which, of course, will be included in the weighings. This plan has been adopted by the International Commission for making the European Metric Standards, and will no doubt be a great improvement on the old Commercial Standard of France, which is made of brass. The volume of these weights is to be 125 cubic centimetres, so that the density will be 8·0; which is a little lower than that of good sound weights of brass, and materially lower that that of gilt bronze; while it is greater than that of iron.

Certainly, the visible Commercial unit, to which reference can be made, appears preferable to the imaginary unit of England. Such a weight would vary in Calcutta with respect to the scientific unit to the extent of about 11 milligrams, and it would be needless to take notice (for commercial purposes) of the much smaller variations with respect to such weight as may be compared with it.

VI.—*On the High Atmospheric Pressure of* 1876-78 *in Asia and Australia, in relation to the Sun-spot Cycle.—By* Henry F. Blanford, *Met. Rep. to the Govt. of India.*

(Received December 24th, 1879; Read January 6th, 1880.)

(With Plate I.)

The three years 1876, 1877, and 1878, more especially the two former, were characterized by a deficiency of rainfall in one or many parts of India, and by a more general and very persistent excess of atmospheric pressure. With but slight and local interruptions, from August (in some parts of India from May) 1876 to August (in some cases only to May) 1878, over the whole of the Indian area, the barometer ranged above the average of many years. Nor was this excess of pressure restricted to the land. The register of Port Blair at the Andaman Islands, and that of Nancowry at the Nicobars, shew that, at these insular stations, the excessive pressure was of greater duration and more persistent and intense than at any continental station at or near the sea-level; indeed, with one striking exception, more intense than at any other station in the entire region. At these islands, the pressure rose above the average in May 1876; and, from that time to August 1878 inclusive, the mean pressure of every month was from ·004″ to ·071″ in excess of the average; derived, in the case of Port Blair from eleven, and, in that of Nancowry, from six years' registers. On the mean of the whole period and of the two stations, the excess amounted to ·0327″.

The single exceptional station, which shews a greater average excess than the Bay islands, is the hill station of Darjiling in the Sikkim Himalaya, at an elevation of nearly 7000 feet above the sea. At this station, where the barometer has been registered steadily for upwards of 12 years, the mean excess of the same period of 28 months was not less than ·0332″; or, since the first rise took place in August 1876, the mean of the whole unbroken period of 25 months' excess was ·0379″. On the plains of Bengal, the mean excess (average of six stations) was only ·0298 on the 28 months and ·0354 on the 25 months, a reduction, as compared with Darjiling, which is probably explained by the fact that, in Bengal, as indeed generally in India, the mean temperature of the air was also on the whole considerably in excess of the average; so that the stratum of air resting on the plains had less than the average density. This fact is of pregnant importance; for it shews that the excessive pressure in question was due to the condition of the higher atmosphere; of those strata, at all events, that lay above the elevation of 7000 feet; and that, in fact, the prevailing excess, instead of being caused by the conditions recorded at observatories on the plains, was to some extent counteracted by a deficiency in the mass and static pressure of the lower strata.

In his report on the Meteorology of India in 1877, Mr. Eliot drew attention to the persistently high barometric pressure of that year, and pointed out that the barometric registers of Sydney and Melbourne in Australia also "indicated, on the whole, a marked tendency to excessive pressure; and that, therefore, there is a slight probability that this is a feature of the whole area, from India southwards to Australia, including the sea area of the Indian Ocean." Furthermore, that it appeared, from the register of Hongkong, "that the pressure in that part of China was as markedly and persistently in defect as it was in excess in India."

A re-examination of the data shews, however, that this latter conclusion is extremely doubtful, and indeed probably mistaken. I find that the Hongkong barometric registers of past years have been so variously treated that no trustworthy comparison can be instituted on them; and, on the other hand, I find that the excellent registers of Zi-ka-wei near Shanghai point to an opposite conclusion, and shew that here also, on the east coast of China, the pressure was excessive during the greater part of the period in question, though to a much less degree than in the Indian region.

In the case of Australia, Mr. Eliot compared the registers of Sydney and Melbourne only. I have examined that of Adelaide in addition, and find that not only does it confirm the general conclusion drawn from the two former registers, but, further, shews that in South Australia the excess was more intense than at any other station yet examined either in Australia or India. At this station, the pressure rose above the average in May 1876 (as at the islands in the Bay of Bengal) and, with the exception of 4 months, remained in excess until June 1878; the average excess of the whole period being not less than ·0681″ or $\frac{1}{15}$ of an inch of the barometer. At Melbourne, during the same period, it averaged ·0387″ and was less prolonged. For Sydney, I have registers only up to September 1878, and these shew an excess much below that of Melbourne. It would seem, therefore, that in Australia as in Asia the excessive pressure diminished towards the east coast of the continent.

As a link between the data of the Indian and Australian regions, I have the registers of Singapore and Batavia; for the latter of which I am indebted to the kindness of Dr. Bergsma. At Singapore, the same barometer has not been in use throughout. The barometer registered in 1869 and 1870 having been injured, was replaced by another in 1871 which had never been compared directly or indirectly with the former; and the relative values of the registers in the two former and subsequent years are, therefore, more or less open to doubt. The position of the instrument also has been changed once or twice; but, in comparing the registers of past years, I have applied an appropriate correction for the changes of level. The registers extend from May 1869 to the present time. According to these, during the four and a half years, from May 1869 to October 1873, and certainly from July 1871, in only two months, was the mean pressure of any month slightly above the general average of the month, as deduced from the whole series of years; whereas, from November 1873 to February 1875 (16 months in all), ten months ranged above it, and six only below it; and from March 1875 to June 1878, every month shews an excess, excepting April 1876 (which was the same as the average) and November 1876 and December 1877, which were slightly below it. Hence, it appears that the excessive pressure began earlier and was more prolonged at Singapore than at any other station yet examined; but it was less than half as intense as at Adelaide; the average of the 26 months, May 1876 to June 1878, being only ·0293″.

The register of Batavia affords evidence very similar to that of Singapore. Here also from November 1869 to August 1873, a period of 3 years and 10 months, in only four months did the pressure range slightly above the average; from the latter date to April 1876, in ten months it exceeded the average; and from May 1876 to August 1878, it was above the average in every month except three. The average excess of this period was ·0256.″ Thus, at these two sub-equatorial stations, there is evidence of a gradual rise of atmospheric pressure since 1870; and the Batavian register recorded under the careful superintendence of Dr. Bergsma is of the highest validity.

In Ceylon and Southern India, the excessive pressure was of shorter duration than at the Bay islands, and on the average of the whole period not more than half as great; *viz.*, ·020′.

As far as can be judged, then, from the available evidence, the excess appears to have been greatest (in the Indian region) on an axis lying between the Nicobars and Bengal. And, in Australia, at Adelaide, or possibly to the westward of that station. In the absence of any sufficient registers for Western Australia, this must remain an open question. To the eastward, however, it certainly diminished greatly at Melbourne, and still more at Sydney. Whether, however, the condition of excessive pressure was continuous between Batavia and South Australia or otherwise, there is no distinct evidence to show.

In Asia, the excess was less in Assam than in Bengal, and was comparatively small at Shanghai (Zi-ka-wei). To the westward, it also diminished, but not quite regularly; since, in Orissa and on the Gangetic plains, it was less than on the plateaux of Chutia Nagpur and Bundelkand, and slightly less than in Rajputana and Sind. Some of these irregularities probably depend on variations of the temperature, and therefore density, of the lower atmosphere; and partly also are apparent only, and owing to the fact that the averages which have served as the standard of the comparison are derived, in some cases, from longer series of years than in others. That, notwithstanding these irregularities, there was, on the whole, a general decrease of the excessive pressure to the westward of the axis above defined, appears, however, pretty clearly, from the following average values of this excess for the whole period of the 28 months of its duration.

		Gangetic plain	+ ·0191″...	Punjab	+ ·0132″		
Bengal	+ ·0298″	Chutia Nagpur & Bundelkand	+ ·0284′	Rajputana and Sind	+ ·0215″		
Arakan	+ 0317″						
Bay islands	+ 0327″						
		Orissa	+ ·0164″	Nagpur and Berar	+ ·0219″	Bombay	+ ·0196″
				Dakhan	+ ·0127″	W. Coast	+ ·0102″
				Carnatic	+ ·0199″	Ceylon	+ ·020″

It may here be observed that this axis or ridge of greatest intensity, if prolonged, lay across the middle of the two great continental masses, Asia and Australia, from Western Siberia to South Australia; a position which suggests the probability that the phenomenon was in some measure dependent on the presence and position of these large land masses.

The variation of the anomalous pressure from month to month, at all the stations above referred to, is given in the accompanying Table I, which shows the deviation of the pressure, in each month, from the average of that month and place (or district), as derived from the registers of many years.

Table I.—*Deviation of pressure in each month from the*

		Punjab.	Gangetic plain.	Bundelkand, &c.	South Central Provinces and Berar.	Dakhan and Mysore.	East Coast and Carnatic.
1876.	April, ...	— ·045	— ·054	— ·033	— ·055	— ·043	— ·054
	May, ...	— ·045	— ·046	— ·037	— ·043	— ·018	— ·029
	June, ...	— ·008	— ·012	+ ·008	— ·003	— ·002	— ·008
	July, ...	— ·037	— ·048	— ·049	— ·041	— ·026	— ·025
	August, ...	+ ·004	+ ·005	+ ·015	0	+ ·005	— ·015
	September, ...	+ ·024	+ ·014	+ ·016	+ ·010	+ ·020	— ·001
	October, ...	+ ·034	+ ·044	+ ·044	+ ·042	+ ·028	+ ·023
	November, ...	— ·008	— ·015	— ·004	— ·004	— ·009	— ·004
	December, ...	+ ·051	+ ·034	+ ·042	+ ·044	+ ·032	+ ·044
1877.	January, ...	+ ·067	+ ·067	+ ·069	+ ·059	+ ·030	+ ·056
	February, ...	+ ·024	+ ·052	+ ·054	+ ·031	— ·004	+ ·021
	March, ...	+ ·015	+ ·024	+ ·033	+ ·029	+ ·005	+ ·026
	April, ...	+ ·053	+ ·060	+ ·065	+ ·050	+ ·025	+ ·045
	May, ...	+ ·030	+ ·025	+ ·055	+ ·033	+ ·010	+ ·019
	June, ...	+ ·032	+ ·037	+ ·038	+ ·034	+ ·026	+ ·033
	July, ...	+ ·011	+ ·012	+ ·040	+ ·057	+ ·054	+ ·038
	August, ...	— ·022	— ·027	— ·005	+ ·011	+ ·032	+ ·022
	September, ...	+ ·020	+ ·018	+ ·051	+ ·060	+ ·028	+ ·045
	October, ...	+ ·043	+ ·048	+ ·053	+ ·060	+ ·033	+ ·067
	November, ...	+ ·014	+ ·008	+ ·016	+ ·041	+ ·032	+ ·031
	December, ...	— ·008	— ·007	— ·004	+ ·002	+ ·003	+ ·009
1878.	January, ...	+ ·031	+ ·035	+ ·044	+ ·018	+ ·011	+ ·030
	February, ...	+ ·030	+ ·028	+ ·034	+ ·028	+ ·038	+ ·046
	March, ...	+ ·040	+ ·043	+ ·062	+ ·034	+ ·031	+ ·046
	April, ...	+ ·022	+ ·041	+ ·050	+ ·035	+ ·027	+ 038
	May, ...	+ ·029	+ ·050	+ ·048	+ ·023	+ ·012	+ ·023
	June, ...	+ ·014	— ·007	+ ·020	+ ·006	— ·010	— ·008
	July, ...	+ ·034	+ ·033	+ ·035	+ ·012	— ·015	— ·005
	August, ...	+ ·018	+ ·019	+ ·002	— ·014	— ·030	— ·009
	September, ...	— ·039	— ·031	— ·023	— ·041	— ·039	— ·028

average of the month and place.

Orissa.	Lower Bengal.	Darjeeling.	Assam and Cachar.	Arakan.	Bay Islands.	Singapore.	Batavia.	Rajputana and Sind.
—·062	—·052	—·016	—·048	—·044	—·023	0	—·037	—·040
—·037	—·017	—·005	—·002	—·012	+ ·025	+ ·033	+ ·008	—·025
—·003	+ ·014	+ ·004	—·002	+ ·012	+ ·023	+ ·030	+ ·001	+ ·002
—·050	—·045	—·018	—·035	—·027	+ ·019	+ ·032	+ ·009	—·047
—·017	+ ·005	+ ·025	—·018	—·010	+ ·009	+ ·023	—·003	+ ·002
—·017	+ ·014	+ ·046	+ ·003	+ ·013	+ ·033	+ ·025	+ ·003	+ ·030
+ ·022	+ ·047	+ ·060	+ ·058	+ ·048	+ ·034	+ ·040	+ ·012	+ ·036
—·036	—·029	+ ·002	—·029	—·030	+ ·008	—·014	+ ·004	+ ·009
+ ·034	+ ·028	+ ·043	+ ·030	+ ·042	+ ·049	+ ·037	+ ·033	+ ·038
+ ·064	+ ·065	+ ·107	+ ·084	+ ·073	+ ·066	+ ·060	+ ·054	+ ·054
+ ·062	+ ·072	+ ·031	+ ·065	+ ·060	+ ·039	+ ·043	+ ·047	+ ·023
+ ·034	+ ·038	+ ·029	+ ·027	+ ·044	+ ·029	+ ·026	+ ·028	+ ·014
+ ·065	+ ·070	+ ·028	+ ·061	+ ·058	+ ·034	+ ·029	+ ·030	+ ·039
+ ·041	+ ·042	+ ·019	+ ·032	+ ·037	+ ·027	+ ·020	+ ·016	+ ·047
+ ·015	+ ·032	+ ·041	+ ·022	+ ·014	+ ·049	+ ·049	+ ·051	+ ·034
+ ·032	+ ·023	+ ·015	—·001	+ ·002	+ ·045	+ ·045	+ ·057	+ ·065
—·032	—·032	+ ·012	—·037	—·040	+ ·034	+ ·054	+ ·066	+ ·044
+ ·057	+ ·058	+ ·037	+ ·051	+ ·078	+ ·056	+ ·040	+ ·054	+ ·055
+ ·062	+ ·077	+ ·066	+ ·081	+ ·082	+ ·071	+ ·049	+ ·058	+ ·032
+ ·008	+ ·008	+ ·028	+ ·017	+ ·031	+ ·042	+ ·036	+ ·033	+ ·017
—·018	—·003	+ ·011	—·004	+ ·016	+ ·015	—·003	+ ·008	—·008
+ ·019	+ ·045	+ ·021	+ ·044	+ ·054	+ ·035	+ ·015	+ ·026	+ ·038
+ ·017	+ ·030	+ ·042	+ ·035	+ ·062	+ ·046	+ ·033	+ ·051	+ 037
+ ·036	+ ·050	+ ·068	+ ·069	+ ·073	+ ·051	+ ·036	+ ·039	+ ·041
+ ·040	+ ·055	+ ·059	+ ·058	+ ·042	+ ·032	+ ·016	+ ·012	+ ·029
+ ·035	+ ·060	+ ·029	+ ·049	+ ·035	+ ·004	+ ·002	—·002	+ ·013
—·011	+ ·015	+ ·026	+ ·011	+ ·019	+ ·007	+ ·005	+ ·006	+ ·017
+ ·024	+ ·067	+ ·056	+ ·066	+ ·071	+ ·012	—·014	—·022	+ ·001
+ ·003	+ ·047	+ ·047	+ ·050	+ ·061	+ ·021	+ ·014	+ ·002	—·036
—·042	—·023	—·009	—·028	—·025	—·014	—·011	—·015	—·040

TABLE I.—*Deviation of pressure in each month from the average of the month and place.*—(Continued.)

		Bombay.	Ceylon.	Zi-ka-wei.	Sydney.	Melbourne.	Adelaide.
1876.	April, ...	— ·039	— ·039	— ·037	— ·167	— ·094	— ·002
	May, ...	+ ·009	— ·003	+ ·030	+ ·072	— ·106	+ ·110
	June, ...	+ ·026	+ ·002	+ ·018	+ ·039	+ ·043	+ ·094
	July, ...	— ·020	— ·007	+ ·021	+ ·007	+ ·097	+ ·072
	August, ...	+ ·018	— ·007	— ·016	+ ·013	+ ·048	+ ·101
	September, ...	+ ·034	+ ·006	+ ·043	— ·061	+ ·001	+ ·100
	October, ...	+ ·045	+ ·017	— ·018	+ ·120	— ·060	— ·031
	November, ...	— ·004	— ·013	— ·071	— ·191	— ·119	— ·053
	December, ...	+ ·023	+ ·028	+ ·014	+ ·035	+ ·056	+ ·077
1877.	January, ...	+ ·038	+ ·045	+ ·022	— ·051	+ ·007	+ ·040
	February, ...	+ ·027	+ ·032	+ ·036	+ ·052	+ ·026	+ ·026
	March, ...	+ ·025	+ ·017	— ·011	+ ·061	+ ·060	+ ·057
	April, ...	+ ·029	+ ·027	— ·019	+ ·024	+ ·053	+ ·079
	May, ...	+ ·035	+ ·017	+ ·012	— ·209	— ·152	— ·112
	June, ...	+ ·055	+ ·057	+ ·006	+ ·196	+ ·204	+ ·285
	July, ...	+ ·097	+ ·043	+ ·005	+ ·137	+ ·163	+ ·090
	August, ...	+ ·052	+ ·050	+ ·015	+ ·065	+ ·087	+ ·118
	September, ...	+ ·038	+ ·040	+ ·024	+ ·077	+ ·152	+ ·162
	October, ...	+ ·034	+ ·060	+ ·030		+ ·121	+ ·101
	November, ...	+ ·020	+ ·029	+ ·004		— ·002	+ ·081
	December, ...	— ·015	— ·003	— ·008		+ ·011	+ ·063
1878.	January, ...	+ ·015	+ ·020	+ ·045		+ 125	+ ·114
	February, ...	+ ·043	+ ·037	+ ·079		+ ·064	+ ·092
	March, ...	+ ·039	+ ·035	+ ·080		— ·018	+ ·013
	April, ...	+ ·020	+ ·026	+ ·052	Not received.	— ·039	— ·025
	May, ...	+ ·025	+ ·009	— ·015		+ ·072	+ ·104
	June, ...	+ ·022	+ ·007	— ·001		— ·099	+ ·014
	July, ...	0	— ·010	+ ·020		— ·155	— ·161
	August, ...	— ·049	— ·003	+ ·033		— ·076	+ ·003
	September, ...	— ·083	— ·009	— ·058		— ·115	— ·133

Evidence bearing on the northern prolongation of the axis of maximum pressure across Central Asia (at least up to the end of 1877) is afforded by the old established observatories of the Russian empire; the registers of which, since 1847, are given in the 'Annales de l'Observatoire Physique Central de Russie'. Before, however, proceeding to notice the barometric condition of this region during the special period in question, I must draw attention to another class of facts, which have an important bearing on the subject, and which, although not entirely new, have been brought out in the present investigation with remarkable clearness and prominence.

I have already noticed the evidence furnished by the registers of Singapore and Batavia, of a persistently low pressure from 1869 to the latter part of 1873, of its gradual rise during the subsequent years, and its culmination in 1877. The Batavian register extends as far back as 1866; comprising, therefore, a period of 13 years, and somewhat more than a complete cycle of sun-spot variation. The deviation of the mean pressure of each year from the general average of the whole period is given in the second column of Table II; and, in the first, I have given the variation of Wolf's sun-spots numbers up to 1875, the latest date for which I have them. I need only add that from 1875 to the early part of the present year, was a prolonged period of minimum solar activity. The coincidence of the barometric variation with that of the sun-spots is too obvious to need comment; and it is emphatically to be noticed that the minimum of pressure coincides with the maximum of spots, and *vice versâ*. The remaining columns of the table give the annual deviation of the mean pressure of each year from the general local averages, for the stations Singapore, Port Blair, Colombo, Akyab, Chittagong, Calcutta, and Darjiling, from 1867 to 1878; and the accompanying plate represents graphically the course of variation at each station from year to year. All these exhibit, more or less distinctly, an oscillation similar to that of Batavia; being most pronounced at insular and sub-equatorial stations. Table III gives the annual barometric variation of Calcutta and Bombay from 1848 and 1852 respectively, and Plate I, the corresponding curves.

TABLE II.—*Annual variation of barometric pressure in Indo-Malayan region.*

Years.	Wolf's sun-spot numbers.	Batavia.	Singapore.	Colombo.	Port Blair.	Akyab.	Chittagong.	Calcutta.	Darjiling.	Bombay.
1867	8·8	+ ·006	...	...	...	+ ·009	— ·017	+ ·022	(6) — ·008	+ ·015
'68	36·8	+ .020	...	...	+ ·029	+ ·003	— ·019	+ ·022	— ·017	+ ·027
'69	78·6	+ ·011	(1) — ·018	...	+ ·006	(4) + ·012	— ·019	+ ·006	— ·019	+ ·005
'70	131·8	— ·023	— ·044	...	— ·042	(5) — ·001	— ·026	— ·011	— ·009	— ·012
'71	113·8	— ·009	(2) — ·011	...	(3) — ·006	— ·013	— ·008	— ·008	— ·007	— ·004
'72	99·7	— ·020	— ·023	— ·020	— ·020	— ·017	— ·001	+ ·004	+ ·009	— ·014
'73	67·7	— ·010	— ·017	— ·005	— ·013	— ·021	+ ·007	— ·008	+ ·001	— ·010
'74	43·1	— ·006	+ ·018	+ ·003	— ·007	+ ·001	+ ·023	+ ·005	+ ·008	— ·011
'75	18·9	— ·011	+ ·018	— ·004	— ·006	— ·008	+ ·002	— ·008	+ ·009	0
'76	...	— ·002	+ ·019	+ ·002	+ ·010	— ·009	— ·003	— ·009	+ ·006	+ ·007
'77	...	+ ·042	+ ·037	+ ·037	+ ·052	+ ·036	+ ·039	+ ·044	+ ·085	+ ·037
'78	...	— ·001	— ·002	0	+ ·010	+ ·012	+ ·022	+ ·014	+ ·012	— ·011

(1) Last eight months.

(2) Last six months.

(3) January, February and last six months.

(4) Wanting February and December.

(5) Wanting January.

(6) Last six months only.

TABLE III.—*Annual variation of pressure at Calcutta and Bombay.*

Years.	Calcutta.	Bombay.	Years.	Calcutta.	Bombay.
1847	...	—·012	1858	—·003	+ ·003
'48	...	—·004	'59	+ ·009	+ ·004
'49	...	—·011	'60	—·019	—·005
'50	...	—·001	'61	—·023	—·012
'51	...	—·013	'62	—·017	—·026
'52	...	—·004	'63	—·024	—·017
'53	—·013	+ ·005	'64	—·011	+ ·023
'54	—·002	—·005	'65	+ ·018	+ ·002
'55	+ ·005	+ ·015	'66	+ ·004	+ ·013
'56	—·004	—·003	'67	+ ·022	+ ·015
'57	—·013	—·001	'68	+ ·022	+ ·027

From these facts, it may be concluded that, in the Indo-Malayan region, the pressure of the atmosphere is subject to a cyclical variation, coinciding in period with that of the sun-spots; and such that the epoch of maximum pressure corresponds to that of minimum sun-spots and that of minimum pressure to that of maximum sun-spots. When, however, we turn to Western Siberia, we find an oscillation, not less, nay, far more pronounced, and precisely of the opposite character; the maximum of pressure there coinciding with the maximum of sun-spots, and *vice versâ.* The station which exhibits this most prominently, is Ekaterinenburg at the eastern foot of the Oural. But it is also very distinctly recognizable at Bogolowsk to the North, at Slatoust to the South-west, at Barnoul at the northern foot of the Altai, and, as Mr. Archibald pointed out some time since in the pages of 'Nature,' at St. Petersburg. The annual differences at these stations are given in Table IV, and the corresponding curves in the accompanying plate.

TABLE IV.—*Annual variation of barometric pressure in Russia and Western Siberia.*

Years.	Wolf's sun-spot numbers.	St. Petersburgh.	Bogolowsk.	Ekaterinenburg.	Slatoust.	Barnoul.
1847	97·4	+ ·045	— ·034	+ ·022	+ ·097	— ·011
'48	124·9	+ ·044	— ·027	+ ·049	+ ·078	+ ·028
'49	95·4	+ ·003	+ ·053	+ ·011	+ ·033	— ·017
'50	69·8	— ·027	— ·009	+ ·006	+ ·037	+ ·011
'51	63.2	+ ·036	+ ·023	+ ·014	— ·055	+ ·007
'52	52·7	— ·012	— ·012	— ·015	— ·118	+ ·019
'53	38·5	+ ·065	+ ·059	+ ·065	— ·074	+ ·023
'54	21·0	— ·081	— ·034	— ·032	— ·019	— ·013
'55	7·7	+ ·008	— ·003	— ·023	— ·024	— ·013
'56	5·1	— ·104	— ·087	— ·087	— ·069	— ·024
'57	22·9	+ ·064	— ·032	— ·029	+ ·009	— ·040
'58	56·2	— .010	— ·062	— ·045	— ·010	— ·031
'59	90·3	— ·022	— ·016	— ·004	+ ·015	+ .008
'60	94·8	+ ·061	+ ·171	+ ·046	+ ·028	+ ·055
'61	77·7	— ·005	+ ·014	— ·016	— ·021	
'62	61·0	+ ·086	+ ·022	+ ·006	+ ·014	
'63	45·4	— ·049	— ·064	— ·031	— ·023	— ·062
'64	45·2	+ ·021	— ·014	— ·034	+ ·021	+ ·013
'65	31·4	+ ·018	— ·018	— ·056	— ·036	— ·017
'66	14·7	— ·071	— ·004	— ·052	— ·025	+ ·008
'67	8·8	— ·073	— ·052	— ·053	— ·035	— ·003
'68	36·8	— ·017	— ·017	+ ·008	+ ·017	+ ·030
'69	78·6	— ·034	— ·019	+ ·071	+ ·082	+ ·050
'70	131·8	+ ·023	— ·001	+ ·030	+ ·025	+ ·002
'71	113·8	— ·012	— ·029	— ·009	— ·007	— ·011
'72	99 7	+ ·070	+ ·030	+ ·017	?	— 020
'73	67·7	— ·040	— ·033	— ·038	— ·034	— ·001
'74	43·1	— ·087	+ ·066	+ ·016	— ·060	+ ·019
'75	18·9	+ ·051	+ ·022	— ·007	— .088	+ .003
'76	...	+ ·031	+ ·015	0	— ·080	— ·001
'77	...	+ ·008	+ ·121	+ ·095	+ .010	+ ·098

All these stations, be it observed, are in Western Siberia or European Russia; and it now becomes of interest to ascertain over what area this kind of oscillation obtains. To do this, I have tabulated the barometric data for Tiflis on the South-west, and Nertschinsk and Pekin on the East. No one of these stations exhibits characters resembling those of the stations in Western Siberia; and the curve of Pekin, which is fragmentary, seems rather to exhibit the Indo-Malayan type of variation than that of the Ural stations. Hence, it would seem there is a reciprocal oscillation of atmospheric pressure between Western Siberia and the Indo-Malayan region (perhaps including China) having a period which coincides with that of sun-spot variation; and that Tiflis on the one hand and Nertschinsk on the other lie beyond the limits of its influence.

Now, seeing that the Indo-Malayan barometric maximum of 1876-78 coincided with a portion of the prolonged sun-spot minimum of 1876-79, the facts detailed above would lead us to expect a corresponding deficiency of pressure in Western Siberia. Strange to say, however, this was not the case. The registers of Bogolowsk, Ekaterinenburg, Slatoust, and Barnoul agree in showing a great excess of pressure in 1877, which in the case of Ekaterinenburg was greater than that of any Indian stations, and nearly as great as that of Adelaide. I have not yet received the volume of the 'Annales' for the year 1878; but, on the average of the 20 months from May 1876 to December 1877, it amounted to ·0611." The great excess appears to have been restricted to the stations in Western Siberia. At St. Petersburg, although the pressure was above the average in 1876 and 1877, the excess was far less striking; and that of 1877 was less than that of 1876. At Tiflis, the pressure of the two years was either about the average or below it; and, at Pekin and Nertschinsk, it was not greater than at Shanghai [Zi-ka-wei].

Hence, there prevailed in Asia generally, in 1877, an anomalous (*i. e.*, apparently non-periodic) accumulation of atmospheric pressure, culminating in Western Siberia, and diminishing both to East and West, and also to South. And this seat of maximum lies on the prolongation to the North-west of the Indo-Malayan axis of excessive pressure noticed in the earlier part of this paper. It is at least probable that this anomalous accumulation of pressure extended in a much diminished degree to the Indo-Malayan region, where it was superimposed on the normal periodic excess of that region, and produced a maximum which was more intense than any previously recorded. Also that the excessive pressure of Australia was a phenomenon of the same order as that of Siberia; indeed its southern counterpart. It is at least certain that they exhibit a resemblance in certain not unimportant features to which I shall draw attention in a subsequent paper; merely remarking that, in both cases, these great oscillations of pressure, both periodic and non-periodic, appear to depend mainly, perhaps, indeed, entirely, on the variations of the winter season. Of this, in the case of Ekaterinenburg more especially, the evidence is most striking and convincing, and, as far as I have yet examined the Australian registers, it appears to hold good in their case also.

VII.—*Synopsis of the Species of* Choeradodis, *a remarkable Genus of* Mantodea *common to India and Tropical America.*—*By* J. Wood-Mason, *Officiating Superintendent Indian Museum, and Professor of Comparative Anatomy, Medical College, Calcutta.*

(Received May 1st;—Read June 2nd, 1880.)

The paper of which the following is an abstract, will be published in full as soon as the illustrations which have been drawn on the wood under my supervision and sent to London to be cut are returned to this country.

The remarkable distribution of this genus of *Mantodea* is exactly paralleled by that of another genus of *Orthoptera*, namely *Mastax*, species of which from the southern slopes of the Peruvian Andes have recently been described by Dr. S. H. Scudder.

The nearest allies of *Chœradodis* are the Australian *Orthoderas*, which its young 'larvæ' resemble in the form of the pronotum.

Genus Choeradodis, Serville.

A. Fore femora without a black blotch on the inner side.

1. Choeradodis strumaria.

Madame Mérian, Ins. de Surinam, 1726, tab. 27, ♀ et nymph.

Roesel von Rosenhof, Der monatlich-herausgegebenen Insecten Belustigung, 2ter Theil, 1749, Locust. tab. iii, fig. 1 et 2, ♀ et nymph (copied from Mérian).

Mantis strumaria, Linn., Syst. nat. Ins. t. i, pt. ii, 1767, p. 691, no. 13, ♀.

——— ——— Fabr., Ent. Syst. ii, 1793, p. 18, no. 21.

? —— *cancellata*, Fabr., l. c., 23.

——— ————, Stoll, Spectres et Mantes, pl. xi, fig. 42, ♀.

——— ————, Lichtenstein, Trans. Linn. Soc. Lond. vol. 6, p. 25.

Chœradodis cancellata, Serville, Hist. nat. des Orthopt. 1839, p. 206, ♀.

Craurusa cancellata, Burmeister, Handb. d. Entom. 1839, Band ii, p. 542, (Syn. Serv. et Stoll. fig. 75, exclus.)

Choeradodis cancellata, Saussure, Mant. Americ. p. 19, ♂, ♀.

Hab. Cayenne (♀, *Serville*); Surinam (♀, *Mérian*, *Stoll*; ♂ ♀, *Saussure*).

B. Fore femora with a black blotch on the inner side.

(a.) *The blotch on the lower half of the joint* (American).

In the females of the following two species, the posterior angles of the pronotal expansions are broadly rounded and are not produced backwards beyond the level of the hinder end of the primitive pronotum.

2. Choeradodis rhombicollis.

Mantis rhombicollis, Latr. in Voy. de Humboldt, Zool., Ins. p. 103, pl. 39, figs. 2, 3, ♂.

Choeradodis peruviana, Serville, Hist. nat. des Orthopt. 1839, p. 207, ♂.
——— *strumaria*, Stål, Syst. Mant., 1877, p. 15, ♂ ♀.

The blotch commences, in both sexes, near the base of the femur, extends through the ungual groove nearly to the middle of the joint, and is there succeeded by a marginal row of black points in contact with the bases of alternate spines.

Hab. ♂ ♀, Guayaquil, in the collection of the British Museum; nymph, Santa Fé de Bogota, in the collection of the Indian Museum, Calcutta; New Granada (♂ ♀, *Stål*).

3. Choeradodis servillei, n. sp.

♀. Closely allied to the preceding, from which it differs in having the marginal field of the tegmina proportionately narrower, and in the smaller size, as well as in the different shape, of the femoral blotch, which is small and oval, commences just beyond the ungual groove, and is followed by a marginal row of small black points.

Hab. 2 ♀, Cache, Costa Rica, in the collection of Messrs. Godman and Salvin; nymph, Chiriqui, in the collection of the Indian Museum, Calcutta.

In the females of the next two species, and in all probability in those of *Ch. rhomboidea* also, the posterior angles of the pronotal lamellæ are rounded-angulate and produced backwards so that the hinder end of the primitive pronotum projects in the bottom of an angular emargination.

4. Choeradodis laticollis.

Choeradodis laticollis, Serville, Revue p. 24; Hist. nat. des Orthopt. 1839, p. 208, pl. iv, fig. 2, ♀.
——— ——— Saussure, Mantes Americ. p. 20, ♀.
——— *strumaria*, Id., ibid. p. 18, ♂.
——— *laticollis*, Stal, Syst. Mant. 1877, 17, ♀.

The blotch is situated, in both sexes, just beyond the ungual groove, is oblong-rhomboidal in shape, and is followed by two black points on the bases of alternate spines; there is a fuscous speck at the end of the stigmatal spot of the tegmina; and the antero-lateral margins of the pronotal lamellæ are arcuate or convex, especially in the female.

Hab. 5 ♂, 5 ♀, Ecuador (*Buckley*), in the collection of the Indian Museum, Calcutta; Peru (♀, *Stal*); Cayenne (♀, *Serville* et *Stal*); Surinam (♂, *Saussure*).

5. Choeradodis stalii, n. sp.

Differs from the preceding in the shape of the blotch (which is pointed at both ends and commences in the ungual groove, and on either side of which the femur is pale luteous-yellow instead of being clouded with fuscous); in being without a fuscous speck at the distal end of the stigma; in its shorter and differently shaped facial shield; and in having the antero-lateral margins and the lateral angles of the pronotal expansions sinuous-concave and more broadly rounded off respectively.

HAB. 1 ♂, 4 ♀, Ecuador *(Buckley)*, in the collection of the Indian Museum, Calcutta.

6. CHOERADODIS RHOMBOIDEA.

Mantis rhomboidea, Stoll, Spectres et Mantes, pl. xi, fig. 45, ♂.

The male insect from Pará, in the British Museum, agrees neither with Saussure's description (*loc. supra cit.* p. 18), nor with any of the specimens in the Indian Museum; it more nearly approaches Stoll's figure, agreeing therewith in the points in which it differs from them.

The blotch commences in the ungual groove, thence extending as far along the femur as in the preceding four species, but it is not followed by a marginal row of black points. The pronotal lamellæ have no posterior angles.

HAB. ♂, Pará, in the collection of the British Museum. A nymph, from Ega, in the same collection, probably also belongs to this species.

This species is nearest allied to *Ch. laticollis*.

(β) *The blotch on the upper half of the joint* (Indian.)

7. CHOERADODIS SQUILLA.

? *Mantis cancellata*, Fabr. Ent. Syst. II, 1793, p. 18.

Choeradodis squilla, Saussure, Mél. Orthopt. t. i, 3me fasc. p. 161, pl. iv, figs. 3, 3a, ♂ et nymph.

—— —— Lucas, Ann. Entom. Soc. Fr. 5 sér. t. ii, 1872, p. 32, ♀.

HAB. India generally, from Ceylon (♂ et nymph, *Saussure*; larva, in I. M. Calc.); Madras (♀, *Lucas*); Central India (in coll. Hop. Oxon.); to the banks of the Killing River, in the N. Khasi Hills, on the N. E. Frontier (nymph, *A. W. Chennell*).

Obs. A specimen of this species in the British Museum is erroneously marked "Brazil."

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VIII.—*On the past and present Water supplies of Calcutta.*—By ALEXANDER PEDLER, F. I. C., F. C. S., London and Berlin.

At the present day it is I believe universally acknowledged, that every town should be provided with a pure and sufficient supply of water for drinking, domestic and sanitary purposes. If the quantity be not sufficient or if the quality be not good, it may be safely asserted that injury, more or less profound, to the general health of its inhabitants will be the consequence. The very great importance which is attached to the quality and quantity of the water supply of towns, is clear from the prominence which this subject has attained throughout the civilized world during the past few years. In the present paper, it will be my purpose to contrast the nature of the water employed in Calcutta in former years (before the introduction of the present hydrant water) with the supply as it has been since the introduction of the Hooghly water, which is collected and filtered at Pultah, and then distributed by the hydrants, etc. It will be my endeavour to show that the old supply was deficient in quantity, and filthy and abominable in quality, whilst the present supply, though perhaps not so abundant in quantity as it ought to be, is in quality very good and wholesome.

Before proceeding to the discussion of the question of the two supplies, it will perhaps be well to consider what is the general history of natural waters, as this will enable us to understand some of the actual results which have been found by analysis.

The primary form of natural water is rain, and although at first sight it might appear that rain water should be very pure, yet it has been clearly shown* that it is very seldom that such is the case, and that rain water almost always contains, as impurities, small quantities of organic matter, ammonia, and ammonium salts, derived from the atmosphere. In large towns especially, the rain water is so impure, that it cannot be considered a safe water supply for drinking and other domestic purposes. On reaching the ground the water becomes charged to a greater or less extent with the various soluble constituents of the soil, and with any other matters which may have accumulated in it. If it falls on land either cultivated or uncultivated, it rapidly drains off, and finds its way into streams and rivers, which in the earlier parts of their course certainly, will be tolerably free from organic impurity, except that derived from any manure, etc. which may have been on the land. Unless the river water is subsequently rendered impure by the admission of sewage from towns, villages, etc., or by the admission of manufacturing refuse, it will form, generally speaking, a comparatively pure and wholesome supply of water. In some cases, however, such water is used by the inhabitants of towns on its banks, and is after use returned to the river in the form of sewage, which will be charged with impurity derived from animal excreta, household and manufacturing refuse, soap, and other filth. Water contaminated in such a way is clearly unfit for domestic use. After returning to the stream it will perhaps in its course towards the sea become partially purified by slow oxidation of the organic matter and by the absorbent action of vegetation, but as will be subsequently shown this process of purification is an extremely slow one.

In the case of rain water falling in towns such as Calcutta, it will, as pointed out previously, be impure from the presence of organic matter, ammonia, etc.; of this impure water a considerable proportion of it as before shewn will find its way into the river or into smaller streams communicating with it, but another portion will be collected in the tanks, which are dug for this purpose, and a third portion after percolating through the soil will find its way into numerous shallow wells. These tanks and shallow wells may therefore be considered as being merely pits for the accumulation of drainage from the immediately surrounding soil. In the case of Calcutta the town is densely populated, and as the manners and customs of the native inhabitants are in many respects very primitive, the soil must be inevitably charged with excretal and other refuse, so that the water when it reaches the tank or well, will be largely contaminated with the impurities derived from these sources. In the absence of any system of drainage, as was the case in Calcutta some years ago, such tank or well water could only

* Angus Smith on Air and Rain.

after use be thrown on the surface of the ground, or into the nearest ditch, from which it would either run or percolate into the tank or well a second time, and would naturally be in a still more impure condition. Such would appear to be the natural conclusions as to supplies of water derived from rivers, and from tanks and shallow wells in towns, and it will be subsequently seen that the quality of the Hooghly river water, and of the water of the tanks and wells within Calcutta, as deduced from numerous analyses fully bears out the above suggestions.

In speaking of the former supply of water to Calcutta, I have assumed that it was confined to the various tanks and wells distributed throughout the town; for though there is no doubt that the river water was used considerably by the inhabitants who lived near the banks of the river, yet the greater number of the inhabitants living as they did at a distance from the river, must have depended for their supply of household water on the tanks and wells nearest to them. The modern water supply of Calcutta which we have to consider is of course the Hooghly water collected at Pultah and, after filtration, etc., distributed through the ordinary mains.

For the purposes of this paper I have not thought it necessary to analyze all the tank and well waters in the town, which amount to many hundreds, but as I have examined 200 samples, some from the crowded districts of the northern part of the town, and some from the open maidan, I think a fair conclusion can be derived from them. I have also to mention, that a very large number of the well and tank waters which I have analyzed, have been noticeable for their bad quality, and for having apparently given rise to disease of one kind or another to the persons who were living in the neighbourhood. Therefore the numbers usually obtained represent the bad rather than the good waters of the old supply. I should however wish to point out, that there is every probability, that the water in the tanks and wells now, is of a much better quality then formerly it was, for by the present system of drainage and conservancy, a vast amount of excreta and filth of all kinds is removed from the town, which in former days must have remained to choke up the soil, and to render the tank and well water very much more impure than at present.

I will attempt first to shew, that, when the inhabitants of this town depended for their water supply on the tanks and wells, the quantity was decidedly insufficient during at least one half of the year.

With regard to the necessity of a sufficient supply of water being given to a town for domestic and sanitary purposes, a well known author on Hygiene, writes—*

"It was there shown that want of water leads to impurities of all kinds; the person and clothes are not washed, or are washed repeatedly in

* Parkes' Hygiene, 5th edition, p. 37.

the same water; cooking water is used scantily, or more than once; habitations become dirty, streets are not cleaned, sewers become clogged; and in these various ways a want of water produces uncleanliness of the very air itself.

"The result of such a state of things is a general lowered state of health among the population; it has been thought also that some skin diseases—scabies, and the epiphytic affections especially—and ophthalmia in some cases, are thus propagated. It has also appeared to me that the remarkable cessation of spotted typhus among the civilized and cleanly nations, is in part owing, not merely to better ventilation, but to more frequent and thorough washing of clothes.

"The deficiency of water leading to insufficient cleansing of sewers has a great effect on the spread of typhoid fever and of choleraic diarrhœa; and cases have been known in which outbreaks of the latter disease have been arrested by a heavy fall of rain."

In judging of the quantity of water necessary to be supplied to a town, notice must be taken of the purposes for which the water is used. These we may roughly summarise by saying that water is required for drinking, cooking and the washing of persons, clothes, utensils and houses, for the flushing and cleansing of sewers and drains and for the watering of streets, for the drinking and washing of animals, the cleansing of carriages and stables, for trade purposes, etc.

From European statistics given by the authority just quoted, it would appear to be generally admitted, that a fair allowance of water for the purposes above enumerated is 25 gallons per head of population per day. Thus taking some of the largest towns in England and including Paris, each inhabitant receives 27½ gallons per day; the average daily supply of 14 English towns of second rate magnitude was 24 gallons per head, and that of 72 English and Scotch towns was found to be 26·7 gallons per inhabitant.

Let us now see the amount of water available in Calcutta during certain portions of the year when the old supply was depended upon. The tanks and wells in any town can of course only receive their supply of water from rain, and the rainfall of Calcutta is so unequally distributed, that almost three quarters of the whole fall takes place within 4 months of the year, whilst within 6 months, ten-elevenths of the rain falls. Thus the annual rainfall of Calcutta from 49 years' observation, has been found to be 65·85 inches, and during the months from November to April inclusive, only 6·03 inches fall on the average.

If we exclude from our calculation the months of heaviest rainfall, when the water would almost entirely run off into the river and be lost, and assuming for a moment that during these six months from November to April, the whole of the water which fell could be collected and stored for use; then knowing that, according to the last Calcutta Census, the density of the population was 109 persons per acre, it is easy to calculate that each person could receive but 6·8 gallons of *fresh* water daily. In all probability, however, not one-fifth of the rainfall finds its way into these tanks and wells, and this would leave the inhabitants less than 1½ gallons of *fresh* water per day during the hot season of the year. In the Coomartolle Section of the town where the density of the population is 214 per acre, this supply must be reduced to one half or to about three quarters of a gallon of *fresh* water per day.

If even we were to assume, that it was possible to store up the water which fell during the rains, for use during the dry season of the year, and granting as before that one fifth found its way into the tanks and wells, even then each inhabitant of the town could not have had more than 6 or 7 gallons of fresh water daily, and an inhabitant of some parts of the northern division, could not have had more than 3 or 4 gallons.

The conclusion seems to me to be inevitable, that at the time when Calcutta depended for its water supply on its tanks and wells, the inhabitants must have used the same water over and over again though of course without knowing it, not only for such purposes as bathing, washing clothes etc., but probably also for cooking and even for drinking, and it would also appear that there could have been absolutely no water for necessary sanitary measures.

That Calcutta, under these circumstances, should have had a high rate of mortality is scarcely surprising.

I will now endeavour to show that the quality of the old water supply was even less satisfactory than its quantity, and that in a large number of instances of tank and well water, if not in the majority of cases, the water was, and still is, simply sewage, sometimes concentrated, sometimes dilute.

That impure water may be the source of disease is, I believe, now admitted on all hands, and if confirmation were required, abundant evidence to this effect is given in the various reports of the Rivers Pollution Commissioners in England. The researches too of Chauveau, Burdon, Sanderson, Klein and others scarcely leave room for doubt that the specific poisons of the so-called zymotic diseases consist of organized and living matter; and it is now certain that water is the medium through which some at least of these diseases are propagated. There does not appear indeed to be any doubt whatever that such diseases as cholera, typhoid fever, dysentery and diarrhœa may be produced by drinking impure or infected water. An excellent and most conclusive instance of the propagation of typhoid fever by water from one infected case near Basel in Switzerland is admirably described by Dr. Hägler, and is given in the sixth report of the Commissioners above referred to.

It is then evident that, in the analysis of water, the point to be aimed at would be, the detection of the presence of those impurities whether they be of the nature of germs or not, which would give rise to the diseases just mentioned, but unfortunately in the present state of science, we are quite unable even to say with any certainty whether such germs of disease will ever be isolated, and it is therefore clearly out of the power of the chemist to detect their presence in any sample of water. Failing therefore in this endeavour, the chemical analyst has to rest content with the detection and estimation of other substances, such as organic nitrogenous matter etc., which cannot be present in water, unless it has previously been in contact with the various forms of impurity, which we denominate sewage; and if such bodies are present in quantity, it is fair to infer that these germs or other bodies which produce the zymotic diseases, and which are undoubtedly present very frequently in sewage, may also be present in the sample of water. It has also been clearly shown, that in many instances water which is impregnated with animal or vegetable organic matter, even assuming any specific poison to be absent, will give rise to various unpleasant symptoms, such as diarrhœa, etc. It is therefore quite permissible and necessary to condemn any sample of water which is to be used as a potable or domestic supply, if it contains any quantity of organic matter, more especially if the organic matter be of animal origin.

The methods of water analysis have been improved very greatly during the past fifteen years, but even now there is a very warm discussion being carried on as to the respective merits of at least three distinct processes, and opinions differ materially as to which method gives most accurate and reliable results. The two methods for the determination of the amount of organic matter present in water, which have met with the greatest amount of support, are those of Professors Wanklyn and Frankland.

The method proposed by Prof. Wanklyn, which consists in the conversion of the nitrogenous organic matter into ammonia by boiling with an alkaline solution of potassium permanganate, has the immense advantage of being quickly performed with tolerably simple apparatus, and a whole water analysis by this method does not occupy more than a few hours. Against this method there is the well recognized fact, that it sometimes fails to detect and estimate the whole of the nitrogenous organic matter present in the water. It is therefore possible that a water may escape the condemnation which it deserves, but I believe it is generally accepted that a water which is condemned by this process must be really of very bad quality.

The method of analysis which was introduced by Dr. Frankland is an extremely elaborate one, and requires the use of very delicate and expensive apparatus. The greatest drawback to this process is however, the amount of work and time which is required for it, as a satisfactory analysis by it cannot be performed in less than 4 or 5 days. On the other hand the results obtained by Frankland's process are eminently trustworthy, and the character of a water is determined by it with great precision.

As I have been obliged to perform the work of analysis of the tank and well waters of Calcutta during the spare time from my current duties, and as some two hundred analyses had to be made by my own hands, it was clearly impossible for me to use Frankland's more accurate process, and I was compelled rather against my own notions of scientific accuracy to work with Wanklyn's process, which as I have pointed out is not so trustworthy as the other. In addition to this reason, I found that my predecessor in the office of Analyst to the Corporation had been in the habit of testing the Calcutta hydrant water by Wanklyn's process. As I had to carry on this method of analysis on behalf of the Corporation, this therefore formed a very intelligible standard of comparison for my work with the former water supply of Calcutta. In addition however to these analyses of the hydrant water, as will be seen subsequently, I have carried out for the last four years monthly analyses of the hydrant water by Frankland's process, and it is upon these numbers that I shall base my conclusions as to the character and quality of the present water supply.

In Wanklyn's process there are two principal determinations. The first is the estimation of the free ammonia present in the water, and of the albuminoid ammonia obtained by distillation with alkaline potassium permanganate. In India, I have frequently combined these two processes, and the ammonia from both is called the "Total Ammonia." The reason why these two processes have been combined is, that in almost every case when I have tested the *potable* waters of India for free ammonia, I have found it to be almost entirely absent. The fact appears to be, that at the very high temperature which here obtains, the ammonia oxidizes with such extreme rapidity, that if any free ammonia were present at the collection of the water, it would become partially or wholly converted into inorganic nitrogenous matters before the analysis could be performed, or, if the whole of the free ammonia were not thus oxidized, the changes which go on from day to day are so great, that for any true comparison in respect of this constituent between the samples of water analyzed, it would be necessary to analyze them at definite intervals after collection. The "total ammonia" then, which is spoken of subsequently, is the free ammonia present, if any, added to the ammonia produced from the nitrogenous organic matter by the oxidizing action of alkaline potassium permanganate. As pointed out before, it frequently happens that the whole of the nitrogenous organic matter present in the water is not decomposed, and therefore the numbers obtained always represent the minimum amount of impurity which can be present in the water.

Professor Wanklyn says with regard to this method of analysis, that by the aid of the ammonia process, we are now able to divide potable waters into three broad classes:

(1) Waters which are of "extraordinary organic purity," *i. e.*, those which are almost free from any nitrogenous organic matter, and which contain less than 0·05 parts of albuminoid (or total) ammonia per million of water.

(2) "Safe waters," which are devoid of any excess of nitrogenous organic impurity, and which contain from 0·05 to 0·10 parts per million of albuminoid ammonia.

(3) Waters which are "dirty," *i. e.* charged with an abnormal quantity of organic matter, and which contain more than 0·10 parts of albuminoid ammonia per million of water.

The second important consideration is the determination of the amount of chlorine present in the water. Chlorine occurs in potable water in combination with several metals (as chlorides), such as sodium, magnesium, calcium and possibly potassium. The amount of chlorides or of chlorine present in drinking water is in itself of little importance, for as most people are aware, common table salt is simply sodium chloride, and this substance is a necessary ingredient of our food. The water analyst determines the amount of chlorine present in water because the presence of this substance in water is in most instances a clear indication of contamination by sewage in some form or another.

It will be understood how this is the case when we consider that rain water, which is the source of all water supplies when collected in the open country and at inland stations is practically free from chlorine. Drinking water also which is uncontaminated by sewage is comparatively free from this substance, but sewage and urine,* are highly charged with chlorides, of which common salt is probably in largest quantity. If then a given sample of water contains no chlorine or very little, it *cannot* have been in contact with sewage, but if any considerable amount is present in a water, which is known not to have come from a tidal river or from any geological formation where deposits of salt are found, such a water would be viewed with the gravest suspicion, and if this were supported by other evidence, the water would at once be condemned. Unpolluted river and spring waters usually contain less than ten parts of chlorine per million of water, average town sewage in England about one hundred and ten parts; shallow well water may contain any quantity from a mere trace up to 500 parts or even more. The amount of chlorides is scarcely affected by any degree of filtration through soil; thus the effluent water from land irrigated with sewage contains the same proportion of chlorine

* Human urine contains about 5000 parts of chlorine per million of liquid.

as the sewage, unless it has been diluted by subsoil water or concentrated by evaporation.

As an illustration of the quantities of total ammonia and of chlorine as chlorides found in samples of *good* or *fairly good* drinking water, I may quote some numbers taken partly from Prof. Wanklyn's work on water analysis, and partly from other sources such as the Rivers Pollution Commissioners' Reports. The numbers given in the following table show the number of parts of total ammonia and of chlorine in every million parts of the water, and the samples of water it will be seen are selected from a variety of sources, such as lakes, rivers, wells, springs, &c.

Description of Water.	Total Ammonia parts per million of water.	Chlorine parts per million of water.
London water, Kent Company, ...	0·03	23·5
" " New River Company, ...	0·08	15·7
Glasgow water from Loch Katrine, ...	0·08	7·6
Edinburgh town water, ...	0·07	14·3
Manchester town water, ...	0·07	9·0
Chester (Dee) town water, ...	0·07	5·0
Oxton (Birkenhead) town water, ...	0·02	
Guildford water, ...	0·01	12·6
Caterham water from deep spring, ...	0·04	15·5
Deep spring at Dorking, ...	0·01	
Deep Well at Chatham, ...	0·06	

As an additional comparison of the quantities of "Total Ammonia" and of Chlorine, which a good potable water should yield, I will quote the amounts of these substances which have been obtained during the last four years from analyses of the Calcutta Hydrant water made twice in each week. In the following table there are given the average results obtained for each of the last four years, as well as the general average for the whole of this period.

Calcutta Hydrant Water.

	No. of days of Analysis.	No. of days when transparent and colorless.*	No. of days when not perfectly filtered.	Total ammonia in parts per million.	Chlorine in parts per million.
Average 1876, ...	155	137	18	0·037	10·65
" 1877, ...	104	72	32	0·046	10·40
" 1878, ...	103	75	28	0·034	8·37
" 1879, ...	103	91	12	0·035	8·50
Sums, ...	465	375	90	0·152	37·92
Average, ...	116	94	22	0·038	9·48

* When examined by transmitted light in a tube three feet in length.

