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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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ERRATA.

Page 74, line 27, *for* $\frac{m\,1}{}$ *read* m_1.

" line 28, *for* $\frac{m\,2}{}$ *read* m_2.

" line 29, *for* $\frac{m\,3}{}$ *read* m_2.

JOURNAL

OF THE

ASIATIC SOCIETY OF BENGAL.

Part II.—NATURAL SCIENCE.

No. I.—1887.

I.—*On the Influence of Indian Forests on the Rainfall.—By* HENRY F. BLANFORD, F. R. S., *Meteorological Reporter to the Government of India.*

[Received Jan. 20th ;—Read Feb. 2nd, 1887.]

(With a Woodcut.)

The following paper is an extract from the yet unpublished manuscript of the second part of a paper on the Rainfall of India; the first part of which has already been issued as an official publication in the Indian Meteorological Memoirs. In consideration of the great economic importance of the subject treated of, and also with a view to encourage and assist further enquiries, whenever favourable opportunities may offer, it has seemed desirable to publish this discussion in an independent form, and in anticipation of its appearance in the Indian Meteorological Memoirs; where it will form but a small and subordinate part of a memoir dealing with a subject of much wider range.

In an instructive paper originally communicated to *Petermann's Mittesilungen*, and subsequently published in translation in the *Quarterly Journal of the Royal Meteorological Society*, M. Woeikoff appeals emphatically to the evidence afforded by the Indian rainfall registers, in support of his contention that the action of forests is to increase the rainfall of a country. His appeal is directed chiefly to the contrast afforded by the Assam rainfall with that of the Gangetic valley plain, in about the same latitude and the same distance from the sea; and he apparently attributes the great difference displayed by these two provinces, wholly or mainly, to the fact that, while the former is extensively covered with forest, the latter, up to the Terai, is a broad sheet of field cultivation.

In this view I am unable to coincide. Without denying or even questioning the effect of forests as one element of the result, the conclusion thus formulated seems to me far too sweeping. M. Woeikoff considers, and I think rightly, the action of forests in enhancing the rainfall to be twofold. Firstly, they help to store water, by protecting the soil, and to keep up a constant evaporation; and secondly, by checking and obstructing the movement of the wind, they prevent the evaporated vapour being carried away, and tend to produce that calm state of the atmosphere that is favourable to ascending currents and local precipitation. But swamps, such as occupy large tracts of the Assam valley, and the numerous broad river channels that intersect it, must contribute a not unimportant quota to the vapour constituent of the local atmosphere; and the comparative stagnation of the air in the Assam valleys and the exclusion of those dry westerly winds which play so important a part in the meteorology of the Gangetic plain are certainly due, in far larger measure, to the fencing in of the Assam valley by the Patkoi, Naga, Khasi, and Garo hills, and, as regards Upper Assam, to the interception of westerly currents by the mid-valley obstruction of the Mekhir hills, than to any retardation of wind movement that can be effected by the forests. Furthermore, the action of the surrounding hills in setting up a diurnal convection of the humid-atmosphere, and its consequent dynamic cooling and precipitation, an action which also takes place in the much less humid hill tracts of the peninsula, is a very important item in the causes which contribute to produce the heavy spring rainfall of Assam; a precipitation not very greatly inferior to that of the summer monsoon. The other or passive effect of hills in enhancing rainfall, namely, the forced ascent of horizontal air currents, is less important in Upper Assam (the tract more particularly referred to by M. Woeikoff), although exhibited by the southern face of the Khasi hills, overlooking Sylhet, in a degree without parallel elsewhere in the world. But to the other causes above specified must certainly be attributed by far the larger part of that prevailing high humidity and copious rainfall which foster the exuberant vegetation of the province; rendering it, in the rich variety of its flora and its prolific insect life, comparable with the teeming productiveness of the Malay region.

The difficulty so conspicuously illustrated in the foregoing example, namely, of disentangling the combined effects of a number of causes all favourable to increased rainfall or the reverse, is one which renders it almost hopeless to seek for decisive evidence of the influence of forests by any comparison of the rainfall of different provinces, or of areas sufficiently large to display the contrasted effects in a striking and convincing manner. The best and perhaps only satisfactory kind of evidence, were it obtainable, would be the comparison of the rainfall of one and the same tract (one of at least some hundreds of square miles in extent) for many years, first while covered with forest, and again for many years after clearing. It is, however, not until a tract of virgin forest has been brought under the destructive operation of civilizing agencies, that, as a general rule, any attempt is made to record its rainfall; and when, therefore, the conditions necessary to obtain one term of the comparison are rapidly disappearing. The reversal of this order of things, the conversion of bare or at least partially wasted tracts into protected forest, is one, however, of which India already furnishes some examples, and with the progress of forest protection may yet furnish more; and if due advantage be taken of these as they present themselves, it may yet be possible to obtain rainfall data which may afford valuable and indeed practically onclusive evidence on the point in question, even if not fulfilling in all respects the rigorous conditions of the logical method of differences.

One instance of the kind, on a scale large enough for all reasonable demand, has lately been brought to my notice by Mr. Ribbentrop, and has been quoted in my Report on the Administration of the Meteorological Department in 1885-86; and despite some shortcomings in the due verification of the data it furnishes, shortcomings which it is now impossible to make good, it will probably, in the course of some years, as nearly fulfil the conditions of a test case as we are likely to attain to in an experiment of such magnitude. In some respects, indeed, the circumstances of this case are unusually favourable. The vicissitudes of the rainfall of the Central Provinces are smaller, proportionally, than those of any other province of an equally moderate average, and of the 22 stations, the rainfall registers of which will be brought in evidence, not less than 10 are regular meteorological observatories, working under the Meteorological Department of the Government of India.

The region referred to in the 1st part of my Memoir on the Rainfall of India as the Central Provinces south, has been described as a hilly and jungle clad country, including some extensive fertile plains, especially that which surrounds Raipur. The northern portion consists of the range of broken tablelands and hills here spoken of as the Satpuras, and these are largely clothed with forest. According to the most recent report of the Officiating Inspector General of Forests, the area of forest in the Central Provinces is estimated at 54,600 square miles, of which about nine-tenths are either in or to the south of the Satpura range. The area of the Central Provinces south is about 61,000 square miles. Hence about five-sixths of the whole are under forest. Now, prior to the year 1875, these forests were systematically wasted by the destructive method of cultivation practised by the hill tribes of Gondwana, as of other wild tracts in India and Burma. It is known under various local names, such as *Kumri*, or in the Central Provinces *dáhya* cultivation, and is thus described by Dr. Brandis: "A few acres of forest are felled one year, the wood is burnt and a crop of grain raised on the clearing; the next year this is abandoned, a fresh piece of forest is felled elsewhere, a crop is raised, and it too is abandoned in its turn; and so on, a fresh clearing being made every year."

It will be readily understood how under such a system, in the course of some years, extensive forests may be devastated, even by a sparse hill population of nomad habits. And accordingly, in the introduction of the Central Provinces Gazetteer, published in 1870, Mr. C. Grant speaks of the state of the forests in the following terms: "The tree forests of the Central Provinces have, however, been so much exhausted, mainly owing to the destructive *dáhya* system of cultivation practised by the hill tribes, that, except in one or two localities, the labours of the Forest Officers will, for many years, be limited to guarding against further damage, and thus allowing the forests to recover themselves by rest. By far the greater part of the uncultivated lands belonging to Government are stony wastes, incapable of producing a strong straight growth of timber."

In 1875,* the suppression of *dáhya* cultivation was taken systematically in hand, and in the course of a few years, with such success, that Mr. Ribbentrop writes in 1886, "My attention was directed during a recent visit to the Central Provinces, to the extensive growth of young forests in areas formerly under *Kumri* cultivation. Ten or fifteen years ago, such temporary cultivation was practised throughout the country, and thousands of square miles were thereby laid barren year after year. Since then, this method of cultivation was stopped, and though a great part of the area affected was subject to annual fires, a more or less dense forest growth has sprung up. I concluded that this must have had an influence on the rainfall, sufficiently appreciable to be gauged by meteo-

* I understand from Mr. C. E. Elliott who worked as Settlement Officer in the Central Provinces prior to 1875, that endeavours were then in progress to check *dáhya* cultivation, so that the statement in the text which I make on the authority of Mr. Ribbentrop must not be taken as rigorously exclusive. The interpretation of the evidence here adduced will not, however be appreciably affected by this correction.

rological records. The results gathered from such records are beyond expectation and shew that, with the exception of stations situated in the cultivated valley of the Nerbudda, a steady increase of rainfall has taken place during the last ten years, and, as might be expected, especially during the last period of five years."

In dealing with the evidence of the rainfall registers, I shall, in the first place, compare the averages of the 9 or in some cases 10 or 11 years ending with 1875 (the year in which the suppression of the *dáhya* cultivation is stated to have been taken in hand) with those of the ten subsequent years, 1876—1885; and this I shall do separately for the stations within the area immediately affected by the forest preservation and for those at a greater or less distance therefrom. These latter are Saugor and Damoh, the forests near which have not been frequented by *dáhya* cultivators, or which are surrounded by native states in which no change of system has been attempted, Jubbulpore, Narsinghpur, Hoshangabad, and Khandwa in the fertile and highly cultivated valley of the Nerbudda, and where the tendency of late years has been towards an extension of permanent cultivation, and Raipur in the centre of the great wheat-growing district of Chattisgarh.

Comparison of the Average Rainfall of 9 *to* 11 *years of Dáhya Cultivation with that of* 10 *years of Protected Forests.*

A. In affected areas.

Stations.	Forests unprotected.		Forests protected.		Increase.
	Period.	Inches Rain-fall.	Period.	Inches Rain-fall.	Inches.
Badnur	1867-75	39·83	1876-85	47·83	+ 8·00
Chhindwara	1865-75	41·43	1876-85	48·48	+ 7·05
Seoni	1865-75	52·07	1876-85	54·76	+ 2·69
Mandla	1867-75	53·58	1876-85	56·32	+ 2·74
Burha	1867-75	64·51	1876-85	71·65	+ 7·14
Bilaspur	1865-75	41·85	1876-85	54·81	+12·96
Sambalpur	1867-75	54·80	1876-85	67·93	+13·13
Dhamtari	1867-75	48·83	1876-85	46·90	— 1·93
Bhandara	1867-75	49·90	1876-85	57·79	+ 7·89
Nagpur	1866-75	41·54	1876-85	51·85	+10·31
Wardha	1866-75	36·10	1876-85	46·63	+10·53
Brahmapuri	1867-75	53·95	1876-85	57·48	+ 3·53
Chanda	1866-75	47·14	1876-85	54·29	+ 7·15
Sironcha	1867-75	44·17	1876-85	48·38	+ 4·21
				Mean	+ 6·81

B. In unaffected areas.

Saugor	1866-75	55·97	1876-85	40·62	—15·35
Damoh	1867-75	54·76	1876-85	46·82	— 7·94
Jubbulpore	1866-75	60·66	1876-85	56·28	— 4·38
Narsinghpur	1866-75	55·46	1876-85	50·40	— 5·06
Hoshangabad	1866-75	47-08	1876-85	57·73	+10·65
Khandwa	1867-75	34·74	1876-85	33·32	— 1·42
Raipur	1866-75	51·59	1876-85	54·47	+ 2·92
				Mean	— 2·94

The contrast, thus shewn, is sufficiently striking; but taken as they stand, it can hardly be said that the figures do more than afford a certain presumption in favour of the view that the difference shewn by the two series of stations is to be attributed to the preservation of the forests. In the first place, as I shall shew elsewhere, the probable error of a ten years' rainfall average of a station in the Central Provinces is about 5 per cent., and this may be either in excess or defect. In the extreme case of the errors being in opposite directions in the two decennial periods compared, the greater part of the apparent increase of list A would vanish. And, in the second place, the majority of the stations in the second list lie to the north of the Satpura range, those of the first list either on the range itself or to the south of it; and, as this range about coincides with the southern margin of the tract commonly followed by the cyclonic storms of the summer monsoon, the distribution of the rainfall might be much affected by the fact of a series of such storms following a more southerly or more northerly path, or by the western branch of the monsoon, which brings nearly the whole rainfall to the region south of the Nerbudda valley, being in several years, relatively to its normal average, stronger and more rainy than the eastern branch, which contributes to the rainfall north of that river.

But there is another way of dealing with the facts which will not be open to such objection. Any effect really due to forest protection must necessarily have been progressive. Some few years were passed in inducing the jungle tribes to take to settled cultivation; again, the reproduction of the forest growth on the tracts formerly denuded is a process requiring many years for its accomplishment; and, finally, the protection of the forests from destruction by annual fires in the dry season has been steadily extended year by year. If, then, it should appear, on comparing the rainfall of the affected tract in successive years, that the increase has been steadily progressive and on the whole in a degree commensurate with the average difference of the two decennial periods above compared, the probability of such increase having been brought about by the protection of the forests will be enormously enhanced.

The data for this comparison are afforded by the following table which exhibits, in the second column, the mean rainfall of the 14 stations, enumerated in the A list of the previous table, in each year from 1867 to 1885. The third column gives what may be termed progressive averages. Each average is that of 5 years, obtained by the formula,

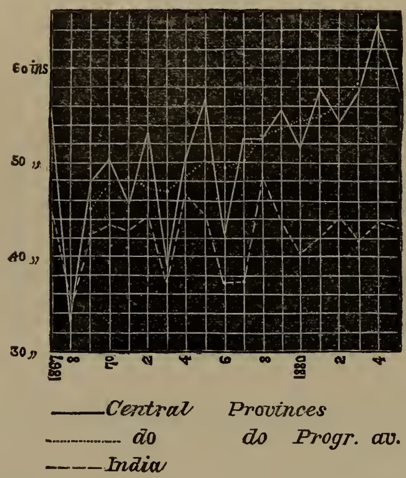
$$c, = \frac{a + 4b + 6c + 4d + e}{16}$$

wherein *a*, *b*, *c*, *d*, *e*, represent the mean rainfall in any five concecutive years and *c*, the progressive average for the third year of the series. As a standard of comparison, I give, in the fourth column, the average rainfall of the whole Indian area (with the omission of unrepresented tracts). The average rainfall is taken at 42 inches. Lastly, the fifth column shews the progressive averages of the rainfall of India computed from column four.

Comparative Table of the Mean Annual Rainfall of the Forest Region in the Central Provinces and of India from 1867 *to* 1885.

Year.	Condition.	Central Provinces.		India.	
		Annual mean	Progressive average.	Annual mean.	Progressive average.
		Inches.	Inches.	Inches.	Inches.
1867	Under dáhya	55·08	......	44·8	40·2
68		33·59	......	35·4	40·3
69		47·97	45·28	42·4	41·0
70		50·42	47·71	43·5	42·6
71		45·52	48·45	42·9	43·0
72		53·31	47·47	44·3	41·7
73		39·18	47·02	37·5	42·2
74		50·48	48·85	46·6	42·4
75		56·60	50·15	44·4	42·4
76		42·32	49·58	37·5	40·5
77	×	52·50	50·40	37·7	41·1
78	Protected	52·47	52·60	48·3	43·3
79		55·67	53·85	43·7	43·5
80		51·83	54·50	40·4	42·4
81		57·90	55·31	42·1	42·4
82		54·22	56·52	44·6	43·0
83		57·73	58·57	41·9	43·1
84		64·63	......	43·7	......
85		57·43	......	43·1	......

The variations exhibited in this table are represented graphically in the following figure.



Now the third column of this table shews, not only that the increased rainfall of the protected forest region has been on the whole progressive since 1876 (the year after protection was systematically enforced), but that its progression has been commensurate with the increase of the decennial average shewn in the previous table; a very important point. As compared with the general average of the period antecedent to 1875, a rainfall of 48 inches, in integral figures, had risen to 58 inches in 1883, an increase of more than 20 per cent. Whether this increase will be sustained at its full amount by the results of future years is, however, very questionable. The rainfall of 1884 was extraordinarily high, and whereas, as may be observed in the graphic representation of these changes, the rainfall of the Central Provinces rises and falls *pari passu* with that of the whole of India in a somewhat remarkable degree (having regard to the comparative smallness of its area), the progressive average rainfall of India as a whole for 1883 was nearly 3 per cent. above the general average between 1867 and 1875. But after making all due allowances, in so far as any legitimate conclusion can be drawn from the experience of the last ten years, it would seem that, owing to some local cause, the mean rainfall of the afforested region of the Central Provinces here considered, an area of nearly

50,000 square miles, has been increased in a very remarkable degree, and I am unable to assign any other probable cause for this than that of the protection and consequent restoration of the formerly wasted forests.

The evidence thus afforded in favour of the influence of forests on rainfall appears to me to be of considerable weight and importance, in virtue both of the magnitude of the area yielding it and of the apparent distinctness of the result. With one exception and one only, it fulfils all the conditions of a rigorous test case. The area is one and the same; the history of the changes to which it has been subject are definitely and accurately known; and, as will be shewn elsewhere, the rainfall registers, if but few in proportion to the area, are sufficient to afford a datum the probable error of which is small in comparison with the magnitude of the effect shewn. The only remaining points to which exception may conceivably be taken are the trustworthiness of the records used, and the sufficiency of the periods compared to yield valid averages.

On the first of these points, I can add but little to what has been already written in the introduction of Vol. III, Part I, of the Indian Meteorological Memoirs. Speaking from recollection (for I have been unable to obtain the desired verification of the fact from official records), I believe that new rain-gauges, of Glaisher's pattern, from one of the principal London makers, were furnished to all the stations the registers of which are here dealt with, about the year 1867, at all events before 1870, that is to say, at or near the beginning of the period for which the registers are complete, and there are therefore no grounds for suspecting that the increase of the registered rainfall during the last ten years has been influenced by a change in the instruments used. And this is the most important consideration. With respect to the registering agency, as far as I have information, it has been the same throughout. Dr. S. C. Townshend, who was Sanitary Commissioner of the Central Provinces, and who in 1868 established the observatories, which, in 1875, were incorporated in the Imperial system, took much personal interest in all the meteorological work of the province, and there is no doubt that his action was attended with beneficial results. But this change, like that of the instruments, dates from the beginning of the period now under consideration; at all events from 7 or 8 years anterior to 1875.

On the second point, namely, the sufficiency of the periods compared to yield valid averages, I have ascertained that a ten years' register of the Central Provinces' stations, Jubbulpore and Nagpur, has a probable error of 5 per cent., namely, in the case of Jubbulpore of 2·7 inches, in that of Nagpur of 2·2 inches, and these may be taken as fairly illustrative examples of the whole province. These, however, are the probable errors of individual stations, and, as will be further demonstrated elsewhere, the mean rainfall of a whole province is much less variable than that of a single station. For, if we take the average of either the first ten years or the last ten years of the figures in the third column of the table, on page 7, we have an average of 1867—1876, 47·45 ins. probable error ± 1·56; average of 1876—1885, 54·67 ins. probable error ± 1·22, which is but little more than half the probable error of either Jubbulpore or Nagpur for an equal period. This is small in comparison with the difference of the two averages, namely, 7·22 inches. Assuming the extreme case, that the first average is 1·56 inches below the real mean and the second 1·22 inches about it, these differences being both due to fortuitous and not steadily progressive causes, there would still remain 4·44 inches of increase unaccounted for. This is perhaps not such as to warrant conviction that the average rainfall of the Central Provinces south of the Nerbudda has really increased by that amount; still less does it warrant the positive assertion that such increase, assumed as real, is due to the preservation of the forests; but at least, in so far as any inference is admissible from such data, the evidence seems to afford much support to that view.

Direct observations of a character similar to those of Prof. Ebermeyer in Bavaria, namely, comparative measurements of the rainfall at pairs of stations near the margin of forests, the one within, the other without the forest, have been carried on in Dehra Dún and Ajmere, during the last year or two, by officers of the Forest Department. Some of the results of these were given in the Administration Report of the Meteorological Department for 1885—86, and I have since visited the Dehra Dún stations and some of those in Ajmere. In the case of the former, the conditions are satisfactory, in so far that the forest on the site of the observatories is a vigorous growth of chiefly Sál coppice* with a well-defined boundary, and the observatory stations are, in the one case, well within the forest, in an opening only just large enough to prevent the gauge being sheltered, or its contents unduly added to by the drip of the trees; in the other, in an open maidan of coarse grass and scrub, with only a rare tree here and there. But the interval between the two

* As testifying to the importance of this condition, I extract the following from a letter lately received from Dr. D. Brandis, for many years Inspector-General of Forests in India; "I would draw your attention to a point which I used to urge in India, whenever I wrote on the subject; *viz.*, that forests, in order to exercise an effect (on the rainfall), must be dense, and must not consist of a few bushes and trees, here and there. Fire protection alone has the effect of making the forest grow up dense, and I am disposed to think that the large extent of fire protected forest in the Central Provinces may, in course of time, affect the rainfall."

stations of each pair is hardly enough to shew the full influence of forest in the one case, or to exclude it in the other; and it can only be expected that, under such circumstances, any difference depending on that influence will be very small.

There are two such pairs within about 6 miles of Dehra Dún, on the skirts of the Sivalik forests, the one at the Ramgarh, the other at the Rajah's forest. In the case of the Ramgarh forest, at which the observatories have been longest in existence, the two observatories are 750 yards apart; the outer 400 yards from the forest boundary, the inner 350 yards from it. At each station, there are two rain-gauges, the one on the ground, the other at a height of 60 feet, being perched on the summit of a scaffold, which raises it above the tops of the neighbouring trees. The rain-gauges are Symon's pattern, 5 inches in diameter, and the measurements are all made with the same measure glass. The observer has been regularly trained in his duties (which include keeping 4 registers of temperature and humidity, under corresponding conditions), and his work seems to have been regularly performed. The results for the years 1884 and 1885 are given in the following table:—

Months.	Lower gauges.			Upper gauges.		
	Outer.	Inner.	Diff. I—O	Outer.	Inner.	Diff. I—O
June 1884	3·66	4·07	+0·41	3·61	3·88	+0·27
July "	25·64	26·46	+0·82	24·72	26·44	+1·72
August "	21·18	21·74	+0·56	19·88	21·23	+1·35
September "	17·53	18·78	+1·25	17·19	18·01	+0·82
October "	0·28	0·39	+0·11	0·26	0·37	+0·11
November "	0	0	0	0	0	0
December "	0	0	0	0	0	0
Total ...	68·29	71·44	+3·15	65·66	69·63	+4·27
January 1885	4·20	4·48	+0·28	4·56	4·63	+0·07
February "	0·85	0·70	—0·15	0·77	0·67	—0·10
March "	0·48	0·39	—0·09	0·42	0·36	—0·06
April "	0·44	0·55	+0·11	0·45	0·50	+0·05
May "	5·35	5·99	+0·64	5·06	5·79	+0·73
June "	10·31	10·76	+0·45	9·75	10·61	+0·86
July "	9·81	9·90	+0·09	9·27	9·88	+0·61
August "	44·64	44·91	+0·27	43·56	44·45	+0·89
September "	6·24	5·51	—0·73	6·06	5·47	—0·59
October "	0	0	0	0	0	0
November "	0	0	0	0	0	0
December "	3·45	3·49	+0·04	3·48	3·52	+0·04
Total ...	85·77	86·88	+0·91	83·38	85·88	+2·50

The observations at the Rajah's forest extend over a shorter period. The stations are less than a mile distant from the former, and the arrangements are similar; the surrounding conditions of each of the pair being being strongly contrasted. The outer observatory is 1,750 yards from the forest boundary, the inner 1,000 within the forest, which is of the same character as the Ramgarh forest.

Months.	Lower Gauges.			Upper Gauges.		
	Outer.	Inner.	Diff. I—O	Outer.	Inner.	Diff. I O
March 1885	?	0·27	?	0·21	0·23	+0·02
April "	0·06	0·42	+0·36	0·32	0·36	+0·04
May "	4·69	3·99	—0·70	4·36	4·04	—0·32
June "	10·47	11·70	+1·23	10·07	11·42	+1·35
July "	9·81	10·63	+0·82	9·47	9·88	+0·41
August "	47·50	45·87	—1·63	46·99	45·87	—1·12
September "	2·43	2·46	+0·03	2·40	2·41	+0·01
October "	0	0	0	0	0	0
November "	0	0	0	0	0	0
December "	3·40	3·54	+0·14	3·43	3·45	+0·02
Total ...	78·36	78·88	+0·25	77·25	77·66	+0·41

In this case, while, in most months, the rainfall at the inner station is appreciably higher than at the outer station, as shewn both by the elevated and ground level gauges, this gross excess appears to have been nearly neutralized by falls in May and August, which were in excess at the outer station. The result of the evidence is therefore doubtful. But in the case of the Ramgarh station there does appear to be a decided balance of rainfall in favour of the inner station.

I do not give the results of the Ajmere observations, because the difference of the conditions within and without the boundary of the forest, as far as I have seen them, depend much more on the form and slope of the ground than on the density of the forest growth, and I do not think the comparative observations have much bearing on the question at issue.

There remains one case which, although dependant on purely artificial conditions, might yet afford evidence of some weight in connection with the present subject, could we only be sure that the observations had been taken with the care and precaution indispensible to any valid comparison.* In the very heart of the plain between the Ravi

* For the following information I am indebted to Col. Home, R.E., late Secretary to the Punjab Government in the Irrigation Department of the Public

and the Jhelum (two of the five rivers of the Punjab), and about 50 miles to the south of Lahore, a vigorous forest has been established, by planting and irrigating the planted land from the Bari doab canal. The forest area covers $31\frac{2}{3}$ square miles and has now been established 16 years.* Outside the forest and to the east and south-east are lands which are cultivated, also with irrigation from the canal; and on the margin of this tract, four miles from the forest, is the small civil station of Chunian. Since 1864, a rainfall register has been kept regularly at Vahn (within the forest, half a mile distant from the nearest forest boundary), and also at Chunian; and since 1870, a third register has been kept at Bhambeh, a station on the Bari doab canal, in a position very similar to Chunian, but 13 miles to the north-east of the forest boundary and 19 miles north-east from Ghanga Manga or Vahn.

The rainfall chart of the Punjab shews that, in this part of the province, there is a steady increase of rainfall in a north-east direction or from Chunian to Bhambeh; steady, that is to say, apart from the influence of purely local conditions, and therefore, were the whole surface of the tract such as it is immediately around Chunian and Bhambeh, it might be anticipated that the mean rainfall of any intermediate station should be intermediate between those of Chunian and Bhambeh, in inverse proportion to their respective distances. The mean rainfall of Bhambeh, deduced from 17 years' registers, is 17·27 inches; that of Chunian, deduced from the same period, is 14·05 ins. If, then, Vahn, which is 19 miles from the former and $6\frac{1}{2}$ miles from the latter station, had a rainfall intermediate between the

Works and now Secretary to the Government of India. "Two gauges are placed side by side, the receivers are $4\frac{1}{2}$ feet above the ground. One is an ordinary tube gauge, measurements made with a graduated rod. The other a Watsen's continuous self-registering gauge, which is taken to pieces, cleaned and re-adjusted on the 1st April yearly. The bearings of the gauge are silver plated copper tubes and with very ordinary care in adjustment, they register very correctly. Instructions about registering rainfall are very distinct and I believe they are obeyed."

* Mr. H. C. Hill, Conservator of Forests in the Punjab, writes, "Changa Manga is a compact block of 20,242 acres, of which 8,399 are wooded with planted Sissoo (*Dalbugia Sissoo*). The remainder is under ordinary scrub. The age of the plantation dates back to 1866-67, but little was done for 3 years and the age of the forest may be taken as 16 years. The trees (excepting those in the canal avenue averaging 63 feet) of our best compartments average 50, 51 and 53 feet in height and all compartments have an average of 40 or more."

"The watering of the forest begins in April and goes on more or less till September. Very little of it ever gets a second watering in the year, but that given is a good soaker of 3 or 4 feet depth of water. The ground to the east and south except where 2 *rahhs* are touched, is all under cultivation and irrigated. Irrigation mostly from June to April.

above amounts, in inverse proportion to the distances of the two stations, the average of the same 17 years would be 14·85 inches. It is actually 15·76 ins., or nearly 1 inch above the computed proportion.

I am far from considering this result as conclusive on the point at issue. In some years, the deviation from the mean proportions is very large, and the average of the last three years (which, in this part of the Punjab, have been characterized by a remarkably low rainfall) shows that the Vahn rainfall has been almost exactly in the inverse ratio of the relative distances of the two outer stations. Still, the evidence, so far as it goes, favours the idea that the *forest increases* the rainfall.

The general conclusion to be drawn from the facts set forth in the foregoing pages is that, while no one of the instances cited fulfils the requirements of scientific proof, the tendency of the evidence they afford is uniformly favourable to the idea that the presence of forest increases the rainfall.

The evidence is of three kinds. First, we have that of a large province some five-sixths of which have always been a forest wilderness, but in which, for the first ten years of the period of registration, the forest growth was greatly devastated; partly by *dáhya* cultivation, which completely destroyed the forest for the time being, whenever it was carried on, and partly by annual forest fires, which destroyed the under-growth and injured the larger trees. For the next ten years, these destructive operations were suppressed and the visible result is a forest growth of such vigour and luxuriance as to attract the attention of the Inspector-General, when on his tour of inspection, to the question of its probable effect on the rainfall. During these last ten years the rainfall of the province has progessively increased until it would appear to amount to 20 per cent. more than the average of the first ten years.

The second instance is that of two pairs of comparative observatories, established on the Ebermeyer plan, in near proximity to each other on the boundary of a protected forest; one of each pair being within, the other without the forest, on open grouud. Notwithstanding their proximity, in most months the outer observatories shew a slight excess over the inner. At each observatory there are two gauges ; one at 60 feet above the ground, the other on the ground; and both afford consistent results. In the case of one pair of observatories, the total of 18 months' register shew an excess in the inner high level gauge of 4 per cent., in the lower of two per cent. In the case of the other pair, the registers of 12 months only shew an inappreciable net difference of the totals, although, in most months, the forest-gauges shew a slightly enhanced fall.

Fig. 1.

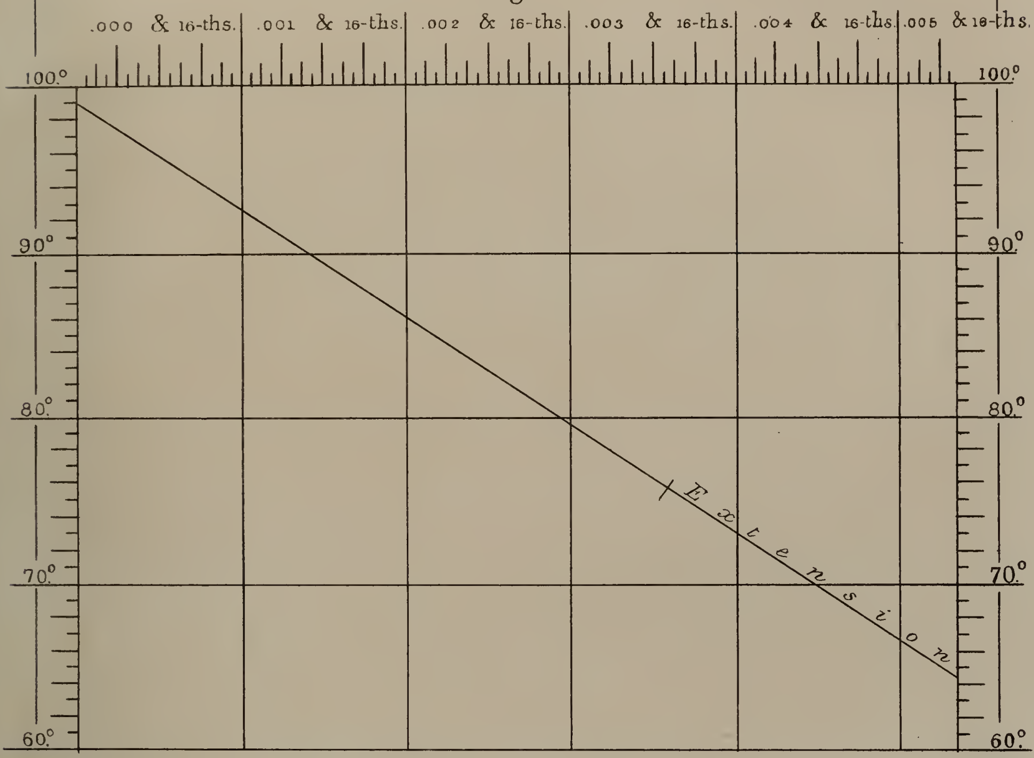
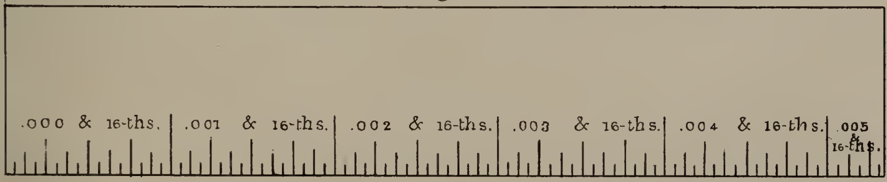


Fig. 2.



W Newman & C° L^{d}, Lith: Calcutta.

Lastly, we have the case of a forest artificially produced by irrigation (during the two driest months of the year) in a region so dry that cultivation is rendered possible only by irrigation. Seventeen years' registers at a station within the forest shew an excess of 6 per cent. over the probable rainfall of that station, as computed from the registers of two stations, one of which is 4 miles, the other 13 miles distant from the forest, and both on the borders of the cultivation.

The evidence is, then, in kind, not rigorously conclusive, and it must be admitted that in no case has it been guarded by those special precautions which are demanded by strict scientific enquiry. But I have no reason to believe that it is not as trustworthy as observations made under the general supervision of intelligent and educated men usually are; and such as it is, it tends to support and confirm the conclusions drawn *a priori* from general physical considerations. It justifies, I think, at least, the view I have already expressed elsewhere, namely, that I can no longer regard the long suspected influence of forests on rainfall as a question of equally balanced probabilities.

II.—*On the Changes observed in the Density of the Surface Sea-water, coincident with, and due to Aerial Disturbances, and consequent Alteration of Baric Pressure over adjacent Sea Areas: and on the Usefulness of a more exact Measurement of the Specific Gravity of Sea-water: more especially with Reference to the Waters near, and about, the Hooghly River Pilot Station.—By* SAMUEL R. ELSON.

[Received March ;—Read February 2nd, 1887.]

(With Pl. IX.)

In a work which I published some years since, entitled 'The Hooghly Sandheads Sailing Directory,' on the strength of observations made with a small glass instrument, the stem of which was graduated to two thousandths only, I asserted, that the sea water at the Hooghly River Pilot Station contained more salt at low water than it did at high water. But this seeming paradox requires some slight modification, for, I have since then found, with a soda-water bottle hydrometer, which readily weighs the sixteenth of a thousandth of salt in the water, that, in every case, on the least tendency of the sea thereabouts to set to the westward, in response, as I suppose, to aerial disturbances which lessen the baric pressure over the sea area to the southward, the water shows at once a decrease in salinity, consequently, the relative degree of saltness between these westward flowing waters outside, and those situated under the lee of Saugor and Edmonstone Islands, and their continuations, as outlying, partially dry, sands, to the northwards, will be altered, as I shall presently endeavour to show.

As an instance out of many I have known of the suddenness of a change of this sort:—At 1·30 P. M. of the 10th of August last, I found the sea at the Pilot Station registered a specific gravity of 1·024: but only four days afterwards, at the same hour with regard to the tide, and almost in the same position, it was only 1·013$\frac{8}{16}$ or was ·010$\frac{8}{16}$ less salt. But gradually, during these four days, a westward set of the sea hereabouts had got up, which steadily increased until it was running at the rate of two miles an hour or more, and, as is always the case, its presence was unmistakably announced by a rather sudden change in the colour and appearance of the sea (in fact, it was this marked change that induced me to test the water again), the water changing from a wholesome sea-green to a yellowish (but not muddy or turbid) hue, or of the colour of stagnant ditch, or tank water.

But, generally speaking, after the westward set has run for some time, this sickly looking water changes its appearance for the more natural green. And, so far as my limited and solitary observations go to show, the amount of salt increases as the westward set slackens. Therefore, these intermittent incursions of greater or less supplies of fresher water from, I suppose, the great easterly mouths of the Ganges, must be taken into consideration, when making comparisons as to the relative amounts of salt contained in the sea-water off, and in, the different parts of the outlet channels of the Hooghly and its estuary.

As I have said before, in a paper read before your Society some time back, entitled ‘The Tides and Currents of the Hooghly &c., &c.,’ none, or but very little, of the water from the river Hooghly can possibly reach the Pilot Station, situated as it is about 36 miles S. S. E. from Saugor Roads, seeing that, by the direction vessels ride when at anchor, in all the lower part of the river, from Mud Point to Saugor, the ebb tide sets S. W. and S. S. W. away towards Balasore Roads, or Bay, which is an extensive circular and shallow basin some 40 miles broad. Therefore, Saugor Island and its outlying, partially dry reef, called Saugor Sand, running down as it does over 22 miles S. S. E. from the tail end of Saugor Island, whilst the over-active sun's rays are copiously extracting vapour therefrom, must, and undoubtedly does, afford efficient shelter to the muddier and semi-opaque, and therefore, warmer water on its immediate westward side, from an early incursion of the above-mentioned drift of fresher waters, from the eastward, as, doubtless, the following serial observations, carefully taken for the purpose, show.

		Temperature. Air.	Water.	Specific gravity.
June 18th, 1886	Saugor Roads (bound out)	84·5°	85·5°	1·023$\frac{14}{16}$
„ 20th „	Eastern Channel Light. W. by N., 4 miles	85·4°	86°	1·018
„ 21st „	Eastern Channel Light. North, 9 miles	85·5°	86·5°	1·021
„ 22nd „	Intermediate Light (bound in)	...	86·5°	1·020$\frac{6}{16}$
„ „ „	Lower Gasper Light ...	...	86·5°	1·021
„ „ „	Upper Gasper Light ...	...	86·5°	1·023$\frac{2}{16}$
„ „ „	Saugor Roads ...	...	86·5°	1·023$\frac{4}{16}$

Note :—The Saugor Roads observation of the 18th was taken on the last quarter flood, and that of the 22nd on the last quarter ebb.

By this we have an accumulation of salt in Saugor Roads of ·005$\frac{4}{16}$ over and above what was found in the water at the Eastern Channel Light Station, thirty-six miles farther seawards, only a day or two previous. There was a set to the westward of the yellowish green water at the Sandheads, or Eastern Channel Light Station, on the 20th and 21st June, which would probably account for some of the above great differences in the relative specific gravity, though not for all. We also see by the above observations that at a distance of eight or nine miles dead to seaward of the above station, and well out in the 20 fathom line of soundings, there was an increase in the density of the sea water of ·003, this indicating that the induced lateral stream of fresher water from the eastward was not of necessity a very broad one : the reason of which I will attempt to explain further on, when I come to speak of the influence which the Swatch of no Ground doubtless has upon this westward set of the outside waters of the littoral. But even out there, we see the density did not exceed that of the sheltered muddy waters at the Lower Gasper Light Station, thirty-three miles farther north, and that it fell far short of that of Saugor Roads.

With reference to this very interesting question of the increased specific gravity of these inshore waters of the littoral during the dry months of the year, it is worthy of note that our late senior pilot, Mr. C. Smyth, used to say his long experience led him to believe that the reason vessels so seldom 'felt the ground,' or 'bumped,' in the Gasper Channel,—when their known draft of water, depth given by the charts, height of sea-surface above 'lowest low water,' or zero, as given by the tide table, and allowance for swell running, showed they had apparently not much water to spare under their keels,—was, that some sort of meeting of the tidal currents piled up the water, as it were, about this spot, on the ebb tide. He was evidently not far wrong in his surmises as to there being a *something* which assisted vessels to cross the Gasper bar in safety.

Ever anxious to learn something more of the causes of these *freaks*, as some would call them, of the currents at the Sandheads, and of the varying specific gravity of its waters, on the 13th of November last I gladly availed myself of an unexpected opportunity for further investigation by taking serial observations of the sea-surface temperature and density on some one line, or compass bearing, right off from the turbid water of the Pilot, or Eastern Channel Light Station, out into the deep blue sea of the Bay of Bengal. Nor, for my purpose, could it have occurred at a better time, with regard to the relative state of the weather, when going and returning, as will be seen. I went off S. E. towards Rangoon as acting special pilot in the B. I. S. N. Company's 6 *S. S. Sirsa* and, commencing at the Lower Saugor Sand buoy, which is about 5 miles farther inshore and towards the land than the Eastern Channel Light Vessel, I took observations with the bottle hydrometer, and thermometer, every two hours, with the following results:—

	Temperature. Air.	Sea.	Specific gravity.
November 13th, 1886 Noon, 2 miles S. W. from Lower Saugor Sand buoy ...	86°	83°	$1{\cdot}009\frac{13}{16}$
At 2 P. M. 20 miles S. E. of E. C. Light Station	...	83·5°	$1{\cdot}009\frac{6}{16}$
At 3·30 P. M. Passed through a frothy line of demarcation running E. and W. between light and dark green coloured water.			
At 4 P. M. 45 miles on same line ...	81°	83°	$1{\cdot}021\frac{7}{16}$
At 5·30 P. M. 60 miles on same line ...	...	82°	$1{\cdot}022\frac{11}{15}$
November 14th 6 30 A. M. 200 miles on same line or in 19° 80′ N. 91° 2′ E. ...	81°	83°	$1{\cdot}022\frac{6}{16}$
At Noon 265 miles miles on same line ...	81°	81·5°	$1.022\frac{6}{16}$
At 5·30 P. M. 320 miles on same line ...	81°	82·5°	$1{\cdot}023\frac{10}{16}$

On this outward trip the ordinary fine weather of the winter monsoon prevailed, following a rather heavy cyclonic disturbance down the bay: but on the return journey on the 20th, 21st, and 22nd of the same month there was a hard cyclone prevailing to the south, and then southwest of the Hooghly Pilot Station; and a strong set of the sea up along the eastern side and, I suppose, the centre of the Bay of Bengal, carrying the vessel I was on board of, the B. I. S. N. Company's

S. S. "*Nowshera,*" onwards to the N. W., some three or four miles an hour faster over the ground than her dead reckoning showed her to be going through the water, on her N. W. course towards the Pilot Station and Hooghly River Sandheads, even all the way from the Alguada Reef, and I found the following :—

	Temperature. Air.	Temperature. Sea.	Specific gravity.
November 22nd, 1886 7 A. M. Sea indigo. 55 miles S. E. of Eastern Channel Light Station	81°	83°	$1{\cdot}023\frac{10}{16}$
Note :—This temperature accords with, and the specific gravity exceeds what we had found at a distance of 200 miles, when bound the other way, only eight days before.			
At 8·30 A. M. 14 miles S. E. of E. C. Light Vessel. Sea dark green ...	...	80·5°	$1{\cdot}022\frac{3}{16}$
At 10·10 A. M. 2 miles N. N. E. of E. C. Light Vessel. 1st quarter ebb ...	79·5°	79·5°	$1{\cdot}016\frac{2}{16}$
Note :—This gives a difference of — 3°·5 in temperature and of + $006\frac{3}{16}$ in the specific gravity from what prevailed at, and near about the same spot, on the 13th inst. or only eight days before.			
At 11·30 A. M. at Intermediate Light Station. Half ebb	...	79·5°	$1{\cdot}013\frac{7}{16}$
At 3 P. M. 2 miles above Saugor Light House S. W.	81°	81°	1·007

We will now take the observations which were made at a position near the Eastern Channel Light Station, and compare them, to show what changes of density and temperature of the sea are there due to these fitful changes and disturbances of weather in the bay, during this month of November last.

	Temperature. Air.	Temperature. Sea.	Specific gravity.
On the 31st October 1886, 2 miles N. E. of E. C. Light, and just previous to a cyclonic whirl in the Bay, with its usual precursory westward set of the sea at the Sandheads	84·5°	86·5°	$1{\cdot}015\frac{5}{16}$

	Temperature. Air.	Temperature. Sea.	Specific gravity.
(After this I was absent from Sandheads until the 13th.)			
On 13th November 1886, in nearly same position, just after the cessation of the strong westward set caused by a cyclonic whirl down the Bay, and all was again quieted	86°	83°	$1{\cdot}009\frac{15}{16}$
On 22nd November, in same position, during a severe and widespread cyclonic disturbance farther down the Bay which had been some days in existence: and when a strong north westward set of the sea was pouring in towards this position from, and across, and most likely out of, the depths of the peculiar sub-marine ravine, or gut of deep, and (as Commander Carpenter has told us) cold water, called 'The Swatch of No Ground*	79·5°	79·5°	$1{\cdot}016\frac{3}{16}$

From the above, and what has been shown before, it seems the fresher water setting from the eastward, off and on, ever since the 31st of October (on the evening of which day the changed colour and appearance of the sea alongside led me to test it, and I found a slight diminution in its density, even then), or for half a month, was completely crowded out, as it were, by the last mentioned north-westward moving current of the 20th, 21st, and 22nd of November: which the *S. S. Nowshera's* log book furnishes ample proofs of; and, as a consequence, the salinity of the water at the station increased too, and probably, for a while, exceeded its normal: but, on this point, the few observations I have had opportunity to make and record will not permit me to write with that degree of assurance that I should like to do.

Maury says of the hydrometer:—'In the physical machinery of the universe there is no compensation to be found that is more exquisite or beautiful than that which, by means of this little instrument has been discovered in the sea between its salts, the air, and the sun: but Maury could hardly have meant the instrument commonly found on shipboard,

* For a description of which see paper by Commander Carpenter, R. N. (read before your Society some time back).

which can only be guessed at, if read to less than the nearest ·002, but, if so, what an amount of really valuable information may be got out of an instrument, which, although a rough and rude one, is so much more exact: the one is as different from the other as was the old cross staff of Christopher Columbus' time from the double reflecting sextant of to-day. Our forefathers were content to find their vessel's position to the nearest two or three miles, but modern navigators are not satisfied unless they get it to the fraction of a mile.

Doubtless, the energy which brings the waters up from the ever-frigid bed of the deep sea:—the energy of attraction and repulsion;—of contraction and expansion, or, of deadweight and buoyancy:—this energy of motion, under different states and circumstances, of the chemically suspended salt atoms, contained in each ocean drop, will yet be made to divulge its partially hidden and secret treasures to the practical scientist for the navigator's benefit: as has been the case with the latent energy of that other heat vehicle and prime motor of the hurricane blast, as well as of the gentle zephyr—the invisible water-vapour globule in the air strata aloft. All that is required is the aid of willing workers and their faithful records: for all the facts as set forth above, meagre as have been the opportunities for observing them, go far to prove that the hydrometer, when constructed to show minute aggregation, or segration of salt atoms in the water, must prove to be no mean aid to the sailor, more especially to the coasting navigator, since it is near coasts that the currents generally are more capricious, or disguised by others which have never been properly explained. It will aid him either as a monitor of his vessel's proximity to land; of her being caught in the toils of some abnormal current, which may be hurrying his vessel on to her destruction (as was nearly the case during the cyclone in the Bay of the 19th, 20th, 21st and 22nd of November last, with the ship "*Airlie*:" which vessel was found to have been driven by the storm-impelled current 140 miles to the N. W., out of her dead reckoning, right through the dangerous South Preparis Channel, and actually had an oyster shell washed up on to her deck); or its indications may be made even to warn the watchful shipmaster of the on-coming, though yet distant, cyclone; let alone its probable use to scientists, in more ways than one.

My instrument, a rather large soda-water bottle, when ballasted, or weighted, so as just to float with its wire pedestal (or support and cup or pan for weights) in water at a temperature of 95° (which is the warmest of any sea water), happens to have a fluid displacement, or, which is the same thing, weighs in air exactly 10,000 grains—a convenient figure for calculating the several counterbalancing weights by. The weights are made by dividing and subdividing 320 grains weight of copper wire: the whole 320 grains being, of course, equivalent to 1·032, or thirty-two thousandths—a figure far above any degree of saltness of sea water, but chosen on account of its convenience of divisability:—thus, the 320 grains of wire doubled, straightened out and cut, gives ·016, or sixteen one-thousandths: of which make sixteen coils, or loops to denote it, of one piece. The other piece doubled as before and cut gives ·008, and so on, until the one-sixteenth of a thousandth is arrived at,—a fraction which will be found to readily sink the bottle, or 'turn the scale' of this frictionless balance.

Below is added a diagram (Pl. IX) for corrections for temperature of fresh water; and a suitable table of corrections for temperature of sea water will be found in '*Maury's Physical Geography of the Sea*,' and in many other books of a like character, for those who like to seek out for themselves the "*exquisite and beautiful compensations*" which as a part of its machinery the sea salts provide in the physical economy of the Ocean.

III.—*Notes on Indian* Rhynchota: Heteroptera, No. 1.

By E. T. Atkinson, B. A., President.

[Received and Read December 1, 1886.]

Order Rhynchota, Burmeister.

Hemiptera, Linn.: *Rhyngota* Fabr.: *Proboscidea*, Scop.: *Dermaptera*, Retz.

Insects with an incomplete metamorphosis, not exhibiting the marked changes from larva to pupa and imago observable in the *Lepidoptera*: furnished with a mouth or rostrum which is fitted for piercing and sucking. The rostrum is usually 3—4-jointed and contains four seta that arise from the anterior portion of the lower surface of the head and represent the maxillæ and mandibles of other orders of insects. Antennæ with 3—5 joints, rarely more; the wings are usually four in number, but are sometimes abbreviated or altogether wanting.

Suborder Hemiptera, Latreille.

The first pair of wings (*hemelytra*) are horizontal, with the veins arranged differently from those of the second pair (*wings*), and usually comprise a basal coriaceous portion (*corium* and *clavus*), and a membranous portion (*membrane*) at the apex. This membrane is sometimes entirely absent. The wings are entirely membranous and are sometimes absent.

GYMNOCERATA, Fieber, Reuter.

Cimex, Linn.: *Cimicides*, Latr.: *Geocorisæ*, Latr.: *Geocores*, Burm., Dallas: *Aurocorisa*, Westw.: *Terrestria*, Leach: *Geocorisæ* and *Amphibicorisæ*, L. Dufour, Spin., Sahlb. et auct.

Antennæ exserted, at least as long as the head, joints without lateral processes: rostrum 3—4-jointed, rising from the anterior and usually the upper part of the head, at the base remote from the first pair of coxæ: feet not adapted for swimming: antennæ with 4—5 joints rarely with only three joints.

Fam. PENTATOMIDÆ, Kolenati.

Pentatoma, pt. Olivier, En. Méth. iv, p. 25 (1789) : *Cimex*, pt. Fabr. Ent. Syst. iv, p. 79 (1794) : *Scutati*, Burm. Handb. Ent. ii (i), p. 343 (1835): *Longiscuti*, Am. and Serv. Hist. Nat. Ins. Hém. p. 19 (1843) : *Scutata*, Dallas, List Hem. i, p. 2 (1851) : *Pentatomidæ*, Kolenati, Mel. Ent. iv, (1846) : Stål, En. Hem. v, p. 3 (1876) : *Pentatomida*, pt., Stål, Hem. Afric. i, p. 32 (1864).

Head very often clypeated, rostrum 4-jointed, inserted usually near the labrum towards the apex of the head, seldom towards the base of the head: antennæ with 4—5 joints, inserted on the lower side of the head below the lateral margins: scutellum very large, reaching at least the base of the membrane.

Subfam. PLATASPINA, Stål.

Enum. Hem. v, p. 3 (1876) :—*Plataspidæ*, Dallas, List Hem. B. M. i p. 61 (1851): *Plataspidina*, Stål, Ofvers. K. V. A. Förh., p. 611 (1870) : *Arthropteridæ*, Fieber, Eur. Hem. p. 27 (1861) ; *Arthropterida*, Stål, Hem. Afric. i, p. 1 (1864).

Head clypeated: rostrum 4-jointed, inserted towards the base of the head, remote from the source of the labrum: scutellum very large, covering the entire abdomen: hemelytra longer than the body, with the apical half folded inwards: longitudinal veins of membrane simple: tarsi 2-jointed, the first joint very short.

Genus TARICHEA, Stål.

A. S. E. F. (4 s.) v, p. 163 (1865) : Stål, En. Hem. v, p. 6 (1876) : Walker, Cat. Het. i, p. 10 (1867).

Body very broadly ovate, above very much convex, beneath somewhat flat: head clypeate, very broadly rounded before the eyes, juga contiguous before the tylus: eyes slightly transverse: ocelli more distant from each other than from the eyes: lateral margins of thorax roundly dilated: scutellum covering entire abdomen, abruptly amplified at the base: feet somewhat short (*Stål*).

1. Tarichea nitens, Dallas.

Plataspis nitens, Dallas, List Hem. i, p. 74 (1851).
Tarichea nitens, Stål, A. S. E. F. (4 s.) v, p. 163 (1865); En. Hem. v, p. 6 (1876): Walker, Cat. Het. i, p. 111 (1867).

♀. Above brassy, very smooth and shining, rather thickly and finely punctured: head, disc of abdomen, anus, sutures and stigmata, black: pectus dull black: eyes reddish: abdomen bright red, shining: legs bright orange-red: head beneath black with an orange spot in the middle of the base: rostrum pitchy red, with the basal joint orange-red: antennæ orange-red, with the two (?) apical joints black (*Dallas*). Body long 9½ mill.

Reported from N. India.

Genus Calacta, Stål.

A. S. E. F. (4 s.) v, p. 163 (1866): En. Hem. v, p. 6 (1876).

Body very broadly ovate or oval, rather convex, flat beneath: head produced before the eyes, somewhat amplified forwards, truncated at the apex; juga contiguous before the middle; eyes transverse, oblique; ocelli almost twice as distant from each other as from the eyes: lateral margins of thorax roundly amplified, anterior angles produced to the apex of the head, rounded: scutellum covering the entire abdomen, not abruptly amplified at the base: costal margin of hemelytra, broadly lobate at the base: feet somewhat short *(Stål)*.