In passing I may here remark, that a comparison of these numbers with those of the previous table, shows that the present water supply of Calcutta is really of excellent quality, and that very few of the *good* waters selected from those given in the works alluded to, are as pure as our hydrant water. That the purity of the hydrant water as determined by this process of analysis is not merely exceptional, is clear from the close agreement of the results of each year with the average of the four years. It will also be noticed that the hydrant water will fall in class one of Prof. Wanklyn's classification, as being a water of extraordinary organic purity.

On the other hand as examples of waters which are considered in England to be exceptionally bad, and which are at once condemned as sources of water for domestic purposes, and as examples of the results obtained from sewage, I may quote the following from Prof. Wanklyn's work on water analysis.

Description of Water.	Total ammonia parts per million of water.	Chlorine parts per million of water.
Unfiltered Thames water at Hampton Court, ...	0·32	11·4
" Thames water at London Bridge, ...	2·11	17·1
Well at Leek Workhouse (Staffordshire), ...	0·36	7·1
Well in Windsor, ...	1·28	80·0
Well in Eton, ...	0·84	80·0
Pump in Drapers Hall, London, ...	6·31	
" " Bishopsgate St., London, ...	7·75	
" " Goodge St., London, ...	......	177·0
" " Oxford Market, ...	......	474·3
Sample of Sewage, ...	17·10	141·4

In addition to these examples I have analysed the Calcutta sewage by the same process. Thus on December 18th, 1877, samples of sewage were collected at each hour from 6 A. M. to 6 P. M. at the Pumping Station, and the amounts of total ammonia obtained from three of the samples showed 84·0, 87·0 and 145·6 parts per million of water. The average amount of chlorine was 170·4 parts in the same volume. This shows a much more concentrated sewage than that analysed by Prof. Wanklyn, but it is fair to state that the three samples of Calcutta sewage were of extreme concentration, and of a most repulsive and disgusting character.

If we take the first two tables above given as representing good drinking waters, and the last as representing sewage, either dilute or concentrated as the case may be, we are now in a position to understand the meaning of the numbers obtained by the analyses of two hundred samples of Calcutta tank and well waters, which are given in the tables below.

I have previously noticed the three standards of purity suggested by Prof. Wanklyn, but as in the case of these Calcutta tank and well waters, we shall be dealing with very impure samples, it will be well to adopt some standards of greater impurity than before given. I think it will be well within the mark to consider, that any sample of water which produces more than 10 parts of total ammonia should be classed as a sewage and not as a water, and that if the amount produced is between 10 and 5 parts, the sample may be called a dilute sewage; from 5 parts to 1 part we have a water considerably contaminated with sewage, and from 1 part down to Prof. Wanklyn's limit of 0·10 parts of total ammonia, we have the class of Dirty Waters, which represent water contaminated more or less with organic or sewage matter. In the same way we may adopt a classification of the amounts of chlorine present, and there is apparently no doubt that a Calcutta tank or well water which contains more than 250 parts of chlorine per million should be classed as a sewage; that a water containing from 250 to 150 parts of chlorine may be looked on as a dilute sewage; that with from 150 to 100 parts of chlorine present we have a water considerably contaminated with sewage; and when from 100 to 50 parts are present a water may be said to be slightly contaminated, whilst if less than 50 parts of chlorine are present, the water may be considered moderately safe.

The first of the two following tables contains the results obtained from the analysis of the tank waters, and the second the numbers obtained from the well waters. The tables contain 9 columns, most of which are explained by their headings. Column 1 gives the date on which the water was analysed, 2 and 3 the locality from which the sample was drawn and the section of the town in which the tank or well is situated. Column 4 gives the reason why my attention was called to the state of the tank or well, and which lead to the water being analysed. Column 5 gives a very brief description of the physical characters of the sample, principally as to colour, smell, presence or absence of solid matters in suspension, presence of animal life etc., and under this head it may be mentioned that as most of the waters were extremely dirty and thick, the examination as to colour was made in a glass cylinder only six inches high standing on a white surface. Columns 6 and 7 give the amounts of total ammonia and of chlorine present in every million parts of water. Column 8 gives the decision as to whether the water was considered fit for potable purposes or whether it was condemned for such uses, and the last column shews whether the tank or well has been subsequently filled up or dewatered.

Most of these results have been submitted to the Health Officer to the Municipality in my capacity of Water Analyst, and it is due to the courtesy of Dr. McLeod that I am able to give the columns 4, 8 and 9.

Tank Waters, 1876.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the Tank.
March. 1	No. 19, Goa Bagan Street, North Tank.	C	For cholera death in neighbourhood.	Yellowish green color, very turbid. Full of life.	18·52	582·00	Condemned.	Filled up.
„	No. 19, Goa Bagan Street, South Tank.	C	Do.	Yellowish green color, very turbid. Full of life.	26·20	639·00	Do.	
„ 16	Name of locality not clearly ascertained.		Do. and complaint.	Greenish color. Full of animal life.	24·80	568·00	Do.	
„ 24	Nihareeparah.	A	Filthy state.	Green color, unpleasant smell, suspended matter.	18·00	550·25	Do.	
„ 27	Nundoram Sen's Street.	B	Do.	Brown white color. Very turbid, Full of life.	10·00	390·50	Do.	Filled up.
„ 28	Krupanauth's Lane.	B	Do.	Tolerably clear. Full of life.	2·40	443·75	Do.	
„ 29	Boloram Ghose's Street.	A	Do.	Greenish color, very turbid. Full of life.	2·00	514·75	Do.	Filled up.
„ 30	Raja Rajbullub Street.	A	Do.	Rather clear; small floating worms.	2·00	514·75	Do.	Filled up.
April 20.	Bortollah Tank.	C	Cholera death in neighbourhood.	Yellowish white color, turbid, contains animal life.	2·20	255·60	Do.	Filling.
May 2.	7, Grey Street.	C	Filthy state.	Yellowish green color, stinks horribly, full of suspended matter and animal life.	20·00	710·00	Do.	Filled up.
„ 3.	Kerr's Lane.	M	Do.	Green color, stinks horribly, full of sediment, animal life	13·75	319·50	Do.	Do.
„ 9.	141, Dhurrumtollah Street.	K	Do.	Whitish green color, rather strong stink, full of animal life.	9·60	266·25	Do.	Do.
„ 10.	102, Jaun Bazar Street.	N	Do.	Green color, stinks horribly, full of life, animal and vegetable.	9·60	284·00	Do.	
Aug. 15.	Presidency Jail Tank.	Q	Do.	Of greenish color, slightly turbid.	1·30	46·15	Do.	
„	Alipore Jail Tank.		Do.	Yellowish color, slightly turbid.	0·68	35·50		Filled up.
Sept. 19.	Sookea's St. Thana, North Tank.	D	Do.	Brownish color, contains suspended matter and considerable amount of animal life.	1·62	184·60	Do.	
„	Sookea's St. Thana, South Tank.	D	Cholera death in neighbourhood.	Almost colorless, contains suspended matter, little if any animal life visible.	·35	142·00	Do.	Filling.
Dec. 16.	Komadan Bagan, Double Tank.	N	Do.	Slight greenish color, faint smell, turbid, full of animal life.	2·40	266·25	Do.	
„	Tank Haree Tollowa.	N	Do.	Greenish white color, very unpleasant smell, very turbid, full of animal life.	7·65	372·75	Do.	
„ 22.	D Tank Water.			Of a whitish color, turbid, contains animal life, but apparently not in large quantity.	0·60	31·95		

Tank Waters, 1877.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the Tank.
Jan. 9.	Godai Khansama's Lane, Colinga.	O	Filthy state.	Greenish white color, turbid, and full of animal life.	3·06	156·20	Condemned.	De-watered.
„ 12.	Gopal Mitter's Tank in Brindabun Mullick's Lane.	D	Cholera death in neighbourhood.	Of a greenish color, turbid, and full of animal life.	2·52	475·70	Do.	
„ 16.	Dhankhit Tank, Colvin's Bustee.	Q	Filthy state.	Of a whitish color, turbid, and full of animal life.	16·00	170·40	Do.	
Feb. 13.	74, Dhurumtollah Street.	B	Complaint of do.	Of a whitish color, and turbid.	14·80	195·25	Do.	
„ 28.	Tolley's Nullah.	R	Filthy state.	Of a whitish color, and turbid.	·10	71·00		
„	Hastings Bridge, (foot of).	R	Do.	Of a whitish color, and turbid.	·10	65·67		
Mar. 6.	Tolley's Nullah taken between High water and mid ebb-tide.	R	Do.	Of a whitish color, and turbid.	·08	22·36		
„ 12.	31, Neogipuker East Lane.	N	Cholera death in neighbourhood.	Green color, stinks horribly, turbid, full of green suspended matter.	8·00	230·75	Do.	No. 30, Filled up.
„ 13.	42, Hareepara Lane.	N	Do.	Whitish brown color, smells badly, very turbid.	61·28	355·00	Do.	Filled up.
„ 14.	62, Lower Circular Road.	N	Do.	Green color, suspended matter, stinks, turbid, full of animal life.	47·04	230·75	Do.	Do.
„ 15.	32, Neogipuker East Lane.	N	Do.	Green color, suspended matter, stinks, turbid.	24·00	142·00	Do.	No. 33, Filled up.
„ 16.	30, Hareepara Lane.	N	Filthy state.	Brownish color, faint smell, slightly turbid.	24·00	230·75	Do.	Filled up.
„ 17.	16, Neogipuker W. Lane.	N	Do.	Greenish white color, faint odour, very turbid, green suspended matter.	120·00	337·25	Do.	
„ 18.	19, Okur Dutt's Lane.	K	Cholera death in neighbourhood.	Greenish white color, faint smell, turbid.	12·84	159·75	Do.	Filled up.
„ 19.	18, Holodhur Buddan's Lane.	K	Filthy state.	Brown almost black color, stinks, very turbid, full suspended matter.	40·80	319·50	Do.	
„ 20.	15, Takoor Doss Paulit's L.	K	Do.	Brownish white color, stinks, excessively turbid.	16·00	248·50	Do.	

Tank Waters, 1877—*Continued.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the Tank.
Mar. 20.	10, Okur Dutt's Lane.	K	For Cholera death in neighbourhood.	Brownish or blackish white color, stinks, excessively turbid.	24·00	266·25	Condemned.	Filled up.
,,	15, Ooriahpara Lane.	K	Do.	Do. Do. Do.	60·00	355·00	Do.	
,, 21.	16, Cornwallis Street.	D	Do.	Greenish white color, stinks, turbid.	16·00	159·75	Do.	
,,	22, Sunkur Ghose's Lane.	D	Do.	Brownish white color, smells, slightly turbid.	16·00	284·00	Do.	
,, 22.	36, Sankaritollah Lane.	K	Do.	Brownish white color, stinks, excessively turbid.	16·16	408·25	Do.	
,,	103 & 104, Serpentine Lane.	K	Do.	Greenish brown, stinks horribly, excessively turbid.	240·00	319·50	Do.	
,, 23.	2 & 3, Holodhur Buddan's Lane.	K	Do.	Brownish white color, slightly turbid, little suspended matter.	8·40	230·75	Do.	
,,	21, Jalliapara Lane.	K	Do.	Almost transparent, little suspended matter.	200·00	159·75	Do.	
,, 25.	8, Ukur Dutt's Lane.	K	Do.	Brownish color, smells, turbid.	1·80	479·25	Do.	
,,	8, Kisto Laha's Lane.	K	Complaint.	Stinks horribly, excessively turbid, full of bright green suspended matter.	26·40	426·00	Do.	
,, 26.	9, Sepentine Lane.	K	Cholera death.	Whitish green color, stinks, very turbid.	8·00	355·00	Do.	
,,	90, Chitpore Road.	G	On H. O.'s report.	Yellowish brown color, no smell, slightly turbid with suspended matter.	0·48	117·00	Do.	
,, 28.	7, Grey Street.	C	For Cholera death in neighbourhood.	Yellowish brown color, smells, opalescent, little suspended matter.	16·00	461·50	Do.	Filled up.
,,	115, Upper Chitpore Road.	G	Do.	Brownish color, smells, opalescent, suspended and animal matter.	8·00	266·25	Do.	
,, 29.	22, Musjeedbarree Street.	C	Do.	Bright green color, stinks horribly, extremely opalescent, suspended matter.	19·84	390·50	Do.	
,, 30.	63, Hurry Ghose's Street.	C	Do.	Brownish almost black color, stinks, suspended matter.	12·60	248·50	Do.	
,,	5, Fukeer Chand Chatterjee's Street.	C	Do.	Brown color, stinks horribly, extremely opalescent, much suspended matter.	28·56	585·75	Do.	
,, 31.	27, Taruk Chatterjee's Lane.	C	Do.	Brown color, smells, opalescent, suspended matter.	20·00	301·75	Do.	
,,	31, Durjeeparah Street.	C	Do.	Yellow color, smells, suspended matter.	8·00	390·50	Do.	

April 10.	28, Goa Bagan W. Goallapara.	C	Complaint of raging cholera.	Greenish black color, stinks, opalescent, full of suspended matter.	6·40	426·00	Condemned.	
„	16, Do. Do.	C	Do.	Bright green color, stinks, excessively opalescent, full of suspended matter.	20·96	337·25	Do.	
„ 12.	Double Tank, Komadar Bagan, Joratolla.	O	Foul state.	Greenish white color, stinks, with much suspended matter and animal matter.	3·90	177·50	Do.	Nos. 19 4 and 96 filled up.
„	99, Jaun Bazar Street.	N	Do.	Yellowish color, unpleasant smell, slightly turbid, suspended matter & also animal life.	7·20	124·25	Do.	
„ 16.	Tank A.		Do.	Almost colorless and smells unpleasantly; much suspended matter.	Lost.	74·50		
„	Tank B.		Do.	Stinks of sulphuretted hydrogen, becomes opalescent on exposure, much suspended matter.	3·20	81·60	Do.	
Aug. 7.	75 & 76, South Colinga St.	O	Foul state.	Yellow color, smells slightly, contains suspended matter.	2·36	159·75	Do.	No. 74, dewatered
„ 10.	24, Baranosee Ghose's St., Singhee Bagan.	F	Cholera death in neighbourhood.	Almost colorless, faint unpleasant smell, and suspended matter, much animal life.	2·68	142·00	Do.	Filled up.
„ 28.	29, Neogipukur East Lane.	N	Do.	Water of a yellowish color, faint unpleasant smell, much animal life.	2·64	276·90	Do.	
Oct. 9.	10 & 12, Elliot's Road.	O	Do.	Yellowish color, stinks, opalescent, contains animal life.	4·29	71·00	Do.	Filled up.
„ 10.	6, Hill's Lane.	O	Complaint.	Yellowish color, smells slightly, slightly opalescent, animal life.	3·95	142·00	Do.	
„ 26.	62, Machooa Bazar Street.	I	Cholera death in neighbourhood.	Greenish white color, stinks badly, full of suspended matter and animal matter.	4·40	213·00	Do.	Filled up.
„ 27.	44, Musjeedbarry Street.	C	Filthy state.	Yellowish green color, stinks, some suspended matter, animal life.	2·59	266·25	Do.	
„ 30.	38, Nilmoney Mitter's St.	C	Complaint.	Greenish brown color, stinks, suspended matter, animal life.	9·00	301·75	Do.	Filled up.
Nov. 2.	7, Sookea's St., Bye-Lane.	D	Cholera death in neighbourhood.	Yellowish green color, slight smell, slightly opalescent, small quantity suspended matter, full of animal life.	3·40	185·25	Do.	
„ 3.	11, Carey's Church Lane.	I	On Tank Committee's report.	Brownish white color, unpleasant smell, slightly opalescent, small quantity suspended matter, full of animal life.	12·00	185·25	Do.	

Tank Waters, 1877—*Concluded.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Cholerine parts per million.	Whether condemned for domestic purposes or not.	What was done to the Tank.
Nov. 8.	Colvin Bustee Tank.	Q	Cholera death in neighbourhood.	Greenish white color, stinks, opalescent, full of green suspended matter and animal life.	13·00	195·25	Condemned.	
„ 10.	9, Shampuker Street.	A	Do.	Greenish color, slight smell, slightly opalescent, full of green suspended matter and animal life.	9·84	181·05	Do.	
„ 11.	85, Machooa Bazar Street.	D	Do.	Yellowish brown color, slight smell, opalescent, full animal life.	11·30	159·75	Do.	
„ 12.	6, Emambaug 2nd Lane.	J	Complaint.	Green color, faint smell, much suspended matter, and animal life.	8·00	113·60	Do.	
„ 13.	75, Jaun Bazar Street.	N	Cholera in neighbourhood.	Greenish yellow color, stinks, rather opalescent, small quantity of suspended matter, full of animal life.	2·76	202·35	Do.	
Dec. 10.	46, Kally Prosad Dutt's St.	C	Do.	Dark green brown color, on being kept a few days stinks horribly, full of green suspended matter, and animal life.	28·56	205·90	Do.	No. 54, Filled up.
„ 11.	104, Upper Circular Road.	C	Do.	Whitish brown color, when kept a few days has a very bad smell, full of green suspended matter, contains animal life.	23·52	262·70	Do.	
„	12, Nusur Nuzubullah's Lane.	O	On the report of Tank Committee.	Greenish white color, has unpleasant smell, moderate amount of suspended matter, much animal life.	8·40	181·05	Do.	
„ 18.	18, Hareepara Lane, and 15, Neogipuker West Lane.	N	Filthy state.	Green color, stinks most horribly, much suspended matter, full of animal life.	11·16	244·95	Do.	Filled up.

Tank Waters, 1878.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the Tank.
Jan. 2.	54, Raja Rajbullub Street.	A	Cholera death in neighbourhood.	Deep yellowish color, very unpleasant smell, full of suspended matter and animal life.	21·30	475·70	Condemned.	
„ 7.	3, Fukeer Chand Mitter's Lane.	D	Do.	Yellowish green color, unpleasant smell, little suspended matter, contains animal life.	3·46	92·30	Do.	
„ 8.	129, Cornwallis Street.	C	Do.	Bright green color, stinks, much suspended matter, much animal life.	21·06	280·45	Do.	No. 30, Filled up.
„ 9.	4, Fukeer Chand Mitter's Lane.	D	Do.	Water yellowish color, some suspended matter.	12·00	149·10	Do.	
„ 10.	21, Do. Do. Do.	D	Do.	Yellowish green color, unpleasant smell, slightly opalescent, little suspended matter, animal life.	4·70	127·80	Do.	
„ 19.	81, Shampookur Street.	A	Do.	Yellow color, slight smell, little suspended matter, much animal life.	2·72	142·00	Do.	
„ 30.	27, Noyau Chunder Dutt's Lane.	C	Do.	Yellow, stinks, small quantity suspended matter, no visible animal life.	1·47	124·25	Do.	
„	Karbala tank water.	C	Do.	Has a brown color, unpleasant smell, contains suspended matter, animal life.	1·49	276·90	Do.	
Feb. 27.	162, Bow Bazar.	I	Do.	Yellow brown color, stinks, opalescent, much suspended matter, no life.	40·66	266·25	Do.	
„	1, Nemoo Gosain's Lane.	B	Do.	Brown color, stinks badly of sulphuretted hydrogen, opalescent, much suspended matter, animal life.	23·20	479·25	Do.	
Mar. 5.	Jinghu Bagan.	J	Do.	Green yellow color, stinks horribly of sulphuretted hydrogen, opalescent, much suspended matter.	11·50	408·25	Do.	
„ 8.	2, Manicktollah Street.	J	Do.	Brownish color, stinks, very opalescent, much suspended matter, animal life.	38·74	461·50	Do.	

Tank Waters, 1878—*Continued.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the tank.
Mar. 11.	222, Cornwallis Street.	J	Cholera death in neighbourhood.	Greenish color, stinks, very opalescent, animal life.	3·52	248·50	Do.	
"	26, Prossunno Coomar Tagore's Street.	E	Do.	Bright green color, stinks horribly, very opalescent, full of green suspended matter, full of animal life.	17·00	319·50	Do.	
" 12.	22, Horo Lall Mitter's Street.	A	Do.	Brownish color, bad smell, very opalescent, small quantity suspended matter, animal life.	7·68	301·75	Do.	
" 13.	45, Shampookur Lane.	A	Complaint.	Yellowish white color, stinks, large quantity suspended matter, visible animal life.	3·02	230·75	Do.	
"	54, Old Boytuckhanah Bazar Street.	I	Cholera death in neighbourhood.	Brown color, stinks, much suspended matter, much animal life.	42·66	355·00	Do.	
" 26.	Mirzapore Public Tank.	I	Do.	Greenish color, faint smell, small quantity suspended matter, animal life.	1·31	102·95	Do.	
"	Badoorbagan Tank, 83, Upper Circular Road.	D	Do.	Greenish color, stinks, green suspended matter in large quantity, animal matter in quantity.	2·16	220·10	Do.	
April 27.	Dhurumtollah Public Tank.	M			0·80	24·80		
May 10.	Wellesley Street.	M		Yellow color, slight smell, small quantity suspended matter.	0·34	147·68		
"	Palmer's Bridge.	R		Yellowish brown, slight smell of sulphuretted hydrogen, much suspended matter.	0·17	2378·5	Do.	

Tank Waters, 1879.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million of water.	Chlorine parts per million of water.	Whether condemned for domestic purposes or not.	What was done to the tank.
Jan. 22.	82, Upper Circular Road.	N	Cholera death in neighbourhood.	Blackish green color, very bad smell, suspended matter, contains animal life.	2·68	248·50	Condemned.	
„ 22.	83, Upper Circular Road.	N	Do.	Yellow color, stinks badly, much suspended matter, contains animal life.	9·00	213·00	Do.	
June 20.	Rawdon Street.	Q		Yellowish color, slight odour, small quantity of suspended matter, animal life in small quantity.	4·20	269·80	Do.	
July 4.	36, Goorooprosad Chaudry's Lane.	D	Do.	Blackish color, stinks abominably, much suspended matter.	1·98	209·45	Do.	
„ 5.	22, Durga Churn Mukerjea's Street.	A	Do.	Brownish color, stinks badly, much suspended matter.	3·72	213·00	Do.	
„ 7.	4, Brindabun Mullick's Lane.	D	Do.	Brownish color, bad smell, opalescent, small quantity of suspended matter.	7·20	223·65	Do.	
Oct. 10.	5, Peary Mohun Paul's Lane.	H	Complaint.	Brownish black color, unpleasant smell, very opalescent, large quantity of suspended matter.	92·40	177·50	Do.	
„ 11.	10 and 11, Jorapukor Lane.	F	Cholera.	Blackish brown color, stinks badly, very opalescent, large quantity of suspended matter.	77·60	177·50	Do.	
„ 14.	160, Gokul Mitter's Lane, Baug Bazar.	A	Complaint.	Brown color, stinks abominably, very opalescent, large quantity of suspended matter.	11·52	248·50	Do.	
1880.								
Jan. 24.	No. 19, Goa Bagan Street.	C	Cholera.	Grey color, slight odour, much suspended matter, much animal life.	13·86	319·50	Do.	Filled up.

Tank Waters, 1880—*Continued.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million of water.	Chlorine parts per million of water.	Whether condemned for domestic purposes or not.	What was done to the tank.
Jan. 24.	32, Elliott's Road.	O	Prevalence of Swelling fever.	Grey color, unpleasant odour, much suspended matter, much animal life.	15·20	195·25	Condemned.	
„ 26.	31, Elliott's Road.	O	Do.	Green color, slight odour, much green suspended matter, animal life.	4·00	159·75	Do.	
„ 28.	35, Elliott's Road.	O	Do.	Green color, stinks abominably, much suspended matter, animal life.	6·00	142·00	Do.	
„ 29.	11, Mohendra Gossain's Lane.	F	Complaint.	Bright yellow color, unpleasant smell, suspended matter, much animal life.	23·20	337·25	Do.	
„ 30.	Radhanath Bose's Lane.	C	Do.	Green color, unpleasant smell, suspended matter, much animal life.	6·30	355·00	Do.	
May 29.	31, Bachoo Chatterjea's Street.	D	Do.	Green color, stinks badly, very turbid, suspended matter, animal life.	8·00	401·15	Do.	
July 5.	South of Park Street old Cemetery.			Slight yellow color, no smell, almost clear and transparent, small quantity of animal life.	0·16	255·60		
„ 6.	Birju Tank, south of Cathedral.	Maidan.		Greyish color, no smell, rather turbid, small quantity of animal life.	0·09	13·84		
„ 7.	Elliot's Tank, north of Cathedral.			Slight greyish color, no smell, rather turbid, small quantity of animal life.	0·10	8·16		
„ 8.	General's Tank opposite Bengal Club.			Grey color, no smell, rather turbid, small quantity of animal life.	0·10	82·66		
„ 9.	Monohar Dass's Tank opposite Lindsay Street.			Almost colorless, no smell, almost clear and transparent, very small quantity of animal life.	0·07	16·68		
„ 10.	Tank opposite Esplanade.			Almost colorless, no smell, almost transparent, small quantity of animal life.	0·11	24·14		

Well Waters, 1877.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the well.
May 8.	5, Jorabagan.	E	Cholera death in neighbourhood.	Greenish black color, stinks horribly, slightly opalescent, full of suspended matter.	1·68	177·50	Condemned.	
„ 9.	1, Horo Lall Doss's Lane.	E	Filthy state.	Slight brownish color, no smell, little suspended matter.	0·80	248·50	Do.	
„ 10.	16, Burrabazar Moydaputty.	G	Do.	Almost colorless, no suspended matter.	0·40	213·00	Do.	
„ 11.	Jaunbazar Bustee.	M		Yellowish color, no smell, traces of suspended matter.	8·20	514·75	Do.	
„ 12.	24, Jorabagan Street.	E	Filthy state.	Almost colorless, faint smell, small amount of suspended matter.	0·62	621·25	Do.	
„ 13.	6, Jorabagan Street.	E	Do.	Brownish color, faint smell, small amount of suspended matter.	0·50	248·50	Do.	
„ 14.	7, Horo Lall Doss's Bustee.	E	Do.	Brownish color, nasty smell, opalescent, suspended matter.	1·76	142·00	Do.	
„ 15.	9, Shama Bye's Gully.	E	Do.	Slight yellowish color, faint smell, small amount of suspended matter.	0·90	426·00	Do.	
„ 16.	30, Burtollah Street.	E	Do.	Almost colorless, faint smell, small amount of suspended matter.	0·50	39·50		
„ 17.	9, Burrabazar Baneaputty.	G	Do.	Brownish color, faint smell, suspended matter.	0·40	177·50	Do.	
„	145, „ Hookaputty.	G		Yellowish color, faint smell, much suspended matter.	0·30	710·00	Do.	
„ 18.	3, Hanspookur Gully.	E	Filthy state.	Strong yellowish brown color, faint smell, much suspended matter.	4·15	307·70	Do.	
„ 19.	159, Machooa Bazar Street.	E		Yellowish color, faint unpleasant smell, little suspended matter.	2·40	390·50	Do.	
Aug. 10.	145, Burra Bazar.	G	Filthy state.	Almost colorless, faint unpleasant smell, suspended matter.	3·68	791·65	Do.	

Well Waters, 1877—*Continued.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Amt. of Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the well.
Aug. 10.	24, Jorabagan Street.	E	Cholera death in neighbourhood.	Yellowish green color, faint unpleasant smell, suspended matter, animal life distinct.	2·84	265·25	Condemned.	
„ 11.	3, Hanspookur Lane.	E		Almost colorless, faint smell, small quantity suspended matter.	1·42	390·50	Do.	
„ 12.	6, Jorabagan Street.	E	Cholera death.	Yellowish color, faint unpleasant smell, small quantity suspended matter, distinct animal life.	3·76	159·75	Do.	
„ 13.	30, Burtolah Street.	E		Colorless, faint unpleasant smell, large quantity of suspended matter, distinct animal life.	2·73	319·50	Do.	
„ 14.	9, Shama Bay's Lane.	E		Almost colorless, faint unpleasant smell, small quantity suspended matter.	2·64	408·50	Do.	
„ 15.	24, Bustee Joraban Street.	E		Brown color, stinks badly, very opalescent, much suspended matter, distinct animal life.	17·40	159·75	Do.	
„ 16.	1, Horo Lall Doss's Lane.	E		Almost colorless, faint smell, small quantity of suspended matter.	3·95	177·50	Do.	
„ 17.	16, Burra Bazar Moydaputty.	G		Colorless, faint unpleasant smell, little suspended matter.	2·83	177·50	Do.	
„ 18.	5, Jorabagan Street.	E	Cholera death.	Whitish yellow color, smells unpleasantly, opalescent, suspended matter, and traces of animal life.	15·80	88·75	Do,	
„ 19.	9, Burrabazar Baneaputty.	G		Almost colorless, faint unpleasant smell, suspended matter, animal life.	3·28	195·25	Do.	
„ 20.	Bustee Horo Lall Doss's Lane.	E		Yellow color, decided unpleasant smell, suspended matter.	4·32	248·50	Do.	
„ 22.	136, Serpentine Lane.	K		Yellow color, unpleasant smell, little suspended matter, much animal life.	6·40	621·25	Do.	

Well Waters, 1878.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the well.
Jan. 28.	Doorga Churn Mittur's Street.	C	Cholera death in neighbourhood.	Almost colorless, but in long cylinder appears yellowish, faint unpleasant smell, small quantity suspended matter, no animal life perceptible.	1·40	88·75	Condemned.	
„ 30.	13-A, Nattur Bagan.	B	Do.	Almost black, unpleasant smell, excessively turbid, animal life.	51·50	841·35	Do.	
Feb. 7.	13-B, Nattur Bagan.	B	Do.	Slight brownish tinge, slight smell, small quantity suspended matter, no visible animal life.	3·30	639·00	Do.	
„	14, Smith's Lane.	N	Do.	Yellow color, slight smell, some suspended matter, small traces of animal life.	3·30	479·25	Do.	
„	30, Noyau Chaund Dutt's Street.	C	Do.	Yellow color, unpleasant smell, small quantity suspended matter, distinct animal life.	1·92	152·65	Do.	
„ 15.	10, Ram Kanto Bose's Lane.	A	Do.	Yellowish color, unpleasant smell, moderate amount suspended matter, no visible animal life.	12·80	582·20	Do.	
„ 19.	Railway Tank, Sealdah.		Do.	Almost colorless, slight smell, small quantity suspended matter, no visible animal life.	0·80	452·60	Do.	
„ 20.	128-J, Bow Bazar Street.	K	Do.	Almost colorless, no smell, very small quantity suspended matter, no visible animal life.	0·60	450·85	Do.	
„ 22.	20, Bamutollah Street.	B	Do.	Yellow color, unpleasant smell, much suspended matter, animal life.	48·00	816·50	Do.	
„ 25.	34, Serang's Lane.	N	Do.	Almost colorless, slight smell, small quantity suspended matter, no visible animal life.	0·94	603·50	Do.	
„ 28.	1-D, Nemoo Gawsat's Lane.	B	Do.	Yellow color, unpleasant smell, much suspended matter, no visible animal life.	17·52	514·75	Do.	Filled up.

Well Waters, 1878—*Continued.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the well.
Feb. 28.	13-J, Patwai Bagan.	I	Cholera death in neighbourhood.	Yellowish color, slight smell, small quantity of suspended matter, no visible animal life.	0·94	603·50	Condemned.	
"	21, Nathu Bagan.	B	Do.	Brownish color, unpleasant smell, slightly opalescent, small quantity suspended matter.	41·06	532·50	Do.	
"	1, Nemoo Gosain's Lane.	B	Do.	Brownish color, stinks, suspended matter, and much animal life.	6·96	390·50	Do.	
Mar. 4.	71, Dhurumtollah Street.	B	Do.	Yellow color, slight smell, small quantity suspended matter, no animal life.	8·36	319·50	Do.	
"	9, Boloram Mozoomdar's Street.	B	Do.	Black color, horrible stench of sulphuretted hydrogen, very opalescent, much suspended matter.	11·17	492·00	Do.	
" 7.	168, Cotton Street.	E	Do.	Slight yellowish tinge, slight smell, little suspended matter.	0·20	195·25		
"	113, Dhurumtollah Street.	E	Do.	No smell, small quantity suspended matter, no visible animal life.	2·50	53·25	Do.	
"	82-5, Burtollah Street.	E	Do.	Full yellow color, slight smell, much suspended matter, distinct animal life visible under microscope.	222·00	781·00	Do.	
" 8.	27, Bonomally Sircar's Street.	B	Do.	Almost colorless, very slight smell, little suspended matter, distinct animal life under microscope.	18·60	319·50	Do.	
" 5.	23-9, Durponaryan's Lane.	E	Do.	Almost colorless, very slight smell, much suspended matter, no visible animal life.	14·80	514·75	Do.	
"	17-22, Durponaryan's Tagor's Street.	E	Do.	Slight yellowish color, very slight smell, little suspended matter, no animal life.	2·00	284·00	Do.	
" 5.	3, Antony Bagan Lane.	I	Do.	Yellowish color, no smell, little suspended matter.	9·48	230·75	Do.	

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Mar. 5,	25, Baranosee Ghose's Street.	F	Cholera death in neighbourhood.	Greyish white color, stinks badly, very opalescent, much suspended matter.	1·92	71·00	Condemned.
„ 6.	7-a, Bysack's Lane.	E	Do.	Deep brown color, unpleasant smell, opalescent.	219·00	1384·5	Do.
„	124, Manicktollah Street.	D	Do.	Yellow color, stinks badly, little suspended matter, no animal life.	35·74	727·75	Do.
„ 8.	21, Machoo Pal's Street.	B	Do.	Almost clear, transparent and colorless, no smell, no visible animal life.	5·24	218·00	Do.
„ 11.	6, Ashutosh Dey's Lane.	F	Do.	Colorless, slight smell, little suspended matter, no visible animal life.	9·96	319·50	Do.
„	5, Suri's Lane.	K	Do.	Blackish color, stinks badly, very opalescent, full of suspended matter, animal life.	68·00	550·25	Do.
„	12, Nilmony Mitter's Lane.	C	Do.	Almost colorless, very slight smell, little suspended matter, no animal life.	8·52	426·00	Do.
„ 12.	82-17, Burtollah Street.	E	Do	Almost colorless, slight smell, small quantity suspended matter.	0·46	126025	Do.
„	14-C, Goomgur Lane.	G	Do.	Yellowish color, nasty smell, little suspended matter.	3 31	727·75	Do.
„	222, Cornwallis Street.	F	Do.	Yellowish color, very unpleasant smell, little suspended matter, animal life.	5·68	177·50	Do.
„	1, Ram Chunder Banerjee's Lane.	I	Do.	Almost colorless and transparent, very little suspended matter.	0·60	35·50	
„ 13.	22, Free School Street.	M	Do.	Greenish yellow color, unpleasant smell, much suspended matter.	5·04	337·25	Do.
„	15, Nilmony Mitter's Lane.	C	Do.	White color, slightly opalescent, little suspended matter, animal life.	5·04	319·50	Do.
„	135, Machooa Bazar Street.	F	Do.	Yellowish green color, slight smell, much suspended matter, animal life.	22·40	1029·5	Do.
„	54, Old Boytuckhana Bazar Street.	I	Do.	Almost colorless, no smell, little suspended matter, no visible animal life.	3·62	532·50	Do.

Well Waters, 1878—*Concluded.*

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million.	Whether condemned for domestic purposes or not.	What was done to the well.
July 12.	27, Zig Zag Lane.	J	Complaint.	Brownish color, faint smell, much suspended matter, animal life.	0·10	85 20	Condemned.	
„ 15.	48-2-2, Bulloram Dey's St.	F	Complaint.	Deep yellow brown color, unpleasant smell, large quantity of suspended matter, animal life.	7·20	426·00	Do.	
Sep. 23.	Gangaram Barick's Well, 4, Bysack Bagan Lane.	F	For improving Gowala Bustee.	Deep yellow brown color, slight smell, small quantity of suspended matter, no visible animal life.	45·12	869·75	Do.	
„ 24.	Jogendra Nath Matee, 4, Bysack Bagan Lane.	F	For improving Gowala Bustee.	Yellow brown color, unpleasant smell, small quantity of suspended matter, visible animal life.	46·80	852·00	Do.	
Dec. 16.	19, Durjeepara Street.	C	Cholera in neighbourhood.	Almost colorless, no smell, small quantity of suspended matter, no visible animal life.	3·07	213·00	Do.	
„ 17.	1, Outram Street.	O	Complaint.	Slight color, stinks on keeping, considerable quantity of suspended matter.	4·52	17·75	Do.	
„ 18.	4, Nursing's Lane.	I	Cholera in neighbourhood.	Yellow color, faint unpleasant smell, no suspended matter.	7·28	301·75	Do.	
„ 19.	340, Upper Chitpore Road.	B	Do.	Yellow color, slight unpleasant smell on keeping, small quantity of suspended matter.	1·17	213·00	Do.	

Well Waters, 1879.

Date.	Locality.	Section.	Reason why water was submitted to analysis.	Description.	Total Ammonia parts per million.	Chlorine parts per million of water.	Whether condemned for domestic purposes or not.	What was done to the well.
Jan. 10.	14-2-89, Machooa Bazar Street.	H	On the receipt of objection from the owner to dewater.	Almost colorless, no smell, small quantity suspended matter, animal life.	0·33	639·00	Condemned.	
„ 15.	69, Sitanarain Ghosh's Street.	I	Do.	Yellow color, no smell, opalescent, contains suspended matter.	12·60	372·75	Do.	
June 17.	29, E. Gopee Kristo Paul's Lane.	B	Do.	Bright yellow color, unpleasant smell, small quantity suspended matter, no animal life.	7·92	301·75	Do.	
				1880.				
Jan. 23.	6, Brindabun Mullik's Lane.	D	Complaint.	Black color, stinks abominably, large quantity of suspended matter, animal life.	64·00	514·75	Do.	

Taking the results obtained by the Total Ammonia Test, and judged by the standards which have been put forward by Prof. Wanklyn, and the additional somewhat rough ones suggested by myself, it will be seen, as might be expected, that no single tank or well water was of extraordinary organic purity, and that there were only seven tank waters included under the head of "safe" waters, five of which were from tanks on the maidan. Of dirty waters there were 26 out of the 200 or 13 per cent.; of waters considerably contaminated with sewage matter 64 were found, or 32 per cent.; of dilute sewages there were 32, or 16 per cent.; and of real genuine sewages 71 were found or 35½ per cent., that is rather more than one third of the whole number.

In the following table these results are separated into the two classes of tank and well waters, and it will be seen that the impurity of both descriptions of waters is nearly equal when judged by this test.

	Sewages more than 10 parts of total ammonia.	Dilute Sewages from 10 to 5 parts of total ammonia.	Waters contaminated with considerable quantities of sewage, from 5-1 parts of total ammonia.	Dirty waters from 1 to 0·1 parts of total ammonia.	Safe waters from 0·1 to 0·05 parts of total ammonia.	Very pure waters less than 0·05 parts of total ammonia.	Total.
Tank waters, ...	52	19	36	10	7	0	124
Percentage, ...	42	15	30	7	6	0	100
Well waters, ...	19	13	28	16	0	0	76
Percentage, ...	25	17	37	21	0	0	100
Percentage of both well and tank water, ...	35½	16	32	13	3½	0	100

In considering the quantities of chlorine present, notice must be taken of the fact that in a well water the amount of chlorine will be relatively greater than that of the total ammonia derived from the organic matter, because in the filtration of the water through the soil to reach the well, all the insoluble portions of the organic matter present in the sewage, etc., will be stopped, whilst the chlorides will readily pass through in solution. Again in the filtration of contaminated water through layers of earth or soil, a certain proportion of the organic matter will be oxidized and converted into inorganic compounds such as nitrates, which will not yield any ammonia on distillation with alkaline potassium permanganate. Thus we may expect, that a larger proportion of the well waters will be condemned by the chlorine process than would be condemned by the total ammonia test.

The following table will show the classification of the tank and well waters according to the amounts of chlorine.

	Sewages containing more than 250 parts of chlorine per million.	Dilute sewages containing from 250 to 150 parts of chlorine per million.	Waters contaminated with considerable quantities of sewage containing from 150 to 100 parts of chlorine per million.	Dirty waters containing from 100 to 50 parts of chlorine per million.	Moderately safe waters containing from 50 to 20 parts of chlo. per million.	Good waters less than 20 parts of chlorine per million.	Total.
Tank waters, ..	56	38	14	6	7	3	124
Percentage, ...	45	30	11	5	6	3	100
Well waters,...	49	18	1	5	2	1	76
Percentage, ...	64	24	1	7	3	1	100
Percentage of well and tank waters, ...	52½	28	7½	5½	4½	2	100

It would of course be quite permissible to consider waters which have been condemned by *either* of these two methods to be sewages, dilute sewages or unfit for domestic use, etc., but on inspection of the tables it will be seen, that as a general rule a water which is condemned by the total ammonia test is also condemned by the amount of chlorine present.

The results, however, are sufficiently startling, if we only take the mean of the results of the two determinations; and at the very lowest estimate it must be said, that of the 200 samples of Calcutta tank and well waters examined by me, forty-four per cent. were true sewages, twenty-two per cent. were dilute sewages, twenty per cent. of the waters were contaminated with considerable quantities of sewage, nine per cent. were "dirty waters," and about four or five per cent. only were moderately safe waters. These last consisted principally of the well kept tanks on the maidan, and two or three others in the southern part of the town.

In the next table I have grouped the well and tank waters according to the sections of the town to which they belong; in this table I have given, first the name of each section and its population per acre according to the census of 1876, then the total number of waters analysed from each section, with their classification according to the plan before adopted. There is also given the average composition of all the waters analysed in each section. It will be strikingly seen from this table, how much more impure the tanks and wells of the northern divisions are, than those of the southern sections of the town.

Name of Section.	Sectional letter.	Population per acre by Census of 1876.	No. of waters analysed.	No. classed as Sewages.	No. classed as Dilute Sewages.	No. classed as waters containing considerable quantities of sewage.	No. classed as Dirty waters.	No. classed as Moderately Safe waters.	No. classed as Good waters.	Average composition of all waters.	
										Total ammonia parts per million.	Chlorine parts per million.
A. *Tank Waters.*											
Shampooker, ...	A	75	10	4	1	5	0	0	0	8·86	339·0
Koomartooly, ...	B	163	4	3	1	0	0	0	0	12·60	377·2
Burtolla, ...	C	84	21	15	2	4	0	0	0	14·62	367·7
Sookea's Street, ...	D	87	14	5	2	6	1	0	0	6·48	215·3
Jorabagan, ...	E	152	1	1	0	0	0	0	0	17·00	319·5
Jorasanko, ...	F	137	6	4	1	1	0	0	0	26·21	295·8
Burra Bazar, ...	G	108	2	1	0	0	1	0	0	4·24	191·6
Colootollah, ...	H	214	1	1	0	0	0	0	0	92·40	177·5
Moocheeparra, ...	I	141	2	1	1	0	0	0	0	8·20	199·1
Bow Bazar, ...	J	156	4	2	0	2	0	0	0	21·93	209·5
Puddopooker, ...	K	119	13	11	2	0	0	0	0	51·77	307·2
Waterloo Street, ...	L	27	0	0	0	0	0	0	0		
Fenwick Bazar, ...	M	135	3	1	0	0	2	0	0	4·96	164·0
Taltollah, ...	N	124	14	7	3	4	0	0	0	23·70	241·9
Colinga, ...	O	72	10	1	2	6	1	0	0	5·13	164·0
Park Street, ...	P	23	0	0	0	0	0	0	0		
Bamun Bustee, ...	Q	30	3	1	1	0	1	0	0	7·17	162·1
Hastings, ...	R	86	3	0	0	0	0	2	1	0·09	53·0
Maidan, ...	...	...	5	0	0	0	0	2	3	0·09	19·1
B. *Well Waters.*											
Shampooker, ...	A	75	1	1	0	0	0	0	0	12·80	582·2
Koomartooly, ...	B	163	12	8	3	1	0	0	0	17·90	466·1
Burtolla, ...	C	84	5	1	1	3	0	0	0	3·99	240·0
Sookea's Street, ...	D	87	2	2	0	0	0	0	0	49·87	621·2
Jorabagan, ...	E	152	25	5	2	16	2	0	0	21·17	371·7
Jorasanko, ...	F	137	7	5	1	1	0	0	0	19.87	535·0
Burra Bazar, ...	G	108	6	0	1	3	2	0	0	1·82	410·8
Colootollah, ...	H	214	1	0	0	1	0	0	0	0·33	639·0
Moocheeparra, ...	I	141	7	2	2	2	0	1	0	5·58	299·4
Bow Bazar, ...	J	156	2	0	1	0	1	0	0	1·71	406·5
Puddapooker, ...	K	119	4	2	0	2	0	0	0	18·95	518·7
Fenwick Bazar, ...	M	135	2	1	1	0	0	0	0	6·62	426·0
Taltollah, ...	N	124	2	0	1	1	0	0	0	2·12	541·4

In classifying these waters I have not separately considered the two numbers I obtained by analysis for the total ammonia and chlorine, but have decided on the character of each water from the amounts of both these substances, and this table would therefore show the exact character which I have attached to the waters which I have analysed.

I scarcely think that it is necessary to criticise in detail the numbers which I have obtained in these analyses. In some instances the results of analyses showed that the tank and well waters are considerably more impure than the very concentrated Calcutta sewage, which was collected at the Pumping Station on December 18th, 1876. I have indeed never read in any work or research of such horribly filthy waters as these are, and they are waters which are now, or have been formerly used for domestic purposes by many of the poorer inhabitants of Calcutta.

Taking the numbers given in the foregoing tables, it may be said as a general result of the whole of these analyses, that an average Calcutta tank or well water contains 16·2 parts of total ammonia and 320·6 parts of chlorine per million of water. This it will be remembered from one of the previous tables, is if anything rather more impure than ordinary English sewage as obtained and analysed by Prof. Wanklyn. In the table referred to Prof. Wanklyn found in a sample of sewage 17·10 parts of Total Ammonia and 141·4 parts of Chlorine. We may also say that the average Calcutta tank or well water contains more than 400 times as much organic nitrogenous matter as is usually present in the hydrant water.

I have, however, no wish to enlarge to any extent on this decidedly nauseous topic, but perhaps the most striking condemnation of the well and tank waters of Calcutta, and which will appeal to every inhabitant, whether scientific or otherwise, is to say, that a good average quality of Calcutta tank or shallow well water may be made, by mixing six parts of our present hydrant water with from one to two parts of the most concentrated Calcutta sewage. This artificial tank or well water will be of about the average composition; it will also be so far as can be judged, equally healthy for potable and domestic purposes, and as for its taste, odour, etc., it will probably be rather superior to the general run of Calcutta tank and well waters.

So far as I can ascertain this was the kind of water which was commonly used for drinking and domestic purposes in Calcutta in former days, and which may to a certain extent be still used by the poorer inhabitants of the northern quarter of the town.

The present water supply, i. e., the Hydrant water.

I need scarcely mention that our present hydrant water consists of the Hooghly water pumped from the river at Pultah; it is there collected in settling tanks, and after subsidence it is filtered through sand and then supplied to Calcutta. As I have made some remarks as to the quantity of the former water supply of Calcutta, this paper would not be complete if I did not refer to the quantity of our present supply. From the Report of the Municipality for the year 1879, I find that as the average for the whole year, 7,464,159 gallons of filtered water were daily supplied to the town. According to Mr. Beverley's Census of 1876, the number of inhabitants was 429,535, and each inhabitant would therefore receive 17·4 gallons of filtered water daily. But in addition to the filtered water, there is an unfiltered supply pumped up at Chandpal Ghat which is widely distributed through the town, where it is I believe used for such purposes as watering the roads and streets, flushing latrines and sewers, filling reserved tanks, etc. The daily unfiltered supply was on the average of the whole year, 1,091,866 gallons, and therefore the total daily supply in Calcutta for the past year was 8,556,025 gallons, equivalent to 19·92 gallons per head, or practically there were 20 gallons of water available for domestic and sanitary purposes for each inhabitant. This though perhaps not an abundant supply is a fairly liberal one, and is very much larger than the quantity of the old supply from tanks and wells. It is, however, not equal to the quantity allowed in most European towns, for as pointed out in a former part of this paper the average daily water supply of English towns is at least 25 gallons per head of population. In this country, however, it would appear that a more liberal supply would be required than in a European climate, and it has therefore been proposed to double the present amount of filtered water, in which case Calcutta would receive a daily supply of 16,000,000 gallons equivalent to 37·2 gallons per head. If this proposal is carried out, the supply of filtered water will be most abundant, and it will be amply sufficient for every possible want of the town so long as it keeps to its present dimensions.

The quality of the hydrant water as I mentioned before has been determined for four years, month by month, by Dr. Frankland's process of analysis. This is certainly the most elaborate and complete method discovered, and it is believed to show the quality of a water, not only as regards its present actual constituents, but also to indicate to a certain extent, what its previous history has been. In this process it may be stated the following operations are performed: first the amount of total solids dissolved in the water is estimated, then the amounts of carbon and nitrogen present in the organic matter are determined (these are called organic carbon and organic nitrogen in the following tables); next the amount of free ammonia present (if any) is determined, and the amount of nitrogen contained in the form of nitrates or nitrites is estimated; the amount of chlorine present as chlorides is also determined, and finally the hardness of the water, temporary, permanent and total is estimated. Of these determinations the second, third, fourth and fifth are the most important from a hygienic point of view. Thus the amounts of organic carbon and nitrogen represent the organic matter existing as such in the water, at the time of analysis. The ammonia may to a certain extent be due to the original ammonia we find in rain water, but more generally it may have been produced by the introduction of sewage matter into the water. The nitrates and nitrites present in water are derived from the oxidation of nitrogenous organic matter; this oxidation may have taken place either in the water itself, or in the soil on which the rain water fell. These last constituents are to be looked on with suspicion unless the water is derived from a deep well, when it may contain considerable quantities of these substances without giving rise to any alarm. It is not that nitrates in themselves are injurious in any way, but their occurrence in any quantity in river or shallow well waters shows, that the water must have been either contaminated with some nitrogenous organic matter in a state of decomposition, or in some circumstances where decomposing nitrogenous organic matter had been previously present. It is pointed out that it must be more or less dangerous to drink water that has thus been contaminated with organic matter or with nitrates derived from organic matter, for it is possible if not probable that in such a water the most noxious of all its constituents would entirely escape oxidation or any kind of change. The reason for this opinion is very clearly expressed in one of Dr. Frankland's papers on potable water. In the Journal of the Chemical Society, March 1868, at page 81 of his Memoir, he says—"There is also another aspect in which the previous sewage contamination of a water (*i. e.*, the presence of large quantities of nitrates etc.) assumes a high degree of importance; if the shell of an egg were broken, and its contents beaten up with water, and thrown into the Thames at Oxford, the albumen would probably be entirely converted into mineral compounds before it reached Teddington, but no such destruction of the nitrogenous organic matter would ensue, if the egg were carried down the stream unbroken for the same distance; the egg would even retain its vitality under circumstances which would break up and destroy dead or unorganised organic matter. Now excrementitious matters certainly, sometimes, if not always, contain the germs or ova of organized beings, and as many of these can doubtless retain their vitality for a long time in water, it follows that they can resist the oxidizing influences which destroy the excrementitious matters associated with them. Hence great previous sewage contamination in a water means great risk of the presence of these germs, which, on account of their sparseness and minute size, utterly elude the most delicate determinations of chemical analysis." A considerable number of chemists have put forward the statement, that a river water which has been contaminated with sewage matters will entirely purify itself in a flow of a few miles, and will thus again become fit for potable and domestic purposes. The weight of the evidence appears however to disprove this statement, and further experiments made by Dr. Frankland have shown that this oxidation of sewage matter when present in running water is a process of extreme slowness. Thus in the report of the Rivers Pollution Commissioners, he writes:

"Assuming, however, that if the polluted water had been constantly exposed to the air, a portion at least of the oxygen used would have been replaced, and assuming further that the oxidation proceeded during 168 hours at the maximum rate observed, then at the end of that time, only 62·3 per cent. of the sewage would be oxidized.

"It is thus evident that so far from sewage mixed with 20 times its volume of water being oxidized during a flow of 10 or 12 miles, scarcely two-thirds of it would be so destroyed in a flow of 168 miles, at the rate of one mile per hour, or after the lapse of a week. But even this result is arrived at by a series of assumptions which are all greatly in favour of the efficiency of the oxidizing process. Thus, for instance, it is assumed that 62·3 per cent. of sewage is thoroughly oxidized, and converted into inoffensive inorganic matter, but the experiments showed that, in fact, no sewage matter whatever was converted or destroyed even after the lapse of a week, since the amount of carbonic acid dissolved in the water remained constant during the whole period of the experiment, whilst, if the sewage had been converted into inorganic compounds, the carbonic acid, as one of these compounds, must have increased in quantity.

"Thus, whether we examine the organic pollution of a river at different points of its flow, or the rate of disappearance of the organic matter of sewage when the latter is mixed with fresh water, and violently agitated in contact with air, or finally, the rate at which dissolved oxygen disappears in water polluted with 5 per cent. of sewage, we are led in each case to the inevitable conclusion, that the oxidation of the organic matter in sewage proceeds with extreme slowness, even when the sewage is mixed with a large volume of unpolluted water, and that it is impossible to say how far such water must flow before the sewage matter becomes thoroughly oxidized. It will be safe to infer, however, from the above results, that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

Thus Dr. Frankland is of opinion that a river water once largely contaminated with sewage or organic matter can never of itself become sufficiently pure again to be a safe water supply. To this point I shall again have occasion to refer, when speaking of the proposed sources of the new supply.

From these remarks it will be seen that in judging of the quality of a potable water by Frankland's process of analysis, we pay the greatest amount of attention to the amounts of ammonia and of organic carbon and nitrogen, as representing organic matter actually present, whilst we depend upon the amount of nitrates (and to a considerable extent also on the amount of chlorides as explained in the previous part of this paper) to indicate organic contamination which has become oxidized. The amounts of total solids and of Hardness although important from a manufacturer's point of view, do not seem to have any marked action on the health of persons drinking such water, except when such constituents are present in very large quantities.

Dr. Frankland has unfortunately not fixed upon any very definite standard as to the amounts of the above substances which may be present in water and yet not render it dangerous, and in fact it is almost impossible to draw any hard and fast rule; but so far as can be ascertained from his writings, Dr. Frankland appears to think that a supply which contains 0·10 parts of organic carbon and nitrogen in every hundred thousand parts of water is of "great organic purity," whilst one containing 0·30 parts of the same substances in the same volume should be considered a water of "fair organic purity." If the quantity is above this a water would be of doubtful purity, and if in still larger quantities the water would be recognized as impure.

In order to give an idea of the quantities of these various substances present in the water supplies of many of the large towns in England, and to show the average composition of different samples of water from various sources, I append a table giving the results by this method of analysis of the London water supply from the rivers Thames and Lea, and from the deep wells in the chalk, also the results of the Edinburgh, Glasgow, Liverpool, Manchester and Dublin water supplies, and the average composition derived from the analysis of a large number of samples of rain water, upland surface water, spring water, and sea water. Most of these numbers are taken from the various reports of the Royal Commissioners who were appointed to investigate the Pollution of Rivers in England, but some of the numbers come from the article on Water Analysis given in "Sutton's Volumetric Analysis."

See Table, page 120.

Having thus settled our standards for comparison, we can now discuss the present water supply of Calcutta. The results obtained by the analysis of the Hydrant water are given in the following table; the numbers shown for each month are the averages for the past four years, and at the foot of the table, the general average for the whole of tho four years is appended.

See Table, page 121.

Results of Analysis expressed in parts per 100,000.

	Total solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
London Water supply, average for 7 years.											
From the Thames, ...	27·26	·201	·033	·001	·204	·238	1·77	...	...	21·20	
From the Lea, ...	27·79	·135	·024	·000	·199	·223	1·79	...	...	21·30	
From the Deep-wells in the Chalk, ...	40·26	·047	·012	·000	·421	·433	2·43	...	...	28·70	
Edinburgh water supply, ...	14·10	·203	·042	·000	None.	·042	0·89	4·40	4·80	9·20	
Glasgow water supply from Loch Katrine, ...	2·40	·185	·022	·001	Do.	·023	0·85	0·00	0·90	0·90	
Liverpool water supply, ...	9·66	·210	·029	·002	Do.	·031	1·53	0·30	3·70	4·00	
Manchester do., ...	7·00	·132	·031	·002	Do.	·033	0·90	0·00	2·70	2·70	
Dublin do., ...	6·34	·238	·024	·001	Do.	·025	1·24	0·00	2·97	2·97	
Switzerland the Rhine above Schaffhausen,	15·80	·108	·012	·003	Do.	·015	0·20	3·99	6·77	10·76	
London Sewage, ...	64·50	4·386	2·484	5·557	Do.	7·060	10·37	...	...	...	
Average composition of UNPOLLUTED WATER.											
Rain water 39 samples, ...	2·95	·070	·015	·024	·008	·042	0·22	...	...	·30	
Upland surface water 195 „	9·67	·322	·032	·002	·009	·043	1·13	1·50	4·30	5·80	
Deep well water 157 „	43·78	·061	·018	·010	·495	·523	5·11	15·80	9·20	25·00	
Spring water 198 „	28·20	·056	·013	·001	·383	·397	2·49	11·00	7·50	18·50	
Sea water 23 „	3898·7	·278	·165	·005	·033	·203	1975·6	48·90	748·00	796·90	

CALCUTTA HYDRANT WATER.

Average results from the Analysis of four years.

Results of Analysis expressed in parts per 100,000.

	Total solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
Average for 1st of January, ...	21·57	·131	·037	None.	·016	·053	0·87	3·72	2·97	6·69	
Do. February	21·79	·179	·058	Do.	·035	·093	1·00	3·56	2·92	6·48	
Do. March, ...	22·37	·114	·063	Do.	·048	·111	1·20	3·64	2·97	6·61	
Do. April,...	21·68	·124	.046	Do.	·034	·080	1·32	3·07	2·72	5·79	
Do. May, ...	21·23	·120	·045	Do.	·030	·075	1·37	3·08	3·16	6·24	
Do. June,...	19·43	·155	·037	Do.	·017	·054	1·37	2·44	3·79	6·23	
Do. July, ...	13·04	·093	·044	Do.	·049	·093	0·85	1·65	2·83	4·48	
Do. August, ...	12·07	·081	·047	Do.	·055	·102	0·67	0·93	2·64	3·57	
Do. September, ...	11·36	·104	·049	Do.	·046	·095	0·58	1·34	3·00	4·34	
Do. October, ...	11·30	·099	·050	Do.	·027	·077	0·61	1·39	3·32	4·71	
Do. November, ...	12·27	·118	·054	Do.	·021	·075	0·73	2·15	2·92	5·07	
Do. December, ...	19·44	·090	·042	Do.	·025	·067	0·88	2·55	2·93	5·48	
Sums, ...	207·55	1·408	·572	Do.	·403	·975	11·45	29.52	36·17	65·69	
Average for year	17·30	·117	·047	Do.	·034	·081	0·95	2·46	3·02	5·48	

Taking the numbers representing the general average for the year and comparing them with the standards which I have suggested from Dr. Frankland's works, we find that the Calcutta water falls just outside the class of waters of "great organic purity," but that it is well within the class of waters of "fair organic purity."

Comparing again the numbers with those given in the previous table we find that the Calcutta Hydrant water though not so pure as the London waters derived from the deep wells in the Chalk, is certainly purer than the waters derived from the Thames, and perhaps also from the Lea. It is also decidedly more free from impurity than the water supplies of Edinburgh, Liverpool and Dublin, but taking all the constituents into consideration, it is not so pure as the Glasgow or Manchester supplies, or as the Rhine water above Schaffhausen. Comparing the Hydrant water with the average composition of *unpolluted* upland surface water as given by Dr. Frankland, we find that it is scarcely so pure as unpolluted water should be, and we are therefore compelled to admit that the Hooghly water has been slightly contaminated before it reaches Pultah. The amount of contamination is, however, not very great and as pointed out before, the Calcutta water falls well within the class of waters of medium purity. That the Calcutta water must be contaminated to a certain extent will be I think obvious to any one who is acquainted with the customs of the inhabitants of India, and more particularly of the inhabitants of villages and towns on the banks of the rivers. This contamination is a drawback to the complete safety of our water supply, for as pointed out previously, Dr. Frankland is of opinion, that a water once contaminated is always dangerous, and that the self-purification of a river which is so strongly insisted upon by certain persons is exceedingly slight. It does not however at present appear to be possible to cut off these sources of contamination, and the Hydrant water though good is not a perfect supply. Every effort however should be made to keep this previous contamination down to the lowest possible point, and it is to be hoped when systems of drainage are being introduced into the up-country towns, that the sewage from them will not be allowed to find its way into our river. Speaking generally the sewage from any one town should not be allowed to find its way into a river which is used as a source of water supply for other towns lower down.

It is not my intention to criticise these average numbers in detail, but it will suffice to say that from the absence of ammonia and from the smallness of the amounts of organic carbon and nitrogen, and of nitrates and nitrites, and also of chlorine, it is clearly evident that the contamination of the Calcutta water is really much smaller than might have been expected under the circumstances, and we may rest assured that our water supply is of fairly good quality, better in fact than that received by the majority of large towns in Europe.

In considering the results of the analysis of the Calcutta water month by month, we find that its composition varies considerably at different parts of the year. A close inspection of the table will show that apparently there are two distinct causes at work in modifying the composition of the water. The first prominent cause, and the one which has by far the greater influence, is to be found in the commencement, and during the continuance of the rainy season; the second and smaller cause appears to be the melting of the Himalayan snows by the burning sun of March, April, May and June. These changes are most clearly noticed in the column of Total Solid Impurity, and here we read that starting in January the amounts of total solids gradually increase up to March, when 22·37 parts are present in every hundred thousand parts of water; in April and May the quantities steadily and gradually diminish, the numbers being 21·68 and 21·23 respectively; this decrease continues until June 1st when there are only 19·43 parts of solid impurity present. These numbers of course correspond with the gradual and increasing diluting effect due to the admixture of pure snow water with the ordinary river water. In the middle of June, however, the rainy season usually commences, and there is a sudden decrease in the solids owing to the diluting action of the enormous volumes of rain water, and we find only 13·04 parts on July 1st; from this time there is a slight but steady decrease until October, when the water contains the smallest amount of solids present at any time of the year; the average for October 1st showing 11·30 parts. After the complete cessation of the rains (after November 1st) there is again a sudden rise in the total solids, and on December 1st, 19·44 parts are present. Some of the other columns of figures show a somewhat similar change, but in the case of the organic matter the change is not very marked. In the amount of nitrates present in the water, there appear to be two distinct maximum quantities during the year, one in March at the time of greatest concentration of the water as before mentioned, and the second at the commencement of the rains. This second maximum is readily accounted for when we consider, that the first effect of the rains will be to dissolve out the nitrates which have been accumulating in the soil of the drier parts of the country during the hot season; the amount of nitrates, however, it will be seen, steadily decreases towards the end of the rains, and this to a certain extent confirms the explanation.

Indeed during the first weeks or even days of the rainy season, the composition of our water supply is undergoing very rapid change, owing to the diluting action of the rain, and to the fact that the first showers of rain will wash out considerable quantities of soluble organic matter, nitrates etc., from the soil; afterwards, however, the rain water will run off comparatively pure. We shall therefore expect that the first action of the rain will be to decrease the total solids, and to increase the amounts of organic impurity and of nitrates, and that afterwards all the constituents will decrease in quantity.

That such is the case may be seen by the following analyses made on June 1st, 23rd and 26th and July 1st of last year. Each of the analyses shows the gradual dilution of the water by the heavy falls of rain in the districts from which our supply is collected, and the increase of organic matter and of nitrates due to the washing out of the substances from the soil by the first showers of rain.

HOOGHLY WATER.

Results of Analysis expressed in parts per 100,000.

Number of Sample.	Date of collection of Sample.	Total solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness.		
									Temporary.	Permanent.	Total.
1	June 1st, 1879,	19·56	0·130	0·052	·000	Traces only.	0·052	1·32	4·24	2·45	6·79
2	June 23rd, „	17·08	0·148	0·099	·001	·023	0·123	0·923	3·46	3·25	6·71
3	June 26th, „	16·68	0·138	0·075	·002	·053	0·130	0·852	3·33	3·38	6·71
4	July 1st, „	12·48	0·113	0·093	·000	·039	0·132	0·89	0·72	4·57	5·29

Extension of the Present Water Supply.

As pointed out previously it is now proposed to double the supply of filtered water for Calcutta, and recently a proposal has been urged on the Corporation to collect the new supply of water at Cossipore or Dukhinsahar instead of as at present at Pultah. As I was consulted on this subject and gave a strong recommendation that the water should not be taken from any place near to Calcutta, but that the present source at Pultah should still be used, I may perhaps be allowed to give the substance of my arguments against the two proposed sources of supply at Cossipore and at Dukhinsahar.

My opinions on this point are to a great extent founded on some previous analyses of the river water taken at various points near to Calcutta, which were made by Dr. Macnamara and Mr. Waldie, when the Calcutta supply was first being introduced, but in addition I have myself made a few analyses which have confirmed me in my conclusions.

The usual time for pumping up the water from the river into the settling tanks is at five hours' ebb; this is of course done so as to avoid the possibility of taking in any tidal water and as far as possible to secure only the true river water. The proposals for taking the water for these two places appeared then to resolve themselves into two questions.

(*a*) Whether at five hours of ebb the water off Cossipore, *at all seasons of the year* can be relied on as a safe source of water-supply.

(*b*) Whether at five hours of ebb, the water at a distance of two or three miles above Cossipore, *at all seasons of the year*, can be relied on as a safe source of water-supply. For I think it will be generally admitted, if at either place, at any one season of the year, the quality of the water cannot be relied on, this would be equivalent to a condemnation of the proposed place of supply.

Before proceeding to deal with the actual results of the analyses which have been previously made by the two gentlemen abovementioned, it will be well to take a general review of the conditions of our river from which the water-supply is to be derived. The river, as is well known, is a tidal one to a considerable distance above its mouth, and it appears certain that the tidal water does not at any season of the year, or under any ordinary circumstances, reach higher than Chinsurah. I have already shown in a previous part of this paper that the true river water, as it has been delivered of late years in Calcutta, is a tolerably pure and reliable supply, and that there has never been the slightest suspicion of any appreciable admixture of tidal water with the natural river water, in the hydrant water now supplied from Pultah. This of course, is because the water is collected at a considerable distance up the river, and that it is taken at five hours' ebb.

The tidal water however, in flowing up past Calcutta undoubtedly, must become contaminated with a variety of impurities. It may be true that a large proportion, or perhaps nearly the whole of the sewage, as collected in the drains of this town, is now carried to the Salt Water Lakes, but no one, knowing the habits of the lower orders of the natives of this country, will believe, that this represents the sum total of the sewage. In all probability, there is a large amount of filth of various kinds, which finds its way direct into the river. Again, on the banks of the river numerous factories have now sprung up, and it will be quite unlike the usual experience in England if these factories, unrestrained by Acts of Parliament, do not also send a large amount of filth, refuse, &c, into the running stream beside them. I am not aware what sanitary arrangements are made on the Howrah side of the river, but it has always appeared to me, that a large amount of drainage reaches the river from that source.

Also it must be remembered that Calcutta is a large shipping port; thus on the average I believe there are about 2,000 vessels annually arriving and departing from the port, aggregating nearly two and a half millions of tons; to these must be added the very large numbers of country boats, dinghis, &c., which line the shores and which help to carry on the great and increasing trade of Calcutta. Omitting the actual business operations carried on, it must be admitted, that the crews of these vessels will add a not inconsiderable amount of sewage contamination to the river water. The tidal water, in flowing past Calcutta, must of necessity then carry with it all such contamination, and will in that state be probably, if not certainly, unfit for drinking, or even for domestic purposes.

I think it cannot be disputed that, in selecting a site from which to collect water for *drinking and domestic* purposes, it will be essential, that at all seasons of the year, at the ordinary time of collection, (five hours' ebb) there shall be practically no admixture of tidal water with river water proper; for it is evident, that the tidal water will always be contaminated with various kinds of organic matter.

The two questions which I suggested previously, thus become limited to the consideration of whether at Cossipore, or at two or three miles above it, the water at five hours' ebb is free from contamination with tidal water at *all* seasons of the year. It would be bad enough to supply brackish tidal water for drinking purposes, but far worse to supply tidal water, which had collected all sorts of filth and abomination on its way up.

Having suggested what it appears necessary to prove, we can now pass on to the consideration of the analyses which have been made on this point. Most of these analyses were made from 12 to 18 years since, when comparatively little attention had been given to the subject of water analysis, and an important part of the method of analysis then employed has been since shown to be eminently untrustworthy and unreliable. The suitability of a water for domestic purposes is (as pointed out previously) believed to depend principally on its freedom from organic contamination, I am sorry to say that the methods for the determination of organic matter in water, used in the old analyses under notice, have been since shown to give at the best but very rough indications, which do not at all represent the absolute amounts of organic matter present. Though these methods of analysis failed to give thoroughly reliable information, yet I do not think it too much to assume that, to a certain extent, they gave information as to comparative purity of samples of the same variety of water, and valuable information may thus be extracted from them. By this I do not mean to say that the exact *proportional* freedom of the water from organic matter will be represented by the figures given in these analyses, but I do think that they may indicate that certain samples are less pure than others, and so on. For the purpose of a simple comparison, these results will be almost as useful as absolute statements, for we may work on the basis, that the good quality of our Hydrant water has been satisfactorily demonstrated.

In passing I may mention that Mr. Waldie disputes the correctness of Dr. Macnamara's results as to amount of organic matter present in the water, but it would be quite as easy for me, with a knowledge of the progress of the last ten years, to dispute the correctness of Mr. Waldie's results, so that in both cases, the results of the old analyses as to organic matter are to be accepted as comparative statements, rather than actual truths. It must be clearly understood, however, that I have no wish to under-rate the value of the work done by Dr. Macnamara and by Mr. Waldie; far from it, I believe that the results criticized are as accurate and reliable as could be obtained by the processes then known, and in those portions of the work, where the methods of analysis have not been changed, I think we may rely, with certainty, on the accuracy of the results given.

In the face of the above facts, I may be pardoned, if in considering these old analyses I draw more particular attention to the determination of the inorganic substances present, where the methods of analysis have scarcely changed, and refer less to the determinations of the organic substances present in the water.

In tidal water, that is water of which a part at least has been derived from the sea, sodium chloride, or common salt, is a prominent ingredient. In the table given on p. 120, it will be seen that sea water contains no less than 1975·6 parts of chlorine per hundred thousand of water; this substance, on the other hand, is present in very minute quantities in the true river water, and hence we have a crucial test to apply, in order to determine the presence or absence of tidal water in the samples in question. It may here also be well to remark that the process of analysis for the determination of chlorine in waters has not changed since the period when the analyses by Dr. Macnamara and Mr. Waldie were made, and therefore we may entirely rely on the accuracy of the results given as to the amounts of this constituent present in the samples of water analysed.

In the following table I quote four sets of analyses made by Dr. Macnamara of water collected, *at low water in each case*, from three different points in the river, namely, at Chinsurah, Pultah and off Cossipore, (one mile above Baug Bazar Bridge). For the sake of comparison I have added to the table some of the numbers obtained in the regular analysis of water for the year 1878.

ANALYSES OF WATER TAKEN IN THE MIDDLE OF STREAM SIX FEET FROM SURFACE.

Results expressed in parts per 100,000 *of water.*

	Constituent.	Low water. 17th December 1861.	Low water. 15th March 1862.	Low water. 12th June 1862.	Low water. 8th September 1862.
Chinsurah.	Total solid residue from filtered water	26·6	27·9	..	12·9
	Organic matter	6·0	5·6	..	2·6
	Insoluble earthy salts	16·9	19 9	..	8·0
	Soluble salts	3·6	1·9	..	1·5
	Sodium chloride	..	1·1	..	0·8
Pultah.	Total solid residue from filtered water	23·1	27·3	26·3	14·6
	Organic matter	6·0	5·6	5·0	2 1
	Insoluble earthy salts	14·1	19.0	17·0	8·7
	Soluble salts	2·7	1 7	3 6	2·0
	Sodium chloride	..	1·1	3·6	0·9
Cossipore.	Total solid residue from filtered water	24·6	34·7	97·1	13·3
	Organic matter	5·0	5·6	11·9	2·1
	Insoluble earthy salts	16·7	19·3	16·4	9·0
	Soluble salts	2·6	8·9	67·6	1·3
	Sodium chloride	..	7·6	55·7	..
		1st December 1878.	1st March 1878.	1st June 1878.	1st September 1878.
Hydrant water.	Total solid residue	16·80	24·34	15·16	11·13
	Carbon and nitrogen of organic matter ..	0·158	0·164	0·111	0·124
	Sodium chloride	1·01	1·87	1·70	0·79

An examination of this table and of the numbers given in previous parts of this paper shows clearly that the pure river water, *i. e.*, the present hydrant water never contains more than two or at the outside three parts of sodium chloride per 100,000 of water. This is proved by Dr. Macnamara's analyses of the water at Chinsurah and Pultah, and also by the numbers obtained weekly and monthly by myself.

When however the analyses of Cossipore water are considered, it will be seen that, whilst at low water in September and December, its composition is very similar to that of pure river water collected higher up : in March and more particularly in June, there are very striking differences. Thus on June 12th 1862 whilst at Pultah, there were only 26 parts of solid impurity and 3·6 parts of sodium chloride or salt in every 100,000 parts of water, at Cossipore (one mile above Baug Bazar Bridge) on the same day, and *at low water*, in the same volume there were no less than 97·1 parts of solid impurity, of which 55·7 parts were sodium chloride. This clearly indicates that on this occasion, there was a very large admixture of tidal water with the river water. Dr. Macnamara's results, as to the amount of organic matter, also appear to show that in June, there was much more present in the Cossipore water than in that collected at Pultah, and this is really what would be expected to be the case. The ratio of the organic matter shown in the two instances is greater than 2 to 1, and I think that this difference must indicate that the water at Cossipore did contain an excess of organic matter over that contained at Pultah. The *absolute* amounts of organic matter were, we now know, very much smaller than the numbers given in the table, but we can probably rely, to a certain extent, on the *relative* correctness of the numbers given.

There appears then to be no escape from the conclusion which Dr. Macnamara draws in his criticism of these results when he says—"the water (at Cossipore) during March, April, May and June is largely intermixed with the saline matters of the sea water and the sewerage of Calcutta, and during that time is unfit for human consumption."

As before pointed out the sewage contamination would be very much less at the present time than it was then, but I have tried to prove that we cannot have an admixture of tidal water without at the same time having organic and sewage contamination. I have no doubt that during the rains when a powerful stream is running down, the water at Cossipore may be nearly as pure as that at Pultah, but I think that Dr. Macnamara's analyses alone prove that, during the hot weather months, the water at Cossipore is by no means pure enough to be selected as a water-supply.

Turning now to the analyses made by Mr. Waldie, it appears to me that they essentially confirm the results given by Dr. Macnamara. The water tested by Mr. Waldie was taken usually from the river at Burranagur, which is said to be two miles above Cossipore. Here on June 14th, 1866 at 11-5 A. M., (*at low water*) 30·7 parts of solid matter, of which 14·5 parts were sodium chloride, were found; again on May 1866, two hours before the commencement of tide, there were 21·50 parts of salt present; on May 2nd 1866, there were 15·50 parts of salt at ebb-tide, and on June 1st 1866 at nearly low water, 16·50 parts of sodium chloride were found; these numbers being the quantities present in 100,000 parts of water.

With regard to organic matter also Mr. Waldie's results, though showing much less organic matter than Dr. Macnamara's analyses, to a great extent confirm his statements, and prove that as a rule, there is a larger amount of organic matter in the water collected at ebb-tide off Burranagur, than in the water collected at higher points of the river. The numbers above quoted show unmistakeably that at *two miles above Cossipore* during the hot season, there is a decided admixture of tidal water and probably of sewage contamination with the pure river water, and that this is the case even with samples collected at low water.

The opinion of Dr. Macnamara as to the suitability of Cossipore water for drinking purposes, has already been given. I will now quote Mr. Waldie's remark in his general summary of results—"Can the supply be safely taken from the river at Cossipore? We can scarcely answer in the affirmative."

In conclusion, then, I may say that, so far as can be ascertained from the old analyses by Dr. Macnamara and Mr. Waldie, and from my own results, it is my opinion—

That during the rainy season, and whilst the river is in *full* stream, the water collected two miles above Cossipore, or perhaps even at Cossipore, could probably be used as a fairly safe water-supply.

That during the hot weather months, if the water is collected two miles above Cossipore, even at five hours' ebb, there will frequently, if not always, be contamination with tidal water to an extent, which unfits it for a safe water-supply, and the water will be contaminated to a still greater degree if collected at Cossipore.

That this tidal contamination would involve also organic contamination to a considerable extent, and that, as pointed out in a previous part of this paper, such organic or sewage contamination cannot become oxidized or destroyed during the flow of the water, nor can the water be purified by the ordinary processes of settling, filtration through sand etc. so as to render it a safe supply for domestic purposes. Such water therefore would be eminently unsafe for potable purposes and should be at once condemned.

That unless contrary evidence is furnished, the proposed new sources of supply are too near to the mouth of the river and to Calcutta, and consequently that it is strongly desirable that the extension of the water supply should be carried out on the same principle as formerly, and that the water should always be collected at Pultah, and not at the other points which have been suggested.

IX.—*On the Zoological Position of the Bharal, or Blue-Sheep, of Tibet.*—*By* R. Lydekker, B. A.

(Received Jan. 4th;—Read Feb. 4th, 1880.)

The Bharal or Blue-Sheep of the Tibetan region is one of those animals which are peculiarly interesting, and at the same time peculiarly puzzling, to the naturalist, on account of its presenting affinities to two distinct groups of animals, whereby the determination of its position in the zoological scale is a matter of some considerably difficulty.

As I shall show below, the bharal presents points of resemblance both to the sheep and the goats, and this intermediate character of the animal seems to have been the cause of considerable diversity of opinion among naturalists, as to what genus the animal should be referred. The late Mr. Bryan Hodgson, in the Society's Journal,* proposed the generic name *Pseudois* for the bharal. Mr. Hodgson, however, together with the late Mr. Blyth, thought that there were two species of the genus, to which were given the names *P. nahura* and *P. barhal.* The latter writer, however, according to the late Dr. Jerdon, seems finally to have come to the conclusion, that there was only one species of the genus, known as *P. nahura.* The late Dr. Gray, and, I believe, all subsequent writers, have adopted the view of there being but one species of bharal. Hodgson's generic distinction was adopted by Dr. Gray.† The late Mr. H. N. Turner,‡ however, and Mr. W. T. Blanford,§ class the bharal in the genus *Ovis,* though the last named writer does not give his reasons for so doing.

In the present paper, I shall notice certain points in the osteology of this animal, which indicate its close relationship to the goats, and which, I venture to think, are sufficient to confirm its generic distinction from *Ovis.*

Mr. Hodgson, in his above quoted paper, first pointed out that the bharal differed from all the true sheep in having no "eye-pits," but did not point out that the absence of these "eye-pits" was a character common to the bharal and the goats.||

The so-called "eye-pits" are the depressions which occur in the lachrymal bones of many ruminants for the gland known as the "larmier." In all the true sheep, the lachrymal bone has a very considerable larmial depression, and the greater part of the outer surface of that bone is placed

* J. A. S. B., Vol. xvi, p. 702.

† Cat. of Mammalia in Brit. Mus. Pt. iii, p. 177, 1852.

‡ "Scientific Results of 2nd Yarkund Mission," Mammalia, p. 85, Calcutta, 1874.

§ Pro. Zool. Soc. Lon. 1850, p. 176.

|| I exclude the genus *Nemorhaedus* from the goats.

more or less nearly at right angles to the surface of the frontals; the suture connecting the lachrymal with the maxilla is placed in advance of the suture between the maxilla and the malar. In the goats, the outer surface of the lachrymal has no larmial depression, and the greater part of such surface is continuous with the plane of the frontals; the lachrymo-maxillary and malo-maxillary sutures are in one oblique line. In the bharal, there is likewise no larmial depression on the lachrymal and the outer surface of this bone slopes gradually away from the plane of the frontals; while the lachrymo-maxillary suture is only slightly in advance of the malo-maxillary suture. In the form and relations of the lachrymal, therefore, the bharal is decidedly much nearer to the goats than to the sheep.

The next most important caprine character presented by the bharal skull, is in the basioccipital. In the true goats this bone is oblong in shape, with a pair of tubercles at the posterior and anterior extremities; of these, the posterior pair are considerably the larger and more prominent, but both are situated on the same antero-posterior line. In the true sheep, on the other hand, the basioccipital is always considerably wider in front than behind, while the anterior pair of tubercles are much larger than the posterior, and are placed wider apart. The basioccipital of the bharal agrees exactly with the basioccipital of the goats, and is, consequently, widely different from this part in the sheep.

In the form of its lower jaw, the bharal agrees with the sheep, and differs from the goats.

In the structure of its horns, the bharal again presents caprine affinities. In the true sheep the horns are always thrown into parallel transverse wrinkles extending completely round the horns; the colour of the horns is light brown, or greenish brown, and the direction of the extremity of the first curve is always downwards and forwards.

In the goats, on the other hand, the horns are never thrown into coarse and parallel transverse wrinkles, but are marked by finer striæ, and may or may not carry knobs anteriorly. Their colour is dark blackish brown: they are always more or less angulated; and the extremity of the first curve is directed backwards and upwards.

In the bharal, the structure and colour of the horns is the same as in the goats; the extremities of the horns are directed backwards and upwards: their angulation is less marked than in the goats. The horns of the bharal are indeed directed more outwards than those of the goats, and in this respect they present some points of resemblance to the sheep; the upward twist of their extremities, however, shows an approximation to the curved horn of the Markhoor and is quite different from the curve of any sheep's horn.

The profile of many goats, like the Ibex, is markedly concave; in others, however, as the Thar, it is nearly straight; the profile is also nearly straight in the sheep and bharal, and we cannot, therefore, draw any classificatory inference from this character.

In other cranial characters, there do not seem to be any well marked distinctions between sheep and goats. It, therefore, seems pretty evident that as far as cranial characters go, the bharal is undoubtedly much more closely related to the goats than to the sheep.

The bharal is, however, externally distinguished from the goats, by the absence of any odour or any trace of a beard or mane in the males There are feet-pits (interdigital pores) in all the feet of the bharal, in which respect it agrees with the sheep, and differs from the goats, in which these pits are either absent *(Hemitragus)*, or present only in the fore feet (*Capra*). The tail, according to Mr. Hodgson, is unlike that of the sheep.

From the above comparisons it will be seen that in the osteological characters of the head, the bharal is nearer the goats than the sheep, while in its external characters it is nearer to the sheep. The cranial characters pointed out above appear to me to be of such importance as to preclude classing the bharal in the genus *Ovis*, and I accordingly think that Mr. Hodgson's genus *Pseudois* should be retained for its reception. The animal most certainly forms a very closely connecting link between the genera *Capra* and *Ovis*, and it seems to be very difficult to say to which it is most nearly related.

X.—*Description of a new Species of Diurnal Lepidoptera belonging to the Genus* Hebomoia.—*By* J. Wood-Mason.

The beautiful insect described below has been recently received by the Indian Museum from the Andaman Islands, where it was obtained by Mr. A. de Roepstorff, after whom I have named it.

Hebomoia Roepstorfii, n. sp.

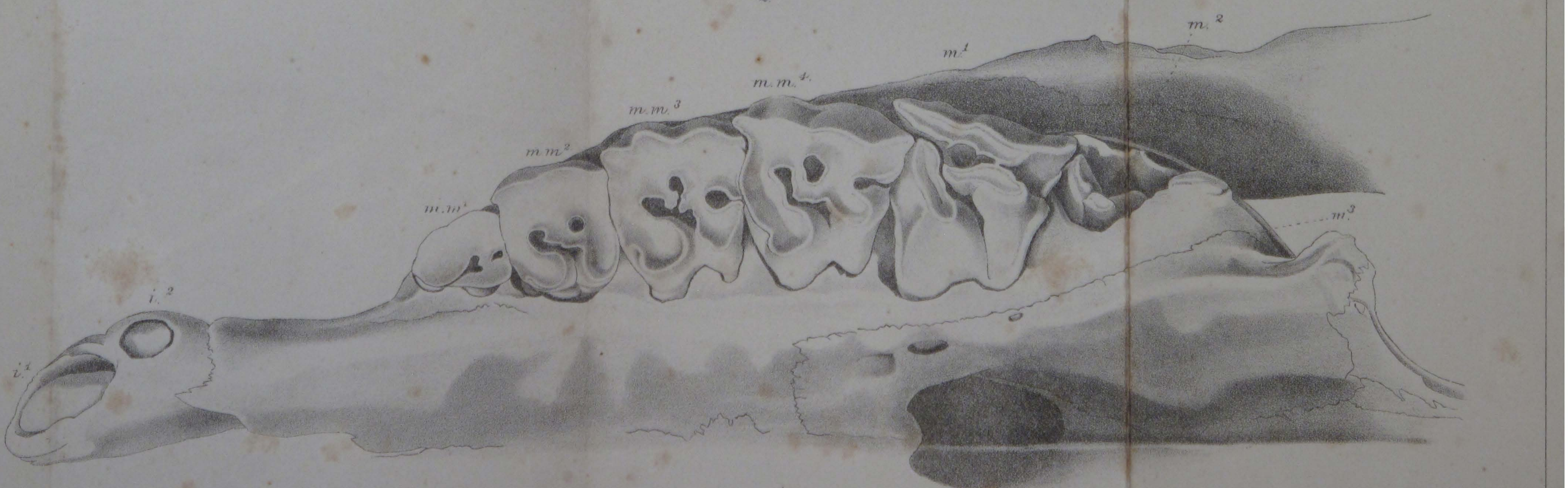
♂. Differs from *H. glaucippe*, the only species of the genus with which I have been able to compare it, *on the upper side*, in having the apical orange patch of the fore-wing larger, extended into the cell, and less broadly bordered with black, both internally and externally; the submarginal black spots smaller and completely isolated from the black of the outer margin; the fore-wing at the posterior angle tinged, and the hind-wing externally broadly bordered, with bright sulphur-yellow, which colour is shaded off into the cream-colour of the rest of both wings; and the outer margin of the hind-wing narrowly edged with black, which gradually broadens from the anal to the anterior angle and extends inwards in points at the veins:—and, *on the under side*, in having the brown mottling of the fore-wing arranged in the form of a tolerably conspicuous band coincident with the macular band of the upper side; and the ground-colour of the hind-wing, as also that of the mottled portion of the fore-wing, of a rich golden-luteous colour.

Expanse 3·5 inches.

Hab. S. Andaman.

The place of this species would seem to be between *H. vossii*, (Maitland) and *H. sulphurea*, Wallace.

2.



1.

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W. Newman & Co. imp.

Abnormal Dentition of
RHINOCEROS INDICUS.

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XI.—*Notes on the Dentition of* Rhinoceros.—*By* R. LYDEKKER, B. A.

(Received March 9th;—Read June 2nd, 1880.)

(With Plate VII.)

A recent examination of the dentition of the fine series of skulls of *Rhinoceros indicus* contained in the collection of the Indian Museum, has brought to my notice several very interesting facts in regard to the development and serial homology of certain of the teeth of that and other species which I have thought of sufficient importance to be put on record, whence the following notes have been penned. My remarks will mainly refer to the dentition of *Rhinoceros indicus*, but some points relating to that of other species of the genus will be incidentally referred to in the course of the paper.

To illustrate my subject, I have had lithographed (through the courtesy of Mr. J. Wood-Mason) the left upper dentition of two adolescent skulls of *R. indicus*, from the collection of the Indian Museum, each of which is remarkable for an abnormality. The dentition exhibited in fig. 1 of the accompanying plate belongs to a young animal, and comprises two incisors (*i.*^{1}, *i.*^{2}), the milk-molar series (*m.m.*^{1} to *m.m.*^{4}), and the true molars (*m.*^{1} to *m.*^{3}), the last of which is still in its alveolus. The second specimen (fig. 2) belongs to a somewhat older animal, and exhibits the alveolus of an incisor (*i.*^{1}), two premolars (*p.m.*^{1}, *p.m.*^{2}), two milk-molars (*m.m.*^{3}, *m.m.*^{4}), and the three true molars (*m.*^{1} to *m.*^{3}), the last of this series, in this instance also, not having yet cut the gum. The grounds on which these teeth are assigned to their respective serial positions will be found in the sequel.

The true molars ($m.^1$, $m.^2$, $m.^3$) in all species of ***Rhinoceros***, whether living or extinct, are invariably three in number, corresponding with the typical mammalian series, and, therefore, require no further notice on this occasion. In advance of the first of the three true molars, there occur, in all young skulls of ***Rhinoceros***, four teeth in serial apposition, but in older skulls there may be only three. It is to these anterior teeth of the milk-molar and premolar series (the one or the other present, according to the age of the animal) to which I now desire to draw attention.

An examination of the skull of which the left dentition is drawn in fig. 1, shows that, of the four teeth ($m.m.^1$, $m.m.^2$, $m.m.^3$, $m.m.^4$) in advance of the first true molar ($m.^1$), the three last ($m.m.^2$, $m.m.^3$, $m.m.^4$) have their fangs and bases absorbed away by the germs of other teeth, which are succeeding them from above: there can, therefore, be no doubt that these three teeth are the three last milk-molars of the typical series. This is also shown by the last tooth of the anterior series ($m.m.^4$) being more worn than the first of the true molar series ($m.^1$): if the tooth preceding the latter were a premolar, it would be the less worn of the two. The first tooth of the whole series ($m.m.^1$) shows, however, no signs of being about to be replaced by a vertically succeeding premolar. I have carefully examined another skull of the same age, in which the alveoli of the teeth have been opened, and I can find there no trace of a replacing premolar above the first of the seven teeth of the molar series. Were this tooth to be replaced by a premolar, such replacement would take place before that of the tooth next in the series. Several other adolescent skulls of ***R. indicus*** which I have examined show no trace of the replacement of the anterior tooth, and it may, therefore, be considered to be proved that in many instances no such replacement ever takes place.

From the development of the tooth in question with the milk-molar series (though it sometimes appears rather later than the next tooth), there would seem to be no doubt that it is the first of that series, and I shall show below that such is undoubtedly the case. From the fact of this tooth having in most instances no vertical successor and persisting for a considerable time during the period of use of the permanent dentition, it is not unfrequently referred to as the first premolar, and though, as I shall show, such a nomenclature is altogether inaccurate, yet it has a certain amount of convenience which may justify its conditional use.

The dentition drawn in fig. 2 also exhibits four teeth in front of the first true molar ($m.^1$), but they are not all homologous with those in the preceding specimen. The two teeth ($m.m.^3$, $m.m.^4$) in advance of the first true molar ($m.^1$) in fig. 2 are more worn than the former, and will consequently be the third and fourth milk-molars, or the homologues of the corresponding teeth in fig. 1. The first and second teeth ($p.m.^1$, $p.m.^2$), however, in fig. 2 are still in germ, and as being totally unworn must be of a later development than the third and fourth milk-molars: consequently, the former must be the first and second premolars, which have replaced the first and second milk-molars. In this instance, therefore, the first milk-molar, which, as we have seen, is normally persistant, has been replaced by a vertically succeeding premolar, from which replacement there can be no question as to the correctness of the serial position assigned to the former tooth. The replacing premolar (fig. 2, *p.m.*[1],) is of considerably larger size and more complex structure than the replaced milk-molar (fig. 1, *m.m.*[1]).

In the lower jaws of all the skulls of *R. indicus* which have come under my notice, I cannot find any instance of the vertical replacement of the first milk-molar, which generally persists until the permanent dentition is well in wear, and subsequently falls out at a comparatively early period. Neither can I find any instance of the replacement of the first milk-molar of either jaw in *R. sumatrensis* (*sumatranus*) or *R. javanicus* (*sondaicus*).

The formula of the molar dentition of *R. indicus*, taking into account the abnormal form, may be written as follows:—*m.m.* $\frac{4-4}{4-4}$ *p.m.* $\frac{(3\cdot4)-(3\cdot4)}{3-3}$ *m.* $\frac{3-3}{3-3}$; the adult molar dentition of the normal form, *m.m.* $\frac{1-1}{1-1}$ *p.m.* $\frac{3-3}{3-3}$ *m.* $\frac{3-3}{3-3}$; and of the abnormal form, *m.m.* $\frac{0-0}{1-1}$ *p.m.* $\frac{4-4}{3-3}$ *m.* $\frac{3-3}{3-3}$.

The succession and homology of the anterior tooth of the molar series appears to have given rise to a certain amount of confusion among naturalists. Thus Professor Huxley when treating of the dentition of the genus *Rhinoceros*, observes:* "Of the four milk-molars, the first, as in the Horse, is smaller than the others, and is not replaced;" two pages back in the same work, however, the Professor gives the formula of the premolars as $\frac{4-4}{4-4}$, which would imply either that the first tooth of the molar series is replaced, or else that it is reckoned as a premolar, in which case there would be only three milk-molars.† Professor Owen appears to have come to a conclusion totally opposite to that of Professor Huxley, and seems to consider that the first milk-molar is always replaced. Thus on page 592 of his 'Odontography' the Professor observes that "the first of the

* 'Anatomy of Vertebrated Animals,' p. 362.

† In a work explanatory of the homology of the teeth, as is Professor Huxley's, there can be no doubt that this homology should be given with the most strict accuracy. In descriptive zoology and palæontology, however, it will still be convenient, in referring to the dentition of the genus *Rhinoceros*, to count the first milk-molar, when persistent, as a premolar, in order to avoid introducing another term into the dental series. The same conventional arrangement may be adopted in regard to the permanent and milk-incisors, referred to below.

permanent series of seven molar teeth is very small in both jaws, and is soon shed;" and again on page 599, "the first milk-molar soon yields place to the first premolar." The above given instances of the dentition of *R. indicus* show that this view cannot be normally correct: the difference in the form of the first upper milk-molar (*m.m.*1) and the first premolar (*p.m.*1) shows, in cases where the former tooth persists, that it cannot be a premolar which has supplanted a milk-molar *in utero,* as might otherwise be the explanation according to Professor Owen's views.

I now come to the consideration of the non-molar dentition, and shall first treat of the teeth of the upper and secondly of the lower jaw.

According to Professor Owen,* there is developed in the fœtal skull of *R. indicus,* immediately behind the maxillo-premaxillary suture, a very small tooth, which, from its position must be the milk-canine: this tooth disappears at an extremely early age, and no permanent successor is ever developed. I can find no record of an upper canine ever having been observed in the fœtus of any other species of the genus, and no permanent upper canine occurs in any species.

In a very young skull of *R. indicus,* figured by Cuvier,† there appear in the premaxilla the alveoli of two teeth, which must be those of the first and second milk-incisors. Two, indeed, appear to be the normal number of upper milk-incisors developed in the genus, though Professor Huxley‡ speaks of there being three on either side in some species.§

Normally, in *R. indicus* there is only one permanent incisor developed, succeeding the first (innermost) milk-incisor; the former tooth is easily recognized by its lateral elongation. Occasionally, however, as in the skull of which the left upper dentition is represented in fig. 1, a second upper incisor (*i.*2) is developed, replacing the second milk-incisor. In the figured specimen, the two incisors (*i.*1, *i.*2) are still in the condition of germs just protruding from their alveoli; from the condition of wear of the molar series it is quite evident that the two incisors belong to the second series, which is also shown by the characteristic form of the innermost (*i.*1); the second incisor (*i.*2) is not lengthened laterally like the first. In the right premaxilla of the same skull, only the first incisor is developed. Another instance of the development of the second incisor of one side of the upper jaw is afforded by the skull belonging to a mounted skeleton of an old individual of *R. indicus* in the Indian Museum, in which all the teeth of the permanent series are much worn. In the right premaxilla of that skull

* 'Odontography,' p. 592.

† 'Ossemens fossiles,' Ed. 1836. Atlas, pl. xliii, fig. 3.

‡ Loc. cit. p. 362.

§ I am not aware which species is referred to.

there occur two large and well-worn permanent incisors not differing to such an extent in size as do those of the figured specimen. No trace of a second incisor is to be found in the left premaxilla, and I cannot, indeed, find any instance of the development of the two upper incisors of both sides in the same individual of *R. indicus*. The occasional development on one side only of the second permanent incisor in the last-named species, would seem to be a pretty clear indication that it is descended from an ancestor in which two pairs of upper incisors were normally present. It seems, indeed, that, when teeth normally absent do present themselves, they usually appear only on one side, as in the instance of the lower jaw of a tiger with an extra premolar, described by myself in a former volume of the Society's Journal.*

In all species of the genus, the normal number of permanent upper incisors (if any are present) appears to be one only on either side, and I have not come across any instance of the abnormal development of the second upper incisor in any species but *R. indicus*. It may not improbably be, however, that such abnormal development may occur in other species.

It has, indeed, been stated on the authority of the late Dr. Falconer† that the extinct Indian *R. sivalensis* was furnished with three pairs of upper (and lower) permanent incisors; none of the numerous specimens of the skull of this species figured in the 'Fauna Antiqua Sivalensis,' however, exhibit any incisors at all, and we have, therefore, no tangible evidence whatever to support the new genus *Zalabis* lately proposed by Professor Cope‡ for the reception of this species on the ground of the unusual number of incisors with which it was provided.

Turning now to the lower jaw, we shall find that there is some considerable difficulty in arriving at a satisfactory conclusion as to the homologies of the teeth in advance of the molar series.

In *R. indicus*, there normally exist in the young animal an inner pair of very small conical teeth, and an outer pair of larger teeth. The outer pair are succeeded from below by a pair of much larger triangular and pointed teeth, which, therefore, evidently belong to the permanent series. Normally, I believe, the inner pair are not succeeded by permanent teeth, as I can find no trace of such in most lower jaws; in the lower jaw of the skull drawn in fig. 1, however, there occurs, a little above and internal to the middle pair of teeth, a second pair of small teeth, which are less protruded from the jaw, and which, I think, certainly belong to the second dentition.

* Vol. xlvii, pt. ii, pl. 2.

† Owen, loc. cit. p. 589.

‡ Bul. U. S. Geol. Geog. Surv. Vol. v, p. 229.

We may, therefore, say that in *R. indicus* there are always developed in the symphysis of the mandible two pairs of milk-teeth, and always one, and occasionally two pairs of permanent teeth. When the middle pair of milk-teeth are not replaced, they remain during the permanent dentition, as in the analogous case of the first upper milk-molar.

It now remains to consider the serial position of the teeth in question. With regard to the middle pair of teeth, there can be no question but that they are incisors, and probably the first of that series. With regard to the homology of the larger outer pair of teeth, two views are entertained. By the older writers, this pair of teeth were unhesitatingly classed as incisors; a view adopted both by Prof. Huxley and by Prof. Owen. Latterly, however, some writers, among whom may be mentioned Professors Cope* and Gaudry,† have come to the conclusion that this outer pair of teeth are really canines, apparently from their resemblance to the undoubted canines of certain genera of extinct Mammals. To distinguish between a canine and an incisor tooth in the lower jaws of animals in which the incisors are reduced and no upper canine is present, is indeed a matter of extreme difficulty, and I do not desire on the present occasion to enter into the reasons either for or against the innovation. I provisionally, however, adopt the old nomenclature.‡ With this view of the homology of the teeth in question, the anterior milk dentition of *R. indicus* may be formulated as follows:—$c. \frac{1-1}{0-0}\ i. \frac{2-2}{2-2}$, the adult dentition will be normally $c. \frac{0-0}{0-0}$ $m.i. \frac{0-0}{1-1}\ i. \frac{1-1}{1-1}$, or abnormally $c. \frac{0-0}{0-0}\ i. \frac{2-2}{2-2}$.

In treating of the milk dentition of *Rhinoceros*, Professor Huxley§ remarks of the two pairs of lower incisors that "it seems probable that only one pair, in *any case*, are permanent teeth." I have shown that occasionally in *R. indicus* both pairs may be replaced by permanent teeth, and I now proceed to show that such is at all events sometimes the case in another species. In a lower jaw of *R. javanicus* figured by De Blainville,‖ there are the germs of two incisors on each side *in alveolo*, below protruded incisors; the former, therefore, are clearly permanent teeth. I have no means of knowing whether this replacement is abnormal or normal. In

* Loc. cit.

† 'Les Enchainements du Monde Animal: Mammifères Tertiaries,' p. 50, et seq.

‡ I may perhaps observe that there seems to be some discrepancy in M. Gaudry's nomenclature, since on page 58 of his work quoted above, he speaks of there being two pairs of small incisors in the lower jaw of *R. bicornis (africanus)*, and yet does not produce any evidence to show that these teeth are not the homologues of the two pair of teeth in the mandible of *R indicus*, which are reckoned as incisors and canines.

§ Loc. cit p. 362.

‖ 'Osteographie,' Atlas, Rhinoceros, pl. viii.

R. sumatrensis, there is in the adult state no median pair of lower incisors,* and it is, therefore, probable that permanent middle lower incisors are never developed in this species.†

In the living African species of *Rhinoceros*, in the extinct Indian *R. deccanensis*, and other extinct species, no permanent incisors, in either jaw, were ever developed, and in the adult the symphysis of the mandible and the premaxillæ are consequently edentulous. It has been said that three pair of lower incisors were developed in *R. sivalensis*, but none of the lower jaws of the genus figured in the 'Fauna Ant. Siv.' show more than two pairs of these teeth, and none are present in the specimen referred to *R. sivalensis*.

From the foregoing brief notes it will be gathered that the dental system of the genus *Rhinoceros* presents very considerable differences in different species, and occasionally in different individuals of the same species. These differences are mainly due to the varying extent to which specialization has operated in the genus, and to the occasional development by 'reversion' of teeth normally absent.

The genus *Rhinoceros* (using the term in its original comprehensive sense) is indeed one of those in which the dental system may be said to be in a condition of change, and this variability in the matter of the development or suppresion of certain teeth in species and individuals, appears to me to render the splitting up of the old genus into a number of new genera or subgenera (except in the case of *Acerotherium*) a very questionable measure. The relative prominence or insignificance of the anterior teeth may be traced in a graduated scale from one species to another as has been most ably done by M. Gaudry in his invaluable work already quoted in this paper.

Explanation of Plate VII.

Fig. 1. The left upper dentition of an immature specimen of *R. indicus*, showing the germs of two permanent incisors ($i.^1$, $i.^2$), four milk-molars ($m.m.^1$, $m.m.^2$, $m.m.^3$, $m.m.^4$), first and second true molars ($m.^1$, $m.^2$), and the alveolus of the third ($m.^3$). (The animal to which this skull belonged was killed by Mr. W. T. Blanford.)

Fig. 2. The left upper dentition of a somewhat older individual of the same species, showing the alveolus of the first permanent incisor ($i.^1$), the first and second premolars ($p.m.^1$, $p.m.^2$), the third and fourth milk-molars ($m.m.^3$, $m.m.^4$), the first and second true molars ($m.^1$, $m.^2$), and the alveolus of the third ($m.^3$).

Both specimens are drawn one half the natural size.

* Professor Cope (loc. cit. p. 229) is in error when he gives two pairs of mandibular teeth to this species.

† I should doubt if the lower jaw drawn in fig. 15 of plate 138 of Owen's 'Odontography' as of *R. sumatrensis* belongs to that species.

XII.—*On a Species of* Trochalopterum *from Travancore.* *By* W. T. Blanford, F. R. S.

(Received Sept. 2nd;—Read November 3rd, 1880.)

A very interesting series of bird-skins obtained in Southern Travancore has recently been brought to England by Mr. F. W. Bourdillon. Collections previously made by the same gentleman in the locality named have been described by Mr. Hume in Stray Feathers, Vol. IV, p. 351, and Vol. VII, p. 33. One of the species noticed in the second paper is *Trochalopterum fairbanki*, a bird originally obtained by Mr. S. Fairbank on the Palni hills, about 100 miles north of the range, east of Trevandrum, on which Mr. Bourdillon's skins were collected. Mr. Hume, l. c. p. 37, points out some differences between the Travancore and Palni forms, but remarks that he has not a sufficient series to determine whether these differences are constant.

In the collection now brought are three skins of the Travancore *Trochalopterum*, and on comparing them with the original type of *T. fairbanki* in the British Museum, I find, besides the differences noticed by Mr. Hume, a few other distinctions, sufficient, I think, to justify a separate title being bestowed on the Travancore bird. The following is a full description of the latter.

Trochalopterum meridionale, sp. nov.

T. Trochaloptero fairbanki *peraffine, sed dorso grisescente, abdomine medio albo, supercilio albo haud post oculum producto, regione postoculari grisea nec fusca, rostroque robustiore distinguendum: pileo brunneo, dorso griseo-olivaceo, postice olivaceo, coloribus transeuntibus; supercilio brevi albo, loris brunneis, cum pileo concoloribus; capitis lateribus cum regione parotica pallide rufescenti-griseis, colli lateribus cinereis; rectricibus remigibusque brunneis, illis remigibusque secundariis ultimis subobsolete transfasciatis; mento, gula, atque pectore albescenti-griseis, conspicue fusco-striatis, media gula fere alba; abdomine medio albido, lateribus cum pennis subcaudalibus tectricibusque inferioribus alarum ferrugineis, tibiis olivaceis; rostro nigro, pedibus fuscis, iridibus saturate rufis.*

Long. tota exempli masculini 9, alæ 3·5, caudæ 3·6, tarsi 1·45, rostri a fronte 0·8, ejusdem a rictu 1, culminis 0·9 poll. Angl.

Hab. In summis montibus provinciæ Travancore, ad extremitatem meridionalem peninsulæ Indicæ.

Head above hair-brown, the feathers rather pale-shafted, the colour passing gradually into that of the back, which is greyish olive, becoming greener on the rump; a very short white supercilium, only extending from the base of the bill to above the middle of the eye; lores the same colour as the crown; sides of head, including the ear-coverts, grey, with a slight rufescent tinge; sides of neck purer grey; wing and tail-feathers brown with olivaceous margins, all the tail-feathers and the last (proximal) secondary quill-feathers with faintly marked narrow transverse bars on the upper surface; chin, throat, and breast pale grey, with conspicuous dusky striæ, the central portion of each feather being much darker than the edges; the middle of the throat is very pale, almost white, middle of abdomen white, lateral portions and flanks with the under tail-coverts and under wing-coverts ferruginous; thigh-coverts olivaceous. Irides dark red,* bill black, legs dusky.

The three specimens were all shot at an elevation of 4000 feet. Two are from Mynall, one from the Travancore and Tinnevelly boundary. Two are males; of the third, the sex has not been ascertained. The differences in measurement are trifling: the wing is 3·4 to 3 55 inches; tail, 3·4 to 3·65; tarsus, 1·4 to 1·45; culmen, 0 9 to 0·95. The length is given by Mr. Bourdillon from 8½ to 9½ inches in different specimens.

T. meridionale is distinguished from *T. fairbanki* by (1) the much shorter white superciliary stripe terminating above the eye, whereas, in *T. fairbanki*, it extends back above the ear-coverts; (2) by there being no brown band behind the eye, the feathers immediately behind the eye being rufescent grey like the cheeks in *T. meridionale*, whilst they are brown like the lores and the crown in *T. fairbanki;* (3) by the back and upper parts generally being much greyer and by the brown colour of the crown passing gradually into the olivaceous tinge of the back and not being separated by a distinct margin; (4) by the tail-feathers being browner and more distinctly transversely barred above; (5) by the striation on the throat and breast being more strongly marked; (6) by the middle of the abdomen being white instead of ferruginous†; and (7) by the rather stouter bill. I consider the differences marked 1, 2, and 3 characteristic; the others taken alone would scarcely justify the separation of the two forms.

From *T. jerdoni* the present species may be known by the absence of a black chin‡, by the flanks and under tail-coverts being rufous instead of

* Noted by Mr. Bourdillon, as also are the dimensions taken in the flesh. The length above quoted is from these measurements.