2. Calacta rufo-notata, Stål.

Calacta rufo-notata, Stål, A. S. E. F. (4 s.) v, p. 164 (1865); En. Hem. v, p. 6 (1876).

♂. Broadly oval, moderately convex, remotely and finely punctulate: disc of thorax and scutellum very finely punctulate: eyes rufous-piceous: small spots, one marginal near the posterior angles of the thorax, another on the basal lobe of the hemelytra, two marginal dorsal before the middle of the abdomen, sanguineous: tarsi weakly testaceous flavescent: anteocular part of the head hardly amplified forwards (*Stål*). Long, 6; broad 2¾ mill.

Reported from Siam.

Genus Oncylaspis, Stål.

Hem. Afric. i, p. 2 (1864); En. Hem. v. p. 4, 6 (1876).

Body depressed, rather strongly convex: head broad, slightly or moderately bending forwards; vertex about thrice broader than the eyes which are transverse, oblique, narrowed inwards, deeply immersed.

very slightly prominulous beyond the sides of the head: ocelli remote from the eyes: antennæ inserted in the middle or almost in the middle between the eyes and the rostrum, the first joint somewhat equal in length to the two following: pronotum about twice as broad as the head, anterior margin gradually rather strongly sinuated behind the entire head; anterior angles obtuse, distinct, not rounded: feet generally short: sixth ventral segment in ♀ produced forwards in an acute angle reaching the base of the fifth segment; forming anteriorly (in ♀) a less produced right or somewhat obtuse angle *(Stål).*

Type, *P. ruficeps*, Dallas.

3. Oncylaspis ruficeps, Dallas.

Plataspis ruficeps, Dallas, List Hem. i, 73, (1851): Walker, Cat. Het. i, p. 110 (1867).

Oncylaspis ruficeps, Stål, En. Hem. v. p. 6 (1876).

♂, ♀. Above brassy black, shining, very finely punctured, with the head and the anterior angles of the thorax reddish brown: coriaceous portion of the hemelytra brown: membrane brownish, semitransparent, with dark brown veins. Body beneath reddish brown, shining, finely punctured; the anal apparatus and the middle of the disc of the abdomen, black: legs, antennæ and rostrum reddish brown, the latter rostrum with the tip pitchy *(Dallas).* Body long 9—10 mill.

Reported from Burma, Tenasserim.

Genus Poseidon, Vollenhoven.

Tijdschr. Ent. Ned. viii, p. 63 (1865).

Body elliptical, rather broader, a little tumid above, shining: head in the ♂, broad, anteriorly with three horns which are channeled, the lateral pair curved inwards in the ♀, the head is broad, semicircular, the juga unite at the tip of the tylus: antennæ inserted below the head, 5-jointed; the first very long, cylindrical, rather broad, the second very small, only one-eighth of the length of the first, the third neither so long nor so stout as the first, slightly clavate, the rest gradually decreasing in length and thickness: eyes pyriform, very distant; ocelli much nearer to each other than to the eyes: rostrum extending beyond the posterior coxæ, the second and third joints of equal length: lateral margins of pronotum arched: scutellum scarcely emarginate posteriorly in the ♂: venter flat, with, in ♀, a short longitudinal groove on the first segment: feet rather short and stout *(Voll.)*

4. Poseidon malayanus, Vollenhoven.

Poseidon malayanus, Voll., Tijds. Ent. Ned. viii, p. 64, t. 1, f. 3-5 (1865).

♂, ♀. Bronzed black above : eyes brownish-white : two spots and two lines encircling the tylus, these lines in the ♂ are in the middle of the median cephalic horn : two small spots near the anterior margin of the pronotum, a thin line along its entire lateral margin and two round spots on the scutellum near, and a fine line around, the anterior margin, orange : scutellum rather strongly and pronotum more weakly punctured, head smooth : hemelytra piceous-brown : antennæ weakly pilose, black, with the joints whitish : rostrum ferruginous : body beneath shining black, except pectus which is dull cinereous : each segment of the abdomen in the ♀ has two small orange spots on each side on the margin : feet black, tarsi brownish (*Voll.*). ♂, long, 15; ♀, long, 13 mill.

Reported from Malacca, India ?

Genus Brachyplatys, Boisduval.

Voy. Astrolabe, Ent. ii, p. 627 (1832) : Westwood in Charlesworth's Mag. Nat. Hist. ii, p. 26 (1838) ; White, id., iii, p. 539 (1839) : Dallas, List Hem. i, p. 61 (1851); Walker, Cat. Het. i, p. 98 (1867) : Stål, Hem. Afric. i, p. 8 (1864) ; En. Hem. v, p. 4, 7 (1876) :—Includes *Coptosoma*, subg. *Platycephala*, Lap., Ess. Hém, p. 74 (1832).

Body very broadly ovate, generally slightly convex above, flat beneath : head foliaceous, transverse, broad, broadly rounded at the apex ; vertex 4-5 times broader than the eyes ; antennæ remote from the eyes, the first joint not longer than the third, almost equal in length : eyes slightly transverse, not oblique, slightly immersed, strongly prominulous beyond the sides of the head, narrowed outwards : ocelli a little more distant from each other than from the eyes : pronotum about one half broader than the head, sinuated at the apex behind the vertex, truncated behind the eyes, anterior angles obtuse, rounded at the apex, not produced. As pointed out by Westwood, the scutellum in the ♂, in, both *Brachyplatys* and *Coptosoma*, is notched and in the ♀, entire. In the former the sixth ventral segment, in the ♂, is produced forwards in an acute angle reaching the base of the fifth segment, and in the ♀, forms anteriorly a less produced right or somewhat obtuse angle : in *Coptosoma*, the same segment forms an obtuse, or very obtuse angle, or is merely obtusely rounded. In *Brachyplatys*, the first joint of the last tarsi is nearly as long as the second, and in *Coptosoma* is much shorter.

5. Brachyplatys vahlii, Fabricius.

Cimex vahlii, Fabr. Mant. Ins. ii, p. 283 (1787) ; Ent. Syst. iv, p. 89 (1794) Coquebert, Ill. ii, p. 79, t. 18, f. 14 (1801) ; Wolff, Ic. Cim. p. 96, t. 9, f. 90 (1802) ?

Tetyra vahlii Fabr., Syst. Rhyng. p. 142 (1803).

Thyreocoris vahlii, var. Germar, Zeitsch. i (i) p. 33 (1839) ; Herr. Schäff. Wanz Ins. v. p. 31, 33 (1839).

Plataspis vahlii, Am. & Serv. Hist. Nat. Ins. Hém., p. 64 (1843).

Brachyplatys vahlii, Dallas, List Hem. i, p. 70 (1851) excl. syn. pt.; Walker, Cat. Het. i, p. 100 (1867); Stål. Ofvers K. V.-A. Förh. p. 611 (1870) ; En. Hem. v, p. 7 (1876): Distant, A. M. N. H. (5s.) iii, p. 44 (1879).

Head, thorax, scutellum and abdomen, black: two large marks on the head, the margin of the thorax and a small oblique line before the margin, also the margin of the scutellum, flavescent: thorax gibbous, shining: two lines on each segment of the abdomen on both sides and which unite at the apex, also the feet, yellow *(C. vahlii,* Fabr.).

♂, ♀. Head with yellow transverse lines: pronotum with a sinuated transverse line on the anterior margin, abruptly curved before the anterior angle, before reaching the posterior angle ; an arcuate line on the border of each anterior angle and another similar intramarginal line around the scutellum, below which is another slender line; margins of abdomen, transverse lines on each side of the venter, rostrum, feet and antennæ, yellow: some specimens have a small yellow dot on each side of the disc of the pronotum and another like it on each side at the base of the scutellum *(P. vahlii,* Am. and Serv.) Long 5-6 mill. Differs from *B. radians,* Voll., in its smaller size and having the intramarginal flavescent line on the scutellum punctured fuscous. Differs from *B. nigriventris,* Westw. in having transverse yellow lines on the head.

Reported from Philippines, Cochin-China, Assam: not uncommon in Sikkim.

6. Brachyplatys radians, Vollenhoven.

Brachyplatys radians, Voll., Faune Ent. l'Arch. Ind. Néerl. i, p. 52 (1863): Walker, Cat. Het. iii, p. 527 (1868) : Stål, En. Hem. v, p. 8 (1876).

Var. *Brachyplatys vahlii,* Voll., l. c. p. 52 (1863).

Brassy-black: head spotted yellow; anterior margin of thorax and oblique submarginal line yellow: two marginal lines on scutellum of which the interior line is the broader: venter yellow, with a large discal radiating patch (*Voll.*). Long 7 mill. Vollenhoven suggests that this is only a variety of his *B. vahlii.* It is a little larger: over almost the entire head extends a broad yellow patch in which winds a black streak that has its outline twice interrupted: the margin and yellow spots on the pronotum are broader and brighter: the venter black, with the yellow spots on the margin of a conical shape or it may be said that the venter is yellow with a broad black discal patch emitting rays towards the margin. Stål suggests that Vollenhoven's figure (l. c.) t. 4, f. 8 should be referred to this species: the yellow rays from the venter vary much in length and he has never seen specimens in which the small discoidal spots on the pronotum and the basal spots on the scutellum are wanting.

Reported from Philippines, Celebes, Sumatra, Amboina, Ternate, India (?).

7. Brachyplatys silphoides, Fabricius.

Cimex silphoides, Fabr., Ent. Syst. iv, p. 86 (1794).

Tetyra silphoides, Fabr., Syst. Rhyng. p. 141 (1803): Schiödte in Kroyer's Nat. Tids. iv, p. 301 (1842), excl. syn. Burmeister.

Brachyplatys silphoides, Dallas, List Hem. i, p. 71 (1851), excl. syn. pt: Walker, Cat. Het. i, p. 100 (1867): Stål, Hem. Fabr. i, p. 5 (1868); En. Hem. v, p. 8, 1876).

Body entirely glabrous, brassy-black, immaculate: margin of abdomen broadly white with a row of black dots: wings lineated: feet yellow *(Fabr.)*

♂, ♀. Aenescent-black, very distinctly and rather densely punctured, head somewhat rugose, four small spots on head, lateral submarginal line and line obliquely drawn from lateral angles towards the interior part of the eyes and here confluent with the intramarginal line, also two small spots placed before the middle and very distant from each other, elevated margin of scutellum and intramarginal line, also four basal spots, yellow-testaceous: ventral limbus emitting on each segment two somewhat short flavescent rays of which the anterior is marked by a small black spot: feet flavescent *(Stål)*. Long 6—8; broad, 5—6 mill.

Reported from India, Panjab, Ceylon, China. Westermann records its occurrence on rice (Serampore ?).

8. Brachyplatys subæneus, Westwood.

Plataspis subænea, Westw., in Hope Cat. Hem. i. p. 17 (1837).

Thyreocoris septus, Germar, Zeitschr. i (i) p. 32 (1839).

Brachyplatys subænea, Dallas, List Hem. i, p. 70 (1851): Vollenhoven, Faune Ent. l'Arch. Ind. Néerl. i, p. 54 (1863), excl. t. 4, f. 8: Walker. Cat. Het. i, p, 100 (1867): Stål, En. Hem. v, p. 8 (1876).

Brassy: head with a broad submarginal line and four dots on the rhombus (between the eyes), anterior and lateral margins of thorax and an angulated sublateral line and margin of scutellum, fulvous: feet palely luteous: abdomen brassy, marked by very many transverse conical spots on the sides (*Westw.*). Long 6½ mill.

Reported from China, Philippines, Ceylon, Malacca, Burma, Assam, India.

9. Brachyplatys burmeisteri, Distant.

Thyreocoris silphoides, Burm., Handb. ii (i) p. 384 (1835): Stål, En. Hem. v, p. 8 (1876).

Brachyplatys burmeisteri, Distant, A. M. N. H. (5s.) iii, p. 46 (1879).

Brassy-black: entire margin, the feet and marginal spots on the abdomen luteous (*Burm.*). Long 6-8 mill. Can be at once distinguished from *B. vahlii*, Fabr. and *B. silphoides*, Fabr. by its uniform coloration above and absence of luteous markings on the head and pronotum: the luteous abdominal radial streaks are as in *B. radians*, Voll.

Reported from Tranquebar, Noa-Dehing valley and Sadiya (Assam).

10. Brachyplatys nitidus, Westwood.

Plataspis nitidus, Westw., in Hope Cat. Hem. i, p. 17 (1837); Walker, Cat. Het. i, p. 110 (1867).

Thyreocoris nitidus, Germar, Zeitschr. i (i) p. 35 (1839).

Brachyplatys nitidus, Stål, En. Hem. v. p. 9 (1876).

Altogether black, shining, finely punctured: head broad; scutellum posteriorly emarginate (*Westw.*). Long, 6¼ mill.

Reported from India.

11. Brachyplatys bistriga, Walker.

Brachyplatys bistriga, Walker, Cat. Het. i, p. 100 (1867).

Aeneous, finely punctured: head about two-thirds of the breadth of the thorax: antennæ, legs, marginal line on pronotum on each side which does not extend to the posterior angle, a very short line connecting the marginal line with the posterior angle, border of scutellum, marginal transverse lanceolate streaks on venter, each containing a black point, and the corium, pale luteous: costa of hemelytra black: wings blackish cinereous (*Walker*). Long 5¼ mill.

Reported from Bangalore.

12. Brachyplatys cognata, Walker.

Brachyplatys cognata, Walker, Cat. Het. i, p. 101 (1867).

Aeneous-black, minutely punctured: head about two-thirds of the breadth of the thorax: an irregular interrupted line near the fore border of the head, a twice interrupted line between the eyes and a dot with a small longitudinal line on each side in the middle, the legs, antennæ, a waved line on pronotum which diverges on each side from the anterior margin to the posterior angle, a marginal line on each side ending near the posterior angle, sides of scutellum and transverse streaks on each side of the venter, luteous : scutellum slightly excavated at the tip (*Walker*). Long 4—5 mill.

Reported from Burma.

13. Brachyplatys adjuncta, Walker.

Brachyplatys adjuncta, Walker, Cat. Het. i. p. 101 (1867).

Aeneous, minutely punctured: head about two-thirds of the breadth of the thorax : a mark on the disc of the head between two transverse interrupted lines and the lines themselves, antennæ, legs, a transverse undulating line on the thorax which extends along the foreborder and diverges on each side to the posterior angle and two marginal lines which do not extend to the posterior angle, border of scutellum, border of venter which emits short streaks to the disc, luteous : scutellum excavated at the tip (*Walker*). Body long, $4\frac{1}{4}$ mill.

Reported from Burma.

Genus Coptosoma, Laporte.

Coptosoma. subg. *Coptosoma*, Lap., Ess. Hém. p. 73 (1832) :—*Coptosoma*, Dallas, List. Hem. i, p. 61 (1851) ; Walker, Cat. Het. i, p. 83 (1867) ; Stål, Hem. Afric. i, p. 1, 9 (1864) ; En. Hem. v, p. 4, 10 (1876). Includes *Globocoris*, Hahn, Wanz. Ins. ii. p. 40 (1834).

Body very broadly ovate, above moderately convex, beneath somewhat flat or very slightly convex : head usually small and perpendicularly, or somewhat so, deflexed, narrower than the pronotum ; tylus not reflexed anteriorly, lying entirely in the same plane : eyes rather prominulous ; ocelli nearer to the eyes than to each other : antennæ inserted at the eyes : lateral margins of thorax posteriorly sinuate, before the sinus, usually distinctly amplified and foliaceous : scutellum somewhat amplified hindwards : feet somewhat short.

14. Coptosoma duodecimpunctata, Germar.

Thyreocoris duodecimpunctatus, Germar, Zeitsch. i (i) p. 30 (1839) ; Herr. Schäff. Wanz. Ins. v, p. 14, t. 150, f. 474 (1839).

Coptosoma duodecimpunctatum, Dallas, List Hem. i, p. 62 (1851).

Coptosoma duodecimpunctata, Walker, Cat. Het. i, p. 86 (1867) : Stål, En. Hem. v, p. 10 (1876) : Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Body brassy-black : border of thorax and venter ; eight spots on the thorax (four on anterior margin, one on each lateral margin, and one in each lateral one-third) and four spots on the scutellum, red *(Germar)*. The feet are cinnamon-colour, brown towards the base ; the broad red border of the abdomen is bidentate on each segment and has large black spiracula : scutellum with a yellow line within the free black border. Long, 6 mill.

Reported from Tranquebar, Assam: the Indian Museum has specimens from Sikkim and Samaguting (Assam).

15. Coptosoma cribraria, Fabricius.

Cimex cribrarius, Fabr., Ent. Syst. Suppt. p. 531 (1798).

Tetyra cribraria, Fabr. Syst. Rhyng. p. 143 (1803) : Schiödte in Kröyer's Nat. Tidsskr. iv, p. 305 (1842).

Thyreocoris cribraria. Burm. Handb. ii (i) p. 384 (1835) : Germar, Zeitschr i, (i) p. 26 (1839) ; Herr. Schäff. Wanz. iv, p. 84, t. 134, f. 416 (1834) and v, p. 31 (1839).

Coptosoma cribrarium, Am. & Serv. Hist. Nat. Ins. Hém. p. 66, t. 2, f. 4, (1843) ; Dallas, List Hem. B. M. i, p. 67 (1851 ; Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 50 (1863) ; Stål, Hem. Fabr. i, p. 6 (1868).

Coptosoma atomarium, pt. Vollen. l. c. i, p. 50 (1863) ♂.

Coptosoma cribraria, Walker, Cat. Het. B. M. i, p. 87 (1867) ; Stål, En. Hem. v, p. 12 (1876) : Scott, A. M. N. H. (4 s.) xiv, p. 289 (1874) ; Distant, Trans. Ent. Soc. p. 414 (1883).

Body small, somewhat round : thorax and scutellum flavescent, with very numerous impressed fuscous spots : scutellum somewhat emarginate at the tip : abdomen dull black in the middle ; feet yellow (*Fabr.*). Long $3\frac{1}{2}$—5 mill.

Vollenhoven's *C. atomarium* (nec Germar) is the ♂ of *C. cribraria* and is of a greyish or greenish-yellow, irregularly covered with deep black punctures on the posterior portion of the pronotum and on the scutellum : the head is small with an extremely fine edging of black on the anterior margin, a crescent-shaped black line on the vertex extending from one eye to the other : antennæ yellow, with the tip of the last joint brownish : eyes red : pronotum divided into two unequal parts by a row of excavated brown points, in front of this row there is sometimes a waved brown line ; the posterior is punctured black : basal elevation on scutellum not tumid, excavated points larger but more distant than those on the thorax ; beneath, head and pronotum yellow : meso- and meta-thorax slaty-grey ; abdomen shining black with a broad yellow margin in which are the finely black-irised stigmata : feet yellow, last joint of tarsi, brown. Vollenhoven makes *C. cribraria* differ from his *C. atomarium* in its usually greater size, colour egg-yellow or greenish-yellow : punctuation blacker and smaller, the row of points on the pronotum is not so straight ; scutellum throughout with a submarginal black line except on the basal elevation : abdomen yellow, with a large black patch in the middle from which proceed black rays running along the anterior margins of the segments and between these rays are small transverse black lines (*Voll.*). Long $3\frac{1}{2}$—4 mill. ♂; 4—$4\frac{1}{2}$ mill. ♀.

Reported from Japan, Cochin-China, Burma, India, Ceylon, Timor, Sumatra; the Indian Museum has examples from Java, Calcutta, Sibságar and Dikrang valley (Assam). The Sumatran specimens have the yellow inclined to orange, those from Bengal are paler.

16. Coptosoma pardalina, Stål.

En. Hem. v, p. 13 (1876).

Yellow: pronotum behind the middle and on the impressions, finely punctured, the scutellum rather more strongly punctured, the punctures on the scutellum confluent in subreticulate and irregularly confluent masses and small lines, posteriorly less numerous, finer on the basal half: head semicircularly rounded before the eyes, margin narrow tylus and two triangular spots black: pronotum with the two typical, black transverse lines before the middle: pectus and venter black; ventral limbus and double row of lateral spots on each segment, flavescent; the anterior spot large, subtransverse, posterior spot small, sometimes very minute. Easily distinguished from *C. cribraria* by the head anteriorly more gradually rounded, dorsal punctuation stronger, marking blacker and more extended and the absence of lateral spots produced in long rays on the venter. Very like *C. lynceæ*, Stål, from Australia, differs in the punctuation and the black dorsal marking also in the sparingly punctulate base of scutellum and the ventral marking (*Stål*) Long, $4\frac{1}{2}$; breadth of pronotum, $3\frac{1}{2}$ mill.

Reported from India.

17. Coptosoma nepalensis, Westwood.

Coptosoma nepalensis, Westwood, Hope Cat. Hem. i, p. 17 (1837): Stål. En. Hem. v, p. 13 (1876).

Thyreocoris nepalensis, Germar, Zeitschr, i, (i), p. 28 (1839).

Thyreocoris circumscriptus, Germar, l. c. p. 29 (1839).

Coptosoma nepalense, Dallas, List. Hem. i, p. 63 (1851).

Coptosoma circumscriptum, Dallas, l. c. p. 63 (1851): Walker, Cat. Het. i, p. 86 (1867).

Coptosoma cinctum, Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 46 (1863).

Brassy black, very shining, punctured: head small, with two whitish cuneate spots before the eyes: pronotum with a very slender lateral and anterior border (interrupted in the middle), and a sublateral, angulated line, whitish; two small basal dots and a slender border on the scutellum, whitish; antennæ pale fuscous: feet whitish; femora fuscescent at the base; abdomen æneous; margin and sublateral spots, whitish (*Westw.*). Body long, 4 mill.

Reported from Nepál. The Indian Museum has specimens from Sikkim.

18. Coptosoma cincta, Esch.

Scutellera cincta, Esch. Dorpat Abh. i, p. 161 (1822); Entomographia, p. 105 (1822).

Thyreocoris seminulum, Burm. Nov. Ac. Ac. Leop. xvi, Sup. i, p. 290 (1834).

Thyreocoris variegatus, Herr. Schäff. Wanz. Ins. iv, p. 83, t. 134, f. 414 (1839).

Thyreocoris cinctus, Germar, Zeitschr. i, (i), p. 27 (1839).

Coptosoma cinctum, Dallas, List Hem. i, p. 64 (1851); Walker, Cat. Het. i, p. 89 (1867); Stål, Ofvers. K. V.-A. Förh. p. 613 (1870).

Coptosoma cincta, Stål, En. Hem. v, p. 13 (1876).

Head somewhat longer than broad, forming anteriorly a stout angle, yellow; a median line, dark brown: eyes large, yellow: antennæ as long as the thorax, yellow, second joint shortest: thorax twice as broad as long, strongly excised anteriorly and much narrower than behind, sides weakly excised, surface convex, thickly punctured, black-brown: entire side-border yellow (with a brown longitudinal line on the anterior half), sides of fore-borders, a transverse line interrupted in the middle on the anterior half, and another irregular line in the middle towards the posterior margin: scutellum broad as long, posteriorly entirely obtuse, anteriorly convex, sloped posteriorly, grossly punctured, black-brown; the broad fore-border and the narrow outer margin smooth, yellow; with yellow dots in the middle: hemelytra yellow at the base: beneath and pectus pale grey: abdomen black, shining, punctured, the margin of each segment with a stout three-cornered yellow spot: feet yellow (*Esch.*). Long, 2½—3; broad, 2—2½ mill.

Reported from Philippines. Specimens most probably representing this species come from Assam and Ceylon. Differs from *C. nepalensis*, Westw. in its smaller size and proportionately larger and more numerous yellow marks above.

19. Coptosoma sphærula, Germar.

Thyreocoris sphærula, Germar, Zeitschr.; (i) p. 25 (1839); Herr. Schäff. Wanz v, p. 15 and 30, t. 150, f. 476 (1839).

Coptosoma sphærulum, Dallas, List Hem. i, p. 64 (1851).

Coptosoma sphærula, Vollenhoven, Faune, Ent. l'Arch. Indo-Néer. p. 47 (1863); Walker, Cat. Het. i, p. 86 (1867); Stål, En. Hem. v, p. 14 (1873).

Bronzed black, shining, finely punctured: head without a spot; antennæ brownish-yellow: pronotum with a fine double border, yellow, extending from the anterior almost up to the posterior angles: scutellum bordered with yellow, except at its base : hemelytra brown with a broad yellow border. Beneath, head black, pectus dull black with a transparent yellow border at the anterior angles : abdomen shining bronzed black, with a slight edging and with small sub-costal lines, yellow : feet yellowish-brown, deeper towards the coxæ (*Voll.*). Long, 2—3 mills.

Reported from Java, China, Ceylon, N. Bengal.

20. Coptosoma parvula, Dallas.

Coptosoma parvulum, Dallas, List Hem. i, p. 65 (1851) : Walker, Cat. Het. i, p. 87 (1867).

Coptosoma parvula, Stål, En. Hem. v, p. 15 (1876).

♂, ♀. Black, shining, convex, broader behind, very finely and densely punctured : head with a small reddish spot on each side before the eyes; the tylus reaching the anterior margin : eyes reddish brown : thorax with a faint transverse furrow across the middle; the anterior portion of the lateral margins yellow : scutellum wider behind, with a distinct transverse impressed line, near the base : hemelytra margined with yellow at the base : body beneath black : abdomen with the outer margin and a submarginal spot on each side of each segment, orange : legs pale brownish orange, with the base of the femora brown : antennæ pale brownish orange, with the apical joint darker. (*Dallas.*) Long, 2½—3 mill.

Reported from India.

21. Coptosoma cicatricosa, Dallas.

Coptosoma cicatricosum, Dallas, List Hem. i, p. 66 (1851) ; Walker, Cat. Het. i, p. 87 (1867).

Coptosoma cicatricosa, Stål, En. Hem. v, p. 15 (1876).

♂. Body and abdomen black, shining, punctured : head rugose, eyes red : the lateral margins of the thorax much dilated, distinctly emarginate in front of the lateral angles ; a strong transverse punctured furrow across the disc before the middle : scutellum with a strong transverse furrow at the base, the included space not elevated ; the whole surface covered with smooth reddish, elevated spots, with the interstices thickly punctured : pectus grey, obscure : legs black : rostrum pitchy red with the apex black : antennæ black (*Dallas*). Long, 6¼ mill.

Reported from N. India.

22. Coptosoma xanthochlora, Walker.

Coptosoma xanthochlora, Walker, Cat. Het. i, p. 87 (1867).

Luteous, thinly and largely punctured, a little longer than broad : head about one-third of the breadth of the pronotum, with an abbreviated transverse black line on the hind border and with two short piceous longitudinal lines in front: pronotum with a large green patch on each side of the posterior margin: scutellum green, except the fore-part where there is a distinct abbreviated transverse furrow: pectus with a black disc: abdomen beneath, with black points on each side (*Walker*). Body long, $4\frac{1}{2}$—$5\frac{1}{2}$ mill.

Reported from India.

23. Coptosoma integra, Walker.

Coptosoma integra, Walker, Cat. Het. i, p. 88 (1867).

Æneous-black, largely punctured: head a little more than one-third of the breadth of the pronotum, luteous along each side in front: pronotum with a luteous transverse line which extends along the anterior border and is dilated on each side where it includes a slender black streak: scutellum with the border luteous, not excavated at the tip, with a transverse furrow in front: abdomen beneath, luteous on each side: legs luteous (*Walker*). Body long, $2\frac{1}{2}$—3 mill.

Reported from India.

24. Coptosoma brevis, Walker.

Coptosoma brevis, Walker, Cat. Het. i, p. 89 (1867).

Black, very minutely punctured, not longer than broad: head one-third of the breadth of the thorax with a broad curved yellow stripe on each side in front: eyes red: antennæ tawny: pronotum with two yellow lateral stripes which are interlined with black; the forepart with two narrow, yellow, slightly interrupted and undulating bands: scutellum bordered with yellow, except in front, where there is a yellow band: abdomen beneath, yellow on each side; legs yellow. Differs from *C. sphœrula*, Germ. in the continuous band at the base of the scutellum and from *C. hilaris*, Walker, by the speckled scutellum (*Walker*). Body long, 3—$3\frac{1}{4}$ mill.

Reported from Burma.

The following species of this sub-family may be noted as likely to occur in India.

Tarichea chinensis, Dallas, List Hem. i, p. 74 (1851). China.
Calacta lugubris, Stål, A. S. E. F. (4 s.) v, p. 163 (1865). Hongkong.
Coptosoma tigrina, Stål, En. Hem. v, p. 13 (1876). Cochin-China.
Coptosoma punctiventris, Stål, l. c., p. 13. Malacca.

25. Coptosoma assamensis, Atkinson.

Proc. A. S. B. p. 174 (1886).

Bronzed-black, shining, very closely and finely punctured: juga yellow, with a very fine blackish external limbus: eyes large, prominulous, deep castaneous: lateral margins of pronotum (enclosing anteriorly a black longitudinal streak) broadly forward, narrowly hindward, also four oblong transverse spots (2 and 2) on anterior part, the pair nearest anterior margin smaller, and a broadly oval spot at each posterior basal angle, yellow: the third basal part of scutellum, black arcuate hindward, with two yellow, oblong, transverse elongate spots before the basal impression: sides very broadly and apical two-thirds rather sordid yellow, thickly and coarsely punctured fuscous, with a large rounded black spot in the middle of each posterior angle: abdomen beneath shining black; feet sordid flavescent. Long, $2\frac{1}{2}$—3; broad, $2\frac{1}{2}$ mill.

Reported from N. E. Assam.

Subfam. Cydnina, Stål.

En. Hem. v, p. 17 (1876):—*Cydnida*, Stål, Hem. Afric. i, p. 18 (1864): *Cydnini*, Schiödte, Nat. Tidsskr. p. 454 (1849): *Cydnidæ*, Dallas, List Hem. i, p. 109 (1851); Walker, Cat. Het. i, p. 147 (1867): *Cydnides*, Signoret, A. S. E. F. (6 s.) i, p. 25 (1881).

Antennæ remote from the lateral margins of the head, inserted near the base of the head, or not more remote therefrom than the anterior margin of the eyes, 4-5 jointed: rostrum 4-jointed, rising near the labrum and apex of the head: scutellum variable, moderate or very large: costal margin of corium prominulous beyond the lateral margins of the body throughout its entire length, or at least for half its length: first ventral segment, or at least the sides, covered by the metastethium, the extreme posterior margin only visible: lateral margins of venter completely entire, not incised between the segments, the angles of the segments not prominulous: tibiæ spinose: propleura convex, posteriorly depressed (*Stål*).

Sec. I Cydnides, Signoret.

A. S. E. F. (6 s.) i, p. 25 (1881); iii, p. 521 (1883): *Cydnida*, Stål, Hem. Afric. i, p. 11 (1864).

Having piliferous points on the vertex and the pronotum both in front near the anterior margin and also on the disc near the transverse impression and above. These piliferous points exist almost in the same places in all species—four on the disc of the head, of which two are situate above the eyes, one on each side, and two towards the tip of the lateral lobes (*juga*); six on the pronotum of which four are situate on the anterior margin, and two lateral on the disc near the transverse impression. Where the pile or hairs are wanting, their existence is indicated by points or dots which do not occur amongst the second section comprising the *Sehirides*. The generic characters of the *Cydnides* are chiefly drawn from the piliferous points or dots other than those mentioned which are especially found along the lateral margins of the head, the pronotum or the hemelytra.

Genus Cephalocteus, Leon Dufour.

A. S. E. F. (1 s.) iii, p. 342 (1834) ; Am. & Serv. Hist. Nat. Ins. Hém., p. 94 (1843) ; Fieber. Eur. Hem. p. 83, 362 (1861) ; Walker, Cat. Het. i, p. 163 (1867) ; Stål, En. Hem. v, p. 21 (1876) ; Signoret, A. S. E. F. (6 s.) i, p. 38 (1881) :—*Cephaloctenus*, Schiödte, Kroyer's Tidsskr. iv, p. 330 (1843) ; (2 s.) ii, p. 449 (1849).

Eyes hardly visible, composed only of a small tubercle surmounted by one or two others ; ocelli absent : head longer than broad, spinulose, ciliated on the margin and the vertex ; the juga are longer than the tylus which is, however, free in front : antennæ 5-jointed, the first joint is the longest, the two last shortest, globose : rostrum reaching the intermediate pair of feet : the second joint stoutest and longest : pronotum twice as broad as long, very pilose on the sides and on part of the disc : scutellum longer than broad, acuminate : hemelytra shorter than the abdomen, membrane very short, veinless, also the corium which is bordered with numerous hairs and has some on the disc : wings rudimentary : feet short and stout ; femora amplified ; the intermediate and last tibiæ much ciliated over their whole surface ; the first pair with ten spines on the outer side, apparently mobile, and increasing in length and breadth from base to tip, the internal side furnished with four spines having very long hairs ; tarsi long and slender ; claws with appendages in the form of bristles : abdomen with numerous hairs on the disc and on the sides, the ostiolar canal more or less confused in the mesosternal groove with the ostiole towards the middle and forming an oblique opening with a distinct margin at the base and almost none at the tip *(Sign.)*.

26. Cephalocteus melolonthoides, Schiödte.

Cephaloctenus melolonthoides, Schiödte, in Kröyer's Nat. Tidsskr. iv, p. 332 (1843).

Cephalocteus melolonthoides, Stål, En. Hem. v, p. 21 (1876) : Sign. A. S. E. F. (6 s.) i, p. 40 (1881).

Fuscous or piceous, with ferruginous hairs ; scutellum and hemelytra at the apex of a weaker colour, membrane albescent at the apex : antennæ and rostrum ferruginous : neck pale yellow : feet rufous ; posterior tibiæ piceous, spines fuscous ; all the tarsi pale. Head occupying almost one-sixth of the length of the body, broader than long by one half, somewhat convex, impressed towards the sides with some unequal punctures ; anterior margin of the head between the somewhat exserted eyes broadly rounded, deeply incised in the middle : sides of clypeus converging towards the apex, united by a small transverse furrow behind the middle : pronotum at least twice as broad as its median length, scarcely twice as long as the head, narrower than the basal breadth by one-third at apex, convex, the convexity transverse, almost the third part of a circle ; disc often flatly impressed in the middle, convexly sloped anteriorly and at the sides ; densely and minutely punctured, somewhat smooth towards the anterior angles : scutellum almost twice as long as the pronotum, longer by a fourth than the basal breadth, somewhat convex, densely punctured ; anterior angles very acute ; lateral margins, straight, apex broadly rounded : hemelytra as broad as half of the anterior margin of the scutellum, densely punctured, somewhat convex, sides convexly sloped, externally rounded : venter somewhat smoothish, with ferruginous hairs (*Schiödte*). Long, $3\frac{3}{4}$ mill.

Reported from Travancore.

Genus Stibaropus, Dallas.

List Hem. i, p. 111, 125 (1851) : Walker Cat. Het. i, p. 166 (1867) : Stål, En. Hem. v, p. 13 (1876) : Sign. A. S. E. F. (6 s.) i, p. 43 (1881). Includes *Pachycnemis,* Jakowleff, Hém. Cauc., Trudy Russ. Ent. Obch. viii, p. 54 (1875).

Head very little longer than broad, rounded in front, with the apex very slightly emarginate ; the margins closely set with spines, the juga meeting beyond the tylus ; eyes of moderate size, globose, prominent : ocelli very large, distant, placed close to the anterior margin of the pronotum : antennæ short, not twice the length of the head, five-jointed, gradually increasing in thickness from the base to the apex ; basal joint short, second very small, third longest, gradually thickened towards the apex, fourth and fifth ovate : rostrum slender, reaching the posterior coxæ, inserted close to the apex of the head ; basal and third joints about equal, second and fourth also about equal, longer than the others, fourth thinnest : body oblong-ovate : thorax a little broader than long, almost semicircular in front : scutellum rather longer than broad, with the apex broad. Membrane well developed, passing beyond the apex of the abdomen, with longitudinal veins : anterior tibiæ compressed, cheliform, slightly curved, with tbe basal half of the outer margin spinose, the inner margin fringed with hairs, especially at the apex ; tarsi inserted at about one-third of the length of the tibiæ from the apex, very long and slender, three-jointed ; basal joint very long, forming more than half the tarsus, second shortest, third about half as long as the first ; intermediate tibiæ somewhat clavate, strongly curved, thickly set with spines on the outside, especially towards the apex ; tarsi inserted at the apex of the tibiæ, rather short, three-jointed, apical joint longest, second shortest; posterior legs very stout, rather short; femora very broad, somewhat compressed; tibiæ very short, sparingly spinous on the outside, much enlarged and abruptly truncated at the extremity, forming a large oval disc, surrounded by closely set spines; these spines at the extremity of the inner margin run in a single oblique line across the inner surface of the tibiæ, towards the upper margin and in the angle formed by this row of spines with the truncated posterior margin, the tarsi are inserted, and lie so concealed by the ring of spines surrounding this margin as to elude detection except upon a very close examination; the tarsi are short, three-jointed, the apical joint largest, the basal joint very little longer than the second (*Dallas*).

27. Stibaropus latipes, Westwood.

Cydnus latipes, Westwood, Hope, Cat. Hem. i, p. 18 (1837): Stål, En. Hem. v, p. 26 (1876).

Stibaropus brunneus, Dallas, List Hem. i, p. 125, t. 3, f. 1 (1851); Walker, Cat. Het. i, p. 166 (1867); Stål, En. Hem. v, p. 17 (1876).

Stibaropus latipes, Signoret, A. S. E. F. (6 s.) i, p. 44, t. 1, f. 4 (1881).

♀. Head, thorax and scutellum pitchy castaneous, more or less transversely rugose: head castaneous in front with the vertex pitchy: ocelli red: thorax with a shallow furrow across about the middle, in front of which is a distinct, transverse, elevated line; the portion of the thorax behind the furrow is finely transversely rugose as also the scutellum which is furnished with a few scattered punctures. Corium and clavus castaneous-brown, finely and densely punctured; membrane pale brownish-yellow, semitransparent: body beneath pale castaneous, impunctate; abdomen clothed with short hairs and with the apex pitchy: legs pale castaneous, with the posterior tibiæ, darker; anterior tibiæ with the apex black; tarsi reddish: rostrum and antennæ reddish testaceous; antennæ darker (*S. brunneus*, Dallas., Long, $10\frac{1}{2}$ mill.

Reported from N. India.

28. Stibaropus molginus, Schiödte.

Scaptocoris molginus, Schiödte, Kröyer's Nat. Tidsskr (2 s.) ii, p. 458 (1849).
Stibaropus molginus, Stål, En. Hem. v, p, 17 (1876): Sign. A. S. E. F. (6 s.) i, p. 45 (1881).

Suboval: rostrum as long as the pectus: second joint of the antennæ longer by half than the third: scutellum transversely rugose, broadly rounded at the apex: hemelytra punctured, piceous-castaneous; vertex and anterior part of pronotum, black piceous: clavus and exterior margin of corium on the hemelytra, castaneous-rufous: beneath with feet castaneous: pleura piceous; first pair of tibiæ black at the apex. Head very densely rugulose: last joint of the antennæ oblong-oval, as large as the third: second joint of the rostrum a little thickened, distinctly curved: anterior part of the pronotum minutely reticulose, the reticulation unequal, posterior part transversely rugulose, the wrinklets equal, very dense, punctulate: scutellum as long as the pronotum, rugulose like the posterior part of the pronotum, exceeding by one-sixth the basal breadth; a little dilated at the extreme tip, broadly rounded, almost truncated, margin broadly depressed: hemelytra distinctly punctured; exterior area of corium divided into two parts by a straight stria; marginal part narrow, puuctulate, the anterior part broad, very smooth: membrane flavescent (*Schiödte*). Long, 9½—10½ mill.

Reported from Rangpur (Bengal): a single specimen from Jalpaigori.

29. Stibaropus tabulatus, Schiödte.

Scaptocoris tabulatus, Schiödte, Kröyer's Nat. Tidsskr. (2 s.) ii, p. 459 (1849).
Stibaropus tabulatus, Stål, En. Hem. v, p. 17 (1876): Sign. A. S. E. F. (6 s.) i, p. 45 (1881).

Briefly obovate: rostrum as long as the pectus: second joint of antennæ one-fourth longer than the third: scutellum transversely striated, acutely rounded at the apex: hemelytra smooth. Weakly fulvous-castaneous; a double somewhat ring-shaped patch on the anterior part of the pronotum and the humeral protuberances, piceous: first pair of tibiæ fuscous at the apex; a transversely linear black spot near the posterior margin of the fifth ventral segment, somewhat triangularly dilated forwards in the middle of the segment: last ventral segment in ♂, piceous. Head strongly rugose: last joint of the antennæ elongate. Sovate, one fourth longer than the third: second joint of rostrum curved as regards the form of the anterior setæ: pronotum more distinctly constricted than in *S. molginus* and more narrowed towards the apex, anterior part more deeply reticulose, posterior part transversely striated, the striæ robust, here and there confluent: scutellum scarcely longer than the pronotum, exceeding by one sixth the basal breadth, transversely striated, the striæ rather regular, deep, gradually more distant towards the apex; apex scarcely dilated, acutely rounded, margin narrowly depressed: hemelytra smooth or very obsoletely punctured, exterior area of corium divided by an inwardly arched stria; marginal part broad, interior part narrow, linear, dilated towards the apex: membrane flavescent (*Schiödte*). Long, 7 mill.

Reported from Travancore.

30. Stibaropus callidus, Schiödte.

Scaptocoris callidus, Schiödte, Nat. Tidsskr. (1 s.) ii, p. 460 (1849).
Stibaropus callidus, Stål, En. Hem. v, p. 17 (1876) : Sign. A. S. E. F. (6 s.) i, p. 46 (1881).

Obovate : rostrum as long as the prosternum : second joint of the antennæ as long as the third : scutellum somewhat convex, rugosely punctured, rounded at the apex : hemelytra minutely punctured. Ferruginous-castaneous, anterior part of the pronotum and base of the scutellum and hemelytra more obscure : apices of femora usually piceous, first pair of tibiæ fuscous at the apex : last ventral segment in ♂ with a blackish spot. Head densely punctured, punctuation rugose : last joint of antennæ oval, one-fourth longer than the third : second joint of rostrum straight, third roundly dilated above : anterior part of pronotum very minutely reticulose, the reticulation unequal, disc usually somewhat smooth, posterior part deeply and densely punctured, the punctures transverse, here and there confluent : scutellum one-fourth longer than the pronotum, longer by half than the basal breadth, punctures transverse, very dense at the base, here and there confluent, more distant towards the apex and gradually decreasing in size ; apex scarcely dilated, obsoletely margined, broadly rounded : the hemelytra minutely punctured ; exterior area of corium without a dividing line ; with a longitudinal impression at the base, deeply punctured, remotely and very minutely punctured towards the apex : membrane whitish (*Schiödte*). Long, 5—5½ mill

Reported from Serampur (Bengal). Found flying in the evening on the banks of the Hughli river.

31. Stibaropus flavidus, Signoret.

Stibaropus flavidus, Sign., A. S. E. F. (6 s.) i, p. 47, t. 2, f. 6 (1881).

Yellow, rugose : head semi-horizontal, semi-perpendicular, the tylus shorter than the juga, with two bristles at the tip, the juga with six : eyes very prominent ; ocelli almost pedunculate or at least borne on a small tubercle : rostrum reaching the insertion of the intermediate feet, the first joint very long : the second joint of the antennæ very short, the third thrice as long as the second, the first almost as long as the third : pronotum rugose, twice as broad behind as in front, the anterior border marginate ; a transverse groove beyond the middle ; lateral margins pubescent : scutellum longer than broad, rugose, almost carinate in the middle, broadly rounded at the tip : hemelytra long, finely punctured ; membrane broad, white, with five veins : feet robust, pubescent, spinose, the anterior small ; tibiæ curved, concave beneath, having the tarsi inserted before the tip ; the posterior very stout, the tibiæ ending in a robust, spinose stump : abdomen pubescent; ostiolar canal much grooved, reaching three-fourths of the metasternum and ending in a rounded lobe with the odoriferous aperture invisible. Allied to *S. callidus.* Schiödte, differs in having the second joint of the antennæ shorter than the third, and the rostrum being longer (*Sign.*). Long, 6 ; broad, 2¾ mill.

Reported from N. India.

32. Stibaropus (?) minor, Walker.

Stibaropus minor, Cat. Het. i, p. 166 (1867).

Piceous, elliptical, convex, shining ; head slightly rugulose, about one-third of the breadth of the thorax: rostrum, antennæ and legs ferruginous: thorax minutely punctured in front of the antemedial transverse furrow; hind part transversely rugulose : scutellum minutely rugulose, with a transverse impression very near the tip : legs incrassated; tibiæ clavate, setose; tarsi slender: hemelytra minutely punctured; membrane pale cinereous (*Walker*). Long, 5¼ mill.

Reported from Burma.

33. Stibaropus (?) testaceus, Walker.

Stibaropus testaceus, Walker; Cat. Het. i, p. 166 (1867).

Testaceous, oval, thick, convex, shining: head somewhat conical, slightly rugulose, about one-third of the breadth of the thorax which is thickly and minutely punctured, with a transverse median furrow: scutellum transversely and minutely rugulose : legs short ; tibiæ setose ; anterior femora and tibiæ thick; hind femora and tibiæ much incrassated : hemelytra very minutely punctured; membrane pale cinereous (*Walker*). Long, 5¼ mill.

Reported from India.

Genus Lactistes, Schiödte.

Kröyer's Nat. Tidsskr. (2 s.) ii, p. 456 (1849); Stål, En. Hem. v, p. 17 (1876), Sign. A. S. E. F. (5 s.) ix, p. clxxii (1879) ; l. c. (6 s.) i, p. 48 (1881).

In this genus, as in the preceding, the anterior tarsi appear to be inserted before the end of the tibiæ, due to a prolongation of the end of the tibia (which is itself more or less emarginate) arising from the union of the apical spines. Head normally ciliated : juga inclosing the tylus: vertex more or less rugulose ; eyes spinose at the base: pronotum much narrower in front, with a median transverse impression: corium almost twice as long as the membrane, the latter extending slightly beyond the abdomen : ostiolar canal more or less rugose, with the *ostiole* in an emargination beneath and usually accompanied by a small hook-shaped tongue (*Sign.*). In *Stibaropus*, the posterior tibiæ are thickened; in *Lactistes*, they are slender; in *Scoparipes*, they have a longitudinal row of brush-shaped hairs, and in *Adrisa*, they are cylindrical. Schiödte separates *Cephalocteus* and *Lactistes* thus:—

Cephalocteus.	*Lactistes.*
Tarsi equal, very minute. Posterior tibiæ clavate, setose, externally very spiny. First tibiæ pectinate, truncate.	Tarsi unequal, first pair longer, last tibiæ narrow, compressed, spiny. First tibiæ pectinate, hamate.

34. Lactistes rastellus, Schiödte.

Lactistes rastellus, Schiödte, Kröyer's Nat. Tidsskr. (2 s.) ii, p. 457 (1849): Stål, Overs. K. V.-A. Förh. p. 614 (1870); En. Hem. v, p. 17 (1876): Sign. A. S. E. F. (6 s.) i, p. 49, t. 2, f. 8 (1881).

Blackish-brown, shining, oval: first pair of tibiæ rounded internally before the apex: third joint of antennæ one-fourth shorter than the second which is cylindrical. One-half longer than its greatest breadth before the base of the pronotum; somewhat convex, shining, castaneous, the antennæ and feet of a weaker colour. Head shorter by one-third than its greatest breadth through the eyes, rugosely punctured, flattish, margin somewhat elevated, minutely incised in the middle, frontal striæ converging from the median length: rostrum reaching the intermediate coxæ, second joint straight above: antennæ exceeding the head by one-fifth, first and second joints of the same length, cylindrical, the second twice as slender, third obconical, last two equal, ovate, one-fourth longer than the third: pronotum one-sixth longer than the anterior breadth, shorter by half than the basal breadth, convex, somewhat flatly sloped towards the apex, distinctly constricted behind the middle, densely punctured, posterior margin and anterior protuberances very smooth; sides sinuated behind the middle; anterior angles obtuse, posterior angle somewhat straight, callous, prominulous beyond the margin of the hemelytra: scutellum as long as the pronotum, scarcely exceeding the basal breadth, rather densely punctured, apex somewhat deflexed, somewhat obtuse: hemelytra densely punctured, membrane hyaline (*Schiödte*). Long, $5\frac{1}{4}$ mill.

Reported from Serampur (Bengal), Philippines.

35. Lactistes vicinus, Signoret.

Lactistes vicinus, Sign., A. S. E. F. (6 s.) i, p. 50 t. 2, f. 9 (1881).

♀. Close to *L. rastellus*, Schiödte, but differs from it in the much shorter, broad, and rounded tip of the tibiæ, in the internal edge of the tibiæ being without tubercles, whilst the external edge has 5-6 robust spines or teeth. Head rounded, emarginate in front, juga united with the tylus, borders with a rim; less rugose: pronotum punctured, margins ciliated: hemelytra with three piliferous points: abdomen punctured: the ostiolar canal more sinuous in front and behind, ending in a lobe more angularly rounded, with a small tooth at the emargination: smooth part of the mesosternum punctured: third joint of antennæ oval, as long as the second but stout; 4-5 joints are equal and longest (*Sign.*). Long, $7\frac{1}{4}$; broad, $3\frac{1}{3}$ mill.

Reported from N. India.

36. Lactistes truncato-serratus, Signoret.

Lactistes truncato-serratus, Sign., A. S. E. F. (6 s.) i, p. 51, t. 2, f. 10 (1881).

♀. In colour and form like *L. vicinus,* Sign., but differs especially in the dilated prolongation of the posterior tibiæ which is short and presents at the last spine of the external side two emarginations that form three rounded teeth: the tarsi are very long. Head rounded, emarginate in front, the tylus shorter than the juga but free, the juga not touching at the tip: pronotum more punctured, with two irregular smooth spaces on the anterior disc: scutellum less densely punctured: hemelytra without piliferous points: abdomen punctured on the sides, on the mesosternum in the glossy lateral part, and on part of the metasternum and near the insertion of the posterior femora: the episternum much punctured: the ostiolar canal very irregular, ending in a small lobe, rounded, with a valveless emargination, not a tooth (*Sign.*). Long, $7\frac{1}{2}$; broad, $3\frac{1}{2}$ mill.

Reported from N. India.

Genus Scoparipes, Signoret.

B. S. E. F. (5 s.) ix, p. clxxii (1879); l. c. p. 235 (1879): l. c. (6 s.) i, p. 202 (1881).

Distinguished by the form of the posterior tibiæ in the ♂ which are long, flattened, more narrow at the base and at the tip and have on the internal surface a line or edge furnished with short, stiff hairs very close, and the same line but with a few hairs only in the ♀; on the external surface, there are spines as in the other genera of this section. Head more or less rounded and furnished on the margin with hairs and rather stout spinules; antennæ 5-jointed of which the third is shorter than the second: ostiolar canal broad, grooved transversely and ending in a broad lobe with the lower opening surrounded by a kind of hood (*Sign.*).

37. Scoparipes longirostris, Signoret.

Scoparipes ? longirostris, Sign., A. S. E. F. (6 s.) i, p. 205, t. 7, f. 24 (1881).

Brown-black; somewhat parallel, elongate: rostrum and tarsi, yellowish: two first joints of the antennæ, black, the rest brownish. Head rounded in front, striated, finely punctured, spinulose, and ciliated on the margin: second joint of the antennæ longer than the third: rostrum very long, reaching the second ventral segment, the joints almost equal, the second joint much arched: pronotum almost square, anterior angles rounded, anterior border much emarginate, and strongly impressed, finely punctured, also the lateral margins and on the median transverse line; much ciliated on the borders: scutellum rounded, impressed at the tip and very concave; disc punctured: hemelytra shorter and narrower than the abdomen, finely punctured, with 7-8 piliferous points on the external side; membrane brown: feet black: anterior tibiæ, broad, with the usual spines: abdomen glossy in the middle, punctured and striated on the sides (*Sign.)*. Long, 12; broad, 6 mill.

Reported from India ?

Genus Adrisa, Am. & Serv.

Hist. Nat. Ins. Hém. p. 89 (1843): Stål, En. Hem. v, p. 20 (1876): Signoret. A. S. E. F. (6 s.) i, p. 205 (1881). Includes *Acatalectus*, Dallas, List Hem. i, p. 110, 122 (1851); Walker, Cat. Het. i, p. 64 (1867) and *Geobia*, Montr. Ann, Soc. Linn. Lyon. (2 s.) v, p. 245 (1858).

Distinguished by its 4-jointed antennæ, due to the union of the second and third joints; first joint short, not extending beyond the anterior margin of the head, second scarcely or as long as the third and fourth together, second joint gradually thickened from base to tip and a little pubescent, third and fourth almost of equal length and very pubescent: second joint of rostrum thickest and longest, the fourth is shortest, almost as long as the first; body oval, a little convex; corium twice as large as the membrane: scutellum angular at the tip: the meso-and meta-sternal *plaques mates* very large, the upper reaching the lateral margin above the mesosternal furrow: the ostiolar canal which reaches the middle of the metasternal space is more or less waved and ends in a tubercle or rounded or angulated lobe; it is emarginate beneath with a lage valvule varying with the species: feet and abdomen normal (*Sign).*

38. Adrisa magna, Uhler.

Acatalectus magnus, Uhler, Proc. Ac. Nat. Sci. Phil. p. 222 (1860); Stål, En. Hem. v, p. 27 (1876).

Adrisa magna, Signoret, A. S. E. F. (6 s.) i, p. 206, t. 7, f. 25 (1881).

♀. Black, shining, much punctured, the punctuation more or less confluent, head rounded, emarginate, with the anterior margin narrowly recurved, juga meeting by a point of their surface in front of the tylus, coarsely and deeply rugosely punctured : eyes testaceous, ocelli reddish : antennæ piceous, pubescent, terminal joints paler; rostrum pitchy black, second joint thickened ; thorax subquadrate, anterior angles a little oblique and rounded, behind the head, a slightly elevated, irregularly crescent-formed surface, smooth and impunctate, remaining surface very deeply, coarsely and confluently punctured, a series of very fine punctures along the lateral margins, basal margin subtruncate, smooth, with a very few coarse punctures : scutellum shining, rugosely punctured, impunctate at the apex : corium subopaque, very finely and closely punctured ; membrane fuliginous, somewhat opaque, freckled with spots of yellow, beneath scabrescently punctured, venter densely so, its disc shining, impunctate, margins trenchant ; legs deep black, shining, anterior and middle femora ciliated beneath, with a row of long slender spines, those upon the posterior pairs very short, tibiæ densely spinose (*Uhler*). Long, 19 ; breadth of abdomen, 10½ mill.

Reported from Hong-Kong.

39. Adrisa (?) clara, Walker.

Acatalectus clarus, Walker, Cat. Het. iii, p. 535 (1868).

Black, elliptical, rather flat : sides of the head and of the thorax with a few bristles : head hardly punctured ; sides and fore border very slightly reflexed : eyes, rostrum, antennæ and legs, piceous : rostrum extending to the middle coxæ : 1-4 joints of the antennæ successively increasing in length : thorax sparingly aud minutely punctured, smooth, except on each side in front of a transverse middle furrow ; a ferruginous patch on each hind angle : scutellum rather thinly punctured, smooth at the base, with a narrow ferruginous border on each side : legs stout ; femora slightly dentate beneath ; tibiæ spinose : hemelytra piceous, more thickly punctured than the thorax, with two veins near the costa and with four near the hind border ; membrane colourless (*Walker*). Long, 10½ mill.

Reported from India.

Genus Æthus, Dallas.

Pt., List Hem. i. p. 110 (1851) : Walker, Cat. Het, i, p. 148 (1867) : Stål, Hem. Afric. i, p. 19, 20 (1864) ; En. Hem. v, p. 18 (1876) : Sign. A. S. E. F. (6 s.) i, p. 423 (1881). Includes *Cydnus*, Fieber, Eur. Hem. p. 83, 363 (1861).

Body oval or ovate, slightly convex ; margins at least of the head, pilose or setose : head rounded at the apex, juga and tylus equally long ;

bucculæ continued through, slightly elevated : first joint of the rostrum not extending posteriorly beyond the bucculæ: antennæ 5-jointed, very often somewhat short and furnished with subfusiform apical joints; scutellum triangular, longer than broad, frena extended almost to the apex: corium longer than the scutellum, with the apical margin straight : prosternum longitudinally impressed: feet moderate, femora sparingly setose, tibiæ very spinose, first pair much compressed, upper margin spinosely pectinate *(Stål)*.

Signoret (l. c.) restricts *Æthus*, to those species of Dallas which have the head spinulose and ciliated and in which the ostiolar canal does not end in a cornet or ear-shaped opening of which the borders are more or less flattened.

40. Æthus indicus, Westwood.

Cydnus indicus, Westwood, Hope, Cat. Hem. i, p. 19 (1837); Stål, En. Hem. v. p. 26 (1876); Sign. An. Mus. Gen. xvi, p. 632 (1880); Lethierry, l, c. xviii, p. 649 (1883).

Æthus perosus, Stål, Ofvers. K. V.-A. Förh. p. 214 (1853); Hem. Afric. i, p. 23 (1864); Ofvers. K. V.-A. p. 614 (1870); En. Hem. v, p. 18 (1876).

Æthus impressicollis, Signoret, A. S. E. F. (3 s.) viii, p. 923 (1861).

Æthus indicus, Dallas, List Hem. i, p. 114 (1851); Walker. Cat. Het. i, p. 155 (1867); Signoret, A. S. E. F. (6 s.) ii, p. 28, t. 1, f. 69 (1882).

Small, black, shining, ovate, punctured: antennæ moderate; sides of body setose: feet moderate, black: anterior tibiæ, broad, spinose, four posterior setiferous (*Westwood)*. Body long 6 mill.

♂, ♀. Oval or ovate, black-piceous: head somewhat obtusely rounded, rarely somewhat semicircnlar, distinctly punctured, the base and the tylus smooth, margin slightly reflexed, remotely pilose: antennæ fuscous-piceous, apical joints of a weaker colour, somewhat short, three last joints somewhat incrassate, second a little shorter than the third: thorax convex, in ♂, impressed before the middle, rather densely and distinctly punctured, the base and transverse space before the middle, smooth, lateral margins remotely pilose: scutellum moderately densely punctured: hemelytra distinctly punctured; membrane sordid hyaline or very slightly infuscate: sides of venter sparingly punctured: tarsi yellow piceeus (*Æ. porosus*, Stål). Long, 5½—6; broad, 3—3½ mill.

Reported from S. Africa, Madagascar, Flores, Celebes, Borneo, Java, China, Burma, India, Bombay.

41. Æthus borrei, Signoret.

Æthus borrei, Signoret, A. S. E. F. (6 s.) ii, p. 32, t. 2, f. 73 (1882).

♂. Brown, oval, shining, sparingly and strongly punctured: rostrum, antennæ coxæ and feet, yellow; tarsi of a lighter colour; spines on feet, black. Head rounded, emarginate in the middle, the tylus shorter than the juga, the latter inclosing it, the borders also defined and posteriorly with 13-14 piliferous points on each side: vertex almost smooth, obsoletely striated: three ocelli near the eyes: rostrum reaching the intermediate coxæ, antennæ short, the second joint shorter than the third: pronotum very convex, with a strong line of dots behind the emargination and a slight impression; others at the anterior angles and on the transverse impression; the lateral margins sinuate and with 13-14 ciliated points: scutellum with the tip angularly rounded, rugosely and sparingly punctured on the disc, the base smooth: hemelytra strongly punctured; the marginal side visible to the tip but indistinct from the middle of the corium, and appearing crenulated, due to the presence of nine piliferous points or dots: the internal radial vein ending in the middle of the corium: membrane very long, of a light yellow hyaline and extending from near its half beyond the abdomen; feet yellow, with black spines; anterior tibiæ very broad, with seven stout spines, the sixth and seventh almost united as in *Lactistes:* abdomen smooth, impressed on the sides, in the space occupied by the ciliated points and the stigmata: *plaques mates* striated and punctured, the upper ending in a point on the suture, the lower separated from the smooth lateral space by an almost straight line; the ostiolar canal not reaching the middle of the metasternum and ending in a reniform lobe, with a valvular tooth in the indentation. Differs from *Ae. indicus*, Westw. by its much broader head, almost smooth, and the tylus shorter than the juga which inclose it. In *Ae. indicus*, the head is longer than broad between the eyes and the tylus is very narrow in front and as long as the juga which almost inclose it (*Sign.*). Long, 7; broad, 4 mill.

Reported from Silhet.

42. ÆTHUS PERPUNCTATUS, Signoret.

Æthus ? perpunctatus, Sign., An. Mus. Gen. xvi, p. 634 (1881); A. S. E. F. (6 s.) ii, p. 34, t. 2, f. 75 (1882).

Black: broadly oval, convex, much punctured over its entire surface, much ciliated on the head and pronotum: two glossy spaces on the anterior disc of the pronotum, at the basal angles of the scutellum and a median line on the latter almost carinate. Head rounded in front; the tylus very narrow at the tip which reaches the juga, margins slightly reflexed: pronotum ciliated on the sides and on the surface near the margin at the anterior angles; hemelytra much ciliated on the marginal side, with 12-13 piliferous points: membrane short, brown: feet black; tarsi pale; anterior tibiæ with eight spines on the external side and four on the internal side : second joint of the antennæ much longer than the third : rostrum reaching the intermediate feet : ostiolar canal ending in the middle of the episternum, much rounded at the tip which is curved back beneath, with a valvular emargination : the episternums with three small dull plates *(plaques mates)*, that of the mesosternum occupying the entire internal angle along the coxa and continued on the suture up to the border ; the lower, or that of the metasternum, occupying only the space above the extreme lobe of the ostiolar canal (*Sign.*) Easily distinguished by its abundant punctuation and the form of the ostiolar canal. Long, 6 ; broad, 3½ mill.

Reported from Khandalla (Bombay ?).

43. Æthus maurus, Dallas.

Æthus maurus, Dallas, List Hem. i, p. 118 (1851) ; Walker, Cat. Het. i, p. 158 (1867) ; Stål, En. Hem. v, p. 26 (1876) ; Distant, Scien. Res. 2nd Yarkand Miss. p. 3 (1879).

♂, ♀. Black somewhat shining, very thickly and finely punctured : head as long as broad, with the anterior margin semicircular, very faintly notched at the tip, juga not passing the tylus : ocelli not very large, red : thorax with a faint punctured transverse furrow about the middle, the anterior and lateral margins, and the portion of the disc behind the transverse furrow, very thickly and finely punctured : scutellum rather elongated, very thickly and finely punctured. Coriaceous portion of the hemelytra pitchy castaneous, finely and rather thickly punctured, the punctures closer on the line of the veins, near which it is darker than on the rest of the surface ; membrane brownish, transparent : abdomen very thickly and finely punctured on the sides, the middle of the disc, smooth, shining, impunctate ; the posterior margins of the segments very minutely denticulated : legs pitchy black, with the tarsi ferruginous : rostrum ferruginous : antennæ ferruginous brown (*Dallas*). Long, 6¼ mill.

Reported from India ?

Genus Cydnus, Fabricius.

Pt. Syst. Rhyng. p. 184 (1803) : *Cydnus*, Dallas, List Hem. i, p. 110, 120 (1851) : Walker, Cat. Het. i, p. 164 (1867) : Stål, Hem. Afric. i, p. 18, 19 (1864) ; En. Hem. v, p. 20 (1876) : Sign. pt. A. S. E. F. (6 s.) ii, p. 145 (1882). Includes *Brachypelta*, Am. & Serv., Hist. Nat. Ins. Hém. p. 89 (1843).

Body oval : head produced, semicircularly rounded at the apex and slightly emarginate in the middle, juga longer than the tylus, contiguous at the apex, margins reflexed, remotely ciliated ; bucculæ rather elevated, higher posteriorly than anteriorly : first joint of rostrum not extending beyond the bucculæ posteriorly : antennæ 5-jointed, first joint not reaching the apex of the head : the lateral margins of the thorax ciliated : scutellum broader than long, narrow at the apex : frena extended almost to the apex of the scutellum : costal margin of the hemelytra remotely ciliated, apical margin waved : prosternum longitudinally excavated : feet robust, tibiæ spinose, first pair compressed, upper margin spinosely pectinated (*Stål*). Signoret's diagnosis slightly differs as he makes the tylus and juga usually equal in length and bases his differentiation from *Æthus* on the ostiolar canal having at the tip a free lobe, more or less elevated, horn-shaped and more or less flattened on the sides.

44. Cydnus varians, Fabricius.

Cydnus varians, Fabr., Syst. Rhyng. p. 187 (1803) : Stål, En. Hem. v. p. 26 (1876) ; Sign., A. S. E. F. (6 s.) ii, p. 155, t. 6, f. 92 (1882).

Æthus varians, Stål, Hem. Fabr. i, p. 6 (1868).

Cydnus cyrtomenoides, Dohrn, Stettin Ent. Zeit. p. 40 (1860).

♂, ♀. Black-piceous or piceous, basal margin of thorax and feet, paler : membrane sordid whitish : tarsi piceous-whitish : head anteriorly very finely and remotely punctulate : thorax and hemelytra distinctly punctured. In stature like *Æthus indicus*, Westw., but differs in its much smaller size, head more obtuse, anteriorly very obsoletely and remotely punctulate, tylus very slightly narrowed forwards, antennæ much shorter, ocelli situate nearer to the eyes, thorax more narrowed anteriorly, punctuation on thorax, scutellum and hemelytra finer, first pair of tibiæ with fewer spines but apparently longer and the venter remotely sprinkled with fine, obsolete, small punctures (*Stål*). Long, 4 ; broad $2\frac{1}{5}$ mill.

Reported from Bengal, Bombay, Ceylon.

45. Cydnus aterrimus, Forster.

Cimex aterrimus, Förster, Nov. Spec. Ins. p. 71 (1771).

Cimex niger, De Géer, Mém. iii, p. 269 (1773).

Cimex tristis, Fabr., Syst. Ent. p. 716 (1775) ; Ent. Syst. iv, p. 124 (1794).

Cydnus tristis, Fabr., Syst. Rhyng. p. 185 (1803) : Hahn, Wanz. Ins. i, p. 161, t. 25, f. 83 (1831).

Brachypelta tristis, Am. & Serv., Hist. Nat. Ins. Hém. p. 90 (1843).

Cydnus carbonarius, Fourcroy, Ent. Paris (1785) : sec. Sign.

Cydnus spinipes, Schranck, Enum. Ins. Austr. p. 275 (1781).

Brachypelta elevata, Uhler, Proc. Ac. Sci. Phil. p. 222 (1860) ; *Cydnus id*, Stål, En. Hem. v, p. 20 (1876)

Var. (*b*). *Cydnus sanguinicollis*, Fabr., Syst. Rhyng. p. 185 (1803).

Var. (*c*). *Cydnus brunnipennis*, Fabr., l. c. p. 185 (1803).

Brachypeltus aterrimus, Signoret, A. S. E. F. (6 s.) iii, p. 358, t. 9, f. 186 (1883.)

Cydnus aterrimus, Dallas, List Hem. i, p. 12 (1851) excl. syn. pt.; Walker, Cat Het. i. p. 164 (1867): Stål, Hem. Afric. i, p. 19 (1864); Hem. Fabr. i, p. 6 (1868); En. Hem. v, p. 20 (1876).

Black, somewhat shining, densely and distinctly punctulate: membrane whitish hyaline, margined black at the base: thorax in ♂ anteriorly intruded and slightly transversely elevated in the middle (*Stål.*) ♂, ♀, long, 9-13; broad 5-6 mill.

Var. *b.* has the antennæ, and basal limbus of thorax yellow-castaneous. ♂, long 12; broad, 6¼ mill.

Var. *c.* has the antennæ, corium and clavus, yellow castaneous, the corium and clavus infuscate at the base. ♂, long, 9; broad 5 mill.

Oval, elongate, deep black, finely punctured: base of vertex, anterior disc of the pronotum, two basal angles of the scutellum, smooth, the last a little elevated: beneath smooth, shining in the middle, the sides more or less granulated or punctured: feet smooth, shining, sometimes of a lighter colour, femora with several rows of spinose hairs, anterior and middle pair with two spines at the tip: anterior tibiæ strongly amplified, the end having eleven strong spines on the external side and four on the internal side and at the tip, several others on the anterior and posterior disc: trochanters, rostrum and antennæ, piceous. Head longer than broad, margins much raised in front, without hairs on the border and shining only those proceeding from the piliferous points on the vertex and those anterior below the head which spring from each side of the base of the rostrum: the tylus strongly inclosed by the juga: eyes small, without a spine at the base: ocelli very small nearer to the eyes, than to the median line: rostrum short, stout, scarcely extending beyond the anterior coxæ, first joint entirely hidden by the rostral ridges which are rather raised; the second joint stouter, equal to the third, the last one-third less than the preceding: first joint of the antennæ shortest, the third less than the rest, second, fourth and fifth almost equal: anterior border of pronotum strongly emarginate and showing behind the indentation an impression, very strong in the ♂ and less so in the ♀: scutellum triangular, the side hardly shorter than the base, tip angular: hemelytra with 1—3 hairs, external margin very narrow: membrane almost as long as the corium and extending by one-fourth beyond the abdomen, dull plates (*plaques mates*) with the angles rounded and weakly grooved; the glossy parts and grooves closely punctured: *ostiole* ending in a broad, tumid, smooth, shining plate with the posterior convexity circular (*Sign.*). Long, 10—13 mill.

Reported from Europe, Africa, India: specimens from Hardwar (N.-W. P.).

Add perhaps

Cydnus nigritus, Fabr., Ent. Syst. iv, p. 123 (1794); Sign. A. S. E. F. (6 s.), ii, p. 147, t. 6, f. 85 (1882). Reported from China, Cochin-China, Europe.

Cydnus laticeps, Sign., l. c. p. 162, t. 7, f. 98 (1882). Reported from Hong-Kong.

Genus Gampsotes, Signoret.

A. S. E. F. (6 s.) ii, p. 243 (1882).

Stenocoris and *Gampsotes* differ from the other genera of *Cydnina* in the length of the rostrum which reaches the tip of the second segment of the abdomen. In *Stenocoris*, the third joint of the antennæ is much smaller than the second, and the 4-5 joints equal or almost so, whilst the base of the second joint moves in a median groove on the mesosternum. In *Gampsotes*, the second joint of the antennæ is longer than the third, the third is shorter than the fourth which itself is almost as long as the second: the base of the second joint is free, crosier-shaped and slender, further the first joint is only partly hidden by the rostral ridges which leave the apical half of the joint free (*Sign.*).

46. Gampsotes parallelus, Signoret.

Gampsotes parallelus, B. S. E. F. (6 s.), i, p. xxix (1881): ii, p. 243, t. 8, f. 103 (1882).

Two and half times longer than broad, parallel, piceous: antennæ especially the joints, and the tarsi ferruginous; rostrum of a lighter colour. Head longer than broad between the eyes, finely punctured, a little ciliated: second joint of the antennæ hardly less long than the third, fourth and fifth longest, the latter longer than the fourth: rostrum very long, reaching the third abdominal segment, second joint arched and somewhat crosier-form at the base, third joint shortest, equal to the first, the fourth slender and long, equal to the second: pronotum strongly emarginate in front and punctured, except on the anterior disc and at the posterior margin, weakly ciliated on the sides: scutellum very long, rounded at the tip, much punctured, except at the basal angles: hemelytra very long; membrane yellow hyaline, extending slightly beyond the abdomen, with four obsolete veins; corium convex at the tip, much punctured, cubital portion with two almost complete rows of points and a third smaller towards the scutellum: feet comparatively short, normally ciliated and spinulose; anterior tibiæ much dilated: ostiolar canal ending in an irregular tuberculous lobe: dull plates *(plaques mates)* occupying almost the entire meso- and metathoracic space and weakly striated: abdomen very rough on the sides and smooth in the middle (*Sign.*). Long, $5\frac{1}{2}$; broad, 2 mill.

Reported from India.

Genus Macroscytus, Fieber.

Eur. Hem. p. 83, 362, (1861) : Stål, Hem. Afric. i, p. 19, 23 (1864) ; En. Hem. v, p. 18 (1876) : Sign. A. S. E. F. (6 s.) ii, p. 465 (1882).

Body oval, depressed, ciliated with rare or very rare hairs : head flat, semicircularly or somewhat obtusely rounded ; juga and tylus of equal length ; bucculæ continued through : antennæ 5-jointed, moderate, filiform, second and third joints somewhat equal, somewhat longer than the basal : scutellum triangular, longer than broad, the frena continued almost to the apex : corium longer than the scutellum, exterior apical angle acute : prosternum longitudinally impressed : feet moderate, tibiæ slender, first pair somewhat compressed, upper margin pectinated with remote spines, last femora beneath armed near the apex with a spine or tooth. Closely allied to *Æthus*, Dallas, differs in having the body very remotely ciliated, margin of the head always without small spines and especially in its habit (*Stål*). Signoret makes the distinguishing characters the large scutellum and especially the presence of a spine at the tip of the posterior femora.

47. Macroscytus foveolus, Dallas.

Æthus foveolus, Dallas, List Hem. i, p. 113 (1851) ; Walker, Cat. Het. i, p. 157 (1847) ; Stål, En. Hem. v, p. 25 (1876).

Macroscytus foveolus, Signoret, A. S. E. F. (6 s.) ii, p. 472, t. 12, f. 131 (1882).

♂. Head rather small, with the anterior margin rounded, entire, the juga not meeting beyond the tylus ; pitchy brown, with the margins paler and fringed with fine bristles : ocelli very large, red : thorax pitchy brown, with the posterior margin castaneous, anterior margin with a faint, finely punctured, transverse fovea ; lateral margins finely and thickly punctured, and fringed with long, stout, bristles : posterior portion of the disc finely and sparingly punctured : scutellum pitchy brown at the base, becoming castaneous-brown towards the apex, rather strongly but sparingly punctured ; the tip with a distinct fovea. Coriaceous portion of the hemelytra bright castaneous-brown, thickly and finely punctured ; membrane brownish, semi-transparent : abdomen beneath pitchy, very smooth, shining, with the disc impunctate, the sides thickly and finely punctured : pectus pitchy, thickly and finely punctured : anterior legs pitchy red ; four posterior pitchy, with the coxæ reddish ; all the tarsi ferruginous : rostrum pitchy red, with the apex pitchy : antennæ ferruginous, dusky towards the base (*Dallas*). Long, $11\frac{1}{2}$ mill.

Reported from N. India.

48. Macroscytus brunneus, Fabricius.

Cydnus brunneus, Fabr., Syst. Rhyng. p. 185 (1803). Tanger.

Æthus brunneus, Walker, Cat. Het. i, p. 149 (1867) excl. syn. Syria.

Cydnus proximus, Ramb., Fauna Andal. p. 112 (1839). Spain.

Æthus badius, Walker, Cat. Het. p. 159 (1867). India, Ceylon, N. China.

Var. (*b.*) *Æthus opacus*, Stål, Ofvers. K. V.-A., Förh., p. 214 (1853); *Macroscytus id*, Hem. Afric. i, p. 26 (1864); En. Hem. v, p. 19 (1876). Caffraria.

Var. (*c.*) *Cimex spinipes*, Fabr., Spec. Ins. ii, p. 360 (1781); Mant. Ins. ii, p. 172 (1787); Ent. Syst. iv, p. 124 (1794). Cen. Africa.

Cydnus spinipes, Fabr., Syst. Rhyng. p. 186 (1803): Stål, En. Hem. v, p. 25 (1876).

Macroscytus brunneus, Fieber, Eur. Hem. p. 362 (1861) excl. syn. pt.; Muls. and Rey, Pun. Fran. ii, p. 32 (1866), Stål, Hem. Fabr. i, p. 6 (1868): Sign. A. S. E. F. (6s.) ii, p. 477, t. 14, f. 136 (1882).

Stature and size of *C. aterrimus*, Förster, but entirely brunneous and more flat, thorax not retuse nor impressed with a median stria: antennæ 5-jointed: feet spinose: last pair of femora inwardly dentate (*M. brunneus*, Fabr.).

Oval: of a more or less deep brown; the varieties *brunneus* and *opacus*, black and *spinipes* more or less finely punctured: corium sometimes glossy: rostrum, base of antennæ and the tarsi, yellow. Head rounded circularly in front; tylus as long as the juga which have 5-6 hairs along the margin: vertex scarcely carinate: ocelli approximate to the eyes: rostrum reaching the tips of the intermediate coxæ: two first joints of the antennæ, yellow; the third shorter than the second, the fourth and fifth the longest: pronotum convex in front, transversely flattened without an impression; borders slightly margined and with several hairs: scutellum long, reaching three-fourths of the abdomen, angular at the tip which is sloped, convex at the base and on the sides, very finely punctured on the disc: hemelytra almost flat, finely punctured, the radial veins scarcely prominent, the marginal side with 3-6 piliferous points; membrane short, white, hyaline, veins clouded brown: feet obscure, more or less deeply coloured, the tarsi yellow, all the femora spinose beneath, the posterior femora with two stouter spines at the tip which causes the posterior tibiæ to become somewhat distorted at the base, this portion is reddish and glabrous: abdomen black and smooth with some hairs on the margin: ostiolar canal grooved; the tip with two lobes having a broad irregular valvule in the posterior indentation; the dull plates (*plaques mates*) finely striated, the upper rounded at the anterior angle and between it and the mesosternal groove a smooth space which extends to the level of the tip of the ostiolar canal. In var. *opacus*, there is a weak punctuation in the smooth space of the metasternum (*Sign.*). Long, 8; broad, $4\frac{1}{2}$ mill.

Reported from Europe, Africa, Asia: China, Ceylon, India.

49. Macroscytus expansus, Signoret.

A. S. E. F. (6 s.), ii, p. 479, t. 14, f. 138 (1882).

Body oblong, oval, of a blackish-brown: rostrum, base and tip of the antennæ and the feet of a lighter colour: tarsi, yellow: hemelytra light brown; finely punctured on the posterior disc of the pronotum, the scutellum and the hemelytra. Tylus on a level with the juga which have six hairs; vertex weakly furrowed: third joint of the antennæ shorter than the second: pronotum with 10—11 hairs on the lateral margins; behind the emargination the points are very obsolete: scutellum smooth at the base, sparingly punctured on the disc, tip angular: membrane hyaline; abdomen smooth in the middle, with very fine small striæ, on the sides: the mesosternal dull plate (*plaque mate*) finely striated, rounded at anterior angle, separated from the mesosternal groove by a broad glossy band which is punctured and furnished with small striæ, that of the metasternum is finely striated and punctured: the ostiolar canal ends in a two-lobed part of which the external lobe is broadly dilated and there is a broad rounded valve in the indentation. Possibly only a local variety of *M. brunneus*, Fabr., from which it differs in its appearance but especially in the form of the tip of the ostiolar canal which is here much dilated and is confused with the thickened fold of the mesosternal groove (*Sign.*). Long, 7; broad, 4 mill.

Reported from Bombay.

Genus Geotomus, Mulsant & Rey.

Pun, France, p. 34 (1866); Sign. A. S. E. F. (6 s.), iii, p. 33 (1883).

Differs from *Cydnus* in the absence of small spines on the head. The rostrum is short, usually not extending beyond the intermediate trochanters which distinguishes it from *Gampsotes*: the anterior border of the pronotum is not margined which separates it from *Pangæus*: the absence of the tumidity on the lateral angles of the disc of the pronotum which conceals the real angle as in *Macroscytus* and the posterior femora being spinose at the tip give sufficient characters for distinguishing it. Moreover the ostiolar canal is terminated by a reniform or cornet-shaped lobe *(Sign.)*.

50. Geotomus pygmæus, Dallas.

Æthus pygmæus, Dallas, List Hem. i, p. 120 (1851); Walker, Cat. Het. i, p. 158 (1867); Stal, En. Hem. v, p. 26 (1876).

Cydnus rarociliatus, Ellenr., Nat. Tijd. Ned. Ind., xxiv, p. 139, f. 7 (1862) Vollen., Faun. Ent. Ind. Neerl. p. 18 (1868).

Cydnus pallidicornis, Vollen., l. c., p. 17 (1868).

Cydnus apicalis, Horvath, Hem. Het. récoltés en Chine, p. 3 (1879).

Æthus palliditarsus, Scott, Hem. Japan, Trans. Ent. Soc. iv, p. 309 (1880).
Geotomus jucundus, F. B. White, A. M. N. H. (4 s.) xx, p. 110 (1877).
Geotomus subtristis, F. B. White, l. c., p. 111 (1877).
Geotomus ? minutus, Motsch., Sign., Ann. Mus. Civ. Gen. xvi, p. 650 (1880).
Geotomus pygmæus, Sign., A. S. E. F. (6 s.) iii, p. 51, t. 3, f. 160 (1883).

♀. Elongate-ovate, black, shining: head with the juga sparingly punctured; ocelli red; thorax smooth, somewhat quadrate, transverse, with a short line of fine punctures close to the middle of the anterior margin, a line of similar punctures across the middle, and a few scattered punctures on the sides, scutellum long, rather thickly and finely punctured, with the base impunctate. Coriaceous portion of the hemelytra pitchy, very thickly and finely punctured, the punctures larger along the veins; membrane whitish; body beneath, black; abdomen thickly and finely punctured on the sides; the disc smooth: legs pitchy; tarsi pale orange; antennæ pale brown, with the tips of the fourth and fifth joints paler or testaceous *(Dallas)*. Long, $3\frac{1}{2}$—$4\frac{1}{4}$; broad, $1\frac{3}{4}$—2 mill.

Reported from India, Sumatra, Java, New Caledonia, Japan, China, Hawaii.

51. Geotomus elongatus, Herrich Schäffer.

Cydnus elongatus, Herr. Schäff., Wanz. Ins. v, p. 97, t. 27, f. 546 (1839).
Cydnus oblongus, Ramb., Fauna Andal. p. 115 (1839); Fieber, Eur. Hem. p. 364 (1861).
Æthus elongatus, Walker, Cat. Het. i, p. 148 (1876).
Geotomus elongatus, Muls. and Rey, Pun. France, ii, p. 35, 38 (1866); Sign. A. S. E. F. (6 s.) iii, p. 212, t. 5, f. 176 (1883).

Body oblong, elongate, parallel on the sides: black-brown, corium a little lighter: rostrum, antennæ and feet, yellow-brown; tarsi yellow: punctured on the head, the posterior disc and the sides of the pronotum, the scutellum (except the basal angles), and the hemelytra. Head rounded in front, tylus as long as the juga and presenting two hairs at the tip, the juga with 4—5 hairs: second joint of the antennæ as long as the third, the fourth and fifth longest: rostrum reaching the base of the intermediate coxæ: pronotum slightly impressed, punctured on the posterior disc, also on the lateral margins and behind the anterior indentation; 7—8 piliferous points on the sides: scutellum long, punctured, angular at the tip, with a longitudinal impression, basal angles smooth: hemelytra punctured, a single piliferous point on the marginal side: membrane white hyaline: abdomen black, smooth in the middle, sides punctured: mesosternal plate extending to the lateral margin, metasternal plate separated from the smooth space which has two rows of dots, by an almost straight line, concave above, convex below: ostiolar canal very rough, narrow at the base, very broad at the tip which forms a much rounded lobe presenting behind a strong excavation in which is hidden the *ostiole* (*Sign.*). Long, 4; broad $2\frac{1}{4}$ mill,

Reported from Europe, Asia, Africa.

52. GEOTOMUS ABDOMINALIS, Signoret.

A. S. E. F. (6 s.) iii, p. 219, t. 9, f. 184 (1883).

♂. Oval, elongate: pitchy brown, the hemelytra of a lighter colour. Head rounded in front; the tylus broader in the middle than at the tip, as long as the juga and having two hairs at the tip, the juga with five hairs on the margin: vertex finely punctured: the second joint of the antennæ longer than the third: rostrum reaching the level of the intermediate coxæ: pronotum strongly impressed in front behind the anterior indentation and finely punctured in that space also on the transverse line and along the lateral margins; the transverse groove, absent in the middle, is visible on the sides below the piliferous points; lateral margins with five hairs: scutellum long, narrowly rounded at the tip, finely punctured on its disc, basal angles smooth and very convex: hemelytra punctured, corium more sparingly: membrane slightly smoky, hyaline, projecting beyond the abdomen which is smooth in the middle, strongly punctured on the sides: meso- and meta-sternum without dull plates *(plaques mates)*, and both sparingly but broadly punctured: ostiolar canal, broad, short, ending in a broad ear or cornet (*Sign.*). Long, $3\frac{1}{2}$; broad, 2 mill.

Reported from India.

Genus CHILOCORIS, Mayr.

Verh. Zool. Bot. Gess. Wien, xiv, p. 907 (1864); Walker, Cat. Het. i, p. 170 (1867): Stal, En. Hem. v, p. 21 (1876): Sign., A. S. E. F. (6 s.) iii, p. 517 (1883). Includes *Amnestoides*, Sign., B. S. E. F, (5 s.) ix, p. viii. (1880).

Margin of head with erect spinules: tylus as long as the juga: eyes prominent, ocelli distinct: antennæ 5-jointed, second joint scarcely half as long as the third: margin of pronotum anteriorly and on both sides, elevated; scutellum short, triangular, reaching the base of the fourth abdominal segment: odoriferous orifice with a long furrow, with a rounded elevated lobe at the apex: first pair of tibiæ gradually broader towards the apex, externally spinosely pectinated: tarsi inserted at the apex of the tibiæ *(Mayr.)*

53. CHILOCORIS NITIDUS, Mayr.

Chilocoris nitidus, Mayr, Verh. Zool.-Bot. Gess. Wien, xiv, p. 907 (1864): Walker Cat. Het. i, p, 170 (1867); Stål, En. Hem. v, p. 21 (1876): Distant, Trans. Ent. Soc p. 415 (1883); Sign., A. S. E. F. (6 s.) iii, p. 518 (1883).

Shining, piceous-black: posterior margin of the pronotum, hemelytra, antennæ, rostrum and feet, rufous castaneous: head strongly, posterior part of pronotum and hemelytra finely, and the apex of scutellum, punctured; membrane hyaline: abdomen smooth *(Mayr)*. Long, 5 mill.

Reported from Kashmir.

54. Chilocoris piceus, Sign.

A. S. E. F. (6 s.) iii, p. 518, t. 15, f. 201 (1883).

Blackish-brown, lighter on the corium and on the lateral and posterior margins of the pronotum. Head broad, eyes very stout; ocelli nearer to the eyes than to the median line; vertex with a longitudinal impression; the border of the head, margined: tylus broader in the middle than towards the tip: pronotum strongly margined in front with a longitudinal line and impressions; anterior disc smooth, shining, not punctured (except on the sides which are finely punctured), transverse groove very distinct, with a line of dots; posterior disc weakly punctured: scutellum blunt at the tip, sparingly punctured on the disc, more so but more finely on the lateral margins: hemelytra strongly punctured along the cubital veins with two rows of lines on the clavus, the corium very finely punctured at the tip, almost smooth at the base: membrane hyaline yellow: meso- and meta-sternum dull: ostiolar canal very long but not extending beyond the margin, ending in a lobe truncated at the tip, rounded behind, with a median canal which disappears towards the terminal lobe (*Sign.*). Long, $3\frac{1}{2}$; broad $1\frac{3}{4}$ mill.

Reported from India. Possibly same as preceding.

55. Chilocoris parumpunctatus, Sign.

A. S. E. F. (6 s.) iii, p. 520, t. 15, f, 202 (1883).

This species is distinguishable by the serrated margins of the pronotum and of the base of the hemelytra from the teeth of which issue hairs, nine on the pronotum and six on the hemelytra. Light chestnut brown, shining, weakly punctured on the head; tylus very convex and much amplified in the middle, narrow at the tip and on the vertex much broader than the juga: pronotum strongly margined in front, with 3—4 stout points behind the anterior indentation, the anterior disc smooth, shining, longer than the posterior, very convex, and separated from the latter by a strong punctured impression; beyond the groove on the posterior disc are some twelve stouter points and on the groove on each side of the eyes, 3—4 stout points: scutellum blunt, rounded at the tip, sparingly and strongly punctured on the disc, a little more abundantly on the sides: hemelytra sparingly punctured on the corium which is almost smooth, more abundantly along the cubital suture, the clavus showing a complete line along the suture and a half-line near the scutellum; a second line of punctures on the external radial vein and a strong impunctate line, not extending beyond the middle of the hemelytra, on the internal radial vein: membrane hyaline, extending beyond the abdomen which is smooth and shining: meso- and meta-sternum entirely dull: ostiolar canal very long, extending beyond the mososternum, stout at the source; then narrowing and ending in a rounded lobe which points backwards; in the middle, a narrow groove gradually widened until it is lost in the rounded lobe (*Sign.*). Long, 2¼; broad, 1 mill.

Reported from India.

Sec. II. Sehirides Signoret.

A. S. E. F. (6 s.) i, p. 26 (1881); iii, p. 521 (1883):—*Sehirida*, Stål, Hem. Afric. i. p. 27 (1864).

Without piliferous or setigerous points or dots on the vertex and pronotum in front near the anterior margin and on the disc near the transverse impression and above. These characters are, however, so weak and variable that Stål was probably right in sinking the divisions into *Cydnida* and *Sehirida* made by him in 1864 and including the whole as one sub-family of the Pentatomidæ in 1876 (En. Hem, v. p. 17, 1876).

Genus Peltoxys, Signoret.

B. S. E. F. (5 s.) x, p. xxxiii (1880); l. c. (6 s.) iii. p. 522 (1883). Includes *Legnotus*, Stål (nec Schiödte), Hem. Fabr. p. 7 (1868); En. Hem. v, p. 22 (1876).

Scutellum short, sides almost equal at the base, tip acuminate; membrane very large, but not projecting beyond the abdomen: rostrum short, scarcely extending beyond the anterior feet: intermediate femora ciliated and with four short spines at the tip; anterior tibiæ a little dilated, the posterior tibiæ straight: ostiolar canal broad, long, with an opening of one half its size *(Sign.)*.

56. Peltoxys brevipennis, Fabricius.

Cimex brevipennis, Fabr., Ent. Syst. Suppl. p. 536 (1798).
Cydnus brevipennis, Fabr., Syst. Rhyng. p. 187 (1803).
Æthus brevipennis, Walker, Cat. Het. i, p. 158 (1867).
Legnotus brevipennis, Stal, Hem. Fabr. i, p. 8 (1868); En. Hem. v, p. 22 (1876).
Peltoxys pubescens, Sign., B. S. E. F. (5 s.) X, p. xxxiii (1880).
Peltoxys brevipennis, Sign., l. c. (6 s.) iii, p. 522, t, 15, f. 203 (1883).

♂. Black, shining, above and beneath very densely and distinctly punctured : first joint of the antennæ and the rostrum, piceous : tarsi pale yellow piceous. Tylus remotely punctured towards the base, impunctate before the middle, transversely rugose : thorax in the middle almost twice longer than the head, convex towards the sides, behind the middle, and anteriorly transversely slightly depressed, somewhat convex before the middle, this convex part somewhat depressed in the middle, anteriorly somewhat sloped: clavus with two rows of punctures: corium in the interior part behind the middle with four rows of punctures, towards the base, and on the exterior part sparsely punctured : membrane fuscous, *(Stål)*. Long, $4\frac{1}{3}$: broad, 2 mill.

Reported from Tranquebar, India, Saigon.

Genus Tritomegas, Amyot & Serville.

Hist. Nat. Ins. Hém. p. 92 (1843) : Signoret, A. S. E. F. (6 s.) iv, p. 50 (1884).

Second joint of the antennæ much smaller than the third : *plaques mates* of the episternums small : lobes of the head, unequal or equal which causes the anterior margin to appear more or less emarginate : tylus almost as long as the juga. Head slightly reflexed on the margins and appearing impressed or more or less emarginate in front : pronotum appearing flattened in the margins although really possessing a marginal ridge: median angles of the prosternum less pronounced than in the other genera of this section and therefore the median groove is not so deep : mesosternal ridge indistinct, metasternum smooth : ostiolar canal with an ear-shaped small tongue very distinct, the dull plates *(plaques mates)* weakly developed above and below the mesosternal groove *(Sign.)*.

57. Tritomegas bicolor, Linnæus.

Cimex bicolor, Linnæus, Faun. Suec., No. 936 (1761) ; Syst. Nat. ; (ed. 13) p. 722 (1767) ; De Géer, Mem. iii, p. 268 (1773) ; Fabr., Syst. Rhyng., p. 176 (1803 : Wolff, Icon. Cim. p. 63, t. 7, f. 60 (1801) : Stoll, Pun., p. 126, t. 32, f. 224 (1788).

Cydnus bicolor, Hahn, Wanz. Ins. i, p. 192, t. 31, f. 99 (1831).

Cydnus nubilosa, Harris, Exp. Eng. Ins. 90, t. 26, f. 8 (1776).

Sehirus bicolor, Dallas, List Hem. i, p. 129 (1851).

Tritomegas bicolor, Am. & Serv., Hist. Nat. Ins. Hém., p. 98 (1843) Schlb. Mon. Geoc. Fenn. p. 21 (1848) : Sign., A. S. E. F. (6 s), iv, p. 50, t. 2, f. 217 (1884).

More or less oval : bluish-black, shining, punctured, spotted white ; two irregular spots on the anterior angles of the pronotum, two others at the external base of the hemelytra and two not so large at the external angle of the corium : usually also two small white dots at the external angle and at the base of the pronotum as in the type, white : head indented in front, juga with a channeled rim : feet blush-brown, with a more or less broad white ring at the base of the tibiæ:

antennæ brown, second joint shorter than the third, the latter sometimes twice as long as the former: dull plates *(plaques mates)* less developed with some strong, deep points, especially in the mesosternal angle: ostiolar canal very long, projecting beyond the transverse two-thirds of the metasternum *(Sign.)*. Long, 5-7; broad, $2\frac{1}{2}$-5 mill.

Common in Europe and Asia.

IV.—*A second series of New Species of* Ficus *from New Guinea.—By* George King, M. B., LL. D., F. L. S., *Superintendent of the Royal Botanic Garden, Calcutta.*

[Received March 23rd;—Read April 6th, 1887.]

Since reading my paper before this Society "on some new species of *Ficus* from New Guinea," in January last, I have received from the distinguished botanist and explorer, Signor Beccari of Florence, materials which enable me to describe seven additional new species from that island. The whole of these species were collected either by Sig. Beccari himself, or by his companion Count D'Albertis. These seven species all belong to the third of the sub-groups defined in my paper just referred to, namely, the group characterised by having "unisexual flowers, the males and galls being in one set of receptacles and the fertile female flowers alone occupying another set of receptacles." In this group these seven species are distributed amongst the sections *Sycidium*, *Covellia*, *Eusyce*, and *Neomorphe*, for the distinguishing characters of which I must refer to the paper already mentioned.

Sycidium.

Ficus conspicabilis, King. A tree (?) the young branches and leaf-buds covered with short deciduous yellow hairs; leaves broadly ovate or elliptic, the apex acute or shortly acuminate, the edges entire; the base broad, slightly unequal, sub-cordate, 7-nerved; primary lateral nerves about 6 pairs; secondary nerves sub-transverse, little curved; lower surface pubescent especially on the midrib and nerves, reticulations minute distinct; upper surface minutely lepidote; length of blade about 8 inches; petiole ·8 in.; stipules densely covered with long, yellow, silky hairs. Receptacles large, shortly pedunculate, axillary, solitary, depressed-turbinate, both base and apex very concave, the surface wrinkled, rough, minutely tuberculate, deciduously hispid-tomentose; length from base to apex 1·1 in.; breadth 1·6 in.; umbilicus much depressed, large, with numerous scales; basal bracts 3, broadly triangular; pedicel ·2 in. long, hispid; female flowers sub-sessile or pedicellate, perianth of three distinct dark-coloured pieces; ovary ovoid, smooth; style terminal, longer than the ovary in the sessile, shorter than the ovary in the pedicellate flowers.

New Guinea: Sig. Beccari (Herb. Beccari, P. P. No. 651.)

Ficus mespiloides, King. A tree; the young shoots with long, tawny, adpressed, rather stiff hairs which are ultimately deciduous; leaves hard and rather harsh to the touch, sub-coriaceous, petiolate, elliptic, inequilateral, the apex shortly cuspidate; the edges, entire, recurved; the base narrowed, cordate or emarginate, sometimes oblique, 5 to 7-nerved; primary lateral nerves about 6 pairs, prominent beneath and minutely adpressed-pubescent as is also the midrib; the rest of the under surface puberulous and obscurely and minutely tuberculate; upper surface minutely lepidote, glabrous, rigid; length of blade 5 to 7 in.; petiole scurfy and with a few scattered adpressed fulvous hairs; 4 in. long; stipules ovate, acute, pilose externally, ·4 in. long. Receptacles sessile, axillary, solitary, sub-globose (the base and apex truncate), the surfaces with many faint vertical ridges especially towards the apex, slightly verrucose, when young scurfy pubescent, when mature nearly glabrous; 1 in. long by 1·3 in. broad; the umbilicus large, wide, surrounded by a rigid but in no way projecting annulus; basal bracts 3, leaving an annular scar where they fall off: fertile female flowers ellipsoid, rather flat, smooth, the style long, terminal; perianth of 3 lanceolate, dark-coloured, free pieces; male and gall flowers unknown.

New Guinea on Mount Arfak: Sig. Beccari (Herb. Beccari, P. P. No. 962.)

Covellia.

Ficus conora King. A tree, all the young parts softly pubescent, the young branches pale-coloured; leaves petiolate, membranous, elongate-lanceolate, slightly inequilateral, the apex acuminate, the edges entire, the base narrowed, 3-nerved; primary lateral nerves 5 to 8 pairs, slightly prominent beneath and, like the midrib, tomentose; the rest of the under surface pale in colour and (in the adult state) very shortly hispid and minutely papillose (the papillæ white); upper surface covered with very minute white dots but no hairs; length of blade 4 to 7 inches; petioles ·35 in. long, tomentose; stipules lanceolate, pubescent externally, ·6 in. long. Receptacles borne on long, thin, flexuose, leafless, nearly glabrous, branches which issue from the base of the stem, solitary, long pedunculate, turbinate, the apex very broad and depressed, the sides faintly ridged, scurfy-pubescent, and with numerous flat smooth warts, 1 in. across when ripe; umbilical scales large and thick; basal bracts none; peduncle thick, pubescent, bearing 3, small, broadly triangular bracts at or below the middle, varying in length from ·5 in. to 1·25 in.; fertile female flowers pedicillate or sessile, the ovary subglobular, smooth; style elongate, subterminal; receptacular hairs few, pale, long: male and gall flowers unknown.

New Guinea, Ramoi: Beccari (Herb. Becc. P. P. No. 388).

Ternate, Acqui-Conora: Beccari.

The receptacles are often either partially or entirely covered by the soil.

Ficus Arfakensis, King. A tree, the young shoots scurfy and softly pubescent; leaves petiolate, sub-coriaceous, lanceolate, acute, gradually narrowed to the faintly 3-nerved base, edges entire; primary lateral nerves 6 to 8 pairs, obsolete on the upper, prominent on the lower surface, and like the midrib and secondary nerves adpressed pilose, the rest of the lower surface minutely covered with white tubercles, sparsely pilose; upper surface sparsely covered with adpressed whitish hairs: length of blade 4·5 to 7 inches; petiole pilose, 6 in. long; stipules linear-lanceolate, glabrous, nearly 1 inch loug. Receptacles borne on long, ramous, slender branches which emerge from the base of the stem and apparently creep on or beneath the surface of the ground, pedunculate, ovoid, scabrid, slightly verrucose, ·45 in across; umbilical scales numerous, prominent; basal bracts 3, triangular.

Mount Arfak in New Guinea, at from 5000 to 7000 feet above the sea: Sig. Beccari (Herb. Becc. without number).

The receptacle-bearing branches often carry towards their extremities small leaves and modified stipules.

Eusyce.

Ficus Comitis, King. Young branches glabrous; leaves membranous, elliptic, the apex shortly and narrowly cuspidate, the base broad, 3-nerved; primary lateral nerves about 8 pairs, diverging from the thick strong midrib at a wide angle, prominent on both surfaces but especially so on the lower which is thickly dotted with minute white tubercles; glabrous except on the midrib and primary nerves which are densely and softly puberulous, reticulations minute, very distinct: upper surface glabrous, thickly dotted with tubercles like those on the under surface, but slightly larger; length of blade 4 to 6 inches; petiole from ·75 in. to 1·75 in. Stipules lanceolate, ·6 in. long. Receptacles pedunculate, axillary, in pairs, sub-globose or sub-pyriform, the umbilicus rather prominent, gradually narrowed to the peduncle, adpressed-puberulous, slightly verrucose; about ·25 in. across; basal bracts none; pedicel ·3 in. long, bearing 3 minute bracteoles below its middle.

New Guinea, Andai: D'Albertis (Herb. Beccari, P. Papuanae No. 531).

This has been collected only by Count D'Albertis. Its affinities are with *F. chartacea*, Wall.

NEOMORPHE.

Ficus grandis, King. A tree; the young branches deciduously hispid-tomentose; leaves large, membranous, petiolate, ovate-elliptic, the apex acute, edges irregularly and coarsely crenate-dentate, the base rounded, not cordate, 7-nerved (2 being minute); primary lateral nerves about 8 pairs diverging from the midrib at rather an acute angle; the under surface finely reticulate and with numerous minute white papillae, rather softly and minutely pubescent especially on the midrib and nerves; upper surface scabrous from rather minute sub-adpressed hairs; length of blade 10 to 13 inches; petiole deeply channelled, pubescent, rather stout, 2·5 to 3·5 inches long; stipules ovate-acuminate, smooth inside, puberulous outside, about 1·2 inches long. Receptacles on short, thick, multibracteate, tubercled, leafless branches from the main stem, on long thin peduncles, depressed-globular or shortly pyriform, the surface slightly verrucose and scurfy but without hairs, red when ripe; 1·4 in. long and 2 inches broad; the apex very broad, flat, slightly depressed; umbilical scales numerous, prominent; basal bracts 3, large, ovate-triangular, acuminate, glabrous; peduncles nearly 3 inches long: male flowers with 1 or 2 stamens; anther ovate, on a thick filament; perianth of 3; obcordate, inflated, hyaline, pieces: gall flowers pedicillate or sessile, the style sub-terminal, perianth absent; fertile female flowers unknown.

New Guinea: Sig. Beccari (Herb. Becc. No. 601).

This vies with *F. Roxburghii*, in having the largest leaves and receptacles of any Asiatic member of the genus *Ficus*.

Ficus D'Albertisii, King. A tree; the young branches with annular swellings at the nodes, completely covered with closely adpressed, minute, rusty, pubesence; leaves broadly ovate or elliptic, sometimes obovate-elliptic, the apex acute, shortly cuspidate, the edges minutely dentate or sub-entire; base rounded, emarginate, or sub-cordate, sometimes unequal, 5-nerved; primary lateral nerves about 7 pairs; both surfaces closely covered with very minute adpressed hairs, the upper surface slightly harsh, the lower soft; length of blade about 9 inches, petiole about 1·5 in., pubescent, swollen at its insertion on the stem; stipules ovate-lanceolate, acuminate, adpressed-pubescent externally, 1·5 in. long. Receptacles in small clusters from leafless ebracteate tubercles on the stem, pedunculate, pyriform, the sides with numerous vertical ridges and clothed with short adpressed, apparently deciduous, scurfy pubescence; length 1·2 in., breadth 1 inch; the umbilicus large, closed by 5 broad, rounded scales; basal bracts 3, ovate, deciduous; peduncle stout, glabrous, ·75 in. long; female flowers sessile or pedicillate, slightly rugose, the style long, terminal, hairy: male and gall flowers unknown.

Fly River, New Guinea, D'Albertis: (no number). Sumatra, Beccari: (Herb. Becc. P. S. No. 736.)

V.—*On some New Species of* Ficus *from Sumatra.*—*By* George King, M. B., LL. D., F. L. S., *Superintendent, Botanic Garden, Calcutta.*

[Received April 1st;—Read April 6th, 1887.]

Amongst the collections of dried plants made by Mr. H. O. Forbes, during the journey in Eastern Sumatra of which an account is given in his interesting volume entitled, 'A Naturalist's Wanderings in the Eastern Archipelago,' I find four undescribed species. Three of these belong to the section *Covellia*, and one to *Eusyce*. They are as follows:—

Covellia.

Ficus brachiata, King. A tree, the young shoots adpressed-pilose: leaves thinly coriaceous, inequilateral, elliptic-lanceolate, the apex acute or shortly acuminate, the edges entire or sometimes irregularly and minutely undulate; base acute, obscurely 3-nerved; lateral primary nerves 8 to 10 pairs, sub-horizontal, rather prominent beneath and adpressed-pubescent, as are the midrib and secondary nerves, the rest of the lower surface puberulous or glabrous, the reticulations minute, indistinct; upper surface glabrous; length of blade 4 to 5 inches; petiole ·5 in. long; stipules 1 in. long, glabrous. Receptacles borne on long leafless, glabrous, very ramous branches which issue from the stem near the ground, pedunculate, turbinate, verrucose, puberulous, about ·5 in. across; the umbilical scales numerous and prominent; basal bracts 3, broadly ovate; peduncle ·35 in. long; male and gall flowers not seen: fertile female flowers mostly sessile, without perianth, the style elongate, terminal and straight in young, lateral and curved in old, ovaries.

Mount Dempe, Eastern Sumatra, at elevations of about 4500 feet: Mr. H. O. Forbes (Herb. No. 2313).

This approaches *F. Miquelii*, but has smaller, narrower leaves; the receptacles are also smaller and borne on much longer branches.

Ficus Forbesii, King. A tree, the young branches, petioles and midribs of the leaves covered with dense short tawny tomemtum ; leaves thickly membranous, shortly petiolate, elliptic or obovate-elliptic, the apex suddenly and shortly cuspidate ; gradually narrowed from above the middle to the blunt, 3-nerved base ; the edges entire ; primary lateral nerves 12 to 20 pairs, prominent on the lower surface as are the midrib and straight transverse secondary nerves, the whole of the rest of the lower surface sparsely covered with stellate tawny hairs ; length of blade 12 to 15 inches ; petiole stout, ·25 in. long. Receptacles in lax umbels from long, leafless, glabrous, little divided branches which issue from the stem near its base, pedunculate, globose, glabrous, ·25 in. across, slightly umbonate at the apex, the base constricted into a short stalk at the junction of which with the peduncle proper are 3 ovate acute bracts ; male and gall florets not seen ; female flower without obvious perianth ; ovary obovate, about half as long as the style.

Sumatra, Mr. H. O. Forbes (Herb. Forb. without number).

The receptacular branches ramify very little ; at their apices there are whorls of stipule-like, lanceolate, bracteoles. The stellate pubescence is very peculiar. This species comes very near *F. ribes*, Reinw., from which it differs chiefly in its leaves. The female flowers of this are exactly like those of *F. ribes.* I have been able to find no male flowers, and I think it probable that, like *ribes*, this species is practically dioecious, male flowers occurring only in the receptacles of certain individual trees. The species is known only from Mr. Forbes's specimens, which were probably all collected from one tree.