† This may not be constant; I have an indistinct recollection of having seen a specimen of *T. fairbanki* with the middle of the abdomen whitish, but I am not sure.

‡ With reference to this distinction between *T. jerdoni* and the two Southern forms *T. fairbanki* and *T. meridionale*, it is as well to note that the presence of a black chin in the former is mentioned by Blyth in his original description J. A. S. B., 1851, xx, p. 522. I call attention to this distinction, as Mr. Hume has overlooked it in his note on the species (Stray Feathers, vii, p. 36).

olivaceous, and the middle of the abdomen white instead of rufous. It is greatly to be regretted that *T. jerdoni* has never been collected again, so far as can be judged by published accounts, since Jerdon first procured it.

XIII.—*On a new Species of* Papilio *from South India, with Remarks on the Species allied thereto.—By* J. Wood-Mason, *Officiating Superintendent, Indian Museum, and Professor of Comparative Anatomy and Zoology, Medical College, Calcutta.*

(Received Oct. 16th;—Read Nov. 3rd, 1880.)

(With Plates VIII and IX.)

In December last, the Indian Museum received from Mr. F. W. Bourdillon of Trevandrum, a small collection of diurnal Lepidoptera, amongst which was a much worn and tattered example of a female insect evidently closely allied to the North Indian *P. Castor* and to the Burmese *P. Mahadeva*, with the same sex of the latter of which it turned out on examination to agree in having the discal markings of the hind-wing confined to the median region of the organ, where they form a transverse band of lanceolate spots, instead of being diffused over the whole disk and extending into the cell, as in the former.

About a month ago, a few species of butterflies were received from Mr. G. H. Kearney of the Berkodee Coffee Estate, Koppa Anche, Mysore, and amongst them is a fine specimen of the male, which proves that the species is, as the above-mentioned female specimen had already indicated, more nearly related to *P. Mahadeva* than to *P. Castor*, and enables me to describe it.

Papilio Dravidarum, n. sp., Pl. VIII, Fig. 1, ♂.

Allied to *P. Castor* and to *P. Mahadeva*,† but more closely so to the latter, with which it agrees in the form of the wings in both sexes.

Sexes alike, having not only the same form of wings but also the same general type of coloration as the females of the two described species; the male differing from the female only in the darker and richer tints of its upper surface.

♂. Upperside rich fuscous of a much lighter shade than in *P. Castor*, or even than in *P. Mahadeva*, and more densely powdered with fulvous scales than in either. *Anterior wing* with the basal area of a richer and darker shade of brown than the rest of the organ; with four distinct longitudinal lines of fulvous scales in the cell, at the extremity of which is a minute but distinct cream-coloured speck; with the outer portion beyond

* Moore, P. Z. S. 1878, p. 840, pl. li, fig. 1.

the cell very densely covered with fulvous scales between the veins; with a marginal row of ochraceous-white spots placed at the incisures; and with a submarginal series of nine conical or sublanceolate ochraceous ones; each series decreasing at either end and paling towards the costal margin. *Posterior wing* with the anterior third of its surface devoid of fulvous scales; with the incisures of the outer margin very narrowly edged with ochraceous-white; with a sub-marginal series of seven strongly and angularly curved lunules or arrow-shaped spots, the four posterior of which are ochraceous-white, and the three apical ones cream-coloured; and with a discal band of seven externally-dentate lanceolate cream-coloured spots all irrorated with fuscous scales except the anterior two; with the cell and the parts of the wing-membrane external and internal to it tolerably thickly sprinkled with fulvous scales. The wing-membrane being in *both wings* devoid of fulvous scales in the intervals between the sub-marginal and incisural markings presents the appearance of having a sub-marginal row of dark blotches. UNDERSIDE less richly and deeply coloured, with the markings, especially the spot at the end of the cell, all slightly larger and white, with the exception of the discal series of the hind-wing, which are tinged with cream-colour at their inner points; and with the fulvous scales similarly though not quite so thickly distributed over the fore-wing, but evenly sprinkled over the whole of the hind-wing. Body lighter-coloured than in *P. Castor*, but marked in identically the same manner.

Length of fore-wing 2·2; whence expanse = 4·5 inches.

HAB. Koppa Anche, Kadur District, Mysore, S. India, at about 2,500 feet elevation. Obtained by Mr. G. H. Kearney.

♀. Marked above and below, spot for spot, as in the male, but lighter and less richly coloured, with the spot at the end of cell larger and apparently more distinctly visible on the upper side, and with all the markings (except the sub-marginal series of the underside of the hind-wing, which are white) straw-coloured.

Length of fore-wing 2·3; whence expanse = 4·7 inches.

HAB. Trevandrum. Obtained by Mr. F. W. Bourdillon.

In the male of *P. Dravidarum*, there are visible upon the upper surface of the fore-wing a spot at the end of the cell, a sub-marginal row of conical or sub-lanceolate spots, and a marginal row of incisural spots; and upon that of the hind-wing a discal row of lanceolate spots, a sub-marginal series of lunules, and incisural spots as in the fore-wing.

In the male of the darker-coloured *P. Mahadeva*, the incisural spots of the fore-wing alone remain, but the hind-wing retains its three series of spots, which, however, are all smaller and apparently less clouded with dark scales than in the preceding species.

In the fuscous-black male of *P. Castor*, the fore-wing may be said to be uniform black, the incisural spots, which alone remain, being so reduced in size as to be barely visiblė, being, in fact, mere specks confined to the fringe; the hind-wing has lost all but the incisural specks (which are similarly confined to the fringe) and the first three or four spots of the discal series, which together form a large and conspicuous cream-coloured blotch divided by the veins: *P. Castor* may, in fact, be described as a rich dead-black insect with a conspicuous cream-coloured blotch near the outer angle of each hind-wing.

In *P. Castor*, then, the sexes are, as regards colour and markings, as strongly differentiated from one another as in any species with which I am acquainted; they also differ to some extent in form, the male having the fore-wing narrower, with the external margin obviously emarginate, and the hind-wing also narrower and produced, with the same margin more deeply incised and lobed than in the female, both pairs of whose wings in form more or less closely* resemble those of both sexes in the other two species.

In *P. Mahadeva*, the sexes are also tolerably well, though not so conspicuously, differentiated in point of colour and markings as in *P. Castor*, but not at all in form, the wings being of the same shape in both sexes.

In *P. Dravidarum*, the sexes agree perfectly both in form of wings and markings, differing very slightly in colour only; so that but little sexual differentiation has here taken place.

The female of *P. Dravidarum* is scarcely distinguishable, as far as one can tell from a description alone, from that of *P. Mahadeva*, the only differences that I can make out being that in the latter "the fore-wings have very small and less distinct sub-marginal white spots, and no spot at the end of the cell." From that of *P. Castor*, however, it is readily distinguished by having, as I have already pointed out, the discal markings of the hind-wing in the form of a transverse band of short lanceolate spots.

At the meeting of the Linnæan Society of London held on the 18th March last, a paper by Prof. Westwood, on a supposed polymorphic butterfly from India, was read. In this memoir the following conclusions are said (*vide* abstract in 'Nature' Vol. XXI, p. 531, April 1st, 1880) to have been arrived at by the author:—(1) "That *Papilio Castor* is the male of a species whose females have not yet been discovered; (2) that the typical *P. Pollux* are females of which the males with rounded hind-wings having a diffused row of markings has yet to be discovered; and (3) that the coloured figures given by the author represent the two sexes of a dimorphic form of the species."

* The females present an inconspicuous dimorphism, some having retained the primordial form of hind-wing, while others have the outer margin of this wing toothed as in the male (*vide infra*).

With regard to the last of these conclusions I cannot speak, because neither the paintings nor the specimens in question are accessible to me; but, having spoken above as if the opposite sex of *P. Castor* were perfectly well-known to naturalists, while, according to Prof. Westwood, it is still undiscovered, I ought perhaps to say a few words about the material on which my remarks are based.

Papilio Castor is restricted in its distribution to the slopes and valleys of the hill-ranges of North Eastern India and to the parts of the plains in immediate contiguity with them; its place being taken elsewhere, as in Southern India, by the new species described in the preceding pages, and, in Burmah, by *P. Mahadeva.* The Indian Museum possesses specimens from the Southern slopes of the Khasi Hills (Silhet), from the Sikkim Hills (Darjiling), Cherra Punji in the Khasi Hills, and the Naga Hills; and three males were taken by Lieut.-Col. Godwin-Austen during the Dafla Expedition; in these last, in a large male from Cherra Punji, and in two specimens of the same sex from the Naga Hills the upper surface is dark brown of a much lighter tint than in nine males recently received from Sikkim (2) and Silhet (7), which are all brown-black of so dark a shade as to appear quite black except when a strong light falls upon them when their colour appears brownish; in fact, the brown of the former is to that of the latter series of specimens what dark green is to the colour known as "invisible-green." In the large Cherra Punji specimen, the short tooth, or rudimentary tail, into which the third branch ($d.^3$, pl. ix, fig. 1) of the median vein of the hind-wing is usually produced, does not extend beyond the line of the other lobes of the outer margin, and one of the three dwarfed winter specimens* captured by Col. Austen approaches it in this respect; moreover, one of the Silhet specimens has this tooth smaller in one wing than in the other, so that this, like secondary sexual characters in general, is subject to variation. It is possibly to difference of station, but probably to long exposure to the vicissitudes of the Calcutta climate, and to the applications of benzine and other noxious substances to which they were subjected before I took over charge of the collection of Lepidoptera, that these brown specimens owe their lighter coloration. However this may be, it may confidently be asserted that it would be impossible for the most inveterate species-maker to discover any character by which to separate them as a distinct species or race from the fresh and consequently dark Sikkim and Silhet specimens. So much for the males.

Of the nine females in the collection referred by me to *P. Castor*, seven being perfect can readily be divided into two sets according to the form of the outer margin of the hind-wing—three (one from Assam, one

* The insect figured by Westwood (Arcana Entom. vol. ii, pl. 80, fig. 2) seems to have been a similarly dwarfed and faded individual.

from Cherra Punji,* and a large one from Silhet) having the third branch ($d.^3$, pl. viii, fig. 2) of the median vein not produced and the outer margin of the wing consequently 'rounder,' being, in fact, typical *P. Pollux*—and four (two from Silhet† and two from Sikkim‡) having that veinlet produced into a small tooth ($d.^3$, pl. ix, fig. 2) as in the male. I consider that these two different forms are both females of *P. Castor*, and that the slight differences they present are explained on the supposition, warranted by numerous analogous facts in nature, that the secondary sexual characters acquired by the male have been partially transmitted to some females but not to others (*P. Pollux*), which have retained the primordial rounded form of wing.

The fact that the discoidal markings of the hind-wing in the two Silhet females with toothed wings are lighter and more distinctly cream-coloured than in any of the females with rounded wings; that the malformed specimen from the same locality (which certainly belongs to the form with toothed hind-wings) has these markings in the fourth, fifth, and sixth interspaces, those, that is to say, corresponding to the ones forming the principal part of the blotch in the male, of almost as rich and pure a colour as in that sex; and that one of the two former has the spot at the end of the cell and the submarginal markings of both fore-wings obsolete and is thus still further approximated to the male; do certainly seem to me to tell rather for than against the above supposition.

The *Helenus*-group of Papilios, to which *Papilio Castor* and its allies

* There is another specimen from Cherra Punji, the largest of all in the collection, with the outer margins of its hind wings so ragged that it is impossible to be quite sure to which form it belongs, though, from its close agreement in other respects with Westwood's figure in the 'Arcana' as well as with the other insect from the same locality, I should say it is a typical *P Pollux*.

† There is a third specimen from Silhet in the collection, taken at the same time and place as the other two, but it unfortunately has the hind-wings symmetrically malformed at their outer margins, the third lobule on each side being short and angulated and the fourth being somewhat longer than usual and also angulated. This malformation is interesting as showing in the same specimen the instability of this character, the strong tendency to the assumption of the male form of wing exhibited in the lengthening of the lobule next in order, and the unmistakable 'reversion' to the rounded form of wing in the suppression of the rudimentary tail.

It should be mentioned that a gynandromorphous example of the form of female described by Prof. Westwood as *P. Pollux* has been figured and described as *P. Castor* by G. Semper in Wien. Entom. Monatschr. 1863, Band vii, p. 281, Taf. 19. In this specimen both the wings of the left side are truly female, but on the opposite side the posterior portion of the fore-wing from the first discoidal veinlet to the inner margin on the upper side only, and the anterior portion of the hind-wing from the costal margin to the second branch of the sub-costal on both sides, exhibit the masculine livery not unmingled with female characters (*Conf.* Westwood in Thes Ent. Oxon. p. 187).

‡ The two Sikkim specimens have the tooth less developed and the discal markings of the hind-wings exactly like those of the other form (*P. Pollux*).

unquestionably belong, taken as a whole, presents us with a remarkable series of gradations in the amount of difference between the sexes, comprising as it does: one species (*P. Dravidarum*) in which the sexes closely resemble one another in the form of the wings and in colour and markings, and there is only an incipient sexual differentiation: another (*P. Mahadeva*) in which, while agreeing in structure, they differ to a considerable extent in markings and colour, and the secondary sexual characters of the male are much more pronounced: another (*P. Castor*) in which they differ from one another to such a remarkable extent that no lesser an authority than Prof. Westwood originally described them under different names and still maintains their distinctness, and Mr. Wallace* placed them in different groups of the genus; the male having acquired the most pronounced secondary sexual characters (including rudimentary tails), which have been partially transmitted to some females but not to others; and the two forms of female having retained, one of them the form of wings, and both the general style of colouring, characteristic of both sexes in the first-named species: and, finally, others (*P. Helenus*, *P. Chaon*, etc.) in which the male has perfectly transmitted to the opposite sex all the secondary sexual characters (including the long tails) that he had acquired, the female only differing from him in such trifling points as the lighter coloration of the outer half of both wings and the dingier shade of her upper surface generally.

From these and other facts, we are, I think, entitled to infer the probable descent of all the members of this group from an ancestor with tailless, rounded wings in both sexes, closely resembling *P. Dravidarum*, but with diffused discal markings in the hind-wings and probably also in the fore-wings; the conspicuous wing-blotches of *P. Helenus*, *P. Castor*, etc., having apparently resulted from the concentration, so to speak, of such diffused colouring in the direction of the breadth of the wing, just as have the discal bands of short spots in *P. Dravidarum* and *P. Mahadeva* from a similar process of modification in the opposite direction.

If his conclusions are correctly reported, Prof. Westwood's drawings must represent a species different from either of those alluded to herein, and I look forward with much interest to the appearance of his paper.

Explanation of the Plates.

Plate VIII.

Fig. 1. *Papilio Dravidarum*, W.-M., ♂.
Fig. 2. *Papilio Castor*, Westw. ♀ 2nd Form (*P. Pollux*, Westw.), from Silhet.

Plate IX.

Fig. 1. *Papilio Castor*, Westw. ♂, from Silhet.
Fig. 2. —— —— ♀ 1st Form, from Silhet.

d.[3] = third branch of the median vein.

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* In his well-known memoir 'On the Phenomena of Variation and Geographical Distribution as illustrated by the *Papilionidæ* of the Malayan Region' in Trans. Linn. Soc. Lond., vol. xxv, pp. 33, 34.

XIV.—*Description of the Female of* Hebomoia Roepstorffii. *By* J. Wood-Mason.

(Received October 27;—Read November 3rd, 1880.)

Hebomoia Roepstorffii.

H. Roepstorffii, Wood-Mason, antea, p. 134, ♂.

♀. Upperside. *Fore-wing* with the orange patch devoid of amethystine gloss, externally more broadly bordered with fuscous (which at each veinlet gives off inwards an angular process the extremity of which is continued on as a very narrow edging to each side of the veinlet), but internally much less distinctly so than in the male; with the cell more clouded with dark scales; and with the sulphur-colour at the inner angle more diffused. *Hind-wing* with a marginal row of large subtriangular fuscous spots placed upon the veinlets from the first subcostal to the first median (the two last obsolete), decreasing from the second in the direction of the anal angle, and connected together at the extreme margin of the wing by a narrow edging of the same colour, which extends to the anal angle; with a submarginal series of six roundish spots, similarly decreasing from the first, and alternating with those of the marginal series, each being placed upon a fold, the first and largest on the fold between the costa and the first branch of the subcostal, and the last on that between the first and second median veinlets; and with the sulphur-colour around the four intermediate submarginal spots stained with orange. Underside of *both wings* paler.

Length of fore-wing 1·7; whence expanse = 3·5 inches.

Hab. South Andaman.

Described from a specimen in the collection of Captain G. F. L. Marshall, R. E., who courteously offered me the loan of the insect for description as soon as he had seen the description of the male published in the last number of this Journal.

In Captain Marshall's specimen of the male the submarginal spots of the fore-wing are obsolete.

XV.—*Notes on and Drawings of the Animals of various Indian Land Mollusca* (Pulmonifera).—*By* Lieut.-Col. H. H. Godwin-Austen, F. R. S., F. Z. S., &c.

(Received July 15th;—Read Nov. 3rd, 1880.)

(With Plates X and XI.)

Previous to his appointment to the Yarkand Mission, Dr. F. Stoliczka had been working for some years at the animals of the Indian land Mollusca, and had enriched this Journal with many valuable papers. Among the numerous MSS. he left behind him in Calcutta, there were found, after his death, some very excellent drawings that had been made under his superintendance from the living animals; they had been drawn on scattered sheets of paper, and remarks on the colour and other characters of the soft parts had been made in pencil on the margins, which were fast becoming illegible. I, therefore, with the concurrence of Dr. J. Anderson, pasted these interesting drawings into a scrap-book* and copied into it, as well as I was able to decipher them, the names, localities, and remarks noted.

As it may be some years before many of these species are obtained again by any naturalist with the means or talent to correctly draw them, I have thought that lithographed copies published in this Journal would not only be preserving, but in a measure carrying out the work of so good an observer, and would be of use to those in India who are interested in the land-shells of the country. There is an immense amount of work to be done in this particular branch of Natural History. We know as yet very little of the relationship of the many species, especially among the *Zonitidæ* (Semper); the anatomy of most of them has never been examined, and, until this is done, or at least more careful descriptions and sketches of the outward form of the animals are made, our attempts at a satisfactory classification must fail.

I have to each species figured given Stoliczka's remarks and identifications in full, and added a few notes extracted from my field-book wherever I could do so, and I also distinguish a few identifications by Messrs. W. T. Blanford and Geoffrey Nevill.

The plates that will be given contain species of the family *Zonitidæ* variously assigned to the genera *Ariophanta*, *Hemiplecta*,† *Rhysota*, *Xesta*, and *Rotula*; and one plate has been required for the *Helicidæ* of such very different genera as *Plectopylis*, *Fruticicola*, &c; those of the genus *Macrochlamys*, I have also copied, but as I am engaged on a paper treating of this group more in detail, which I propose to send to the Zoological Society of London, the plate will I hope appear in the Journal of that Society.

* In the Library of the Indian Museum, Calcutta.

† *Oxytes.*

Genus ARIOPHANTA, Des Moulins.

Bull. Soc. Bord. III, p. 227, (Nov. 1829).

With plate giving three figures of shell and two of the animal from life; type *lævipes*, Müller, Bombay.

The description by Albers (Die Heliceen, p. 62, 1860) is as follows: "Testa sinistrorsa, umbilicata, tenuis, diaphana; anfractus ultimus angulatus vel carinatus; apertura obliqua, lunaris, peristoma simplex, acutum, margine columellari reflexo"; in the sub-genus, thus defined by shell alone, this writer places the following species:—

himalayana, Lea = **interrupta,** Bs. Bengal.
lævipes, Müll. Bombay.
retrorsa, Gould (*Hemiplecta*, Sect. E of Theobald) Tavoy.
janus, Chem. Malacca.
rumphii, v. d. Busch. Java.

Adams adds to these:—

ryssolemma, Albers (? *Thyreus*, Bs.) Java?
trifasciata, Chemn, = *lævipes*, var. Malabar.

and he figures *lævipes*, quoting M. E. Gray, Fig. Moll. Anim. pl. 288, fig. 7, which is a trace of Des Moulins' original drawing (l. c.).

Mr. Geoffrey Nevill, in his Hand-List of Shells in the Indian Museum Calcutta, adds to the above:—

laidlayana, Bs. Lower Bengal.
kadapaensis, Nevill, Madras.

= *nicobarica*, Chemn. re-named, as it is not found in the Nicobar Islands.

cysis, Bs. Nilgiris.
thyreus, Bs. Nilgiris.
intumescens, W. T. Blf. Bombay.
immerita, W. T. Blf. (in coll. Beddome) South Canara.

near *interrupta*.

cambojensis, Reeve Siam.
regalis, Bs. Borneo.

= *vittata*, Adams and Reeve, (*vide* Adams. Gen. Moll. pl. lxxix, fig. 5, as *Nanina*).

bajadera, Pfr. = *ammonia*, Valenciennes Bombay.

Mr. William Theobald (Cat. Land and Freshwater Shells of Brit. India) includes—

auris, Pfr. (? *cysis*, Bs.) Kundah Hills, Madras.
cyclotrema, Bs. Sumeysar Hills, North of Tirhoot.

a true *Helix* belonging to the *delibrata*-group.

foveola for *foveata*, Pfr. Java.

Mr. Edgar Smith agrees with me, on a comparison of the species in the British Museum, that this is *rumphi*, Mus. Cuming.

saccata, Pfr. Tavoy.

and this is only the young of *retrorsa*, Mus. Cum.

Dr. C. Semper (Reis. Arch. Philip. p. 50, 1870), on the character of the horn above the tail-gland and foot, places one sinistral species (*rumphi*, v. d. Busch.) and the following dextral shells in the sub-genus:—

martini, Pfr. Sumatra.
nemorensis, Müll.
javanica, Lamark Java.
rareguttata, Mouss. (*Xesta*) Adenare, near Timor.
striata, Gray (*Nanina*) Singapur.
atrofusca, Albers. Singapur.

It is very unlikely that these last six species from the islands of the Malay Archipelago have any very close relationship to the typical sinistral Bombay species *lævipes*, although the tail-gland does assimilate, and it would be better to keep them, as well as all the other species from the same region, separate for the present, as nothing is yet known of the anatomy of the Indian species. Only those purely Indian forms which I distinguish by antique type can be with certainty placed in this sub-genus.

Pfeiffer has also, besides typical forms and others (Zeits. 1855):—
ammonia, Valenciennes, (sp. in Brit. Mus.) Habitat ?
regalis, Bs., (I do not consider should be included.) Borneo.
sannio, Pfr. Habitat ?
ampullarioides, Reeve (Mus. Taylor = *cysis*.) Nilgiris.
linstedti, Pfr. (Mus. Cum.) Malacca.

is closely allied to *rumphi*, but it is sharper keeled, and, if the latter should prove a true *Ariophanta*, it should also be included.

Des Moulins founded his genus on the animal of a specimen which had been sent to him alive from the island of Elephanta, Bombay, by M. Théophile Laterrade in March 1829. The mollusk lived some short time and two drawings of it were made. Previous to this the shell only had been described by Müller.

To M. Des Moulins, therefore, belongs all the credit of first noticing and distinguishing the very distinct and large group of Asiatic Helices possessing a mucous pore at the extremity of the foot, and for which group so characterized he proposed the title PHEREPORÆ, placing the Bombay shell in his sub-genus *Ariophanta*.

Dr. J. E. Gray four years afterwards, on the similar characters of another but very distinct species, created the genus *Nanina*, for Asiatic

Helices of this type, and his genus was adopted by Adams and others, although Thos. Hutton first, and Benson afterwards, had pointed out the distinction in the sub-genus *Macrochlamys;* I do not, therefore, see how in fairness and by all rules of nomenclature Mr. Gray's title can be adopted, as it has been, for the whole group (Indian and Malayan) of these Eastern Helices provided with a mucous pore which Des Moulins described so well and so accurately; the latter saw at once the important differences such an organ implied in the general anatomy of the animal and understood its great value in classification, and he shewed also its affinity in this respect to *Arion* by the title he gave it (*vide*, pp. 230, 235, where he gives in full the description of the animal, his remarks on which are well worthy of perusal).

H. (Ariophanta) lævipes, Müll., var. trifasciata, Chemn. Pl. X, Fig. 3, 3*a*.

H. lævipes, Müller, Hist. Verm. 2, p. 22, no. 222.
" —— Gmelin, Syst. Nat. p. 3616, no. 13.
" —— Chemnitz, Conch. 9, t. 108, fig. 915, 916.
" —— sub-genus, *Hélicelle*, 2me group Aplostomes, 3me Sect. rubannées.
" —— Férussac, Hist. Moll. pl. xcii, fig. 3 à 6.
" —— Férussac, Tabl. Syst. p. 41, no. 229.

Sub-genus *Ariophanta*, Des Moulins, var. *a*. all white, without bands, from Island of Elephanta; var. *b*, *c*. banded, from the same locality (only this banded var. *trifasciata* figured in the Conch. Ind. pl. cxxxi, fig. 4.)

The figures are taken from No. 57*a* and 57*b* of the MSS. drawings representing specimens from Bombay.

Ariophanta interrupta, Bs., Pl. X, Fig. 1, 1*a*.

Helix interrupta, Bs. Zool. Jour. Vol. V, p. 461, (1834), from Sikrigalli and on the Jellinghy river (tributary of the Ganges).
= *Himalayana*, Lea.

These figures have been reproduced from No. 44 in MSS. in Ind. Mus. Library; the specimens from which the original drawings were made were obtained in the Botanical Gardens, Calcutta.

Benson's description of this last in above Journal applies to *H. lævipes*, but in his description of the animal, he says the excrements are "voided from an opening in the terminal and posterior part of the foot instead of from the *foramen commune*" he must here evidently be mistaking the mucous gland for the anal orifice, although on the previous page (460), describing the genus Nanina, he shews that they are distinct openings.

H. —— Conch. Ind. Hanley, fig. 3, plate xxvii. Specimens from Faqirabunda, Jessore District, are thus described in my note-book—"The animal being of a pink colour the same tint is given to the shell, while black mottlings shew through the body whorl. The head is dark-coloured up to a well defined black line (extending from posterior part of the neck to below the oral tentacles), thence light-coloured with a pink tinge, which is more intense near the extremity of the foot. The mucous gland has the form of a long slit with a very small lobe above."

Helix (Ariophanta) laidlayana, Bs., Pl. X, Fig. 2.

Ann. Nat. Hist. Ser. 2, Vol. 18, (1856) p. 253.

The figure is a copy of fig. 30 of MSS. drawing of a specimen from Manbhum.

Helix laidlayana, Bs. Hanley, Conch. Ind. Pl. lviii, fig. 3, 4, 5: figure 4, from Cuttack would appear to be a different species from fig. 3, Orissa, which agrees with the original description, fig. 5.

H. (Ariophanta) intumescens, W. T. Blf. Pl. X, Fig. 4.

J. A. S. B. 1866, p. 33, type from Mahableshwar, Western Ghats of Hindustan.

The figure is from fig. 17 of MSS. drawings and bears the following remark "*N. Canarica* from Fairbank" [Stoliczka].

Mr. Blanford writing of the animal and comparing it with *bajadera* says—"The animals also shew a difference in colour, that of *intumescens* is uniformly, so far as I have seen, dark cinerous, while that of *bajadera* is much lighter, but very variable. The latter shell is found mostly on shrubs, the former on the ground, and while *intumescens* has as yet only been found at Mahableshwar 4,500 feet above the sea, *bajadera* (which is rare at Mahableshwar) abounds on the equally or nearly equally high hills of Singhur and Poorundhur, and along the summit of the Western Ghats at about 2000 feet. It abounds at Khandalla at the top of the Bore Ghat."

Genus HEMIPLECTA, Albers.

Die Heliceen, p. 60, (1850).

Founded on the shell alone; type *humpfreysiana*, Lea, from Singapur.

"Testa supra granulosa vel decussatim striata; subtus polita, anfractus ultimus plus minusve angulatus vel carinatus."

Albers gives for the distribution of the species of this group the large islands of the Malay Archipelago, Java and the Philippines, New Ireland, &c.; only one species *labiata* (= *monticola*, Hutton) being from India, and that not agreeing with the description, the last whorl being well rounded. The two characters given would embrace a vast number of species having a much wider geographical range, and I should be inclined to restrict it to the Malay region and not to include any of the Indian forms, until other characters in common can be found after examination of the animals.

To Albers' list, Adams added, it is difficult to say why, several other species, among them *ligulata*, *semirugata*, and *tranquebarica*, shells widely differing in their very globose form from the generic description. Semper does not follow Albers, but places many of the species under

Rhysota, on the character of the odontophore; these I have marked with an asterisk.

Albers refers the following species to *Hemiplecta* :—

**bulla*, Pfr. (*Rhysota*, Albers)	Luzon.
fulvida, Pfr.	Mindanao.
biamensis, Mouss.	Java.
halata, Mouss.	Java.
rufa, Less.	New Ireland.
xanthotricha, Pfr.	Guimares Is. and Negros.
**setigera*, Sow.	Luzon.
**gummata*, Sow.	Luzon.
theodori, Phil.	Mergui.
bataviana, v. d. Busch.	Java.
centralis, Mouss.	Java.
cuvieriana, Lea	Luzon.
novæ-hiberniæ, Quoy.	New Ireland.
humphreysiana, Sea	Singapur.
—— *var. gemina*, v. d. Busch.	Java.
? *labiata*, Pfr.	Landour.
semigranosa, Sow.	Phillippines.
panayensis, Brod.	Panay, do.
**semiglobosa*, Pfr.	Samar, do.

Adams gives some others, three of which are Indian :—

blainvilliana, Lea.	
conoidalis, Adams and Reeve	Mindoro.
densa, Adams and Reeve	Philippines.
? *ligulata*, Férus.	Bengal.
limaënsis, Mouss.	
lurida, Gould	Feejee.
rubricata, Gould	Feejee.
rufescens, Gratel.	Madagascar?
? *semirugata*, Beck.	Bengal.
steursii, Shuttl.	Amboina.
? *tranquebaricha*, Fabr.	India.
velutina, Sow. = *xanthotricha*, Pfr.	Philippines.

Theobald has included a large number of Indian species in this subgenus, with forms so varied he subdivided it into 5 sections; he does not give the characters, but notes the typical species in each (*vide* Suppl. Index, Conch. Indica).

Nevill in his Hand-List makes it much more circumscribed and admits

distincta, Pfr.	Saigon.
neptunus, Pfr.	Cambodia.

**cymatium*, Bs.	Penang.
sylvicola, W. Blf. MSS.	Naga Hills.
basileus, Bs.	Annamullys.
beddomei, Blf.	Travancore.
basilessa, Bs.	Annamullys.
? *undosa*, W. Blf.	Mandalay.
chenui, Pfr.	Ceylon.
†*oxytes*, Bs.	Khasi Hills.
†*cycloplax*, Bs.	Do.
? †*castor*, Theobald	Do.
? †*pollux*, Theobald	Do.
? †*blanfordi*, Theobald	Darjiling.
orobia, Bs.	Do.

Genus OXYTES, Pfeiffer.

Zeits. 1855, p. 188 [Without description.]

1. *Nanina oxytes*, Bs. (type.)

2. *thyreus*, Bs.

is a true *Ariophanta*.

3. *avus*, Pfr. ?

sinistral and it is difficult to understand on what grounds it is placed here.

4. *pallasiana*, Pfr. ?

This sub-genus would be the same as *Hemiplecta* (Sec. D) of Theobald (l. c. p. 22): who places therein :—

basilessa, Bs. Travancore.

this should not be included. I do not recognize any resemblance even in form of the shell.

blanfordi, Theob.	Darjiling.
castor, Theob.	Khasi.
—— var. *a. cherraensis*, W. Blf.	Do.
cycloplax, Bs.	Darjiling.
oxytes, Bs.	Khasi.
pollux, Theob.	Khasi.

HEMIPLECTA OROBIA, Bs., Pl. XI, Figs. 1 and 1*a*.

No locality given.

HELIX (HEMIPLECTA ?) LIGULATA, Fér., Pl. XI, Fig. 3.

No locality given.

Vide Nevill's Hand-List (1878), p. 50, No. 284, as *Xesta ?* his notes on the animal are taken from this drawing. Madras ranging to Bhagulpur and Patna. (H. H. G.-A.)

* Placed in *Rhysota* by Stoliczka, J. A. S. B. 1878, p. 11.

† Sub-genus *Oxytes*, Pfr. (see further on) forms a very recognizable group.

Helix (Oxytes) oxytes, Benson, Pl. XI, Fig. 2.

"No projection above the gland which is rather small; sole broadly margined, and with a double line," (W. T. B.) Nevill's Hand-List (1878) p. 47, No. 261.

I would call attention in this drawing to the close contiguity of the base of the eye-tentacles.

Helix (Oxytes) pollux?, Theobald, Pl. XI, Fig. 4.

"Cherra Poonjee from Godwin-Austen" [Stoliczka].

"Animal of a pale light yellowish ochre. Head rather darker, eye pedicels long and rather thick at the base. Extremity of foot and under part of it very pale, short, flat and rounded, the mucous gland has a very small lobe above it.

"I found this shell very abundant on the limestone in the forest below Nongkulang in the West Khasi Hills, and it ranges westward to the Garo Hills following the band of the Nummulitic rocks. The very peculiar thick shape and drooping form of the tentacles is to be noted in the drawing, their bases adjacent as in *H. oxytes.*" (H. H. G.-A.)

"A small lobe above the mucous pore; margins of mantle not produced over the edge of the shell, sole of foot narrowly margined." (W. T. B.) Nevill's Hand-List, p. 48, No. 264.

Explanation of the Plates.

Plate X.

Fig. 1, 1a. *Helix* (*Ariophanta*) *interrupta*, Bs.
Fig. 2. —— —— *laidlayana*, Bs.
Fig. 3. —— —— *lævipes*, Müller, var. *trifasciata.*
Fig. 4. —— —— *intumescens*, W. T. Blf.

Plate XI.

Fig. 1, 1a. *Hemiplecta orobia*, Benson.
Fig. 2. *Helix* (*Oxytes*) *oxytes*, Benson.
Fig. 8. *Helix* (*Hemiplecta ?*) *ligulata*, Fér.
Fig. 4. *Helix* (*Oxytes*) *pollux ?*, Theob.

XVI.—*New Species of Brackish-water Mollusks.*

By Geoffrey Nevill, C. M. Z. S.

(Received November 1st;—Read December 1880.)

Subfamily BYTHINIINÆ, Troschel [emend.].

Gebiss der Schnecken, I, 1857, as Group "Bythiniae"; emend. Stimpson, 1865, and Clessin, Malak. Blät. 1880, as subfamily of the Rissoidæ.

Stenothyra woodmasoniana, n. sp.

T. parva, imperforata, ovato-acuta, solida, crassa, pallide viridula, polita, nitida, (sub lente) obsolete submalleata; spira aculeiformis, subconcava, producta, apice peracutissimo; anfr. 6, *haud convexi, ultimus pertumidus, medio subangulatus, basi applanatus, antice ad aperturam abrupte et valide deflectus; apertura percontracta, perfecte rotundata, marginibus continuis, valide incrassatis.*

Long. $3\frac{1}{8}$, diam. vix 2 mill.

Hab. Port Canning.

This interesting form is easily recognized by the very acute and concavely-excavated spire, the subangulate last whorl, flattened round the umbilical region; it is not spirally pitted, as in most species of the genus, but appears obsoletely malleated or indented under a powerful lens.

This is one of Mr. Wood-Mason's interesting discoveries from the still imperfectly explored brackish-water Sunderbunds (embouchure of the rivers Hooghly, &c.).

Type Indian Museum, Calcutta; also in coll. Dohrn, Beddome, Theobald, Blanford, and Hungerford.

Stenothyra hungerfordiana, n. sp.

T. parva, imperforata, ovato-elongata, solidiuscula, viridula, vix nitida, (sub lente) lineis impressis ac dense puncticulatis confertim cingulata; spira paululum elongata, ovato-convexa, apice obtuso, sutura profunda ac obsoleta marginata; anfr. 4, *convexi, ultimus compresse ovuliformis, antice subapplanatus, valde descendens; apertura perpusilla, suboblique rotundato-ovata, superne leviter angulata, sulco profundiori ab anfractu ventrali separata, peristomate obtuso.*

Long. $2\frac{1}{2}$, diam. $1\frac{1}{8}$ mill.

Hab. Andaman Islands.

This is one of the most distinct and interesting species of the genus as yet discovered: the few imperforate whorls, with markedly obtuse apex; the distinct, though minute, close punctulation; the unusually convex whorls, with the remarkable long, compressed, slightly flattened, and egg-shaped last whorl are all good characters. The suture is very distinct and, on the last whorl, distinctly marginate below. The operculum is normal.

Type Indian Museum, Calcutta; also in coll. Dohrn, Warneford, Theobald, Blanford, and Hungerford.

STENOTHYRA BLANFORDIANA, n. sp.

T. minima, superficie rimata, subventricoso-ovata, vix solidiuscula, nitida, laevis, pallide cornea, subpellucida; spira subacuta, apice minuto, subobtuso; anfr. 4½, *convexi, ultimus magnus, subsolutus, tumide-ventricosus, subbiangulatus, antice subapplanatus; apertura subovalis, paululum postice retrorsa, peristomate continuo, superne angulato. Operculum ovale, superne leviter acuminatum, vix crassiusculum, subtranslucidum, spirale, apice subcentrali, interne testaceo-costatum.*

Long. $3\frac{1}{10}$, diam. $2\frac{1}{10}$ mill.

HAB. Chilka-lake (type); also Port Canning and Madras.

I am indebted to Mr. Wood-Mason for a careful examination of the operculum of this small form: "it is oval, subtransparent, spiral, of few whorls, with the apex almost central, on the inner side three ridges, one semicircular and two short ones with a slight S-curvature, for the attachment of the animal."

The species is somewhat variable, especially as regards size and the greater or less distinctness of the angulation of the last whorl. Specimens from Port Canning agree better with the above-described typical form than do those from Madras.

I have named this species in honour of its first discoverer, Mr. H. F. Blanford. It appears to be abundant at Port Canning, Chilka Lake, and Town of Madras; living with it there occurs another form, nearer *St. minima*, Sow. (but I think distinct), with more produced spire than *St. blanfordiana*, less tumid last whorl, without any trace of biangulation, with the aperture rounder, and not angled above; there is yet another still smaller decollate form from Port Canning, probably also a distinct species.

Type Indian Museum, Calcutta; also in coll. Hungerford, Theobald, Beddome, Blanford, and Dohrn.

Subfamily HYDROBIINÆ, *Troschel* [emend.].

Gebiss der Schnecken, I, 1857, as Group "Hydrobiae"; emend. Stimpson, 1865.

HYDROBIA (BELGRANDIA) MILIACEA, n. sp.

T. minuta, vix rimata, conico-elongatula, solida, parum nitida, albido-viridula, lævigata; spira paululum producta, apice minuto, acutiusculo; anfr. 5, *convexiusculi, ultimis duobus rapide accrescentibus, ultimo basi subplanulato, ad aperturam gibbositate crassa circumscripto; apertura ovato-rotundata, intus incrassata, peristoma continuum, valide incrassatum, margine externo arcuato, basi sinuato, margine columellari subangulatim contorto, subreflexo. Operculum sat profunde immersum, tenue, pellucidum, vitreum.*

Long. vix 2¾, diam. 1¾ mill.

HAB. Port Canning.

Var. *minor*; long. 2, diam. 1¼ mill.

HAB. Port Canning.

Found in great abundance in brackish-water ponds, associated with *Valvata (?) microscopica*, Nev., new species of *Bythinia, Martesia, Teredo (?), Pharella, Theora, Stenothyra blanfordiana*, &c. From the last-named, the remarkable callosity behind the outer lip, besides many other characters above recorded, at once distinguishes it.

This interesting shell is the first extra European species described of the genus (?) *Belgrandia*, Bourg.

Type Indian Museum, Calcutta; also in coll. Beddome, Theobald, Hungerford, Joly, Dohrn, and Blanford.

Subfamily ASSIMINEINÆ, [emend.].

Group Lithoglyphi, Troschel, Gebiss der Schnecken, I, 1857 [pars].
Fam. Assiminidae, H. and A. Adams, Genera Moll. 1858.
Fam. Assimineidae, Clessin, 1880.
Section of sub-fam. Pomatiopsinae, Stoliczka, Gast. I, 1868.

ASSIMINEA SINENSIS, n. sp.

T. imperforata, ovato-conica, solidula, nitida, subglabra, castaneo-fusca, linea impressa infra suturam subobsolete notata; spira producta, conica, apice subacuto; anfr. 7½, *subplaniusculi, ultimus compressus, vix convexiusculus, carina nulla munitus; apertura parva, subverticalis, marginibus callo subobsolete junctis, margine externo tenui, margine columellari arcuato, incrassato, saturate castaneo-fusco, inferne subangulato.*

Long. 5, diam. 3 mill.

HAB. Hongkong.

I am indebted for this, as for many other novelties, to Surgeon-Major R. Hungerford.

Type Indian Museum, Calcutta; also in coll. Hungerford.

ASSIMINEA PEASEANA, H. Nevill, MSS.

T. peranguste perforata, ovato-conica, notabiliter tenuis, glabra, nitida, vivide straminea, ad suturam fascia livida (plus minusve subobsolete) marginata; spira convexo-conica, producta, apice acuto; anfr. 7, convexiusculi, ultimus rotundatus, inferne convexus, circa perforationem haud carinatus; peristoma perregulariter rotundatum, ad basim haud angulatum; margo columellaris late dilatatus, subduplex, castaneo vivide tinctus; apertura subrotundata, marginibus callo subobsolete castaneo junctis.

Long. 5¾, diam. 3½ mil.

HAB. Lake Negombo, Ceylon.

Named in manuscript by my brother, in honour of the late Harper Pease of Honolulu; it is a very distinct species, easily distinguished from *Ass. subconica*, *Ass. marginata*, &c., by its thin texture, peculiar coloration, absence of any trace of sculpture, rounded margins of the aperture, &c. Specimens of rather larger size than that of which the measurements are above recorded occasionally occur.

Type Indian Museum, Calcutta; also in coll. H. Nevill and H. Dohrn.

ASSIMINEA BIFASCIATA, n. sp.

T. imperforata, ovato-conica, solida, vix glabriuscula, subnitida, sordide viridula, fasciis binis fuscis et subobsoletis cincta; spira moderate producta, convexo-conica, apice subacuto; anfr. 6½, convexiusculi, ultimus tumide ventricosus, ad peripheriam subangulatus; apertura ampla, subverticalis, marginibus callo pervalido fusco-limbato junctis, margine columellari fere recto, valide incrassato, sordide fusco, inferne subrotundato.

Long. 5½, diam. 3½ mill.

HAB. Brackish-water lagoon, Port Natal.

A common species, quite distinct from the three forms described by Krauss.

Type Indian Museum, Calcutta.

ASSIMINEA DOHRNIANA, n. sp.

T. parva, solidiuscula, ovata, fusco-viridescens, anguste umbilicata, laevigata, sutura lineari, haud marginata; spira curta, apice perobtuso; anfr. 4, rotundato-convexi ac tumidi, ultimus inflatus, subtus convexus, basi prope regionem umbilicalem subexcavate depressus; apertura subverticalis, ovato-pyriformis, dimidiam totius longitudinis aequans, intus pallide *viridescens ; margo columellaris superne valide intortus, reflexus, inconspicue fulvo tinctus, inferne vix rotundatus.*

Long. 3, diam. 2½ mill.

HAB. Hongkong.

The short spire, with obtuse apex, the depression of the last whorl round the narrow umbilicus, the bent columella, and the thick somewhat eroded texture, of a greenish colour unusual in the genus, are the best characteristics of this small species, for which I am indebted to my friend Surgeon-Major R. Hungerford; I have named it after my esteemed correspondent Dr. Henry Dohrn of Stettin.

Type Indian Museum, Calcutta; also in coll. Dohrn and Hungerford.

ASSIMINEA WOODMASONIANA, n. sp.

T. imperforata (vel ad regionem umbilicalem mintissime perforata), carina parva ac subobsoleta circumscripta, lanceolata, conica, solidiuscula, nitida, subglabra, dilecte castanea, prope suturam pallide rubido fasciata ac linea impressa marginata ; spira conico-elongata, anfractum ultimum fere aequans, apice perminuto, acutissimo ; anfr. 7½, *vix convexiusculi, regulariter crescentes, ultimus subcompressus, obscure subangulatus ; apertura parva, subverticalis, ovata, marginibus callo tenui junctis, margine columellari pallide castaneo, paululum incrassato, subrecto, inferne subangulato.*

Long. 4, diam. 2⅕ mill.

HAB. Port Canning, near Calcutta.

I have named this pretty and very distinct species after my friend Mr. J. Wood-Mason, to whose very successful researches in the Sunderbunds the Museum is indebted for so many interesting mollusks, as I have already pointed out in my Catalogue, Fasc. E. p. 22, when describing the operculum of *Larina burmana*. The small, almost obsolete, keel round the very minute perforation (which is sometimes completely covered) is very characteristic.

Mr. Wood-Mason has favoured me with the following extract from his note-book on the animal of this species—"Eyes large, intensely black, situated on the upper side and near the extremity of the peduncle; animal transparent, above very slightly greyish, between the tentacles reddish, which are so transparent that the eye-spots can be seen very nearly as well from the under side."

Type Indian Museum, Calcutta; also in coll. Beddome, Hungerford, Blanford, Dohrn, Theobald, and Joly.

ASSIMINEA BEDDOMEANA, n. sp.

T. depresso-turbinata, quoad formam species generis Colloniæ *quodammodo memorans, peculiariter obscure sed profunde umbilicata, de-*

presso-conoidea, solida, crassiuscula, nitida, subglabra, ad basim (sub lente) striis incrementi subobsoletis munita, saturatissime fulvo-livida, infra suturam albo fasciata, fascia prope aperturam plus minusve evanescente; sutura vix distincta, linea obscure impressa et subobsoleta notata; spira obtuse depresso-conoidea, apice minutissimo; anfr. 5, *ultimus subtus perglobose ventricosus, ad peripheriam obsolete subsubangulatus, infra subplanulatus, circa umbilicum callo lato pallide fusco et obscure albo-limbato munitus; apertura ampla, subrotundata, intus incrassata, marginibus callo albido prope aperturam valido ac distincto (interdum subobsoleto) junctis; columella pernotabiliter et valide incrassata, inferne abrupte retrorsa, triangulari-linguiformis, applanata ac excavate rugosa, superne in umbilicum abrupte desinens. Operculum tenue ac corneum; anfr.* 3 *(sub lente vix distinguendi) in umbonem subcentralem ac prominentem desinentes.*

Alt. 3, diam. $3\frac{1}{5}$ mill.

HAB. Port Canning.

The most remarkable and abnormal species of the genus as yet described. The animal is that of a typical *Assiminea*, both the late Dr. Stoliczka and myself having examined numerous specimens. The Museum is indebted for its extensive series of this and the following species to Mr. Wood-Mason.

Type Indian Museum, Calcutta; also in coll. Dohrn, Hungerford, Blanford, Theobald, Joly, and Beddome.

ASSIMINEA THEOBALDIANA, n. sp.

T. parva, anguste umbilicata, ovato-conica, solidiuscula, vix nitida, corneo-fulvida, sub lente spiraliter minutissime confertimque sulcata, striis incrementi plus minusve obsolete decussata; spira conica, vix producta, apice acuto; anfr. $6\frac{1}{2}$, *convexi, supremi sublaeves, caeteri infra suturam distincte angulati, superne sublaeves, inferne spiraliter confertimque sulcati, oblique subgranulatim decussati, ultimus globose subrotundatus, in medio striis decussantibus plus minusve subobsoletis, prope umbilicum distinctioribus, notatus; apertura sat ampla, subverticalis, marginibus callo nitido junctis, margine columellari supra leviter contorto, infra rotundato.*

Long. $4\frac{1}{3}$, diam. 3 mill.

HAB. Port Canning.

In old specimens, the last two or three whorls have a pitted appearance, as in many species of *Stenothyra*; in younger ones, the two antepenultimate whorls have a beautiful granulose appearance under the lens. The oblique and decussating striae are always obsolete on the last whorl, except near the umbilicus and in the interstices of the spiral sulcations; the narrow smooth ledge below the suture, on the last two or three whorls, formed by an abrupt cessation of the sculpture, is very peculiar and characteristic. I need scarcely say that I have named this remarkable species after my friend Mr. William Theobald of the Geological Survey of India.

Type Indian Museum, Calcutta; also in coll. Theobald, Hungerford, Beddome, Blanford, Dohrn, and Joly.

Assiminea microsculpta, n. sp.

T. parva, vix perforata, cylindrico-conica, solidiuscula, vix nitida, fulvo-cinerea, spiraliter distincte sulcata, striis longitudinalibus obliquis ac flexuosis decussata, apice acuto; anfr. 5½, *gradato-cylindrici, supremi laeves,* 2*dus spiraliter sulcatus,* 3*tuis et* 4*tus insigne equaliterque decussati (quasi gemmulati), ultimus subbiangulatus, supra peripheriam angulatus, striis decussantibus paululum subobsoletis notatus, sculptura infra evanescente; apertura subverticalis, parva, marginibus callo indistincto junctis, margine columellari haud contorto, leviter rotundato.*

Long. 2¾, diam. 1¾ mill.

Hab. Port Canning.

Type Indian Museum, Calcutta; also in coll. Dohrn, Joly, Hungerford, Theobald, Blanford, and Beddome.

It presents some resemblance to the preceding species in the sculpture, which in *Ass. microsculpta*, however, is much more strongly developed, the difference in young specimens being especially marked. The shape is quite different, the whorls being cylindrically-gradated, instead of convexly-swollen, &c.

Assiminea hungerfordiana, n. sp.

T. imperforata, ovato-conica, solida, nitida, glabra, polita, omnino laete castanea, sutura subindistincta; spira brevis, apice vix acuto; anfr. 6, *subtumide convexiusculi, ultimus magnus, regulariter ovuliformis, infra suturam linea impressa subobsolete notatus; apertura verticalis, marginibus callo castaneo junctis, margine externo tenui, margine columellari incrassato, recto, paululum retrorso, ad basim subabrupte angulato.*

Long. 4, diam. 2½ mill.

Hab. Mouth of the Rangoon River.

I have much pleasure in naming this beautiful and very distinct species after its discoverer, Surgeon-Major R. Hungerford, who has lately been most successful in collecting and dredging Mollusca both at Hongkong and the Philippine Islands. The rich chocolate, or chesnut, colour of the species is very characteristic; there is a slight tendency on the upper portions of the whorls to be of a darker and duller shade; the indistinct suture, short but produced spire, large and regularly egg-shaped last whorl, straight and slightly twisted columella, forming an angle at its base, are all well-marked characters. Under a very powerful lens, striæ of growth are discernible, which become more developed behind the outer lip.

Type Indian Museum, Calcutta; also in coll. Hungerford.

ASSIMINEA TEMPLEANA, n. sp.

T. imperforata, ovato-conica, persolida, crassa, nitida, laevis, fusco-cornea, sutura distincta, haud marginata; spira conica breviter producta, apice acuto; anfr. 5½, *convexiusculi, rapide crescentes, ultimus magnus, tumide ventricosus, ad peripheriam subangulatus, basi subapplanatus; apertura sat magna, marginibus callo acuto valido et albo junctis, margine externo regulariter convexo-rotundato, columellari subrotundato, duplice ac valide reflexo, regionem umbilicalem tegente, supra distincte transversimque unisulcato.*

Long. 3¾, diam. 2½ mill.

HAB. Nicobar Islands.

I have named this interesting small species after Lieutenant R. C. Temple, who has presented the Museum with many valuable shells from the Andamans, Ferozepore, and other places. It is eminently characterized by the remarkable callously-reflected, duplex columella, transversely notched or sulcated above.

XVII.—*On some Experiments instituted to supply* all *the Lines terminating at the Calcutta Telegraph Office with Currents tapped from the Main-Current produced by a Dynamo-electric Machine.** —*By* Louis Schwendler, M. Inst. C. E.

Introduction.—On the 5th November 1879, I had the honour to read a short paper before this Society entitled,† "On a simple Method of using an insignificant Fraction of the Main-Current produced by a Dynamo-Electric Machine for Telegraphic Purposes."

In the present paper, I wish to record some more experiments on the same subject. As stated in my former paper, the dynamo-electric machine, during this first experiment, was placed at the store-yard, and was driven by the steam engine of that place. The telegraph current was conveyed to the Calcutta Telegraph Office by the store-yard line, which is about 4 miles in length. This first trial proved so successful that I ventured to propose a larger trial to supply *all* the lines entering the Calcutta Telegraph Office with signalling currents derived in this manner. But I could not then execute the new trial, as in the first place there were no proper driving arrangements at the store-yard (the erection of these would have cost money), and in the second place the dynamo-electric machine at my disposal had, by an accident, been temporarily spoiled. It was thought advisable, therefore, to postpone the suggested trial on a larger scale until the electric light arrangements at Howrah‡ should be completed, when an easy opportunity would offer itself for trying different dynamo-electric machines for the purpose. Besides, telegraph lines being already up between the Howrah Railway Station and the Calcutta Telegraph Office, no additional expense would need to be incurred.

New trial on a larger scale.—The preliminary trial was instituted on the 28th August, the final one on Sunday the 29th August 1880.

In the accompanying diagram, *M* is the dynamo-electric machine which produces the main current to be made use of for any required purpose; the negative pole of the dynamo-electric machine is connected

* The results given in this paper are taken from my report submitted to the Director General of Telegraphs in India on the 7th September 1880.

† J. A. S. B., Vol. xlix, part ii, 1880, and Phil. Mag. No. 52. Suppl., December 1879.

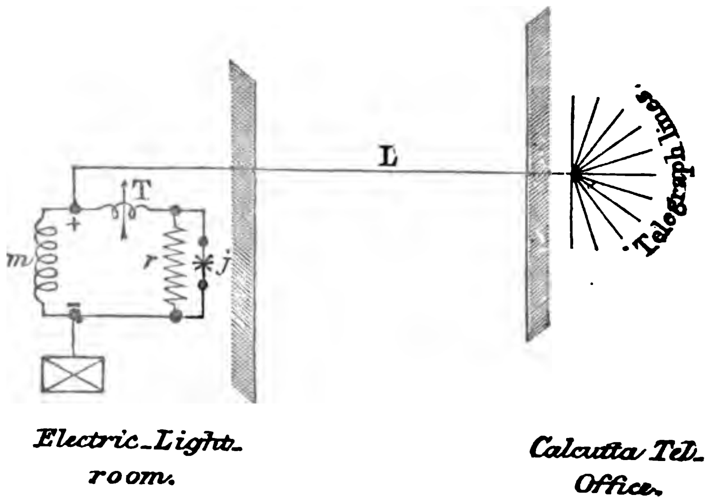
‡ Mr. Bradford Leslie, Agent of the East Indian Railway Company. gave me permission to use the electric light arrangements at Howrah for the purpose. He also kindly permitted the use of the telegraph line connecting his office at Calcutta with the Railway Station at Howrah. This line was required to give orders during the experiment.

permanently to earth. The earth consists of 3 copper plates* joined parallel and offering a parallel resistance of 1·67 ohms.†

T is a tangent galvanometer for measuring the main current. In this case it was the tangent galvanometer employed in my electric light experiments in London in 1878. The resistance of the copper ring of this instrument is *nil*. Taking the late Mr. Brough's value for H, the horizontal component of the Earth's magnetic intensity at Calcutta to be H = 0·37158 dynes, the formula for calculating the currents c from the deflections observed by this tangent galvanometer, is :—

$$c = 47330 \text{ tang } \alpha \text{ (milli-oersted).}$$

r is a coil of iron wire (No. 24 i. w. g., 0·21″ diameter) offering a resistance of 1·517 ohms at 85° F. The wire is coiled on a large wooden drum and serves as the constant resistance by which from time to time the efficiency of the dynamo-electric machines at Howrah can be gauged.



J represents an electric light, in this case produced by a large Serrin-lamp.

In the following experiments, either *r* or *J* was used as the external resistance for closing the poles of the dynamo-electric machine to produce the *main* current ; but *never* the *two* joined parallel.

L is the telegraph line from the dynamo-electric machine to the Calcutta Telegraph Office. This line is 1·75 miles in length and consists, from the electric light room to the Howrah Railway Station, of Hooper's india-rubber cable core, from the Howrah Station to the Kirk, of No. 6

* The three single earths measured gave : 7·7, 3·1, and 6·9 B. A. U.

† The dimensions are 4′ × 2′ and $\frac{1}{16}$″.

i. w. g., and thence to the Calcutta Telegraph Office it is American compound wire of the same resistance as iron wire of No. 27 i. w. g.

At the Calcutta Telegraph Office, the *battery wire** could at a moment's notice be connected with the key of each instrument, after throwing off the copper of the signalling battery in ordinary use. The telegraph lines terminating at the Calcutta Office were therefore all connected *parallel* to the battery wire, as is indicated in the foregoing diagram.

In order to enable me to directly compare the signalling current sent into the lines by batteries and by a dynamo-electric machine, each line is as tested for *sent current* at Calcutta, and for *received current* at the out-station.

Preliminary trial on 28th August 1880.—The line used for tapping the signalling current was No. 5, Calcutta to Allahabad, 577 miles in length, worked *direct* and having a real conduction resistance of about 3075 ohms. (taken from the August 1880 tests). The resistance of the relay at Allahabad equals 492 ohms.

1st Experiment.—This consisted in taking the *sent current* at *Calcutta* and *the received current at Allahabad* as produced by a battery of 60 minotti-cells connected up in series. This is the usual signalling battery during the monsoon.

2nd Experiment.—The main current in this experiment was produced by dynamo-electric machine A† through the resistance r. The resistance in circuit was not measured, but may be taken to be as follows :—

	$m = 0{\cdot}652$	ohms at 85° F.	internal.
	$r = 1{\cdot}517$		} = 1·543 external.
Leading wire to tangent galv.	$l = 0{\cdot}026$		
Total,	2·195	ohms.	

The main current gave a mean deflection of 37·9°; $\frac{\text{max.}}{\text{min.}} = \frac{39}{36{\cdot}2}$; mean speed of engine 60·3 revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{62}{58{\cdot}5}$. The variation of the current corresponds with the variation of the speed.

3rd Experiment.—The main current in this experiment was produced by dynamo-electric machine E.‡ through the resistance r. This experi-

* The Telegraph line conveying the current produced by the dynamo-electric machine to the Telegraph Office may be called most appropriately the *battery wire.*

† This is a Siemens' dynamo-electric machine called *medium size* (see my *précis* of report on the electric light experiments in London).

‡ This is a Siemens' medium machine altered according to my specification (See *précis* of report on the electric light experiments in London).

ment was made in order to see whether A or E machine would suit the circumstances best.

The resistance in circuit was not measured, but may be taken to be the same as given for A. The main current gave a mean deflection of $30{\cdot}6^\circ$; $\frac{\text{max.}}{\text{min.}} = \frac{33{\cdot}7}{27{\cdot}0}$; mean speed of engine = 59·9 revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{66}{54}$. The variation of the current corresponds with that of the speed.

The results of the preliminary trial are given in the following table:—

No. of Experiment.	Mode of producing the current.	Speed of engine per minute.		Mean speed per minute of dynamo-electric machine.	Mean of main current in milli-oersteds.	Current in milli-oersteds.	
		Mean.	Max./Min.			Sent at Calcutta.	Received at Allahabad
1	60 Minotti	...	...	...	9·8	9·8	5·1
2	Dyn. el. machine A.	$60{\cdot}3^{7}$*	$\frac{62^{1}}{58{\cdot}5^{1}}$	783	36,846	14·5	7·7
3	Dyn. el. machine E.	$59{\cdot}9^{6}$	$\frac{66^{1}}{54^{1}}$	641	27,991	9·4	6·6

The three experiments were made in the order given. Nos. 2 and 3 were made from 11 to 11·44 hours, during which time messages were sent. The insulation of the battery wire L was variable from 71,000 to 95,000 ohms absolute.

From Experiments 2 and 3, it will be seen that A machine produces a larger main current than E, which is due to the higher speed of A; further, that the *sent current* tapped from the main current of A is larger than the *sent current* tapped from that of E, just as it ought to be. In fact, if the line during the two experiments had kept constant, and if also r had kept constant (r increases considerably by heating), the proportion of the two *main currents* would have been the same as that of the two sent currents, and this is very nearly the case.† No. 3 Experiment with E machine gives about the same result as No. 1 Experiment with battery. To produce the

* The small numbers in the form of exponents mean the number of observations made.

† $\frac{A}{E}$ main currents = 1·32.

$\frac{A}{E}$ sent currents = 1·55.

main current by A is therefore more advantageous than to produce it by E. Hence I employed A in the final trial.

The final trial on Sunday 29th August 1880.—The battery wire, before the trial began, was tested for insulation, and gave an absolute insulation greater than 1 Ω ohm. The main current, as already mentioned, was produced by dynamo-electric machine A; *i. e.*, from 8·45 to 11·5 hours through the wire coil of resistance *r*, and from 11·5 to 11·32 hours through the arc of an electric lamp producing the light J. The light of the lamp was not measured, but may have been equal to about 6,000 standard candles.* The first line was connected to the battery wire at 8·45 hours; the last line at 10·53 hours. The whole trial was completed at 11·32 hours.

The change from *r* to lamp (J) was made in so short a time that none of the out-stations noticed it. Messages were sent and received in the usual regular style.

Mr. C. B. P. Gordon, the Superintendent of the Bengal Division, attended at the Signal Office.

At the beginning of the experiments, the resistances in circuit were measured.

Internal resistance of dynamo-electric machine A	$m = 0·652$	internal	ohms at 85° F.
Wire coil	$r = 1·517$	1·543 external	
Leading wire to tangent galvanometer	$l = 0·026$		

After the experiments were over, these resistances were not measured again; however, on account of the very considerable heating by the strong main current, they must, we know, *all* have increased considerably.

When *r* closed the poles of the dynamo-electric machine (8·45 to 11·5 hours) the mean speed of the engine was 60^{13} revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{64'}{56'}$; while the mean deflection of the main-current was $37·87^{68}$; $\frac{\text{max.}}{\text{min.}} = \frac{40·25^{1}}{35·0^{1}}$.

When the lamp was in circuit (from 11·5 to 11·32 hours), the mean speed of the engine was again 60^{13}; $\frac{\text{max.}}{\text{min.}} = \frac{61}{59}$; while the mean deflection of the main-current was 44^{17}, $\frac{\text{max.}}{\text{min.}} = \frac{46^{2}}{42^{1}}$.

In the following table all the results are given :—

* When measured under 45° with the horizon.

Table shewing the Sent and Received Currents and other particulars.

1	2	3	4	5	6	7	8
No. of Experiment.	Number and name of line and length in miles.	Real conduction resistance of line in b. a. u.	Resistance of Relay at receiving station in b. a. u.	Currents in milli-oersteds. Sent at Calcutta.	Received at out-station.	Mode of producing the currents.	Remarks.
I	No. 1 Jubbulpore 738	4,412	905	6·18 9·81 5·89	4·00 7·60 4·45	100 cells Dyn.-el. m. A 100 cells	The several lines were connected to the battery wire in the order given in this table. The first line, Jubbulpore No. 1, was connected at 8·45 hours; the last line No. 3, Agra, at 10·53 hours. Before the actual experiments began, *i. e.*, before 8·45 hours, all the lines were tested for *sent currents* at Calcutta, and *received currents* at the outstations, when the usual signalling battery was on. Directly after each line had been connected to the battery wire of the dynamo - electric machine, the *sent currents* at Calcutta and the *received currents* at outstations were taken.
II	No. 4 Jubbulpore 803	5,795	406	7·07 10·23 7·41	3·60 4·71 3·50	60 cells Dyn.-el. m. A 60 cells	
III	No. 5 Allahabad 577	3,075	492	9·81 13·79 9·41	6.50 8·57 5·08	60 cells Dyn.-el. m. A 60 cells	
IV	No. 6 Sahibgunge 225	2,000	506	7·14 21·65 6·63	4·09 11·40 4·23	20 cells Dyn.-el. m. A 20 cells	
V	No. 7 Cuttack 400	2,800	953	6·63 11·00 6·63	3·00 6·00 3·38	35 cells Dyn.-el. m. A 35 cells	
VI	No. 8 Coconada 800	7,000	3,711	4·00 8·15 4·00	3·60 7·20 2·01	119 cells Dyn.-el. m. A 119 cells	
VII	No. 9 Akyab 560	3,460	3,470	7·69 6·77 6·18	4·00 3·90 5·35	120 cells Dyn.-el. m. A 120 cells	
VIII	No. 11 Dhubri	...	1,427	6·40 11·78 6·42	5·00 11·45 5·73	40 cells Dyn.-el. m. A 40 cells	
IX	No. 10 Akyab 561	4,400	...	15·39 15·39 17·43	3·10 3 90 3·30	80 cells Dyn.-el. m. A 80 cells	
X	No. 2 Agra 915	6,700	829	15·30 7·14 14·52	6·40 3·90 6·15	195 cells Dyn.-el. m. A 195 cells	
XI	No. 3 Agra 850	5,800	1,959	13·54 13·38 9·41	3·25 3·10 4 14	100 cells Dyn.-el. m. A 100 cells.	

After the dynamo-current was stopped at 11·32 hours, and the batteries had been connected up again, the ***sent currents*** at Calcutta and the ***received currents*** at outstations were again ascertained. Hence columns 5 and 6 contain 3 readings of ***sent*** and ***received currents*** for each line; first, with battery, secondly, with the dynamo-electric machine, and, thirdly, with the battery again. All the readings of the currents tapped from the main current of the dynamo-electric machine were taken between 8·45 and 10·53 hours, when the iron wire coil of resistance r was connected to the poles of the dynamo-electric machine. From 11·5 to 11·32 hours, when the lamp was substituted for r, no current readings at Calcutta and the outstations were taken.

The main current of the dynamo-electric machine, when r was in circuit, was 36,801 m. ö; when the lamp was in circuit, 45,706 m. ö.* From this it does not follow, however, that the tapped currents in the second case were larger than in the first, because it would also depend on the resistance offered by the arc, which is not known. The resistance of the arc, as more current was produced with the same speed of the dynamo-electric machine, must naturally have been smaller than $r = 1·517$ b. a. u. (iron wire coil), especially as there is an e. m. f. in the arc opposite to the e. m. f. of the dynamo-electric machine.

To produce 36,801 milli-oersteds through an external resistance of about 1·543 b. a. u., a total energy is consumed by the dynamo-electric machine of about 27,000 Ω ergs per second (representing about 3 h. p. per second).

Conclusions.—These experiments shew that it is perfectly possible and practicable to tap from the main current produced by a dynamo-electric machine *all* the signalling currents required at the Calcutta Telegraph Office. These currents were for the 11 lines connected up = 129·1 m. ö, if all keys were simultaneously and permanently sending. This represents only 0·35 °/₀ of the main current (36,801 m. ö) with r in circuit, and ·28 °/₀ of the main current (45,706 m. ö) with lamp in circuit. Further it will be clear that such a small variation of the main-current could not influence the regularity of any work done by that main-current.

Further, it will be seen that in all the experiments the sent currents tapped from the main current of the dynamo-electric machine were considerably larger than when produced by the large batteries at present in use. Experiments IX and X only form an exception. However, I think these exceptions are in both cases due to errors of observation, because the battery readings in Experiment IX do not all agree. The dynamo-current readings in No. X must be wrong, because in No. XI, for a total circuit resistance of 7759 units, the sent current is 13·38 m. ö,

* Calcutta by the formula: e = 47330 to (m. 0″).

while in No. X, for a total circuit resistance of 65·29, the sent current is only 7·14. The error of observation is therefore obvious.

That with such strong received currents as are produced when the dynamo-electric machine is used, the lines should work well, is not to be wondered at. But it was also confirmed by the outstations having to adjust their relays much more unsensitively.

Supposing now that we had useful work *day* and *night* for the strong main current, and that on the whole the new method could be always depended upon, I believe these experiments have proved that the signalling currents required in telegraph stations could be had for *nothing*, and that the method would be quite practicable.

The useful work for the main current at night would most conveniently take the shape of an electric light to illuminate very efficiently the Signal Office. The electric light, besides being more powerful, would possess the additional advantage of being produced by at least 50 times less heat than if the same light were obtained by combustion. This is no doubt a great advantage in a hot climate. During the daytime, I would use the main current for pulling punkhas, lifting messages, or, more generally, for working a pneumatic system of sending and receiving messages, &c., &c. If Calcutta had the good fortune to possess a colder climate, it might be suggested that the heat developed in the coil of wire should be used for warming rooms. It would then only be necessary to lead the wire along the walls, in a manner similar to that in which hot water pipes often are for heating rooms; the electric method being only far more economical. The heat given up by the wire, after dynamic equilibrium of the system has been established, is quite regular, and the method is obviously exceedingly clean and very convenient for domestic purposes. The wire attained its constant temperature of 93° C. after the current had acted for about half an hour, the air of the room having a temperature of 30° C.

The heat given out by the wire is by no means small. For instance, in our case, the average current working through a resistance $r = 1{\cdot}548$ b. a. u. was 36801 milli-oersteds. This represents work done at a rate of 20473 Ω ergs per second, and supposing the wire has obtained its constant temperature, this whole energy is developed into heat emitted by the wire into space at a rate of $\frac{20473}{42} = 488$ gramme-degree-centigrade per second. This is equal to the heat produced by an ordinary German stove consuming 6lbs of coals per hour; supposing that the loss of heat when coals are burnt under a steam-boiler is four times as great as when they are burnt in a German stove. It appears, therefore, that the heat developed by the wire would be sufficient to keep a moderately sized and ordinarily ventilated room at a comfortable temperature even when situated in the highest latitudes.

XVIII.—*On the Lepidopterous Genus* Æmona, *with the Description of a new Species.—By* J. Wood-Mason.

(With Part of Plate VI).

Several years ago, three plain pale-fulvous butterflies of moderate size were forwarded to the Indian Museum by Mr. S. E. Peal of Sibsagar, Assam. All three are of the male sex, and they agree so remarkably closely in size and colour as to have been taken for specimens of one and the same species. On examination, however, I find that, though superficially so similar to one another, they differ in structure and represent two distinct but closely-allied species, one of them being a male (hitherto undescribed) of *Æmona Amathusia*, and the other two, males of an undescribed form belonging to the same genus. For the benefit of naturalists in India to whom the costly works in which they occur are inaccessible, I have extracted the original descriptions of the two described species.

The genus *Æmona* was established by W. C. Hewitson in 1868 for the reception of an insect from Northern India which he had previously described under the name of *Clerome Amathusia*. Hewitson appears to have had some misgivings as to the propriety of this step, but, as will be seen from the following amended diagnosis, the genus is at least as distinct from *Clerome* as this is from *Thaumantis*, or as *Zeuxidia* from *Amathusia*.

Genus Æmona, Hewitson.

Head small. *Antennæ* rather short. *Anterior wing* acutely pointed and produced, or sharply angulated, at the apex; its inner margin straight in both sexes, not being lobed at the base in the male as it is in *Clerome* and less distinctly in *Thaumantis;* the costal vein reaching to the end of the fifth seventh of the length of the anterior margin; the subcostal 4-branched, the first branch given off just before the end of the cell, and, after running free for nearly the same distance beyond that point as it originates before it, completely coalescing with the costal, but again becoming free just before this last-named vein turns off to the anterior margin, the three remaining branches free. *Posterior wing* more elongated than, and not quite so rounded as, in *Clerome;* without the pencil of erectile setæ which, in the males of *Clerome* and *Thaumantis*, arises from the wing-membrane of the discoidal cell close to the subcostal vein and lies obliquely across a patch of elevated and crowded scales on the other side of this vein, the male scent-fans, if such are really present in this genus, being situated in a different part of the wing, *viz.*, in the anal region, where a line of setæ running along the anterior side of the submedian vein ends in a curled whisp which, when at rest, lies in a slight groove or fold of the wing-membrane.

Plain and delicate butterflies of a pale fulvous colour inconspicuously or obsoletely ocellated on the underside.

In the form of the hind-wings and in the position of the male scent-fans *Æmona* agrees with *Xanthotænia*, and in its pointed fore-wings with *Zeuxidia*, *Enispe*, and *Discophora*, but it differs from these and from all the other Indian genera of *Morphinæ* in the relations of the costal and subcostal veins to one another, and in other respects.

(*a*.) ***Fore-wing produced and pointed at apex with its outer margin concave-sinuous.***

1. ÆMONA AMATHUSIA. Pl. VI, Figs. 3, 4, ♂.

Clerome Amathusia, Hewitson, Trans. Entom. Soc. Lond. ser. 3, vol. iv, 1867, p. 566, ♀.

Æmona Amathusia, Id., Exot. Butt. vol. iv, 1868, *Zeux.* et *Æm.* pl. i, fig. 3—4, ♀.

♀. "UPPERSIDE rufous-brown, the bands of the underside seen through. *Anterior wing* crossed beyond the middle by a band of orange-yellow: the apex dark brown. *Posterior wing* with some arcuate spots near the apex.

"UNDERSIDE rufous, tinted with darker colour. *Both wings* crossed at the middle by a common rufous-brown band: both with a band of minute rufous ocelli some of which are pupilled with white: both with a submarginal band rufous. *Anterior wing* with a pale rufous band near the base and a spot of the same colour at the end of the cell. *Posterior wing* with a dark rufous band near the base.

"Expanse $3\frac{2}{10}$ inches

"HAB. Northern India."

The female is only known to me from Hewitson's description and figures.

♂. Lighter-coloured than the female. UPPERSIDE pale fulvous, the strigæ or bands of the underside showing through. *Anterior wing* darker at the base and at the tip, between which darker parts the colour is very pale yellowish-fulvous. *Posterior wing* of the same shade as the base of the anterior one to within a short distance of the margin, whence it is paler, and with an indistinct submarginal series of arcuate marks extending from the apical to the anal angle. UNDERSIDE uniform pale fulvous; the strigæ as in the female; the ocelli (one, the second and largest, perfect, the remaining five rudimentary) of the posterior wing also as in the female, but in the anterior wing only the one between the first and second median veinlet and faint traces of that between the first median veinlet and the submedian vein are present; the thin submarginal brown line more obviously engrailed than in the female.

Length of anterior wing 1·4; whence expanse = 2·9 inches.

HAB. Naga Hills *(S. E. Peal)*. A single specimen.

2. ÆMONA LENA.

Æ. lena, Atkinson, Proc. Zool. Soc. Lond. 1871, p. 215, pl. xii, fig. 1, ♂.

♂. "UPPERSIDE. *Fore wing* pale brownish grey, crossed by a dark brown band, interrupted by the nervures from before the apex to near the posterior margin at two-thirds of its length from the base, beyond the band darker, with a slightly marked and incomplete submarginal line, before which is a series of five pale lanceolate blotches between the nervures directed towards the outer margin. All the nervures tinged with yellow and more or less dark-bordered. *Hind wing:* anterior portion from base to outer margin pale, posterior portion bright yellow, crossed by a submarginal series of three dark-bordered white blotches, and a fourth fainter blotch between the nervures, forming a short interrupted band from near the apex to the second median nervure. The submedian nervure fringed from its origin to near its extremity with long yellowish hairs, longest and most conspicuous towards its extremity.

"UNDERSIDE. *Both wings* crossed by a dark ferruginous band with sharply defined outer edge from the costa of the fore-wing near the apex to near the extremity of the submedian nervure of the hind-wing, and having a faintly traced submarginal line, before which is a series of blind white-centred ocelli. The cell of the fore-wing crossed near its middle by a curved ferruginous band. *Hind-wing* crossed by a ferruginous band near the base.

"*Antennæ* ferruginous; *palpi* and *legs* tawny yellow.

"Expanse of wings 3½ inches.

"HAB. Yunan." Moolai, Upper Tennasserim 3,000—6,000 ft. *(Moore)*.

Atkinson does not give the sex of the specimen described and figured by him, but, as the two specimens in the Indian Museum obtained at the same time are males and agree perfectly in size and markings with his figure, he may be presumed to have described a male. In a specimen of the male recently received from the upper Thoungyeen forests, British Burmah, by Captain G. F. L. Marshall, the three white spots on the anterior half of the hind-wing are larger, forming a band divided by the veins.

(β.) *Fore-wing sharply angulated at the apex with its outer margin arched.*

3. ÆMONA PEALII. Pl. VI, Figs. 5, 6, ♂.

Æ. Pealii, Wood-Mason, Proc. Asiatic Soc. Bengal, July 1880, p. 123.

♂. Closely allied to *Æm. Amathusia*. UPPERSIDE coloured and marked in the same manner, but with the ocelli as well as the strigæ of the underside showing through. *Anterior wing* with the apex angulated but not produced, the outer margin arched instead of concave-sinuous, and the inner angle not so broadly rounded. *Posterior wing* darker-coloured and also paling towards the outer margin, but with the submarginal series of arcuate marks smaller and less distinct. UNDERSIDE coloured and marked in much the same manner, but with more perfectly formed and more numerous ocelli; the anterior wing having three (the first between the submedian vein and the first median veinlet, the second the largest and best defined) perfect ocelli and two or three rudimentary ones following them, and the posterior wing, one rudimentary (close to the submedian vein) and six (the first in the same interspace with the rudimentary one, and the second the largest of all) perfect ones; each ocellus dark brown encircled by a very fine line of the colour of the strigæ and pupilled with iridescent silvery-white; the thin submarginal brown line rather more deeply engrailed.

Length of anterior wing 1·35; whence expanse = 2·8 inches.

HAB. Sibsagar, Assam (*S. E. Peal*). Two specimens.

XIX.—*Description of a new* Papilio *from the Andaman Islands.*—*By* J. WOOD-MASON.

(With Part of Plate VI.)

PAPILIO LÆSTRYGONUM. Pl. VI. Figs. 1, 2, ♂.

P. Laestrygonum, Wood-Mason, Proc. Asiat. Soc. Bengal, June, 1880, p. 102.

♂. Wings above cretaceous-white, the anterior ones black at the insertion, scarcely tinged with greenish at the base, with five black bands commencing at the anterior margin and cutting the cell, the first basal, extending to the inner margin, the second rather broader, also extending to the inner margin, and emitting a short conical process at the origin of the first median veinlet, the third scarcely broader, extending to the median vein, the fourth narrower, triangular, reaching or all but reaching the median vein, the fifth much the broadest of all, triangular, divided anteriorly into two forks by a curved narrow decreasing and interrupted band of the ground-colour running from the costal vein to the third median veinlet, extending to the inner margin, separated from the black outer marginal band by a band of the ground-colour divided by the black veins and very slightly if at all narrowing from the anterior margin up to the second median veinlet, whence it gradually decreases in width and distinctness to the inner angle; all these black bands connected at the anterior margin, and the first, second, and fifth of them at the inner margin also, by a very narrow edging of black.

Posterior wings with two black bands commencing and connected at the anterior margin and coinciding with bands of the underside, one basal, extending to the end of the first half of the first median veinlet, and the other discal, extending a short distance into the space between the 2nd and 3rd median veinlets; with a small black spot near the end of the cell scarcely distinct from the discal band; with four discal spots immediately beyond the cell running nearly parallel with the band, the first and largest transversly elongated and coinciding with a spot on the underside, the rest smaller than the corresponding ones on the underside, which latter are consequently seen through the wing-membrane beyond the margins of the former; with a black spot succeeded by one of luteous at the anal angle; with a marginal and submarginal series of black lunules coalescent in the anterior third but more distinct in the posterior two-thirds of the wing, where the two series are more or less separated from one another by ashy-grey scales continuous with the ashy patch occupying the outer third of the wing and extending also along so as to obscure the ultra-cellular part of the basal black band; with the discal band and spots more or less irrorated and obscured with ashy-grey scales so that the disk of the wing appears mottled with black and grey; and with the black tails, as also the incisures, margined with cretaceous-white.

Wings below pure white, anterior ones marked as above, with the ground-colour at the base and between the black bands as far as the median vein and its second branch yellowish; with the band of ground-colour separating the fifth black band from the black outer border distinct, and not decreasing but on the contrary rather increasing in breadth, to the inner angle; and with the curved line dividing the fifth black band into two forks more distinct and less discontinuous.

Posterior wings, from the base up to the median vein and the discal black band, yellowish, with three black bands, one narrow running from the insertion along the inner margin close to the abdominal fold, and two broader commencing and connected at the anterior margin and cutting the cell, one of these latter basal, extending nearly to the end of the basal half of the first median veinlet, and the other discal, some distance into the space between the 2nd and 3rd median veinlets, the two first of the three bands connected together at their outer extremities and with two largish coalescent black spots in the anal region; with a small black spot near the extremity of the cell, and six of the same colour immediately beyond it disposed in a line which runs straight from the costal vein as far as the cell, but then curves abruptly inwards, the first of these spots transversely elongated, extending from vein to vein, and connected with the second, which is roundish and itself connected with the discal band, the third oval, about one-third the size of the second, and touching the discocellular veinlet, the fourth twice the size of the third, in contact with the median vein and its two last branches, the fifth rather smaller than the third, the sixth crescentic and connected with the two above-mentioned large spots in the anal region; with six large diffused luteous blotches externally margined with black, and increasing in size and depth of colour from the anterior to the inner margin; with the ground-colour between these blotches and the discal black spots pure white; with an increasing series of six marginal lunules, between which and the wavy black margins of the luteous blotches the ground-colour is white in the anterior and grey or greyish-white in the posterior portion of the wings; and with the incisures and the tails margined with lutescent.

Head black with two white frontal bands; collar with a luteous spot on each side; thorax above jet-black ornamented at the sides with long grey setæ, below cretaceous-white; abdomen cretaceous-white with a tapering dorsal black band and two lateral fuscous ones.

Length of anterior wing 1·7; whence expanse = 3·5 inches.

HAB. South Andaman. Two specimens, both males, obtained by Mr. A. R. de Roepstorff.

To mark its close relationship to *P. Antiphates*, I have called the species *P. Laestrygonum* after the mythical people over whom Antiphates is supposed to have reigned. It differs from its nearest ally in having the upperside much blacker (the bands of the forewing being broader, and the first, second, and fifth of them with the marginal one extending to the inner margin where they are all connected together by a very narrow black edging, and the disk of the hindwing mottled as it were by black and grey) and a much greater extent of grey and more highly developed marginal and submarginal lunules on the hind-wing; in the abdomen being dorsally banded with black and the thorax ornamented with grey setæ, &c.

P. S.—On the 17th Nov., after the above had been sent to press, the fourth part of M. Oberthür's work entitled 'E'tudes d' Entomologie' was received in the Indian Museum, and in it I find the same species described and figured under the name of *P. Epaminondas;* but, as it seems to me not quite certain whether this name was actually published before mine, I have left it to M. Oberthür to effect the change of names that will become necessary if the fourth part of his work should really have been issued to the public before June, 1880.

JOURNAL

OF THE

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Part II.—PHYSICAL SCIENCE.

No. IV.—1880.

XX.—*Contributions to Indian Malacology, No.* XII. *Descriptions of new Land and Freshwater Shells from Southern and Western India, Burmah, the Andaman Islands, &c.—By* W. T. Blanford, F. R. S.

(Received Nov. 20th;—Read December 1st, 1880.)

(With Plates II and III.)

More than ten years have elapsed since the last number of these 'Contributions' was published.* The time that I have been able to devote to Zoology in the interim has been occupied with other subjects, and several forms of Indian land-shells that have been in my possession for years have remained undescribed. Of a number of these, I had drawings made some years ago, and several of the figures that accompany the present paper were included in a plate prepared for publication as long since as 1871, but never lithographed.

These ten years have seen so many additions to the literature of Indian land and freshwater shells that the whole aspect of the study has been changed. Foremost in importance are the late Dr. Stoliczka's papers in this Journal† on the anatomy of several forms of *Helicidæ*. The untimely death of Dr. Stoliczka, one of the most able and energetic workers who ever devoted his attention to Indian Mollusca, has prevented the design he had formed of publishing a monograph of Indian *Cyclostomacea*

* J. A. S. B., 1870, xxxix, pt. 2, pp. 9—25.

† Vol. xl, 1871, pt. 2, pp. 143, 217, and xlii, 1873, pt. 2, p. 11.

from being carried out. A considerable number of drawings had been made for the work, in the preparation of which I had agreed to join, but of these drawings the most important, those representing the anatomy of the various genera, are not, I fear, sufficiently clear for publication in their present form, and notes to explain them are wanting. Some of the most useful of Dr. Stoliczka's anatomical studies, those on the structure of various *Helicidæ*, have, however, I am much pleased to say, been continued by Colonel Godwin-Austen with important results.

The same decade has seen the completion of a series of illustrations, many of them well executed, of Indian land and freshwater shells, the 'Conchologia Indica' of Hanley and Theobald. The work is mainly due to Mr. Hanley, upon whom the whole of the editorial labour has fallen, Mr. Theobald having been absent in India during the publication. Whilst it is impossible to avoid regretting that more complete illustrations of most of the species have not been given, and that some additional details have not been furnished in the accompanying letterpress,* it is unquestionable that the plates are a valuable contribution to the knowledge of Indian Mollusca.

Two other rather important works on Indian land and freshwater shells have been issued since the completion of the 'Conchologia Indica.' One of these is Mr. Theobald's 'Catalogue of the Land and Freshwater Shells of British India'†, the other, Mr. G. Nevill's 'Hand-list of the Mollusca in the Indian Museum, Calcutta', Part I.‡ The value and accuracy of the first-named work are unfortunately seriously diminished by the great number of misprints, errors, and omissions, partly due to the author's absence from Calcutta when the list was printed. Five quarto pages in small print are filled with additions and corrections; this list, however, is not only far from being exhaustive, but contains some additions to the catalogue of mistakes.§ The 'Notes on the 'Conchologia Indica,'' p. 50, contain some important corrections of localities cited in that work.

* One most important omission might yet perhaps be rectified. A large number of the figures are from types, or from typical examples, and, in such cases, if the figure is correct, there can be no question as to the determination of the species. But many of the figures are from shells that, although doubtless in general correctly identified, are not the specimens originally described, nor even in all cases from the same locality. A list of the figures taken from actual types would be useful in cases of disputed identity.

† Calcutta, 1876, published by Thacker, Spink and Co.

‡ Calcutta, 1878.

§ To justify my criticism of my friend Mr. Theobald's 'Catalogue', I will give two instances of the errors it contains. At p. 15, the genus *Omphalotropis* (with two species *O. distermina*, B. and *O. aurantiaca*, Desh., is placed in the family *Rissoidae*, subfamily *Pomatiopsinae*. At p. 43, the same genus *Omphalotropis* (with but one species *O. distermina*, B.) is repeated as a member of the family *Helicinidæ*, subfamily *Hydrocæninæ*.

Mr. Nevill's 'Hand-list of the Mollusca in the Indian Museum' is especially important for the large number of localities given. In some few instances (as in all such lists), some names will be found to require revision, and one or two instances will be given in the present paper. I have already* expressed my reasons for dissenting in some respects from the classification adopted. But it would be unfair to convey the impression that mistakes are numerous, indeed, considering that Mr. Nevill had not the advantage of correcting the proof-sheets himself, errors, so far as I have examined the work critically, appear singularly few in number, and in many points the classification adopted for the *Helicidæ* of India is a considerable improvement on anything that had previously been published. At the same time, there is, I believe, very much more to be done before these puzzling shells are properly arranged.†

In the various works just mentioned, some species are quoted by names given by me, at various times, in manuscript, but never published. Of these forms I have given descriptions in the following pages. In several instances, the shells have been figured in the 'Conchologia Indica.' One form thus figured (*Spiraculum mastersi*), I have already described in this Journal (vol. xlvi, 1877, pt. 2, p. 313), and two other species (*Cremnoconchus fairbanki* and *Corbicula iravadica*) represented in the same work require explanation. To facilitate reference, this is given below under the name of each shell.

This mistake is not corrected in the long list of 'Addenda et Corrigenda.' To shew how grave the error is, it is only necessary to mention that the *Rissoidae* are as distinct from the *Helicinidae* in organization as are the *Littorinidae* from the *Neritidae*, and that *Omphalotropis* has been clearly proved to belong to neither, but to the *Cyclostomidae* (See Ann. Mag. & Nat. Hist. May, 1865, ser. 4, vol. iii, p. 341). Moreover, the Indian locality of *Omphalotropis aurantiaca* had been shewn to be erroneous by Hanley in the 'Conchologia Indica.' The error was long since suggested by Benson (Ann. & Mag. Nat. Hist. Sept. 1851, ser. 2, vol. viii, p. 194).

The other error that I shall notice occurs in the 'Addenda et Corrigenda' and runs thus:—"Page 15, *add* ACMELLA HYDRIA, Godwin-Austen. North East Bengal." The reference quoted is 'Minutes of the Trustees, Imperial Museum,' Calcutta, vol. vii, p. 162. Now the minutes quoted are not published, but merely printed for record, and the notices contained in them of additions to the Museum are mere lists of the names that happen to be attached to specimens, inserted without any attempt at verification. Precisely the same is the case in the 'Register' at the British Museum. Had Mr. Theobald looked at the specimens, or had he made any enquiry about the shell, he would, I think, have easily learned that no such name as '*Acmella hydria*' was ever published, and that the shell so-called, was, if I am not mistaken, *Tricula montana*.

* Proc. A. S. B., 1879, p. 55.

† For instance, I cannot help doubting whether any of the numerous forms referred by Mr. Nevill to *Microcystis* are really congeneric with *H. ornatella* the type of the genus.

Of the remaining species here described, the majority have been collected by Colonel Beddome in the hill-tracts of Southern India. Some of these were sent to me as long as 9 or 10 years ago, others have been received more recently. I feel that I owe many apologies to Col. Beddome and to the other gentlemen, Dr. Anderson, Col. Evezard, and Col. Godwin-Austen, who have kindly entrusted me with the description of their discoveries, for leaving these so long unnoticed.

The plates accompanying the present paper are unfortunately deficient in many respects. Several species are not represented, and some of the representations given are far from being good. The original drawings were, in all cases, excellent, but some of them may, after being kept for several years, have become indistinct in parts, and as the lithographer had not the shells for comparison, he may have misunderstood the details. The larger shells represented in plate iii. are fairly well delineated, but several of the small forms in plate ii. are more or less faulty.

The importance of a careful study of the anatomy in the different forms of *Helicidæ* has already been mentioned. Very much remains to be done before anything like a correct classification of the family can be practicable. That all the forms referred to *Nanina* (a name which has no claim to recognition) must be separated from *Helix* is clear enough; the animals belong to different subfamilies at least, but it is by no means certain how many real generic groups there are in the so-called *Nanina*. I suspect that *Macrochlamys*, very possibly with some of the forms referred by Stoliczka to *Rotula*,* will have to be separated generically from another group comprising the sections known as *Hemiplecta* and *Ariophanta*, which are very closely allied to each other, and which are probably congeneric with *Xesta* and several other forms. For the present, I have simply referred the species described to the sections to which they appear to belong, as Stoliczka did, but I am by no means prepared to follow him in accepting such sections as of generic rank. The difficulty is to determine what generic name or names should be adopted. *Nanina* is utterly bad; it offends every law; the name had been used previously by Risso;† the type is the same as that of Benson's genus *Macrochlamys;* and the term is objectionable on account of its signification. All this has been pointed out by Martens,‡ but still he and others employ the name because it has crept into use. Now, in such difficult matters as these generic terms, unless rules are strictly attended to, utter confusion must result, and undoubtedly it has resulted. When, however, a search is made for a better founded term then *Nanina*, endless difficulties are encountered. The ear-

* These appear, however, to deserve distinction from true *Rotula*, see after.

† See Stoliczka, J. A. S. B., 1871, xl, pt. 2, p. 47.

‡ Albers Heliceen, 2te Ausgabe, p. 46, where the synonymy is fully discussed.

liest name is *Helicarion* of Ferussac (1822), but it is far from clear that this is not generically distinct from both *Macrochlamys* and *Ariophanta.* The next term is *Stenopus* of Guilding (1828), applied to a West Indian shell. This genus is evidently closely allied to the so-called *Nanina:* the only distinction pointed out by H. and A. Adams* is that the sole in *Stenopus* is narrower than the sides of the foot, but this does not hold good universally.† A better difference is probably the position of the genital orifice, which appears to be, in *Stenopus*, some distance behind the head, as in *Zonites*, and not just behind the right tentacle, as in '*Nanina.*' After *Stenopus* follow *Macrochlamys* of Benson (1832) and *Ariophanta* of Desmoulins (1833), the first founded on *H. indica* (Benson *nec.* Pfr.), believed by many authors to be the same as *H. vitrinoides*, the second founded on *H. lævipes.* The name *Nanina* was given in 1834. My impression is that *Helicarion, Macrochlamys*, and *Ariophanta* will have to be accepted as genera, *Nanina* being merely a synonym of *Macrochlamys.*

I must apologize for taking up space by repeating what has been often written before, but it is only right to explain why I now describe as *Hemiplecta, Euplecta*, &c. shells allied to others formerly in these 'Contributions' called *Nanina.*

1. Ariophanta immerita. Plate III, Fig. 4, 4*a*.

Nanina (Ariophanta) immerita, W. Blanf., J. A. S. B., 1870, xxxix. pt. 2, p. 17.

Helix immerita, Pfr., Mon. Hel. vii. p. 128; Hanley & Theobald, Conch. Ind. pl. cl, fig. 7.

This shell was originally described from an immature specimen, and the same was figured in the 'Conchologia Indica.' Subsequently, Col. Beddome obtained an adult shell from the same locality, South Canara. Of this example a figure is now given. The species only differs in sculpture from *A. interrupta*, which is found in various parts of Bengal‡ and Orissa, and has been procured by Col. Beddome as far south as the Golcondah range of hills in Vizagapatam. The two forms replace each other in the eastern and western parts of the Indian peninsula, precisely as do their allies *A. lævipes* and *A. laidlayana.*

2. Oxytes sylvicola, sp. nov.

Testa perforata, depressa, carinata, solidula, oleoso-micans, epidermide crassiuscula obtecta fulva vel luteo-fusca, striis obliquis incrementi

* Gen. Rec. Mollusca, ii, p. 221.

† *E. g.* in *Macrochlamys*, some forms of which at least have the central tract narrower than the lateral.

‡ Amongst the localities given in the 'Hand-list of Mollusca in the Indian Museum,' part i. p. 19, is Singhar. This cannot be Sinhgarh near Poona, in the Deccan.

atque lineis impressis minutis spiralibus subdistantibus superne decussata (nucleo sublævigata), subtus lævior sed distincte decussato-striata. Spira parum elevata depresso-conoidea, fere convexa, apice obtuso, suturâ lineari, antice vix impressâ. Anfr. 5½, *sensim accrescentes, primi planulati, ultimi convexiusculi, ultimus haud descendens, subtus convexus, modice inflatus, sed infra carinam, nisi juxta aperturam, leviter compressus. Apertura obliqua, angulata-lunaris, intus livido-albida; peristoma acutum, intus subincrassato-labiatum, marginibus callo tenui junctis, columellari curvato, breviter reflexo. Diam. maj.* 32, *min.* 29, *axis* 17 *mm. Apert.* 16½ *mm. lata,* 13½ *oblique alta.*

Hab. In montibus 'Burail Range' dictis, ad alt. 3000-4000 pedum, in provincia 'North Cachar' Bengaliæ orientalis (*H. H. Godwin-Austen*).

Shell perforate, depressed, carinate, not very thin, having a greasy lustre, and a thick epidermis, tawny or yellowish brown, marked with oblique raised striæ of growth decussated by fine subdistant spiral impressed lines above (the nucleus almost smooth), and with fainter radiating striæ and concentric impressed lines below. Spire but little raised, almost convex, depressedly conoid, apex obtuse, suture linear at first, but slightly impressed near the mouth. Whorls 5½, gradually increasing, the inner nearly flat above, the outer slightly convex; the last not descending, convex and moderately swollen below, but slightly compressed just below the keel, except near the mouth. Aperture oblique, angulately lunate, a little broader than high, pale livid within. Peristome sharp, with a slightly thickened lip inside, the margins joined by a thin callus, columellar margin curved, reflected for a short distance at the perforation. Major diameter 1·26 inches, minor 1·14, axis 0·69, breadth of aperture 0·65, height (measured obliquely) 0·53.

There is a very remarkable resemblance between this shell and that described by me as *Nanina koondaensis* (J. A. S. B., 1870, xxxix, pt. 2, p. 16, pl. iii, fig. 12), yet I am by no means sure that both belong to the same section or subgeneric group. *N. koondaensis* is an ally of *N. indica* (Pfr.) and *N. shiplayi*, shells doubtless nearly allied to *Hemiplecta*, and very possibly belonging to that subgenus, but hitherto referred to *Rotula*,* or to other sections. *O. sylvicola* is larger, more solid, and covered with a distinct epidermis, and the sculpture is less granulate above, the spiral impressed lines being more distant.

I have seen but one specimen of *O. sylvicola*, for which I am indebted to Col. Godwin-Austen. It is figured here. Other specimens, I learn, are larger.

* Stoliczka, J. A. S. B., 1871, xl, pt. 2, 231.

3. Hemiplecta tinostoma, sp. nov., Plate III, Fig. 1.

Testa anguste umbilicata, convexo-depressa, confertim striis spiralibus minutis lineisque incrementi decussata; fulva, lineâ pallidâ angustâ supra peripheriam, alterâ fuscâ infra, cincta; subtus pallidior, lævior, nitidula. Spira convexa, apice obtuso, suturâ primum lineari, antice impressâ. Anfr. 5, *planiusculi, sensim accrescentes; ultimus convexior, antice latior subascendens, ad peripheriam angulatus, subtus convexus, aperturam versus planulatus. Apertura obliqua, multo latior quam alta, lunato-oblonga, intus albescens, fasciâ peripherali albidâ conspicuâ; peristomatis marginibus subparallelis, callo tenui junctis, basali albo, recto, crassiusculo, longe obliquo, ad umbilicum subreflexo, supero arcuato, leviter inflexo. Diam. maj.* 50, *min.* 39, *axis* 21 *mm.; apert.* 28 *mm. lata,* 18 *oblique alta.*

Hab. In montibus 'Tinnevelly Ghats' dictis Indiæ meridionalis, ad latus orientale provinciæ Travancore (*H. Beddome*).

Shell narrowly umbilicate, convexly depressed, closely decussated with fine spiral striæ and lines of growth, smoother beneath, yellowish brown above, paler below, surrounded by a narrow pale line just above the periphery and a dark line below. Spire convex, apex obtuse; suture at first flat, becoming impressed towards the mouth. Whorls 5, the first nearly flat; the last convex above, becoming more so towards the aperture, where it is rather broader and rises a little; below, the shell is convex, but flattened near the mouth, and the greater breadth of the last whorl near the aperture is more conspicuous than above. Aperture oblique, much wider than high, brownish livid, with a whitish enamel within, the pale peripheral band being conspicuous; peristome slightly sinuate, the upper and lower margins nearly parallel, the former slightly inflexed, the latter oblique, straight, white, and somewhat thicker than the other margins. Major diameter 2 inches, minor 1·55, axis 0·85; breadth of aperture 1·1, height (measured obliquely) 0·72.

This shell somewhat resembles *H. basilessa* and *H. beddomei*, but differs from both in the peculiar form of the aperture and the great flattening of the last whorl beneath. The fine, decussated, almost granulate sculpture of the present species, and the less rapid increase of the last whorls would serve to distinguish it from either of the forms named, even if the peculiar shape of the aperture proved to be an individual peculiarity—not a very probable supposition, as there is a faint approach to the same change of form in the last whorl in *H. basilessa*..

But a single specimen has been procured by Col. H. Beddome, and entrusted to me for description. This shell was obtained on the Tinnevelly Ghats, between Tinnevelly and Travancore, at a spot east of Papanassam, and at an elevation of 5000 feet.

4. HEMIPLECTA ENISA, sp. nov., Plate III, Fig. 2, 2*a*.

Testa anguste umbilicata, depressa, subcarinata, fulvo-castanea, subtus pallidior; fasciâ exiguâ peripherali albidâ circumdata, confertim striis incrementi lineisque minutis spiralibus subgranulatim decussata, circa umbilicum lævior. Spira depresso-convexa, apice obtuso, suturâ primum lineari, antice impressâ. Anfr. 4½, *planiusculi, sensim accrescentes: ultimus superne magis convexus, ad peripheriam subangulatus, antice latior, subtus convexus, juxta aperturam paululo compressus. Apertura obliqua, latior quam alta, lunato-oblonga, supra peripheriam subangulata, intus pallide livida, fasciâ peripherali albescente conspicuâ; peristomatis marginibus subparallelis, callo tenui granulato junctis, supero externoque arcuatis, haud inflexis vel incrassatis, basali albo, recto, obtuso, longe obliquo, ad umbilicum subreflexo. Diam. maj.* 42½, *min.* 36, *axis* 20 *mm.; apertura* 23 *lata*, 17 *oblique alta.*

HAB. In montibus 'Aghastyamullay' dictis, inter provincias Tinnevelley atque Travancore, in Indiâ meridionali (*H. Beddome*).

Shell narrowly umbilicate, depressed, subcarinate, yellowish chestnut, paler and dull yellow below around the umbilicus, surrounded by a narrow pale band, which is only well marked near the mouth; the sculpture is fine and subgranulate, formed by decussating striæ of growth and fine spiral lines, the latter disappearing below near the umbilicus. Spire depressedly convex, apex obtuse; suture linear, and not impressed, except in the anterior half of the last whorl. Whorls 4½, all except the last flat, gradually increasing; the last whorl more convex above, especially towards the mouth, where it is slightly broader, subangulate at the periphery, convex below, but a little compressed close to the mouth. Aperture oblique, broader than high, lunately semioval, subangulate at the upper portion of the outer edge, pale livid within, with the narrow whitish band along the blunt keel very conspicuous. The peristome is not thickened, except very slightly along the basal margin, which is white, oblique, and straight for a considerable distance, being very slightly reflected at the umbilicus; the other margins are regularly convex, the upper and lower margins being subparallel; the callus connecting the free margins of the aperture is thin, but granular. Major diameter 1·72 inches, minor 1·4, axis 0·8; aperture 0·95 inch broad, 0·68 high (measured obliquely).

Col. Beddome has sent to me two specimens of this shell, one adult, the other not quite fully grown. The species is near *H. tinostoma*, but is considerably smaller, and the peculiar flattening and compression of the last whorl, near the mouth, is far less, the aperture being, in consequence, not nearly so broad in proportion to the height. Another allied form, also from Travancore, is *H. basilessa;* but this is a thicker shell, with broader whorls and rather a thick lip to the aperture; the sculpture, too, is different. None of the remaining species of *Hemiplecta* occurring in the Malabar province have the mouth compressed.

5. Xestina* albata, sp. nov., Pl. III, Fig. 3, 3*a*., 3*b*.

Testa angustissime atque subobtecte umbilicata, depresso-globosa, solidiuscula, rugoso-striata, lineis impressis distantibus spiralibus superne circumdata, albida, eburnea. Spira depresso-conica, apice obtuso, suturâ impressâ. Anfr. 5½, *convexiusculi, sensim accrescentes, primi translucentes, sublævigati; ultimus primum, nec antice, ad peripheriam subangulatus, aperturam versus latior, vix descendens, subtus subinflatus. Apertura obliqua, late lunaris; peristomate superne simplici, extus subtusque subreflexo, juxta umbilicum reflexo atque subincrassato, margine basali arcuato. Diam. maj.* 29, *min.* 23½, *axis* 17½ *mm.; apert. intus* 15 *lata,* 14 *oblique alta.*

Hab. Ad Papanassam, in montibus ad latus occidentale provinciæ Tinnevelly, Indiæ meridionalis (*H. Beddome*).

Shell very narrowly and subobtectly umbilicate, depressedly globose, subangulate at the periphery, rather solid, ivory-white, the surface wrinkled, forming a coarse oblique striation across the whorls, with fine spiral distant impressed lines on the upper surface only of the two last whorls. Spire depressedly conical, apex obtuse, suture impressed. Whorls 5½, slightly convex, regularly increasing, the first almost smooth and translucent; the last whorl at first subangulate at the periphery, the angulation disappearing some distance behind the mouth, the lower portion inflated near the aperture, which is oblique and broadly lunate. Peristome simple above, subreflected on the outer and basal margins, rather thicker and turned back near the umbilicus, which it partly covers; the basal margin is curved forwards. Major diameter 1·5 inch, minor 0·95 axis 0·7; breadth of aperture inside 0·6, height (measured obliquely) 0·56.

This form is allied to *X. maderaspatana* (*Helix maderaspatana*, auct.), but it is thicker, much more coarsely sculptured, and white in colour. The peristome too is slightly reflected. There is some resemblance also to *X. belangeri* in form, but the mouth is somewhat differently shaped, and the sculpture of *X. albata* is coarser. *X. belangeri* appears to be a near ally of *X. tranquebarica, semirugata,* and *bombayana,* forms differing in shape, but so variable and so closely allied that it is very doubtful whether they really merit distinction. All of these forms have a horny shell differing from the ivory-white substance of the species now described.

* Pfeiffer, J. B. Jahrbuch d. Mal. Ges. v, p. 257.

But a single specimen has been sent by Col. Beddome. I think I have seen the same, or a very similar form, from either the Pulneys or some other range of Southern India; but I cannot find specimens in my collection.

6. Euplecta vidua. Plate II, Fig. 5.

Helix vidua, W. Bl., MSS.; Hanley, Conchologia Indica, pl. cxxx. figs. 2, 3.

Nanina climacterica, Bens., var. *vidua*, Nevill, Hand-list Mollusca, Indian Museum, Calcutta, pt. i. p. 30.

Testa imperforata, conoideo-depressa, superne oblique confertim atque arcuatim filiformi-costulata, subtus lævigata, polita, radiatim striatula, superne pallide cornea, subtus pallidior. Spira depresso-conica, lateribus subrectis, apice acutiusculo, suturâ impressâ. Anfr. 8, *convexi, arcti, lente accrescentes; ultimus superne ad peripheriam angulatus, antice vix descendens, subtus convexus. Apertura obliqua, lunaris, latior quam alta. Peristoma obtusum, leviter sinuatum, intus vix albo-labiatum, margine basali arcuato, columellari vix reflexo. Diam. maj.* 17, *min.* 15½, *axis* 9½, *mm.*

Hab. In montibus Garo Khasi et Naga dictis, vallem Assamensem meridiem versus contingens (*Masters, Godwin-Austen*).

Varietas minor, depresso-turbinata, spirâ conicâ. Diam. maj. 14, *min.* 12½, *axis* 9 *mm.* (Pl. II, Fig. 2.)

Hab. Cum præcedente.

Shell imperforate, conoidly depressed, above ornamented with oblique, close, and arcuate fine hair-like costulation, smooth and marked with radiating striæ below; pale horny, paler beneath. Spire depressedly conical, the sides nearly straight, apex rather sharp, suture impressed. Whorls 8, convex, narrow, slowly increasing in size, the last angulate above at the periphery, scarcely descending towards the mouth, convex below. Aperture oblique, lunate, broader than high. Peristome not sharp, slightly wavy, with a very slight white thickening inside, the basal margin curved forward, the columellar scarcely reflected. Major diameter 0·67, minor 0·62, axis 0·38 inch.

The above is the typical form; but there is a smaller variety, depressedly turbinate in shape, with the spire conical, measuring 0·55 inch in its major diameter and 0·36 in height. This form passes by insensible gradations into the type.

The shell represented in the 'Conchologia Indica' is intermediate between the two varieties here described and figured; the apex in the 'Conchologia' figure is more prominent and blunt than in the specimens now before me. These were procured from the Naga hills, south of Gola Ghat, Assam, by Mr. Masters in 1859; other specimens were subsequently found on the Garo, Khasi, and Naga hills by Colonel Godwin-Austen. The shells from the Khasi hills have the filiform costulation on the upper surface finer and less regular than those from the Assam side of the Naga hills. In Khasi shells 2, 3, or 4 ribs occur at nearly regular intervals, and then a rib appears to be omitted; this is not the case with those from upper Assam.