Ficus dimorpha, King. A small tree, the young shoots deciduously hispid-tomentose ; leaves petiolate, sub-coriaceous, inequilateral, elliptic or obovate-elliptic ; the apex acute, shortly cuspidate ; the edges rather remotely dentate ; the base rounded, slightly auricled on one side, 3-nerved, with an additional minute nerve on the auricled side ; primary lateral nerves 6 or 7 pairs, not prominent ; the under surface dull, harshly pubescent, especially on the midrib and nerves, the reticulations indistinct ; upper surface glabrous and shining ; length of blade 4·5 to 6 inches ; petiole ·5 to ·75 in., pilose ; stipules ovate-lanceolate, slightly pubescent externally, ·7 in. long. Receptacles pedunculate, in small fascicles from the stem and larger branches, of two forms (*a*) those containing gall and male flowers which are pyriform, truncate at the apex, gradually constricted at the base into a long, thin, stalk at the union of which with the peduncle proper are 3 deciduous bracts, wrinkled, verrucose, pubescent ; total length 2·5 inches, of which the stalk forms more than half ; breadth at apex 1 inch, peduncle proper 5. in., male flowers numerous under the bracts of the mouth, stamen 1 ;

perianth of 3 concave pieces; gall flowers elongate, with a short, sub terminal style; perianth 3-cleft; (*b*) those containing female flowers which are turbinate, the apex concave and the umbilicus depressed, the base constricted into a stalk ·4 in. long, length 1 in., breadth 1·3 in., peduncle proper ·2 in. long; fertile female flowers pedicillate, the achene ovate-rotund, perianth undivided or splitting irregularly.

Mount Dempe, in Eastern Sumatra, at an elevation of about 3000 feet; Mr. H. O. Forbes, Herb. No. 2175.

The elongate receptacles occur mostly on the stem, the globular on the branches. The former contain perfect male flowers, scales with rudimentary anthers, and gall flowers: the latter perfect, fertilised, female flowers.

Eusyce.

Ficus dumosa, King. A shrub 3 to 9 feet high; leaves long-petiolate, membranous, from ovate-elliptic, acuminate, (rarely sinuate) to palmate, with from 3 to 5 deep acuminate lobes, edges of all the forms irregularly dentate, the apices of the lobes cuspidate, base cordate or rounded, sometimes sub-auriculate, 5 to 7-nerved; upper surface scabrid-papillose, each papilla bearing a stiff hair, the nerves tomentose, hispid; under surface more sparsely hispid, hirsute on the nerves; lateral primary nerves 5 to 6 pairs; reticulations distinct; length of blade 5 to 9 inches; petioles slender, hispid, from 2 to 4·5 in. long; stipules lanceolate, hispid at first, subsequently glabrous, about ·8 inch long; receptacles axillary, sessile, in pairs, depressed globose, with a small few-bracted umbilicus, sparsely hispid when young, smooth, scarlet to lake red when ripe, and from ·5 to 1 in. across; basal bracts 3, minute, ovate, spreading; male flowers on the receptacles with the gall flowers and near the mouth only, the perianth of four broad distinct pieces, stamens 2 perfect, or sometimes only, perfect stamen with a rudimentary pistil: gall flowers pedicillate or sub-sessile, the perienth of 5 lanceolate, free pieces; ovary globose, smooth; style short lateral, stigma infundibuliform; fertile female flowers in distinct receptacles, sub-sessile or pedicillate, perianth as in the gall flowers; achene obliquely ovoid, slightly viscid, minutely tuberculate, the style elongate, lateral: stigma pyramidal.

Kaiser's Peak, Mount Dempe, and other hills in Eastern Sumatra from 2000 to 6000 feet, Mr. H. O. Forbes (Herb. No. 2291).

This is closely allied to *F. alba*, Reinw., but it is well distinct, differing from typical *alba* by its larger receptacles, longer petiolate, thinner, leaves, which are sparsely hispid on both surfaces and not tomentose below. I have not been able to find male flowers.

VI.—*On the Mammals and Birds collected by* Captain C. E. Yate, C. S. I. *of the Afghan Boundary Commission.—By* J. Scully.

[Received May 30th ;—Read June 1st, 1887.]

Mr. Wood-Mason has asked me to contribute a paper on the collection of mammals and birds made by Captain C. E. Yate in Northern Afghanistan and presented by that officer to the Indian Museum ; the following notes are the result. The collection, I understand, was made after the departure of the Naturalist of the Commission, so it may possibly include some forms not secured by him, and doubtless additional localities will now be made known for many of the species previously obtained.

The collection contains 13 species of mammals and 110 species of birds, those comprised in the first class being particularly interesting. I have carefully examined every specimen entered in the following lists, and the identifications are as accurate as I can make them with the rather limited means of effecting comparisons. The localities and dates are carefully entered by Captain Yate on every ticket and most of the specimens of birds are sexed also ; but I have found so many errors in the sexing of the birds that I have thought it best to omit this part of the record. When I have noted the sex, I am responsible for the entry.

I have to express my thanks to Mr. Wood-Mason for giving me access to the collections under his charge at all sorts of unofficial hours, for permitting me to take most of Captain Yate's collection to my house for identification, and for procuring for me from many quarters sundry works for reference.

MAMMALIA.

1. Erinaceus albulus, Stoliczka.

1. Maruchak, Murghab, Herat, May 23.
2. Badghis, Herat.

This Hedgehog agrees well with typical examples of the species to which I have referred it, from Yarkand. The fur on the whole lower surface of the body is white, the head and cheeks are pale rufescent fawn, the ears pale isabelline behind and white in front; the hands and feet are brown above, with a few white hairs intermixed. There is no nude area on the vertex; the spines measure 0·8 to 0·9 inch and have two dark and two pale bands, the tip being pale. Length of ear in front, from orifice, 1·45 ; fore foot 0·85, with claws 1·02 ; hind foot 1.4, with claws 1·53 ; tail 0·8. Teeth : $\underline{i.\ 2}$ half the size of $\underline{i.\ 3}$, $\underline{c.}$ has two fangs anterior and posterior, pm. 1 two distinct fangs, pm. 2 three fangs, two buccal and one palatine. *E. albulus* seems quite distinct from *E. auritus* with which I have compared it.

2. Felis caudata (Gray).

1. Maimanab.

A flat skin, without skull. Nose to insertion of tail about 29·5 inches, tail about 13, hairs at tip of tail 0·7, ear from orifice at front 2·2, longest whisker 3·5, palma 3·2, planta 1·4. The ears are pointed, with a small tuft of hair at the apex measuring about 0·25. The general colour of the fur is, above, a pale yellowish grey with dusky streaks mainly along the centre of the back from nape to root of tail. Below, the fur is creamy white with dusky spots showing through here and there. The fur is soft and moderately long, grey at the base all over the body, then isabelline, and, where dark markings appear on the surface, the tips of the hairs are blackish. The head is grizzled grey, darker than the back, the sides of the nose pale fulvous, the cheeks white. The ears are pale isabelline behind, brown at the tips, and inside the hairs are whitish. The limbs are pale yellowish grey in front, with faint dusky markings near the body; inside whitish except the plantar and palmar surfaces, which are brownish black. Tail above on proximal half fulvous grey with dusky dashes resembling the back, below whiter and almost free from dark markings like the belly; rest of tail greyish white with four black rings and a black tip 1 inch long. This specimen is closer to *F. caudata* than to any other species with which I am acquainted, but from want of specimens for comparison, and in the absence of the skull, I cannot feel certain that the identification is correct.

3. Canis lupus, Linn.

1. Afghan Turkistan.

A flat skin, without skull. Nose to root of tail 37·5 inches, tail 12, hair at end of tail 2·5, ear from orifice in front 3·8. There is no black on the ears or the hind limbs; the fore limbs have a narrow black stripe down the front, ending about six inches above the point of the toes. Down the middle line of the back and along the upper surface of the tail the hairs are mainly black, and the tip of the tail is quite black.

4. Vulpes montana, Pearson.

1, 2. Afghan Turkestan.

These are again two flat skins without skulls. From nose to root of tail they measure about 29 and 31 inches, tail 15·5, hairs at end of tail 2·5. The face is rufous with the usual dark patch below the eye, the ears are wholly black behind, the ordinary dark cross on the shoulders is present, and the tail tip is white. One skin has the greater portion of the front of the fore limbs black; in the other this part is rufous; in both specimens the underparts are grey. In the larger animal, probably a male, the fur is much longer and softer, and the tail more bushy than in the other; and the claws, which in both are unusually large, curved, and sharp-pointed, are more powerful. Both these skins can be fairly matched in the large series of *V. montana* which I collected in Gilgit, and to that species I accordingly refer them.

5. SPERMOPHILUS BACTRIANUS, sp. nov.

1. ♀ Khamiab, Afghan Turkestan, June 12.

Ear conch rudimentary, soles of hind feet densely haired, tail short, not longer than hind foot, hair on body harsh, very short, unicolor.

Head and body (from skin) 9·5 inches, tail 1·5, with hairs at end included 2·2, fore foot without claws 1·25, hind foot without claws 2·25. On the head and whole body above and below the hair is very short, harsh, closely adpressed, and of the same colour throughout from base to tip. Upper parts nearly uniform pale fawn, the head slightly darker and more brown, and the rump more tinged with rufous; a pale isabelline band, from nostril to eye. Tail like the rump with a black subterminal ring and pale fulvous tip. Edges of lips, chin, throat, and whole lower surface, including inner aspect of limbs, creamy white. Outer aspect of limbs bright fulvous; upper surface of fore and hind feet pale isabelline, below to root of digits covered with creamy white hairs. The outer toe has a long pencil of whitish hair on its under surface which exceeds the tip of the claw by about half an inch. The vibrissæ are long, fine, and mostly brown; and a pencil of long glistening white hairs grows below the chin. The claws are black with pale horny tips. There are three pairs of mammæ. The skull is imperfect behind and its total length cannot be given; the posterior end of the nasals extends further back than the termination of the premaxillæ:—

	Inch.
Greatest breadth of zygoma,..................................	1·3
Breadth of brain case behind postorbital processes,...	0·78
Length of nasals, ...	0·8
Breadth ,, behind, ...	0·2
,, ,, in front,.......................................	0·26
Premolar to symphysis of premaxillæ, ...	0·6
Posterior margin of palate to incisors, ...	0·98
Breadth of palate between $\underline{pm.\ 2}$, ...	0·27
Length of mandible, condyle to symphysis, ...	1·3

From the characters already given for this souslik, it could not be referred to any species of *Spermophilus* belonging to the section in which the hind feet are not haired below, *e. g.*, *S. fulvus*, *S. rufescens*, *S. erythrogenys*, *S. brevicauda*, *S. mugosaricus*, *S. concolor*, or *S. musicus*. Of the section having well-haired soles, *S. eversmanni* and allies are also excluded by the length of the tail ; Middendorff gives the length of tail in *S. eversmanni* as 4·2 inches, with terminal hairs 5·5. Of the short-tailed sub-section, *S. citellus*, *S. dauricus*, *S. guttatus*, *S. xanthoprymnus*, and *S. mongolicus* are excluded for various, but good and sufficient, reasons which to enumerate would be long. The only likely species that remains is *S. leptodactylus* of Lichtenstein, and, to it, I was at first disposed to refer the specimen collected by Captain Yate. The position of Lichtenstein's species is, in the first place, involved in doubt : it was distinctly described as having the hind feet haired below, but, according to Brandt (Bull Acad. Sc. St. Petersburg II, p. 359), Eversmann proved to his satisfaction that *S. leptodactylus* was the same species as *S. fulvus*, which has the soles bare. However this may be, I have carefully compared Lichtenstein's detailed description of his *Citillus leptodactylus* (Säugethiere, Tab. XXXII.) with the specimen under notice and can only come to the conclusion that the latter is perfectly distinct, even if the question of hair on the soles be left out of consideration. In describing this species as new I have not overlooked Brandt's caution about the young of bare-soled sousliks having sometimes that part tolerably well covered with hairs.

6. Gerbillus, sp.

1. ♂ Balkh, Afghan Turkistan, July 4.

Head and body about 5·4, ear at front from orifice 0·6, fore-foot 0·38, with claws 0·45, hind foot 1·2, with claws 1·3. Fur long, fine, and very soft. Bright rufous brown or fawn colour above, many of the hairs black tipped, the basal parts of the hair leaden grey ; below the hairs white throughout their length. Ears fairly well haired, fawn-coloured behind with a white margin, in front with scanty white hairs at the margins; whiskers white. Fore limbs white above and below, the palms naked; hind feet isabelline above, with whitish hairs on the the soles, including the toes, except part of the hinder portion of the tarsus. The tail is imperfect, but its basal part for about 2·5 inches is coloured like the back above, and is slightly paler below.

The upper incisors are well grooved, the enamel folds of the upper molars are completely united in the middle, exactly as in *G. hurrianæ*, and the hinder molar has not a vestige of any posterior talon—the outline of the crown as seen from above being simply a narrow oval, with the points of the oval buccal and palatine. The following are the principal measurements of the skull:—

	Inch.
Total length,	1·58
Breadth of zygomatic arch,	0·85
,, of brain-case at posterior root of zygoma,	0·69
Length of palate to incisors,	0·69
,, of nasals,	0·6
Mandible, condyle to symphysis,	0·78

Although the upper molars agree best with those of *G. hurrianæ,* this specimen is quite different in character and colour of fur and in shape of skull; neither can it be referred to *G. erythrurus* with which I have compared it. It possibly represents a new species, but, as the tail is imperfect, I do not propose a name for it.

7. Mus bactrianus, Blyth.

1. ♂ Chahar Shamba, Maimanah, April 4.

This specimen agrees fairly well with typical examples of *M. bactrianus,* but the tail is shorter than the head and body, though this is not of importance in a skin. In comparing this specimen, I have had occasion to examine many specimens of *M. pachycercus* Blanford, from Yarkand, and I may note that that species is quite distinct from *M. bactrianus* and has been happily named.

8. Arvicola guentheri, Danford and Alston.

1. Afghan Turkestan.

Head and body 4·4 inches, hind foot 0·77, ear at front 0·4. The external form and colours agree well with the original description of the species from Asia Minor (P. Z. S. 1880, p. 62), except that in this specimen the rudimentary thumb of the forefoot has a small nail. The pattern of the molar teeth is very similar to that of *A. guentheri,* with the following exceptions:—

In this specimen $\frac{m.\,1}{}$ has not the rudimentary 4th angle on the inner side so prominent; it is barely indicated. On $\frac{m.\,2}{}$, however, this posterior inner angle is distinct and must be counted, although in the original description above cited it is omitted. $\frac{m.\,3}{}$ has the posterior lobe less prolonged backwards and tends less to form an angle on the outside than in the Asia Minor species. $\frac{}{m.\,1}$ too has the anterior lobe more compressed laterally in the present specimen. The following table exhibits the molar pattern according to the usual mode of counting:—

	Spaces.	External angles.	Internal angles.
$\underline{m.\ 1}$	5	3	3
$\underline{m.\ 2}$	4	3	3
$\underline{m.\ 3}$	6	3	4
$\overline{m.\ 1}$	9	5	5
$\overline{m.\ 2}$	5	3	3
$\overline{m.\ 3}$	3	2	3

9. ELLOBIUS INTERMEDIUS, sp. nov.

1. Bokun,	Murghab,	Herat,	May	10.
2. Kila Wali,	ditto	ditto	May	14.
3. Ditto	ditto	ditto	May	26.

Head and body (from skins) 4·5 to 5 inches, tail 0·4 to 0·45, hind foot 0·8 to 0·9, forefoot 0·55 to 0·67. Colour above, and on sides of head below the zygomatic projection, bright pale yellowish red (or bright rust colour). Head dark brown. Below greyish white throughout. Tail pale fulvous, the terminal hairs at tip white. Fore and hind feet whitish. Fur short (about 0·35 on hinder part of back), very soft and fine dark grey or leaden at the base, except on centre of belly, where it is white throughout its length. The bright colour of the upper surface being due to the short pale coloured tips of the hair, any abrasion of these gives the animal a dark leaden grey colour above.

Skull :—	Inch.	mm.
Breadth across hinder part of zygomatic arches,	1·05	27
„ of interorbital constriction,	·21	5·5
„ of brain-pan behind posterior termination of zygoma,	·62	16
Length from anterior molar to incisors,	·54	14
„ of upper molar series,	·32	8
„ of palate to incisors,	·86	22·5
Breadth of palate between anterior molars,	·14	4
Length of lower jaw, condyle to symphysis,	1·05	27
„ of lower molar series,	·33	8·5

The nasals are shaped somewhat like a wine-bottle bent in at the sides, their external margins being nearly straight behind, then convex, then strongly concave, and finally convex again at the front end; the posterior ends are pointed, not truncated. The posterior ends of the premaxillæ extend quite 3·5 mm. behind the ends of the nasals and the same distance beyond the origin of the zygomatic arch. The zygomatic arch is high throughout; the maxillary process does not reach the squamosal along the lower margin, a square process from the malar interposing itself and forming the lower edge of the arch for a length of 1·5 mm.

The skull differs from that of *E. fuscocapillus* in having the nasal portion shorter, the distance from anterior root of zygoma to symphysis of premaxillaries being 15 mm. in *E. fuscocapillus* against 12 mm. in the present species ; the zygomatic arch is quite differently shaped, being higher throughout, and the malar bone forms part of the lower margin, while in *E. fuscocapillus* the maxillary and squamosal processes meet along the lower margin, so as to exclude the malar ; and the anterior palatine foramina are much smaller and narrower.

From *E. talpinus*, the skull of the present species differs completely in the shape of the nasals and in the extension backwards of the end of the premaxillæ ; the shape of the zygoma presents even a greater divergence than from *E. fuscocapillus*, but the arrangement of the bones in the arch are closely similar in *E. talpinus* and *E. intermedius ;* the anterior palatine foramina are very much smaller than in *E. talpinus*, and there are other differences which will be apparent on studying Mr. Blanford's very clear account of the contrast between the skulls of *E. fuscocapillus* and *E. talpinus* in J. A. S. B., vol. L, pt. II, 1884, pp. 122 –123.

Teeth. The incisors are very long and pure china-white. The molar pattern is as follows :—

	External angles.	Internal angles.
$\frac{m.\ 1}{}$	3	 3
$\frac{m.\ 2}{}$	3	 2
$\frac{m.\ 3}{}$	3	 2
$\frac{m.\ 1}{}$	4	 5
$\frac{m.\ 2}{}$	3	 3
$\frac{m.\ 3}{}$	3	 3

$\frac{m.\ 1}{}$ and $\frac{m.\ 2}{}$ do not differ from the corresponding teeth in *E. fuscocapillus* and *E. talpinus* in any important particular. $\frac{m.\ 3}{}$ differs markedly from the corresponding tooth in *E. fuscocapillus* and resembles that of *E. talpinus* in wanting a posterior lobe behind the hindmost outer angle; both the internal angles too are less prominent in the present species, the last angle being much rounded.

In $\frac{}{m.\ 1}$ the anterior lobe is less developed than in *E. fuscocapillus*, but still there are 4 external and 5 internal angles, not 3 and 4 as in *E. talpinus*.

The three species of *Ellobius* may be thus contrasted :—

E. talpinus.	*E. intermedius.*	*E. fuscocapillus.*
1. Base of fur almost black.	1. Base of fur dark or leaden grey.	1. Base of fur light grey.
2. Zygoma low, malar interposed between maxillary and squamosal processes in lower margin.	2. Zygoma high throughout, malar interposed between maxillary and squamosal processes in lower margin.	2. Zygoma high in middle, maxillary and squamosal processes alone form lower margin.
3. Nasals convex externally.	3. Nasals bottle-shaped, or external margin alternately convex and concave.	3. Nasals bottle-shaped, or external margin alternately convex and concave.
4. Premaxillæ terminate posteriorly opposite end of nasals.	4. Premaxillæ prolonged behind hind end of nasals.	4. Premaxillæ prolonged behind hind end of nasals.
5. $\underline{m.3}$ has no posterior lobe behind last outer angle.	5. $\underline{m.3}$ has no posterior lobe behind last outer angle.	5. $\underline{m.3}$ has a prominent posterior lobe behind last outer angle.
6. $\overline{m.1}$ angles 3—4.	6. $\overline{m.1}$ angles 4—5 ...	6. $\overline{m.1}$ angles 4—5.

For the comparison of the three specimens collected by Capt. Yate, I have Mr. Blanford's very full description of a skin and skull of *E. fuscocapillus* (with figure of skull and teeth) in the paper before cited, and three skins and a skull of the same species in the Indian Museum. I have no specimen of *E. talpinus* for comparison, but Mr. Blanford has so clearly and, I am sure, accurately given the differences between that form and *E. fuscocapillus* that I have no hesitation in deciding that Capt. Yate's specimen must be referred to a new species. The only known locality for *E. fuscocapillus* is Quetta, and the Russian *E. talpinus* is recorded by Severtsoff from Western Turkestan ; so that the present species is intermediate in its habitat, as well as in its distinctive characters, between the two better known species of the genus. Severtsoff calls his Turkestan specimens *E. talpinus*, var. *rufescens*, and these may prove to belong to the species I have described.

Capt. Yate notes on the ticket of one of the specimens, " Eyes scarcely visible ; caught by day."

10. Lagomys rufescens, Gray.

1. Shadian, Afghan Turkistan, August 2.
2. Ditto ditto ditto, August 6.

The above two examples belonging to a well marked and well known species need no extended notice ; they agree perfectly with specimens collected by Blanford in Persia. The species was originally described from a specimen obtained in Afghanistan.

11. Lepus lehmanni, Severt.

1. Hindu Kush, Afghan Turkistan.

This specimen is not in very good order, and I refer it rather doubtfully to the species described by Severtsoff (*see* Ann. & Mag. Nat. Hist. 1876, "The Mammals of Turkistan"), with which on the whole it seems to agree best. So many species of Asiatic hares have been described which differ only in minute particulars as to make the task of identifying a particular specimen difficult and uncertain; for the number of nominal species probably greatly exceeds the constantly distinguishable forms. In the specimen obtained in the Hindu Kush the ears measure from orifice in front about 4·3 inches, at back 4·8, greatest breadth about 2·7. The anterior external part of the ear is coloured like the back; the posterior part being pale isabelline, black at the tip and partly down the posterior margin.

The general colour above is mixed pale fawn and black. The chin and belly are white and the throat and breast pinkish isabel. The basal part of the fur above and where coloured on the limbs and breast is grey; on the belly the fur is white throughout its length.

The premaxillaries end behind on a level with the nasals, the latter bones having the posterior end sloping inwards and the junction of their outer and hinder margins slightly rounded.

The mandible from condyle to symphysis measures 3·4 inches.

12. Gazella subgutturosa, Guldenst.

1. ♂ Badghis, Herat.

Head and horns, with skin of head preserved. Band from between horns to nostrils rufescent fawn. A pale isabelline band outside this from level of inner canthus of eye to upper lip. A dark rufous fawn stripe from eye-pits to commissure of lips. The ear measures about 5·25 inches in length from orifice to tip in front. The horns from the base curve outwards, forwards, then backwards, and at the tips they curve inwards and forwards. There are 20 rings on each horn, and these end about 2·5 inches from the tips. The horns measure 14·7 inches in length along the curve in front, the distance of the tips apart is 6·9, the greatest distance apart 7·5, and the girth at the base about 4·5.

13. Cervus cashmirianus, Falconer.

1. Banks of Oxus near Balkh, Afghan Turkistan.

This is a cast left antler of an elaphine stag about which Capt. Yate gives the following information, " This was a horn from the banks of the Oxus near Balkh and will help to determine the identity of the deer found in the jungles along that river." The antler is not perfect, as the beam is broken above the royal, so that the form of the crown cannot be ascertained; the following are the measurements :—

	Inches.
Length from burr to broken end of beam along curve inside,	17·8
„ of brow tine, about,	4
„ of bez tine, about,	7
„ of royal tine along curve, about,	7·7
„ of beam above upper angle of royal,	6·9

Viewed in front, the beam is nearly straight (though of course inclined outwards) as far as the royal, where it begins to curve inwards. Viewed from the outer side, it curves slightly back from the bez and forwards to the origin of the royal ; above the royal, it curves gently back and then forwards and inwards. The brow tine is straight and directed somewhat upwards : the much longer bez is directed outwards and upwards, and towards its tip it has a slight curve inwards ; the royal is directed first outwards, then it curves at about 3 inches from the beam strongly upwards and inwards, the point being well inside the line of the broken end of the beam. Without measurement, the bez looks longer than the royal, and the middles of the bez and brow tines, measured along the middle line of the beam, are 2·5 inches apart, or from upper margin of brow to lower margin of bez at junction with beam about 1·7 inches.

It is quite clear I think that this antler agrees better with that of *C. cashmirianus* than with that of any other deer to which it could be referred. It is quite distinct from *C. maral*, as figured by Sclater in Trans. Zool. Soc., Vol. VII. I may mention that Mr. Wood-Mason, who examined this horn before I saw it, came to the conclusion that it must be referred to *C. cashmirianus.* Of course the evidence of such a fragment is not conclusive proof that the stag of the Oxus basin is really identical with the Kashmir species; complete specimens are necessary for the settlement of that point.

AVES.

1. Circus cyaneus, (Linn.).

1. ♀ Zulfikar, Badghis, Herat, November 25.
2. ♂ Chahar Shamba, Maimanah, February 1.
3. ♀ Maruchak, Murghab, Herat, March 13.
4. ♂ Maruchak, ditto ditto March 10.

The males are in immature plumage ; one is noted as having the iris yellow. A female, not adult, had the irides dark brown.

2. Circus macrurus, (Gmel.).

1. ♂ Maruchak, Murghab, Herat, March 18.

Adult, wing 13·7, iris yellow.

3. Circus cineraceus, (Mont.).

1. ♂ Karawal Khana, Murghab, Herat, April 17.

In adult plumage, but with chestnut streaks on belly and flanks.

4. Circus æruginosus, (Linn.).

1.	♂ Maruchak,	Murghab, Herat,	March	12.
2.	♂ Karawal Khana,	ditto ditto,	April	16.
3.	♀ Kila Wali,	ditto ditto,	May	13.

5. Scelospizias badius, (Gmel.).

1. Chahar Shamba, Maimanah, February 13.

In immature plumage; wing 8·75 inches, tail 5·6, tarsus 1·52, mid toe *s. u.* 1·32; seven bars on the tail.

6. Accipiter nisus, (Linn.).

1. Hauz-i-Khan, Badghis, Herat, December 6.

In rather dark plumage; four bands on tail; wing 9·4 inches, tail 7, tarsus 2·35, mid toe 1·6. The specimen is marked male on the ticket, and, if correctly sexed, may be referable to subspecies *A. melaschistus.*

7. Buteo ferox, (Gmel.).

1.	♂ Chahar Shamba,	Mainmanah,	January	27.
2.	♂	Mainmanah,		
3.	♀ Chahar Shamba,	ditto.	February	4.
4.	♀ Kara Bel,	ditto.	March	10.

In all, the tarsi are scutellate in front, the bare portion measuring from 1·8 to 2 inches; the males have the wings 15·9 and 16·5 and the females, 17·1 and 17·8; in the four specimens, the tarsi measure 3·2 to 3·3 and the mid toe 1·5 to 1·6.

8. Milvus migrans, (Bodd.).

1.	Chahar Shamba, Maimanah,	April 4.
2.	Karawal Khana, Murghab, Herat,	April 9.
3.	Ditto ditto ditto,	April 9.

The wings measure 17 and 18 inches.

9. Tinnunculus alaudarius, (Linn.).

1. Jan. 21; 2. Feb. 4; 3. Feb. 7; Chahar Shamba, Maimanah.

10. Tinnunculus cenchris, (Naum.).

1. Maruchak, Badghis, Herat, March 21.
2. Karawal Khana, Badghis, Herat, April 9.

These two specimens are alike; the wing coverts are mostly rufous, and there are a few small black spots on the abdomen and lower flanks. Wing 9 and 8·9 inches, tail 5·6 and 5·75, tarsus 1·23 and 1·25.

11. Asio otus, (Linn.).

1. Kara Baba, Maimanah, March 10.

12. Carine bactriana, (Hutton).

1. Chahar Shamba, Maimanah, January 25.
2. Ditto ditto ditto, February 4.

13. Merops apiaster, Linn.

1, 2, 3, 4 Chahar Shamba, Maimanah, April 29 to May 1.
5, Minar Shadian, Afghan Turkistan.

No. 5 is a young bird with the back green, but the throat coloured as in the adult.

14. Coracias garrula, Linn.

1, 2, 3 Chahar Shamba, Maimanah, April 30 and May 1.
4. Min Darakht, ditto, June 1.

15. Caprimulgus europæus, Linn.

1, 2, Kila Wali, Murghab, Herat, May 12.
3. Afghan Turkistan.

The pale eastern form separated as *C. unwini*. No. 3 has rufous bars on the wing where 1 and 2 have large white spots.

16. Cypselus apus, (Linn.).

1. Karawal Khana, Badghis, Herat, April 12.
2. Ditto ditto ditto ditto, April 17.
3. Kila Wali, Murghab, Herat May 13.

17. Cypselus melba, (Linn.).

1. Murghab, Herat.

Wing 8·5 inches, tail 3·35.

18 Upupa epops, Linn.

1. Maimanah Chul, March 6.

19. Lanius phœnicuroides, Severt.

1.	Maruchak, Badghis, Herat,	March 20.		
2.	Khwaja Gogirdak, Murghab,	ditto,	March	27.
3, 4,	Darband-i-Kil Rekhta ditto	ditto,	May	18.
5.	Maruchak, Badghis,	ditto,	May	18.

All these specimens fall under section B of the rufous-tailed shrikes as characterised by me in the Ibis, 1881, p 433. Nos. 3 and 4 are in full adult plumage, having the head very rufous, the bill, the whole lores, and the post-ocular stripe black, and the lower surface of the body white. Nos. 1, 2 and 5 are in immature plumage with bars on the breast, but the head is distinctly darker than the back. In all, the second primary is either intermediate in length to the fifth and sixth, or equals the sixth. In all stages this species seems to me readily distinguishable from *L. isabellinus*, Hempr. and Ehr.

20. Erythrosterna parva, (Bechst.).

1. ♀ Chahar Shamba, Maimanah, April 29.

21. Pratincola caprata, (Linn.).

1.	♂	Maruchak,	Badghis, Herat,	March	19.
2.	♂	Karawal Khana	ditto ditto,	April	9.
3.	♂	Ditto	ditto ditto,	April	19.
4.	♀	Kila Wali,	Murghab ditto,	May	13.

22. Pratincola maura, (Pallas).

1, 2,	Kara Baba, Maimanah,		March	6.
3.	Maruchak, Badghis,	Herat,	March	18.
4.	Ditto ditto	ditto,	March	24.
5.	Khwajeh Gogirdak, Murghab,	ditto,	March	27.
6.	Karawal Khana, Badghis,	ditto,	April	9.

23. Sylvia affinis, Blyth.

1.	Chahar Shamba,	Maimanah,	April	28.
2.	Ditto	ditto,	May	1.

24. Sylvia minuscula, Hume.

1. Maruchak, Badghis, Herat, March 13.

25. Sylvia mystacea, Ménétr.

1. Kila Wali, Murghab, Herat, April 22.
2. Jalaiar, Maimanah, June 2.

This is the species well described and figured by Blanford in his 'Zoology of Eastern Persia' under the name of *Sylvia rubescens.* Its occurrence in the localities above cited is of much interest, as the distribution of the species is thereby considerably extended to both north and east of its previously known range.

26. Sylvia familiaris, Ménétr.

1. Kila Wali, Murghab, Herat, April 22.
2. Darband-i-Kil Rekhta, ditto ditto, May 18.

27. Hypolais pallida, (Hemp and Ehr.).

1. Jalaiar, Maimanah, June 2.
2. Ditto.

28. Hypolais rama, (Sykes.).

1. Kila Wali, Murghab, Herat, April 22.
2. Ditto ditto, May 13.
3. Darband-i-Kil Rekhta, ditto ditto, May 18.

29. Acrocephalus stentoreus, (Hempr. and Ehr.).

1. 2. Kila Wali, Murghab, Herat, May 15.

30. Cettia cetti, (Marm.).

1. Chahar Shamba, Maimanah, February 20.
2. Ditto ditto, February 22.

31. Merula vulgaris, Selby.

1. ♂ Chahar Shamba, Maimanah, February 2.
2. ♀ Ditto ditto, February 12.

These examples belong to subspecies *M. maxima*, the male having the wing 5·6 inches and the female, 5·25.

32. Merula atrigularis, (Temm.).

1. Chahar Shamba, Maimanah, January 25.
2, 3. Ditto ditto, January 28.
4. Ditto ditto, February 22.
5. Ditto ditto, April 4.

2 and 3 have the lores, chin, throat, and breast quite black.

33. Cyanecula suecica, (Linn.).

1.	Maruchak,	Badghis, Herat,	March	18.
2.	Karawal Khana,	ditto ditto,	March	24.
3.	Ditto	ditto ditto,	April	9.
4.	Yedikul, Maimanah,		May	31.

34. Monticola cyanus, (Linn.).

1.	Darband-i-Kil Rekhta, Murghab Herat,	May	18.
2.	Shadian, Afghan Turkistan,	July	12.
3.	Ditto ditto,	Sept.	1.

Nos. 2 and 3 are in immature plumage.

35. Ruticilla rufiventris, (Vieill.).

1. Deh Tang, Ghorband, Kabul, October 8.

In female plumage.

36. Ruticilla erythronota, (Eversm.).

1.	Chahar Shamba, Maimanah,	March	3.
2.	Andkhui,	Maroh	20.

37. Saxicola morio, Hemp. and Ehr.

1.	Maruchak,	Badghis, Herat,	March	18.
2.	Karawal Khana,	ditto ditto,	April	9.
3.	Shadian,	Afghan Turkistan,	July	9.

No. 3 is a nestling.

38. Saxicola opistholeuca, Strickland.

1. Maruchak, Badghis. Herat, March 20.

39. Saxicola deserti, Temm..

1. Maruchak, Murghat, Herat, March 19.

An adult male, wing 3·55 inches, black on lateral rectrices 1·7; white edge on inner web of primaries not extending to shaft of feathers. Second primary intermediate in length to fifth and sixth.

40. Saxicola finschii, Hengl.

1. Kara Bala, Maimanah, March 14.

41. Saxicola isabellina, Rüpp.

1.	Chahar Shamba, Maimanah,	April	4.
2,	... ditto,	April	17.
3.	Khwaja Gogirdak,		

The black on the lateral tail feathers measures 0·95 inch.

42. Cinclus asiaticus, Bechst.

1. Iskar, Afghan Turkistan, Oct. 5.
2 & 3 Deh Tang, Ghorband, Kabul, Oct. 8.

No. 1 is a grey, spotted, young bird.

43. Hirundo rustica, Linn.

1. 2, Karawal Khana, Badghis, Herat, April 12.

44. Cotyle riparia, (Linn.).

1. Karawal Khana, Badghis, Herat, April 14.

45. Cotyle rupestris, (Scop.).

1. Darband-i-Kil Rekhta, Murghab, Herat, May 18.

46. Troglodytes parvulus, Koch.

1. Chahar Shamba, Maimanah, January 26.
2. Ditto ditto, January 28.
3. Ditto ditto, February 1.

Rather deeply coloured wrens, reddish brown above, the throat grey, and the general barring not so prominent as in *T. nipalensis.*

47. Sitta syriaca, Ehr.

1. 2. Darband-i-Kil Rekhta, Murghab, Herat, May 18.

The wings measure 3·45 and 3·4 inches, tail 2·15, tarsus 1 and culmen 1 and 1·02.

48. Motacilla alba, Linn.

1. Maruchak, Badghis, Herat, December 15.
2. Chahar Shamba, Maimanah, March 3.
3. Ditto ditto, April 4.

49. Motacilla melanope, Pall.

1. Chahar Shamba, Maimanah, April 28.

50. Budytes melanocephala, (Licht.).

1. ♂ Khwaja Gogirdak, Murghab, Herat, Mar. 27.

This example is in full spring plumage.

51. Budytes citreola, (Pall.).

1, 2, Chahar Shamba, Maimanah, April 28.

52. Anthus blakistoni, Swinhoe.

1. Chahar Shamba, Maimanah, February 3.
2. Ditto ditto, February 7.
3. Ditto ditto, February 8.
4, 5. Ditto ditto, Februarry 22.

53. Anthus rosaceus, Hodgs.

1. Maruchak, Badghis, Herat, March 10.

In winter plumage.

54. Alauda guttata, Brooks.

1. Kila Wali, Murghab, Herat.

Wing 3·6 inches, culmen 0·65, hind claw 0·5. Tertials 0·6 short of longest primary, breast finely streaked.

55. Alauda cristata, Linn.

1. Chahar Shamba, Maimanah, January 4.
2. Ditto ditto, January 26.

The wings measure 4·5 and 4·0 inches, culmen 0·85 and 0·75.

56. Calandrella brachydactyla, (Leisl.).

1, 2 Maruchak, Badghis, Herat, March 17.
3. Khwajah Gogirdak, Murghab, ditto, March 27.

57. Melanocorypha bimaculata, (Ménétr.).

1. 2, 3. Hauz-i-Khan, Murghab, Herat, Dec. 12.

58. Carduelis caniceps, (Vig.).

1. Andkhui, March

59. Erythrospiza obsoleta, (Licht.).

1, 2, Khwajah Gogirdak, Murghab, Herat, March 27.

Both examples have the bill black.

60. Passer montanus, Linn.

Chahar Shamba, Maimanah, January 29.

61. Passer indicus, Jard and Selby.

1, 2, 3, 4. ♂ Karawal Khana. Murghab, Herat, April 15.

62. PASSER HISPANIOLENSIS, Temm.

1.	Kara Bel, Maimanah,	March 10.
2.	Yulla Chashma, Murghab, Herat,	March 10.
3, 4,	Khwajah Gogirdak, ditto, ditto,	March 27.
5. 6,	Karawal Khana, ditto, ditto,	April 12.

No. 5 is a young bird.

63. EMBERIZA PYRRHULOIDES, Pall.

1.	♂		Maimanah.	
2.	♀	Chahar Shamba,	ditto,	February 1.

64. EMBERIZA SCHÆNICLUS, Linn.

1.	♀	Chahar Shamba,	Maimanah,	Feb. 20.
2, 3,	♂	Ditto	ditto,	March 3.
4,	♀	Kara Bel,	ditto,	March 10.
5,	♀	Gulla Chashma,	Murghab (Herat)	March 10.

65. EMBERIZA FUCATA, Pall.

1. Shadian, Afghan Turkistan, July 17.

In immature plumage with dark rufous patches appearing on breast. The feet are very pale and the claws pale horny.

66. EUSPIZA LUTEOLA, (Sparrm.).

1, 2,	♂	Chahar Shamba,	Maimanah,	April 28.
3,	♀	Ditto	ditto,	April 30.
4.	♀	Kila Wali, Murghab,	Herat,	May 12.
5.	♂ juv.	ditto	ditto,	May 13.

67. CORVUS FRUGILEGUS, Linn.

1.	Maruchak,	Murghab, Herat,	March 19.
2.	Ditto	ditto,	March 23.

68. CORVUS MONEDULA, Linn.

1.	Maruchak,	Murghab, Herat,	March 18.
2.	Ditto	ditto,	March 21.
3.	Karawal Khana,	ditto,	April 15.
4.	Maruchak,	ditto,	Dec. 25.

69. PICA RUSTICA, (Scop.).

1.	Chahar Shamba,	Maimanah,	February 3.
2.	Ditto	ditto,	February 7.

70. STURNUS VULGARIS, (Linn.).

1. Chahar Shamba, February 11.

71. Sturnus poltaratskyi, Finsch.

1, 2 Chahar Shamba, Maimanah, February 11.
3. Ditto ditto, February 14.

72. Pastor roseus, (Linn.).

1, 2, Karawal Khana, Badghis, Herat, April 14.

73. Columba intermedia, Strickland.

1. Chahar Shamba, Maimanah, February 22.

74. Columba eversmanni, Bonap.

1. Min Darakht, Maimanah, June 1.

75. Turtur auritus, Gray.

1. Chilik, Afghan Turkistan, July 2.

76. Pterocles alchata, (Linn.).

1. 2 ♂ Kham-i-ab, Afghan Turkistan, June 18.
3. ♀ „ ditto

77. Phasianus principalis, Sclater.

1.	♂	Chahar Shamba, Maimanah,		Feb. 10.
2.	♂	Maruchak, Murghab, Herat,		March 10.
3.	♂	Ditto	ditto,	March 20.
4.	♀	Ditto	ditto,	March 26.
5.	♀	Ditto	ditto,	Dec. 25.

This fine pheasant has lately been described as new, from specimens obtained in the basin of the Murghab river by officers of the Afghan Boundary Commission. It is very like *Phasianus shawi* of Eastern Turkistan, but is fairly distinguishable from it by apparently constant characters. I have examined some half dozen males of this pheasant, and I note that the variation between individuals is very small; one, however (No 1) above has a distinct wash of green on the rump and upper tail coverts, and a small snow white spot on one side of the hind-neck, marking the position of a demi-collar. On the characters and distribution of *P. principalis*, *P. shawi*, and other allies of *P. colchicus*, Mr. Seebohm's interesting paper in the Ibis for April 1887, p. 168 may be consulted.

78. Tetraogallus himalayensis (Gray).

1. Dhap Darah, Hindu Kush, Turkistan, Oct. 7.

79. Cotunix communis, Bonn.

1. ♂ Chahar Shamba, Maimanah, April 4.
2. ♀ Karawal Khana, Murghab Herat, April 19.
3. ♂ Chahar Shamba, Maimanah, May 6.

80. Ægialites curonica, Gmel.

1, 2, Karawal Khana, Murghab, Herat, April 10.

81. Chettusia villotæi, (Audouin).

1, 2, Kham-i-ab, Oxus, Afghan Turkistan, June 12.

82. Vanellus cristatus, Meyer.

1. Chahar Shamba, Maimanah, Feb. 11.

83. Scolopax rusticula, (Linn.).

1. Chahar Shamba, Maimanah, Feb. 3.

84. Gallinago solitaria, Hodgs.

1. Deh Tang, Ghorband, Kabul, October 8.

85. Gallinago scolopacinus, Bonap.

1. Chahar Shamba, Maimanah, February 5.

86. Machetes pugnax, (Linn.).

1. ♂ Chahar Shamba, Maimanah, February 19.
2. ☿ Ditto ditto April 4.

87. Totanus ochropus, (Linn.).

1. Karawal Khana, Murghab, Herat, April 14.

88. Tringoides hypoleucus, (Linn.).

1. Darband-i-Kel Rekhta, Murghab, Herat, May 18.
2. Maruchak ditto ditto, May 22.

89. Himantopus candidus, Bonn.

1. Oxus, Afghan Turkistan
2. Kham-i-ab, ditto ditto, June 12.

90. Otis tetrax, Linn.

1. Maruchak, Murghab, Herat, March 12.
2. Chaman-i-Bed, Badghis, ditto Dec.

91. Rallus aquaticus, Linn.

1. Maruchak, Murghab, Herat, Dec. 23.

92. Porzana maruetta, Leach.

1. Karawal Khana, Murghab, Herat, April 9.
2. Chahar Shamba, Maimanah, April 30.

93. Porzana bailloni, (Vieill.).

1, 2 Kila Wali, Murghab, Herat, April 24.

94. Crex pratensis, Bechst.

1. Maruchak, Murghab, Herat, May 7.

95. Fulica atra, Linn.

1. Andkhui, March

96. Larus ridibundus, Linn.

1. Maruchak, Murghab, Herat, March 18.

97. Sterna anglica, Mont.

1. Oxus, Afghan Turkistan.
2. Kham-i-ab, Oxus, Afghan Turkistan, June 12.

98. Sterna minuta, Linn.

1. Kham-i-ab, Afghan Turkistan, June 12.

99. Phalacrocorax carbo, (Linn.).

1. ♂ Maruchak, Badghis, Herat, March 19.

A fine example in full breeding plumage.

100. Anas strepera, Linn.

1. Karawal Khana, Murghab, Herat, April 16.

101. Anas angustirostris Ménétr.

1. Kham-i-ab, Oxus, Afghan Turkistan, June 12.

102. Anas creeca, Linn.

1. ♂ Chahar Shamba, Maimanah, Jan. 25.
2. ♀

103. Anas penelope, Linn.

1. ♂ Maruchak, Murghab, Herat, March 15.

104. Fuligula cristata, (Linn.).

1. Chahar Shamba, Maimanah, Feb. 20.

105. Fuligula nyroca, (Güld.).

1. ♂ 2 ♀	Kila Wali, Murghab, Herat,	March	5.
3. ♂	Maruchak, Badghis, ditto,	March	16.

106. Clangula glaucion, (Linn.).

1. ♀	Chahar Shamba, Maimanah	Feb.	12.
2.	Maruchak, Murghab, Herat,	March	15.
3. ♂	Ditto ditto,	March	20.

107. Erismatura leucocephala, Scop.

1. Maruchak, Afghan Turkistan, March 21.

108. Mergus albellus, (Linn.).

1. ♂	Adult, Maimanah,	Feb.	10.
2. ♂	jno. Chahar Shamba, Maimanah,	Feb.	12.
3. ♀	Ditto ditto,	Feb.	17.

No. 1 is in fine black and white plumage.

109. Tadorna vulpanser, Flem.

1. Oxus, Afghan Turkistan, Feb.

110. Casarca rutila, Pall.

1. Karawal Khana, Murghab, Herat, April 10.

VII.—*On the Species of* Loranthus *indigenous to Perak.—By* George King, M. B., LL. D., F. L. S., *Superintendent of the Royal Botanic Garden, Calcutta.*

[Received 29th March 1887;—Read 4th May 1887.]

Prior to the date of the punitive expedition which was despatched to Perak some years ago, that province was practically an unknown country. One of the results of the expedition just mentioned was the location in the state of a British Resident. And as the office of Resident has, fortunately for the interests of science and civilization, been held, almost from its first institution, by Sir Hugh Low, we are now in possession of the materials for obtaining some knowledge of its natural history. During the past few years considerable botanical collections have been accumulated by the Rev. Father Scortechini (now, alas! no more) who collected on behalf of the Perak Government, and by Mr. H. H. Kunstler, who collected for the Calcutta Botanic Garden. From the materials brought together by these gentlemen and which have come into my hands, I propose to draw up, as time permits, lists of species already described, together with descriptions of any which appear to be new. And I now begin the series by an enumeration of the species of *Loranthus* indigenous to the province.

The list which follows contains in all twenty-five species, of which eleven are described for the first time. At the end of the list I have appended descriptions of two new Sumatran species collected by Mr. H. O. Forbes. The genus being rather large and polymorphic, it has been divided into sections. In the following enumeration, I follow the sectional divisions adopted, in their *Genera Plantarum*, by Sir J. D. Hooker and and the late Mr. Bentham.

Section I. Euloranthus.

1. *L. Lobbii,* Hook. fil. Flora Brit. India, V, 204.

The commonest species in the province; growing on trees of various species, at elevations of from 500 to 4000 feet; found also in Penang and apparently also in Borneo. This species approaches very closely the Sumatran species *L. axanthus,* Korth.

Section II. Phœnicanthemum.

2. *L. pulcher,* DC. Prod. IV, 295; Hook. fil. Fl. Brit. Ind. V, 205; *L. speciosus,* Wall. Cat. 518; *L. coccineus,* Hook. Bot. Misc. t. 58; *Dendrophthoe pulcher,* Miq. Fl. Ind. Bat. I, pt. 1, 821.

Common; but scarcely ascending so high as the last. This varies greatly as to the breadth of its leaves which in some plants is as much as 3 inches, while in others it is barely 1 inch. Found also in Penang, and represented in Tenasserim by the closely allied species *L. Parishii,* Hook. fil., and in Java by *L. Lyndenianus,* Zoll.

3. *L. pentapetalus,* Roxb. Fl. Ind. I, 553, Ed. Carey and Wallich, II, 290.; Hook. fil. Fl. Brit. Ind. V. 206; DC. Prod. IV, 295; Wall. Pl. As. Rar. iii, t. 225, and Cat. 503; Kurz For. Flora Burmah, ii, 322; Griff. Notulae, IV, 617, and Ic. Pl. Asiat. t. 624, 625; Korth. Verhand, Loranth. 66; Blume Fl. Javae Loranth. 39, t. 14 and 23 A.; *Phœn. pentapetalum,* Miq. Fl. Ind. Bat. I, Pt. 1, p. 823: *Dendrophthoe pentapetala,* G. Don. Syst. iii, 419.

This is not very common in the province. It is a widely distributed species, being found in India from Nepal, along the outer and lower Himalaya, to Sikkim; thence through Assam, the Khasia Hills, Chittagong, to Burmah: it extends also to the Andamans, Penang, Malacca, Banka, Java, Sumatra, Borneo, and probably to other islands of the Malayan Archipelago. Sir J. D. Hooker reduces to this species L *polycarpus,* Wall. Cat. 540, and L. *erythrostachys,* Wall. MSS.

4. *L. coccineus*, Jack in Mal. Misc. I, 8; Hook. Bot. Misc. i, 278; Hook. fil. Fl. Brit. Ind. V, 206; Roxb. Fl. Ind. Ed. Carey and Wall. ii, 215; DC. Prod. IV, 296; Korth. Verhand. Loranth. 68; Griff. Notul. IV, 620, and Ic. Pl. Asiat. t. 626. *L. racemiferus*, Wall. Cat. 539; *Phœnicanthemum coccineum* and *Bennetianum*, Miq. Fl. Ind. Bat. I, pt. 1. 825, 826; *Dendrophthoe coccinea*, G. Don. Syst. iii, 419.

At low elevations: not common in the province: is found also in Pegu, Tavoy, Malacca, Singapore, and Penang, and extends to India (Cachar) and to some of the islands of the Malayan Archipelago.

Section III. Heteranthus.

5. *L. heteranthus*, Wall. Cat. 537; Hook. fil. Fl. Brit. Ind. V, 208; DC. Prod. V. 306; *L. eleutheropetalus*, Kurz in Journ. As. Soc. Beng. 1871, ii, 64, and For. Flora Burmah, ii, 321; *Dendrophthoe macrocalyx*, Miq. Fl. Ind. Bat. I. Pt. 1, 821.

Found in this province only in Laroot. This species extends as far northwards as Chittagong, where it was once collected by Mr. Lister. Wallich and Brandis found it in Burmah. Southward it extends to Java and Borneo.

6. *L. crassipetalus*, nov. spec. Glabrous in all its parts, except the bracteoles and calyx-tube which are puberulous; branchlets thick, striate, polished, the bark dark coloured; leaves coriaceous, rigid, petiolate, scattered, broadly ovate-oblong, rarely ovate-elliptic; apex obtuse; base attenuate; shining on the upper, dull on the lower, surface; nerves invisible when fresh, obscure when dry, midrib slightly prominent: length of blade 1·5 to 2 in. (in the ovate-elliptic leaves as much as 2·5 in.); breadth about 1 inch, rarely 1·5 in.; petiole ·25 in. long, stout; racemes longer than the leaves, stout, rigid, erect, axillary, sparsely many-flowered; pedicel thick, ·15 in. long, bearing at its apex a single broad, cochleate, bract, bracteole 0; calyx-tube cylindric, the limb wide-spreading, truncate, cup-shaped; corolla straight, narrowly conical, petals, 5, thick, distinct to their bases, smooth and yellowish externally, ridged and of a bright red internally, ·75 in. long; anthers linear, half as long as the petals, basifixed: style filiform, stigma minute.

Perak, on Gunong Idjou. Scortechini, Nos. 363 and 521.

7. *L. productus*, nov. spec. Quite glabrous; branches long, straight, strongly 4-angled, slightly flattened especially at the nodes, the bark polished and dark in colour; leaves coriaceous, petiolate, opposite, elliptic-lanceolate or ovate-oblong, gradually narrowed to the sub-acute or obtuse apex, narrowed rather suddenly to the petiole at the base; nerves obscure even when dry, midrib slightly prominent; length of blade 3·5 in. to 5 in.; breadth 1·5 in. to nearly 2 in.; petiole about ·5 in.

long; flowers crowded in small, sessile, axillary clusters; bract 0; bracteoles cohering into a short, cylindric, obscurely 2 to 4-crenate tube which, in the unfertilised flower, envelopes the whole of the calyx except its limb; calyx-tube shorter than the cylindric, truncate limb; petals 4, distinct, fleshy, linear, ·35 in. long, reflexed from about the middle; anthers linear, basifixed, nearly as long as the filaments, curved when mature; style shorter than the petals; stigma small, truncate; fruit ·3 in. in diameter, globular, smooth, crowned by the rather long cylindric calyx-limb and enveloped at its base by the persistent bracteolar cup.

Perak, at elevations of from 3000 to 3600 feet; Scortechini, Nos. 391 and 581; Kunstler (King's collector) No. 3240.

A remarkable species; with long, slender, polished branches which are almost black when dry. From the flower-bearing axils there often arise short, leaf-and-flower-bearing branches; and as the leaves on these (in herbarium specimens) usually fall off, they assume the appearance of long-peduncled cymes. This is clearly a *Heteranthus;* but it does not quite conform to the definition of that section given by Mr. Bentham and Sir J. D. Hooker in their *Gen. Plantar.* (iii, 208), inasmuch as there is no bract present, and there are bracteoles which form a cup almost entirely enveloping the calyx in the flower, and persisting even in the ripe fruit.

I have named this species from the length of its branches.

Section IV. Ciclanthus.

8. *L. scurrula*, Linn. var. obtecta, Kurz For. Fl. Burm. ii, 319; Hook. fil. Fl. Brit. Ind. V, 209: *L. obtectus*, Wall. Cat. 534: *L. concavifolius*, Griff. Notul. IV, 615.

Very common at low elevations; Scortechini, Nos. 311*b*, 421*b*.

The typical form of this species occurs throughout the whole of British India; its other varieties, as defined in the Flora of British India, *viz.*, *bengalensis*, *laevigata*, and *graciliflora* having each a more circumscribed distribution.

9. *L. ferrugineus*, Roxb. Fl. Ind. I, 551, ii, 188; DC. Prod. IV, 299; Wall. Cat. 500; Hook. fil. Fl. Brit. Ind. V. 210; Jack in Mal. Misc. i, 9, and in Hook. Bot. Misc. i, 279, t. 59; *Dendrophthoe ferruginea*, G. Don Gen. Syst. iii, 420; Miq. Fl. Ind. Bat. I, Pt. 1, 812.

Not uncommon at low elevations; Scotechini, Nos. 630*b*, 2099.