The species scarcely differs from *E. ornatissima*, found on the other side of the Brahmaputra valley at the base of the Sikkim hills, except in being imperforate. *E. climacterica*, of which Mr. Nevill considers the present shell a variety, is always sharply keeled at the periphery. The two forms may pass into each other, but I have never seen any intermediate links; and as they differ from each other much more than *E. vidua* does from *E. ornatissima*, or *E. climacterica* from *E. austeni*, it is better to have distinctive names for them.

I am indebted to Col. Godwin-Austen for the following note on the animal of *E. vidua* observed at Cherra Poonjee, Khasi hills.

"Animal of a neutral grey tint about the neck and eye-tentacles, which are rather long and fine, the oral tentacles are also of a dark tinge. Extremity of foot truncated, with mucous gland. Body long and thin. No tongue-like processes to the mantle observed."

The genus *Euplecta* was proposed by Semper* for two Ceylonese shells *Helix subopaca* and *H. layardi.* The latter of these is referred by both Theobald† and Nevill‡ to *Situla*, a position which is scarcely tenable, for the animal of *H. layardi* is destitute of shell-lobes, whilst these are present in *Situla*§; and the odontophores are very different, neither the shape nor number of the teeth being similar. At the same time, I am rather doubtful whether *H. layardi* should not be placed in a separate section from *H. subopaca* on account of differences both in the shell and odontophore. The last-named species, however, is, I think, to be accepted as type. It is greatly to be regretted that Semper should have adopted so loose and uncertain a proceeding as to name two distinct forms as types of one genus. In such a case, the only plan is to take the first-named—in this case, *H. subopaca*—as the type of *Euplecta.*

The genus is thus defined by its author in German:—*On the mantle edge only neck-lobes are present, the left is divided into two separate lappets (as in many Helices). Above the caudal gland there is a short horn. The shell entirely exterior, ribbed or striated above, smooth below. On the*

* Reisen im Archipel der Philippinen, 2te theil, Wis. Res. vol. iii, p. 14.

† Cat. p. 20.

‡ Hand-list, p. 34.

§ See, for description of the animal and odontophore of *Situla* (or *Conulema*, which is the same), Stoliczka, J. A. S. B., 1871, vol. xl, pt. 2, p. 236.

genital organs a cylindrical female supplementary gland (Anhangsdrüse) *with a cartilaginous point* (*analogous to the dart?*) *; on the* vas deferens (Samenleiter) *a closed appendage, in which calcareous concretions are formed, and a flagellum.*

The odontophore is not noticed in the generic description. In *E. subopaca*, the number of teeth in each cross-row is about 100, central tooth tricuspid, the neighbouring laterals 12 in number distinctly bicuspid, from the 13th to the 24th almost without a trace of the little lateral point, which, however, reappears in the outer laterals. *Euplecta* belongs to Semper's subdivision *Ceratophora* with a horn-like lobe above the caudal gland, and the sole of the foot divided into a central and two lateral regions as in *Macrochlamys* (and *Stenopus*).

In the characters of both shell and animal, so far as we know the latter, there is a remarkable resemblance between *E. subopaca* and *E. vidua*. The connection between *E. vidua* and *E. climacterica* has already been noticed, and in the latter the odontophore (of which Col. Godwin-Austen has kindly furnished me with notes and drawings) agrees very closely with that of *E. subopaca*. The following is a description of the teeth in *E. climacterica* :—

"Median tooth tricuspid, the central point very long, the lateral cusps very small. The first 14 laterals are long and broad with a single short small cusp on the lower outer margin, the 25 outermost are long narrow, curvilinear, bicuspid, the outer point the shorter, being less than half as long as the inner. Jaw slightly curved, the front edge a little convex."

The number of teeth in a row is apparently 79. A sketch shews that the form of both central tooth and laterals is very similar to that in *E. subopaca*.

Euplecta is by Semper classed apart from *Rotula*. The animal of the type of this latter genus (*H. detecta*, from Bourbon) is still unknown. Semper has described the anatomy of two very different species, and there is no proof that they are congeneric. It is also extremely doubtful whether, of the forms referred to *Rotula* by Stoliczka,* any belong really to the section; and I am disposed to believe that Nevill was right in removing them in his 'Hand-list,' where, however,† he simply classes them in *Nanina* without specifying any subgeneric group. Judging, it is true, chiefly from the shells, I should class the following Indian and Burmese species in *Euplecta* :—

Helix ponsa,‡ Benson ; from Burma.

* J. A. S. B., 1871, xl, pt. 2, p. 231 ; 1873, xlii, pt. 2, p. 14.

† l. c. pp. 28, 29, 30, &c.

‡ I find this short note on specimens of this species obtained in upper Burma in 1861 :—Animal of the *vitrinoides* type, but the projecting lobe (*i. e.*, that above the caudal gland) is small.

Nanina sikrigallensis, Nevill; Bengal, Behar (Hand-list, p. 28).
Helix climacterica, Benson; Assam hills, Burma.
Euplecta vidua, Assam hills.
Nanina austeni, W. Bl.; Garo hills, Assam.
N. falcata, W. Bl.; Garo hills, Assam.
Helix ornatissima, Benson; base of Himalayas, Sikkim and Nipal.

Helix serrula also probably belongs to the same genus. About *H. anceps* and its near ally, *H. arata*, I am more doubtful; for there are shell-lobes to the mantle in the former, and the teeth of the odontophore differ in several particulars.*

As regards *H. indica* (Pfr. nec Benson), *H. shiplayi*, and *H. acuducta*, I cannot now find the notes I made many years since on the animals, but I believe they belong to the forms allied to *Ariophanta*, in which the foot is broad with the sole undivided, and there is no projecting lobe above the caudal gland. The shells present much resemblance to the type of Albers' section *Thalassia*. *H. tugurium* and *H. camura* from Sikkim are still more like *H. subrugata* from Australia, the type of *Thalassia*.

7. Sesara? ingrami.

Helix ingrami, Blanford, Hanley, Conchologia Indica, pl. lx. figs. 9, 10.
Rotula diplodon, Bs., partim, Theobald, Cat. Land & Freshwater Shells Brit. Ind. p. 21.
Nanina (Sesara ?) diplodon, Bs., partim, Nevill, Handlist Moll. Ind. Mus. pt. i. p. 53.

Testa imperforata, trochiformis, tenuis, diaphana, pallide cornea, minutissime atque confertissime granulatim decussato-striata. Spira subconica, lateribus convexiusculi, apice obtuso, suturâ parum impressâ, lineâ filiformi marginatâ. Anfr. 6½, *regulariter accrescentes, vix convexiusculi, superiores lævigati; ultimus acute carinatus, non descendens, et supra et infra carinam compressus, basi extus decussato-striatus, atque, præsertim antice, aperturam versus, planulatus, intus convexiusculus atque lævigatus, striis medium versus evanescentibus, regione umbilicali impressâ. Apertura diagonalis, incurvo-triangularis, intus tridentatus, dentibus lamelliformibus omnibus basalibus, duobus in peristomate, uno majori falcato intrante, extus convexo, in medio margine basali, alio minori obliquo subcolumellari, tertio profundo, incurvo, transversim post majorem posito. Peristoma album, modice incrassatum, margine basali sinistrorsum arcuato, dextrorsum subangulatim sinuato, columellari vix reflexo. Diam. maj.* 6½, *min. vix* 6, *alt.* 4½.

Hab. In montibus 'Yoma' dictis, Pegu ab Arakan secernentibus, haud procul a vico Tongoop.

* Stoliczka, J. A. S. B., 1871, xl, pt. 2, pp. 234, 236.

Shell imperforate, trochiform, thin, translucent, pale horny, very minutely and closely striated both obliquely and spirally, so as to be covered, except on the upper whorls, with fine almost granular decussated sculpture. Spire nearly conical, with the sides slightly convex; apex obtuse; suture very little impressed, and with a filiform line above, the continuation of the keel on the last whorl. Whorls 6½, increasing regularly, nearly flat, only a little convex, the uppermost quite smooth, the sculpture growing stronger on the lower whorls; the last whorl sharply keeled, not descending, compressed both above and below the keel, with the outer portion of the base flat, especially towards the mouth, and decussated, the inner portion moderately convex and smooth, the sculpture gradually disappearing towards the middle; umbilical region impressed. Aperture diagonal, triangular with the sides curved, with three lamelliform teeth inside, all palatal, and in the basal margin: the largest is in the middle of the margin, and is much curved, with its convex side outwards; it begins by forming a kind of thickening to the lip, and then curves away into the interior of the whorl; the second is smaller, oblique, and situated near to the columellar margin; the third is at some distance within the aperture, it is curved, and placed transversely behind the first. Peristome white, somewhat thickened, the basal margin curved forwards near the umbilical region, and angulately curved back near the periphery of the shell; columellar margin scarcely reflected. Major diameter 0·25, minor 0·23, height 0·18 inch.

In the figure in the 'Conchologia Indica,' the internal tooth is not shown, although all the teeth are clearly seen through the semi-transparent base of the shell.

The caudal pore in the animal is very small, and furnished with a lobe in front of it, but the tail is not truncated abruptly as in *Macrochlamys.* This is the only note I can find on the soft parts.

This shell was named in MS. in the year 1861, and a specimen transmitted to Mr. Benson, who, however, doubted whether it could be distinguished from the Khasi-hill form described by him as *Helix diplodon.* The typical specimen of the latter must, I think, have been in poor condition, for it was described as "*lævigata, parum striatula*", whereas fresh specimens exhibit nearly the same fine subgranulate decussating striation as *S.? ingrami*, and Mr. Benson very probably, and very justly, thought that fresh specimens might agree with the Arakan shell in other characters. Subsequently, fresh specimens of *S. ? diplodon* were obtained from the original locality by Colonel Godwin-Austen; and I find that they differ from *S.? ingrami* not only in being minutely perforate, a character to which by itself I should attach little or no importance, but also in having but two teeth in the aperture instead of three, the internal transverse tooth of *S. ? ingrami* being deficient in *S.? diplodon*, whilst the other teeth are differently shaped. The sculpture is somewhat finer in *S. ? diplodon*, and the basal margin of the aperture is subangularly concave, without the curving forwards due to the transverse portion of the larger tooth in *S. ingrami.* The last character is well shown in the 'Conchologia' figure.

8. Macrochlamys ? platychlamys, sp. nov., Plate II, Fig. 9.

Testa perforata, conoideo-depressa, pertenuis, nitida, lævigata, sub lente obsolete striatula, fulvo-cornea. Spira parum elevata, apice obtuso, suturâ levi aliquando marginatâ. Anfr. 5, vix convexiusculi, regulariter accrescentes; ultimus non descendens, peripheriâ rotundatus, subtus convexus. Apertura obliqua, lunaris, latior quam alta. Peristoma tenue, simplex, leviter sinuatum, marginibus remotis, callo tenuissimo junctis, columellari brevissime verticali, peranguste reflexo. Diam. maj. 11, *min.* 9½, *axis* 5½.

Animal pallio maximo indutum, duos lobos latos linguiformes emittente, qui spiram testæ omnino circumtegunt.

Hab. Ad. Bombay.

Shell perforate, conoidly depressed, very thin, smooth, and polished, obsoletely striated beneath the lens, fulvous horny in colour. Spire subconical, but little raised, apex obtuse; suture smooth, scarcely impressed, sometimes marginate. Whorls 5, very slighly convex, regularly increasing in size, the last not descending, rounded at the periphery, convex below. Aperture oblique, lunate, broader than high. Peristome thin, simple, slightly curved when viewed from the side; margins distant and united by a thin callus; the columellar border vertical for a very short distance, slightly reflexed. Major diameter 0·44, minor 0·38, axis 0·22 inch.

This shell belongs to the group of thin, more or less depressed forms allied to the type usually known as *M. vitrinoides* (*M. indicus*, Benson). It appears, so far as I can see, to be undescribed, as is also, I believe, an allied form of darker colour, and with a subangulate periphery, occurring at Trichinopoly and elsewhere in the neighbourhood of the Coromandel coast south of Madras.

The animal of *M. platychlamys* is chiefly distinguished by the peculiarly broad shell-lobes, which, instead of being narrow and attenuate towards the ends, as in most allied species, are broad and flat, so as sometimes to cover the whole spire, and usually to conceal all except a narrow band. These lobes somewhat resemble those in the genus *Helicarion.* The lobe above the caudal gland is very much smaller than it usually is in *Macrochlamys* and rounded, not horn-shaped.

This shell is common in the island of Bombay and neighbouring lowlands on the west coast of India, and I have seen a form from the hills of the Wynaad in Southern India that appears undistinguishable. I have also several specimens of a *Macrochlamys* from the ancient town of Champanir, near Broach, that may very possibly be a variety of *M platychlamys*. The specimens are larger than the Bombay types, an adult measuring 16 mm. by 14 in its two diameters, and some individuals attain even greater dimensions; the mouth too is rather more convex beneath, but otherwise the two forms agree very closely.

The figure gives the idea of a rather thick shell, and the form of the mouth is incorrect, being too convex below and, consequently, too high in comparison with the breadth.

9. Macrochlamys tenuicula. Pl. II, Fig. 8.

Macrochlamys tenuicula, H. Ad., P. Z. S. 1868, p. 14, pl. iv, fig. 9.

Helix tenuicula, Pfr., Mon. Hel. vii. p. 94.—Hanley, Conch. Ind. pl. lxxxix, figs. 7, 10.

Macrochlamys effulgens, W. Bl., MSS.—Theobald, Cat. Land and Freshwater Shells of British India, p. 18.

Nanina (*Macrochlamys*) *effulgens*, Nevill, Hand-list Mollusca, Indian Museum, Calcutta, part i. p. 26.

Nanina (*Microcystis ?*) *tenuicula*, Nevill, ib. p. 36.

Testa aperte perforata, turbinata, tenuis, flavo- vel fulvo-cornea, lævigata, nitida, diaphana, oblique striatula, sub lente lineis impressis confertis minutis in anfractibus superioribus subtilissime decussata. Spira subconica, lateribus convexiusculis, apice obtuso, suturâ leviter impressâ. Anfr. 5½-6, *convexiusculi, regulariter crescentes, ultimus non descendens, ad peripheriam obsolete subangulatus, angulo omnino antice evanescente, sed in testis junioribus validiore, subtus convexus, radiatim striatulus. Apertura obliqua, ovato-lunaris, latior quam alta. Peristoma tenue, rectum, marginibus subconniventibus, columellari subverticali, breviter reflexo. Diam. maj.* 9, *min.* 8½, *axis* 6 *mm.*

Hab. Ad Bombay et in terris vicinis, necnon in montibus 'Western Ghats' seu 'Syhadri' dictis.

Shell openly perforate, turbinate, thin, yellow or fulvous horny, smooth, polished, transparent, obliquely striated, and under the lens finely decussated on the upper whorls with minute, close, impressed spiral lines. Spire subconical, the sides a little convex, apex obtuse, suture slightly impressed. Whorls 5½-6, rather convex, regularly increasing, the last not descending, obsoletely subangulate at the periphery (in immature shells distinctly angulate), the angle disappearing near the mouth, convex below and radiately striated. Aperture oblique, ovately lunate, broader than high. Peristome thin, straight, the margins approaching each other slightly, columellar margin subvertical, reflected for a short distance. Major diameter 0·36, minor 0·33, axis 0·24 inch. The foot of the animal is very long and narrow, and there are the usual pointed shell-lobes to the mantle. The colour of the body is almost black.

The shell described by the late Mr. H. Adams as *Macrochlamys tenuicula* appears to me almost certainly to be the immature form of a species common in Bombay. This form I have had for many years; and I formerly distributed specimens under the MSS. name of *Helix effulgens*, a name which has unfortunately got into print. The adult shell has never been described; but the specimen figured in the 'Conchologia Indica' must have been nearly full-grown. Mr. Adams's original types were said to be from Sattara. It is probable they came from the Western Ghats in the Sattara district; but the species may extend to the damper portions of the Deccan plateau.

The figures herewith given are very unsatisfactory; the left-hand figure is quite inaccurate. This, however, is of less importance, as the shell is very fairly represented in the 'Conchologia Indica.'

10. Macrochlamys? plicifera.

Nanina plicatula, W. Bl., J. A. S. B., 1870, xxxix, pt. 2, p. 13, pl. iii, fig. 7. *nec N. plicatula*, Mart., Nachrichtsbl. mal. Gesellsch., 1869, i, p. 149.

Helix plicatula, Hanley, Conch. Ind., p. 14, pl. xxviii, fig. 1.

Macrochlamys plicatula, Theobald, Cat. Land and Freshwater Shells Brit. Ind. p. 19.

Nanina, n. sp., Nevill, Hand-list Moll. Ind. Mus. Calcutta, p. 27.

I am indebted to Mr. Nevill for calling attention to the fact that the name I gave to this shell was pre-occupied. I propose to change the specific title to *plicifera.*

11. Macrochlamys? wynnei, sp. nov., Plate III, Fig. 5, 5a.

Testa perforata, subturbinato-depressa, striatula, nitida, albido-cornea, diaphana, fasciâ rufâ supra peripheriam circumdata. Spira depresso-conica, apice obtuso, suturâ leviter impressâ, fasciâ rufâ intus marginatâ. Anfr. 5½, *lente accrescentes, ultimus peripheriâ rotundatus, subtus modice convexus, aperturam versus vix descendens. Apertura late lunaris, obliqua, diagonalis; peristoma tenue, intus haud incrassatum, margine basali subrecto obtuso, columellari reflexo. Diam. maj.* 19, *min.* 17½, *axis* 9½ *mm.* (*ex icone*). *In exemplo minore diam. maj.* 13½, *min.* 12¼, *axis* 7½ *mm. apert.* 7 *lata*, 6 *oblique alta.*

Hab. Ad Mari (Murree) in montibus Himalayanis occidentalibus inferioribus haud procul a flumine Jhelum (*A. B. Wynne*).

Var. *major, depressa, anfractibus* 6, *spirâ convexâ, parum elevatâ: diam. maj.* 21½, *min.* 19½, *axis* 10 *mm., apert.* 11½ *lata,* 10 *oblique alta.*

Hab. Etiam ad Mari.

Shell perforate, subturbinately depressed, faintly striated, polished white, translucent, surrounded by a narrow rufous band above the periphery. Spire depressedly conical, apex obtuse, suture slightly impressed, and with a rufous margin inside. Whorls 5½, increasing slowly and regularly, the last rounded at the periphery, moderately convex beneath, scarcely descending towards the mouth. Aperture broadly lunate, oblique, diagonal; peristome thin, not thickened inside, basal margin almost straight, columellar reflected. Major diameter 0·76, minor 0·7, axis 0·37 inch (taken from the figure). A smaller specimen measures:—major diam. 0·54, minor 0·5, axis 0·3, breadth of aperture 0·27, height (obliquely measured) 0·23 inch.

There is a larger variety, more depressed, with the spire convex and six whorls. It may possibly be a distinguishable form, but I think not. A specimen measures:—major diameter 0·85, minor 0·78, axis 0·42, breadth of aperture 0·45, height (obliquely measured) 0·4.

I greatly question whether this form is really a *Macrochlamys*, and cannot help suggesting the possibility of its belonging to a different subgeneric group, or even to *Zonites*. However, it is associated at Mari with a true *Macrochlamys* (*M. prona**) and two or three species of *Helicarion;* so it is evident that a few of these tropical types extend to this extreme north-western portion of the Himalayan range, where, however, the majority of the mollusca consist of *Bulimini* of the *Petræus* section.

The specimen of *M. wynnei* from which the accompanying figure was taken has been mislaid or lost, and the description is drawn up from a smaller individual. I have named the shell after Mr. A. B. Wynne of the Geological Survey of India, to whom I am indebted for several mollusca from the neighbourhood of Mari.

I have been in some doubt as to whether this might not be a form of the shell described by Prof. v. Martens as *Nanina jacquemonti* (Malak. Bl. xvi. 1869, p. 75; Pfr. Nov. Conch. iv. p. 48, pl. cxviii, figs. 6-8); but, in the first place, it can scarcely, I think, be the species figured by Jacquemont (Voyage dans l'Inde, Atlas, pl. xvi. fig. 2), and, secondly, *N. jacquemonti* is described as having "*peristoma obtusum, intus incrassatum, margine...basali leviter arcuato,*" none of which can apply to the present species. Pfeiffer's figure in the 'Novitates' shows a very much less oblique mouth than is found in *Macrochlamys? wynnei*. Now, I have another species from Mari, which agrees admirably with Marten's description in these re-

* Nevill, 'Scientific Results of the Second Yarkand Mission,' Mollusca, p. 17.

spects, and which resembles Jacquemont's figure also, but it wants the red band round the periphery shown in Pfeiffer's figure. It is just possible that two species are included by Martens. The true *N. jacquemonti* is probably a *Bensonia.*

12. Pupa (Pupisoma) evezardi.

"*Pupa (Pupisoma) evezardi,* Blanford," Nevill, Hand-list Moll. Ind. Mus. Calcutta, pt. i. p. 192.

? "*Pupa evezardi,* Blanford MS.," Hanley, Conch. Ind. p. 41. pl. ci, figs. 5, 6.—Theob. Cat. Land & Freshwater Shells Brit. Ind. p. 30.—Pfr. Mon. Hel. viii. p. 415.

Testa imperforata, vix subrimata, conoideo-ovata, tenuis, cornea, lineis elevatis irregularibus filiformibus obliquis ornata. Spira subtus subcylindracea, superne conoidea, lateribus convexis, apice obtuso, suturâ impressâ. Anfr. 4½, *convexi, regulariter crescentes, ultimus parum major, peripheria atque basi rotundatus, haud antice descendens. Apertura diagonalis, truncato-rotunda, edentula; peristoma tenue, rectum, expansiusculum, marginibus conniventibus, columellari verticali, ad basin subtorto, adnato-reflexo, regionem umbilicalem tegente. Long.* 2¾, *diam. fere* 2, *long. ap.* 1 *mm.*

Hab. In cortice arborum ad Khandalla inter Bombay et Poona (*G. Evezard*).

Shell imperforate, with scarcely even a trace of rimation in the umbilical region, conoidly ovate, thin, horny, with raised hair-like oblique lines, rather irregularly disposed, on all the whorls. Spire nearly cylindrical below, conoidal above, the sides convex, apex blunt, suture impressed. Whorls 4½, convex, increasing in size regularly; the last but little larger than the penultimate, rounded at the periphery and below, not descending in front. Aperture diagonal, nearly circular, but truncated above, without teeth; peristome thin, all in one plane, slightly expanded, margins converging; columellar vertical above, slightly twisted below, reflected and united to the whorl so as completely to cover the umbilicus. Length 0·11, diameter 0·08, length of aperture 0·04 inch.

If the form represented by Hanley in the 'Conchologia Indica' be precisely the same as that described above, I am inclined to question the locality given, "Singhur," or, as Mr. Theobald prefers writing it, "Synghar," presumably Sinhgarh, near Poona. The original specimens were found by Colonel Evezard at Karkalla, near Khandalla, at the head of the Bor-ghat; and I suspect that Hanley's figure was taken from one of them. There are two or three allied forms found in the Syhadri range and the Nilgiris, forms that do not appear hitherto to have been described.

The subgenus *Pupisoma* was proposed by Stoliczka* for the Moulmein

* J. A. S. B., 1873, vol. xlii. pt. 2, p. 32.

*P. lignicola,** a form very closely resembling *P. evezardi,* but rather shorter and less ovate. It is by no means improbable that intermediate varieties may be found; indeed, so much do I doubt whether the two are really worthy of distinction that I should not have described the present species if the name had not already crept into print.

Mr. Nevill, in his Hand-list *l. c.*, has referred the *Helix orcula* of Benson to the same section of *Pupa* as *P lignicola;* and in this he is, I think, unquestionably right.

13. Succinea collina.

"*S. collina,* Blanford, MS.," Hanley, Conch. Ind. p. 30, pl. lxviii. figs. 8, 9, 10; Theobald, Cat. Land and Freshwater Shells Brit. Ind. p. 31; Pfr., Mon. Hel. viii. p. 558; Nevill, Hand-list Moll. Ind. Mus. pt. i. p. 212.

Testa conico-ovata, tenuiuscula, parum nitida, distincte atque flexuose striata, viridescenti-cornea. Spira scalāris, apice acutiuscula, suturâ valde impressâ. Anfr. vix 3, *perconvexi, ultimus* $\frac{4}{5}$ *longitudinis subæquans. Apertura ovata, obliqua; peristoma tenue, margine dextro mediocriter arcuato; columella arcuata, recedens, callosa. Long.* 17, *diam.* 10, *alt.* (*v. diam. min.*) 6 *mm., apertura* 13 *mm. longa, vix* 9 *lata.*

Hab. Saxis rupibusque adhærens prope Mahabaleshwar ad summos montes 'Syhadri' seu 'Western Ghats' dictos Indiæ occidentalis.

Var. *aurantiaca v. rufo-cornea; habitat in colle 'Torna' dicto, inter Mahabaleshwar atque urbem Poona.*

Shell conically ovate, rather thin, but little polished, distinctly and flexuously striated, greenish horny in colour. Spire step-like, apex rather pointed, suture much impressed. Whorls scarcely 3, very convex, the last about $\frac{4}{5}$ of the length. Aperture oval, oblique; peristome thin, the right margin moderately curved forwards; the columella arcuate, receding, and covered with a thin callus. Length 0·76, diameter 0·4, height (when laid mouth downwards) 0·24 inch; length of aperture 0·52, breadth 0·36 inch. The largest shell I possess measures 20 mm. in length (0·8 inch). A rufous variety occurs at Torna Hill, near Sinhgarh, west of Poona.

This is a rock-inhabiting species,† found on cliffs and large blocks of basalt at Mahabaleshwar and Torna, and is allied to *S. girnarica,* a larger and thicker form, rather differently shaped, found by Mr. Theobald

* J. A. S. B., 1871, vol. xl. pt. 2, p. 171.

† It is rather difficult to understand why *Succinea* should be placed amongst freshwater shells in the 'Conchologia Indica.' Most of the Indian forms are found either on trees (often on palms) or on rocks, and generally at a distance from water. *Lithotis* and *Camptonyx* are also, I think, incorrectly classed as freshwater shells, both being found on basaltic cliffs.

on the basaltic rocks of Girnar Hill, in Kattywar. The animal of *S. collina* bears a considerable external resemblance to that of the subgenus *Lithotis*, which has a similar habitat.

The figures in the 'Conchologia Indica' give a fair idea of the species, but the spire in fig. 8 is rather too large.

14. STREPTAXIS COMPRESSUS, sp. nov., Plate II, Fig. 13.

"*S. compressus*, Wl. Bl.," Theobald, Cat. Land and Freshwater Shells Brit. Ind. p. 33.

Testa subaperte sed non pervie umbilicata, valde depresso-ovata, cereo-albida, diaphana, nitida, vix striatula. Spira vix convexa, fere plana, suturâ parum impressâ. Anfr. 4½, *penultimus postice compressus, obtuse sed prominenter carinatus ; ultimus valde eccentricus, antrorsum devians, subtus planulatus politusque, circa umbilicum, præsertim antice, angulato-coarctatus, pone aperturam fossiculis impressis constrictus. Apertura diagonalis, semiovalis, laminâ unâ validâ subbifidâ intrante parietali, dente uno duplici columellari, tribus palatalibus in margine dextro, coarctata. Peristoma incrassatum, undique sublate expansum, postice juxta angulum mediocriter sinuatum, marginibus callo lamellifero junctis. Diam. maj.* 6½, *min.* 3¾, *alt. vix* 3 *; ap. long.* 2½, *lat.* 2 *mm.*

HAB. In montibus 'Sivagiri' dictis (Tinnevelly) Indiæ meridionalis (*H. Beddome*).

Varietas anfractibus quinque, superne et in umbilico confertim filiformi-striata, laminâ parietali duplici, in montibus habitat prope urbem Cumbum. Exempli majoris diam. maj. 6½, *minoris* 5¼, *diam. min.* 4 *et* 3½, *alt.* 2¾ *et* 2½.

Shell rather openly but not perviously umbilicated, depressed, oval, yellowish white, translucent, glossy, scarcely striated. Spire almost flat, suture but little impressed. Whorls 4½, the penultimate compressed and prominently but bluntly keeled posteriorly; the last very eccentric, flattened and smooth below, and angulately compressed around the umbilicus, and especially near the mouth, where there are indentations corresponding to the teeth inside. Aperture diagonal, semioval, and furnished with five teeth, one strong re-entering bifid plait on the parietal callus uniting the margins of the peristome, one large double tooth on the columellar side, three palatal teeth on the right side. Peristome thickened and expanded, curved back near the posterior angle. Major diam. 0·25, minor 0·15, height 0·11 inch.

A variety from the Cumbum hills has distinct but very fine close filiform raised lines on the upper surface and inside the umbilicus, and the parietal lamina is double. Some specimens are rather smaller than the type. It is doubtful whether these differences justify a separate name.

15. STREPTAXIS PERSONATUS, sp. nov., Plate II, Fig. 10.

"*S. personatus*, Wl. Bl.," Theobald, Cat. Land and Freshwater Shells Brit. Ind. p. 33.

Testa umbilicata, depressa, sphæroideo-ovata, lævigata, nitidula, diaphana, cereo-albida. Spira depressa, apice vix exserto, suturâ impressâ. Anfr. 5, *convexi, penultimus postice rotundatus, vix ultra ultimum (a basi spectatus) projiciens; ultimus eccentricus, antrorsum devians, subtus convexus, circum umbilicum compressus, post aperturam fossiculis impressis constrictus. Apertura obliqua, fere semiovalis, laminâ unâ validâ flexuosâ intrante parietali, dentibusque* 5, *tribus in margine columellari, duobus in dextro, harum uno inferiore majore laminæ parietali opposito, alio minore superiore, coarctata. Peristoma incrassatum continuum, fere solutum, album, undique late expansum, postice juxta angulum subprofunde retrosinuatum, margine parietali valido, concavo. Diam. maj.* 5, *min.* 3¾, *alt.* 2½.

HAB. In montibus haud procul ab urbe Cumbum (Madura) Indiæ meridionalis (*H. Beddome*).

N. B. *In nonnullis exemplis peristoma quadri-vel tridentatum nec quinquedentatum est, dente uno columellari et aliquando uno palatali carens.*

Shell umbilicated, depressed, spheroidally ovate, smooth, moderately polished, translucent, pale yellowish white. Spire depressed, the apex scarcely exserted, suture impressed. Whorls 5, convex, the penultimate rounded behind, scarcely projecting beyond the last when seen from below; the last eccentric, convex below, compressed around the umbilicus, and constricted by pits corresponding to the teeth inside, just behind the mouth. Aperture oblique, irregularly semioval, and furnished with one strong re-entering parietal lamina, curved inside, and with five teeth, three on the columellar margin, two on the right; of the latter the lower is larger and opposite to the parietal lamina, the smaller is above, nearer to the angle. Peristome thickened, continuous, almost free (the thick callus which unites the columellar and dextral margins projecting from the last whorl, in a hollow curve, the concavity corresponding to the parietal lamina); the outer margins expanded, the right margin deeply recurved close to the posterior angle. Major diameter 0·2, minor 0·15, height 0·1 inch.

In other specimens, rather worn, and with the peristome somewhat less developed, the teeth are rather smaller, the upper columellar tooth is wanting, and in one case the upper tooth on the right margin is also deficient. All, however, are characterized by the great development of the parietal callus.

16. Streptaxis concinnus, sp. nov., Plate II, Fig. 11.

Testa umbilicata, depressa, globoso-ovata, striatula, nitidula, diaphana, cereo-albida. Spira depresso-conica, parum exserta, apice obtusiusculo, suturâ impressâ. Anfr. 5, convexi, penultimus postice rotundatus, haud ultra ultimum (a basi spectatus) projiciens; ultimus inflatus, multo major, eccentricus, antrorsum devians, subtus convexus, lævigatus, politus, circum umbilicum praesertim antice compressus, post aperturam fossiculis impressis constrictus. Apertura obliqua, fere semiovalis, lamellis duobus intrantibus parietalibus, sinistrâ longiore, intus tortâ, dentibusque 5, duobus columellaribus, superiore minore juxta umbilicum, inferiore magno duplici, uno basali lamelliformi transverso, duobusque in margine dextro, inferiore subbifido, superiore minore, coarctata. Peristoma album expansum, ad angulum postice vix sinuatum, marginibus callo duas lamellas ferente junctis. Diam. maj. 5¾, *min.* 4, *alt.* 3½ *mm.*

Hab. In montibus 'Balarangam' dictis (Mysore) Indiæ meridionalis (*H. Beddome*).

Shell umbilicated, depressed, globosely ovate, rather indistinctly striated, shining, translucent, pale yellowish white. Spire very low, scarcely exserted, apex blunt, suture impressed. Whorls 5, convex, the penultimate rounded behind, and not projecting, when viewed from below, beyond the lower whorl; the last whorl much larger than the others, eccentric, convex below, smooth and polished, compressed around the umbilicus, especially near the mouth, and constricted by indentations, corresponding to the teeth inside, just behind the lip. Aperture oblique, nearly semioval, and furnished with two plaits on the parietal side, that to the left (nearest to the umbilicus) longer than the other and bent inside; there are five teeth in the peristome, one on the columellar margin near the umbilicus, a second large and double nearer the base, one lamellar and transverse at the base, two inside the right margin, the lower being larger than the other and almost bifid inside. Peristome white, slightly expanded, scarcely sinuate near the angle, margins joined by a callus bearing the two parietal plaits. Major diameter 0·23, minor 0·2, height 0·13 inch.

This is the only known species from Southern India, so far as I am aware, in which, when the shell is viewed from below in the direction of the axis, the penultimate whorl does not project at all beyond the body-whorl. The transverse lamellar tooth at the base of the aperture is also peculiar.

17. Streptaxis pronus, sp. nov., Plate II, Fig. 12.

Testa umbilicata, depresso-ovata, superne confertim atque arcuatim costulato-striata, nitidula, diaphana, cereo-allida. Spira depresso-conica, parum exserta, apice obtuso, suturâ parum impressâ. Anfr. 5½, *superiores convexiusculi, penultimus postice rotundatus, longe ultrà ultimum (a basi spectatus) projiciens; ultimus valde eccentricus, antrorsum devians, subtus subplanulatus, lævigatus, in umbilico striis filiformibus flexuosis ornatus, circum umbilicum compressus atque aperturam versus angulatus, juxta peristoma scrobiculis constrictus. Apertura obliqua, truncato-ovalis, lamellâ validâ parietali intrante flexuosâ, antice subbifidâ, dentibusque quatuor, uno columellari, alio basali, duobus in margine dextro, coarctata. Peristoma incrassatum, subcontinuum, album, expansum, marginibus callo crasso lamellifero junctis, dextro prope angulum sinuatum. Diam. maj.* 6½, *min.* 4, *alt.* 3 *mm.*

Hab. In montibus haud procul ab urbe Tinnevelly Indiæ meridionalis (*H. Beddome*).

Shell umbilicated, depressedly ovate, closely and arcuately ornamented above with subcostulate striation, polished, translucent, pale yellowish white. Spire low, conical, but little exserted, apex obtuse, suture but little impressed. Whorls 5½, the upper slightly convex, the penultimate rounded behind and projecting considerably beyond the lower whorl when viewed from below; last whorl very eccentric, somewhat flattened beneath, smooth, except within the umbilicus, where there are fine, irregularly flexuous filiform raised lines on the surface, compressed around the umbilicus and angulate near the aperture, where there are deep indentations corresponding to the teeth inside. Aperture oblique, truncately oval, furnished with a strong re-entering parietal plait, curved within and subbifid in front, and with four teeth—one columellar, one basal, and two (of which the upper is small) inside the right margin. Peristome thickened, subcontinuous, white, expanded, the margins joined by a thick callus projecting from the body-whorl and bearing the parietal lamella. Major diameter 0·26, minor 0·16, height 0·12 inch.

This shell resembles *S. compressus* in form, but it wants the angulation of the penultimate whorl. The peristome is much thickened, as in *S. personatus.*

The forms of *Ennea* and *Streptaxis* described in this paper are the principal that have been collected in the Southern Indian mountains by Colonel Beddome, from whom I have received specimens from various localities from time to time. All of the species of *Streptaxis* are somewhat variable, and, with a large collection from South India, it would probably be found that many intermediate varieties occur. As a rule, the general form appears more constant than any other characters, and the teeth in the mouth vary considerably. The parietal lamellæ are peculiarly inconstant. Thus, the original type of *Streptaxis perrotteti*, the common species on the top of the Nilgiri hills, has two lamellæ*; but I have a variety from Ootacamund in which the smaller of the two, that nearer to the angle of the mouth, is obsolete, and in other specimens from the same locality there is but a rudimentary representation of this plait. It was the form with a single lamella which was compared with *S. watsoni* when the latter was originally described (J. A. S. B., 1860, xxix, p. 127). The variation in the teeth of *Streptaxis* has already been noticed in these contributions J. A. S. B., 1861, xxx, p. 359.

The genus *Streptaxis* is abundantly represented on the various hill-groups of Southern India, especially on the higher elevations of the Syhádri, or Western-Ghat range. The most northern locality from which I possess a specimen is the hill-fort of Torna, near Sinhgarh, west of Poona, in the Bombay Presidency. The shell in question is weathered, and not in very good condition; it is a large form (that is, large compared to the minute species described in the preceding pages), measuring 11½ mm. by 8½, and it is nearly allied to the Nilgiri *S. perrotteti*, and perhaps still more nearly to the Ceylon *S. cingalensis*.

18. Ennea macrodon, sp. nov., Plate II, Fig. 15.

Testa flexuose rimata, subcylindrico-turrita, diaphana, nitidula, confertim capillaceo-costulata, cereo-albida. Spira elongata, sursum parum attenuata, lateribus subrectis, apice obtuso, suturâ impressâ. Anfr. 7, convexi, duo superiores lævigati: ultimus aperturam versus subascendens. Apertura verticalis, oblique semiovalis, lamellâ validâ bicruri intrante parietali, aliâ columellari profundâ, dentibusque tribus, uno tuberculiformi columellari, alio magno lamelliformi transverso basali latus dextrum versus, tertio minore in margine dextro, coarctata. Peristoma album, expansum, juxta anfractum penultimum sinuatum, marginibus callo lamellifero junctis. Long. 5, diam. vix 2, ap. long. 1¼ mm.

Hab. Apud Pykara in summos montes 'Nilgiri' dictos Indiæ meridionalis.

Shell flexuously rimate, subcylindrically turreted, translucent, polished, yellowish white, closely sculptured, except on the apical whorls, with fine hair-like vertical costulation. Spire turreted, elongate, diminishing very slowly in thickness upwards, the sides nearly straight, the apex blunt and rounded, the suture impressed. Whorls 7, convex, the first two smooth,

* Petit, quoted by Pfeiffer, Mon. Hel. i. p. 9.

the last ascending very slightly near the aperture. Aperture vertical, semioval, obliquely truncated above, and very much contracted by teeth, consisting of a strong re-entering bifid parietal* plait on the callus connecting the margins of the peristome, an internal re-entering columellar lamina, commencing at a distance within the mouth, and three teeth—one, more or less tubercular, on the left or columellar side, a second tubercular tooth on the right margin, opposite the parietal plait, and with it nearly cutting off the posterior corner of the aperture, and a third, broad, lamelliform, and transverse (parallel to the plane of the mouth) on the right side of the basal margin. Peristome white, expanded throughout, curved a little back near the angle, where it meets the penultimate whorl, the margins united by a callus bearing the parietal lamella. Length 0·21, diameter 0·075, length of aperture 0·05 inch.

I obtained several specimens of this shell near Pykara, on the Nilgiri hills of Southern India, in 1858, and for a long time supposed it to be *E. pirriei* of Pfeiffer,† but I noticed it as a distinct form when describing *E. sculpta* (J. A. S. B., 1869, xxxviii, pt. 2, p. 141), and mentioned some of its peculiarities. *E. macrodon* is distinguished not only from *E pirriei*, but also from all other Indian species of the genus, by its strong basal transverse lamelliform tooth. This character serves to distinguish the two species at all ages; for in the present species, as in *E. sculpta*, *E. pirriei*, and, doubtless, in the two forms (*E. exilis* and *E. subcostulata*) described below, the apertural teeth, and especially the parietal lamella, are well developed in immature shells even before all the whorls are completed. *E. macrodon*, too, is only half the size of *E. pirriei*, and there appear to be several slight differences in form, sculpture, and dentition.

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19. Ennea subcostulata, sp. nov., Plate II, Fig. 14 (*upper*).

Testa arcuato-rimata, subcylindrico-turrita, diaphana, nitida, cereo-albida, confertim subobsolete costulata. Spira parum attenuata, lateribus convexiusculis, apice obtuso, suturâ impressâ. Anfr. 7½, convexiusculi, ultimus antice breviter ascendens. Apertura verticalis, oblique semiovalis, lamellâ validâ intrante bicruri, flexuosâ, parietali juxta angulum, aliâ profundâ columellari, et quatuor dentibus, uno columellari, duobus basalibus, quarto dextrali plicæ parietali opposito, coarctata. Peristoma expansum, albidum, juxta anfractum penultimum sinuatum, marginibus callo lamellifero junctis. Long. diam. 2, ap. long. 1½ mm.

* For the meaning of the terms palatal, parietal, and columellar, applied to teeth within the mouth, see Pfeiffer, Mon. Hel. ii, p. 300, note.

† It was quoted as that shell, J. A. S. B., 1860, xxix, p. 126, and 1861, xxx, p. 364.

HAB. In montibus 'Shevrai' vel 'Shevroy' dictis, haud procul ab urbe Salem, Indiæ meridionalis (*H. Beddome*).

Shell arcuately rimate, subcylindrically turreted, translucent yellowish, white, finely and somewhat indistinctly ribbed. Spire turreted, elongate, becoming rather smaller above, with the sides rather convex, the apex blunt, and the suture impressed. Whorls 7½, moderately convex; the last whorl ascending slightly close to the mouth. Aperture vertical, semioval, obliquely truncated, with a strong re-entering parietal plait, bifid and flexuous within, near the posterior angle, a columellar lamina at a distance within the mouth, and four tubercular teeth—one columellar, two basal, and the fourth inside the right margin opposite to the parietal plait, so as partly to cut off the upper (posterior) portion of the mouth. Peristome white, expanded, except near the junction with the last whorl, where the edge is curved back somewhat; margins united by a callus, on which is the parietal plait. Length 0·22, diam. 0·075, length of aperture (including peristome) ·05 inch.

I have received from Col. Beddome three specimens of this species, two of which are evidently immature; the third I believe to be full-grown, but the peristome may perhaps be more fully expanded in older examples.

E. subcostulata is allied to *E. pirriei*, *E. sculpta*, *E. macrodon*, and their allies, but is distinguished from all by sculpture and the form of the teeth in the mouth. It was, I believe, this species which was erroneously quoted as *E. pirriei* from the Shevroy hills (J A. S. B., 1861, xxx. p. 364).

20. ENNEA EXILIS, sp. nov., Plate II, Fig. 14 (*lower*).

Testa rimata, subcylindrico-turrita, diaphana, lævigata, nitidula, albido-cerea. Spira elongata, sursum vix attenuata, lateribus apicem versus convexis, apice obtuso, suturâ parum impressâ. Anfr. 6½-7, *convexiusculi, ultimus antice subascendens. Apertura fere verticalis. oblique semiovalis, lamellâ validâ intrante bicruri parietali, aliâ profundâ columellari spirali, dentibusque quatuor, uno columellari, duobus basalibus quasijunctis, quartoque minore in margine dextro, coarctata. Peristoma expansum, albidum, postice juxta angulum sinuatum, marginibus callo lamellifero junctis. Long.* 4½, *diam.* 1½, *ap. long.* 1 *mm.*

HAB. In montibus 'Balarangam' dictis provinciæ Mysore in India meridionali (*H. Beddome*).

Shell rimate, subcylindrically turreted, translucent, smooth, polished, yellowish white. Spire turreted, elongate, diminishing very slowly indeed below, but more rapidly above, where the sides are convex, apex blunt, suture slightly impressed. Whorls 6½-7, slightly convex, the last whorl ascending very little near the mouth. Aperture nearly vertical, semioval, obliquely truncated, with a strong re-entering bifid palatal plait on the callus uniting the margins of the peristome, a spiral columellar lamina commencing at a distance within the mouth, and four tubercular teeth just inside the peristome*—one columellar, two joined together at their base, at the lowest part of the aperture, and one, very small, inside the right margin and opposite to the large parietal plait. Peristome white, slightly expanded, except near the junction with the last whorl, where the margin is slightly curved back. Length 0·18, diameter 0·06, length of aperture 0·04 inch.

This form, of which I have received four specimens from Col. Beddome, is distinguished from its allies by being quite smooth. As in the case of some of the allied forms, it is not improbable that in old specimens the peristome may be more broadly expanded and the palatal teeth may become more or less obsolete.

21. Ennea stenostoma, Bedd. MS., Plate II, Fig. 17.

Testa longe profundeque rimata, pupiformis, cylindraceo-ovata, solidula, lævigata (forsan aliquando oblique striata), impolita, haud nitida, albida. Spira subcylindrica, lateribus convexiusculis, apice rotundato, obtuso, suturâ impressâ. Anfr. 6½, *convexi, quatuor penultimi subæquales; ultimus post aperturam valde compressus, haud ascendens, capillaceo-striatus, lateribus ambobus juxta peristoma scrobiculis impressis constrictus. Apertura verticalis, subaxialis, non lateralis, suboblonga, altior quam lata, marginibus lateralibus concaviusculis, basali convexo, dentibus valde coarctata, plicâ unâ validâ simplici intrante parietali juxta angulum, tuberculis duobus columellaribus, uno superiore profundo, alio majore inferiore in peristomate, duobus minoribus basalibus, uno dextrali, alio sinistrali, uno denique majore bifido in margine dextro, plicæ parietali opposito sed inferiore, munita. Peristoma album, reflexum, postice sinuatum, marginibus callo lamellifero junctis. Long.* 3½, *diam.* 1½, *ap. long.* 1¼ *mm.*

Hab. In montibus 'Golconda' dictis, haud procul ab urbe Vizagapatam (*H. Beddome*).

Var. *minor, anfractibus* 5½; long. 3, diam. 1½, ap. long. 1¼ mm. (Pl. II, Fig. 16.)

Hab. In montibus haud procul ab urbe Karnul (Kurnool) Indiæ meridionalis, (*H. Beddome*).

* None of the teeth are well represented in the figure.

Shell with a long deep groove at the base, pupiform or cylindrically ovate, rather thick, smooth (perhaps sometimes obliquely striated), dull, destitute of polish, whitish. Spire subcylindrical, with the sides slightly convex, the apex blunt and rounded, and the suture impressed. Whorls 6½, convex, the four behind the last whorl subequal, the penultimate being scarcely smaller; the last strongly compressed behind the aperture, with raised hair-like lines of sculpture, not ascending, deeply indented on both sides. Aperture* vertical, nearly in the axis of the shell, not lateral, nearly oblong in shape, higher than broad, both the right and left margins slightly concave, lower margin convex. Teeth in the mouth numerous, and consisting of the simple† strong re-entering parietal fold near the posterior angle, two columellar tubercles (the upper and smaller situated at some depth inside the mouth, the smaller and larger in front close to the lip), two small basal teeth right and left of the lowest portion of the mouth, and one large bifid tooth on the right margin nearly opposite to the parietal fold, but not very close to it, and rather inferior to it in position. Peristome white, expanded throughout, curved back near the posterior angle, the margins united by a thick callus, on which the parietal lamina is situated. Length 0·14, diameter 0·06, length of aperture 0·05 inch.

The typical form was obtained in the Golconda hills near Vizagapatam, and the single specimen sent to me by Col. Beddome, from which the accompanying figure was taken, was broken after being drawn. The description is from a specimen in the British Museum.

A smaller variety with 5½ whorls, and measuring 0·12 inch in length, 0·06 in diameter, and 0·37 in length of aperture, was procured by the same naturalist in the hills near Kurnool.

I have received three specimens of this variety from Colonel Beddome, and there are others in the British Museum. All have the same dull weathered appearance, though they look fairly fresh; but on one there appear what may be traces of sculpture, apparently striæ similar to the fine raised lines occurring on the last whorl near the aperture in all.

I am not acquainted with any species of *Ennea* nearly allied to this species. In form, the Sikkim and Khasi *E. stenopylis* shows some resemblance; but that shell is strongly costulate, and its curious aperture, with the posterior portion almost cut off and forming a semi-detached tube, shows the species to be merely an ovate form of the Himalayan and Burmese group, comprising *E. vara*, *E. blanfordiana*, and *E. cylindrelloidea.*

* It is too broad in figure 17, and the shape is incorrect. The teeth, however, are nearly correct.

† Erroneously represented as double in fig. 17 on the accompanying plate.

22. Ennea beddomei, sp. nov.

Testa rimata, subcylindraceo-turrita, cereo-albida, nitida, confertim verticaliter costulata, costulis in anfractu ultimo plus minusve obsoletis. Spira elongata, sursum attenuata, apice obtuso, suturâ impressâ. Anfr. 6, *convexi, ultimus antice ad aperturam vix ascendens. Apertura fere verticalis, semielliptica, lamellis duobus validis parietalibus, unâ anteriore dextrali intrante intus tortâ, aliâ profundâ sinistrali subcolumellari incurvâ, dentibusque lamelliformibus minoribus duobus vel tribus profundis palatalibus coarctata. Peristoma albidum, expansum, postice juxta angulum leviter sinuatum, marginibus callo lamellifero junctis. Long.* 3⅘, *diam.* 1⅕, *ap. long.* ⅗ *mm.*

Hab. In montibus 'Sivagiri' dictis (Tinnevelley) Indiæ meridionalis (*H. Beddome*).

Shell rimate, subcylindrically turreted, pale yellowish white, polished, with close vertical ribbing on all the whorls, the ribs being more or less flattened and obsolete on the last. Spire elongate, becoming more slender above, apex blunt, suture impressed. Whorls 6, convex, the last scarcely ascending in front at the mouth. Aperture nearly vertical, semi-elliptical, with two strong re-entering parietal lamellæ—one of them in front to the right near the angle of the mouth, slightly twisted inside, the other to the left near the columellar margin, commencing at a distance within the mouth, and curved; there are also two or three small depressed lamelliform palatal teeth; but they are seen with difficulty from the front. Peristome white, expanded, the margins united by a callus bearing the parietal folds, the right margin curved back near the angle. Length 0·15, diam. 0·05, length of aperture 0·025 inch.

I have named this shell after the discoverer instead of adopting the term he had given to it in MS., as the latter might be objected to and changed. I have no specimen myself at present, but there are four in the British Museum. The form is peculiarly distinguished by the absence of any teeth in the peristome itself, although there are two or three at a little distance inside the aperture, and two folds on the callus joining the margins of the lip. In general form there is some resemblance to *E. exilis*.

23. Ennea canarica, Beddome, MS.

Testa rimata, turrita, albida, solidula, confertim verticaliter costata. Spira subregulariter attenuata, apice obtuso, suturâ profundiusculâ. Anfr. 5½, *convexi, infra saturam inflati, gradatim crescentes, ultimus antice vix ascendens. Apertura subrotunda, superne truncata, lamellâ validâ parietali intrante subtortâ, partem posteriorem aperturae fere discernente, aliâque* *columellari profundâ, vix in fauce conspicuâ, coarctata; dentibus palatalibus in peristomate nullis. Peristoma continuum, longe adnatum, album, incrassato-patens, undique expansum, intus granulatum, margine columellari angulatim incisum, basali lato, dextrali intus juxta lamellam parietalem breviter projiciente, angulum versus leviter retro-sinuatum. Long.* 3¾, *diam.* 2, *ap. intus* ¾ *mm. alta.*

HAB. In provincia 'South Canara' ad latus occidentale Indiæ meridionalis (*H. Beddome*).

Shell rimate, turreted, white (fresher specimens are probably yellowish white and polished), all the whorls ornamented with close vertical ribs. Spire almost regularly attenuate, apex blunt, suture rather deep. Whorls 6½, convex, swollen, and projecting beneath the suture, increasing in size by degrees, the last not ascending near the mouth. Aperture nearly round, except above, with one strongly developed parietal lamella, commencing in the front and re-entering deeply, a little twisted within, and so large as almost to cut off the upper left or posterior portion of the aperture; another smaller, deep-seated columellar fold is scarcely discernible from the mouth; no palatal teeth. Peristome continuous, attached for a considerable distance to the last whorl, white, thickened, broadly expanded, granulate inside; the columellar margin with an angular incision, the basal margin broader than the others, right margin curved back near the angle, and having a blunt projecting tooth-like process inside, opposite the parietal fold. Length 0·15, diameter 0·08, length of aperture within 0.025 inch.

The above description is taken from the only specimen I have ever seen, which is in the British Museum. The shell is remarkable for its peculiarly shaped whorls, each of which is suddenly swollen below the suture, so as to give almost a step-like appearance to the spire. The rounded mouth, too, with the broadly expanded peristome is quite different from that of any other Indian form of the genus. Perhaps the Khasi-Hill *Ennea vara* is as closely connected as any of the South-Indian forms, though there is but little resemblance between it and the present species, except such as is due to both being strongly ribbed, and to the manner in which the posterior or upper right-hand corner of the mouth is almost isolated by the strong parietal lamella and a projection from the inner margin of the peristome.

24. HELIX CALPIS.

Bens., Ann. & Mag. Nat. Hist. ser. 3, vol. iii, p. 268.—Pfr., Mon. Hel. v. p. 64.—Hanley, Conch. Ind. pl. xvi. fig. 8.

Macrochlamys calpis, Theobald, Cat. Land Freshwater Shells Brit. Ind. p. 19.

? *Nanina (Microcystis) calpis*, Nevill, Hand-list Moll. Ind. Mus. pt. i. p. 38.

This species was described from specimens collected by myself in 1856. I had but an imperfect knowledge of land mollusks at the time, or I should, I think, have seen at once, as I did some years afterwards, when re-examining my collections, that the shells were all young specimens of *Raphaulus* (*Streptaulus*) *blanfordi.* I had altogether a considerable number of specimens of the supposed *Helix calpis;* of these four were sent to England, and were examined by Mr. Benson; and it is manifest, from his description, that there was no difference between his examples and mine. In some of the latter I found the operculum still remaining.