Very common in Malacca, Singapore, and Penang: found also by Kurz in lower Burmah. Distributed also in Sumatra and Java. A specimen in the Calcutta Herbarium and named by him *L. Oortianus* Korth. is the same as this: and, if Junghuhn's identification is correct, Korthal's name, as being the older, must supplant Roxburgh's. *Dendrophthoe ignea*, Scheff. from Banka, according to the specimen in the Calcutta collection, is also the same as this. *L. Schultesii*, Bl., (Fl. Jav. Loranth, t. 2) appears to me referable to *L. scurrula*, Linn. rather than to this.

10. *L. Malaccensis*, Hook. fil. Fl. Brit. India, V, 210.

On high trees, at elevations of from 3000 to 4000 feet. King's Collector (Kunstler) No. 6286: found also at Malacca by Griffith.

Section V. Dendrophthoe.

11. *L. grandifrons*, nov. spec. Young branches rather thin, terete, little swollen at the nodes, the bark dark-coloured, lenticillate: leaves sub-opposite or alternate, rarely exactly opposite, coriaceous, petiolate, broadly ovate or ovate-oblong, the apex sub-acute, the base rounded or emarginate; main nerves 4 to 6 pairs, ascending, prominent (as is the midrib) especially on the lower surface; both surfaces dull, sparsely pulverulent; length of blade 5 to 8 inches, breadth 3 in. to 4·5 in.; petiole ·6 in. to 1 inch: the whole inflorescence covered with minute pulverulent, sub-deciduous, tomentum; racemes solitary, axillary, or from the older leafless branches, woody, erect, or slightly curved, 2·5 in. long, about 30-flowered, pedicels short; bract* small, thick, clawed; calyx-tube cylindric, inflated at the base, the limb much longer than the short, sub-globose, ovary, 5 or 6 toothed; corolla-tube 3 inches long, cylindrical, 5 or 6-striate, slightly inflated towards the limb; lobes of limb ·5 in. long, reflexed, linear; anthers basifixed, linear, about half as long as the lobes; style filiform, a little longer than the stamens; stigma small, sub-globose.

In the low country, not very common. *Scortechini*, No. 926; Kunstler, Nos. 786 and 2067. Found also in the Lampongs, in Sumatra, on trees by the edge of heavy forest. H. O. Forbes, No. 1665.

When young the whole exterior of the corolla is tomentose like the calyx, but when fully expanded it occasionally becomes sub-glabrous. The base of the corolla is whitish; the upper part pink. In advanced bud some of the corollas are constricted at the apex and inflated towards the middle; but when fully expanded the corolla is tubular, gradually widening towards the mouth. This fine species comes near *pentandrus* as to technical characters: but in general appearance it somewhat resembles *L. longiflorus*, Desr. It is, however, well distinct from the latter by its differently shaped, more distinctly nerved leaves; and by its more erect, rigid, and scurfy inflorescence.

12. *L. pentandrus*, Linn. Mant. 63; Bl. Bijdr. 661; Hook. fil. Fl. Brit. Ind. V, 216; DC. Prod. IV, 305; Kurz For. Fl. Burmah, II, 320;

Wall. Cat. 514 : Korth. Verhand. Loranth. 80 ; Blume Fl. Javae, Loranth. 33, t. 10 : *L. farinosus*, Desr. in Lamk. Encycl. iii, 597 ; Roxb. Fl. Ind. Ed. Carey and Wall. ii, 221 ; Griff. Notul. IV, 616, and Ic. Pl. Asiat. t. 620, f. 1, 2 ; *Dendrophthoe pentandra* and *farinosa*, Miq. Fl. Ind. Bat. I ; pt. 1, 818, 819 ; *Elytranthe farinosa*, G. Don. Gen. Syst. IV, 427.

Very common in all parts of the province at low elevations (Kunstler, Nos. 4931, 7538, 7767 ; Scortechini, No. 605) ; distributed northwards through Burmah and Chittagong as far as Sylhet, and southwards in the Malayan Peninsula and Archipelago generally. Sir J. D. Hooker reduces to this species *L. rigidus*, *contractus*, and *Finlaysonianus*, Wall. Cat. Nos. 531, 6864, and 6871.

13. *L. Scortechinii*, nov. spec. Glabrous, the young branches thick, terete, scarcely swollen at the nodes, the bark reddish ; leaves coriaceous, petiolate, in verticels of about 6, oblong-lanceolate or oblong-elliptic, the apex shortly caudate-acuminate, the base attenuate ; midrib prominent on both surfaces, nerves invisible in fresh, obscure in dry, specimens, about 15 pairs, sub-horizontal ; length of blade 7 to 8 inches ; breadth 2·25 to nearly 3 inches ; petioles stout, 1·25 in. ; racemes with a thick, pitted, woody axis little more than 1·5 in. long, axillary ; flowers numerous, crowded ; bract minute, cochleate, clawed ; calyx tube cylindric, the limb irregularly dentate ; corolla curved, tubular, slightly expanded upwards and 6-angled near its junction with the 6-cleft limb ; lobes of limb linear, slightly expanded at the base, about a fifth of the length of the tube ; anthers linear, obtuse, about half as long as the lobes ; style as long as the stamens ; stigma globose, small ; corolla tube 4 in. long, limb 1 inch.

At elevations under 1000 feet, not common : Sortechini, No. 90*b* ; Kunstler (King's collector), No. 6020.

This is a fine species, and is distinguished amongst Asiatic Dendropthoes by its large, verticillate leaves. The corolla is of a pale yellow, the lobes of the limb being tinged with green : the stigma is red.

14. *L. Duthieanus*, nov. spec. Young shoots terete, not swollen at the nodes, bark pale pinkish, sparsely lenticellate ; axis of inflorescence and bracts minutely pubescent ; other parts quite glabrous ; leaves coriaceous, alternate opposite or in verticels of 3, petiolate, oblong-elliptic or elliptic-lanceolate with sub-acute apex and attenuate base, midrib and nerves invisible in the fresh, slightly visible in dry, specimens ; length of blade 2·5 to 3 inches, breadth ·75 in. to 1 in., petiole ·4 in. long ; racemes slender, axillary, shortly pedunculate, about 6-flowered ; bract small, cochleate, clawed ; bracteoles 0 ; calyx-tube cylindric, the limb, short, truncate, waved ; corolla tubular, bright red in colour, curved, inflated upwards, constricted at the base and at the apex when in

bud, 6-striate, limb about one third of the length of the tube; the lobes 6, linear, sub-spathulate, thickened at the tips, reflexed; anther linear, about half as long as the lobes, basifixed; style filiform, as long as the stamens; stigma small, globular.

Collected only once by the late Father Scortechini, the exact locality being unknown.

A species allied to *curvatus*, Bl., but with a hexamerous, glabrous corolla, which is moreover wider and of a different colour from that of *curvatus;* also with narrower and more irregularly disposed leaves than in that species. Named after Mr. J. F. Duthie, Superintendent of the Botanic Garden, Saharunpore.

Section VI. Loxanthera.

15. *L. speciosus*, Bl. Fl. Jav. Loranth. 15, t. 20, and 23 fig. C. Miq. Fl. Ind. Bat. I, Pt. 822.; *L. coccineus*, Reinw. MSS. (not of Jack) Bl. Bijdr. 664; *L. Reinwardtianus*, Schult. Syst. DC. Prod. IV, 706: *L. loxantherus*, DC. l. c. p. 316.

Apparently not common in the Province; Scortechini, No. 1328; on the banks of the Kinta river (Kunstler, No. 767.) There is a single specimen in the Calcutta Herbarium from Malacca. The species is found in Sumatra (Forbes No. 3234*a*) and in Java.

Section VII. Macrosolen.

a. *longiflorae.*

16. *L. formosus*, Bl. Bijdr. 664 and Fl. Jav. Loranth. t. 15; DC. Prod. IV, 297; Kurz For. Flora Burmah ii, 317; Hook. fil. Fl. Brit. Ind. V, 220; *Macrosolen formosus*, Miq. Fl. Ind. Bat. I, Pt. 1, 827; *Elytranthe formosa*, G. Don Gen. Syst. iii, 426.

At elevations of from 3000 to 4000 feet, Kunstler, Nos. 2170 and 6264: found also in Java, and, according to a single leaf specimen in the Calcutta Herbarium (Griffith, No. 2729), also in Burmah.

17. *L. Kunstleri*, nov. spec. Quite glabrous; young branches stout, terete, the bark pale; leaves coriaceous, sub-sessile, opposite, ovate-oblong, gradually narrowed to the sub-acuminate apex, the base rounded, not cordate; midrib and nerves prominent on both surfaces (when dry) but especially on the lower; primary lateral nerves about 6 pairs, secondary about 8 pairs; length of blade 8 to 10 inches, breadth 3 in. to 4·5 in.; petiole very stout, about ·15 in. long; racemes very short, from the axils of the leaves and also from the old wood; bracteoles 3, minute, broad, united by their bases; calyx-tube cylindric, smooth, the limb truncate, slightly wavy; corolla clavate and boldly 6-angled in bud,

slightly curved, tubular, inflated at the base of the limb, lobes of the limb 6, reflexed, sub-spathulate, keeled externally, the tips thickened ; anthers half as long as the lobes, linear, basifixed, with a slight process at the union with the filament ; style filiform, as long as the stamens ; stigma truncate ; berry ·5 in. long, ovoid, bright yellow at first, black when ripe ; length of corolla-tube 2·5 in., of limb ·6 in.

At elevations under 500 feet, H. H. Kunstler (King's collector), Nos. 2669, 2760, 6009, 8460.

This comes near *L. formosus*, Bl., but has much larger leaves, which have rounded (not acute) bases as in that species. The corolla also differs. Mr. Kunstler describes this as a very handsome species, the tube of the corolla being of a rich yellow, the limb bright green externally and dark red inside. It is a large species, plants of it often reaching 8 to 10 feet in length.

18. *L. dianthus*, King and Scort. MSS. Quite glabrous, the young shoots terete, thin, scarcely swollen at the nodes, the bark pale ; leaves thinly coriaceous, entire, shortly petiolate, opposite, exactly lanceolate rarely ovate-lanceolate, the apex acuminate ; midrib and primary nerves slightly visible when fresh, rather distinct when dry ; length of blade 3 in. to 5 in., breadth ·75 in. to 2·5 in. ; petioles slender, ·2 in. long ; cymes axillary, sessile, 2-flowered ; bracts at base of cyme 2, decussate, ovate-acute ; bracteoles of the individual flowers united into a short, thick annulus which surrounds the base of the flower ; calyx-tube smooth, cylindric, the limb short, truncate ; corolla narrowly tubular, inflated and boldly 6-angled just under the limb, clavate in bud ; limb with 6 twisted, reflexed, oblanceolate or sub-spathulate lobes which are keeled and inflated at the base ; anthers basifixed, linear, one-third of the length of the lobes of the limb ; style filiform, as long as the stamens ; stigma small, capitate : fruit globular, smooth, ·5 in. in diam., crowned by the calyx-limb ; length of corolla tube 2·5 in. ; of limb ·75 in.

At elevations under 500 feet ; Scortechini, Nos. 76 and 604*a* ; King's Collector, Nos. 1870, 6446.

This species comes near *formosus*, Bl., from which the sessile, 2-flowered cymes, single, decussate pair of bracts, the annulus formed of the united bracteoles, and the globular berry are the best characters to distinguish it. This also must be near *L. meluitangensis*, Korth., of which I have seen no specimen. The tube of the corolla of this species is described as scarlet, and the lobes of the limb as green, with purple edges and a pale line along the anterior surface. The late Father Scortechini left a drawing of this species, to which I have added the details. He left no MSS. name for the species, but, from a note on the drawing, he appears to have considered it to be *L. formosus*, Bl. or near it.

19. *L. evenius*, Bl. Fl. Javae Loranth. t. 16; *L. avenis*, Bl. Bijdr. 663.; Korthals Verhand. Loranth. 85; DC. Prod. IV, 397; *Elytranthe avenis*, G. Don. Syst. iii, 426.

Found only once in Perak by Father Scortechini: extends also to Sumatra.

20. *L. platyphyllus*, nov. spec. Quite glabrous. Young branches 4-angled; leaves opposite or sub-opposite, thinly coriaceous, subsessile, broadly ovate-rotund or sub-orbicular, edges entire or unequally and remotely crenate, the apex obtuse, the base cordate; primary lateral nerves about 4 pairs, curving, somewhat distinct on both surfaces, the midrib rather prominent; length and breadth of blade about 4·5 in.; petiole less than ·15 in. long, stout; racemes very short, axillary, about 4-flowered; bract single, bracteoles minute, coalescing into a sinuate-edged cup less than a quarter of the length of the cylindrical, truncate, calyx-tube; corolla large, curved, tubular, expanding slightly upwards, 6-angled and inflated below the apex, clavate when in bud; limb 6-cleft, the lobes spreading, linear-lanceolate or sub-spathulate, blunt and inflexed at the tips, each with 2 ridges on the inner surface, inflated and keeled at the base; filaments adherent to the tube; anthers linear, basifixed; tube of corolla 3·5 in. long; limb ·8 in.; style filiform, as long as the stamens; stigma small, sub-capitate; fruit unknown.

Found only once by Scortechini, who has not noted the exact locality.

A species recognisable at once amongst the Asiatic species of *Macrosolen* by its large sub-sessile, nearly orbicular leaves.

b. *racemulosae.*

21. *L. ampullaceus*, Roxb. Fl. Ind. I, 552, ii, 189, and Ed. Carey and Wall. ii, 209; Hook. fil. Fl. Brit. Ind. V, 220; DC. Prod. IV, 296; Kurz For. Fl. Burm. ii, 316; Wall. Cat. 502. *L. sub-umbellatus*, Bl. Bijdr. 662 and Fl. Jav. Loranth. t. 18; *L. sphaerocarpus*, Bl. Bijdr. 661 and Fl. Jav. Loranth. t. 17; DC. Prod. IV, 297; *Macrosolen pallens*, *sphaerocarpus* and *oleioides*, Miq. Fl. Ind. Bat. i, Pt. 1, 830, 831; *Elytranthe sphæroidea*, Don. Gard. Dict. IV, 127.

On Ulu Bubong, at elevations from 500 to 1000 feet: Kunstler, Nos. 7866 and 10697. This species, as limited by Sir J. D. Hooker in his Flora of British India, is distributed from Bengal, Assam, and the Khasia Hills to Penang, Malacca, and Singapore. I agree with Hooker in considering it as probably a mere form of *L. globosus*, Roxb.; and, if this view be correct, the synonymy of *globosus* should be reduced here. The Wallichian species *pallens* (Cat. 523), *carinulatus* (529), *sub-globusus* (538), *oleifolius*, (524), *viridiflorus*, (512), are all forms of the same widely distributed and therefore variable plant.

22. *L. Lowii*, nov. spec. Glabrous everywhere, except the peduncles, pedicels, and bracteoles, which are puberulous ; young shoots thin, terete, slightly swollen at the nodes, the bark pale brown ; leaves rigid, coriaceous, ovate-lanceolate, or elliptic-lanceolate, gradually tapering to either end, the apex acute or acuminate, the edges recurved when dry ; nerves invisible, midrib visible only on the pale, dull, under surface ; length of blade 1·5 in. to 2 in. ; breadth ·6 in., rarely ·8 inch. ; petiole stout, ·15 in. ; racemes umbellate, in clusters of 1 to 3, in the axils of the leaves, on short pedicels, 2 to 4-flowered ; bract and bracteoles minute, broadly ovate, acute, the latter united by their bases into a 3-toothed cup : calyx tubular, smooth, the limb very short, truncate, waved ; corolla about 1 in. long, the tube slightly curved, 6-angled and slightly inflated at the junction with the limb ; lobes of the limb sub-spathulate, thickened at the apex, reflexed, about a third as long as the tube ; anthers about a third as long as the lobes, linear ; style filiform, nearly as long as the stamens ; stigma small, sub-globular.

Found only once in the province (by Fr. Scortechini) and the exact locality not noted.

A species, in the texture of leaves and in inflorescence, approaching *L. retusus*, Jack ; but very distinct from that and from the other Malayan species of *Macrosolen*. Named in honour of Sir Hugh Low, British Resident in Perak.

Section VIII. Elytranthe.

23. *L. albidus*, Bl. Bijdr. 665, and Fl. Jav. Loranth. (sub *Elytranthe*) t. 22 ; Korth. Verhand. Loranth. 87 ; DC. Prod. IV, 299 ; Hook. fil. Fl. Brit. Ind. V, 222 ; *L. lecucosiphon*, Griff., Notul. IV, 623, and Ic. Pl. Asiat. t. 619-623 : *Elytranthe albida*, Miq. Fl. Ind. Bat. I, Pt. 1, 832.

Not common ; Scortechini, Nos. 428*b* and 626. This extends northwards to lower Burmah, and southwards to Malacca, Java, Sumatra, and Borneo.

Section IX. Lepiostegeres.

24. *L. Beccarii*, nov. species. Glabrous ; the younger branches quadrangular (at least when dry), the older branches terete ; leaves on rather long petioles, opposite or sub-opposite, thinly coriaceous, entire, from ovate-lanceolate or ovate-oblong to sub-orbicular, very variable even on the same plant, the apex sub-acute or obtuse, the base cuneate or rounded, midrib prominent, especially on the under surface ; primary nerves about 6 pairs, slightly visible on the under surface (when dry) ; length of blade 3·5 in. to .5 in., breadth 1·5 in. to nearly 3 in. ; petiole ·75 in. to 1·25 in. long ; capitula from the old wood, 20 to 30-flowered,

sessile, sub-globose when young, afterwards strobiliform and much elongate; the bracts large, numerous, imbricate, coloured, from oblong to semi-orbicular, obtuse, the inner 2 to 3 inches long, the outer gradually shorter, all empty; calyx short, cylindric, truncate; corolla, 3 to 3·5 in. long, the tube splitting into 6, very narrow, linear segments which are united for about ·5 in. at the base, and then again slightly just below the twisted, reflexed, linear, obtuse segments of the limb; anthers linear, pointed, basifixed, ·5 in. long: style filiform; stigma small, rounded, exserted slightly beyond the anthers; fruit sub-angular, globose, ·3 in. in diam.

Rare in the province; occurring at elevations under 2000 feet. Scortechini, 1208; King's Collector, Nos. 5793 and 7956. Found also in Borneo by Sig. Beccari (Herb. Becc. P. B. 1171).

This is the finest of all the Asiatic species of *Loranthus*. The enormous bracts are of a pale red colour; the tube of the corolla is of a deep claret purple, while the reflexed limb is yellow. The whole inflorescence is about 6 inches long and forms a most striking object.

25. *Loranthus Kingii*, Scortechini MSS. Young branches pale, terete, swollen at the nodes, slightly lenticillate when young, otherwise quite smooth; leaves coriaceous, petiolate, opposite, exactly ovate-lanceolate, smooth and with the nerves invisible on both surfaces, the midrib prominent below; length of blade 3 in.; breadth 1·25 in. to 1.5 in.; petiole about ·5 in.; capitula sessile, axillary, strobiliform, 4 to 6-flowered; bracts large, empty, coloured, keeled., in two series, an outer and an inner; the outer of 6 to 7 decussate pairs, the uppermost of which is linear-oblong, obtuse, 1·5 in. long, the lower pairs gradually smaller and more or less acute; the inner series of a single lanceolate pair; bracteoles round each individual flower 4, linear-lanceolate, about ·75 inch long; calyx very short, 6-toothed; corolla narrowly infundibuliform, curved below the middle, 1·75 in. long, split nearly half-way down on one side, and cleft at the apex for about one-fifth of its entire length into 5, lanceolate, acuminate, reflexed teeth; anthers basifixed, linear, subulate, with a slight process at their bases; style filiform, about as long as the stamens; stigma small, sub-capitate: fruit elongated ovoid, crowned by the remains of the calyx-tube.

Perak; Scortechini, No. 1251.

The late lamented Father Scortechini left only a single specimen of this with me. It appears, however, to agree with an imperfect specimen in the Calcutta Herbarium from Malacca (Herb. Maingay No. 695).

* * * * * *

I take the present opportunity of describing two new species collected by Mr. H. O. Forbes in Sumatra—both handsome plants, belonging respec tively to the sections *Loxanthera* and *Lepiostegeres.*

Loranthus (Sect. *Loxanthera*) *Lampongus*, nov. spec. Branches terete, scurfy when young, as are the peduncles, ultimately all parts glabrous: leaves thickly coriaceous, opposite or sub-opposite, entire, petiolate, ovate-oblong to broadly ovate, apex sub-acute, or acute, base rounded, rarely sub-acute, the midrib very prominent and the nerves very indistinct on both surfaces, length of blade 4 to 5 inches: petioles stout, about ·75 in. long; flowers in pairs on crowded short, stout, bifurcate axillary peduncles; calyx tube short, cylindric, the limb truncate, irregularly and obscurely sinuate, sub-crenate; corolla nearly 1·5 in. long, clavate in bud, the cylindrical tube slightly inflated about the middle, cleft at the apex to about one third of its length into 6 linear-lanceolate lobes; stamens 6, the filament arcuate, dilated at the apex, and attached to the back of the linear anther below its middle; style filiform; stigma minute, clavate: bracteole short, broad, minute.

Lampongs, Sumatra: H. O. Forbes, No. 1737.

The curved filaments and dorsifixed anthers put this unmistakeably into the section *Loxanthera*. That section, however, as at present defined, is 5-merous. The definition of it must therefore be altered to 5 or 6-merous.

Loranthus (Sect. Lepiostegeres) *Forbesii*, nov. spec. Glabrous; the branches terete, with pale bark, swollen at the nodes; leaves coriaceous, petiolate, entire, opposite, ovate-oblong, sub-acute, the base rounded, or slightly cordate; midrib thick, prominent on the under surface; the nerves about 6 pairs, indistinct on both surfaces when fresh, slightly distinct on the upper surface when dry; length of blade 4·5 in. to 5·5 in.: breadth 2 in. to 2·5 in.; petiole stout, ·75 in. long; capitula 4 to 6-flowered, axillary, sessile, strobiliform, the bracts large, coloured, keeled, in two series, an outer and an inner; the outer series of 5 or 6 decussate pairs of which the upper pair are 2·3 in. long, the second pair about half as long, and the outer pairs gradually shorter, all obtuse; the inner series of 2 pairs, narrower than the outer, acuminate; each flower surrounded by 4 linear-lanceolate, keeled bracteoles about 1 inch in length; calyx tube very short, 6-toothed; corolla tubular, slightly widened above, the tube 6-angled, cleft for about one third of its entire length into 6, lanceolate, acuminate teeth: filaments flattened, grooved, adnate to the corolla-tube; anthers linear, subulate, with a process at their bases: style filiform, as long as the stamens; stigma small, cylindric.

Sumatra, near Kepala, at an elevation of 1200 feet. H. O. Ferbes, Herb. No. 2844.

Mr. Forbes found this superb species growing on a Leguminous tree. The bracts he describes as being scarlet, and the corolla of a brilliant lake colour.

VIII.—*E'tude sur les Arachnides de l' Asie méridionale faisant partie des collections de l' Indian Museum (Calcutta). Par* M. E. Simon, *de Paris.—Communicated by* The Superintendent of the Indian Museum.

[Received December 30th;—Read June 1st, 1887.]

I.

Arachnides recueillis a Tavoy (Tennasserim) par Moti Ram.

Ordo ARANEÆ.

Fam. **Attidæ.**

1.—Plexippus culicivorus, Doleschall, *Tweede Bijdr.* etc., 1859, p. 14 pl. IX, f. 5. *(Attus).*—

Menemerus culicivorus, Thorell, *Rag. Mal.* etc., I., p. 227; III, p. 508.

Egaya, Tavoy.

Répandu à Java, aux Célèbes, et à Amboine.

Fam. **Lycosidæ.**

Cette famille est représentée par deux espèces dont l' habitat est très étendu. *Hippasa greenalliœ* Blackw. est répandu dans toute l' Asie tropicale, dans l' Indoustan jusqu' à Ceylan, et dans l' Indo-Chine jusqu' à Malacca; nous l' avons indiqué nous-même de Birmanie, de Pondichéry, et de Wagra-Karoor dans le centre du Dekkan. *Ocyale atalanta* Sav. est encore plus remarquable par sa distribution: cette espèce, trouvée pour la première fois en Asie, est répandue dans toute l' Afrique tropicale du Sénégal à Mozambique et jusqu' à la Méditerranée par la vallée du Nil.

2.—Hippasa greenalliæ, Blackw, *Ann. Mag. Nat. Hist.* 1867 *(Lycosa).* *Priata agelenoides* E. Sim., *Ann. Mus. Civ. Gen.*, XX, 1884, p. 234. *Hippasa greenalliœ* E. Sim., *Bull. Soc. Zool. Fr.*, 1885, p. 31.

Tavoy.

3.—Ocyale atalanta, Aud. in Sav., *E'g.* 1825-27, Ar. XXII, p. 149, pl. IV., f. 10.

Dolomedes ocyale, Walck., *Apt.*, I, 1837, p. 253.

Lycosa virulenta, Cambr., *P. Z. S. L.*, 1876, p. 600.

Ocyale atalanta, E. Sim., *Ann. Soc. ent. Fr.* 1885, p. 258.

Tavoy.

Fam. **Sparassidæ.**

4.—Heteropoda venatoria, L.

Pour la synonymie cf. E. Sim., *Rév. Sparass.*, 1880, p. 48.

Tavoy.

5.—Heteropoda languida, *sp. nov.*

Ceph.-th. long. 10 *mm.*; lat. 8, 9 *mm.* Abd. long. 13 *mm.* Pedes I long. 36, 5 *mm.*; II 40 *mm.* III 33 *mm.*; IV 37, 5.

Cephalothorax evidenter longior quam latior crassus sat convexus laete rufo-castaneus cervino-pubescens, postice in declivitate testaceo-marginatus, stria thoracica longa. Oculi antici in apicibus lineam rectam formantes, medii lateralibus fere duplo minores inter se quam a lateralibus paulo remotiores sed spatio diametro oculi paulo angustiore sejuncti. Oculi postici in linea evidenter recurva, medii lateralibus saltem $\frac{1}{3}$ minores et a lateralibus quam inter se paulo remotiores. Medii aream non multo longiorem quam latiorem sed antice quam postice multo angustiorem occupantes, subaequales, antici vix minores. Clypeus subverticalis planus oculis lateralibus anticis latior. Sternum coxæ et laminæ rufo-castanea, pars labialis infuscata sed apice anguste testacea. Abdomen oblongum antice obtuse emarginatum fusco-lividum. Pedes mediocres sat robusti rufo-castanei, scopulæ sat densæ in metatarsis anticis basin attingentes sed in posticis partem apicalem tantum occupantes. Tibia IV cephalothoraci circiter aequilonga in parte secunda aculeo dorsali munita. Plaga vulvæ antice depressa foveolata et longitudinaliter carinata postice valde convexa semicirculari sed sulco angusto et profundo longitudinaliter secta.

Tavoy.

H. mediocri E. Sim. valde affinis, sed differt praesertim area oculorum mediorum breviore et sulco plagæ genitalis multo angustiore sublineari.

6.—Heteropoda ferina, *sp. nov.*

♂. Ceph.-th. long. 7, 6 *mm.* lat. 7, 2 *mm.* Pedes I 39, 4 *mm.*; II 43, 6 *mm.*; III 33, 6 *mm.*; IV 37 *mm.*

Cephalothorax vix longior quam latior parum convexus obscure fulvo-rufescens postice in declivitate et antice in clypeo testaceo-marginatus, supra lineis radiantibus obscurioribus notatus, stria thoracica longa. Oculi antici appropinquati in linea recta, medii lateralibus plus duplo minores et inter se quam a lateralibus remotiores spatio diametro oculi vix angustiore sejuncti. Oculi postici in linea evidenter recurva, medii lateralibus saltem $\frac{1}{3}$ minores et a lateralibus quam inter se remotiores. Medii aream longiorem quam latiorem et antice quam postice angustiorem occupantes, antici posticis minores. Clypeus oculis lateralibus anticis paulo angustior. Sternum fulvo-testaceum. Abdomen ovatum lurido-testaceum lurido-pubescens parcissime et inordinate fusco-punctatum et in parte apicali linea fusca transversim arcuata notatum, venter immaculatus. Pedes longi parum robusti fulvo-rufescentes femoribus dilutioribus sed supra levissime fusco-variatis. Scopulæ longæ parum densæ tarsos et metatarsorum extremitates tantum occupantes. Tibia IV cephalothorace multo longior aculeo dorsali in parte apicali sito munita. Pedes-maxillares fulvi tarso leviter infuscato, femore supra ad apicem 4—1 aculeato, patella paulo longiore quam latiore convexa utrinque uniaculeata, tibia patella longiore et graciliore prope basin aculeis longissimis quinque instructa apophysa apicali articulo multo breviore crassa antice directa nigra supra leviter rugosa et impressa ad apicem excisa, breviter emarginata et minute bimucronata (mucrone superiore altero longiore incurvo et acuto) infra in carinam obliquam producta, tarso angusto longissime producto in parte apicali teretiusculo, bulbo ovato simplici longitudinaliter sulcato.

Tavoy.

7.—Palystes kochi, E. Sim., *Rév. Sparass.*, 1880, p. 45.

Nous ne connaissions jusqu' ici que la femelle de cette espèce.

♂. Ceph.-th. long. 9 *mm.* Abd. long. 11 *mm.* Cephalothorax humilior quam in femina et paulo brevior quam tibia 4i paris, fusco-rufescens flavido-pubescens, linea media nigra exillima longitudinaliter sectus. Sternum coxæ oris partes venterque læte rufo-brunnea vel livida. Abdomen supra fulvo-cervinum. Chelarum margo inferior dentibus sat parvis quatuor 1o singulariter posito reliquis subcontiguis, 1o majore 2o et 4o minutissimis. Pedes multo longiores quam in femina fulvo-cervini femoribus infra rufulo-tinctis scopulis nigro-sericeis. Pedes-maxillares fulvi femore compresso leviter arcuato supra in parte apicali 4—1 aculeato, patella longiore quam latiore utrinque uniaculeata, tibia patella longiore terete prope basin et intus aculeis longissimis 4 vel 5 armata, extus apophysa apicali oblique divaricata sat valida valde uncata attenuata sed obtusa, tarso longe ovato supra cervino-piloso sed in parte apicali vitta fusca densius pilosa ornato, bulbo rufulo longe ovato apice depresso et processu membranaceo oblique munito.

Mita, Tavoy ; collines séparant la Birmanie de Siam.

Cette espèce a été découverte à Singapore.

8.—Thelictopis canescens, *sp. nov.*

♀. Ceph.-th. long, 9 *mm.* ; lat. 7, 4 *mm.* Abd. long. 12 *mm.* ; lat. 7, 5 *mm.* Pedes I 24 *mm.* ; II 23, 6 *mm.* ; III 19 *mm.* ; IV 24, 3 *mm.*

Cephalothorax niger laevis pilis albidis pronis, praesertim antice setis nigris mixtis, dense vestitus, crassus et convexus fronte lata, stria remota sat brevi sed profunda. Oculi antici in linea leviter procurva, medii lateralibus circiter $\frac{1}{3}$ majores a lateralibus quam inter se multo remotiores inter se spatio diametro oculi evidenter angustiore sejuncti. Oculi postici in linea levissime procurva, medii parvi spatio diametro oculi saltem quadruplo latiore sejuncti, laterales mediis paulo majores leviter prominuli. Area mediorum latior quam longior et antice quam postice angustior. Clypeus oculis mediis anticis haud vel non multo angustior. Chelæ robustissimæ ad basin valde geniculatæ nigro nitidæ parce setosæ. Partes oris sternum coxæque nigra. Abdomen sat late ovatum postice valde attenuatum et prope mammillas stria annulari profunde constrictum fuscum, fulvo-cinereo pubescens. Pedes breves et robusti femoribus atris reliquis articulis fusco-ravidis nigricanti-lineatis, tarsis dilutioribus, albo-cretaceo pubescentes et nigro-setosi. Tibia cum patella 4i paris cephalothorace paulo brevior. Tibiæ cunctæ aculeis dorsalibus carentes, quatuor anticæ aculeis inferioribus 5—5 sat brevibus munitæ sed lateralibus carentes, posticæ aculeis inferioribus 3—3 et utrinque lateralibus binæ munitæ. Patellæ muticæ. Scopulæ sat breves densæ basin metatarsorum sex anticorum attingentes sed apicem metarsorum posticorum tantum occupantes. Plaga vulvæ oblonga multo longior quam latior nigra rugosa et pilosa sulco medio lato rufulo et depresso longitudinaliter secta.

♂. Ceph.-th. long. 8 *mm*; lat. 7, 2 *mm*. Pedes I 27, 7 *mm* ; II 28 *mm.*; III 23, 2 *mm*; IV 28, 7 *mm*.

Feminæ subsimilis sed cephalothorace paulo latiore, pedibus paulo longioribus, tibiis anticis aculeis inferioribus et utrinque aculeis lateralibus binis instructis, metatarsis anticis aculeo laterali subbasilari et tibiis cunctis aculeo dorsali submedio instructis. Pedes-maxillares obscure fusci breves et robusti, femore brevi supra in parte apicali 3—1 aculeato, patella paulo longiore quam latiore convexa aculeo interiore unico tantum armata, tibia patella breviore extus apophysis duabus longis subæquis et teretibus insigniter armata, tarso magno late ovato ad marginem exteriorem prope basin ample dilatato, bulbo rufulo convexo valde complicato.

Collines séparant la Birmanie de Siam.

T. severæ L. Koch affinis differt imprimis oculis inter se distantioribus, plaga genitali longius ovata, etc.

Fam. **Epeiridæ.**

Les trois espèces qui représentent à Tavoy le groupe des *Gasteracanthinæ* existent également dans le Cambodge et la Cochinchine.

9.—Actinacantha propinqua, Cambr., *P. Z. S. L.*, 1879, p. 288, pl. XXVII., f. 16. *(Gasteracantha).*

id. E. Sim., *Act. Soc. Linn. Bord.*, 1886.

Tavoy,—commun.

On peut ajouter à la description du Rev. O. P. Cambridge : Sternum nigrum dense et grosse nigro-granosum antice linea transversa sæpe in medio interrupta utrinque maculis binis subrotundis ad apicem macula elongata flavo-opacis lævibus decoratum. Pedum coxæ I et IV fulvæ ad basin fusco-notatæ, sed coxæ II et III omnino nigræ. Scutum ad marginem posticum punctis ocelliformibus decem (haud octo), sed punctis II et III conjunctis punctis mediis minutissimis. Longitudo spinarum valde variabilis.

10.—Gasteracantha frontata, Blackw., *A. M. N. H.*, ser. 3, vol. XIV, 1864, p. 40.

id. Cambr. *P. Z. S. L.* 1879, p. 283., pl. XXVI, f. 9.

id. E. Sim., *Act. Soc. Linn. Bord.* 1886.

Tavoy : Mita, Egaya (très commun).

Collines entre la Birmanie et Siam, etc.

11.—Gasteracantha annamita, E. Sim., *Act. Soc. Linn. Bord.* 1886.

Egaya. Tavoy.

12.—Epeira masoni, *sp. nov.*

♀. Ceph.-th. long. 9, 1 ; lat. 8, 3 *mm.* Abd. long. 14, 5 ; lat. 12, 5 *mm.* Pedes I long. 33, 4 ; II long. 32, 4 ; III 19, 5 ; IV 29 *mm.*

Cephalothorax niger parce et inaequaliter granulosus crasse et sat longe flavo-pilosus, parte cephalica lata subparallela sat convexa prope medium impressione transversa vix expressa notata postice striis obliquis angustis discreta. Oculi medii valde prominuli aream obliquam paulo longiorem quam latiorem et antice quam postice paulo latiorem occupantes, medii antici posticis plus duplo majores, spatium inter medios posticos diametro oculi paulo angustius. Oculi laterales a mediis latissime remoti prominuli haud tuberculati antici postico majores, spatio dimidio diametro oculi angustiore sejuncti. Oculi quatuor antici lineam leviter procurvam formantes sed in medio clypeo area ocularum paulo angustiore. Sternum nigrum immaculatum haud rugosum flavo-hirsutum. Chelæ nigræ sublaeves. Abdomen crassum et altum sed supra deplanatum obtusissime triquetrum, supra atrum longissime et crasse flavo-hirsutum immaculatum vel macula anteriore simplici aut duplici albo-opaca notatum. Venter niger pone plicam vitta transversa prope medium maculis transversis binis obscure testaceis ornatus. Pedes robusti et longi nigri vel obscure fusco-ravidi femoribus anticis infra cyaneo-tinctis, tibiis metatarsisque annulis sat angustis albo-cinereo pilosis ornatis, patellis tibiisque supra deplanatis et distincte bisulcatis, aculeis parum longis numerosis fulvo-rufulis ad radicem nigris. Vulvæ uncus sat longus subparallelus et obtusus supra marginatus prope basin leviter convexus parce rugosus et pilosus.

Tavoy.

Ep. de haani Dolesch. sat affinis differt imprimis area oculorum mediorum longiore, oculis mediis magis inaequalibus, lateralibus haud tuberculatis, abdominis angulis humeralibus obtusissimis, vulva haud foveolata unco longo et parallelo munita.

Pedes 4i paris ut in *E. de haani* paulo breviores quam anteriores.

13.—Epeira submucronata, *sp. nov.*

♀. Ceph.-th. long. 8, 5 ; lat. 6, 7 *mm.* Abd. long. 13, 2 ; lat. 11 *mm.* Pedes I long. 24 ; II 23, 2 ; III 14, 7 ; IV 24, 8 *mm.*

Cephalothorax ut in præcedenti sed densius granulosus et impressione cephalica majore et profundiore, obscure fusco-rufescens, parte cephalica breviter albido-pilosa thoracica utrinque longe et crebre flavo-hirsuta postice in declivitate glabra. Oculi medii valde prominuli aream subverticalem haud longiorem quam latiorem et antice quam postice non multo latiorem occupantes, medii antici posticis evidenter majores, spatium inter posticos diametrum oculi fere æquans. Oculi laterales a mediis longissime remoti sub tuberculo infulo conico et divaricato impositi subaequales et spatio dimidio diametro oculi angustiore sejuncti. Oculi quatuor antici lineam evidenter procurvam formantes. Clypeus in medio area oculorum latior. Sternum obscure fuscum immaculatum flavo-pilosum grosse parce et inordinate granulosum. Chelæ fulvo-rufescentes apicem versus sensim obscuriores. Abdomen crassum et altum sed supra deplanatum triquetrum angulis humeralibus acute productis angulo apicali tuberculis tribus contiguis uniseriatis medio reliquis majore instructo, supra fulvo-cervinum parce setosum et brevissime fulvo-nitido pubescens, antice in declivitate fusco-piceum lineis transversis exillimis albo-pilosis transversim sectum linea prima inter tubercula humeralia ducta integra aliis (2 vel 3) in medio late interruptis. Venter obscure fuscus utrinque fulvo-marginatus pone plicam vitta transversa prope medium macula magna subquadrata obscure fulvis ornatus. Pedes robusti et sat longi obscure fulvo-ravidi, femoribus anticis infra cyaneo-tinctis, fulvo-pubescentes metatarsis anticis annulo medio exili tibiis metatarsisque posticis annulo basilari lato albido-pilosis ornatis, patellis tibiisque supra deplanatis et distincte bisulcatis, aculeis numerosis parum longis testaceo-pellucentibus. Vulva antice fovea subquadrata postice tuberculo mediocri semicirculari piloso apice breviter et acute uncato munita.

Var. (♀ junior). Cephalothorax fulvo-rufescens impressionibus cephalicis fuscis. Abdomen fulvo-cervinum linea media longitudinali et utrinque lineis transversis fuscis notatum. Pedes fulvi femoribus infuscatis tibiis metatarsisque posticis fusco-annulatis.

Tavoy. Egaya.

Ep. de haani et *E. caput-lupi* Dolesch. valde affinis, differt praesertim oculis lateralibus longius tuberculatis, apice abdominali trituberculato, etc.

Vulva fere ut in *Ep. de haani.*

Pedes 4i paris ut in *Ep. caput-lupi* longiores quam pedes quatuor anteriores.

14.—Cærostris paradoxa, Dolesch., *Tweede Bijdr. Kenn. Arachn. Ind. Ar.*, 1859, p. 37, pl. IX, f. 11. et pl. X, f. 8. *(Epeira)*.

Mintas et Mita, Tavoy.

Espèce répandue en Malaisie et dans l' Indo-Chine.

15.—Nephila maculata, Fabr., *Ent. Syst.*, II, 1793, p. 425 *(Aranea)*.

N. fuscipes, C. Koch, *Ar.*, VI, 1839, p. 136, f. 528.

(Pour la synonymie cf. Thorell, *Rag. Mal.* etc. III, p. 145).

Tavoy ; Mita, Tavoy.

Répandu dans toute l'Asie méridionale, la Malaisie, les Philippines, et l' Australie septentrionale.

16.—Nephilengys malabarensis, Walck., *Apt.* II, 1841, p. 103 (*Epeira*).

Epeira anama, Walck., *l. c.*, p. 103.

Epeira rhodosternon, Dolesch., *Tweede Bijdr.* etc. 1859, p. 40.

Nephila rivulata, Cambr., *P. Z. S. L.*, 1871, p. 517, pl. XLIX, f. 1-2.

Nephilengys hofmanni, L. Koch, *Ar. Austr.*, 1872, p. 145 ; pl. XI, f. 8.

Nephilengys malabarensis, Thorell, Simon, etc.

Egaya, Tavoy.

Espèce répandue dans presque toutes les régions chaudes du globe : en Afrique, en Australie, et en Amérique ; indiqué de Siam par Thorell et par nous-même.

17.—Meta fastigiata, E. Sim., *Ann. Soc. ent. Fr.* 1877, p. 79.

Meta fastuosa, Thorell, *Rag. Mal.* etc., I, 1877, p. 413.

Meta fastigiata, E. Sim., *Act. Soc. Linn. Bord.*, 1886.

Tavoy ; Mintas, Tavoy.

Répandue aux Philippines, aux Célèbes, et à Siam.

Fam. **Pholcidæ.**

18.—Pholcus elongatus, Vinson, *Ar. Réun.* etc. 1864, p. 135, pl. III, f. 5.

P. phalangioides, Dolesch., *Tweede Bijdr.* etc. 1859, p. 47.

P. tipuloides, L. Koch, *Ar. Austr.*, 1872, p. 281, pl. XXIII, f. 5.

P. distinctus, Cambr., J. L. S. Z., X, 1876, p. 380, pl. XI, f. 28-30.

P. margarita, Workman, *A. & M. N. H.* 5th ser. t. II, 1878, p. 451, pl. XVIII. f. 1-2.

P. elongatus, V. Hasselt, *Tijdr. v. Ent.*, XX, 1877, p. 53.

id. Thorell, *Rag. Mal.* etc. II, 1878, p. 162.

Egaya. Tavoy.

Répandu dans presque toutes les régions chaudes, probablement importé.

Fam. **Drassidæ**.

Subfam. *Ctenini*.

19.—Leptoctenus tumidulus, *sp. nov.*

♂ *(pullus)*. long. 15 *mm.* Cephalothorax ovatus antice parum attenuatus fronte lata postice valde convexus et stria profunda sectus, obscure fulvo-ravidus fulvo-pubescens, parte cephalica utrinque lineolis fuscis obliquis parte thoracica linea marginali et vittis dorsalibus latis pallide fuscis dentatis et lineis radiantibus obscurioribus sectis notatis. Oculi fere ut in *L. denticulato* sed area mediorum latius transversa et oculis lateralibus seriei 2æ a mediis latius remotis. Clypeus oculis anticis haud latior retro obliquus. Abdomen sat late ovatum fusco-testaceum fulvo et albido-pubescens parce et inordinate fusco-punctatum in parte anteriore punctis majoribus biseriatim ordinatis notatum. Mammillæ inferiores fuscæ, superiores flavæ. Sternum fusco-rufescens albido-setosum. Chelæ subnigræ nitidæ subtilissime vix conspicue transversim rugatæ, margine inferiore sulci quadridentato dentibus 1 et 2 reliquis paulo majoribus. Pedes sat breves et robusti fulvo-ravidi confuse olivaceo-annulati. Tibiæ anticæ infra 5—5 aculeatæ (aculeis 3i paris reliquis longioribus) metatarsis aculeis similibus 3—3. Tibiæ posticæ aculeis lateralibus inferioribus atque aculeis dorsalibus 3 uniseriatis instructæ. Patellæ posticæ utrinque uniaculeatæ. Tibia cum patella IV cephalothoraci fere æquilonga. Tarsi cuncti metatarsique quatuor anteriores breviter et sat dense scopulati.

Tavoy.

L. denticulato E. Sim. affinis, differt imprimis cephalothorace postice convexiore, pedibus brevioribus, etc.

Fam. **Aviculariđæ.**

Sect. 1. *Trionichi.*

Genus Atmetochilus *nov.*

Cephalothorax ovatus plus $\frac{1}{4}$ longior quam latior pubescens parte cephalica lata modice convexa, fovea procurva semicirculari profunda, parte thoracica humili postice attenuata et truncata. Area oculorum compactilis circiter triplo latior quam longior utrinque subparallela (oculorum series postica paulo angustior quam antica). Oculi quatuor antici maximi subaequales fere aeque et sat anguste separati (intervalla dimidio diametro oculi vix latiora) in linea modice procurva. Oculi postici subaequales anticis multo minores utrinque approximati. Oculus lateralis posticus antico fere duplo minor et ab antico spatio diametro oculi paulo angustiore sejunctus. Chelæ robustæ supra visæ sat breves intus ad apicem leviter convexæ, rastello ex dentibus numerosissimis inordinatis iniquis et parum robustis composito. Pars labialis paulo longior quam latior leviter attenuata et obtusa immobili a sterno stria snperficiali vix expressa discreta mutica. Coxæ pedum-maxillarium ad basin denticulis paucis armatæ. Sternum ovatum antice attenuatum impressionibus magnis confluentibus antice foveam magnam transversim semicircularem formantibus. Pedes robusti sat longi, metatarsi quatuor anteriores tibiis circiter aequilongi, metatarsi postici tibiis multo longiores. Tarsi metatarsique quatuor anteriores et tarsi pedum-maxillarium scopulis parum densis setis intermixtis vestiti, tarsi postici infra dense setosi. Metatarsi antici aculeis paucis instructi. Ungues tarsorum cunctorum dentibus paucis basilaribus ad marginem exteriorem muniti et ungues tarsorum anticorum dente minutissimo submedio ad marginem interiorem tantum armati. Mammillæ superiores articulo basilari crasso et sat longo, medio breviore, apicali medio longiore basilari fere æquilongo angustiore recto et attenuato.

Gen. *Cystauchenio* Th. sat vicinum differt oculis anticis magnis æquis et parum disjunctis, sterno late foveolato, parte labiali ad basin vix discreta, metatarsis anticis pluriaculeatis, mammillarum articulo ultimo longiore et acuminato, structura ungium tarsalium, etc.

20.—Atmetochilus fossor, *sp. nov.*

♀. Ceph.-th. long. 20; lat. 14, 2 *mm.* Abd. long. 22, 5; lat. 16, 5 *mm.* Pedes I 44, 6; II 40, 5; III 34, 7; IV 48, 8 *mm.*

Cephalothorax sublævis sed opacus læte fusco-rufescens pilis longis pronis sericeis setis nigris mixtis parum dense vestitus. Oculi quatuor antici maximi subæquales, medii rotundi, laterales ovati et obliqui, medii a lateralibus quam inter se vix remotiores spatio dimidio diametro oculi evidenter angustiore sejuncti, medii postici subrotundi levissime angulosi, laterales late ovati mediis vix majores et lateralibus anticis multo minores. Chelæ nigræ sublæves valde et inæqualiter crinitæ. Abdomen convexum late ovatum atro-sericeum tenuiter et parce setosum in lateribus inordinate testaceo-striolatum infra obscure fulvum. Mammillæ fulvæ. Sternum læte fusco-rufescens postice dilutius læve. Pedes-maxillares pedesque subnigri coxis femoribusque infra dilutioribus et rufulis, patellis tibiisque supra vittis duabus latis glabris et rufulis ornatis. Tibiæ anticæ infra aculeis apicalibus binis et aculeis exterioribus uniseriatis 3, metatarsi aculeis apicalibus binis et exterioribus binis armati. Tibiæ posticæ parce metatarsi numerose aculeati.

Tavoy.

Sect. II. *Dionichi.*

21.— ? Phrictus flavopilosus, E. Sim., *Ann. Mus. Civ. Gen.*, XX, 1884, p. 358.

Tavoy.

Je rapporte avec doute à cette espèce quelques jeunes individus en mauvais état.

P. flavopilosus a été découvert en Birmanie.

Genus Cyriopagopus *nov.*

Gen. *Selenocosmiæ* affine. Cephalothorax oblongus multo humilior subplanus fovea sublineari leviter procurva (haud semilunari). Tuber oculorum parum convexum magnum saltem duplo latius quam longius a margine antico spatio diametro oculi lateralis antici latiore sejunctum. Oculi antici in linea parum procurva (margo anticus mediorum ante centrum lateralium situs) subæquales fere æquidistantes spatiis diametro oculi evidenter angustioribus sejuncti. Medii postici multo minores quam medii antici et laterales postici late ovati recti. Laterales postici anticis minores atque ab anticis spatio diametro minore oculi haud latiore sejuncti. Pedes parum longi robustissimi extremitates versus parum attenuati omnino mutici. Patella cum tibia IV evidenter longior quam patella cum tibia I. Scopulæ densissimæ, in metatarsis sex anterioribus basin articuli attingentes, in metatarso 4i paris partem apicalem tantum occupantes. Scopulæ tarsorum cunctorum et metatarsorum sex anticorum integræ sed scopulæ metatarsi postici linea setosa anguste sectæ. Cætera ut in *Selenocosmia.*

Gen. *Phrycto* sat affine imprimis differt scopulis tarsorum integris et linea oculorum anticorum magis procurva.

22.—Cyriopagopus paganus, *sp. nov.*

♀. Ceph.-th. long. 14 *mm*; lat. 11, 5 *mm*. Abd. long. 21 *mm*. Pedes-max. long. 21 *mm*. Pedes I 39 *mm*; II 36 *mm*; III 32, 2 *mm*; IV 43, 6 *mm*.

Cephalothorax humilis subplanus obscure fusco-rufescens sat longe et adpresse fulvo-cervino-pubescens. Area oculorum magna transversa. Oculi quatuor antici subæquales, medii rotundi, laterales longe ovati æquidistantes et spatiis diametro oculi paulo angustioribus separati. Medii postici late ovati subrecti, laterales postici longe ovati mediis duplo majores sed lateralibus anticis minores. Abdomen oblongum nigricans ferrugineo-pubescens et longe setosum. Pars labialis subplana haud striata nec depressa in parte apicali minute et crebre spinulosa. Chelæ sternum pedes-maxillares pedesque nigella ferrugineo-hirsuta, tibiis metatarsisque supra ad apicem pilis albidis paucis angustissime cinctis. Pedes breves et robustissimi. Tibia cum patella I breviores quam iidem articuli IV (circiter ex $\frac{1}{3}$ patellæ). Metatarsus IV tibia haud vel vix longior.

Tavoy. Egaya.

Ordo PEDIPALPI.

23.—Thelyphonus formosus, Butler, *Ann. Mag. Nat. Hist.* 1872, p. 203, pl. XIII, f. 4.

La forme remarquable de la patte-mâchoire indiquée dans cette espèce par Butler (*l. c.* f. 4) est un caractère sexuel propre au mâle. Chez la femelle la patte-mâchoire est de forme normale et se rapproche beaucoup de celle de *T. assamensis*, Stol.; le trochanter offre également cinq dents au bord supérieur.

Les deux espèces different par les caractères suivants :—

In *T. formoso* trochanteris dentibus acutioribus tribus interioribus subsimilibus (in *assamensi* dente basali obsoleto) pedum-maxillarium articulis cunctis supra omnino lævibus (in *assamensi* trochantere et femore parce granosis) oculis mediis minoribus spatio subplano diametro oculi saltem haud angustiore sejunctis (in *assamensi* spatio angustiore et convexo), tarsi pedum Ii paris articulis cunctis muticis I et II subæquis III—VII brevioribus et inter se subæquis ultimo tereti recto præcedentibus duobus simul sumptis haud longiore (in *assamensi* articulis IV, V, VI, et VII intus ad apicem breviter dentatis et articulo V reliquis longiore).

Tavoy.

Déjà indiqué de Tennasserim par Butler.

Ordo SCORPIONES.

24.—Isometrus varius, C. Koch, 1845.

Tityus varius, C. Koch, *Ar.* XI, p. 29, f. 864.

Isometrus varius, E. Sim., *Ann. Mus. civ. Gen.*, XX, 1884, p. 363.

Tavoy.

Nous l' avons déjà indiqué de Birmanie. Il est en outre très répandu en Indo-Chine, à Siam et à Saïgon, et en Malaisie, à Sumatra et à Java.

25.—Palamnæus bengalensis, C. Koch, 1842.

Buthus bengalensis, C. Koch, *Ar.* IX, p. 3, f. 696.

Palamnœus bengalensis, E. Sim., *Ann. Mus. Civ. Gen.*, XX, 1884, p. 360.

Tavoy.

Très répandu en Birmanie.

26.—Scorpiops anthracinus, *sp. nov.*

Long. trunci 25, 5 *mm*. Caudæ 22, 5 *mm*.