In Mr. Nevill's Hand-list of Mollusca in the Indian Museum, Calcutta (*l. c.*), specimens of *Nanina calpis* from the Nága and Khási hills are included. *Streptaulus blanfordi* has been found in Sikkim, and in the Dafla hills, east of Bhutan; and I learn from Col. Godwin-Austen that he obtained a specimen from Brahmakúnd at the head of the Assam valley; but, as no example of the shell is known to have been found in the hill-ranges south of Assam, I think the specimens in the Indian Museum must be something different from the form described as *Helix calpis* by Mr. Benson.

25. Spiraculum travancoricum, Beddome, MS., Plate III, Fig. 6.

Testa late umbilicata, depresso-turbinata, in exemplo vetusto adhuc detecto lævis, albescens (junior forsan epidermide induta, colorataque). Spira elevata, depresso-conica, suturâ profundâ, apice acuto. Anfr. 4½, *rotundati, ultimus cylindraceus, aperturam versus descendens atque breviter solutus,* 3 *mill. pone aperturam tubulo longiusculo antrorsum directo, anfractum penultimum tangente, munitus. Apertura diagonalis, circularis; peristoma duplex, internum breviter porrectum, superne sinistrorsum leviter sinuatum, externum expansum, atque, nisi ad marginem sinistrum, undulatum. Operculum extus fere planum, marginibus anfractuum exteriorum liberis, intus concavum. Diam. maj.* 12½, *min.* 10½, *axis* 7, *diam. apert.* 5½ *mill.*

Hab. In montibus Travancoricis haud procul a Tinnevelly (*H. Beddome*).

Shell broadly umbilicate, depressedly turbinate, and, in the single aged specimen found, decorticated, whitish and smooth throughout. Traces of a brown epidermis remain around the umbilicus, and younger specimens are probably brown in colour, and perhaps ornamented with coloured bands, like other species of the genus. Spire raised, depressedly conical, suture deep, apex acute. Whorls 4½, rounded; the last cylindrical, descending, and free near the aperture, and provided above, about three millimetres behind the mouth, with a rather elongate tube, which projects forward, and is in contact with the penultimate whorl throughout. The tube appears broken at the end, and may have been even longer originally; the anterior termination in the specimen is in a line with the oblique peristome of the shell. Aperture diagonal, circular; peristome double, inner lip sharp, not projecting much, curved backwards near the penultimate whorl; outer peristome expanded, and wavy above externally and below, straight and somewhat narrower on the left margin. Operculum nearly flat externally, concave within; the outer margins of the whorls free and lamellar, except towards the middle; the circumference surrounded by several fine raised lines, the edges of the outermost whorls. Major diameter 0·5 inch, minor 0·42, axis 0·3, diameter of the mouth 0·23.

This species differs from all others of the genus by its higher spire, and by the combination of the mouth being free and the sutural tube being directed forwards and attached to the last whorl. The solitary specimen obtained was procured at a considerable elevation, 4000 or 5000 feet, in the hills between Travancore and Tinnevelly, not far from Cape Comorin.

26. Cataulus costulatus, sp. nov., Plate III, Fig. 7.

Testa subperforata, subovato-turrita, solida, subsinuate costulata, pallide straminea. Spira convexo-turrita, apice obtusiusculo, suturâ valde impressa. Anfr. 7½, *convexi, ultimus arctius convolutus, antice porrectus fere solutus, carinâ basali validâ, compressâ, costulatâ, antice dilatatâ munitus; periomphalo mediocri, costulato. Apertura subcircularis, fere verticalis, canali ad latus sinistrum marginis basalis patente, ore subobliquo, subtus spectante. Peristoma album, incrassato-expansum, revolutum, postice dextrorsum atque antice sinistrorsum ad canalem basalem productum, margine columellari angustiore, cum anfractu penultimo breviter juncto. Long.* 16, *diam. (perist. incl.)* 5, *diam. min.* 5½, *apert. intus* 3 *mm.*

Hab. In montibus 'Tinnevelly Ghats' dictis Indiæ meridionalis, (*H. Beddome*).

Shell subperforate, subovately turreted, solid, rather coarsely and subsinuately costulated, of a pale straw-colour. Spire turreted, with convex sides, apex rather obtuse, sutures well impressed. Whorls 7½, convex, the last more closely wound than the penultimate, to which it is scarcely attached just behind the mouth; the basal keel compressed, costulate, dilated in front; the space inside the keel and around the umbilicus is of moderate size and ribbed. Aperture nearly circular and subvertical, with the opening of the basal canal on the left side of the base, and not quite in the same plane as the aperture, but turned rather downwards. Peristome white, thickened, expanded, and turned back, produced above to the right of the penultimate whorl and below around the canal, narrow on the columellar margin, and only united for a short distance with the penultimate whorl. Length 0·65 inch, breadth (including the peristome) 0·25, minor diameter from front to back 0·23, width of aperture inside 0·13.

This species of *Cataulus*, the third hitherto obtained from the hills of Southern India, is distinguished from all other known forms of the genus by its comparatively coarse ribbing across the whorls. In other respects, it closely approaches *C. calcadensis*, Bedd. (J. A. S. B , 1869, xxxviii. pt. 2, p. 137, pl. xvi. fig. 8), having a similarly shaped spire, aperture, and basal channel. I have only seen one specimen of *C. costulatus ;* this differs from *C. calcadensis* not only in having stronger sculpture, but also in being rather shorter and in having one whorl less in the spire. The colour of *C. costulatus* also is paler than that of the Calcad shell, and the lip of the aperture is white.

Like the other Southern-Indian forms, *C. calcadensis*, *C. recurvatus*, and the species hereafter described, *C. costulatus* has the canal a little to the left of the lowest portion of the aperture, or nearer to the umbilicus than to the outer margin. In most Ceylonese species of the genus, the canal is nearly at the lowest portion of the mouth.* I find that in *C. tortuosus* the position of the canal is precisely as in *C. calcadensis* and *C. costulatus* (in *C. recurvatus*, the sinistral position of the canal is much more marked).

27. CATAULUS ALBESCENS, sp. nov.

Testa subperforata, subovato-turrita, tenuiuscula, albido-cornea, subsinuate costulato-striata. Spira turrita, lateribus convexis, apice obtusiusculo, suturâ valde impressâ. Anfr. 7, *convexi, ultimus arctius convolutus, antice porrectus, fere solutus, vix descendens, carinâ basali transversim striatâ, postice obsoletâ, antice validâ, juxta aperturam dilatatâ munitus ; periomphalo mediocri, plicato-striato. Apertura subcircularis, fere verticalis, canali ad latus sinistrum marginis basalis patente, ore antice spectante. Peristoma album, incrassato-reflexum, postice et ad canalem basalem productum, margine columellari angustiore, cum anfractu penultimo breviter junctum. Long.* 13, *diam. maj.* 5½, *min.* 4½, *apert. diam. intus vix* 3 *mm.*

HAB. In montibus Travancoricis haud procul ab urbe Trevandrum.

Shell subperforate, subovately turreted, rather thin, whitish horny, rather sinuately and costulately striated. Spire turreted, with the sides convex, apex obtuse, suture much impressed. Whorls 7, convex, the last more closely wound than the penultimate, to which it is but slightly attached just behind the mouth. Basal keel transversely striated, subobsolete on the body-whorl near the junction of the peristome, becoming stronger in

* It is slightly to the left in *C. pyramidatus*, *C. eurytrema*, and *C. austenianus ;* basal in the smaller forms, like *C. templemanni* and *C. layardi*.

front and dilated near the mouth; the space inside the keel and around the umbilicus is of moderate size and plicately striated. Aperture nearly circular and subvertical, with the opening of the basal canal to the left of the base, and in nearly the same plane as the aperture. Peristome white, thickened, expanded and turned back, produced slightly above to the right of the penultimate whorl, and to a greater extent below at the mouth of the canal; columellar margin a little narrower, joined for a short distance only to the penultimate whorl. Length 0·53, major diameter 0·22, minor 0·18; breadth of the aperture within 0·12 inch.

This is the smallest form yet obtained of the peculiar group of Southern-Indian *Catauli.* I received three specimens some years ago from Mr. Theobald, who supposed them to be *C. calcadensis.* Mr. Theobald, I believe, procured them from Mr. F. W. Bourdillon, who obtained them near Mynall, on the hills east of Trevandrum. This shell is, I think, mentioned as *Cataulus calcadensis* by Mr. Theobald in his description of Mr. Bourdillon's shells (J. A. S. B., 1876, xlv. p. 185). The present species, however, has one whorl less, and is a much smaller shell, with proportionately shorter whorls, the sculpture is less close and distinct, the colour whitish instead of golden brown, the basal keel less developed, and its opening is in the same plane as the aperture, instead of being turned downwards, &c. From *C. costulatus*, the present form is chiefly distinguished by its much finer sculpture and by the characters of the basal keel.

28. Cataulus calcadensis.

The original specimens of this species described by me in 1869 (J. A. S. B., xxxviii. pt. 2, p. 137) were bleached and chalky. Subsequently, Col. Beddome, who discovered and named this very interesting form of *Cataulus*, procured fresh living specimens of a golden-brown colour, with the aperture of the same tint as the shell.* The peristome in these specimens is not free from the last whorl. The operculum is normal, and precisely similar to that of Ceylonese species of the genus.

The specimens described by Mr. Theobald as *Hapalus travankoricus*† are, I am satisfied, immature shells, and I believe them to be the young of this, of *C. albescens*, or of some nearly allied species of *Cataulus*. Mr. Theobald states that the types of his supposed *Hapalus* differ from the young of *Cataulus calcadensis, i. e., C. albescens*, but he omits to point out the distinction. I had an opportunity of examining the types, which were

* I have not seen specimens of the olive colour represented in the 'Conchologia Indica,' pl. cvi, fig. 10.

† J. A. S. B. 1876, xlv. pt. 2, p. 186, pl. xiv. fig. 5. The name should, in any case, be Latinized as *travancoricus*. There is no such place as Travankor, the common English name Travancore being a corruption of the real name.

shown to me by Mr. Theobald, and I told him my views on the subject, but he did not agree with me.

I have recently examined the specimen of *C. tortuosus* (two in number) at the British Museum, and find the views I expressed several years since (J. A. S. B., 1869, xxxviii. pt. 2, p. 138) as to its alliance to *C. calcadensis* fully confirmed. In form, *C. tortuosus*, *C. calcadensis*, *C. costulatus*, and *C. albescens* are closely allied, all being much more ovate than any of the other species of the genus. The sculpture on *C. tortuosus* is much finer than on *C. calcadensis*, or even than on *C. albescens*. The discovery of two additional forms of this section of the genus in the hills of Southern India, and the absence of the genus from the collections hitherto made in the Nicobar Islands, tend to support the probability that *C. tortuosus* is also in reality a Southern-Indian form. Not a single *Cataulus* has hitherto been discovered in the Andaman Islands, in any of the countries to the east of the Bay of Bengal, or in the Malay Islands, so that the existence of the genus in the Nicobar Islands is extremely improbable.

29. Realia (Omphalotropis) andersoni, sp. nov., Plate II, Fig. 18.

Testa perforata, ovato-conica, tenuiuscula, rufescenti-fulva, lævigata, parum nitida, oblique striatula. Spira conica, lateribus subrectis, apice acuto, suturâ leviter impressâ. Anfr. 7, planiusculi; ultimus ad peripheriam capillaceo-carinatus, subtus convexus, lævigatus, radiatim striatulus, carinâ circumumbilicari obtusâ, fere obsoletâ instructus. Apertura ovata, obliqua, fere diagonalis, spiram altitudine haud æquans. Peristoma obtusum, marginibus subconniventibus, callo tenui junctis, externo recto, basali expansiusculo, columellari subtus expanso, juxta perforationem emarginato, angulatim inciso. Operc.? Long. 7, *diam. vix* 5; *ap. long.* 3¼, *lat.* 2¾ *mm.*

Hab. In insulis Andamanicis (*J. Anderson*).

Shell perforate, ovately conical, thin, reddish brown in colour, smooth, not polished, obliquely striated. Spire conical, with sides nearly straight, apex acute, suture slightly impressed. Whorls 7, rather flat; the last with a hair-like keel at the periphery (the keel sometimes appearing on the upper whorls just above the suture), convex, smooth, and radiately striated below, and furnished with an obtuse, subobsolete keel around the umbilicus, the space inside the umbilical keel being smooth, not ribbed. Aperture ovate, oblique, nearly diagonal, a little shorter than the spire. Peristome obtuse, the margins approaching each other, and joined by a thin callus; outer edge straight, basal expanded, columellar expanded below, but emarginate and cut away into a re-entering angle near the perforation. Length 0·29, diameter 0·19; length of aperture 0·13, breadth 0·11 inch.

This species closely resembles *R.* (*O.*) *rubens* of Mauritius in form, but differs in sculpture, the shape of the whorls, &c. The umbilical keel is but faintly marked. Several specimens were procured about ten years ago by Dr. J. Anderson, Superintendent of the Indian Museum, to whom I am indebted for the types. They were obtained, I believe, at some distance from the coast.

30. Realia pallida, sp. nov., Plate II, Fig. 19.

Testa perforata, ovato-conica, tenuis, albido-cornea, lævigata, nitidula, vix verticaliter striatula. Spira conica, apice acuto, suturâ impressâ. Anfr. 6, *convexiusculi; ultimus ad peripheriam atque subtus rotundatus, circa perforationem radiatim striatus. Apertura fere verticalis, ovata, spiram altitudine haud æquans. Peristoma tenue, marginibus subconniventibus, callo tenui junctis, externo recto, columellari expansiusculo. Operc.? Long.* 4½, *diam.* 3; *ap. long vix* 2, *lat.* 1⅓ *mm.*

Hab. In insulis Andamanicis cum præcedente (*J. Anderson*).

Shell perforate, ovately conical, thin, whitish horny, smooth, moderately polished, with faint subobsolete vertical striation. (There is also, beneath the lens, a faint indication of minute spiral striation, but I am not sure that this is not an individual peculiarity.) Spire conical, apex acute, suture impressed. Whorls 6, slightly convex, the last rounded at the periphery and below, radiately striated around the perforation. Aperture nearly vertical, ovate, shorter than spire. Peristome thin, margins approaching each other, joined by a thin callus; the outer lip simple, the columellar slightly expanded. Length 0·17, diameter 0·12, length of aperture 0·075, breadth 0·06 inch.

I have but a single specimen of this species, which wants both the keels of the last species, and differs besides in size, colour, and sculpture. The specimen is perhaps not quite adult, but there can, I think, be no question of its being a peculiar form.

Neither of the two species above described can be confounded with the globose *R.* (*O.*) *distermina* (Benson, Ann. & Mag. N. H. Dec. 1863; Pfeif., Mon. Pneum. Suppl. ii. p. 178) with its costulate striation near the suture and inside the umbilicus, its rounded whorls, and its aperture equal in length to the spire. A glance at the figure of this shell in the 'Conchologia Indica,' pl. clxv. fig. 10, will suffice to show how different it is from either *R. andersoni* or *R. pallida.* Even if, as is possible, Benson's type was a young shell, it was manifestly a very distinct species, and the adult would probably resemble *Realia* (*Omphalotropis*) *globosa* of Mauritius in shape.

31. Realia decussata, sp. nov.

Testa perforata, ovato-conica, tenuiuscula, striis obliquis incrementi, aliisque spiralibus, minutis, sublente subtilissime decussata, in anfractibus superioribus, nisi duobus supremis, undique, atque in inferioribus et supra et infra suturam costulato-striata, pallide rufescenti-fulva, anfractu ultimo cingulo pallido circumdato. Spira conica, apice acuto, sutura impressâ. Anfr. 6, *convexi; ultimus ad peripheriam rotundatus, subtus convexus, radiatim striatus, in umbilico costulato-striatus, lineâ impressâ basali in loco carinæ circum umbilicum instructus. Apertura obliqua, rotundato-ovata,* $\frac{4}{7}$ *longitudinis subæquans. Peristoma tenue, marginibus subconniventibus, callo tenui junctis, externo basalique rectis, columellari subtus expansiusculo, juxta perforationem retrosinuato. Operc.? Long.* $3\frac{3}{4}$, *diam.* $2\frac{3}{4}$; *ap. long.* $1\frac{3}{4}$, *lat.* $1\frac{1}{3}$ *mm.*

Hab. Cum præcedentibus in insulis Andamanicis (*J. Anderson*).

Shell perforate, ovately conical, rather thin, finely marked with oblique striæ of growth and minute decussating spiral lines (only visible beneath the lens), costulately striated on the upper whorls (except the two uppermost) and close to the suture on the lower whorls, pale rufescent brown, with a pale band round the body whorl. Spire conical, apex sharp, suture impressed. Whorls 6, convex; the last rounded at the periphery and below, radiately striated beneath, more strongly in the umbilicus, and having an impressed line at the base around the umbilicus in the place of a keel. Aperture oblique, oval, but little higher than broad, about $\frac{4}{7}$ of the length. Peristome thin, the margins approaching each other and united by a thin callus; the outer and basal edges simple, columellar margin slightly expanded below, curved back into a shallow re-entering sinus close to the perforation. Length 0·15, diameter 0·11; length of aperture 0·07, breadth 0·06 inch.

This shell is distinguished by its fine decussated striation. I have but a single specimen, received from Dr. J. Anderson, with the others. Unfortunately no figure has been given, as I did not observe the distinction until after the accompanying plate had been drawn. Independently of sculpture, the species may be distinguished from *O. distermina* by its less globose form, and by the absence of the keel around the periphery; from *R. andersoni* by its much smaller size, more rounded whorls, and by the absence of the keel; and from *R. pallida* by rounder whorls, by colour, and by its rather more turreted form.

There is thus evidence of four different forms of *Realia* in the Andaman Islands. The genus is absolutely unknown in either India or Burma, the species of *Omphalotropis* (*O. aurantiaca*) once reported from

Pondicherry being really from the island of Mauritius ;* and it is uncertain that the forms reported from Cochin China, Siam, and Singapore are not *Assiminea*. It is remarkable that the genus is almost entirely insular in its known distribution, and that it is especially common in the Mascarene Islands and in Polynesia.

32. PALUDOMUS TRAVANCORICA, *Beddome*, MS., Plate II, fig. 22.

Testa imperforata, ovato-conica, solidula, epidermide fuscâ induta, sub epidermide albida, fasciis fusco-purpureis flexuosis verticalibus ornata, costis spiralibus subconfertis circumdata, interspatiis glabris, striis incrementi inconspicuis. Spira conica, subturrita, apice eroso, suturâ impressâ. Anfr. superst. 3, *convexi, ultimus dimidium testæ superans. Apertura subverticalis, ovata, postice angulata, intus cærulescenti-albida, strigis flexuosis confertis conspicuis. Peristoma rectum, marginè externo acuto, columellari basalique albis, intus incrassatis, dilatatis. Operc. normale. Diam maj.* 16, *min.* 13½, *alt.* 23 *mm.* (*apiee non eroso ad* 25) ; *apert.* 12 *mm. longa,* 9 *lata.*

HAB. In Travancore (*H. Beddome*).

Shell imperforate, ovately conical, rather thick, covered with a dark-brown epidermis ; beneath the epidermis white, with narrow vertical, very wavy dark purple stripes ; all the whorls spirally ribbed, the ribs rather close together, with the interspaces smooth, the striæ of growth being inconspicuous. Spire conical, apex eroded (doubtless acute when perfect), suture impressed. Whorls remaining 3 (probably in the perfect shell 5 or 6), convex, the last exceeding half the length of the shell. Aperture nearly vertical, ovate, angulate at the posterior extremity, bluish white, with conspicuous, close, vertical, wavy, deep purple bands within ; peristome in one plane, the external margin sharp, the columellar and basal margins white, thickened within, and dilated. Operculum normal. Major diameter 0·65 inch, minor 0·52, height (apex wanting) 0·9 (when perfect about an inch) ; aperture 0·5 high, 0·36 broad.

In a young specimen of *P. travancorica*, there appears to be a tendency to the development of minor parallel ribs between those forming the spiral sculpture, and the latter are rather closer together near the suture.

* See Benson, A. M. N. H. Sept. 1851, Ser. II, Vol. 8. p. 194.—Nevill, Handlist Moll. I. M. pt. i, p. 320. Hanley, Conch. Ind. Systematic list of Species, p. xiii, note 1, whilst pointing out that the species is not Indian, states that it occurs in the Isle of Bourbon. As he does not give his authority, the name of the island may have been inserted by mistake for that of Mauritius, but it is possible that the form occurs, like *O. rubens* and two or three other species, in both islands.

This fine and well-marked from of *Paludomus* was procured by Colonel Beddome in streams traversing the plains between Trevandrum and the foot of the Aghastyamali hill.

So far as I am aware, none of the forms of true *Paludomus* hitherto described from Southern India and Ceylon have the marked spiral sulcation of the present species. There is, however, a remarkable resemblance to the Ceylonese *Philopotamis sulcata*, the shell of which is only distinguished by wanting the conspicuous coloured bands within the peristome, although the operculum is very different. Perhaps the nearest ally of *P. travancorica* is the Burmese *P. regulata*; but that is a less conical form, and differs both in sculpture and coloration, as may be seen by comparing the figure of the present species with that of *P. regulata* in the 'Conchologia Indica' (pl. cviii. fig. 5). In form, *P. travancorica* has some resemblance to the common *P. tanjorica** (*Helix tanshaurica*, Gmelin, Syst. Nat. p. 3655).

33. Bythinia evezardi.

Testa anguste umbilicata, ovato-conica, solida, striis regularibus spiraliter circumdata, albido-cornea, epidermide crassâ olivaceâ obtecta. Spira conica, apice eroso, suturâ valde impressâ. Anfr. superst. 3 (*in testâ integrâ* 4-5), *convexi, ultimus dimidiam longitudinis subæquans, modice ventricosus, subtus circa umbilicum angulatim compressus, umbilico conico, intus lævigato. Apertura subverticalis ovata, antice atque postice subangulata; peristoma simplex, rectum, obtusum. Operculum normale. Long.* 3¾, *diam. maj.* 3¼, *min.* 2 *mm.; apert. intus fere* 2 *longa,* 1⅓ *lata.*

Hab. Ad Lanowlee (Lanaoli) juxta viam ferratum inter Bombay et Poona (*G. Evezard*).

Shell narrowly umbilicate, ovately conical, solid, surrounded by regular spiral impressed lines rather close together, whitish horny, covered with an olive epidermis. Spire conical, apex eroded, suture deeply impressed. Whorls remaining 3 (in a perfect shell about 4 to 5), rounded, the last about half the whole length, moderately ventricose, angulately compressed at the base around the umbilicus, which is conical and smooth inside. Aperture nearly vertical, oval, subangulate in front at the base and at the posterior extremity; peristome simple, straight, obtuse; operculum normal. Length 0·15, major diameter 0·13, minor 0·08 inch; aperture within 0·07 long, 0·05 broad.

This peculiar little species, distinguished by its distinct umbilicus from all other Indian forms, was obtained by Colonel G. Evezard at Lanaoli, a station on the railway from Bombay to Poona, situated a few miles east of Khandalla at the top of the Bor-ghat.

* I think it is to be regretted that Gmelin's spelling should be adopted for this species, as the derivation of the name is thereby rendered obscure.

35. CREMNOCONCHUS FAIRBANKI.

"*Cremnoconchus fairbanki*, Blanford," Hanley, Conch. Ind. p. 58, pl. cxlvi, fig. 7.

I have described the species here attributed to me, and I greatly doubt my being responsible for the specific name, even in manuscript. I find amongst my collection a small box of *C. carinatus*, labelled *C. fairbanki*, but I cannot recollect whence the name was derived. The shell figured in the 'Conchologia Indica' resembles *C. carinatus* in form, but the angulation of the last whorl is not shewn, and the coloured bands represented are not, so far as I know, found in that species.

The shell figured in the same plate of the 'Conchologia Indica' (pl. cxlvi, fig. 10) as *C. carinatus*, is certainly not that species, but *C. conicus*, var. Some of the references in the letterpress, p. 58, to my descriptions and figures of *Cremnoconchus* (J. A. S. B. 1870, xxxix, pt. 2, pp. 10—12, pl. 3, figs. 3, 4, 5) are incorrect.

36. CORBICULA IRAVADICA.

"*Cor. iravadica*, Blanf. MSS." Hanley, Conch. Ind. p. 62, pl. clv, fig. 8.

Testa fere æquilateralis, rhomboideo-ovata, ventricosa, solidiuscula, concentrice striata atque costulis subremotis, interdum plus minusve obsoletis, ornata, epidermide olivaceâ induta, intus violacea: latere antico ante umbones prominentes subhorizontali, tunc fere regulariter convexo, postico declivi, oblique subtruncatulo, demum subangulato, margine ventrali modice arcuato; ligamento postice subito contracto. Lat. 10½ *mm., long.* 9, *crass.* 7. *In alio exemplo long.* 11½, *lat.* 8½, *crass.* 7.

HAB. Ad Mandelay, urbem capitalem regni Avæ.

Shell nearly æquivalve, rhomboidally ovate, ventricose, thickish, concentrically striated and ornamented with ribs rather wide apart often more or less obsolete. The colour of the epidermis is olive, that of the shell inside violet. Anterior side nearly horizontal in front of the prominent umbones, then almost regularly convex, the posterior side slopes away gently at first, then sharply, almost as if truncated, and forms a rounded angle with the ventral margin, which is gently arcuate. The ligament behind is suddenly contracted and compressed, the hindermost portion, about a quarter of the length being very much smaller than the rest.

Dimensions of one specimen:—length 0·42 inch, breadth from umbones to ventral margin 0·36, thickness 0·28; of another much longer shell, the same measurements are 0·46, 0·34, and 0·28 inch.

It is very possible that this may not be separable from some of the numerous other forms of the genus, but I can find none precisely agreeing. The form is more ventricose and the umbones more prominent than in most

Indian *Corbiculæ.* The genus, like *Unio,* appears to have been designed by a beneficent Providence for the amusement of species-makers. Many of the described local races in all probability pass more or less into each other.

Explanation of the Plates.

Plate II.

Fig. 2. *Euplecta vidua,* var. *minor,* natural size.
„ 4. This shell has not been described, the type having been mislaid, and one figure, that shewing the shell from the mouth, omitted in the plate.
„ 5. *Euplecta vidua,* typical form, natural size.
„ 8. *Macrochlamys tenuicula,* two views, natural size. In the left hand figure one whorl too many is represented, and in the right hand figure the peristome is represented as thick instead of very thin.
„ 9. *Macrochlamys platychlamys,* two views, natural size. In the right hand view the lip should have been represented as very thin.
„ 10. *Streptaxis personatus,* three views, enlarged two diameters, fair.
„ 11. *Streptaxis concinnus,* three views, enlarged two diameters, teeth rather indistinct, otherwise good.
„ 12. *Streptaxis pronus,* three views, enlarged two diameters, teeth not correctly represented ; see description.
„ 13. *Streptaxis compressus,* three views, enlarged four diameters ; the teeth are incorrect, especially in the middle figure, where three are represented on the basal margin of the aperture instead of one only.
„ 14. (Upper figure) *Ennea subcostulata,* enlarged four diameters. The columellar tooth should be lower down.
„ 14. (Lower figure) *Ennea exilis,* enlarged four diameters. All the teeth are wrongly represented ; see description.
„ 15. *Ennea macrodon,* enlarged four diameters. The teeth in the peristome are not distinct in the figure, and the large tooth inside the base is omitted altogether.
„ 16. *Ennea stenostoma,* var., enlarged four diameters. Teeth not correct, they should be precisely the same as in fig. 17.
„ 17. *Ennea stenostoma,* typical form, enlarged four diameters. The mouth too broad, it should be of the same shape as in fig. 16. The teeth are correct.
„ 18. *Realia* (*Omphalotropis*) *andersoni,* enlarged two diameters : fair figure.
„ 19. *Realia pallida,* enlarged two diameters, not good, the penultimate whorl is by far too large, and the suture wrongly drawn.
„ 22. *Paludomus travancorica,* natural size, good figure.

N. B. As already noticed in the text, several of the figures in this plate are unsatisfactory. In especial, the teeth in the aperture of some forms of *Ennea* and *Streptaxis* are by no means accurately represented. The plate having been twice lithographed, it appears hopeless at present to try to obtain greater accuracy. The general form of the shells is as a rule correct. The imperfection of the plate is partly due to its having been lithographed during the absence of the author of the present paper.

Plate III.

Fig. 1. *Hemiplecta tinostoma.*
„ 2. *Hemiplecta enisa.*
„ 3. *Xestina albata.*
„ 4. *Ariophanta immerita.*
„ 5. *Macrochlamys wynnei.*
„ 6. *Spiraculum travancoricum.*
„ 7. *Cataulus costulatus.*

N. B. The figures on this plate are all fairly good ; all are of the natural size except 7*b*.

XXI.—*List of Diurnal* Lepidoptera *from Port Blair, Andaman Islands, with Descriptions of some new or little-known Species and of a new Species of* Hestia *from Burmah.—By* J. Wood-Mason, *Deputy Superintendent, Indian Museum, and* L. de Nicéville.

(With Plate XIII.)

The first collection of Andamanese Lepidoptera of any importance was made by the native collector (Moti Ram) who accompanied Mr. Wood-Mason on his first visit to the Andaman Islands in the year 1872, and remained at Port Blair for some months after Mr. Wood-Mason's return to Calcutta, collecting insects in the immediate vicinity of the settlement. This collection was entrusted for determination and description in this Journal to the late Mr. W. S. Atkinson, who, however, only described in the 'Proceedings of the Zoological Society' two of the more obvious novelties, and eventually returned a few of the specimens to Mr. G. Nevill, who at that time had charge of the Museum collection of lepidopterous insects, and who placed them in the collection. These specimens are included in the present list.

Since 1872, numerous collections of Lepidoptera have been formed at Port Blair and at Kamorta in the Nicobars by the officers of the Port Blair establishment, and forwarded by them to England, where in 1877 Mr. F. Moore examined all the material that had been thus collected and drew up a complete list of "The Lepidopterous Fauna of the Andaman and Nicobar Islands," describing therein many new species and varieties both of butterflies and moths. In this list, 71 species of rhopalocerous Lepidoptera are recorded as inhabitants of the Andaman Islands. Since Mr. Moore's paper appeared, 4 new species and varieties of butterflies have been described by as many different authors, bringing up this number to 75. In the present list, 29 additional species, five of them described for the first time, are recorded, making a total of 104,—a number which might no doubt be largely increased by an experienced collector in a few weeks.

Several common species which occur everywhere in the neighbouring regions are not recorded, and these are all the more conspicuous by their absence from the circumstance that their supposed models are also absent; we allude to *Hypolimnas misippus*, *Elymnias undularis*, and the 2nd and 3rd forms of the female of *Papilio polytes*, which respectively mimick *Danais chrysippus*, *Danais plexippus*, *Papilio hector*, and *Papilio aristolochiae*. It is a curious fact that both in the Kulu valley and in the Simla district in the North-Western Himalayas, where *Papilio hector* and *P. aristolochiae* have never been found, the same forms of the female of *Papilio* *polytes* are also absent: whether they are really absent from the Andaman Islands and the other regions mentioned, and, if so, whether they ceased to be developed or rather were exterminated as soon as the species spread into regions wherein neither of the forms which its females mimick exist, are interesting subjects for future enquiry.

Tribe PAPILIONES.

Family NYMPHALIDÆ.

Subfamily Danainæ.

No representative of the genus *Hestia* has been received from Mr. de Roepstorff, but we are indebted to Capt. G. F. L. Marshall, R. E., for the gift of a specimen which that gentleman had received from Colonel Cadell, Chief Commissioner of the Andamans and Nicobars, but which does not agree with Felder's figure and description of *Hestia agamarschana*, the only species of the genus hitherto recorded from those islands, either in the extent and relations of the black markings or in the shape and proportions of the wings; the former being larger, more or less coalescent generally, and completely run together at the outer margin so as to form a distinct black border to each wing, and the posterior pair of the latter being broadly rounded off at the extremity and consequently not presenting the peculiar egg-shaped outline so characteristic of these organs in all the hitherto described Indian *Hestias*, *e. g.*, *H. Lynceus*, *H. Jasonia*, etc., with the latter of which Felder compares his species; the specimen apparently also differs from *H. agamarschana* in having the white of all the wings everywhere more or less clouded with minute black scales. *H. agamarschana*, it is true, to judge from Felder's figure of it, has the posterior wings a little less pointed, the anterior discal spots on the anterior ones obviously more elongated, with more black in the cell and behind it, and the markings generally larger than in *H. Jasonia*, and it is, as might have been expected, more closely related to the specimen obtained by Col. Cadell than to any other species; but, large series of specimens having shown us how extremely constant the different species or local races of *Hestia* are, we cannot unite the two, and we think that the differences they present are in all probability due to a difference of station, and that Helfer may have obtained the specimen that served Felder for type on a different island; all the lepidopterous insects of late years received from the Andamans having been obtained in the immediate vicinity of the settlement at Port Blair, in an area therefore which is a very small fractional part indeed of the Andaman group of islands, which extends through nearly four degrees of latitude. We, therefore, propose to describe the specimen as a new species under the name of

1. HESTIA CADELLI, n. sp., Pl. XIII, Fig. 1, ♂.

♂. Allied to *Hestia agamarschana*, Felder. Wings above pure subpellucid white clouded, especially on the outer halves, with minute black scales, and marked and veined with intense black; all the markings larger, more or less coalescent, and blurred or paler at the margins, the veins more broadly black-bordered, and the marginal spots completely run together so that the wings are all, especially the posterior ones, distinctly bordered externally with black.

Anterior wings relatively narrower and longer, being more than twice as long as broad, with the discoidal cell equal in length to the submedian vein, that is to say, to the inner margin, and all but as long as the outer margin measured in a straight line from the extremity of the submedian vein to that of the subcostal; with the anterior discal spots more elongated and more completely coalesced, the spot between the first and second median veinlets alone constantly free, and the large rounded one internal to it in the same cell coalescent with the enlarged extremity of the cellular mark (which fills the cell nearly to the level of the origin of the second median veinlet, and is divided at the base of the wing by three indistinct longitudinal clouded white streaks), and the large mark in front of the submedian vein larger, triangular, and united by a black streak to the discal black spot beyond it.

Posterior wings shorter and broader, with the outer margin more broadly rounded off, the cell and the interspaces beyond it broader, the spot in it larger, and all those around it free, though exhibiting a tendency to coalesce with the black margins of the veinlets.

Wings below dirty-white of a dull opalescent tinge, with fuscous-black markings and veins.

Length of fore-wing 2·45; extreme length of discoidal cell, 1·38; expanse 5 inches.

HAB. Port Blair, S. Andaman.

We have much pleasure in naming this species after Colonel Cadell, Chief Commissioner of the Andamans and Nicobars, who obtained it, and who has shown himself no less ready than his predecessors to help those who are engaged in working out the interesting fauna of the islands under his charge.

Obs. The specimens of *Hestia* which Hewitson, in his list of Butterflies from the Andamans (Ann. & Mag. Nat. Hist., ser. 4, vol. xiv, 1874, p. 356), considers to be specimens of *H. agamarschana* remarkable for their dark colour, doubtless belong here.

2. DANAIS MELANOLEUCA.

Danais melanoleuca, Moore, Proc. Zool. Soc. Lond. 1877, p. 581, pl. lviii, fig. 3.

Numerous specimens of both sexes (*A. de Roepstorff* and *Moti Ram*).

3. Euplœa core.

Papilio core, Cramer, Pap. Exot. 1782, vol. iii, pl. 266, figs. E, F.
Euplœa core, Butler, Journ Linn. Soc. Lond., Zoology, 1878, vol. xiv, p. 301.

One female (*Moti Ram*) agreeing with Bengal specimens.

4. Euplœa, andamanensis.

Euplœa andamanensis, Atkinson, Proc. Zool. Soc. Lond. 1873, p. 736, pl. lxiii, fig. 2, ♂. Butler, op. cit. p. 300.

Numerous males and females (*A. de R.* and *Moti Ram*).

This is one of the species described from the collection made by Moti Ram in 1872.

Subfamily Satyrinæ.

5. Lethe europa.

Pap. europa, Fabr. Syst. Entom. 1775, p. 500.

Males and females, all remarkably fine specimens.

6. Melanitis leda.

Males and females (*A. de R.* and *Moti Ram*) and males of *M. ismene*, Cr.

7. Mycalesis mineus, Linn.
„ drusia, Cr.
„ blasius, Fabr.

Males and females (*A. de R.* and *Moti Ram*).

8. Mycalesis otrea.

Pap. otrea, Cramer, Pap. Exot. 1782, vol. iv, pl. 314, figs. A, B.
—— *francisca*, Id., ibid., pl. 326, figs. E, F.

A female of one of the numerous varieties of this species.

8. Mycalesis radza.

M. radza, Moore, Proc. Zool. Soc. Lond. 1877, p. 583, pl. lviii, fig. 2.

One male and two females.

9. Elymnias cottonis.

M. cottonis, Hewitson, Ann. Mag. Nat. Hist. 1874, ser. 4, vol. xiv, p. 358, ♂ ♀.

Numerous males (*A. de R.* and *Moti Ram*); one female (*A. de R.*).

Subfamily Morphinæ.

10. Discophora celinde.

Pap. celinde, Stoll, Pap. Exot. Suppl. 1790, pl. 37, figs. 1, 1 A.

One female.

Subfamily Nymphalinæ.

11. Cethosia nicobarica.

Felder, Verhand. zool.-bot. Gesellsch. Wien, 1862, vol. xii, p. 484; Novara Reise, Lep. p. 384, pl. xlviii, figs. 7, 8, ♂.—Moore, Proc. Zool. Soc. Lond. 1877, p. 583, ♀.

Two pairs (*Moti Ram*) and one male (*A. de R.*) agreeing perfectly with specimens from the Nicobars.

12. Atella alcippe.

Pap. alcippe, Cramer, Pap. Exot. 1782, vol. iv, pl. 389, figs. G, H.

Numerous specimens, male and female (*A. de R.* and *Moti Ram*).

13. Cirrhochroa anjira.

C. anjira, Moore, Proc. Zool. Soc. Lond. 1877, p. 584, ♂ ♀.

Males and females.

14. Cynthia erota.

Pap. erota, Fabr., Entom. Syst. 1793, vol. iii, p. 76.

Numerous males and females.

15. Messaras erymanthis, var. nicobarica.

Felder, Verh. zool.-bot. Gesellsch. Wien, 1862, vol. xii, p. 486.

Males and a female.

16. Junonia œnone.

Pap. œnone, Linn., Cramer, Pap. Exot. 1775, vol. i, pl. 35, figs. A, B, C.

Numerous males and females (*A. de R.* and *Moti Ram*).

17. Junonia almana.

Pap: almana. Linn., Gramer, Pap. Exot. 1775, vol. i, pl. 58, figs. F, G.

One pair.

18. Junonia asterie.

Pap. asterie, Linn., Cramer, Pap. Exot. 1775, vol. i, pl. 58, figs. D, E.

Three males and two females.

19. Doleschallia bisaltide.

Pap. bisaltide, Cramer, Pap. Exot. 1779, vol. ii, pl. 102, figs. C, D.

Numerous fine specimens of both sexes. Specimens were also obtained by Moti Ram in 1872.

20. Kallima albofasciata.

K. albofasciata, Moore, Proc. Zool. Soc. Lond. 1877, p. 584.

Male and female.

21. Eurytela horsfieldii.

Eurytela horsfieldii, Boisduval, Faun. Ent. Madag, 1833, p. 54, ♂.
——— *stephensii*, Id., ibid. p. 55, ♀.

A single male.

22. Cyrestis cocles.

Pap. cocles, Fabr., Moore, Proc. Zool Soc. London, 1878, p. 829.
? *Cyrestis formosa*, Felder, Reise Novara, Lep. p. 412, ♂.

A single male of this delicately tinted butterfly.

23. Cyrestis thyodamas.

Cyr. thyodamas, Boisd. in Cuv. R. A. 1836, Ins., pl. 138, fig. 4. Doubld. Westw. and Hew. Gen. D. L., pl. 32, fig. 3.

Amathusia ganescha, Koll. in Hügel's Kaschmir, 1848, vol. iv, p. 430, pl. 7, figs. 3, 4.

One male.

24. Hypolimnas bolina.

Pap. bolina, Linn., Clerk's Icones, pl. 21.—*Diadema bolina*, Wallace, Trans. Ent. Soc. Lond. 1869, p. 278.

Numerous male and females (*A. de R.* and *Moti Ram*).

25. Herona marathus, var. andamana.

Herona marathus, Westw. Doubl. and Hew. Gen. D. Lep. 1850, p. 293, pl. 41, fig. 3.
——— *andamana*, Moore, Proc. Zool. Soc. Lond. 1877, p. 585, ♂ ♀.

Two males and a female.

26. Parthenos gambrisius.

Pap. gambrisius, Fabr.

Numerous specimens of each sex (*A. de R.* and *Moti Ram*).

27. Neptis mananda.

N. mananda, Moore, Proc. Zool. Soc. Lond. 1877, p. 586, pl. lviii, fig. 4, ♀.

Two pairs (*A. de R.* and *Moti Ram*).

Seems very near to *N. khasiana*.

28. Neptis andamana.

N. andamana, Moore, Proc. Zool. Soc. Lond. 1877, p. 586, ♂ ♀.

Five males and a female (*A. de R.* and *Moti Ram*).

29. Athyma selenophora.

Limenitis selenophora, Koll. in Hügel's Kaschmir, 1848, vol. iv, p. 426, pl. vii, figs. 1, 2, ♂.

A female, the only one in the Museum, was obtained by Moti Ram in 1872.

30. Symphædra teuta, var. teutoides.

S. teutoides, Moore, Proc. Zool. Soc. Lond. 1877, p. 586, ♂ ♀.

Males and females (*A. de R.* and *Moti Ram*).

31. Tanaecia cibaritis.

Adolias cibaritis, Hewitson, Ann. & Mag. Nat. Hist. 1874, ser. 4, vol. xiv, p. 358; Exot. Butt. vol. v, *Adolias*, pl. iv, figs. 12, 13, 15, ♂ ♀.

Tanaëcia cibaritis, Moore, Proc. Zool. Soc. Lond. 1877, p. 586.

Numerous males and females (*A. de R.* and *Moti Pam*).

32. Tanaecia acontius.

Adolias acontius, Hewitson, loc. cit. p. 357; Exot. Butt. vol. v, *Adolias*, pl. iv, fig. 11, ♀. *Tanaëcia acontius*, Moore, Proc. Zool. Soc. Lond. 1877, p. 586.

One female.

33. Limenitis procris, var. anarta.

L. anarta, Moore, Proc. Zool. Soc. Lond. 1877, p. 585.

One female.

34. Nymphalis athamas.

Pap. athamas, Drury, Ill. Exot. Entom. 1773, vol. i, pl. ii, fig. 4.

One female.

Family ERYCINIDÆ.

35. Abisara bifasciata.

A. bifasciata, Moore, Proc. Zool. Soc. Lond. 1877, p. 587, pl. lviii, fig. 1, ♀.

Three females.

Family LYCÆNIDÆ.

36. Lampides ardates.

Lycaena ardates, Moore, Proc. Zool. Soc. Lond. 1874, p. 574, pl. lxvii, fig. 1, ♂.

One female.

37. Lampides ælianus.

Hesp. aelianus, Fabr., *Lycaena aelianus*, Horsfield, Cat. Lep. E. I. Co., 1829, p. 78.

One male.

38. Lampides elpis.

Polyomm. elpis, Godt., Encyclo. Méth. Ins. vol. ix, p. 654.—*Lycaena elpis*, Horsfield, opcit. p. 76, pl. 1, fig. 4, ♀ ♂.

One female and one male (*A. de R* and *Moti Ram*).

39. Lampides pandava.

Lycaena pandava, Horsfield, op. cit. p. 84, ♀.

One female.

40. Lampides conf. pactolus.

♀. Wings above much as in *L. pactolus*, differing in having the dark fuscous outer border of the anterior wing spotless and that of the posterior wing very much less distinctly marked in the same manner, no discocellular mark in either wing, and the whole upperside apparently more clouded with smoky fuscous scales.

Wings beneath very pale fuscous, with a submarginal fascia composed of rhomboid spots and a marginal one of narrow oval spots fuscous of a rather darker shade than the ground, both margined and connected together by whitish, the latter of them developed, in the interval between the first and second median branches, into a conspicuous jet-black circular spot divided externally by a semicircle of pale blue metallic scales and encircled internally by luteous white, and into two minute ones, one on each side of the submedian vein, internally covered with blue scales.

Anterior wings with two small subcostal spots, a short discocellular fasciole, and a discal fascia strongly faulted at the second median veinlet so that the outer white margin of its posterior portion is in line with that of its anterior portion, and the inner white margin of its posterior portion in line with the discocellular veinlet.

Posterior wings with a similar discocellular fasciole, and complexly faulted and contorted discal and basal fasciæ; all the fasciæ in all the wings margined on both sides with fuscous of a very slightly deeper tint than the ground and with whitish.

Since the above description was written, we have discovered that five unnamed insects in the Museum from Cherrapunji in the Khasi Hills, the Sikkim Hills, and Sibsagar (*S. E. Peal*) in upper Assam are males of this species, and the following is a brief description of one of them:—

♂. Wings above semitranslucent palish fuscous with a light and tolerably brilliant amethystine lustre, edged with a darker anteciliary line.

Wings below much as in the female, with the macular submarginal fuscous fascia of all the wings broader, and the anal and subanal black spots rather larger and conspicuously encircled with fulvous internally.

Length of anterior wing ♀ ·72, ♂ ·58—·68; whence expanse = ♀ 1·5, ♂ 1·2—1·4 inches.

41. Lampides plumbeomicans, n. sp.

Closely allied to the preceding, but much smaller; with three instead of two fasciæ on the underside of the anterior wings, with all the fasciæ relatively broader, and with those of the posterior wings much less complexly faulted and contorted.

♂. Wings above dark amethyst-purple with a dull greyish leaden metallic lustre, with a deep black anteciliary line and fuscous fringe.

Wings beneath pale fuscous of a purplish tinge, with a marginal and a submarginal fascia composed of suboval spots of a darker shade than the ground, both margined and connected by whitish, the latter of them bearing in the posterior wings subanal and anal black spots in every respect as in the preceding except that the luteous inner line is rather more distinct.

Anterior wings with a basal fascia, a discocellular fasciole, and a discal fascia faulted as in the preceding at the second median veinlet; with the fasciæ as also the fasciole commencing at the costal vein where they are all broken.

Posterior wings with corresponding fasciole and fasciæ, which latter are more or less faulted at every vein though much less contorted and consequently more easily traced than in the preceding; fasciæ and fascioles of both wings margined on both sides with fuscous of a rather deeper shade than the ground and with whitish.

♀. Wings above dull smoky.

Anterior wings with a pale discal patch which has a brilliant metallic pale bluish lustre in certain lights.

Posterior wings with a thin interrupted white line before the dark anteciliary one and a submarginal row of dark spots before it, spots and line increasing in size, breadth, and distinctness from the apical angle to the subanal region, the former obscurely encircled internally with smoky whitish.

Wings beneath lighter, with all the markings more pronounced, being margined with fuscous much darker than the ground and with pure white, and the marginal and submarginal macular fasciæ, especially conspicuous and coarse.

Length of anterior wing ♂ ·56, ♀ ·58, whence expanse = ♂ 1·12, ♀ 1·16 inches.

Two males and a female.

42. Polyommatus sangra.

P. sangra, Moore, Proc. Zool. Soc. Lond. 1865, p. 772, pl. 41, fig. 8, ♂.

Innumerable males and females. The commonest 'blue' in Calcutta, being obtainable in any number wherever there is a patch of grass.

43. Aphnæus lohita, var. zoilus.

A. zoilus, Moore, Proc. Zool. Soc. Lond. 1877, p. 588, ♂.

♀. Larger than the male. Upperside smoky brown, marked obscurely with darker bands corresponding to those of the underside. Underside with the intervals between the bands wider owing to the greater breadth of the wings. In all other respects as in the male.

Length of fore-wing ·7; whence expanse = 1·46 inches.

Males and one female.

44. Hypolycæna erylus.

H. erylus (Godart), Hewitson, Ill. D. Lep. Lyc. p. 49, pl. xxi, fig. 1 ♂, 2, 4 ♀.

H. andamana, Moore, Proc. Zool. Soc. Lond. 1877, p. 589, ♂ ♀.

Three males and a female. Absolutely indistinguishable from fresh Sikkim specimens.

45. Sithon sugriva, var. areca.

Amblypodia sugriva, Horsfield, Cat. Lep. E. I. Co. 1829, p. 105, pl. i, figs. 10, 10*a*, ♂.

Myrina sugriva, Horsfield and Moore, Cat. Lep E. I. Co. p. 51, pl. 1*a*, fig. 12, ♂.

Myrina areca, Felder, Verhand. zool.-bot. Gesellsch. Wien, 1862, vol. xii, p. 481, ♂.

♀. Smaller than the male. Upperside sepia-brown with a bronzy gloss, the spots and fasciæ of the underside scarcely showing through. *Hindwing* with a pure white patch divided by the brown veins, margined externally by a fine and sharp dark brown or black anteciliary line, and marked by a large circular black spot at the base of the tail on the anterior side and by another smaller lighter and less distinct one on the posterior side; with the caudal lobe blackish, and the tails black with pure white cilia. Underside pure white marked as in the male with dark sepia-brown fasciæ and spots, but with the black caudal spots larger and the cilia of the posterior part of the hind-wing pure white like those of the tails.

Length of fore-wing ·66; whence expanse = 1·38 inches.

It differs from *S. phocides* ♀ (= *S. jolcus* (Felder), Hew., Ill D. Lep. Lyc. pl. xiii, figs. 16, 17) in the far less extent of the white patch on the upperside of the hind-wing, and in the larger size and darker colour of the spots and fasciæ, as well as in the greater pureness of the white, of the underside generally.

One male and one female, the former differing from a specimen from the Indian continent (Sylhet) only in its rather darker and more distinctly marked underside. The lighter apical portion of the fore-wing in the male has a beautiful bronzy gloss changing to dark purple according to the incidence of the light. Both the insular and continental specimen, but especially the former, present slight traces of the blue marginal band so conspicuous in the hind-wings of Javan and Ceylonese examples, in the shape of a small patch of metallic green scales on the anterior caudal lobe.

The male of this species, with its velvety black upperside, rich dark brown underside, and elongated hind-wings produced into long robust buff tails, presents a strong contrast to the dull-coloured female with her pure dazzling white underside conspicuously spotted and banded with dark brown, broader wings, and comparatively short and feeble white and black tails.

Sithon kamorta is not the female of *S. sugriva*, var. *areca*, as Felder has suggested, but that of a distinct though closely-allied species peculiar to the Nicobars, whence the Museum has recently received a specimen of the true male differing from *S. kamorta* just in the same way as *S. sugriva* ♂ does from its female, which appears not to have been previously described.

46. Sithon westermannii, var.

Dipsas westermannii, Felder, Reise Novara, Lep. p. 241, pl. xxx, figs. 21, 22, ♀, from Luzon.

A male and a female, the latter differing from the former in having the upperside smoke-brown instead of purplish fuscous, no discal pale patch in the fore-wing, the hind-wing devoid of blue, and the underside ochraceous-brown instead of dark fawn-colour with a vinous tinge. The male differs from the same sex of *S. westermannii*, in having less blue on the upper surface, and the anal spot completely encircled with grey scales.

A comparison of Andamanese with Philippine specimens would, we have no doubt, show that the former is just as much entitled to a name of its own as the latter. Both are merely insular races of the Indian continental *S. jangala.*

47. Sithon tarpina.

Myrina tarpina, Hewitson, Ill. D. Lep. Lyc. Suppl. 1877, p. 23, pl. (Suppl.) iii *a*, figs. 93, 94, ♀.

♂. Upperside rich deep metallic violet-blue, with the anterior margin of the fore-wing narrowly, and the external margin of both wings more broadly and decreasingly bordered with black. Underside with about the basal two-thirds of both wings cœrulescent or virescent opaque dead white, the rich red-brown of the outer margins darker but similarly banded and marked with white, and the orange spots smaller with a diffused patch of greyish white scales between them and two or three in front of them all somewhat confounded with the white marginal line.

Three specimens.

Length of forewing ·84; whence expanse = 1·78 inches.

48. Deudorix epijarbas.

Dipsas epijarbas, Moore, Cat. Lep E. I. Co. 1857, vol. i, p. 32, ♂ ♀.
Deudorix epijarbas, Hew., Ill. D. Lep. Lyc. pl. vii, figs. 16, 18, ♂, 17, ♀.

Very numerous specimens of both sexes.

49. Deudorix dieneces.

D. dieneces, Hewitson, Ill. D. Lep. Lyc. Suppl. 1878, p. 31, pl. v *a*, figs. 65, 67 ♂, 66 ♀.

Males and females.

The Museum possesses males from Silhet and Calcutta also.

50. Deudorix orseis.

D. orseis, Hewitson, Ill. D. Lep. Lyc. 1863, p. 23, ♂.

♀. Upperside lighter, with a distinct purple gloss which has a light steel-bluish tint at the base of all the wings. Underside lighter, with all the markings more distinct.

Length of fore-wing ·68; whence expanse = 1·42 inches.

Two males and two females.

51. Deudorix varuna.

Thecla varuna, Horsfield, Cat. Lep. E. I. Co. 1829, p. 91, ♂ ♀.

A single male.

52. Myrina atymnus, var. prabha.

Myrina prabha, Moore, Proc. Zool. Soc. Lond. 1877, p. 589, pl. lviii, fig. 5, ♀.

Males and female.

53. Amblypodia narada, var. erichsonii.

Amblypodia narada, Horsfield, Cat. Lep. E. I. Co. 1829, p. 98, pl. 1, fig. 8, ♂ ♀.
——— *erichsonii*, Felder, Reise Novara, Lep. p. 218, ♀, from Luzon.

Two females.

54. Arhopala centaurus, var. coruscans.

Pap. centaurus, Fabr. *Ambly. centaurus*, Horsf., Cat. Lep. E. I. Co. 1829, p. 102. Hewitson, Cat. Lyc. Brit. Mus. pl. ii, figs. 10—13, ♂ ♀.

Male and female; the latter much smaller than the former. The bases of both wings in both sexes, but especially in the female, lighter, with a greenish tinge, so that the whole central portion of the insects appears brilliantly illuminated by a pale greenish blue reflection in most lights.

55. SURENDRA QUERCETORUM, var. LATIMARGO.

S. latimargo, Moore, Proc. Zool. Soc. Lond. 1879, p. 142, ♂ ♀.

A male and two females.

Is *A. quercetorum* itself more than a local race or variety of *A. vivarna*, Horsfield, Cat. Lep. E. I. Co. 1829, p. 99, from Java?

Family PAPILIONIDÆ.

Subfamily PIERINÆ.

56. TERIAS HECABE.

Pap. hecabe, Linn.

Males and a female.

57. TERIAS HARINA.

T. harina, Horsfield, Cat. Lep. E. I. Co. 1829, p. 137.

Males and females.

58. HEBOMOIA ROEPSTORFFII.

H. Roepstorffii, Wood-Mason, antea, p. 134 ♂, et p. 150, ♀.

"♂. Differs from *H. glaucippe*, the only species of the genus with which I have been able to compare it, on the UPPERSIDE, in having the apical orange patch of the fore-wing larger, extended into the cell, and less broadly bordered with fuscous, both internally and externally; the submarginal fuscous spots smaller and completely isolated from the fuscous of the outer margin; the fore-wing at the posterior angle tinged, and the hind-wing externally broadly bordered, with bright sulphur-yellow, which colour is shaded off into the cream-colour of the rest of both wings; and the outer margin of the hind-wing narrowly edged with fuscous, which gradually broadens from the anal to the anterior angle and extends inwards in points at the veins:—and, on the UNDERSIDE, in having the brown mottling of the fore-wing arranged in the form of a tolerably conspicuous band coincident with the macular band of the upperside; and the ground-colour of the hind-wing, as also that of the mottled portion of the fore-wing, of a rich golden-luteous colour.

Length of fore-wing 1·76; whence expanse = 3 62 inches.

♀. UPPERSIDE. *Fore-wing* with the orange patch devoid of amethystine gloss, externally more broadly bordered with fuscous (which at each veinlet gives off inwards an angular process the extremity of which is continued on as a very narrow edging to each side of the veinlet), but internally much less distinctly so than in the male; with the cell more clouded with dark scales; and with the sulphur-colour at the inner angle more diffused. *Hind-wing* with a marginal row of large subtriangular fuscous spots placed upon the veinlets from the first subcostal to the first median (the two last obsolete), decreasing from the second in the direction of the anal angle, and connected together at the extreme margin of the wing by a narrow edging of the same colour, which extends to the anal angle; with a submarginal series of six roundish spots, similarly decreasing from the first, and alternating with those of the marginal series, each being placed upon a fold, the first and largest on the fold between the costa and the first branch of the subcostal, and the last on that between the first and second median veinlets; and with the sulphur-colour around the four intermediate submarginal spots stained with orange. UNDERSIDE of *both wings* paler.

Length of fore-wing 1·7; whence expanse = 3·5 inches.

HAB. South Andaman.

In a specimen of the male from the collection of Captain G. F. L. Marshall, the submarginal fuscous spots of the fore-wing are obsolete.

The place of this species would seem to be between *H. vossii* (Maitland) and *H. sulphurea*, Wallace."

59. IXIAS ANDAMANA.

I. andamana, Moore, Proc. Zool. Soc. Lond. 1877, p. 590, ♂ ♀.

Numerous males and females (*A. de R.* and *Moti Ram*).

60. CATOPSILIA CROCALE.

Pap. crocale, Cramer, Pap. Exot. 1779, vol. i, pl. lv, figs. C, D, ♀.
Callidryas crocale, Butler. Lep. Exot. 1869-74, p. 22, pl. ix, figs. 1, 2, 3, 6, ♂ ♀.

Two males.

61. PIERIS NADINA, var. NAMA.

Pieris nadina, Lucas, in Guérin's Rev. et Mag. Zool. 1852, ser. 2, vol. iv, p. 333, ♂.
P. nama, Moore, Proc. Zool. Soc. Lond. 1857, p. 102, pl. 44, figs. 1, 2, ♂ ♀.
——— Hewitson, Ex. Butt. *Pieridae*, pl. 6, fig. 37.

Males and females.

62. PIERIS CORONIS, var. LICHENOSA.

Pap. coronis, Cramer, Pap. Exot. vol. i, 1776, pl. 44, figs. B, C.
Pier. lichenosa, Moore, Proc. Zool. Soc. Lond. 1877, p. 591.

Two pairs.

63. Eronia valeria, var. naraka.

Pap. valeria, Cramer, Pap. Exot. 1779, vol. i, pl. 85, fig. A, ♂.
Eronia naraka, Moore, Proc. Zool. Soc. Lond. 1877, p. 591, ♂ ♀.

Males and a female.

The Javan specimens of the male described by Horsfield and figured by Cramer both have the black outer border of the anterior as well as the posterior wings immaculate, and thus agree more closely with the S. Indian (var. *pingasa*), Ceylonese (var. *ceylonica*), and Andamanese (var. *naraka*) varieties. As might have been expected from its more northern station, the Andamanese more nearly approaches the north Indian form (var. *gaea*).

64. Tachyris paulina.

Pap. paulina, Cramer, Pap. Exot. vol. ii, pl. 110, figs. E, F, ♀.
Pieris albina, Boisd., Sp. Gén. Lep. p. 480, ♂.
Tachyris paulina, Wallace, Trans. Ent. Soc. Lond. 1867, ser. 3, vol. iv, p. 369.

Two males and two (white) females differing in no respect from those of continental India (Naga Hills, Cachar, Bhutan, and Madras).

Tachyris galathea, Felder, is a perfectly distinct race peculiar to the Nicobars, whence we have specimens.

Subfamily Papilioninæ.

65. Ornithoptera heliaconoides.

Ornith. heliconoides, Moore, Proc. Zool. Soc. Lond. 1877, p. 592, ♂ ♀.

A male and a female.

66. Papilio charicles.

P. charicles, Hewitson, Ann. & Mag. Nat. Hist. 1874, ser. 4, vol. xiv, p. 356; Exot. Butt. vol. v, *Pap.* pl. xiv, fig. 45, ♀.

One female of the 3rd form (*Moti Ram*).

This is the Andaman representative of the continental *P. androgeus;* it is interesting to find that it has acquired the red tails of its model, *P. rhodifer*, the slight Andamanese modification of the continental *P. doubledayi*.

67. Papilio mayo.

P. mayo, Atkinson, Proc. Zool. Soc. Lond. 1873, p. 736, pl. lxiii, fig. 1, ♂.

Two males (*A. de R.* and *Moti Ram*). The species was described by Atkinson without acknowledgment from the specimens obtained by Moti Ram.

The Andamanese representative of the continental *P. polymnestor*.

68. Papilio polytes, var. nikobarus.

Felder, Verh. zool.-bot. Gesellsch. Wien, 1862, vol. xii, p. 483.

Males and females of the first form only (*A. de R.* and *Moti Ram*).

69. Papilio agamemnon.

Males and females (*A. de R.* and *Moti Ram*).

70. Papilio eurypylus.

One pair.

71. Papilio clytia, var. flavolimbatus.

P. dissimilis, var. *flavolimbatus*, Oberthür, Etudes d'Entom. 4 me livr. p. 101, ♀.

This variety agrees in the size and distinctness of the cretaceous white markings of the upperside best with specimens from Silhet, Sibsagar, and Burmah on the Indian mainland, but differs from them, as indeed it does from all specimens in the Museum, in the large amount of rich golden yellow at the outer margin on both sides of the posterior wings: the marginal and submarginal flavous spots seen at the anal angle of the wing in most continental specimens are in this case so completely run together on both sides as to have left only a small central spot of the black ground-colour that separates them from one another in continental specimens; they are succeeded by a series of six (incisural) marginal spots of the same colour; the submarginal lunules are much larger and more spear-shaped and, moreover, sullied with yellow, especially the one near the anal blotch: on the *underside*, the marginal golden yellow spots are larger and tend to coalesce with the hastate submarginal markings, which consequently are more suffused with yellow than they are on the upperside.

A single male.

72. Papilio læstrygonum.

P. laestrygonum, Wood-Mason, Proc. Asiat. Soc. Bengal, June, 1880, p. 102, et antea, p. 178, pl. vi, fig. 1, 1*a*, ♂.

P. epaminondas, Oberthür, Etudes d'Entom. 4 me livr. p. 62, pl. iv, fig. 1, ♂.

" ♂. Wings above cretaceous-white, the anterior ones black at the insertion, scarcely tinged with greenish at the base, with five black bands commencing at the anterior margin and cutting the cell, the first basal, extending to the inner margin, the second rather broader, also extending to the inner margin, and emitting a short conical process at the origin of the first median veinlet, the third scarcely broader, extending to the median vein, the fourth narrower, triangular, reaching or all but reaching the median vein, the fifth much the broadest of all, triangular, divided anteriorly into two forks by a curved narrow decreasing and interrupted band of the ground-colour running from the costal vein to the third median veinlet, extending to the inner margin, separated from the black outer marginal band by a band of the ground-colour divided by the black veins and very slightly if at all narrowing from the anterior margin up to the second median veinlet, whence it gradually decreases in width and distinctness to the inner angle; all these black bands connected at the anterior margin, and the first, second, and fifth of them at the inner margin also, by a very narrow edging of black.

Posterior wings with two black bands commencing and connected at the anterior margin and coinciding with bands of the underside, one basal, extending to the end of the first half of the first median veinlet, and the other discal, extending a short distance into the space between the 2nd and 3rd median veinlets; with a small black spot near the end of the cell scarcely distinct from the discal band; with four discal spots immediately beyond the cell running nearly parallel with the band, the first and largest transversly elongated and coinciding with a spot on the underside, the rest smaller than the corresponding ones on the underside, which latter are consequently seen through the wing-membrane beyond the margins of the former; with a black spot succeeded by one of luteous at the anal angle; with a marginal and submarginal series of black lunules coalescent in the anterior third but more distinct in the posterior two-thirds of the wing, where the two series are more or less separated from one another by ashy-grey scales continuous with the ashy patch occupying the outer third of the wing and extending also along so as to obscure the ultra-cellular part of the basal black band; with the discal band and spots more or less irrorated and obscured with ashy-grey scales so that the disk of the wing appears mottled with black and grey; and with the black tails, as also the incisures, margined with cretaceous-white.

Wings below pure white, anterior ones marked as above, with the ground-colour at the base and between the black bands as far as the median vein and its second branch yellowish; with the band of ground-colour separating the fifth black band from the black outer border distinct, and not decreasing but on the contrary rather increasing in breadth, to the inner angle; and with the curved line dividing the fifth black band into two forks more distinct and less discontinuous.

Posterior wings, from the base up to the median vein and the discal black band, yellowish, with three black bands, one narrow running from the insertion along the inner margin close to the abdominal fold, and two broader commencing and connected at the anterior margin and cutting the cell, one of these latter basal, extending nearly to the end of the basal half of the first median veinlet, and the other discal, some distance into the space between the 2nd and 3rd median veinlets, the two first of the three bands connected together at their outer extremities and with two largish coalescent black spots in the anal region; with a small black spot near the extremity of the cell, and six of the same colour immediately beyond it disposed in a line which runs straight from the costal vein as far as the cell, but then curves abruptly inwards, the first of these spots transversely elongated, extending from vein to vein, and connected with the second, which is roundish and itself connected with the discal band, the third oval, about one-third the size of the second, and touching the discocellular veinlet, the fourth twice the size of the third, in contact with the median vein and its two last branches, the fifth rather smaller than the third, the sixth crescentic and connected with the two above-mentioned large spots in the anal region; with six large diffused luteous blotches externally margined with black, and increasing in size and depth of colour from the anterior to the inner margin; with the ground-colour between these blotches and the discal black spots pure white; with an increasing series of six marginal lunules, between which and the wavy black margins of the luteous blotches the ground-colour is white in the anterior and grey or greyish-white in the posterior portion of the wings; and with the incisures and the tails margined with lutescent.

Head black with two white frontal bands; pronotum with a luteous spot on each side; thorax above jet-black ornamented at the sides with long grey setæ, below cretaceous-white; abdomen cretaceous-white with a tapering dorsal black band and two lateral fuscous ones.

Length of anterior wing 1·7; whence expanse = 3·5 inches.

HAB. South Andaman. Two males.

To mark its close relationship to *A. antiphates*, I have called the species *P. laestrygonum* after the mythical people over whom Antiphates is supposed to have reigned. It differs from its nearest ally in having the upperside much blacker (the bands of the forewing being broader; the first, second, and fifth of them together with the marginal one extending to the inner margin, where they are all connected together by a very narrow black edging; and the disk of the hindwing mottled as it were by black and grey), a much greater extent of grey, and more highly developed marginal and submarginal lunules on the hindwing; in the abdomen being dorsally banded with black and the thorax ornamented with grey setæ, &c."

73. Papilio rhodifer.

P. rhodifer, Butler, Ent. Month. Mag., vol. xiii, 1876, p. 57.

Five males.

Fam. HESPERIDÆ.

74. Ismene chromus.

Numerous examples (*A. de R.* and *Moti Ram*).

75. Ismene aria.

Ismene aria, Moore, Proc. Zool. Soc. Lond., 1865, p. 784, ♂ ♀.—Hewitson, Exot. Butt., vol. iv, *Hesp.*, pl. iii, figs. 24, 25, ♀.

Male and female.

76. Ismene lebadea.

Hesperia lebadea, Hewitson, Exot. Butt., 1868, vol. iv, *Hesp.* pl. iii, figs. 22, 23, ♂.

One male.

77. Ismene druna.

I. druna, Moore, Proc. Zool. Soc. Lond. 1865, p. 784, ♂.—Hewitson, Exot. Butt. vol. iv, 1868, *Hesp.* pl. iii, fig. 26, ♂.

Two males.

78. Tagiades ravi.

Pterygospidea ravi, Moore, Proc. Zool. Soc. Lond. 1865, p. 779, ♂ ♀.

One male and two females.

79. Tagiades alica.

T. alica, Moore, Proc. Zool. Soc. Lond. 1877, p. 593, pl. lviii, fig. 11, ♂.

♀. Above lighter, the dark markings consequently appearing more prominent.

The anterior wing has a minute transparent speck behind the three subapical ones, a very indistinct and small double whitish spot near the end of the cell on the upperside, and two discal whitish spots on the underside, the anterior one of which only is partially transparent and visible on the upperside.

The posterior wing is less white above and has the anal angle rounded as in *T. obscurus*.

Male and female.

80. Plesioneura alysos.

P. alysos, Moore, Proc. Zool. Soc. Lond. 1865, p. 789.

Many specimens.

81. Hesperia oceia.

H. oceia, Hewitson, Desc. Hesp. 1868, p. 31.

Males.

82. Hesperia colaca.

H. colaca, Moore, Proc. Zool. Soc. Lond. 1877, p. 594, pl. lviii, fig. 7, ♂ ♀.

Two specimens.

83. Hesperia cahira.

H. cahira, Moore, Proc. Zool. Soc. Lond. 1877, p. 593, pl. lviii, fig. 8, ♂ ♀.

Males and females.

84. Halpe beturia.

Hesperia beturia, Hewitson, Desc. Hesp. 1868, p. 36.
Halpe beturia, Moore, Proc. Zool. Soc. Lond. 1878, p. 690.

Males and one female. A pair from Calcutta in the Museum. The number of spots in the forewing varies from 6 to 8.

85. Hesperia chaya.

H. chaya, Moore, Proc. Zool. Soc. Lond. 1865, p. 791.

Male.

86. Telegonus thyrsis.

Telegonus thyrsis (Fabr.), Butler, Fabr. Lep. p. 262.
Hesperia pandia, Moore, Proc. Zool. Soc. Lond. 1865, p. 790.

Three males.

87. Pamphila mæsoides.

P. maesoides, Butler, Trans. Linn. Soc. Lond., ser. 2, Zoology, vol. i, p. 554.

Many specimens.

88. Pamphila gola.

P. gola, Moore, Proc. Zool. Soc. Lond. 1877, p. 594, pl. lviii, fig. 9, ♂.

Numerous specimens (*A. de. R.* and *Moti Ram*).

During the preparation of the foregoing list, we received from Bassein, on the mainland, two females of a species of *Hestia* of the same type as *H. cadelli*, in which the modifications of form and markings begun in *H. agamarschana* and continued in *H. cadelli* are carried to an extreme. These insects were obtained by Mr. Algernon Haden, who has generously presented one of them to the Museum, and after whom we have, consequently, all the more pleasure in naming the species

Hestia hadeni, n. sp., Pl. XIII, Fig. 2, ♀.

♀. Closely allied to *H. cadelli.* Wings above pure fleckless white marked and veined with black of a fuscous tint; with the marginal, submarginal, and all but the two posterior (which are subcoalescent with the marginal band) of the discal series of spots in the anterior wings, but with the marginal and submarginal series only in the posterior wings, completely run together so that only the inner portions of the outlines of the innermost series of the coalesced spots are in either case still discernible, and so as to form a very broad outer border of black to each of the wings.

Anterior wings broader and shorter, being less than twice as long as broad, the extreme length of the cell bearing the same relation to the submedian vein and to the less deeply emarginate outer margin; with the spot at the base of the second cell smaller and free of the veins, as also is the discoidal cellular spot at its posterior extremity; the curved club-shaped mark in the 3rd inner marginal cell much as in *H. agamarschana*, but not connected by a black streak with the snbcoalescent marginal spot beyond it; the outer black border with a clouded white spot in the second cell more or less distinctly separating the second discal black spot off from the band; and the black second inner marginal, or sutural, cell longitudinally streaked with clouded white.

Posterior wings broader, with their undulated outer margin still more broadly rounded; the spot in the discoidal cell smaller and the spots around it also rather smaller and free of the black outer border though exhibiting a tendency to coalesce with it in front of the second median veinlet.

Wings below of a less pure white than above, marked and veined with fuscous.

Thorax more conspicuously marked with greyish-white than in *H. cadelli*, in which these marks are almost effaced, but this character, as also the difference in the proportions, and the less obvious emargination of the outer margin, of the wings, may be sexual.

Length of anterior wing 2·54; extreme length of its discoidal cell 1·35; expanse 5·18 inches.

HAB. Bassein, Burmah. Two specimens agreeing in every respect with one another.

EXPLANATION OF PLATE XIII.

Fig. 1. *Hestia cadelli*, W.-M. & de N., ♂.
Fig. 2. *Hestia hadeni*, W.-M. & de N., ♀.

XXII.—*Description of an* Arvicola *from the Punjab Himalayas.*

By W. T. Blanford, F. R. S.

Arvicola wynnei, sp. nov.

A. *superne rufescenti-fuscus, aliquando griseo-lavatus, subtus pallidior, caudâ pedibusque cum dorso concoloribus, caudâ fere* $\frac{2}{7}$ *corporis cum capite æquante; auriculis brevibus, vellere contectis, pilis longiusculis extus munitis; unguibus longis, albidis compressis, pilis haud obtectis; pollice brevi, unguifero; dente molario inferiore antico angulis* 4 *externis,* 5 *internis, spatiis in coronâ* 7 *munito, secondo tertioque singulis angulis utrinque tribus, totidem spatiis; dente superiore primo spatiis* 5, *angulis utrinque tribus, secundo spatiis* 4, *angulis tribus externis, duobus internis, tertio denique angulis tribus, quorum ultimus rotundatus, externis, duobus internis, in lobum elongato-ovatum postice productum desinente notando. Long. corporis cum capite* 0·12 *met., caudæ* 0·032, *auris* 0·07, *pedis posterioris a calcaneo* 0·18, *cranii* 0·028.

Hab. Ad Mari (Murree) in montibus Himalayanis occidentalibus, ad latus occidentale fluminis Jhelum.

General colour above dark rich brown with a slight greyish tint, head rufescent, lower parts pale brown, tail the same colour as the back, feet covered with brown hair above, soles pale. Fur very soft, dark leaden grey at the base and for about $\frac{3}{4}$ the length, tips dark rufous brown on the back, dirty white below. Ears short and rounded, concealed beneath the fur, thinly clad with long hair outside and with short brown hair inside near the border; a tuft of long hair on the anterior edge of the inner surface. Tail between $\frac{1}{3}$ and $\frac{1}{4}$ the length of the head and body, cylindrical, clothed with long hair at the base and with short brown hairs throughout the terminal three quarters of it length. Claws long, compressed, white, not concealed by long hairs, thumb small with a short compressed claw. The under side of the tarsus is hairy.

The following are the dimensions, in inches, of two specimens, both adult males, in spirit:—

	1	2
Length of head and body from nose to anus,...............	4·75	3·5
Ditto tail from anus (hairs at end not included), ...	1·35	1·2
Height of ear from orifice, ...	0·25	0·26
Breadth of ditto, ...	0·25	0·26
Length of fore-foot without claws,...........................	0·4	0·4
Ditto of hind-foot and tarsus without claws,............	0·7	0·7
Ditto of claw of middle toe,...................................	0·11	0·13

The incisors are deep orange. The following are the characters of the molars :—

Upper molar I ;	5	spaces or prisms	3	external and	3	internal angles
„ „ II	4	„	3	„	2	„
„ „ III	4	„	3	„	2	„
Lower molar I	7	„	4	„	5	„
„ „ II	3	„	3	„	3	„
„ „ III	3	„	3	„	3	„

Described from two specimens in spirit and two skins sent by Mr. A. B. Wynne, of the Geological Survey. I have called the species after the discoverer, by whom I am informed that the native name is '*Kanis.*'

I hope to give a fuller description of this and the other Himalayan forms shortly.

XXIII.—*Some new Species of Rhopalocerous* Lepidoptera *from the Indian Region.—By* Captain G. F. L. Marshall, R. E., *and* Lionel de Nice'ville.

(Received December 27th, 1880.)

1. Euplœa (Salpinx) adamsoni, Marshall.

♂. Allied to *E. superba*, Herbst, but differing on the upperside of the *forewing* in that the brilliant blue gloss is confined to the basal two-thirds not reaching to the costa or the inner margin, and that the spots are reduced to four in number all very small, one subcostal above the end of the cell, and one in the cell at the end both lilac, and two near anal angle, one marginal and the other submarginal, white. *Hindwing* as in *E. superba.*

Hab. Moulmein; taken in the autumn by Captain C. H. E. Adamson.

2. Zophoessa jalaurida, de N.

♂. Nearest to *Z. atkinsonia*, Hewitson; from which it differs on the upperside in being deep brown instead of tawny and in having the macular bands and bar in the cell of the *forewing* ochreous. On the underside the ground colour is also deep brown, and the *hindwing* is crossed by several silvery white streaks on the basal half.

Hab. Jalauri pass, N. W. Himalayas.

3. Lethe maitrya, de N.

♂. Allied to *Lethe sidonis*, Hewitson, from which it differs on the upperside in having an obscure ochreous band across the *forewing* beyond the cell, and on the UNDERSIDE in the band in the cell, as also the band beyond the cell, of the *forewing* being very prominent, both of which bands are ochreous instead of silvery white.

HAB. Jalauri pass, N. W. Himalayas.

4. LETHE SIDEREA, Marshall.

♂. Allied to *L. sidonis*, but differs in being smaller, in the uniform spotless upper surface, and the uniform paler brown ground-colour of the underside. *Forewing* entirely wanting the discal bands and the whitish spots on the costal margin; the only markings being three minute submarginal white spots beyond the cell (the middle one faintly circled with black), a single yellowish marginal line edged on both sides with dark brown, and within this a distinct silvery lilac submarginal line extending from the apex to the second median nervule. *Hindwing* with all the silvery streaks brighter and more distinctly lilac; the ocelli all blacker and less prominently pupilled with white; the second and third ocelli from the apex out of line, much nearer the margin, the silvery band within following this curve and deeply sinuated beyond the cell.

HAB. Sikkim.

5. LETHE SATYAVATI, de N.

♀. Similar in outline to *L. latiaris* ♀ and differing from it on the UPPERSIDE only in the absence of the transverse oblique ochreous line and the subcostal spot near apex of forewing. UNDERSIDE pale brown with no ochreous tint, and washed with lilac, especially on the outer half: both wings crossed by a prominent brown nearly straight subbasal line outwardly margined with lilac. *Forewing* with an irregular discal transverse brown line; a bar in the cell within the subbasal line; five indistinct submarginal ocelli circled with lilac and brown on a lilac ground; and a yellowish marginal line edged on both sides with dusky, within which a a brown band on the lilac ground between the ocelli and the margin. *Hindwing* with a discal very much angled dark brown line, within which is a very distinct lilac litura above the third median nervule; the submarginal ocelli large, the upper one distinctly pupilled with white and all of them profusely speckled with white; the usual marginal markings.

HAB. Sibsagar, Assam (*S. E. Peal*).

6. NEOPE BHIMA, Marshall.

♂. Allied to *N. moorei*, Butler. UPPERSIDE: *hindwing* with only six oval black submarginal spots circled with yellow, the first minute, the rest large, prominent; two swarthy submarginal lines and the margin itself swarthy. UNDERSIDE: the basal area of both wings pale olivaceous brown, irrorated and irregularly streaked and spotted with dark brown, with a few ochreous spots and streaks. A nearly straight band of pale ochreous across both wings beyond the middle bordered interiorly with dark brown most broadly on the forewing. *Forewing* with a row of five oval black spots pupilled with white and banded with yellow, the third and fourth much larger, placed on a broad discal brown band; a pale ochreous submarginal band beyond uniting at the anal angle with the pale ochreous median band, the margin and two submarginal lines swarthy on a yellow-brown ground. *Hindwing* with a sinuous band of eight perfect ocelli, the seventh and eighth with yellow irides coalescing.

HAB. Burmah; taken in April in the upper Thoungyeen forests, Tenasserim, by Captain C. T. Bingham.

7. EREBIA SHALLADA, Lang.

♂. ♀. Allied to *E. kalinda* but rather larger, and the male broader-winged than in the species mentioned; darker and less brightly coloured. UPPERSIDE with a small, diffused, dark ferruginous patch within the middle of exterior margin on *both wings*, smaller than in *E. kalinda* on the forewing, and larger on the hindwing.

HAB. Kunawar. This species was discriminated by Col. A. M. Lang, R. E., some years ago, but no description has hitherto been published.

8. EREBIA MANI, de N.

♂. ♀. Allied to *E. kalinda*, Moore, from Kulu specimens of which species it differs on the UPPERSIDE in the larger extent and lighter and yellower colour of the patch on the *forewing;* and in the entire absence of the ferruginous patch on the *hindwing:* and on the UNDERSIDE by having the yellowish patch on the *forewing* as on the upperside and abruptly defined.

HAB. Chung pass and Lingti, Ladak.

9. MYCALESIS OCULUS, Marshall.

♂. ♀. Allied to *M. onatus*, Hewitson. UPPERSIDE: *forewing* with the lower ocellus considerably larger, and broadly surrounded with ferruginous yellow; the yellow almost reaching the inner margin and connected by a band of the same colour with the costa: *hindwing* with four increasing black ocelli white-pupilled and with yellow rings, the yellow rings coalescing. UNDERSIDE with a yellow discal band crossing both wings, prominent in the female, obsolete except near the costa in the male.

HAB. Travancore; taken in May in the Ashamboo hills by Mr. Harold S. Fergusson.

10. LIBYTHEA ROHINI, Marshall.

♀. UPPERSIDE brown with pure white markings. *Forewing* with an oval spot filling the end of the cell, a large quadrate spot on the disc between the first and second median nervules, two spots coalescing one on each side of the upper discoidal nervule, and a spot near the costa divided into three by the subcostal nervules. *Hindwing* with a large square spot on the costa, a straight median band across the wing below the cell not reaching the inner or outer margins and cut by the discoidal and three median nervules, and a small spot above between the subcostal nervules. All the spots and bands pure white.

HAB. Khasi hills; taken near Shillong in May by Mr. J. P. Cock.

With the exception of *Euplœa adamsoni*, *Lethe siderea*, and *L. satyavati*, all the species above characterised will be figured in the descriptive hand-book of the butterflies of the Indian region which we shall shortly publish under the title of 'The Butterflies of India, Burmah, and Ceylon'; and in which fuller detailed descriptions of all will be found.

XXIV.—*Description of* Parantirrhoea Marshalli, *the Type of a new Genus and Species of Rhopalocerous Lepidoptera from South India.—By* J. WOOD-MASON, *Deputy Superintendent, Indian Museum, Calcutta.*

Family NYMPHALIDÆ.

Subfamily SATYRINÆ.

Parantirrhoea,* n. gen.

♂. Anterior wings triangular; anterior margin moderately and regularly arched; apical angle acute; outer margin almost straight, being only just perceptibly convex; inner angle rounded; inner margin sinuous, being lobed at the base much as in the males of *Clerome* and *Æmona*, genera of MORPHINÆ; subcostal vein 4-branched, the first branch given off before, and the second beyond, the end of the discoidal cell, the first, second, and third coalescing successively and respectively with the costal vein, the first, and the second, and all three in turn becoming free and running off at a tangent, like the costal vein, to the anterior margin, the fourth being perfectly free from its origin and running to the apical angle; posterior discocellular veinlet long, very slightly concave outwards, almost straight, intermediate one not quite half the length of the posterior, ante-

* From παρά, by the side of, and *Antirrhoea*, generic name.

rior one rudimentary; submedian vein sinuous, short, terminating in the wing membrane near the inner margin at about the level of the junction of the basal and second fourth of the length of that margin, being, in fact, hardly more developed than is the internal vein of the PAPILIONINÆ as compared with that of many Heterocerous Lepidoptera; the first median veinlet directed straight outwards and backwards, out of its normal course, to the inner angle and supplying the place of the rudimentary submedian; on turning to the underside, it is seen that a narrow rounded lobe of the functional sutural area about six times as long as it is broad is folded back upon the under surface, to which it is firmly adherent; this lobe occupies the middle two-fourths of the length of the inner margin, and is thickly clothed on its surface and fringed at its free edge with firmly attached, long, and somewhat raised modified scales rendered conspicuous by their rich dark brown colour and satiny lustre; the outline of this turned up lobe is marked out on the upperside by a curvilinear groove.

Posterior wings tailed, subquadrate, with four distinct margins, *viz.*, a strongly and irregularly arched anterior margin, nearly straight external and posterior margins, and an inner or abdominal margin, marked out by the obtuse-angled apex, the tail, and the well-rounded anal angle; with a black oval sexual mark, divided by the submedian vein, near the anal angle; costal vein short and straight, terminating before, and the first branch of the subcostal which originates close to the base of its vein ending beyond, the middle of the length of the anterior margin, the second branch being given off before the middle of the discoidal cell and extending into the apical angle; 'discoidal' vein in the same straight or slightly curved line with the subcostal; discocellalar veinlet sinuous; the third median veinlet produced to a conspicuous tail.

Antennæ fine and distinctly clubbed.

Female unknown.

No Asiatic genus of SATYRINÆ presents us with any approach to the remarkable arrangement of the two hindermost veins of the anterior wings described above; but, in the South American genus *Antirrhoea*, we meet with identically the same arrangement, the first median veinlet in *A. archaea* and its congeners running back to the inner angle and the submedian vein ending a considerable distance short of that angle, though not nearly so far short of it as in the Indian form, for which I propose the above name in allusion to these remarkable points of resemblance, reserving all further comparisons and comment until I shall be in possession of specimens of the South American forms.

P. marshalli, n. sp.

♂. Wings above dark fuscous suffused with rich deep violet.

Anterior wings with an outwardly and forwardly arched subcrescentic pale violet or mauve band commencing beyond the middle of the wings at the costal vein, terminating at the inner angle, and crossed obliquely by a series of three small white spots disposed in a straight line parallel to the outer margin and placed upon folds of as many consecutive cells, the last being between the two anterior median veinlets.

Posterior wings relatively longer-tailed than in *Melanitis ismene* (Cramer) with the membranous parts of the divergent tails almost wholly formed by the produced wing-membrane of the interspace between the second and third median veinlets, a very narrow anterior membranous edging only being contributed by the interspace next in front; and with rather more than the basal two-thirds of their length in front of the discoidal and subcostal veins ochreous.

Wings below ochreous obscurely striated with a deeper shade of the same colour, and marked with a submarginal series of inconspicuous brown specks, the probable rudiments of ocelli.

Length of anterior wing 1·16; whence expanse = 2·4 inches.

The female will, in all probability, prove to differ from the male not only in the absence of the sexual spot in the posterior wings, but also in having the inner margin of the anterior wings straight and neither lobed at the base nor turned up in the middle, and the first median veinlet and the submedian vein of the same wings normally arranged and developed and directed respectively to the outer margin and to the inner angle after the manner usual amongst butterflies.

HAB. Trevandrum, Travancore, South India. Described from four specimens of the male, one, the type, recently purchased by the Indian Museum, and three belonging to Captain G. F. L. Marshall, R. E., to whom I am indebted not only for the opportunity of describing this interesting insect, but also for permission to dissect one of the specimens in his collection.

P. S.—The species of the genus *Elymnias* alone present the same disposition of the three anterior veins of the posterior wings.

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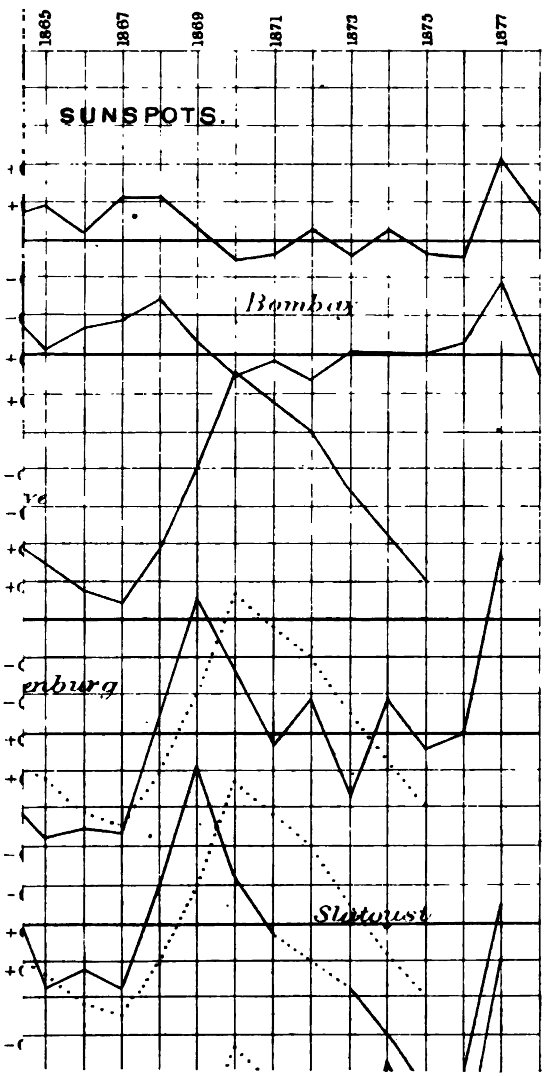

J. Schaumburg Lith.

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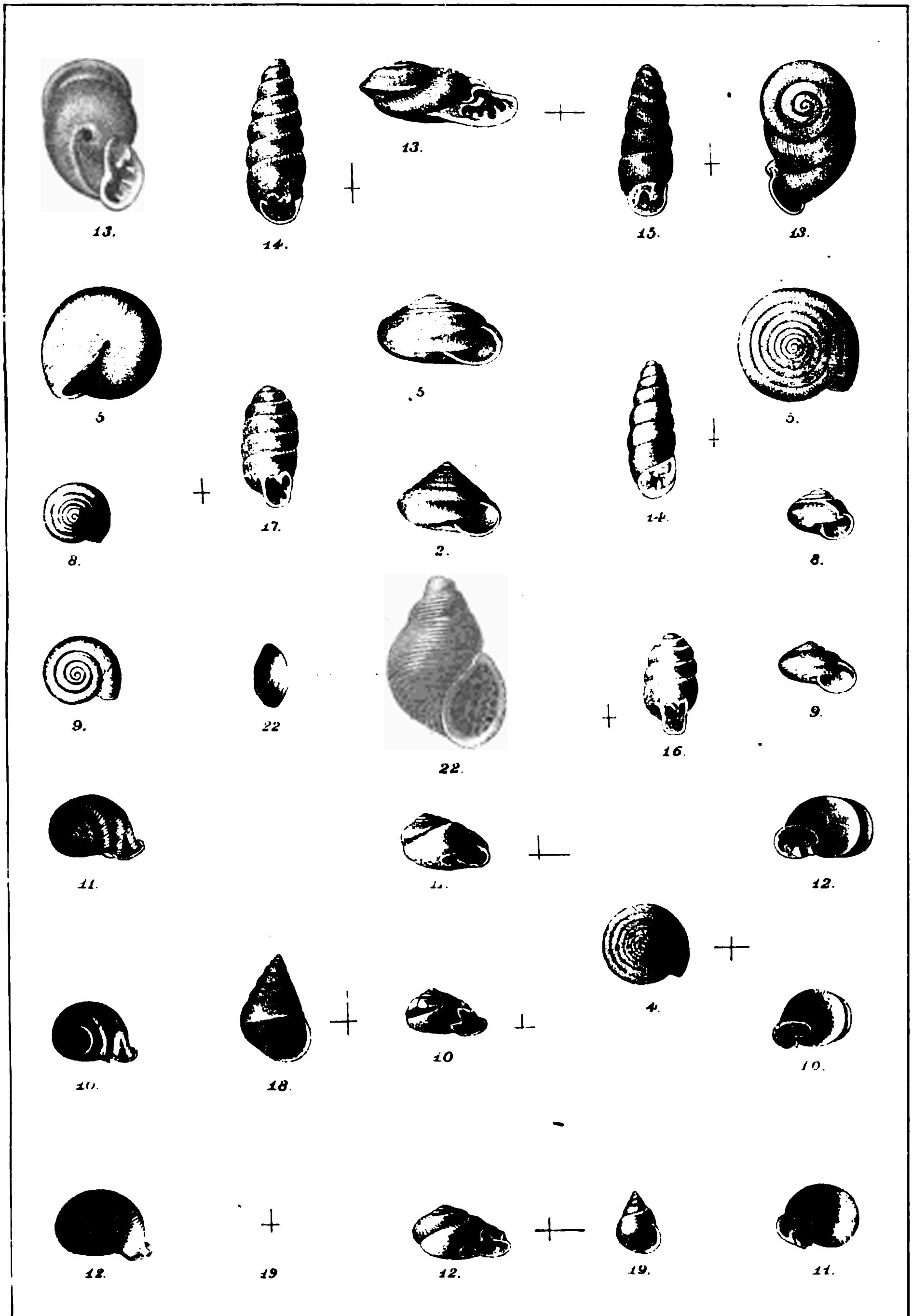

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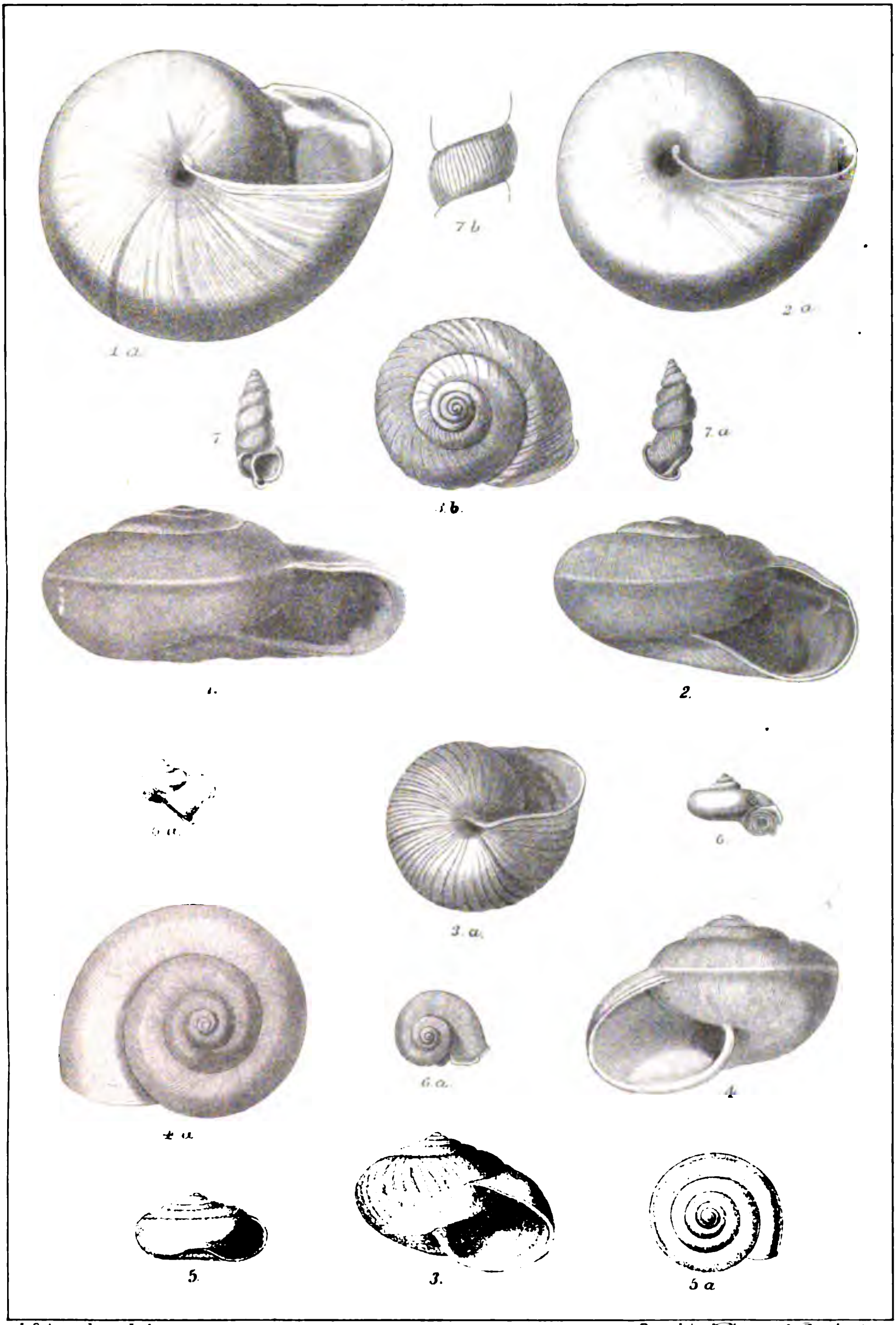

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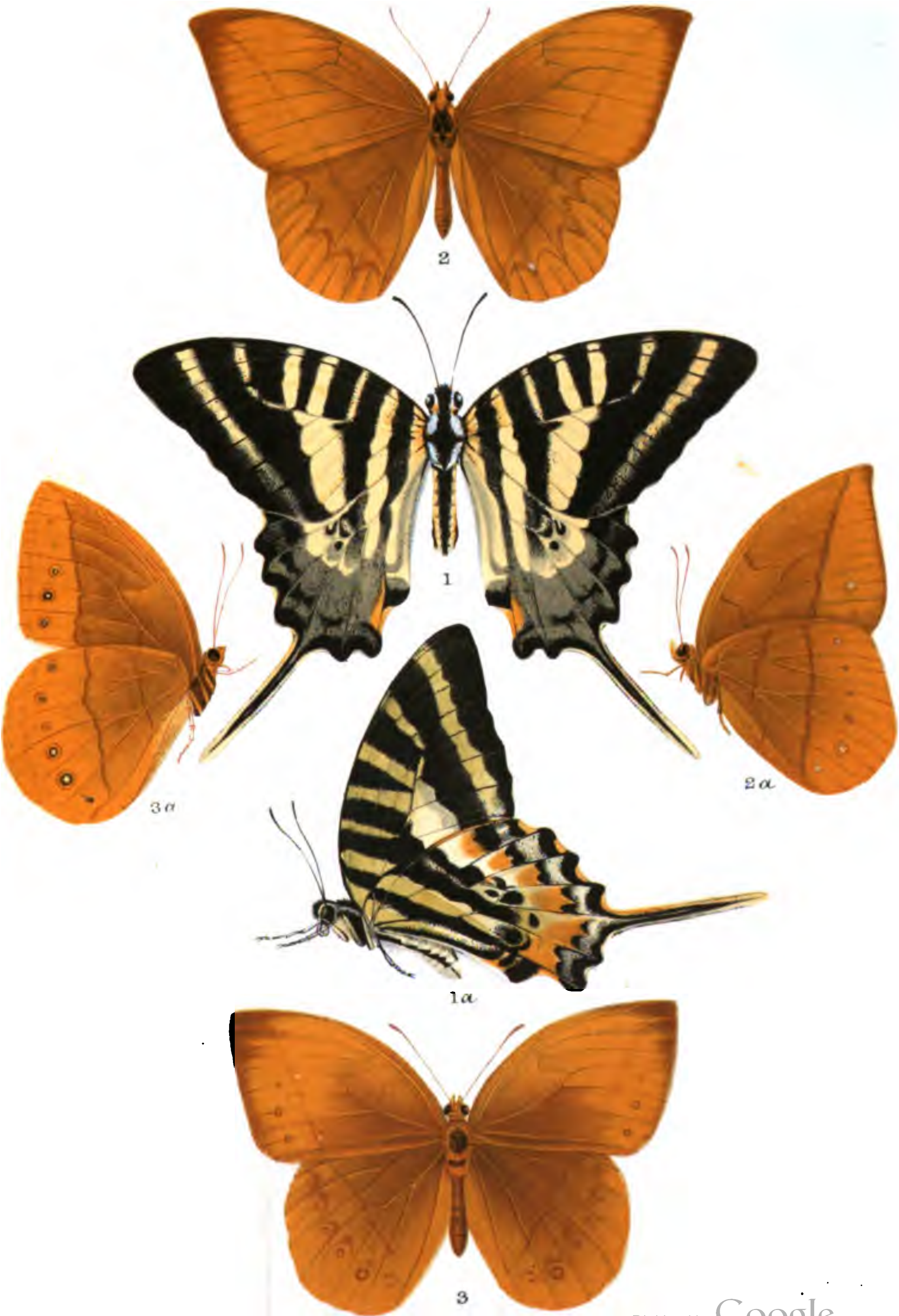
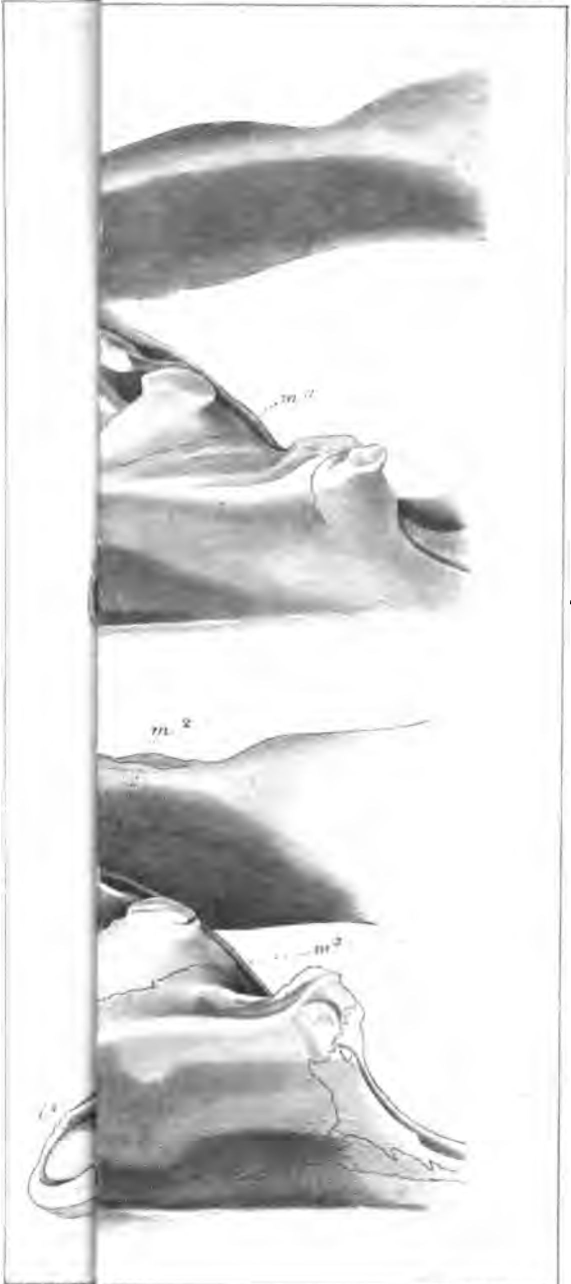
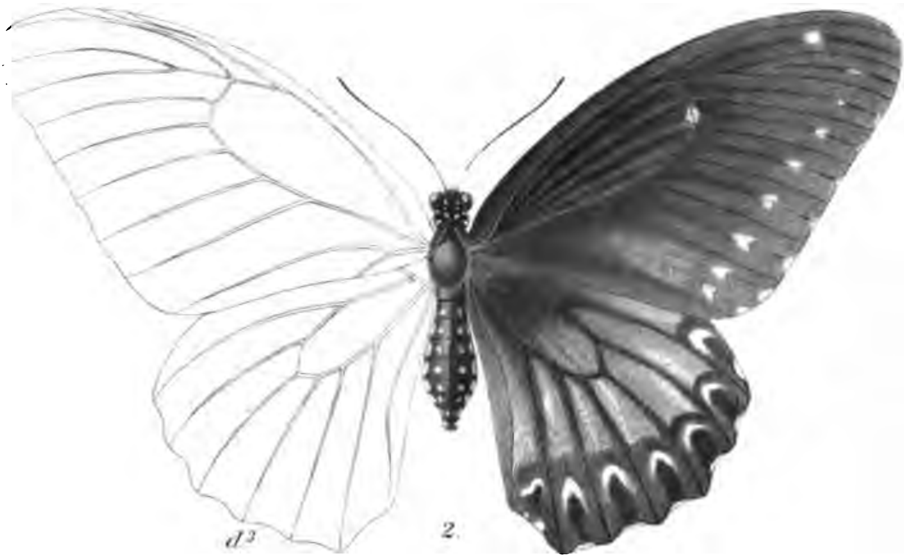


Behari Lal Das del. J. W-M. direxit. West, Newman & Co chr. lith.



Bakon Lit. D[...] W. Newman & Co. Imp.

1.



d^3 2.

B. L. Das del. J. Schaumburg Lith. W. Newman & Co imp.

1. PAPILIO DRAVIDARUM, ♂.
2. PAPILIO CASTOR, ♀.

S L ... del. J. Schaumburg Lith. W. Newman & Co. imp.

PAPILIO CASTOR, ♂ ♀.

Fig 1

Fig 1a

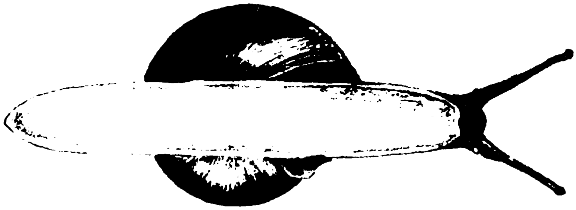


Fig 2

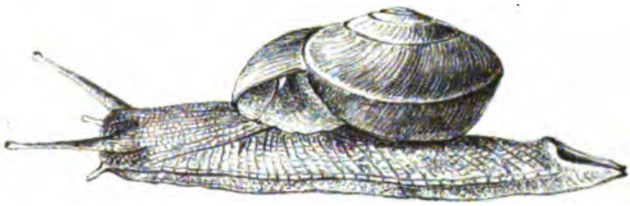
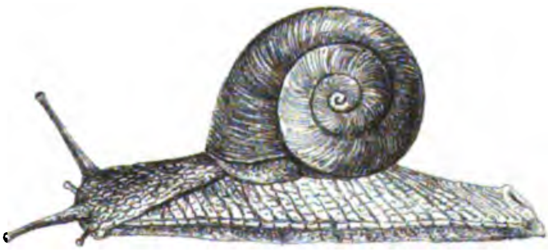


Fig. 3

Fig 4



INDIAN ARIOPHANTA.

Godwin Austen Delt. Maclure & Macd-

Fig. 1.

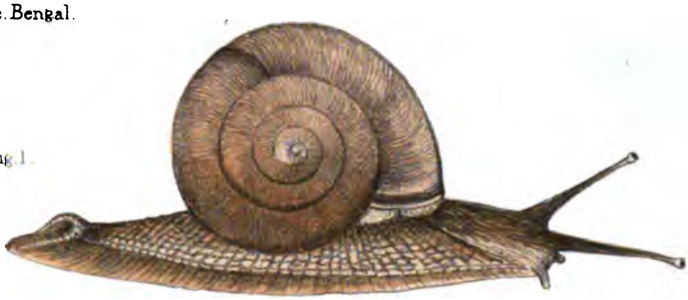


Fig. 1a

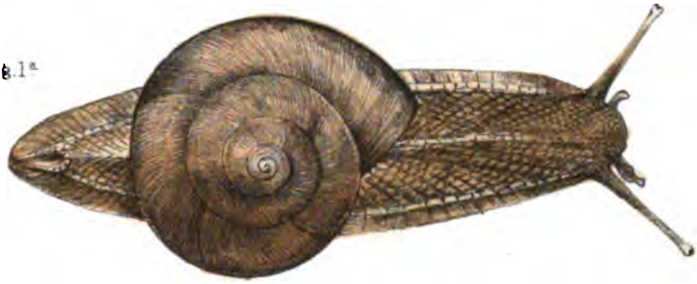


Fig. 2.

Fig. 3.

Fig. 4.

INDIAN HEMIPLECTA.

H Godwin-Austen. Delt Maclure & Macdc

1

2.

R. I. Dos del. J. Schaumburg part. del. et Lith W. Newman & Co. Imp.

Fig. 1 HESTIA CADELLI, ♂.
Fig. 2 HESTIA HADENI, ♀