Nigro-opacus corpore subtus coxis tarsisque dilutioribus et rufescentibus. Cephalothorax segmentis caudæ I, II, et III anterioribus simul sumptis non multo brevior, supra fere planus subparallelus antice parum attenuatus, ad marginem anticum profundissime et obtuse excisus et utrinque in lobum attenuatum et obtuse truncatum productus, supra granulis grossis inæqualibus inordinate conspersus, ante tuber oculorum sulco lato profundo carinis granulosis limitato impressus postice sulco longitudinali angustiore et sulco transverso recto sed utrinque antice flexuoso munitus. Tuber oculorum longe ante medium situm ovatum læve subtiliter sulcatum spatio inter oculos diametro oculi haud latiore seu paulo angustiore. Oculi laterales sub carina granulosa siti in linea recurva I et II æquales tertio minor. Segmenta abdominalia supra grosse dense et inordinate granulosa, segmenta III—VI antice leviter impressa et carina media longitudinali debili notata, segmentum VII parcius granulosum et carinis granulosis binis subrectis munitum. Segmenta ventralia lævia nitida sed ultimum subtiliter coriaceum et in parte apicali carinis quatuor debilibus sublævibus instructum. Cauda sat debilis minute et parce granulosa, segmenta I—IV carinis octo inferioribus sublævibus superioribus dentatis, carinæ dorsales in segmento II, et imprimis in segmentis III et IV alte cristatis et dente apicali fortiore instructæ. Segmentum Vm segmenta III et IV simul sumptis longitudine æquans, carinis septem minute et regulariter dentatis munitum. Vesica longe ovata segmento caudæ Vo vix brevior subtiliter coriacea et infra prope basin minute et parce granulosa, aculeo vesica multo breviore. Pedes-maxillares longi et parum robusti femore et tibia deplanatis et supra et infra carinis dense granulosis munitis supra parce granulosis infra sublævibus, tibia intus dentibus validis æquis binis subbasilaribus instructa infra prope marginem exteriorem punctis impressis piliferis XIX uniseriatis munita, manu tibia non multo latiore sed multo longiore parallela subtiliter granulosa subangulosa et costis granulosis latis munita digiti mobili manu postica paulo longiore. Dent. pect. 10—11.

Tavoy.

A *S. Hardwicki* Gerv. et *solido* Karsch differt manu angusta et carinis dorsalibus segmentorum caudæ dente apicali reliquis dentibus multo validiore; *S. montano* Karsch valde affinis sed differt imprimis cephalothorace grosse granuloso, digito mobili pedum-maxillarium manu longiore, dentibus pectinum 10—11, etc.

27.—Liocheles australasiæ, Fabr., *Syst. Ent.*, 1775, p. 399.

Ischnurus australasiæ, E. Koch, *Ar.* IV, p. 71, f. 294.

Ischnurus pistaceus, E. Sim., *Ann. Soc. Ent. Fr.* 1876.

Hormurus australasiæ, Thorell, *E'tud. Scorpiol.*, 1877, p. 177.

Tavoy.

Très répandu dans la Polynesie, la Malaisie, les Philippines, la Cochinchine, etc.

A *L. complanato* C. Koch differt cephalothorace impresse punctato in medio subtiliter rugoso haud granuloso, segmentis caudæ I et præsertim II et V infra valde dentatis, etc. A *L. neocaledonico*, E. Sim. differt cephalothorace haud granuloso, caudæ segmento V infra dentato, manu impresse punctata et granulis humilibus ornata, etc.

Le genre *Liocheles* Sundevall (*Conspectus Arachnidum*, 1833, p. 31) correspònd au genre *Hormurus* Thorell, comme l' a démontré le Dr. Karsch (*Zeitschrift. f. ges. Naturwissenschft.* 1880, t. LIII, p. 480).

Ordo OPILIONES.

Sub-ordo *OP. MECOSTETHI.*

28.—Maracandus reticulatus, *sp. nov.*

♂. Long. 5, 8 *mm*; Lat. 4, 3 *mm*.

Scutum dorsale paulo longius quam latius antice obtuse truncatum postice sensim ampliatum et recte sectum supra fere planum vix convexum haud striatum nec impressum subtiliter coriaceum haud granulosum fulvo-olivaceum confuse fusco-retriculatum et transversim lineatum ad marginem anticum tuberculo medio minuto et utrinque (supra radicem pedum-maxillarium) tuberculis albis binis longis et teretibus munitum, in regione abdominali tuberculis nigris sex in series duas parallelas ordinatis (anticis quatuor minutissimis granuliformibus ultimis longis erectis et acutis) instructum. Tuber oculorum maximum ovato-transversum haud sulcatum supra tuberculis parvis et obtusis biseriatis (2-2 vel 3-3) notatum. Abdominis segmenta posteriora libera et ventralia brunnea mutica sed serie granulorum minutissimorum munita. Coxæ fulvæ confuse fusco-atomariæ, posticae ad marginem posteriorem pone spiraculum tuberculis crenulatis paucis munitæ reliquæ coxæ utrinque obtuse serratæ et anticæ serie media grossius granulosa ornatæ. Chelæ modicæ fulvæ læves nitidæ articulo basali convexo subgloboso. Pedes-maxillares fulvi plus minus fusco-variati corpore breviores, femore compresso infra tuberculis parvis obtusis et inæqualibus uniseriatis munito atque intus ad apicem tuberculo paulo longiore et acuto instructo, patella saltem triplo longiore quam latiore basin versus longe attenuata supra leviter convexa infra plana, ad marginem interiorem fere mutica ad exteriorem tuberculis parvis et obtusis 4-5 munita, tibia patella saltem $\frac{1}{4}$ breviore subparallela infra plana ad marginem interiorem aculeo subapicali acuto diametro articulo breviore ad exteriorem aculeis similibus binis instructa, tarso tibia breviore sat late ovato valde attenuato utrinque aculeis binis sat parvis munito, ungue gracili tarso haud breviore. Pedes fulvo-olivacei plus minus fusco-retriculati et sublineati sat longi et valde inæquales antici reliquis multo breviores cuncti cylindracei et mutici, tarsus I 9-articulati, tarsi II 19, tarsi III 11, tarsi IV 13-articulati. Ungues mutici.

♀. Long. 8 *mm*, lat. 5, 2 *mm*.

A mare differt corpore crassiore et convexiore brunneo-rufescenti leviter et parce fulvo-variato, tuberculo frontali erecto multo longiore et tuberculis obtusis binis apicalibus oculorum tuberis validioribus, regione abdominali tuberculis quatuor ad basin crassis granulosis et nigris ad apicem acutis et albidis anticis posticis minoribus, pedibus-maxillaribus brevioribus tuberculo femorali interiori minutissimo aculeis tibiæ et tarsi brevioribus, pedibus multo brevioribus fusco-rufescentibus apicem versus sensim dilutioribus, tarso I 8, tarso II 13—14, tarso III 9, tarso IV 10-articulatis.

Tavoy.

Nous ne rapportons qu' avec doute cette espèce au genre *Maracandus ;* elle diffère en effet des espèces types* par le scutum dorsal sans stries transverses, le tubercule oculaire non déprimé, enfin par les stigmates bien visibles—caractère exceptionnel dans la famille des *Phalangodidæ.*

* *M. macei* E. Sim. du Bengale et *M. mouhoti* E. Sim. du Cambodge, cf. *Ann. Soc. ent. Belg.*, 1880.

Sub-ordo *OP. PLAGIOSTETHI.*

Genus Gagrella, Stoliczka.

Ce genre est représenté dans la région de Tavoy par les espèces suivantes.

Conspectus specierum.

1.—Tuber oculorum omnino læve et muticum longitudinaliter sulcatum, corpus nigrum scuto abdominali vittis flavis quatuor ornato,............................ *quadrivittata.*
Tuber oculorum tuberculis parvis æquis biseriatim ordinatis instructum,.................................... 2
2.—Corpus fulvum, scuto abdominali vittata fusca confusa notato, infra omnino sublæve,..................... *cervina.*
Corpus nigrum postice flavo-bimaculatum, infra subtiliter coriaceum et in processu sternali parce granosum,... *binotata.*

29.—Gagrella cervina, *sp. nov.*

Long. 6—8 *mm.*

Corpus brevissime ovatum valde convexum crebre et sat tenuiter coriaceo-rugosum fulvo-cervinum, parte thoracica dilutiore et flavida sed utrinque impressione obliqua infuscata notata, scuto abdominali in parte prima vitta media lata fusca confusa notato, tubere oculorum saltem supra et spina abdominali nigris. Pars thoracica ad marginem mutica. Tuber oculorum altum supra visum subrotundum et tuberculis parvis æquis in series duas antice divaricatas parum regulariter ordinatis instructum, intervallo oculorum diametrum oculi circiter æquanti. Spina abdominalis longa verticalis acuta usque ad basin sat gracilis parce rugosa. Corpus infra sublæve pallide flavo-testaceum, coxis minute et parcissime granulosis sed utrinque crebre nigro-serratis. Chelæ et pedes-maxillares omnino pallide flavi. Chelæ læves muticæ. Pedes-maxillares femore infra patella supra minutissime et inordinate spinulosis, tibia patella haud longiore parallela. Pedes longissimi cylindracei fusco-rufescentes trochanteribus nigricantibus femoribus patellisque sat remote tibiis remotissime et minutissime spinulosis.

Mita, Tavoy.

30.—Gagrella binotata, *sp. nov.*

Long. 8 *mm.*

Corpus breviter ovatum convexum omnino crebre et valde coriaceo-rugosum, nigerrimum, parte thoracica ante tuber lineis binis exilibus et utrinque supra foramen margine tenui obscure rufulis parum distinctis notata, scuto abdominali antice utrinque spatio magno obscure rufulo et postice maculis binis transversis lævibus læte flavis ornato. Pars thoracica ad marginem mutica. Tuber oculorum sat altum supra visum subrotundum tuberculis parvis æquis biseriatim ordinatis munitum, intervallo oculorum diametro oculi non multo latiore. Spina abdominalis verticalis mediocris acuta usque ad basin sat gracilis parce granosa. Segmenta abdominalia infra subtilissime coriacea et in medio granulis minutissimis paucis munita fusca ad marginem posticum et utrinque dilutiora et rufescentia, processu sternali fusco sat remote granuloso. Coxæ nigricantes densius granulosæ utrinque serratæ. Chelæ læves muticæ nigræ, digitis dilutioribus. Pedes-maxillares nigri, femore infra patella tibiaque intus minutissime et sat crebre spinulosis, tibia patella vix longiore angustiore et parallela. Pedes longissimi cylindracei nigri tarsis leviter dilutioribus femoribus minute et sat remote spinulosis.

Tavoy.

31.—Gagrella quadravittata, *sp. nov.*

Long. 8, 5 *mm.*

Corpus breviter ovatum convexum in medio prope spinam abdominalem grosse et crebre granosum antice posticeque sensim lævius, nigerrimum, parte thoracica ante tuber vitta media flava prope marginem linea nigra exili secta postice secundum tuber crasse bifurcata, pone tuber utrinque maculis binis transversis, scuto abdominali vittis flavis quatuor integris dorsalibus duabus antice ampliatis et utrinque marginali angustiore apicem haud attingente. Pars thoracica ad marginem mutica. Tuber oculorum sat humile supra visum paulo latius quam longius omnino læve et muticum sed sulco longitudinali divisum, intervallo oculorum diametro oculi multo latiore. Spina abdominalis mediocris ad basin crassa et valde granulosa ad apicem subacuta. Corpus infra sublæve obscure testaceum segmentis transversim fusco-vittatis et processu sternali infuscato. Coxæ fuscæ præsertim anticæ sat dense granulosæ utrinque crebre serratæ. Chelæ læves muticæ nigræ digitis dilutioribus. Pedes-maxillares obscure fusci femore infra patella tibiaque intus minutissime et inordinate spinulosis, tibia patella vix longiore angustiore et parallela, tarso longissimo compresso apicem versus leviter et sensim incrassato. Pedes longissimi cylindracei fusco-rufescentes trochanteribus femoribusque basin versus nigricantibus femoribus minutissime (vix perspicue) et remotissime spinulosis.

Tavoy.

G. signatæ Stol. sat affinis differt corpore in parte granuloso (in *G. signata* omnino granulosa) et scuto abdominali flavo quadrivittato (in *G. signata* tantum flavo-marginato).

IX.—*On the Differential Equation of a Trajectory.*—*By* Asutosh Mukhopadhyay, M. A., F. R. A. S., F. R. S. E. *Communicated by* The Hon'ble Mahendralal Sarkar, M. D., C. I. E.

[Received April 28th ;—Read May 4th, 1887.]

§ 1. The problem of determining the oblique trajectory of a system of confocal ellipses, appears to have been first solved by the Italian Mathematician Mainardi, in a memoir in the *Annali di Scienze Mathematische e Fisiche*, t. I, page 251, which has been reproduced by Boole (*Differential Equations*, 4th edition, pp. 248-251). Representing half the distance between the foci by h, and the tangent of the angle of intersection by n, we obtain for the equation of the trajectory,

$$-2n\tan^{-1}\sqrt{\left(\frac{h^2}{xM}-1\right)}+\log\frac{1-\sqrt{1-\frac{M}{x}}}{1+\sqrt{1-\frac{M}{x}}}=C\ \ldots\ldots\ldots\ldots\ (1)$$

where C is the constant of integration, and M is given by the quadratic

$$(x^2+y^2+h^2)M=x\,(M^2+h^2)\ldots\ldots\ldots\ldots\ (2)$$

Now, this form of the equation is so complicated that it would be a hopeless task to have to trace the curve from it; indeed, it is so unsymmetrical and inelegant that Professor Forsyth in his splendid work on Differential Equations (page 131) does not at all give the answer. In the present note, the curve is represented by a pair of remarkably simple equations which admit of an interesting geometrical interpretation.

§ 2. Assume then

$$xM = h^2\cos^2\phi$$
$$C = 2n\lambda$$

where λ is a new constant. Substituting in (1), we have

$$\log\frac{1-\sqrt{1-\frac{M}{x}}}{1+\sqrt{1-\frac{M}{x}}}=2n\lambda+2n\phi.$$

$$\therefore \quad \frac{1-\sqrt{1-\frac{M}{x}}}{1+\sqrt{1-\frac{M}{x}}} = e^{2n(\lambda+\phi)}$$

$$\therefore \frac{1}{\sqrt{1-\frac{M}{x}}} = \frac{1+e^{2n(\lambda+\phi)}}{1-e^{2n(\lambda+\phi)}}$$

$$\therefore 1-\frac{M}{x} = \left\{\frac{1-e^{2n(\lambda+\phi)}}{1+e^{2n(\lambda+\phi)}}\right\}^2$$

$$\therefore \frac{M}{x} = 1-\left\{\frac{1-e^{2n(\lambda+\phi)}}{1+e^{2n(\lambda+\phi)}}\right\}^2 = \frac{4e^{2n(\lambda+\phi)}}{\left\{1+e^{2n(\lambda+\phi)}\right\}^2}.$$

But, $$M = \frac{h^2}{x}\cos^2\phi$$

$\therefore$ Substituting in the above and extracting the square root, we get

$$\frac{h}{x}\cos\phi = \frac{2e^{n(\lambda+\phi)}}{1+e^{2n(\lambda+\phi)}}$$

$$\therefore x = h\cos\phi\,\frac{1+e^{2n(\lambda+\phi)}}{2e^{n(\lambda+\phi)}}$$

$$= h\cos\phi\,\tfrac{1}{2}\left\{e^{n(\lambda+\phi)}+e^{-n(\lambda+\phi)}\right\}$$

$$= h\cos\phi.\cosh n(\lambda+\phi).$$

Again, substituting the value of M in (2), we have

$$(x^2+y^2+h^2)\frac{h^2\cos^2\phi}{x} = x\left(\frac{h^4\cos^4\phi}{x^2}+h^2\right)$$

$$\therefore x^2+y^2+h^2 = h^2\cos^2\phi + x^2\sec^2\phi$$

$$\therefore y^2+h^2\sin^2\phi = x^2\tan^2\phi$$

$$\therefore \frac{x^2}{h^2\cos^2\phi} - \frac{y^2}{h^2\sin^2\phi} = 1,$$

and, since we have shewn that

$$x = h\cos\phi.\cosh n(\lambda+\phi),$$

we see at once that

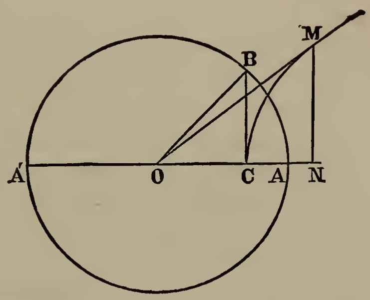
$$y = h\sin\phi\ .\ \sinh n(\lambda+\phi).$$

Therefore, the co-ordinates of any point on the trajectory may be expressed in a very neat and symmetrical form, in terms of a parameter ϕ *viz.*, we have

$$\left.\begin{aligned} x &= h \cos\phi . \cosh n(\lambda+\phi). \\ y &= h \sin\phi . \sinh n(\lambda+\phi). \end{aligned}\right\} \ldots\ldots\ldots\ldots (A).$$

§ 3. The equations (A) admit of a very simple geometrical interpretation.

Let A′A be the line joining the foci of the system of confocal ellipses, so that OA $= h$. On A′A as diameter, describe a circle having its centre at O. Draw any radius OB, making the angle AOB $= \phi$; draw BC perpendicular to OA; then, we have OC $= h \cos\phi$, BC $= h \sin\phi$. Construct a hyperbola CM, having its centre at O, and its transverse and congugate axes equal to OC, BC respectively; then, of course, BC is a tangent and OB an asymptote to this hyperbola. Take a point M on the hyperbola, so that the area of the hyperbolic sector OCM may be $n(\lambda+\phi)$ times the area of the triangle OCB: then, I assert that M is a point on the trajectory, *viz.*, the co-ordinates of M are



$$x = h \cos\phi . \cosh n(\lambda+\phi).$$
$$y = h \sin\phi . \sinh n(\lambda+\phi).$$

To see how this is, drop MN perpendicular on OA. Then, writing for the moment OC $= h\cos\phi = \alpha$, BC $= h \sin\phi = \beta$, the hyperbola is

$$\frac{x^2}{\alpha^2} - \frac{y^2}{\beta^2} = 1$$

and, any point (x_1, y_1) as M on this hyperbola is obviously satisfied by $x_1 = \alpha \cosh\psi$, $y_1 = \beta \sinh\psi$. Now, the area of the portion CMN is given by $\text{CMN} = \int_\alpha^{x_1} y\,dx = \frac{\beta}{\alpha}\int_\alpha^{x_1} \sqrt{x^2-\alpha^2}\,dx$

$$= \frac{\beta}{2\alpha}\left\{ x\sqrt{x^2-\alpha^2} - \alpha^2 \log\left(x+\sqrt{x^2-\alpha^2}\right)\right\}_{x=\alpha}^{x=x_1}$$

$$= \frac{\beta}{2\alpha}\left\{ \alpha^2 \cosh\psi \sinh\psi - \alpha^2 \log\frac{\alpha\cosh\psi+\alpha\sinh\psi}{\alpha}\right\}$$

$$[\because x_1 = \alpha\cosh\psi]$$

$$= \frac{\beta}{2\alpha}\left\{ \alpha^2 \cosh\psi \sinh\psi - \alpha^2\psi \right\}$$

$$= \tfrac{1}{2}\,\alpha\beta \cosh\psi \sinh\psi - \tfrac{1}{2}\,\alpha\beta\psi$$
$$= \tfrac{1}{2}\,\text{ON. NM} - \tfrac{1}{2}\,\alpha\beta\psi = \text{ONM} - \tfrac{1}{2}\alpha\beta\psi$$
$$\therefore\ \text{OCM} = \tfrac{1}{2}\alpha\beta\psi = \text{OCB.}\ \psi.$$

But, *ex hypothesi*, $\text{OCM} = \text{OCB.}\ n(\lambda+\phi)$

$$\therefore\ \psi = n(\lambda+\phi),$$

which shews that the co-ordinates of M are given by

$$x_1 = \alpha\cosh\psi = h\cos\phi.\ \cosh n(\lambda+\phi)$$
$$y_1 = \beta\sinh\psi = h\sin\phi.\ \sinh n(\lambda+\phi),$$

and, therefore, M is a point on the trajectory. We thus see that not only are the co-ordinates of M expressible in a very simple form, but also that the position of M can be determined geometrically, corresponding to any position of B on the circle; hence, the curve can be completely traced. It is easy to remark that whatever may be the value of the arbitrary constant λ, the point M lies on the hyperbola CM, for a given value of ϕ. Finally, a geometrical relation is worth noticing, *viz.*, since the circular sector $\text{AOB} = \tfrac{1}{2}h^2\phi$, we have from

$$\text{OCM} = n(\lambda+\phi)\ \text{OBC},$$

the equation

$$\text{OCM} = n\lambda\ \text{OBC} + 2n\,\frac{\text{OAB. OBC}}{h^2}$$

or,
$$\text{OCM} = n\lambda\ \text{OBC} + 2n\,\frac{\text{OAB}}{\text{OA}}.\,\frac{\text{OBC}}{\text{OB}}.$$

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X.—*On the Effects produced by Small Quantities of Bismuth on the Ductility of Silver.*—*By* SURGEON-MAJOR J. SCULLY, *Assay Master, Calcutta.*

[Received June 13th ;—Read July 6th, 1887.]

It is well known that alloys of silver and bismuth, in certain proportions, are brittle. In Dr. Percy's valuable work on Metallurgy (Silver and Gold—Part I), it is stated that alloys of silver with bismuth, in the proportion of 50 per cent. and 33 per cent. of the latter metal, are brittle; while an ore of silver and bismuth, called Chilenite, in which bismuth occurs only to the extent of 14·4 to 15·3 per cent., is said to be malleable. The least amount of bismuth, however, which will injuriously affect the ductility of silver, for example, in such an operation as the lamination of silver bars for coinage, does not, so far as I am aware, appear to have been experimentally investigated. It may here be mentioned at the outset that an alloy of silver and bismuth may, by careful hammering, be extended considerably, so as to pass muster as malleable; although, if subjected to lamination by means of steel rolls, the same alloy will crack at the edges and thus show a deficient ductility, as compared with pure silver or some silver-copper alloys. It is to the deficiency in ductility, as tested by rolling, of silver containing only very small proportions of bismuth that I here wish to call attention.

My attention was first prominently directed, about two years ago, to the injurious effects caused by small quantities of bismuth in silver by the circumstance that some silver bullion, in the shape of English refined bars of as high a fineness as 990 per mille, proved so brittle as to be unfit for mintage. Attention was first attracted to this matter by the peculiar behaviour under assay of the granulated samples taken from this silver after melting. The appearances noticed under assay will be referred to presently, but they led to the bullion being at once tested for brittleness. A bar, about 21 inches long, 2·25 broad, and 1 inch thick, was hammered out at one end without cracking, but on being passed through the rolls it cracked badly at the edges and was pronounced to be "brittle," in the Mint sense of the term. The bullion was then remelted in five plumbago pots, and a partial refinement of it attempted in the ordinary way with nitre, about eight to ten pounds of this salt being used for each pot. The resulting silver bars were not appreciably improved by this treatment; hammering again proved an inconclusive test, but a bar of the size I have mentioned broke in two by merely dropping on the floor of the melting room.

In the meantime the assay had shown that the brittle bullion contained bismuth, and that this was the only substance present likely to be the cause of brittleness. The Indian process of assaying silver has been described by Dr. Busteed in the Journal of the Asiatic Society of Bengal (1870, Part II. p. 377); and a brief abstract of this paper is given on p. 292 of Dr. Percy's work before mentioned. The main features of the process may here be briefly recapitulated for the purpose I have in view. A fixed weight of the silver bullion to be assayed is dissolved in an assay bottle, by means of nitric acid aided by heat; the solution is diluted with water and an *excess* of hydrochloric acid is added, to precipitate all the silver present as chloride. The silver chloride having been caused to aggregate and settle by vigorous shaking, the bottle is filled up with water and the supernatant fluid is subsequently syphoned off, to remove all the now dissolved matter which may have been contained in the bullion. Under these conditions of solution, precipitation and dilution with water, chemists will readily understand that even a small trace of bismuth, if it be in the silver, will reveal its presence by the partial formation of insoluble oxychloride of bismuth. Now, in the assay of the brittle bullion under consideration, solution in nitric acid had been readily and completely effected by the aid of heat: antimony and tin were consequently absent. After the addition of water and hydrochloric acid, however, the solution in the assay bottles could not be cleared by shaking; the bulk of the silver chloride collected at the bottom of the bottles, but the supernatant fluid remained turbid. Tin and antimony being excluded, only two metals could produce this result in the wet assay of silver, namely, mercury and bismuth. To determine which of these is the interfering metal it is only necessary to note the effect of solar light on the silver chloride formed ; when mercury is present the silver chloride maintains its pure white colour unaltered, while in the presence of bismuth the chloride immediately acquires the well known purple colour under the influence of daylight. Our assays, then, being turbid after precipitation and yet the silver chloride blackening readily under the influence of daylight, it was evident that bismuth was present. The turbidity produced was due to the partial formation of bismuth oxychloride ; and this compound diffusing itself in its characteristic manner through the solution had broken up part of the silver salt into very fine powder, so that some hours had to elapse before the supernatant fluid cleared by the gradual subsidence of both bismuth oxychloride and the finely divided silver chloride. The assay was of course thus rendered unreliable, since the silver chloride to be weighed, and on which the calculation of the fineness rested, was contaminated with bismuth oxychloride. A cupellation assay of this bullion was at once had recourse to for ascertaining its fineness.

So far, then, this tender of silver bullion seemed to establish the following points :—

1. Silver bullion of as high fineness as 990 per mille is rendered unfit for coinage purposes by an amount of bismuth which, in this particular case, could not possibly have exceeded 1 *per cent.*, and was probably less than that proportion.

2. Hammering a bar of silver bullion is not a good test for detecting brittleness, as far as mint purposes are concerned.

3. The toughening of silver bullion 990 fine, and containing only a small amount of bismuth, by the aid of nitre in plumbago melting pots, is not readily effected.

4. The presence of a trace of bismuth in silver of high fineness is immediately detected in the ordinary course of assay by the Indian method, but this bismuth interferes with the perfect accuracy of the results obtained by that process.

A comprehensive research seemed therefore called for to elucidate the whole subject, and the necessity for this investigation has since been emphasized by the fact that silver bullion contaminated with bismuth has frequently found its way to the Mint since its first discovery here. The points to be investigated seemed naturally to group themselves under the following heads :—

I. Is our ordinary wet assay of silver susceptible of such easy modification as will enable us to obtain perfectly accurate results by it, in presence of bismuth, without having recourse to the confessedly less accurate assay by cupellation ? And, how may small quantities of bismuth in silver be readily estimated with the despatch indispensable for mint operations ?

II. What is the smallest amount of bismuth in silver that will render it unfit for coinage, when present in bars of the Indian standard fineness of 916·6 ? And, what is the amount of bismuth that may be tolerated in such bars without materially injuring their ductility ?

III. How is silver bullion containing bismuth which may be tendered to the Mint, to be dealt with, supposing that establishment accepts any metal that is brittle ; and how is the presence of bismuth in refined bars to be accounted for ?

I. As the purity of the bismuth to be used in the experiments now to be detailed was a matter of first importance, I may briefly mention the steps taken to ensure the purity of the metal. Refined bismuth was dissolved in nitric acid, precipitated as basic nitrate by diluting largely with distilled water, the nitrate digested in solution of caustic potash, and then well washed, dried, and reduced by heating with charcoal in a clay crucible. A series of synthetical assays, made by dissolving together pure silver and pure bismuth, the latter in the proportion of from 1 to 5 millièmes, showed that our ordinary process of assay, under such conditions, gave unreliable results, there being a surcharge, or higher report than should have been obtained, which varied from 0·7 to 2·7 mill. when the proportion of bismuth was from 3 to 5 millièmes. A modification in our process of assay was evidently required if it were to be used for determining the fineness of silver bullion containing bismuth ; and the necessary steps to this end were, after repeated experiment, found to consist in adding the smallest possible amount of hydrochloric acid for the precipitation of the silver, and increasing the amount of nitric acid in which it was first dissolved. We use ordinarily for the precipitation of an assay pound of silver 5·4 cc. of hydrochloric acid of sp. gr. 1075, but 2·5 cc. of acid of this strength suffices for the complete precipitation of an assay pound of even fine silver ; so that we have here at once a means of diminishing the tendency of any bismuth in the silver to form insoluble oxychloride. If in addition to diminishing the amount of hydrochloric acid we added a considerable excess of nitric acid to the solution (which acid would not in any way interfere with the silver chloride formed), all risk of the partial formation of insoluble bismuth salts seemed removed. This in fact has proved to be the case, and the successful modified process for the assay of silver containing bismuth is as follows :—

The assay pound of silver bullion containing bismuth is dissolved in 5·5 cc. of nitric acid, sp. gr. 1200, with the aid of heat, about 5 ounces of water are added and then 10 cc. of nitric acid sp. gr. 1320. The silver is now precipitated by the addition of 2·5 cc. of hydrochloric acid, and after vigorous shaking the supernatant fluid will be found perfectly clear; and it will remain so when the bottle is filled up with water, all the bismuth present being in solution. Whenever samples of silver now show the presence of bismuth during the assay, a fresh set is taken up and worked by the modified process, the delay thus caused not amounting to more than a few minutes. It may be mentioned here that all our assays are reported to one-tenth of a millième (0·1 per mille).

Having thus ascertained the presence of bismuth in silver bullion and put in practice a modification of the assay process which renders us indifferent to its presence, it is still of importance to ascertain the exact proportion of bismuth which is present in the bullion; and, to be of practical use for mint work, this determination must be effected rapidly and as simply as possible. The ordinary directions given for the separation of bismuth in the presence of silver, by first removing the latter as chloride and then precipitating the bismuth as carbonate, do not, I find, give accurate results when silver is present in such overwhelming proportions as obtain in the cases under consideration.

I have therefore adopted the following plan, which a number of synthetically prepared solutions have proved to give quick and good results, though sometimes the amount of bismuth present is very slightly under-estimated. The ordinary silver assay having given a rough visual estimate of the amount of bismuth likely to be present, enough of the bullion is taken to yield a fairly weighable amount of bismuth oxide in the final result. The bullion is dissolved in a small amount of nitric acid, the solution carefully diluted, and an excess of ammonium carbonate at once added, the precipitation being aided by heating. The carbonates of silver and copper at first formed are re-dissolved, and the carbonate of bismuth after a time settles completely at the bottom of the beaker. The contents of the beaker are then passed through a filter, of which the weight of ash yielded by incineration is known, and the carbonate of bismuth on the filter washed quite free of all traces of silver. The filter is then dried, its contents transferred to a porcelain crucible for ignition, the filter paper being ignited separately, treated with a drop or two of nitric acid to re-oxidise any bismuth oxide reduced by contact with the carbon of the filter, and the ash added to the crucible. From the weight of bismuth oxide thus found, after deducting the weight of the filter ash, the amount of metallic bismuth present in the sample of bullion taken for analysis can be at once found.

There are only two metals likely to interfere with accuracy of the process here described, namely, cadmium and lead; the carbonates of both these metals being as insoluble in excess of the precipitant employed as bismuth carbonate. Cadmium is very unlikely to be found in silver bullion and its consideration may be neglected, but if the presence of lead is suspected the carbonate filtered from the silver solution is dissolved in nitric acid, evaporated down with the addition of sulphuric acid, and the lead sulphate formed (if any) collected and weighed in the usual way. The bismuth is again precipitated as carbonate and treated as before directed. Many experiments have been made with synthetically prepared mixtures of silver, copper, lead, and bismuth, the latter two metals being in very small proportion to the silver, so as to imitate the composition of some refined bars. Ullgreen's plan for the separation of the carbonates of lead and bismuth, by dissolving them in acetic acid and then precipitating the bismuth by means of a lead rod, does not work satisfactorily and requires too long a time for the precipitation.

II. As it seemed likely that a large number of experiments would be required to determine accurately the smallest amount of bismuth that would injure the ductility of our coinage alloy, and the still smaller proportion that would not sensibly affect this ductility, it was determined to begin the enquiry by a number of laboratory experiments on small bars of silver; before trying the effects of bismuth on ordinary coinage bars and with the procedure for lamination carried out in the Mint. These laboratory experiments were made in the following way: Pure silver prepared for assay check purposes, or an alloy of silver and copper of which the exact composition had been determined by assay, was melted in a clean plumbago crucible under charcoal. When the metal was in fusion the necessary amount of bismuth was rolled in a piece of paper, carried down at once to the bottom of the silver bath, and then thoroughly mixed with the silver by stirring. The calculated composition was confirmed by assay of the silver. When this mixture had been accomplished, the contents of the crucible were poured into an open iron ingot mould, and after cooling, either quickly by plunging the casting into water or slowly in contact with the mould, the bar so cast was tested for brittleness by hammering and rolling. The bars cast were of two sizes, one set being 3·75 inches long, 1·125 broad, 0·375 thick and weighing about 6·2 troy oz.; and another set 2·69 inches long, 1·125 broad, 0·25 thick and weighing about 4·1 troy oz. When reduced to the fullest extent by rolling, these bars were converted into straps about 0·015 in thickness. In laminating them they were twice annealed, first after having undergone four pinches in the rollers, and again after the tenth pinch from the beginning Similarly shaped bars of silver, without bismuth, were occasionally laminated in the same way to obtain a sure means of comparison. Before any result was accepted as to brittleness or its absence, the bar under experiment was always remelted and tried at least a second time. The number of experiments in this series amounted to *fifty-three*, and the following is a summary of the results obtained.

Fine silver when alloyed with only 1 per mille (one thousandth part of its weight) of bismuth, and the casting rapidly cooled by plunging it into water as soon as it has set, has its ductility, as tested by lamination, sensibly but slightly impaired, the straps resulting from rolling having slightly jagged edges. When the proportion of bismuth is increased to 2, 3, 4 and 5 per mille, the plan of cooling remaining the same, the raggedness of the edges of the straps was somewhat increased but not very markedly. If, however, the casting was allowed to cool down completely, but very slowly, in contact either with the mould or a stone floor, the results were very different. Under this condition of cooling, a bar composed of fine silver with 4 per mille of bismuth was completely brittle; it was readily broken and its fracture was strongly crystalline. On laminating it, small cracks appeared all over the surface on the second pinch, the bar emitting a crackling sound under the rolls, much like the "cry" of tin, and on the 4th pinch the bar cracked deeply at the edges. This remarkable effect on the molecular structure of this alloy of silver and bismuth, as due solely to the mode of cooling the casting, was repeatedly verified on the same metal by remelting and cooling rapidly and slowly alternately. The case seems analogous to that of bronze, where slow cooling of the alloy after casting is said to make it hard and brittle.

Fine silver with 6 per mille of bismuth, rapidly cooled, was distinctly cold-short and crystalline on fracture; the bar cracked on the surface at the 4th pinch. With 7 per mille of bismuth these evidences of diminished ductility were slightly more pronounced. With 8 per mille of bismuth the silver was still more brittle, the bar broke readily when hammered, and cracked all over the surface on the 4th pinch from the rolls. With 9, 10 and 11 per mille of bismuth, the bar of silver could be readily broken in two by merely striking it against the edge of an anvil, the fracture was coarsely crystalline, and the bar, in one case, proved to be very red-short, a mere tap from the tongs sufficing to break it in two when heated for the purpose of annealing. Although these bars were so very brittle, it was still possible to roll them into thin straps after careful annealing; but the edges of the straps so produced were deeply jagged and indented by cracks. These bars also all emitted the peculiar crackling noise under the rolls which has before been mentioned.

An alloy containing 990 parts of silver and 10 of copper then had added to it successively 1, 2, 3, 4, and 5 per mille of bismuth, the castings being rapidly cooled. The remarks already made with reference to fine silver alloyed with the same proportions of bismuth would apply here almost exactly, that is to say, the bars were rolled out to a thickness of 0·015 with somewhat ragged edges, so that, although ductility, as thus tested, was impaired, it was only slightly so. With 6 per mille of bismuth (fineness of metal on assay 983·9) the edges cracked a little, and, after annealing and rolling out, the strap had decidedly jagged edges and was split for some distance at one end. The bars containing 4, 5 and 6 per mille of bismuth were now remelted and allowed to cool slowly and completely in the mould. They were all found to be highly brittle, broke easily under the hammer—the fracture being granular and not crystalline—and on being rolled they cracked badly, all over the surface and at the edges, on the 1st or 2nd pinch; in one case the bar broke in two on the 2nd pinch. That these very different results were again solely due to the manner of cooling was proved by remelting and rapidly cooling the castings, when the same metal proved comparatively ductile, as first stated.

Silver of the Indian standard of 916·6 per mille (the rest being copper) to which 2 per mille of bismuth was added, gave on lamination straps with slightly jagged edges and proved to be red-short. With 4 per mille of bismuth the bars showed a few surface cracks on being rolled, and the resulting straps had decidedly jagged edges. Slow cooling of these castings did not affect their ductility, thus showing a marked contrast to what had been observed in the case of fine silver and the alloy containing only 10 per mille of copper. When the amount of bismuth was increased to 5 per mille, the copper present remaining at 83·4 per mille, the bars were decidedly brittle and cracked readily on hammering—the fracture being again granular, and not crystalline as in the case of fine silver. On lamination both surface and edge cracks developed after four pinches from the rolls, and in annealing one of these bars the whole surface blistered considerably, no doubt owing to the temperature having been carried a little too high. Standard silver with 10 per mille of bismuth, reducing the fineness as ascertained by assay to 906·6, was very brittle, the bars breaking easily under the hammer, and on the 4th pinch from the rolls splitting and cracking all over the surface. In the course of these latter experiments it was ascertained that with from 83·5 to 70 per mille of copper present slow or rapid cooling of silver alloys containing bismuth made no appreciable difference in their ductility.

The foregoing experiments having furnished some information as to the amount of bismuth that might be expected to injure our coinage alloy, it was now decided to test that point practically, by operating on coinage bars subjected to the regular procedure for the manufacture of rupees in the Calcutta Mint. The experiments made in this connection were *fourteen* in number. The bars used here for coinage weigh about 253 troy ozs. and are about 20 inches long, 2·25 broad, and 1 inch thick; they are cast in vertical iron moulds. In lamination they are first reduced by 11 pinches to a thickness of 0·23 in.; they are then annealed and finally reduced by 12 additional pinches to a thickness of 0·06 inch. A number of bars, poured from a pot of which the contents had proved on assay of a granulated sample to be 916·6 fine, were selected for the experiments, and as a preliminary step one of the bars was laminated to test its ductility. It rolled out with smooth "wire" edges, and indeed its ductility was beyond suspicion as it resulted from a melting of good coins. Another bar of the same batch was now melted and 1 per mille of bismuth added to it, the result of the addition being checked, in this and all following cases, by the assay of a granulated sample of the metal, taken after thorough stirring. At the 8th pinch both edges of the lower half of this bar began to crack, and at the 11th pinch these cracks extended towards the middle line of the strap for about a quarter of an inch, and occurred at about every half inch of the edge. After annealing, and in the subsequent lamination to a thickness of 0·065 inch, these cracks increased considerably in number, but did not become sensibly deeper. The strap as finished was pronounced unfit for coinage purposes; for although two blanks could have been cut from its width, the edges were too jagged to admit of the blanks being obtained exactly along the line from which it was desired to cut them—this position being attained by means of a fixed lateral guide against which the edge of the strap had to be maintained in cutting. With 2 per mille of bismuth the results obtained on rolling were not much worse than with 1 per mille. But the side cracks opened out more, and here again it was noticed that the lower portion of the bar (upper and lower here having reference to the casting in upright moulds) was somewhat less ductile than the upper part.

With 3 per mille of bismuth (fineness on assay 913·8) the bar began to crack on both edges at the 9th pinch; at the 11th pinch there were many cracks quite a quarter of an inch deep, and after annealing the bar these cracks increased at every pinch, so that at the 21st pinch the strap was cracked all along both edges very badly. It would only have been possible to obtain one blank from the width of this strap.

As it was perfectly clear that no further experiments were required with larger proportions of bismuth, the subsequent trials were made on coinage bars containing 0·5 per mille, 0·25 per mille, and, by dilution of the latter bars with standard silver, to even half and a quarter of the lesser proportion just stated. Here the results were rather discordant; they appear to have been somewhat influenced by the state of different rolls, and by quick or slow annealing. The general outcome of the tests, however, was that although some of the straps, containing the proportions given of bismuth, were jagged at the edges, and so would have yielded a diminished percentage in outturn of good blanks, others were not materially worse than the average of straps without any bismuth at all. As a result of this part of the enquiry, it may, I think, be fairly concluded that if our coinage bars contain less than 0·5 per mille of bismuth their ductility will not be materially affected. It must be borne in mind that these results only apply to bars of the size and shape of those experimented on, and with the particular treatment in lamination above detailed. With thinner bars and a different method of rolling, different results may be expected. The system of cutting out blanks has also to be considered, for in some mints straps with saw edges are not so prejudicial as in others.

III. We have now to consider the best way of dealing with silver tendered for coinage which is proved to contain bismuth; and a few remaining points.

The only experiment on a large scale for refining such silver here, as far as I know, has already been described. The want of success which attended it seemed to be due to the very small amount of base metal in the bullion, for the formation of a slag in which the bismuth oxide could be entangled and removed by skimming; and possibly the reducing action of the plumbago pots used may have added to the difficulty. As it seemed certain, however, that nitre would effect the desired oxidation of the bismuth, some experiments were tried in this direction on a small scale. About 20 troy ozs. of silver containing 2·5 per mille of bismuth, and no other metal in appreciable quantity, was melted in a *clay* pot and repeatedly treated with nitre and borax, the bath being skimmed from time to time. After prolonged treatment in this way, the fineness of the silver being three times tested by a dip assay, the report on the silver was raised from 997·5 to 999·2; so there can be no doubt that bismuth may be removed in this way. But the process, as several experiments showed, is tedious; and of course is attended with a loss of silver which in large operations would be of notable amount. Considering therefore that silver containing bismuth has hitherto only been met with at the Mint in bars of high fineness, and that these are not readily refinable by the ordinary process, it would seem as well, if such silver be accepted at all, to deal with the bismuth in it by the plan of *dilution.* The proportion of bismuth any silver contains being ascertained, it may, if convenient, be mixed by melting with sufficient silver free from bismuth, and with copper, so as to reduce the proportion of bismuth in the coinage bars to less than 0·5 per mille; and thus neutralize its injurious effects on the ductility of the bars.

The explanation of small quantities of bismuth being found in refined silver, *i. e.*, silver which has undergone parting for the extraction of the gold which was contained in it, seems sufficiently indicated in the following extract from Dr. Percy's work (Silver and Gold, Part I, p. 474), where that author is referring to the experience of Dr. Rössler in parting silver: "Bismuth has been found in nearly all kinds of silver; but in parting by sulphuric acid it is lost *partly in the fine silver* and partly in the slags." The italics are mine. That small quantities of bismuth adhere very tenaciously to silver, when once mixed with that metal by melting, is shown by the following experience. A quantity of silver containing bismuth, which had accumulated from the laboratory experiments before detailed, was melted, granulated, dissolved in nitric acid, and the silver precipitated as chloride. The silver chloride, after repeated washings, was reduced by heating in a plumbago pot with chalk and charcoal. The resulting ingots, on assay, showed at once that bismuth was still present in them in very appreciable quantity.

It may here be of interest to mention that I have found about 0·7 per mille of bismuth in some old Hindu punched coins, forming part of of a treasure trove which was found at Chaibassa, in the Singhbhum District.

The following is a summary of the main results detailed in this paper:—

1. The Indian assay process for silver bullion is, incidentally, a delicate qualitative test for the presence of bismuth in such bullion.

2. The assay process can be readily modified so as to give accurate results in the presence of such proportions of bismuth as are likely to be encountered in practice.

3. Fine silver when alloyed with only 1 per mille of bismuth has its ductility sensibly impaired thereby; and 1 per cent. of bismuth is sufficient to render fine silver, or alloys of it with copper down to 906 fine, extremely brittle.

4. Fine silver alloyed with small quantities of bismuth, and silver-copper alloys down to 980 fine when containing small proportions of bismuth, have the remarkable property of being more ductile when rapidly cooled in water after casting than if allowed to cool very slowly, thus resembling bronze in this respect.

5. Coinage bars such as are used in the Calcutta Mint, and with the procedure there adopted for rolling, are quite unfit for coinage

owing to brittleness, if they contain only 3 per mille of bismuth ; while if the latter metal forms less than 0·5 per mille of the whole mass the ductility of the bars is not much affected.

In conclusion, I have much pleasure in recording my appreciation of the services of Messrs. J. R. L. Durham and E. Hood, Head and Second Assistants in the Assay Office, in carrying out under my directions many details of the experiments recorded in this paper.

Calcutta, March, 1887.

P. S.—June 10th. The experiments detailed in the foregoing paper were completed early in November 1886 and it was proposed to embody the conclusions formed in an official report to be submitted this year. It was suggested to me, however, that the subject investigated might be of general interest, and I had determined to publish this paper when I noticed in the Chemical News of March 21st, 1887, (p. 137), a short abstract of a paper on " Silver containing Bismuth " by Messrs. Gowland and Koga of the Japan Mint. I have delayed presenting this paper until I had read the full text of the communication from Japan (Journal of the Chemical Society No. CCXCIV, May, 1887, p. 410), and I may now make a few remarks upon it in connection with what I have advanced.

Messrs. Gowland and Koga's very interesting paper to a great extent covers ground which I had not investigated, *viz.*, the want of uniformity in composition of silver bullion containing bismuth. This part of the subject was suggested to me for experiment, as some of my results seemed to show that bismuth mixed with silver by melting and careful stirring does not diffuse itself evenly throughout the solidified mass. But that fact, now proved by Messrs. Gowland and Koga, was of no practical importance to us in the assay and valuation of bullion, seeing that it is an invariable rule now in the Calcutta Mint to premelt and assay by a granulated sample *every* kind of bullion tendered to the Mint—from refined bars 999·5 fine to Mexican Dollars. The well-known want of homogeneity in solidified silver-copper alloys, and other contingencies to which silver bullion is subject, render this course imperative for purposes of valuation on any extended scale. The cutting of samples from silver bullion for assay, even if the spot where such samples should be cut has been determined after most laborious investigation, can at best give merely approximate results ; as indeed our authors admit for the case of silver containing bismuth.

With regard to the toughening or refining of silver containing bismuth, Messrs. Gowland and Koga mention that this operation is successfully performed in the Japan Mint by prolonged exposure of the molten metal to the oxidising action of the air, aided in some cases by the use of nitre. This may seem at variance with our experience here, but is probably not so after all. The brittle bullion treated in Japan evidently contained a considerable amount of base metal in addition to the bismuth; the slags formed in the early stages of the melting consisting chiefly of litharge, &c. What we had to deal with was refined silver 990 fine, and in this case of course it would be more difficult to free the bullion from bismuth than if lead and other base metals were present in sufficient quantity to form a copious slag. But in any case (without, however, venturing to give any authoritative opinion on the subject) I doubt whether the Indian Mints would willingly undertake any considerable refining operations on bullion. The conditions under which these Mints receive bullion are very different from those obtaining in the case of the American and Australian Mints, and the Imperial Mint of Japan. In those countries encouragement has to be given to native mining industries, and hence a good deal of work in the way of purification and separation of metals is undertaken by their mints. In India practically all the bullion is imported by banks and merchants, from Europe, America, and elsewhere, and tendered to the Mints for coinage at a fixed charge. The Indian Mints may therefore, as in the case of the Royal Mint in London, very properly require that all bullion tendered to them shall be free from taint of brittleness, and so far fit for coinage. It is for the importers to make sure that their purchases are satisfactory in this respect.

As to the amount of bismuth that will render silver brittle, my results seem to be substantially in accord with those of Messrs. Gowland and Koga. They found that pure silver alloyed with only 5 per mille of bismuth was very brittle; the casting, I suspect, was allowed to cool slowly. Coinage bars of 900 fine, containing nearly 14 per mille of bismuth, were brittle and altogether unfit for coinags, as I should have expected. But by special treatment in the way of repeated annealings, some of these bars were rolled down successfully without cracking, although they still could not be used for coinage.

In the other matters treated of in my paper the results obtained will supplement those of my *confrères* in Japan.

XI.—*On Monge's Differential Equation to all Conics.*—*By* ASUTOSH MUKHOPADHYAY, M. A., F. R. A. S., F. R. S. E., *Communicated by* THE HON'BLE MAHENDRALAL SIRCAR, M. D., C. I. E.

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§. 1. *Introduction.*

The present paper relates to the general differential equation of all conics, which was first published by the French mathematician Gaspard Monge in his memoir " Sur les E'quations différentielles des Courbes du Second Degré," (Corresp. sur l'E'cole Polytech. Paris, 1809-13, t. II, pp. 51-54, and, Bulletin de la Soc. Philom. Paris, 1810, pp. 87-88). The subject seems to have attracted the notice of English mathematicians, from the following statement made by Boole in his Differential Equations, pp. 19—20 :

" Monge has deduced the general differential equation of lines of the second order, expressed by the algebraic equation

$$ax^2+bxy+cy^2+ex+fy=1.$$

It is

$$9\left(\frac{d^2y}{dx^2}\right)^2\frac{d^5y}{dx^5}-45\,\frac{d^2y}{dx^2}\,\frac{d^3y}{dx^3}\,\frac{d^4y}{dx^4}+40\left(\frac{d^3y}{dx^3}\right)^3=0.$$

But, here our powers of geometrical interpretation fail, and results such as this can scarcely be otherwise useful than as a registry of integrable forms."

It will be noticed that Boole adds no specific reference ; and as the equation was not found, even after diligent search, as well in the printed works of Monge as in his manuscripts, it was at one time believed that Boole had made a misquotation, till Professor Beman pointed out the source of Boole's statement (Nature, t. XXXIII, pp. 581-582). But I remark that the matter could have been settled in no time, by a reference to the *Royal Society Catalogue of Scientific Papers*, where Monge's memoir is actually mentioned (see Vol. IV, p. 441, tit. Monge, No. 22).* Lastly, it is to be noted that the subject has been very recently considered by Professor Sylvester, in his brilliant Lectures on the Theory of Reciprocants, which have been reported with commendable promptitude by Mr. Hammond in the American Journal of Mathematics (See, in particular, Vol. IX, pp. 18-19).

§. 2. *Derivation of the Mongian.*

We shall first consider the question of deriving the Mongian from the equation of the conic ; the known methods are more or less lengthy

* Monge's Equation was also noticed by Lacroix ; see his great work *Traité du Calcul Différentiel et du Calcul Intégral,* Paris, 1810—1819, t. III, pp. 698—699, as a note to § 634, t. II, pp. 371—372 ; I may add that Lacroix gives the reference to Monge's original memoir.

and tedious; the easiest way known is that of Professor Michael Roberts, who gave the following theorem in the Dublin Examination Papers for 1876 (p. 269, Ques. 6):

"Prove that

$$c\left(\frac{d^2y}{dx^2}\right)^{\frac{8}{3}}+c'\left(\frac{d^2y}{dx^2}\right)^{\frac{10}{3}}=\left(\frac{d^3y}{dx^3}\right)^2,$$

where c, c' are arbitrary constants, is a second integral of the differential equation of the fifth order which represents a conic section."

For Professor Wolstenholme's solution of this question, as well as for the method of obtaining the Mongian by twice differentiating the above equation, see Educational Times Reprint, Vol. XXIV, pp. 104-106, Question 4821; see also, Professor Burnside's Question 7104, in Vol. XXXVIII, p. 71. The method which I propose is as follows:

Let the equation of the conic be written in the standard form

(1) $ax^2+2hxy+by^2+2gx+2fy+c=0.$

Solving this as a quadratic in y, we have (*cf.* Salmon's *Conics*, p. 72, Ed. 1879)

(2) $by=-(hx+f)\pm\left\{(h^2-ab)x^2+2(hf-bg)x+(f^2-bc)\right\}^{\frac{1}{2}},$

which may be written,

(3) $y=\mathrm{P}x+\mathrm{Q}\pm\sqrt{\mathrm{A}x^2+2\mathrm{H}x+\mathrm{B}}.$

Operating on both sides with $\left(\frac{d}{dx}\right)^2$, we have

$$\frac{d^2y}{dx^2}=\pm\left(\frac{d}{dx}\right)^2[(\mathrm{A}x^2+2\mathrm{H}x+\mathrm{B})^{\frac{1}{2}}]$$

$$=\pm\frac{\mathrm{AB}-\mathrm{H}^2}{(\mathrm{A}x^2+2\mathrm{H}x+\mathrm{B})^{\frac{3}{2}}}$$

Therefore,

$$\left(\frac{d^2y}{dx^2}\right)^{-\frac{2}{3}}=\pm(\mathrm{AB}-\mathrm{H}^2)^{-\frac{2}{3}}(\mathrm{A}x^2+2\mathrm{H}x+\mathrm{B}).$$

Operating with $\left(\frac{d}{dx}\right)^3$, we have

$$\left(\frac{d}{dx}\right)^3\left[\left(\frac{d^2y}{dx^2}\right)^{-\frac{2}{3}}\right]=0,$$

which is accordingly the general differential equation to all conics; if we write it in its developed form, after performing the operations indicated, we have

$$9\left(\frac{d^2y}{dx^2}\right)^2\frac{d^5y}{dx^5}-45\frac{d^2y}{dx^2}\frac{d^3y}{dx^3}\frac{d^4y}{dx^4}+40\left(\frac{d^3y}{dx^3}\right)^3=0,$$

which is exactly the equation of Monge who wrote it in the now familiar form

$$9q^2t-45qrs+40r^3=0.$$

It may not be altogether uninstructive to point out that the ease with which the Mongian is derived above is simply due to the fact that, instead of differentiating (as other writers have done) the equation (1) which is an implicit function of x and y, we first express y as an explicit function of x in (3), and then proceed to the differentiation.

It is interesting to investigate the differential equations of all parabolas and circles by the above process. If the curve is a parabola, we have $h^2 = ab$ in the general equation (1), and (2) reduces to

$$by = -(hx+f) \pm \left\{ 2(hf-bg)x + (f^2-bc) \right\}^{\frac{1}{2}},$$

which may be written

$$y = \mathrm{P}x + \mathrm{Q} \pm \sqrt{\mathrm{R}x+\mathrm{S}}.$$

Operating on both sides, as before, with $\left(\frac{d}{dx}\right)^2$, we get

$$\frac{d^2y}{dx^2} = \pm \left(\frac{d}{dx}\right)^2 [(\mathrm{R}x+\mathrm{S})^{\frac{1}{2}}]$$

$$= \mp \frac{1}{4} \frac{\mathrm{R}^2}{(\mathrm{R}x+\mathrm{S})^{\frac{3}{2}}}.$$

Therefore,

$$\left(\frac{d^2y}{dx^2}\right)^{-\frac{2}{3}} = lx+m,$$

so that

$$\left(\frac{d}{dx}\right)^2 \left[\left(\frac{d^2y}{dx^2}\right)^{-\frac{2}{3}}\right] = 0,$$

which is accordingly the general differential equation of all parabolas. When developed, this may be written

$$3\frac{d^2y}{dx^2}\frac{d^4x}{dx^4} = 5\left(\frac{d^3y}{dx^3}\right)^2,$$

which equation was given by Professor M. Roberts in the Dublin Examination Papers for 1875, (p. 277, Question 3).

If the curve is a circle, we must have $a = b$, $h = 0$ in the general equation (1), so that (2) becomes

$$ay = -f \pm \left\{ -a^2x^2 - 2agx + f^2 - ac \right\}^{\frac{1}{2}},$$

which may be written,

$$y = \mathrm{Q} \pm \sqrt{-x^2 + 2\mathrm{H}x + \mathrm{B}},$$

which leads to

$$\frac{dy}{dx} = \pm \frac{-x+\mathrm{H}}{(-x^2+2\mathrm{H}x+\mathrm{B})^{\frac{1}{2}}}$$

$$\frac{d^2y}{dx^2} = \pm \frac{-(\mathrm{B}+\mathrm{H}^2)}{(-x^2+2\mathrm{H}x+\mathrm{B})^{\frac{3}{2}}}.$$

From these, we have

$$1+\left(\frac{dy}{dx}\right)^2 = \frac{B+H^2}{-x^2+2Hx+B},$$

and

$$\frac{\dfrac{d^2y}{dx^2}}{\left[1+\left(\dfrac{dy}{dx}\right)^2\right]^{\frac{3}{2}}} = \text{Constant},$$

whence the differential equation of all circles is

$$\left(\frac{d}{dx}\right)\left\{\frac{\dfrac{d^2y}{dx^2}}{\left[1+\left(\dfrac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}\right\} = 0.$$

But, again, from the above values of $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, we may derive

$$\left(\frac{dy}{dx}\right) \div \left(\frac{d^2y}{dx^2}\right)^{\frac{1}{3}} = \frac{H-x}{(B+H^2)^{\frac{1}{3}}},$$

whence

$$\left(\frac{d}{dx}\right)^2 \left\{\frac{\dfrac{dy}{dx}}{\left(\dfrac{d^2y}{dx^2}\right)^{\frac{1}{3}}}\right\} = 0,$$

or

$$3\left(\frac{d^2y}{dx^2}\right)^2 \frac{d^3y}{dx^3} + 4\frac{dy}{dx}\left(\frac{d^3y}{dx^3}\right)^2 = 3\frac{dy}{dx}\frac{d^2y}{dx^2}\frac{d^4y}{dx^4},$$

and this would also be the differential equation of all circles. But, then, if we examine this equation for a moment, we see that it contains $\frac{d^4y}{dx^4}$, and, therefore, the integral equation corresponding to it contains four arbitrary constants; hence the equation not only includes all circles, but something more, *viz.*, it denotes a certain family of conics which include all circles. In fact, if we integrate the equation, the result comes out in the form

$$Ax^2+By^2+2Gx+2Fy+C = 0,$$

which represents conics referred to the centre.

§. 3. *First Method of integrating the Mongian.*

We shall next proceed to integrate the Mongian equation by ordinary methods. As far as we are aware (and the same view is apparently held by Boole and Sylvester), no direct integration of the equation has as yet been performed, except Professor Sylvester's solution by the Theory of Reciprocants (Amer. Jour. Vol. IX, pp. 18-19).

If we assume $\dfrac{d^2y}{dx^2} = z$, the equation reduces to

$$9z^2 \frac{d^3z}{dx^3} - 45z \frac{dz}{dx}\frac{d^2z}{dx^2} + 40\left(\frac{dz}{dx}\right)^3 = 0.$$

As this is homogeneous in z and its differential coefficients, if we put

$$z = e^{\int u dx},$$

the equation is transformed into

$$9\frac{d^2u}{dx^2} - 18u\frac{du}{dx} + 4u^3 = 0.$$

As this involves only the differential coefficients and the dependent variable, a legitimate transformation is to put $\dfrac{du}{dx} = v$, $\dfrac{d^2u}{dx^2} = \dfrac{dv}{dx} = v\dfrac{dv}{du}$, which give

$$9v\frac{dv}{du} - 18uv + 4u^3 = 0.$$

To separate the variables, assume

$$v = (\lambda + \tfrac{1}{3})u^2,$$

whence
$$\frac{dv}{du} = u^2\frac{d\lambda}{du} + 2u(\lambda + \tfrac{1}{3}).$$

Substituting and simplifying, we have

$$u\frac{d\lambda}{du} = \frac{2\lambda - 6\lambda^2}{1 + 3\lambda},$$

where the variables are separated,

viz.,
$$2\frac{du}{u} = \frac{1+3\lambda}{\lambda(1-3\lambda)}d\lambda = \left\{\frac{1}{\lambda} + \frac{6}{1-3\lambda}\right\}d\lambda.$$

Integrating,

$$2\log ku = \log\lambda - 2\log(1-3\lambda),$$

where k is the constant of integration.

Therefore
$$k^2u^2(1-3\lambda)^2 = \lambda,$$

which is the complete primitive required. It now only remains to express u, λ in terms of x, y; for this purpose, it will be convenient to enumerate the successive transformations we have used, *viz.,*

$$\frac{d^2y}{dx^2} = z = e^{\int u dx},$$

$$\frac{du}{dx} = v = (\lambda + \tfrac{1}{3})u^2.$$

From these we get

$$\lambda = \frac{v - \frac{1}{3}u^2}{u^2},\quad 1 - 3\lambda = 2 - \frac{3v}{u^2},$$

which, being substituted in the equation $k^2u^2(1-3\lambda)^2 = \lambda$, transform it into

$$k^2(2u^2-3v)^2 = v - \frac{u^2}{3},$$

which may be written

$$27k^2v^2 - 3(1+12k^2u^2)v + u^2(1+12k^2u^2) = 0.$$

Solving this as a quadratic in v, we have

$$18k^2v = (1+12k^2u^2) \pm (1+12k^2u^2)^{\frac{1}{2}}.$$

Introducing a new constant m, such that $12k^2m^2 = 1$, this may be written

$$v = \frac{du}{dx} = \tfrac{2}{3}\left\{ (u^2+m^2) \pm m(u^2+m^2)^{\frac{1}{2}} \right\},$$

which gives

$$\tfrac{2}{3}dx = \frac{du}{(u^2+m^2) \pm m(u \;+m^2)^{\frac{1}{2}}}.$$

Let

$$u = m \tan \phi.$$

Therefore

$$\tfrac{2}{3}dx = \frac{d\phi}{m(1 \pm \cos\phi)}$$

$$\frac{2m}{3}dx = \frac{d\phi}{2\cos^2\frac{\phi}{2}}, \text{ or, } \frac{d\phi}{2\sin^2\frac{\phi}{2}}.$$

Integrating,

$$\frac{2mx}{3} + n = \tan\frac{\phi}{2}, \text{ or, } -\cot\frac{\phi}{2}.$$

But

$$\frac{u}{m} = \tan\phi = \frac{2\tan\frac{\phi}{2}}{1-\tan^2\frac{\phi}{2}}, \text{ or, } \frac{2\cot\frac{\phi}{2}}{\cot^2\frac{\phi}{2} - 1}$$

$$= \frac{2\left(\frac{2mx}{3}+n\right)}{1-\left(\frac{2mx}{3}+n\right)^2}.$$

Hence,

$$\log z = \int u dx = m\int \frac{2\left(\frac{2mx}{3}+n\right)}{1-\left(\frac{2mx}{3}+n\right)^2}dx$$

$$= -\tfrac{3}{2}\log p \left\{ 1 - \left(\frac{2mx}{3}+n\right)^2 \right\}$$

Therefore

$$z = p^{-\frac{3}{2}} \left\{ 1 - \left(\frac{2mx}{3} + n \right)^2 \right\}^{-\frac{3}{2}},$$

and

$$\frac{d^2y}{dx^2} = \left\{ \mathrm{A}'x^2 + 2\mathrm{H}'x + \mathrm{B}' \right\}^{-\frac{3}{2}},$$

whence, by two simple integrations, we easily pass to

$$y = \mathrm{P}x + \mathrm{Q} \pm \sqrt{\mathrm{A}x^2 + 2\mathrm{H}x + \mathrm{B}},$$

which at once leads to

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0,$$

the general conic-primitive sought.

§. 4. *Second method of integrating the Mongian.*

We shall next proceed to shew how the Mongian equation may be integrated by means of an integrating factor. The equation being written, as before, in the form

$$9z^2 \frac{d^3z}{dx^3} - 45z \frac{dz}{dx} \frac{d^2z}{dx^2} + 40 \left(\frac{dz}{dx} \right)^3 = 0,$$

if we multiply this by the integrating factor $z^{-\frac{11}{3}}$, it may be written,

$$z^{-\frac{5}{3}} \frac{d^3z}{dx^3} - 5z^{-\frac{8}{3}} \frac{dz}{dx} \frac{d^2z}{dx^2} + \frac{40}{9} z^{-\frac{11}{3}} \left(\frac{dz}{dx} \right)^3 = 0.$$

By the application of ordinary methods (Boole, pp. 222—226. Forsyth, pp. 82—85), the left hand member is seen to be a perfect differential, and, integrating, we get

$$z^{-\frac{5}{3}} \frac{d^2z}{dx^2} - \tfrac{5}{3} z^{-\frac{8}{3}} \left(\frac{dz}{dx} \right)^2 = -3c_1,$$

which may be written

$$\frac{d}{dx} \left\{ z^{-\frac{5}{3}} \frac{dz}{dx} \right\} = -3c_1,$$

whence

$$z^{-\frac{5}{3}} \frac{dz}{dx} = -3c_1 x + 3c_2.$$

Integrating again,

$$z^{-\frac{2}{3}} = c_1 x^2 - 2c_2 x + c_3,$$

whence

$$z = \frac{d^2y}{dx^2} = (c_1 x^2 - 2c_2 x + c_3)^{-\frac{3}{2}},$$

and the solution may be completed as before by two simple integrations.

It is worth noting that though this second method is apparently much shorter than the first method, it may seem to be rather artificial in the absence of any clue to the discovery of the proper integrating factor; the process, however, has the merit of furnishing an immediate proof of Professor Roberts' theorem, quoted above in §. 2. Thus, since

$$z^{-\frac{5}{3}}\frac{dz}{dx} = -3c_1x+3c_2,$$

we have

$$z^{-\frac{10}{3}}\left(\frac{dz}{dx}\right)^2 = 9c_1^2x^2-18c_1c_2x+9c_2^2$$

$$= 9c_1(c_1x^2-2c_2x+c_3)+9(c_2^2-c_1c_3)$$

$$= 9c_1z^{-\frac{2}{3}}+9(c_2^2-c_1c_3).$$

Multiplying both sides by $z^{\frac{10}{3}}$, and then substituting $z = \frac{d^2y}{dx^2}$, $9c_1 = c$, and $9(c_2^2-c_1c_3) = c'$, we get

$$c\left(\frac{d^2y}{dx^2}\right)^{\frac{8}{3}}+c'\left(\frac{d^2y}{dx^2}\right)^{\frac{10}{3}} = \left(\frac{d^3y}{dx^3}\right)^2,$$

which is exactly Roberts' theorem quoted above; and this not only shews that the Mongian can be derived from this equation, but also that it is a second integral of the Mongian.

§. 5. *Permanency of Form.*

Professor Sylvester has remarked that the Mongian equation has permanency of form, that is to say, if we seek the transformation of the Mongian when y is the independent and x the dependent variable, the required formula is obtained by interchanging x and y in the Mongian; this theorem, which is proved from the properties of projective reciprocants, may easily be established as follows. Corresponding to the integral equation

$$(4)\quad ax^2+2hxy+by^2+2gx+2fy+c = 0,$$

we have Monge's differential equation. If we interchange x, y, we get, corresponding to the integral equation

$$(5)\quad ay^2+2hyx+bx^2+2gy+2fx+c = 0,$$

the differential equation

$$(6)\quad 9\left(\frac{d^2x}{dy^2}\right)^2\frac{d^5x}{dy^5}-45\frac{d^2x}{dy^2}\frac{d^3x}{dy^3}\frac{d^4x}{dy^4}+40\left(\frac{d^3x}{dy^3}\right)^3 = 0.$$

But the equation (5) represents a conic, and as all conics are represented by the Mongian, the Mongian corresponds to (5); but, as (6) also corresponds to (5), we see that the Mongian and (6) are identical, or mutually transformable, which establishes the theorem in question.

By a similar reasoning, we can prove that the equation

$$3\frac{d^2y}{dx^2}\frac{d^4y}{dx^4}=5\left(\frac{d^3y}{dx^3}\right)^2,$$

which denotes all parabolas, the equation

$$3\left(\frac{d^2y}{dx^2}\right)^2\frac{d^3y}{dx^3}+4\frac{dy}{dx}\left(\frac{d^3y}{dx^3}\right)^2=3\frac{dy}{dx}\frac{d^2y}{dx^2}\frac{d^4y}{dx^4},$$

which represents all conics referred to co-ordinate axes through the centre, the equation

$$x\left(\frac{dy}{dx}\right)^2+xy\frac{d^2y}{dx^2}=y\frac{dy}{dx},$$

which represents all conics referred to principal axes through the centre, the equation

$$\left(x\frac{dy}{dx}-y\right)\frac{dy}{dx}=2xy\frac{d^2y}{dx^2},$$

which represents all parabolas referred to two tangents as axes, and the equation

$$\left\{1+\left(\frac{dy}{dx}\right)^2\right\}\frac{d^3y}{dx^3}=3\frac{dy}{dx}\left(\frac{d^2y}{dx^2}\right)^2,$$

which represents all circles, have permanency of form. Of course, by actual calculation we can establish that, if in each of these equations we make y the independent and x the dependent variable, we have simply to interchange x and y. We subjoin below the formulæ necessary for such a verification.

$$\frac{dy}{dx}=\frac{1}{\frac{dx}{dy}}$$

$$\frac{d^2y}{dx^2}=-\frac{\frac{d^2x}{dy^2}}{\left(\frac{dx}{dy}\right)^3}$$

$$\frac{d^3y}{dx^3}=\frac{3\left(\frac{d^2x}{dy^2}\right)^2-\frac{dx}{dy}\frac{d^3x}{dy^3}}{\left(\frac{dx}{dy}\right)^5}$$

$$\frac{d^4y}{dx^4}=\frac{10\frac{dx}{dy}\frac{d^2x}{dy^2}\frac{d^3x}{dy^3}-\left(\frac{dx}{dy}\right)^2\frac{d^4x}{dy^4}-15\left(\frac{d^2x}{dy^2}\right)^3}{\left(\frac{dx}{dy}\right)^7}$$

$$\frac{d^5y}{dx^5} = \frac{105\left(\frac{d^2x}{d^2y}\right)^4 - 105\,\frac{dx}{dy}\left(\frac{d^2x}{dy^2}\right)^2\frac{d^3x}{dy^3}}{\left(\frac{dx}{dy}\right)^9}$$

$$+\frac{5\left(\frac{dx}{dy}\right)^2\left\{3\,\frac{d^2x}{dy^2}\,\frac{d^4x}{dy^4}+2\left(\frac{d^3x}{dy^3}\right)^2\right\} - \left(\frac{dx}{dy}\right)^3\frac{d^5x}{dy^5}}{\left(\frac{dx}{dy}\right)^9}.$$

From the character of these formulæ, it must be evident that considerable calculation is unavoidable even in the simplest cases of verification.

§. 6. *Geometrical Interpretation.*

We shall, in the last place, refer to the geometrical signification of the Mongian equation. It will be seen from the passage quoted above (§. 1) from Boole, that he regarded this as a case where our powers of geometrical interpretation fail. With respect to this passage, Professor Sylvester, in his Lectures on the Theory of Reciprocants already mentioned (Amer. Jour., Vol. IX, p. 18), remarks, "The theory of reciprocants, however, furnishes both a simple interpretation of the Mongian equation, and an obvious method of integrating it"; and the geometrical interpretation which the learned professor arrives at, is that the differential equation of a conic is satisfied at the sextactic points of any given curve. With regard to this geometric interpretation, it may be remarked that it was not necessary to call in the aid of the theory of reciprocants to establish this theorem. The theorem is self-evident from the very definition of a sextactic point as one where an infinite number of conics can be drawn having five-pointic contact with the given curve; the integral equation of a conic, with its five available arbitrary constants, denotes a determinable conic for any given values of the constants, while the differential equation, being free from constants, appropriately and adequately represents all conics; and, as an infinite number of conics may be made to pass through a sextactic point, the Mongian must be satisfied at such a point. But, apart from this, and with all deference to the opinion of Professor Sylvester as that of one of the greatest of living mathematicians, I believe that his geometrical interpretation is *not* the one contemplated by Boole. A careful examination of the section on "geometrical illustrations" (Boole, pp. 18—20) will make it clear that, by the process of the geometrical interpretation of the differential equation of a curve, Boole meant the determination of some particular geometrical property which belonged to every curve of the system covered by the differential equation, and the inherence of which property was adequately represented by the equation; take, for example, the case of the circle, of which the differential equation is

$$\left\{1+\left(\frac{dy}{dx}\right)^2\right\}\frac{d^3y}{dx^3}-3\frac{dy}{dx}\left(\frac{d^2y}{dx^2}\right)^2=0.$$

Boole points out that this equation represents in an "absolute character" the geometrical fact of the invariability of the radius of curvature of all circles; in fact, I may remark in passing that this equation represents the vanishing of the angle of aberrancy at every point of every circle; for, if δ be the angle of aberrancy, and, p, q, r, the first, second, and third differential coefficients of y in regard to x, we have the formula

$$\tan\delta = p-\frac{(1+p^2)r}{3q^2}.$$

(See Salmon's Higher Plane Curves, p. 369, Ed. 1879). Hence, when the angle of aberrancy vanishes, we have

$$(1+p^2)r = 3pq^2,$$

which is the differential equation of all circles. We see, then, that the differential equation of a circle is the "absolute" analytical representation of some geometrical property which belongs to all circles, and the existence of which is manifested by the differential equation. But Professor Sylvester's interpretation of the Mongian equation is of an entirely different character; it does not furnish us with some property common to all conics; it is simply regarded as the representative of a sextactic point on any curve. What Boole wanted was some intrinsic property, that is, a property belonging to the curve whose differential equation we are interpreting; what Professor Sylvester arrives at, is, if I am allowed the expression, an extrinsic property, that is to say, a property belonging *not* to the curve in question, but to some *extraneous* curve which has six-point contact with the given one. If Professor Sylvester's interpretation were the one contemplated by Boole, nothing would be easier than to interpret a differential equation. Thus, for example, with reference to the differential equation of a circle, we might simply say that it is satisfied at a quadruple point on any curve. Again, the equation

$$3\frac{d^2y}{dx^2}\frac{d^4y}{dx^4}=5\left(\frac{d^3y}{dx^3}\right)^2$$

when integrated, is found to represent all parabolas; but would it be a sufficient geometrical interpretation to say that the equation is satisfied at a quintic point on any curve? The whole point of the matter is, it seems to me, that the property discovered must belong to the curve with which alone we are concerned, and must also be represented by the differential equation to be interpreted. We miss the mark, if we bring in any other curve which is totally foreign to our purpose. I believe, then, that though the theorem enunciated by Professor Sylvester is perfectly correct, it is *not* the geometrical interpretation of the Mongian equation as contemplated by Boole; what Boole sought for in vain, has yet to be discovered.

26*th June* 1887.

XII.—*Notes on Indian* Rhynchota, Heteroptera, No. 2.

By E. T. Atkinson, B. A., President.

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Fam. Pentatomidæ.

Subfam. Scutellerina, Stål.

En. Hem. i, p. 4 (1870); iii, p. 3 (1873):—*Scutellerides, Pachycorides, Tetyyrides* and *Eurygastrides*, pt, Am. & Serv., Hist. Nat. Ins. Hém. pp. 25-51 (1843):—*Praanguli* pt, Amyot, A. S. E. F. (2 s.) iii, p. 401 (1845):—*Pachycoridæ* and *Eurygastridæ*, Dallas, List Hem. i, p. 3, 43 (1851); Walker, Cat. Het. i, p. 1, 61 (1867):—*Scutellerida*, Stål, Hem. Afric. i, p. 32, 33 (1864); Hem. Fabr. i, p. 9 (1868).

Primary and subtended veins of wings distant, including a broad area in the middle: hamus present: scutellum very large, without frena.

Div. Elvisuraria, Stål.

Meso- and meta-sternum with two high wrinkles or ridges, those on the former higher forwards: thorax and scutellum at base, together gradually convex; thorax, at base, produced hindward between the basal angles of the scutellum: second joint of rostrum much shorter than the two apical joints taken together, and a little longer than the apical joint: venter furrowed, without stridulatory strigose spots, incisures gradually curved on the disc.

Genus Oxyprymna, Stål.

En. Hem. iii, p. 5 (1873):—*Elvisura*, Stål (nec Spinola) Hem. Afric, i, p. 35 (1864.)

Venter with a distinct broad furrow continued through it: scutellum with a small spine at the apex. In *Elvisura*, the spine is wanting.

58. Oxyprymna spinolæ, Sign.

Elvisura spinollæ, Sign., A. S. E. F. (4 s.) i, p. 55, t. 2, f. 5 (1861); Walker Cat. Het. i, p. 61 (1867).
Oxyprymna spinolæ, Stål, En. Hém. iii, p. 5 (1873).

Black shining: the head, pronotum, scutellum and especially the abdomen, covered with a grey, powdery, pubescence: pronotum and scutellum with round yellow spots. Head stout, rounded in front, the tylus not extending beyond the juga; the lateral margins weakly sinuate; eyes a little prominent; ocelli equally distant from the eyes and the median line and somewhat near the posterior border; entire head, above and below, except some weakly convex portions, covered with a greyish pubescence which when removed discloses an extremely fine punctuation: anterior border of pronotum straight, sides scarcely sinuated, posterior border strongly rounded, and extending over the scutellum; posterior angles obtusely rounded; near the anterior border are some depressions in which is the grey pubescence, also on the sides and behind the posterior angles; on the disc are some small, round, yellowish marks: scutellum acuminate at the tip, reaching the end of the abdomen, and furnished with a strong median ridge; on each side, near the lateral borders, are depressions clothed with the grey pubescence, and on the disc 6-7 small yellowish patches like those on the pronotum, and towards the second-third a punctured, yellowish band: hemelytra extending weakly beyond the scutellum: abdomen with a strong median groove and covered with a silken grey pubescence, very abundant: feet short, stout, covered with the same pubescence. (*Sign.*) Long, 16; broad 9 mill. Reported from India.

Genus Solenostethium, Spinola.

Solenosthedium, Spinola, Ess. p. 360 (1837); Dallas. List Hem. i, p. 36 (1851)). *Solenostethium*, Am. & Serv., Hist. Nat. Ins. Hém. p. 26 (1843); Mayr, Reise Novara, Hem. p. 13 (1866); Stål, En. Hem. iii, p. 5 (1873). Includes *Cœloglossa*, Germar, Zeitschr. i (i) p. 130 (1839); Herr. Schäff., Wanz. Ins. v, p. 59 (1839); Stål, Hem. Afric. i, pp. 35, 52 (1864).

Body obovate: head a little convex, triangular, rather inclined and flattened; eyes rather stout, globose; ocelli more distant from each other than from the eyes; tylus longer than the juga; antennæ, slender, 5-jointed, somewhat short, second joint shortest, 3-5 joints successively increasing in length: first joint of rostrum not extending beyond the lower surface of the head, fourth joint reaching the end of the rostral canal, between the third pair of feet: thorax sexangular, basal produced part truncate, basal margin straight, posterior and lateral angles rounded : scutellum very large, as broad as the abdomen : sterna and venter furrowed, the sternal furrow ended on both sides by a high ridge, the mesosternal ridges not produced anteriorly : venter in ♂ with two large, opaque, remotely somewhat-pilose spots : tibiæ cylindrical, above slightly bisubsulcate, furnished with a median ridge, margined on both sides *(Spin., Stål)*.

59. Solenostethium rubro-punctatum, Guérin.

Scutellera rubro-punctata, Guérin, Voy. Coq. Zool. ii. (2) p. 157 (1838).

Solenosthedium rubro-punctatum, Dallas, List Hem. i, p. 7 (1851).

Solenostedium rubro-punctatum, Voll., Faune Ent. l'Arch. Indo-Néer. i, p. 4, t. 1, f. 1 (♂) (1843) : Walker, Cat. Het. i, p. 4 (1867).

Solenostethium rubropunctatum, Stål, En. Hem. iii, p. 6 (1873) : Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Head, thorax and scutellum of a rather deep reddish brown : head triangular, immaculate, with a small longitudinal elevation in the middle ; antennæ black : thorax sprinkled with numerous, very small, indistinct, green dots ; three round orange spots on each side, of which one on the anterior margin immediately behind the eyes, another in the middle and a third near the posterior margin ; anteriorly a seventh spot in the middle : the scutellum is without green dots and has six orange spots at the base at an equal distance from each other, and four in the middle behind these, also at an equal distance from each other : body beneath ferruginous yellow with a small black spot on each side of each segment of the abdomen : femora reddish, with the tibiæ and tarsi black *(Guérin)*. Long, 13 ; broad 8½ mill.

Reported from China, Java, Assam. The Indian Museum has specimens from Naga hills, Sikkim. The ♂ has 10, the ♀ 8 spots on the scutellum. *S. chinense*, Stål, is probably only a local variety, as the links between it and *S. rubro-punctatum* are nearly complete.

Div. Sphærocoraria, Stål.

Meso- and meta-sternum without ridges, sometimes furrowed. Body above very convex, beneath very slightly so : head transverse, very much inclined or perpendicular : thorax and scutellum at the base, together, gradually longitudinally convex, basal margin of thorax obtusely rounded towards the basal angles of the scutellum, posterior angles usually obtusely rounded, not distinguishable as angles : second joint of the rostrum much shorter than the two apical together : venter without stridulatory, strigose spots, incisures gradually curved towards the middle.

Genus Hyperoncus, Stål.

Ofvers. K. V.-A. Förh. p. 615 (1870); En. Hem. iii, p. 7 (1873).

Body obovate, above much, beneath slightly convex: head much inclined, triangular, with the eyes broader than long, very slightly convex, lateral margins slightly sinuate near the eyes: rostrum reaching the apex of the third ventral segment, second and third joints almost equally long, first and fourth shorter than them: antennæ 5-jointed (?), first joint not reaching the apex of the head: thorax sexangular, anterior margin very broadly sinuate between the eyes, anterior lateral margins subacute not retusely-sinuated before the lateral angles, basal margin straight, posterior angles obtusely rounded: scutellum as broad as the abdomen, gradually less convex towards the posterior part, anterior margin of prostethium obtusely roundly-dilated towards the coxæ: mesosternum slightly sulcated: odoriferous openings continued outwards in a long furrow: venter longitudinally, slightly furrowed before the middle, sides flat, margins acute, incisures gradually curved in the middle: feet somewhat shortish, tibiæ furnished with two furrows above. Differs from *Sphærocoris* in having the anterior lateral margins of the thorax not retusely sinuated at the lateral angles, the sixth ventral segment in ♂ is roundly produced at the apex and covers the genital segment and in ♀ is arcuately sinuate, leaving the genital valvules free, also the tibiæ above are slightly somewhat 2-furrowed, with a distinct wrinkle between the furrows.

60. Hyperoncus lateritius, Westwood.

Sphærocoris lateritia, Westw., Hope, Cat. Hem. i, p. 13 (1837).

Sphærocoris lateritius, Germar, Zeitschr. i (i) p. 79 (1839): Dallas, List Hem. i, p. 10 (1851); Walker, Cat. Het. i, p. 6 (1867).

Hyperoncus lateritius, Stål, En. Hem. iii, p. 7 (1873).

Obscurely rufescent, much punctured: pronotum with four dots arranged in a transverse line; scutellum with twelve (six, four, two); body beneath antennæ and feet, rufescent; abdomen with a large basal spot (*Westw.*). Body long 11-11½ millims.

Reported from China: there is a doubtful specimen in the Indian museum from the Dikrang valley (Assam).

Div. Scutellaria, Stål.

Meso- and meta-sternum without wrinkles or ridges, sometimes furrowed: body beneath distinctly convex, generally above and below equally convex or beneath more convex. Thorax at the base hindwards, scutellum at the basef orwards, more or less convexly-inclined which is best seen from the side; thorax generally distinctly truncated posteriorly before the entire base of the scutellum, basal angles generally very distinct, situate before or outside the basal angles of the scutellum: venter without stridulatory strigose spots, rarely in ♂ with two opaque spots, incisures gradually curved towards the middle: second joint of rostrum generally shorter and often much shorter than the two apical joints taken together.

Genus Cantao, Am. & Serv.

Hist. Nat. Ins. Hém. p. 29 (1843); Dallas, List Hem. i, p. 3, 17 (1851); Walker, Cat. Het. i, p. 14 (1867): Stål, Hem. Afric, i, p. 33 (1864); En. Hem. iii, pp. 8, 10, (1873); Mayr, Reise Novara, p. 14 (1866).

Body narrowly obovate, elongate: head narrow, elongate, lateral margins slightly sinuate; rostrum not extending beyond the first segment of the abdomen: pronotum broader than long, basal margin straight towards the sides, posterior angles very distinct, dentated, no transverse furrow; scutellum as broad as the abdomen, longer, distinctly impressed at the base near the angles, somewhat truncate or flattened at the tip; exterior margin of corium straight; membrane extending beyond the end of abdomen; anterior margin of propleura entirely obtuse, somewhat callous, posterior margin not sinuate at the angles: venter without opaque spots, with a longitudinal groove in the middle, sides more or less convex, genital segment in ♂ duplicate or divided into two parts, the basal rounded at its tip, the other extremely trilobed and truncate at the tip; vulvar plates in ♀, narrow.

61. Cantao ocellatus, Thunberg.

Cimex ocellatus, Thunberg, Nov. Ins. Spec. iii, p. 60, f. 72 (1784): Gmelin, ed. Syst. Nat. i (4), p. 2133 (1788).

Cimex dispar, Fabr., Ent. Syst. iv, p. 81 (1794); Donovan, Ins. China, Hem., t. 13, f. 1 (1798), sec. Dallas: Stoll, Punaises, p. 143, t. 37, f. 260 A. & B. (1788).

Tetyra dispar, Fabr., Syst. Rhyng. p. 129 (1803); Schiödte, Kroyer's Nat. Tidsskr., iv, p. 281 (1842).

Callidea dispar, Burm., Handb. ii (i) p. 394 (1835); Herr. Schäff., Wanz. Ins. iii, p. 99, t. 105, f. 324 (1835).

Calliphara dispar, Germar, Zeitschr., i (i) p. 123 (1839).

Callidea ocellata, Westw., Donovan l. c. p. 47, t. 20, f. 1. (1842).

Scutellera dispar, Blanchard, Hist. Nat. Ins. iii, p. 158, Hém. t. 8, f. 2 (1840).

Cantao dispar, Am. & Serv., Hist. Ins. Hém. p. 29 (1843).

Cantao rufipes, Dallas, List Hem. i, p. 17 (1851); Walker, Cat. Het. i, p. 14 (1867).

Cantao ocellatus, Dallas, l. c. p. 17 (1851); Vollen., Faune Ent. l' Arch. Indo-Néerl., i, p. 10 (1863); Walker, l. c., p. 14 (1867); Stål, Hem. Fabr., i p. 9 (1868); Ofvers. K. V.-A. Förh. p. 616 (1870); En. Hem. iii, p. 10 (1873): Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Orange yellow or carneous: head yellow, the base and antennæ cœrulean: pronotum and scutellum carneous, the former with sometimes many, sometimes fewer flavescent spots, some with a black point scutellum large, with a small impressed moon-shaped black spot on each side at the base, then three yellow rings marked with a black point, the median larger, behind the middle are two small yellow lunules spotted black and posteriorly rings with a black point in the middle: pectus cyaneous: abdomen carneous with four cyaneous macular striæ; of which the median are larger: feet cyaneous, femora rufous: varies with the sex, with thorax having on both sides a very acute, incurved porrect spine, yellow at base, black at apex (*C. dispar*, Fabr.). Long 14-23 mill. Very variable in the colour above, from a pale sordid yellow to a deep rich orange-red, and in the spots on the pronotum and scutellum, from almost immaculate with merely traces of spots, to the full number; all these varieties occur in India.

Reported from Java, Sumatra, Philippines, China, India. The Indian Museum has specimens from Assam, Sikkim, N. India, Malabar, Ceylon, China.

Genus Pœcilocoris, White, Dallas.

Pœcilochroma, White, Trans. Ent. Soc. iii, p. 84 (1842): Stål, En. Hem. iii, p. 11 (1873): *Pœcilocoris*, Dallas, Trans. Ent. Soc. v, p. 100 (1848); List Hem. i, p. 4 (1851); Stål, Hem. Afric., i, p. 33 (1864); Mayr, Reise Novara, Hem., p. 17 (1866); Walker, Cat. Het. i, p. 8 (1867). The name *Pœcilochroma* was used by Stephens in 1829 for a Lepidopterous genus of *Tortrices*, and Dallas with White's consent changed the name of the Hemipterous genus to *Pœcilocoris* in 1848 and described it for the first time, so that for very good reasons, the new name must stand.

Body ovate, convex: head rather large, broad, the lateral margins sinuated before the eyes: antennæ about half the length of the body, 5-jointed; basal joint short, robust; second, shorter and most slender; 3-5 joints each as long as, or longer, than the two basal united, nearly equal, compressed, broad and furrowed longitudinally on the sides: rostrum usually extending beyond the second segment of the abdomen, sometimes nearly to its apex: scutellum slightly truncated at the apex: abdomen with a more or less distinct furrow beneath; the three penultimate segments in the ♂ not bearing the dull space on each side which exists in *Tectocoris*, Hahn, and the anal plate, in ♂, simple, formed of one piece, sinuated at the tip and fringed with hairs (*Dallas*).

62. Pœcilocoris hardwickii, Westwood.

Tectocoris Hardwickii, Westwood, Hope, Cat. i, p. 13 (1837).
Tectocoris affinis, Westwood, l. c. p. 13 (1837).
Pachycoris nepalensis, Herr. Schäff. Wanz. Ins. iv, p. 1. t. 109, f. 339 (1839).

Scutellera Hardwickii, Germar, Zeitschr. i (i) p. 135 (1839).

Pœcilochroma Hardwickii, Stål, En. Hem. iii, p. 12 (1873); Distant, A. M. N. H. (5 s.), iii, p. 44 (1879).

Pœcilocoris Hardwickii, Dallas, Trans. E. S. v, p. 107, t. 13, f. 8 (1848): List Hem. i, p. 13, (1851); Walker, Cat. Het. i. p. 8 (1867).

♂, ♀. Ovate, convex, above yellowish orange or red, opaque, rather finely and thickly punctured, head black, thickly and strongly punctured; eyes and ocelli brownish: pronotum with the anterior portion and two large spots on the disc, black: scutellum slightly wrinkled transversely at the base; normally, with eleven black spots, placed, three at the base of which the median one is large and elongated-triangular, a small round one on each side of the apex of this, a transverse row of four across the disc, behind the middle, the two intermediate of which are the largest and the two smaller towards the apex; these spots are generally more or less confluent or partially obsolete, forming several varieties: margins of the hemelytra black piceous: abdomen beneath orange-red, very faintly wrinkled, the basal segment entirely, the second (except the middle), the third and fourth on the lateral margins, the terminal segment, except its lateral margins, (and in the ♂, the base) and the anal apparatus, violet-black; the penultimate segment is entirely red: pectus black, tinted with violet, finely punctured; the lateral angles of the prostethium and part of the antero-lateral margins, red: legs violet-black: antennæ and rostrum black. Dallas remarks that in *P. nepalensis*, Herr. Schäff., the spots have become confluent so that the general colour of the upper surface is black: the pronotum is nearly covered by the two spots on the disc which extend forwards to the black anterior margin and posteriorly to the hinder margin; the five spots at the base of the scutellum are united, forming a large waved band across the base, from the middle of which the apex of the triangular basal spot projects, while the two intermediate spots of the transverse row are joined to one another and to the two subapical ones, forming a large, rounded lobate patch. In *P. affinis*, Westwood, the two subbasal and the two subapical spots are wanting and the two spots on the disc are sometimes obsolete. There are numerous varieties between these, but all are distinguishable by the uniform red colour of the fifth abdominal segment (*Dallas*). Body long, 17-20 mill. a very variable species: in some the spots are large and confluent so as to make the general appearance of the upper surface of the scutellum black, and in others red is the prevailing colour. *P. nepalensis*, Herr. Schäff., if not specifically different, forms a well marked variety. Obovate, moderately convex; black, shining, finely and closely punctured, on the antennæ, feet and the underside, bright shining violet: the posterior greater part of the thorax (except two round black spots), a broad transverse band above the middle of the scutellum having forwards four and hindwards three obtuse teeth, and the apical margin of the scutellum, sanguineous. In it, the subbasal spots on the scutellum are confluent so as to form a black band more or less broad, posteriorly dentate; whilst in *T. affinis*, Westwood both the sub-basal and sub-apical spots are wanting. *P. hardwickii* in Dallas' figure, forms the mean between these two extremes.

Reported from India, Nepál, Silhat: the Indian Museum has specimens from the Khasiya and Nága hills, Sibságar and Sikkim.

63. Pœcilocoris latus, Dallas.

Pœcilocoris latus, Dallas, Trans. Ent. Soc. v, p. 101, t. 13, f. 4 (1843); List Hem. i, p. 12 (1851); Walker, Cat. Het. i, p. 9 (1867).

Pœcilochroma lata, Stål, En. Hem. iii, p. 12 (1873).

♂, ♀, Rounded-ovate, not very convex; above yellow, clouded with orange-red, thickly punctured: head violet, shining, thickly and strongly punctured; eyes brown; ocelli red: pronotum thickly punctured, somewhat rugose, with the anterior angles, and two large spots on the disc, extending to the posterior margin, deep blue-violet: scutellum thickly and finely punctured, slightly wrinkled transversely at the base; with a spot in each basal angle, a large, irregular, transverse patch in the middle of the base, and a transverse row of four spots of which the two intermediate are by much the largest, across the disc, behind the middle, deep blue-violet; the surface around all the spots clouded with orange-red: margins of hemelytra, black: abdomen beneath red, immaculate, thickly and finely punctured, and slightly pilose, with a strong median furrow at the base: anal apparatus reddish: pectus thickly punctured, yellowish, variegated with blackish violet, the prostethium pale red, with a violet-black spot at the base of the anterior legs: femora testaceous, [sometimes violet-black] their apices with the tibiæ and tarsi shining violet-black: head beneath yellowish in the middle, with its margins violet: antennæ black, the two basal joints with a violet tinge: rostrum testaceous with the two last joints black, the tip reaching the base of the fourth ventral segment. In some the fine spots in the middle of the base of the scutellum are confluent but normally they are as in *P. Druræi*, Dallas. Body, long 19-21 mill.

Reported from China, Assam. The Indian Museum has specimens from Assam. The variety with the five spots at the base of the scutellum confluent agrees with *P. donovani*, Burm. in this particular, and also in the absence of the two subapical spots and the length of the rostrum, but differs in form and general colouring.

64. PŒCILOCORIS ORNATUS, Dallas.

Pœcilocoris ornatus, Dallas, List Hem. i, p. 15 (1851); Walker, Cat. Het. i, p. 9 (1867).

Pœcilochroma ornata, Stål, En. Hem. iii, p. 12 (1873): Scott, A. M. N. H. (4 s.) xiv, p. 289 (1874).

Above orange-yellow, finely punctured with black: head rather short, the tylus considerably longer than the juga, with the apex slightly turned up; vertex black, with three rows of golden green punctures of which the lateral are broadest, and include the ocelli; front of head, deep red, punctured with violet and green; the apex orange: thorax with the anterior and lateral margins and two large spots on the posterior margin, black, leaving only a narrow transverse band and a longitudinal median line, orange; scutellum with fine confluent black spots on the basal half, forming a broad, irregular W; four others across the middle, united in pairs; forming a band interrupted in the middle, and two close to the apex; all the black spots are tinted with violet and brassy green; abdomen beneath ochreous, very finely punctured, with a large strongly punctured golden-green spot, on each side of every segment; ventral furrow reaching the apex of the fifth segment; pectus testaceous, variegated with golden-green: femora of the same colour with golden-green reflections; tibiæ brown, slightly metallic; tarsi piceous: rostrum yellowish-brown, with the tip black, reaching the middle of the fourth ventral segment: antennæ violet black; basal joint orange-black at the tip (*Dallas*). Long 15—15½ mill.

Reported from N. India, Japan.

65. PŒCILOCORIS DRURÆI, Linn.

Cimex druræi, Linn., Mant. Pl. ii, p. 534 (1771): Drury, Ill. Ins. i, p. 94, t. 42, f. 1 & 5, a, b (1770): Sulzer, Gesch. i, p. 95, t. 10, f. 5 (1776): Fabr., Syst. Ent. p. 697 (1775): Spec. Ins. ii, p. 339 (1781); Mant. Ins. ii, p. 281 (1787); Ent. Syst. iv, p. 83 (1794); Gmelin ed. Syst. Nat. i (4), p. 2129 (1788): Stoll, Punaises, p. 147, t. 37, f. 267 (1788). India.

Tetyra druræi, Fabr. Syst. Rhyng. p. 132 (1803): Burm. Nov. Acta Leop. xvi, Suppt. i, p. 287 (1834).

Scutellera druræi, Germar, Zeitschr. i (i), p. 135 (1839).

Pœcilocoris druræi, Dallas, Trans. Ent. Soc. v, p. 103, t. 13, f. 6 (1848); List Hem. i, p. 12 (1851): Walker, Cat. Het. i, p. 8 (1867).

Pœcilochroma druræi, Stål, En. Hem. iii, p. 12 (1873); Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Scarlet: head and antennæ black; antennæ 5-jointed, a little longer than the thorax, the two first joints, shortest: thorax convex, the lateral margins slightly reflexed, two suboval spots which form an obtuse angle with the head and are truncated on the sides, black:

scutellum with two black bands formed of confluent spots [not always confluent], the basal allowing two scarlet spots to be seen, that just below the middle, irregularly indented on both sides and two round black spots at the apex: hemelytra opaque, membrane fine and with the wings semi-transparent: abdomen beneath scarlet, with an oblong black spot at the anus, and four others on each side reaching the margin: pectus, rostrum and legs blue-black *(Drury)*. Long 18 mill.

Dallas remarks that the normal condition of this species exhibits the typical colouring of the genus: in it the spots on the scutellum are arranged,—five basal, of which the median one is somewhat triangular and rather short, the two intermediate smallest; two behind these, placed opposite the intermedial basal ones, a row of four across the disc, rather behind the middle and two towards the apex: the seven spots at the base are frequently confluent, forming a large basal patch with three large notches in its posterior margin (as in Drury's figure); the row of spots across the disc is also often united to form a transverse band. The narrow basal segment of the abdomen and generally the second segment also, are violet-black; the stigmata of the other segments are surrounded by spots of the same colour which generally occupy the entire lateral margins of the segments and thus form a black border to the abdomen; the terminal segment, except the posterior and lateral margins, is black.

Reported from Hong-Kong, Silhat, Assam: the Indian Museum possesses specimens from Sikkim and Assam.

66. Pœcilocris obsoletus, Dallas.

Pœcilocoris obsoletus, Dallas, Trans. Ent. Soc. v, p. 104 (1848); List Hem. i, p. 12 (1851); Walker, Cat. Het. i, p. 8 (1867).

♂. Ovate, above bright velvety-red, thickly punctured: head and eyes, black; ocelli reddish: thorax with the anterior and lateral margins smooth, shining, rather coarsely and irregularly punctured; two indistinct yellowish patches within the anterior angles, and faint indications of two elongated violet spots on the disc: scutellum slightly wrinkled transversely at the base, and with indications of eleven violet spots, placed five at the base, two behind these, and four in a transverse row across the middle; the apical portion orange, finely reticulated with red; margins of hemelytra bright red, thickly and coarsely punctured: abdomen red, shining, with a few scattered punctures, and a faint longitudinal furrow at the base; the basal segment pitchy black, a small spot around each of the stigmata, and a large crescent-shaped one, on the terminal segment, black: anal apparatus red: pectus violet-black, shining, finely and sparingly punctured, a dull space on each side of the meso- and meta-stethium; the antero-lateral margins and the lateral angles red: femora brownish, slightly tinted brassy, their apices, the tibiæ and tarsi, brassy black; head beneath shining violet, punctured, yellowish at the base: antennæ black, the three basal joints tinted with violet and brassy, the two apical covered with short greyish hairs; rostrum pitchy *(Dallas)*. Long, 19 mill.

Reported from Hong-Kong: I possess specimens from Assam and Sikkim. Dr. Stål united this species with *P. druræi*, and, although the indications of spots are arranged in exactly the same manner as in *P. druræi*, the two subapical ones are generally wanting, whilst the red colour of the margins of the hemelytra, the colour of the legs, the peculiar texture of the margins of the thorax, and the clothing of the two last joints of the antennæ, mark it as a distinct species. In some, beneath, the colouring is exactly as in the preceding, whilst, in others, the pectus and venter are entirely brassy green, and only the anal apparatus and the antero-lateral and lateral margins of the pectus are red.

67. Pœcilocoris interruptus, Westwood.

Tectocoris interrupta, Westwood, Hope, Cat. Hem. i, p. 14 (1837).

Scutellera interrupta, Germar, Zeitschr. i (i), p. 134 (1839): Herr. Schäff., Wanz. Ins. v, p. 73, t. 172, f. 531 (1839).

Pœcilocoris interruptus, Dallas, Trans. Ent. Soc. v, p. 102 (1848): List Hem. i, p. 12 (1851); Walker, Cat. Het. i. p. 8 (1867).

Pœcilochroma interrupta, Stål, En. Hem. iii, p. 13 (1873).

Broadly ovate, rather flat; above brassy black, thickly and finely punctured: eyes pale brown, ocelli red: pronotum with the posterior margin and a curved longitudinal line on each side, within the lateral angles, bright [orange] red: scutellum with a narrow, transverse line on the disc near the middle, interrupted in the middle, and the apical margin, bright [orange] red: margins of hemelytra brassy black, of the abdomen black, variegated with bright red; abdomen beneath, black, shining, slightly brassy, the bases of 2-5 segments in the middle, and a marginal spot on the junction of each segment, red: anal aparatus, black, margined with red in the ♀: pectus brassy black, thickly and finely punctured: antennæ, rostrum and legs, black *(Dallas)*. Dallas remarks that in a long series of this insect there is no indication of distinct spots, but it is probable that the anterior margin and two spots on the disc of the pronotum are black, and that the spots on the scutellum are arranged much as in *P. hardwickii*. Body long 15-19 mill.

Reported from Nepál, India. The Indian Museum has a specimen.

68. Pœcilocoris purpurascens, Westwood.

Tectocoris purpurascens, Westwood, Hope, Cat. i, p. 14 (1837).
Scutellera purpurascens, Germar, Zeitschr. i. (i), p. 135 (1839).
Pœcilocoris purpurascens, Dallas, Trans. Ent. Soc. v, p. 103, t. 13, f. 5 (1848); List Hem. i, p. 13 (1851): Walker, Cat. Het. i. p. 8 (1867).
Pœcilochroma purpurascens, Stål, En. Hem. iii, p. 13 (1873).

♂, ♀. Ovate; above variegated with violet and black, thickly and strongly punctured: head nearly smooth, shining, slightly wrinkled and punctured at the base and the apex; eyes and ocelli brown: pronotum with a small red spot in the middle of the anterior margin, a corresponding one on the posterior margin and a small streak of the same colour on each side towards the lateral angles: scutellum with a small transverse streak on each side before the middle, a smaller longitudinal one towards the apex and an oblique one on each side of this, on the lateral margins, bright red: margins of hemelytra violet-black: abdomen beneath slightly wrinkled, shining brassy-green, the margins violet with an irregular, transverse, red streak on each side of the 2-5 segments: anal apparatus brassy black: pectus violet and green, shining, finely punctured, with a dull black patch on the meso- and meta-stethium: legs violet-black: head beneath violet and green, shining, punctured: antennæ and rostrum, black *(Dallas)*. Dallas observes that the normal arrangement of the spots (indicated by the strong violet tints on various parts of the surface) is the same as in *P. druræi*. Body long 17—19 mill.

Reported from Nepál, Sikkim.

69. Pœcilocoris pulcher, Dallas.

Pœcilocoris pulcher, Dallas, Trans. Ent. Soc. v, p. 105, t. 13, f. 7 (1848): List Hem. i, p. 13 (1851): Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 5, t. 1, f. 2, 2a, (1863); Walker, Cat. Het. i. p. 8 (1867).
Pœcilochroma pulchra, Stål, En. Hem. iii, p. 13 (1873).

♂ Ovate, deep velvety purple, closely and finely punctured: head above of a vinaceous purple, below violet and green, shining, orange at the base, with four longitudinal impressions along the tylus and two oblique dotted hollows at the inner side of the eyes, blackish along the margins of the lobes: eyes brownish, ocelli small, reddish: 1-2 joints of antennæ violet, smooth, rest black, pubescent: pronotum broadly margined with red laterally and anteriorly, and with a narrow, median longitudinal line of the same colour, on the disc, reaching the posterior border: scutellum deep purple with the base (irregularly), a transverse band across the disc before the middle, and a narrow median line uniting these one to the other, also a small spot on each side of the latter (sometimes wanting), shining violaceous: margins of the hemelytra brownish purple: abdomen with a strong furrow at the base, bright red, with a violet reflection, smooth, shining, very finely and moderately punctured; a black spot around each of the stigmata and a faint band of the same colour across the terminal segment: anal plate red: pectus purple variegated with violet and greenish tints, shining, thickly and finely punctured, the antero-lateral margins and lateral angles, red: femora brassy-purple; tibiæ, shining violet; tarsi black: rostrum brassy black, basal joint pale pinkish violet. Spots as in *P. druræi* except that the two subapical ones are wanting, others easily traced in the violet tints of the base, and the broad band across the middle of the scutellum. (*Dallas*). Body long 18-19 mill.

Reported from Malabar, Sumatra.

70. Pœcilocoris childreni, White.

Tectocoris childreni, White, Charlesworth Mag. N. H. iii, p. 542 (1839).

Tectocoris (*Pœcilochroma*) *childreni*, White, Trans. Ent. Soc. iii, p. 84, t. 7, f. 1 (1838).

Pœcilocoris childreni, Dallas, Trans. Ent. Soc. v, p. 106 (1848); List Hem. i, p. 13 (1851): Walker, Cat. Het. i, p. 8 (1867).

Pœcilochroma childreni, Stål, iii, p. 13 (1873).

Head (including eyes, antennæ, and rostrum) black, distinctly margined; ocelli yellow: thorax and scutellum yellowish-fulvous, the former in front black, the black colour extending in a narrow line along the slightly raised lateral margin, with four transverse black spots, the two dorsal ones larger and rather quadrate: legs green: scutellum obtuse, with eleven black spots, three at the base, the median one triangular and largest, two behind these sub-rotundate, four in the middle (the two inner largest) and two near the tip: hemelytra black, somewhat shining: body beneath, purplish black, sides of abdomen with four transverse yellow lines, sometimes confluent at the base and forming a yellow patch, end of abdomen green (*White*). Long, 18; breadth of pronotum, 11 mill.

Reported from Nepál, Sikkim.

The spots on the scutellum are placed,—three basal, of which the median one is large, triangular and produced on each side at the base, in such a manner that it appears as though in the normal state there would be an additional spot on each side, as in *P. druræi*; two behind these, a row of four across the disc, rather behind the middle and two subapical. Distinguished from *P. druræi* by the broad, black anterior margin of the pronotum and the black anal plates: from *P. hardwickii* by the margins of all the segments of the abdomen being violet-black and from both, by the presence of four spots on the disc of the pronotum and by the entire pectus being violet-black. It is possible that in the normal condition the disc of the abdomen may be yellow or orange margined with black *(Dallas)*.

71. Pœcilocoris obesus, Dallas.

Pœcilocoris obesus, Dallas, List Hem. i, p. 13 (1851); Walker, Cat. Het. i, p. 9 (1867).

Pœcilochroma obesa, Stål, En. Hem, iii, p. 13 (1873).

Convex, rather short: above bright red, shining, very finely and rather sparingly punctured, with the head, the fore-part of the thorax and three or more less distinct spots at the base of the scutellum, brassy green: thorax slightly excavated on the anterior margin, the impression strongly punctured and with a strong impression about the middle of each antero-lateral margin: body beneath, antennæ and legs bright brassy green; the antero-lateral margins of the pectus and a spot in the middle of the abdomen, red: rostrum black, reaching the middle of the third segment of the abdomen *(Dallas)*. Body, long $13\frac{1}{2}$-$14\frac{3}{4}$ mill.

Reported from Assam, N. India.

72. Pœcilocoris rufigenis, Dallas.

Pœcilocoris rufigenis, Dallas, List Hem. i, p. 14 (1851); Walker, Cat. Het. i, p. 9 (1867).

Pœcilochroma rufigenis, Stål, En. Hem, iii, p. 13 (1873).

Above orange-yellow with violet reflections, thickly and finely punctured: head purplish red with the base and the whole of the tylus black: thorax with the anterior and lateral margins violet and with a black spot within each anterior angle: scutellum with a narrow black band across the base and a black triangular spot on each side before the middle, touching the lateral margin, its base faintly wrinkled; basal angles strongly rugosely-punctate: margins of hemelytra, black: abdomen beneath and anal plate reddish orange tinted with violet, smooth, shining, very faintly punctured, the terminal segment violet-black, except its margins and a transverse streak of the same colour on each side of the rest of the segments, except the basal one: ventral furrow distinct, reaching apex of the fifth segment: breast shining violet, with the antero-lateral margins, red: legs brassy black: rostrum black, reaching the base of the terminal segment of the abdomen: head, beneath red; with the rostral canal violet-black: antennæ black *(Dallas)*. Long, 19 mill.

Reported from Assam.

73. Pœcilocoris anisospilus, Walker.

Pœcilocoris anisospilus, Walker, Cat. Het. i, p. 9 (1867).

Black: head smooth, with a punctured furrow on each side between the eyes, and with another on each side in front: thorax bright red, with a black spot on each side on the disc and with a smooth black band along the anterior margin which is largely punctured: pectus with a lanceolate red streak along each side: scutellum bright red, with three bands of black marks: the first band of five spots of which the median is large and triangular reaching the fore border, the inner pair are small and isolated, the outer pair large and lateral and touching the anterior margin: of the second band of four black spots, the inner pair are large, the outer pair, small and lateral; the third band is composed of two black points: abdomen beneath red, black at the base and at the tip *(Walker)*. Rather shorter than *P. dives*, Guérin; differs in the markings on the thorax and scutellum and the abdomen beneath has no black spots on each side. Possibly only a small variety of *P. ornatus*, Dallas. Long, 13 mill.

Reported from Cachar (Assam).

Genus Tetrarthia, Dallas.

List Hem. i, p. 3, 20 (1851): Stål, Hem. Afric. i, p. 33 (1864); En. Hem. iii, p. 8, 13 (1873): Mayr, Reise Nov. Hem. p. 12 (1866): Walker, Cat. Het. i, p. 18 (1867).

Body elongate, sericeous: head rather long, convex, especially anteriorly, lateral margins somewhat acute before the middle and sinuated, no longitudinal impression near the eyes, tylus longer than the juga: rostrum long, reaching the posterior margin of the fourth ventral segment, first joint very short, second and fourth about equal in length, twice as long as the first, second joint compressed, third longest, about equal in length to the first and second taken together; antennæ 4-jointed, second joint about thrice longer than the basal joint which does not reach the apex of the head: posterior angles of thorax obtusely rounded, entire anterior margin of the propleura obtuse, elevated, posterior margin straight at the angles: scutellum rounded at the apex, covering nearly the whole of the hemelytra: venter with a long furrow, sides flattish, anteriorly somewhat convex, posterior margin of segments straight on both sides, the furrow of the orifices long, straight or very slightly curved, abruptly produced forwards at the apex or emitting forwards a wrinkle or ridge: pectus without a furrow for the reception of the rostrum or projecting flaps covering the base of the antennæ; legs moderate: tarsi 3-jointed, second joint shortest *(Dallas)*.

74. Tetrarthia lineata, Walker.

Tetrarthia lineata, Walker, Cat. Het. i, p. 18 (1867).

Ferruginous-red, fusiform, bright-red beneath: four stripes on the head and beneath on both sides, five stripes on thorax, of which the outer pair are oblique, its anterior and lateral margins, a dot on each side of the anterior margin of the scutellum and two oblique streaks which converge hindward and a broad stripe on each side of pectus, emerald-green: antennæ piceous, fourth joint pale yellowish towards the base: scutellum with a luteous dot on each side at two-thirds of the length: abdomen beneath with two rows of black spots on each side and with a black subapical patch: legs pubescent; tibiæ and tarsi above and femora towards their tips tinged with green: wings brown: costa of the corium purple. Var.? No emerald-green markings: head bluish-black: thorax bluish-black in front and on each side: scutellum with no luteous dot: pectus blackish *(Walker)*. Long, 14¾ mill.

Reported from Hong-Kong; variety from Burma.

75. Tetrarthria variegata, Dallas.

Tetrarthria variegvta, Dallas, List Hem. i, p. 20, t. 1, f. 1 (1851); Stål, Ofvers. K. V.-A. Förh. p. 616 (1870); En. Hem. iii, p. 14 (1873).

Tetrathria margine-punctata, Vollenhoven, Faune Ent. l'Arch. Indo-Néer. p. 13, t. 1, f. 6 a-b (1863); Walker, Cat. Het. iii, p. 508 (1868).

Tetrathria quinquemaculata, A. Dohrn, Stettin Ent. Zeit. xxiv, p. 347 (1863).

Head black, with some scattered, coarse punctures, the lateral margins and two parallel longitudinal lines brassy-green; eyes pale brown; thorax with a large, semicircular brassy green patch on the disc, touching the posterior margin, and surrounded by a broad dull red band which runs from one posterior angle to the other; four spots on the disc, near the posterior margin, of which the two intermediate are largest, and the anterior and lateral margins black: scutellum brassy green in the middle, the margins dull red, punctured and thickly clothed with fine golden hairs, with a large black patch in the middle of the base, two small spots of the same colour immediately behind this, and two large ones on the lateral margins immediately behind the middle; a large T-shaped black patch occupies the disc of the scutellum, formed by a transverse band, before the middle, and a median longitudinal one which reaches nearly to the apex, and is furcate posteriorly: abdomen beneath red, with broad black margins: rostrum red: legs black with the basal half of the femora bright red: antennæ black with the basal joint reddish and a pale band near the base of the fourth joint *(Dallas)*. Varies in having the scutellum and thorax rufous-testaceous: anal segment in ♂ truncate at apex; finely erosulous and in the middle with a somewhat prominent tooth. Long, 16¾ mill.

Walker remarked that *T. margine-punctata*, Voll. was probably only a variety of *T. variegata*, Dallas ; and it is now recognized as such. The type of this variety has the borders of the body above and the entire body below covered with a grey villosity ; head a little punctured, with a glossy chocolate-brown line in the middle ; two longitudinal lines and the border of the eyes, golden-green ; antennæ pale brown, pubescent ; base of fourth joint whitish : eyes brown, ocelli yellow : pronotum punctured, with a row of deep dots on the anterior border, preceding a transverse glossy space which is of a chocolate-brown, the border being golden-green : disc of pronotum and scutellum purplish black with several obscure metallic-blue lines : border surrounded by a row of yellow triangular patches : body beneath yellow with some golden-green lines on the head and pectus : ventral borders marbled with brown ; 5th and 6th segments altogether brown ; rostrum pale yellow, with the tip obscure : coxæ and half of femora of a pale yellow, other half deep brown : tibiæ and tarsi, yellowish brown. Long, 15 mill. A Silhat specimen is paler and has the border of the scutellum interrupted at the tip.

Reported from Phillipines, Java, Tondano, Celebes, Silhat. The Indian Museum possesses specimens from Sibságar (Assam).

Genus Scutellera, Lamarck.

Syst. p. 293 (1801) : Dallas, List Hem. i, p. 4, 18 (1851) : Walker, Cat. Het. i, p. 15 (1867) : Stål, Hem. Afric. i, p. 33 (1864) ; En. Hem. iii, p. 9, 14 (1873) : Mayr, Reise Nov. Hem, p. 17 (1866). Includes *Calliphara*, Am. & Serv. Hist. Nat. Ins. Hém. p. 30 (1843), nec Germar.

Body subsericeous or pilosulous, very oblong : head triangular, obtuse, sloped : rostrum extending beyond the second ventral segment : antennæ 5-jointed, second joint not or only a little shorter than the first, fourth the longest : pronotum with a transverse linear impression before the middle, generally strongly punctured, the base distinctly truncated, posterior angles distinct, posterior margin of propleura generally distinctly sinuated at the angles, anterior margin obtuse, thickened, slightly amplified near the prosternum : the meso-sternum furrowed : venter furrowed beyond the middle ; the furrow of the orifices very long, gradually curved forwards towards the apex, the part of the metapleura situate before the furrow, smooth, shining : feet rather long.

76. Scutellera nobilis, Fabricius.

Cimex nobilis, Fabr. (nec Linn.), Syst. Ent. p. 697 (1775) ; Spec. Ins. ii, p. 338 (1781) ; Mant. Ins. ii, p. 280 (1787) ; Ent. Syst. iv, p. 80 (1794) : Gmelin, ed. Syst. Nat. i (4) p. 2128 (1788) ; Panzer in Voet, Col. iv, p. iii, t. 47, f. 1 (1798) ; Wolff, Ic. Cim. ii, p. 49, t. 5, f. 46 *a-d*, (1801) : Stoll, Punaises, p. 8, t. 1, f. 1 ; p. 13, t. 2, f. 7, and p. 20, t. 4, f. 22, 23 (1788).

Tetyra nobilis, Fabr., Syst. Rhyng. p. 129 (1803).
Tectocoris nobilis, Hahn, Wanz. Ins. iii, p. 24, t. 81, f. 247 (1835).
Tectocoris perplexa, Westwood, Hope, Cat. Hem. 1, p. 4 and 15 (1837).
Calliphara nobilis, Germar, Zeitschr. i, (i) p. 124 (1839): Am. & Serv. Hist. Nat. Ins. Hém. p. 30 (1843).
Scutellera nobilis, Lam. Hist. Nat. iii, p. 491 (1816) : Burm. Handb. ii, (i) p. 395 (1835) ; Blanchard, Hist. Nat. Ins. iii, p. 158, Hèm. t. 8, f. 3 (1840) ; Dallas, List Hem. i, p. 18 (1851) ; Walker, Cat. Het. i, p. 15 (1867) ; Vollenhoven, Faune Ent. l'Arch. Indo-Néer. p. 11 (1863) ; Stål, En. Hem. iii, p. 14 (1873) ; Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Oblong; cærulean-golden, spotted black: beneath rufous, with lateral bands shining blue and gold (*C. nobilis*, Fabr.).

Light metallic green, varying to deep blue or even purple: body above and beneath and legs covered with a fine greyish pubescence more abundant on the head and anterior part of pronotum, abdomen and legs : eyes brown, ocelli red : rostrum reddish or brown : first joint of antennæ reddish brown, rest black : pronotum with a deep transverse groove anteriorly, a row of excavated points on anterior margin, lateral margins reddish brown, three irregular spots towards anterior margin, a median longitudinal line, a spot on each side thereof and on the humeral angles, black : scutellum with a median longitudinal line reaching to about the middle and three spots on each side thereof, black, a smaller sublateral spot on each side between the second and third pairs, sometimes also a sublateral spot between the first and second pairs, and sometimes all or some are more or less obsolete : body beneath red with a purplish tint ; head beneath, patches on pectus, and oblique transverse bands on abdominal segments, interrupted in the middle and not reaching the margins, golden blue or green : coxæ and femora red, tips of femora, tibiæ and tarsi deep metallic violet. Varies much in size from 14 to 21 mill.

Var. :—Head green with three black spots : first joint of the antennæ black not red : lateral margins of pronotum without a red limbus, first third green, rest blue with traces of five black spots ; scutellum blue with ten black spots : abdomen beneath golden green, shining, with a large orange yellow patch on the disc, margin orange, crenulated black : anal plate green *(Voll.)*.

Reported from Bengal, Pondicheri, Assam (Silhat, Cachar), Burma, Panjab, India, Siam. The Indian Museum possesses specimens from N. India, S. India, Karachi, Sikkim, Assam, and Calcutta.

77. Scutellera fasciata, Panzer.

Cimex fasciatus, Panzer, in Voet, Col. iv, p. 108, t. 46, f. 2 (1798) : Stoll, Punaises, p. 138, t. 36, f. 251 ; var. p. 34; t. 7, f. 49 (1788).

Tectocoris nepalensis, Westwood, Hope, Cat. Hem. 1. p. 14 (1837).

Calliphara nepalensis, Germar, Zeitschr. i (i) p. 125 (1839).

Calliphara amethystina, Germar, Zeitschr. i (i) p. 124 (1839).

Scutellera amethystina, Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 12 (1863): Walker, Cat. Het. iii, p. 507 (1868).

Callidea lanius, Stål, Ofvers. K. V.-A. Förh. p. 231 (1854).

Scutellera lanius, Stål, l. c. p. 51 (1856): Walker, l. c. i, p. 15 (1867).

Scutellera fasciata, Dallas, List Hem. i, p. 19 (1851); Walker, l. c. i, p. 15 (1867); Stål, En. Hem. iii, p. 14 (1873).

Body fusiform; pilose on the head; first third of pronotum, body beneath and feet, purple: head wrinkled only on the margins, beneath and two first joints of the antennæ, violet: eyes brown, ocelli red: rostrum, half red, rest black: pronotum deeply grooved and with a row of excavations on the anterior margin, lateral margins greenish or golden; two spots at the anterior angles and four near the base brown or blackish: scutellum with three bands, often interrupted (especially the first), and two small lateral and one large median spot of the same colour, all of them are sometimes more or less obsolete: body beneath red, pectus with several violet spots, venter with two rows of oblique spots, alternately violet and golden: stigmata black: coxæ and femora red: tips of femora, tibiæ and tarsi, deep violet. (*S. amethystina*, Voll.). Body long 18-20 mill.

Westwood describes his *T. nepalensis* as cærulean-green, clypeus golden, head with a median line and two oblique spots between the eyes, black; sides of thorax golden-yellow; dorsum with three interrupted longitudinal lateral lines; scutellum with two round spots at the base, a broad waved band before the middle, two round lateral spots and two others much larger and confluent beyond the middle, and the apex, black. Long 19 mill. Stål makes his *S. lanius* from Java a variety marked by its greater size, more robust, subsanguineous above, slightly shining violaceous, spots unicolorous without the violaceous tinge. Long, 22; broad 9 mill.

Reported from Java, Borneo, Malacca, China, Burma, Assam, Nepál, Sikkim.

Genus Brachyaulax, Stål.

Ofvers. K. V.-A. Förh. p. 616 (1870); En. Hem. iii, p. 9, 14 (1873).

Body very oblong, above slightly, beneath very convex, briefly pilose, shining: head triangular, somewhat convex, sides very convex before the eyes, lateral margins sinuate towards the base, rounded towards the apex; bucculæ continuing through it, slightly elevated: ocelli twice more distant from each other than from the eyes: rostrum extending to somewhat behind the last coxæ: antennæ shorter by half than the body, first and second joints short, the latter extending to the apex of the head and a little shorter than the first, third somewhat longer than the two basal together, fourth and fifth longer than the rest, fourth especially compressed, dilated: thorax sexangular, anteriorly truncated, distinctly transversely impressed before the middle, anterior lateral margins, obtusely sinuated, obtuse: scutellum covering the entire abdomen: prostethium triangularly impressed, margins of impression elevated, subdilated: mesostethium obtusely sulcate: odoriferous apertures continued outwards in an elongated furrow, slightly curved and abruptly abbreviated : sides of venter very convex, incisures gradually curved second segment broadly sulcate in the middle: feet moderate, tibiæ distinctly sulcate above. Differs from *Scutellera*, Lam. in having the furrow of the odoriferous apertures shorter, less curved, and the venter furrowed only at the base *(Stål)*.

78. Brachyaulax oblonga, Westwood.

Tectocoris oblonga, Westwood, Hope, Cat. i, p. 14 (1837).
Calliphara oblonga, Germar, Zeitschr. i (i) p. 129 (1839).
Scutellera oblonga, Dallas, List Hem. i, p. 19 (1851); Walker, Cat. Het. i, p. 15 (1867).
Brachyaulax oblonga, Stål, En. Hem. iii, p. 14 (1873); Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Ovate-oblong, metallic bluish-green; head with three spots between the eyes; thorax with six, three by three, the posterior larger; scutellum with three small basal, two larger rounded, two lateral small, two behind the middle, rounded, large, and one sub-apical spot, or ten in all: body beneath cærulean-green, base of the abdomen in the middle and the sides irregularly fulvous; antennæ black, feet green *(Westw.)*. Body long, $13\frac{1}{4}$ mill.

Reported from Java, Assam, China. The Indian Museum has a specimen from Assam which differs from the type in having the large median spots on the scutellum confluent, forming two waved transverse bands (*Dist.*) and in some these are connected by a median, longitudinal arrow-shaped mark.

Genus Calliphara, Germar.

Calliphara, pt, Germar, Zeitschr. i (i) p. 122 (1839): Stål, En. Hem. iii, p. 9, 16 (1873). Includes *Calliphara*, Stål, Hem. Afric. i, p. 34 (1864) and *Lamprophara*, l. c. p. 34 (1864).

Stål distributes the species belonging to this genus amongst the subgenera *Lamprophara*, *Calliphara* and *Chrysophara* to none of which does he assign the only species recorded from India. The third joint of the antennæ is over twice as long as the second: rostrum reaching at least the middle of the second ventral segment: the ventral segments (at least the last and the penultimate) furnished at the apical angles with a small tooth or spine which is sometimes covered by the hemelytra and then with difficulty distinguished: the scutellum does not cover the exterior margin of the connexivum *(Stål)*.

79. Calliphara obscura, Westwood.

Tectocoris obscura, Westwood, Hope, Cat. i, p. 14 (1837).
Calliphara obscura, Stål, En. Hem. iii, p. 18 (1873).

Head and pronotum black-cœrulean; the latter with three posterior spots; scutellum green, with seven spots (two, two subconfluent, two rounded beyond the middle, and one small, subapical); body beneath, black-cœrulean, venter green, with black lateral spots; femora luteous at the base. Body, long 17¾ millims.

Reported from Nepál. Stål inquires 'an potius Insulæ Philippinæ.'

80. Calliphara nobilis, Linnæus.

Cimex nobilis, Linn., Cent. Ins. i, p. 17 (1763); Amæn. Ac. vi, p. 400 (1763).
Cimex pustulatus, Panzer in Voet, Coll. iv, p. 111, t. 47, f. 11 (1798).
Scutellera Buquetii, Guérin, Voy. Coq. Ins. ii (2), p. 159, 162 (1830).
Callidea nobilis, Dallas, List Hem. i, p. 25 (1851); Walker, Cat. Het. i, p. 32 (1867).
Calliphara buquetii, Stål, Berlin Ent. Zeitschr. x, p. 153 (1866); Ofvers. K V.-A, Förh. p. 618 (1870).
Calliphara nobilis, Stål, En. Hem. iii, p. 17 (1873).

Above light green, shining, in some specimens with violet reflections: head rather small, triangular; eyes brown very prominent; in the middle, a small smooth green elevation, a little dilated hindward and bounded by two small grooves: antennæ in ♂, nearly half the length of the head, in ♀ a little shorter, black, with the joints flattened: thorax almost straight or only a little emarginate on the sides, punctured; on each side in front an impression, black at the bottom, placed obliquely, and four small round black spots, a little beyond the middle; in some specimens there is an oblong red spot between the two anterior impressions, in others there are only two spots on the sides: scutellum slightly grooved at the base, much punctured, with a longitudinal line in the middle having no punctures and feebly marked; three small, round, black spots on each side, and a smaller in the middle and near the tip: thorax beneath, red, with large green spots, confluent on the sides; margin red, partly visible above: abdomen vermillion, sides broadly bordered green and on their external margin are four large black dots, and inwards four black patches less well defined, the extreme external margin is red: rostrum black, red at the base: femora red, tips partly green; tibiæ and tarsi deep green (*S. buquetii*, Guérin). Long, 16—17; broad, 8—8½ mill. at base of scutellum.

Reported from Philippines, Java, Timor, China, Burma.

Genus Chrysocoris, Hahn.

Wanz. Ins. ii, p. 38 (1834); White, Trans. Ent. Soc. iii, p. 85 (1841-43); Stål, Hem. Afric. i, p. 34 (1864); En. Hem. iii, p. 9, 18 (1873).

Includes *Callidea*, Am. & Serv. (nec Burm.), Hist. Nat. Ins. Hèm. p. 31 (1843); pt. Dallas, List Hem. i, p. 22 (1850); Walker, Cat. Het. i, p. 25 (1867):—*Eucorysses*, Am. & Serv., l. c. p. 31 (1843); Stål, Hem. Afric. i, p. 34 (1864); Mayr, Reise Nov. Hem. p. 18 (1866):—*Galostha*, Am. & Serv., l. c. p. 32 (1843):—*Cosmocoris*, Stål, Hem. Afric. i, p. 34 (1864); Mayr, Reise Nov. Hem. p. 18 (1866).

Stål distributes the species belonging to this genus amongst the subgenera *Eucorysses*, *Cosmocoris*, and *Chrysocoris*, all of which are represented in India. Differs from *Calliphara* in having the scutellum covering the whole connexivum, except the basal part. Body above glabrous: the third joint of the antennæ at least twice as long as the second: the three last joints of the rostrum unequal in length: lateral margins of the head neither carinated nor reflexed, anterior margin of the prostethium not callous behind the eyes, obtuse: meso-sternum, at least anteriorly, somewhat sulcated, the furrow generally slightly carinated on both sides: posterior margin of the propleura distinctly sinuated at the posterior angles: the ventral segments, at least the last or the penultimate, furnished at the apical angles with a small tooth, often covered by the hemelytra and then difficult to distinguish.

Subg. Eucorysses, Am. & Serv.

Head somewhat large, not much inclined, sides not deeply sinuated: anterior lateral margins of pronotum straight or somewhat so: basal part of the scutellum not, or but very obsoletely, elevated: entire tibiæ above furrowed: sixth ventral segment in ♀, as far as known, obtusely or very obtusely angulately prominulous in the middle of the apex.

81. Chrysocoris grandis, Thunberg, Stål.

Eucorysses grandis, Stål, Berlin Ent. Zeitschr. x, p. 154 (1866).

Chrysocoris (Eucorysses) grandis, Stål, En. Hem. iii, p. 18, (1873): Scott, A. M. N. H. (4 s.) xiv, p. 289 (1874): Distant, l. c. (5 s.) iii, p. 44 (1879); J. A. S. Ben. xlviii, (2) p. 37, (1879).

Var. *a*:—*Cimex grandis*, Thunberg, Nov. Ins. Spec. p. 31, t. 2, f. 46 (1783): Gmelin, ed. Syst. Nat. i (4), p. 2133 (1788).

Calliphara grandis, Germar, Zeitschr. i (1), p. 128 (1839).

Callidea grandis, Dallas, List Hem. i, p. 23 (1851): Vollenhoven, Faune Ent: l'Arch. Indo-Néerl. p. 18 (1863): Walker, Cat. Het. i, p. 32 (1867).

Eucorysses superbus, Uhler, Proc. Ac. Nat. Sci. Phil. p. 221 (1860).

Callidea distinguenda, Uhler, l. c. p. 286 (1861).

Var. *b* :—*Cimex baro*, Fabr., Ent. Syst. Suppt. p. 528 (1798).

Tetyra baro, Fabr., Syst. Rhyng. p. 129 (1803); Schiödte in Kröyer's Nat. Tidsskr. iv, p. 279 (1842).

Calliphara baro, Germar, Zeitschr. i (1) p. 127 (1839).

Callidea baro, Dallas, List Hem. i, p. 22 (1851): Walker, Cat. Het. i, p. 26 (1867).

Tetrarthia tetraspila, Walker, l. c. i, p. 19 (1867).

Var. *c.* :—*Eucorysses pallens*, Am. & Serv. Hist. Nat. Ins. Hém. p. 31, t. 1, f. 4 (1843).

Callidea baro, Vollenhoven, l. c. p. 17 (1863).

Head and spots on pectus at the coxæ, flavescent, the head sometimes shining purplish, median streak and basal intraocular part, black: rostrum reaching the middle of the third ventral segment.

Var. *a.* Large, elongate, tumid, glossy, violet beneath, sanguineous above with black spots: head blue with the median line and antennæ black: pronotum sanguineous, much swollen, the anterior margin fringed with violet, at the base, black: a dot on each side behind the anterior angle and a large spot on the disc, black: scutellum sanguineous, the black of the pronotum appears to extend over the base; five black spots on the scutellum one rounded on the median line near the base, two others costal appearing like a band interrupted in the middle, another forms a band abbreviated on two sides and the fifth is near the anal margin: a sanguineous spot sometimes occurs in the middle of the venter: feet black (*Cimex grandis*, Thunb.). Body long, 25 mill.

Var. *a.* ♀, sec. Stål:—Black, thorax, scutellum, spots on pectus at coxæ and transverse median spot on 4—5 ventral segments, yellow-testaceous: margins of thorax and of scutellum shining-violaceous: entire narrow margin, discoidal spot and lateral angles of thorax, basal limbus, spot near base, lateral transverse spot on both sides before middle, abbreviated band behind middle and obsolete subapical spot on scutellum, black: spot on basal angles of ventral segments, yellow-testaceous, much tinted violaceous.

Var. *b.*:—Body large: head pale; antennæ, median line and margin black-cyaneous: thorax pale, shining, with a large ovate spot reaching anterior margin, cyaneous: scutellum large, smooth, pale, shining, with three cyaneous-black spots, the median one cordate: pectus cyaneous: abdomen pale with cyaneous bands: feet cyaneous (*Cimex baro*, Fabr.) Stål describes this variety as flavescent or yellow-testaceous: antennæ, rostrum, anterior spot on thorax, basal limbus and three spots before middle of scutellum, pectus, lateral posterior band on segments, basal streak and apical spot on venter and the feet, black: six spots on the pectus, three at the coxæ and three at the lateral margins, flavescent.

Var. *c.* :—♂. Pale yellowish, shining above : head with a median longitudinal line and its posterior part, shining black : lateral margins of the pronotum slightly sinuate in the middle, a patch of shiningblack rounded hindwards, touching the anterior margin : two oblong, black, transverse patches on the disc of the scutellum, its base having on each side a similar black spot : body beneath shining black-bluish with transverse lateral bands of a pale shining yellow which unite on the two penultimate ventral segments : anal plate pale shining yellow, feet black metallic-bluish : antennæ black (*E. pallens*, Am. & Serv.). Long, 25 mill.

All these varieties occur in India and are represented in the Indian museum collection. Reported from Japan, China, Siam, Assam, (Silhat), Bengal, Tenasserim, Java.

82. Chrysocoris iris, Germar.

Calliphara iris, Germar, Zeitschr. i (i), p. 128 (1839) : Herr. Schäff., Wanz. Ins. V, p. 80, t. 171, f. 526 (1839). Bintam.

Callidea sexmaculata, Dallas (nec Leach), List Hem. i, p. 23 (1851); Vollen., Faune Ent. l'Arch. Indo-Néerl., p. 18, t. 1, f. 7 (1863) : Walker, Cat. Het. i, p. 31 (1867). Java.

Chrysocoris (Eucorysses) iris, Stål, En. Hem. iii, p. 19 (1873).

Purpurascent, shining violaceous : antennæ and feet black, three spots on thorax also its posterior margin, and six spots on scutellum, black (*Germar*). Schäffer observes that in the example figured by him the ground colour appears to be brown, lighter posteriorly ; head, thorax and base of scutellum of a rich violet with rosy red, turning to green on the sides of the thorax and scutellum : feet and antennæ darker. His figure shows anterior and posterior margins of thorax black, a median longitudinal streak proceeding from the anterior margin and posteriorly behind the middle confluent with a short transverse, streak, black : four spots on scutellum joining an arcuate interrupted transverse band before the middle, and two larger oblong transverse spots behind the middle. Long, 24 mill. It is like *C. sexmaculatus*, Leach, but differs in its smaller size, body (especially the head) purpurascent-flavescent, smooth head and shorter rostrum which somewhat reaches the apex of the third ventral segment.

Body above purple with silvery blue reflections : head transversely wrinkled at the apex, vertex of a bronzed blackish green ; eyes brown, ocelli brown-yellowish : beneath, the sheath of the rostrum of a metallic green, labrum yellow : antennæ black, second joint one-sixth of the following : thorax punctured, most strongly in the middle of the anterior margin which is of a bronzed green and on the disc, the space between these two is smooth ; a cordiform spot on the disc, an abbreviated band along the posterior border and two small spots at the lateral angles, black, these angles slightly, acuminate: scutellum punctured, more strongly at the anterior angle, basal elevation smooth: two bronzed-black spots behind the basal elevation, a black spot at each anterior angle, another pair much larger, almost quadrate behind these near the lateral margin, and a transverse band interrupted in the middle, black; hemelytra black, with the costal margin purple; pectus varied with green, black and red: venter red with purple margins; a large basal spot, a smaller anal spot, an oblique stria on the sides, shining black: feet metallic black, pubescent (*C. sexmaculata*, Voll.). Body long, 24 mill.

Reported from Java, Bintam, Singapore, Tenasserim.

Subg. Cosmocoris, Stål.

Head somewhat large, not much inclined: pronotum with the anterior lateral margins more or less distinctly sinuated in the middle, furnished in the ♂ anteriorly with a rather deep triangular impression, scutellum transversely elevated at the base: tibiæ above towards the apex somewhat flat or furrowed.

83. Chrysocoris coxalis, Stål.

Callidea coxalis, Stål, A. S. E. F. (4 s.) iv, p. 47 (1864): Walker, Cat. Het. i, p. 28 (1867). Tringany.

C. (*Cosmocoris*) *coxalis*, Stål, En. Hem. iii, p. 19 (1873).

♀ Brassy-green, shining, feet more obscure, of the colour of steel: antennæ and rostrum black; a small spot towards the ocelli and a median stripe on the head, five spots on the pronotum and eight on the scutellum, subviolaceous-black; disc brassy-black varying in breadth: coxæ, trochanters and base of femora sordid yellow-whitish. Head moderate, distinctly sinuate before the eyes: second joint of antennæ one-third shorter than basal, the fourth (in ♂ at least) dilated, furrowed; pronotum sparingly and finely punctured, disc before the middle a little more distinctly punctured; antero-lateral margins very slightly sinuate, narrowly and distinctly reflexed, with two anterior transverse spots, one orbicular on each side at the lateral angles, and three large median elongate reaching the base, the median one in the form of a continued stripe, the other two extended forwards beyond the middle of the pronotum: scutellum as broad as the abdomen, not so densely punctured, slightly transversely elevated at the base, there smooth, with eight spots, the subbasal median one formed like the letter T, the rest, transverse, large: sixth ventral segment in ♀, posteriorly obtusely sinuate (*Stål*). Long, 13-15; breadth of pronotum, 7-8 mill.

Reported from Singapore, Tringani, Tenasserim (?).

Subg. Chrysocoris, Hahn.

Head somewhat small, bending much forwards, sides generally strongly sinuated : thorax in ♂ without an anterior triangular impression : basal part of the scutellum not or only slightly elevated : tibiæ above towards the apex flat or furrowed. Stål still further divides this subgenus into the sections *Chlorolampra* including *C. germari*, Esch. ; *Chlorochrysa*, including *C. stockerus*, Linn. and *Chrysocoris* including *C. dilaticollis*, Germar.

As the species of this subgenus are not readily distinguishable I adopt the following scheme partly from Stål (Hem. Fabr. i, p. 11) as some help to identification :—

1-2. Venter without any flavescent spot or mark.—*C. atriventris*, mihi.

2-1. Venter with disc, at least, flavescent.

3-17. Lateral margins of pronotum straight or nearly so.

4-16. Pronotum posteriorly with a single black spot in the middle, sometimes wanting, the antero-lateral margins entirely or nearly entirely reflexed.

5-9. Disc of venter flavescent, with four long rays occupying the apical part of the segments, terminated anteriorly inwards by a black transverse spot that reaches the base of the segments and is remote from the black-irised spiracula.

6-8. Ventral limbus cœrulean or brassy-green : posterior margin of pro- and meso-stethium concolorous : femora flavescent beyond the middle.

7-8. Pronotum with ten black or black-cœrulean spots.—*C. elatus*, Stål.

8-6. Ventral limbus, rufescent or purplish, rarely flavescent and purple : posterior margin of parts of pectus, flavescent : femora beyond the middle, miniaceous.—*C. patricius*, Fabr.

9-5. Almost entire venter or a very great part of the disc flavescent, with on both sides short rays that occupy the base and the apex of the segments and are not terminated by a transverse black spot : scutellum typically with the apex black or obscurely violaceous, no sub-apical rounded spot.

10-8. Posterior black spots on the pronotum remote from the base, rather small ; ventral limbus brassy-green, or cœrulean, or purplish-violaceous.

11-12. Pronotum with 5 or 7 black spots, that on the lateral angles very small or wanting : femora beyond the middle, flavescent.—*C. purpureus*, Westw. *C. viridis*, mihi.

12-11. Pronotum with 7 or 8 black spots, the anterior median one sometimes wanting, 3 large median posterior spots, reaching the base.—*C. stolii*, Wolff.

13-12. Spots larger and broader, colour more purplish above.—*C. porphyricolus*, Walk.

14-12. Pectus without flavescent spots and lines.—*C. ornatus*, Dallas.

15-12. Scutellum broadly orange at the apex.—*C. andamanensis*, mihi.

16-4. Pronotum with 11 black spots and posteriorly in the middle with 2 oblong spots, antero-lateral margins somewhat acute posteriorly, and a little reflexed.—*C. marginellus*, Westw.; *C. pulchellus*, Westw.

17-3. Lateral margins of anterior part of the thorax, depressed, flat, rounded.—*C. eques*, Fabr.; *C. dilaticollis*, Guérin.

84. Chrysocoris atriventris, Atkinson.

Proc. A. S. B. p. 11, (1887).

Closely allied to *C. hypomelæna*, Voll. from Borneo, differs in the markings on the thorax and in the entire venter being almost wholly deep black. Brassy-green, irrorated golden, shining, closely punctured: head beneath and feet lighter brassy-green, very shining: venter deep black, smooth, slightly shining. Head much inclined, obtusely triangular, rounded at the apex; except the tylus, irrorated golden: eyes, ocelli, antennæ and rostrum, black; 3-5 joints of antennæ somewhat flattened; rostrum reaching almost the apex of the second ventral segment, extremity of tip brownish: thorax with three black spots towards the anterior margin, the lateral subovate-oblong, transverse, impressed, smoothish, the median irregularly triangular, smallest; towards the posterior margin three larger spots, of which the lateral oblong, longitudinal, and the median obtusely triangular, smallest; lateral margins reflexed, a very small black spot on the slightly prominulous posterior angles: scutellum with the basal elevation smooth, shining, and with seven black spots; on each side three lateral, of which the two first are ovate-oblong, transverse, and the third is somewhat rounded posteriorly, also one subbasal median, obtusely-triangular, having its apex pointing hindwards. Head beneath and pectus very bright, shining, brassy-green; antennæ black: entire venter intensely black, smooth, slightly shining; barely traces, under the microscope in the sun, of a slightly purplish limbus and a slightly brassy-green margin to the stigmata: feet blackish, femora tinted brassy-green towards the apex; tibiæ finely ciliated, externally of a blue-steel colour. Long 14; breadth of pronotum, 8 mill.

Example from Delhi.

85. Chrysocoris elatus, Stål.

Callidea Stockerus, Germar, Zeitschr. i (i) p. 114 (1839), excl. syn.
Chrysocoris elatus, Stål, Hem. Fabr. i, p. 11 (1868); En. Hem. iii, p. 20 (1873).

Thorax with ten bluish-black or black spots: discoidal spot on scutellum narrow, linear or somewhat so; disc of venter flavescent with four long rays, occupying the apex of the segments and terminated anteriorly inwards by a black transverse spot that reaches the base and apex of the segments, remote from the black-cinctured spiraculan, ventral limbus cœrulean or brassy-black; posterior margin of pro- and meta-stethium concolorous; femora flavescent beyond the middle.

Reported from India.

86. Chrysocoris, Fabricius.

Cimex patricius, Fabr., Ent. Syst. Suppt. p. 527 (1798); Stoll, Punaises, p. 125, t. 32, f. 222A (1788).

Tetyra patricia, Fabr., Syst. Rhyng. p. 131 (1803); Schiödte in Kröyer's Nat. Tidsskr. iv, p. 286 (1842).

Scutellera patricius, Guérin, Voy. La Coquille, Ins. p. 159 (1830).

Callidea bengalensis, Westwood, Hope, Cat. Hem. i, p. 15 (1837); Germar, Zeitschr. i (i), p. 118, (1839); Dallas, List Hem. i, p. 28 (1851): Walker, Cat. Het. i, p. 27 (1867).

Callidea basilica, Germar, Zeitschr. i (i), p. 117 (1839): Walker, l. c. i, p. 28 (1867).

Callidea patricia, Germar, *l. c.* p. 121 (1839); Walker, l. c. i, p. 2 8 (1867).

C. (Chrysocoris) patricius, Stål, Hem. Fabr. i, p. 11 (1868); En. Hem. iii, p. 20 (1873).

Oblong, one-third the size of *S. nobilis:* head, thorax and scutellum cœrulean blue: head shining, with a dorsal line and a spot on each side at the base, black: thorax with a dorsal line and four spots on each side, black: scutellum large, with nine spots arranged 3, 3, 2, 1, black: body flavescent, marginal bands cœrulean, and the margin of the abdomen, red: feet black, femora rufous *(Fabr.)*. Dark greenish-blue; pronotum with seven spots, scutellum with eight large black spots; femora rufous, apex and tibiæ green; trochanters whitish; abdomen palely luteous, margin purplish-rufous, with oblong, transverse, greenish-black spots *(C. bengalensis*, West.), a somewhat ovate median oblong spot, with a longitudinal row of three rounded spots on both sides and a rounded spot before apex black. Pectus shining, sparingly punctured, brassy-green or cyaneous, six spots at the insertion of the feet and anterior and posterior margins of meso- and meta-sternum, yellow; posterior margin of pro-sternum, yellow, lateral margin and posterior angles, red: lobes of anterior margin very short, truncate, externally angulate. Hemelytra black-cœrulean, internally fuscescent their exterior margin yellow towards the base; membrane and wings fuscous-black. Feet pubescent; coxæ, trochanters and femora, red, the femora cyaneous at apex, tibiæ with a small groove before apex, cyaneous; tarsi-black: venter moderately convex with the sides punctured, shining, yellow, margin above the black stigmata red or luteous, a large quadrate spot occupying the middle of the three anterior segments and another rounded on penultimate segment, black or fuscous; 2-5 segments with a brassy-green spot on each side: anal segment horizontal, æenescent, thrice broader than length, deeply transversely impressed, the apex broadly emarginate.

♀. The ♀ has the antennæ more slender, shorter than head and pronotum, two basal joints longer than the eyes, 3-5 joints with small obsolete grooves: sides of pronotum more narrowly margined before the eyes, margin not dilated in the middle: anal segment of venter deep red (*Schiödte*). Long, 7½-8 mill., humeral breadth, 4¾ mill.

The discoidal spot in the scutellum is broader than in *C. elatus*, Stål, gradually amplified forwards before the middle: genitalia in ♂ more reflexed behind the middle than usual: subapical rounded spot in the scutellum black.

Reported from Bengal, Tranquebar: the Indian museum has specimens from Calcutta and Ceylon.

♂. Antennæ a little longer than the head and pronotum together, stoutish; two basal joints much shorter than the head, scarcely as long as the eyes, either black, or fuscous, or rufescent; second joint very short, one-fourth the length of the basal; remaining joints black, pubescent, almost of the same length, depressed, with a small groove on the upperside; third thrice as long as the basal, fourth and fifth with a deep groove on the lower side. Head deflexed much shorter than broad, obtusely three-angled, and a little convex, smooth, shining, cœrulean greenish or cyanean; clypeus obscurely cyaneous, at the extreme apex ruddy; eyes of moderate size, prominent; clypeus linear, obtusely prominulous at apex; margins of the rostral groove, narrowly elevated: rostrum reaching the base of the abdomen subcylindrical, piceous, rufescent at base, second joint a little longer than the rest. Pronotum broader than long, convex at the base, as high as the scutellum, more sparingly punctured, denser towards the somewhat elevated humeri, anteriorly convexly sloped, smooth, within the apex depressed and rather densely punctured; entirely brassy-green or shining cyaneous, sometimes purpurascent at the sides, with three longitudinal rows of black spots of which the median row is composed of two large quadrate spots and the lateral rows of three smaller, rounded spots: the humeral protuberances are also black and the lateral margins before the obtuse-angled, rounded humeri somewhat straight. Scutellum ovate almost twice as long as the pronotum, almost one-half longer than basal breadth, shorter than abdomen, moderately convex, basal semilunar elevation rather high, flatly inclined at the sides, posteriorly convexly sloped, somewhat depressed and truncate at the extreme apex ; densely punctured, basal callus smooth, shining cœrulean or cyaneous, sides and apex more or less purple.

87. Chrysocoris purpureus, Westwood.

Cimex stockerus, Fabricius, (nec Linn.) Syst. Ent. p. 696 (1775); Spec. Ins. ii, p. 338 (1781); Mant. Ins. ii, p. 280 (1787); Ent. Syst. iv, p. 79 (1794); Wolff, Ic. Cim. ii, p. 47, t. 5, f. 44 (1801): Stoll, Punaises, p. 17, f. 15, 16A. (1788).

Tetyra stockerus, Fabr., Syst. Rhyng. p. 131 (1803).

Scutellera stockerus, Latr., Gen. Ins. iii, p. 131 (1807).

Callidea stockerus, Burm., Handb. ii (i) p. 394 (1835): Westwood in Donovan's Ins. China, p. 48, t, 21, f. 1 (1842).

Callidea purpurea, Westwood, Hope, Cat. Hem. i, p. 15 (1837): Germar, Zeitschr. i (i) p. 115 (1839); Dallas, List Hem. i, p. 26 (1851); Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 31 (1863); Walker, Cat. Het. i, p. 26 (1867).

C. (*Chrysocoris*) *purpureus*, Stål, Hem. Fabr. i, p. 10, 11 (1868); En. Hem. iii, p. 21 (1873): Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Cærulean-purple: pronotum with 5 and scutellum with 6-7 spots, antennæ and tarsi, black; body beneath, luteous, margined purple and with purple stigmata; anus golden ; femora luteous with apex and tibiæ purple ; tarsi black (*C. purpureus*, Westw.) Stål notes that in his examples the pronotum has only two spots anteriorly and the discoidal spot on the scutellum is smallish and oblong. Vollenhoven gives the colour above as deep blue, head slightly tumid, and transversely wrinkled, eyes blackish, ocelli yellowish-brown; antennæ black, first joint blue, orange at the base, second joint one-fourth the length of the third in the ♀ : basal half of the rostrum yellow, rest brown, reaching second ventral segment: pronotum rather elevated, without a transverse groove, strongly punctured, with five (2 and 3) black spots : scutellum strongly punctured (except at the basal elevation which is almost smooth,) with six black spots arranged in two rows and a median triangular spot which is sometimes obsolete and is replaced by a green reflection : body beneath yellow or orange with the exception of the head and the margins of the pectus which are violet, of the margin of the abdomen which is purple and of a basal spot on the venter and small stigmatal spots which are black : feet orange as far as two-thirds of the femora, remainder violet, tarsi black. Body long. 15-17 mill.

Reported from Bengal, Bombay, Assam. Specimens from Assam vary in colour from purplish to sanguineous above. The Indian museum has specimens from Utakamand, S. India and Bihár.

88. CHRYSOCORIS VIRIDIS, Atkinson.

Proc. A. S. B. p. 12, (1887).

Allied to *C. purpureus*, Westw. Above light brassy-green, densely punctured: antennæ black, basal joint brown, rostrum almost reaching apex of second ventral segment: head and pronotum irrorated golden, the latter with a smoother transverse band close to, and parallel with anterior margin, and bearing slight traces of three blackish spots also traces of three median distant spots, lateral margins slightly reflexed, posterior angles slightly prominulous: scutellum with a steel-blue, smooth, semicircular, basal elevation; on each side, three smallish black spots, the basal resting on the basal elevation, no discoidal or apical mark; beneath very sordid flavescent turning into ferruginous, sides of pectus brassy-green, stigmata black, irrorated green, base of anal segment slightly black, no black spot on basal segment: feet somewhat ferruginous, apex of femora, and tibiæ externally, brassy-green. Differs from *C. purpureus* in colour and markings above, in the less-obtuse apex of scutellum, and absence of purple border and black basal patch on the abdomen. Long, 15-16 mill.

From the Panjab,

89. CHRYSOCORIS STOLLII, Wolff.

Cimex stollii, Wolff, Ic. Cim. ii, p. 48, t. 5, f. 45 (1801).

Scutellum stockerus, Guérin, Voy. La Coquille, Ins. ii, p. 159 and 161 (1830).

Callidea stollii, Germar, Zeitschr. i (i) p. 114 (1839); Dallas, List Hem. i, p. 26 (1851); Walker, Cat. Het. i, p. 27 (1867), excl. syn.

C. (*Chrysocoris*) *stollii*, Stål, Hem. Fabr. i, p. 11 (1868): En. Hem. iii, p. 21 (1873).

Antennæ 5-jointed, black, first joint ferruginous: head, thorax and scutellum cœrulean: head very shining with a longitudinal streak and a spot on both sides at the fuscous eyes, black; two small impressed lines on the apex: rostrum 4-jointed, black, flavescent at the base: thorax with six black spots, the anterior three small, the posterior three large, oblong; posterior angles rather prominulous, black: scutellum shining greenish, margin and apex purple; with eight black spots, three on each side, one in the middle oblong and large, and one at the apex (sometimes obsolete) transverse: hemelytra black, shining cœrulean; exterior margin, rufous; interior margin broadly whitish: membrane fuscescent, striated externally black: wings hyaline with a large black spot on the apex: abdomen beneath flavescent, throughout very finely impressly punctured, margin purple, on both sides with five black points on some of which is a small line: pectus flavescent with three violaceous spots on each side: anus with a black spot: feet unarmed; femora flavescent, at the apex violaceous; tibiæ violaceous (*Wolff*). Long, $13\frac{1}{2}$—14 mill.

Reported from China, Cambodia, Siam, Tenasserim, Burma, Assam, N. India.

Differs from *C. purpureus*, Westw. in its smaller, narrower body, thorax more elevated posteriorly, scutellum deeply impressed at the base and the number of the spots.

The discoidal spot on the scutellum is broadish and obovate.

90. Chrysocoris porphyricolus, Walker.

Callidea porphyricala, Walker, Cat. Het. i, p. 29 (1867).
Chrysocoris porphyricolus, Distant, J. A. S. Ben. xlviii (2), p. 37 (1879).

Gilded green, nearly fusiform, minutely punctured: head with a blackish stripe which has on each side of it a blackish spot and is bordered by two deep parallel furrows: pronotum with three longitudinally elongated purple spots in front of which there are three transversely elongated spots; a small cupreous spot on each angle near the hird border; scutellum with three large purple spots on each side; a slight transverse furrow which is curved to the anterior border on each side, tip purple: abdomen beneath red with black dots along each side of it and with a black subapical patch: legs red; femora towards their tips and tibiæ purple; tarsi black. (*Walker.*) Body long, 15 mill.

Reported from India, the Indian museum has specimens from Tenasserim and Sikkim: differs from preceding in the purplish tint more or less throughout above and the larger size of the spots.

91. Chrysocoris ornatus, Dallas.

Callidea ornata, Dallas, List Hem. i, p. 27 (1851).
C. (*Chrysocoris*) *ornatus*, Stål En. Hem. iii, p. 21 (1873).

Above brilliant golden-green, becoming purplish after death(?), thickly and rather strongly punctured: head impunctate with a black spot on the vertex: pronotum with three small black spots close to the anterior margin, three large ones touching the posterior margin and one in each lateral angle: scutellum with the basal elevation smooth nearly impunctate, with a large triangular black patch on the disc, a large oblong black spot on each side of this, at the middle of the scutellum, and two smaller ones towards the apex: abdomen bright orange-red with the margins crimson; the stigmata and a large spot at the base and the apex, black: pectus violet, tinged with golden green: legs, rostrum and antennæ black, the legs tinged with violet (*Dallas*). Body long, $13\frac{1}{2}$-14 mill.

Reported from China, Assam. Not strongly distinct from *C. stollii*, pectus without flavescent spots and lines, entire feet cœrulean-black.

92. Chrysocoris pulchellus, Dallas.

Callidea pulchella, Dallas, List Hem. i p. 25 (1851): Walker, Cat. Het. i, p. 26 (1867).

Chrysocoris pulchellus, Stål, En. Hem. iii, p. 22 (1873).

Closely allied to *C. marginellus*, Westw., but differs in its smaller size, in having the antennæ much broader and thicker and the second joint smaller than in that species; the head, in addition to the median longitudinal line has a small black spot on each side in front of the ocelli; the black spots also occupy more of the surface than in *C. marginellus* and are arranged precisely in the same manner; namely, nine on the pronotum of which three small ones on the anterior margin, one in each lateral angle and four large oblong ones on the disc towards the posterior margin; eight on the scutellum, placed, two, close to the base, forming an interrupted transverse band, a somewhat triangular one on middle of disc, one on each side of this, two behind the middle and one close to the apex: abdomen yellow with the margin crimson; stigmata, black, with a row of golden green spots within them and within these, another row of black ones; a black patch at the base and apex of abdomen: pectus violet and green: coxæ yellow: femora red with their tips, tibiæ, tarsi, rostrum and antennæ black. (*Dallas.*) Body long, 12½ mill.

Reported from India, Silhat.

93. Chrysocoris andamanensis, Atkinson.

Proc. A. S. B. p. 12, (1887):

Above deep blue turning into purplish or into green, or green, shining, deeply and densely punctured: eyes and ocelli brown: antennæ black, basal joint flavescent (except the apex): rostrum flavescent, reaching posterior coxæ: thorax densely punctured, transversely sulcate before the middle, with a broad smooth band close to anterior border, marked by three black, oblong, transverre spots, also between the band and the base, three large, longitudinal, black spots of which the median is triangular with its apex pointing forwards; margins slightly reflexed, posterior angles slightly prominulous and blackish: scutellum with a semicircular basal elevation, smooth, immaculate; three rounded spots on each side, of which the last is the largest, and a linear longitudinal median basal streak, black; broad apical limbus bright orange: body beneath flavescent, sides of pectus, stigmata, and transverse streaks therefrom on anterior margin of each segment on both sides, apex of femora and tibiæ externally, steel-blue; anal segment violet-black. Easily distinguished by its size and the broad, orange, apical limbus of the scutellum. Long, 17; breadth of pronotum, 9 mill.

The Indian Museum possesses a long series from the Andaman Islands.

94. Chrysocoris marginellus, Westwood.

Callidea marginella, Westwood, Hope, Cat. Hem. i, p. 15 (1837): Germar, Zeitschr. i (i) p. 117 (1839); Dallas, List Hem. i, p. 25 (1851); Walker, Cat. Het. i, p. 26 (1867).

Callidea cœlestis, Stål, Ofvers. K. V.-A. Förh. xii, p. 181 (1855); l. c. xiii, p. 52 (1856); Walker, l. c. iii, p. 510 (1868).

C. (*Chrysocoris*) *marginellus*, Stål, Hem. Fabr. i, p. 12 (1868); En. Hem. iii, p. 21 (1873).

Size of *C. purpureus*, Westw.: cœrulean-green, thorax with twelve spots, two intermediate, oblong; scutellum with nine, and an oblong anterior median stripe, black: thorax beneath golden-green; abdomen palely luteous with golden-greenish submarginal spots, margin broadly purple, stigmata black; femora rufous-fulvous, apex and tibiæ green (*Westw.*). Body long, 13-14 mill.

♂. Obscurely virescent-chalybeous; thorax with 11 black spots; scutellum densely and deeply punctured, with a basal transverse elevation, with 8 black spots of which the median longitudinal: pectus more obscure, yellow at the coxæ; abdomen yellow, each segment having on both sides a chalybeous-violaceous spot, last segment violaceous-black: femora cinnabar, apex and the tibiæ chalybeous: antennæ and tarsi, black. Head green chalybeous, subimpunctate, shining, tylus more obscure: antennæ black, second joint very minute: thorax sinuate anteriorly, sides oblique, broadly obliquely truncate on both sides posteriorly; scarcely so anteriorly, posteriorly (especially on the sides) more punctured, shining, chalybeous; adorned with eleven spots of which 3 anteriorly, 2 basal close together subelongate and 3 on each side placed triangularly, black: scutellum flatly-produced at the apex, densely and roughly punctured especially on the sides, transversely elevated at the base and there impunctate, green-chalybeous, adorned with seven rounded spots (arranged 2, 2, 2, 1) and an elongate median spot sometimes dilated at the base, black: pectus obscurely chalybeous-violaceous, yellow at the coxæ: abdomen roughly punctured on both sides, yellow, adorned with a black basal spot and obscurely chalybeous, transverse, lateral spots, last segment, violaceous-black: femora cinnabar, with apex and the tibiæ chalybeous: tarsi black. Colour sometimes somewhat golden green, margin of abdomen, weakly violacescent (*Stål*). Long, 19; broad, 9 mill.

Reported from Madras, Bengal, Bombay, Celebes, Borneo. The Indian Museum has specimens from Chandbali (S. coast of Bengal).

95. Chrysocoris eques, Fabricius.

Callidea eques, Dallas, List Hem. i, p. 28 (1851); Walker, Cat. Het. i., p. 32 (1867).

Chrysocoris eques, Stål, Hem. Fabr. i, p. 11, 12 (1868).

C. (*Chrysocoris*) *eques*, Stål, En. Hem. iii, p. 21 (1873).

Var. *a.* *Cimex eques*, Fabr., Ent. Syst. iv, p. 79 (1794). Tranquebar.

Tetyra eques, Fabr., Syst. Rhyng. p. 131 (1803): Schiödte in Kröyer's Tidsskr. iv. p. 284 (1842).

Scutellera eques, Guérin, Voy. La Coquille, Zool. ii, p. 158 (1830). Philippines.

Callidea eques, Burm., Handb. ii (i) p. 394 (1835); Germar, Zeitschr. i (i) p. 112 (1839): Voll., Faune Ent. l'Arch. Indo-Néer. p. 27 (1863).

Galostha eques, Am. & Serv., Hist. Nat. Ins. Hèm. p. 33 (1843).

Var. *b.* *Callidea schwaneri*, Vollenhoven, Faune l'Arch. Indo-Néer. p. 26, t. 2, f. 7 (1863); Walker, l. c. iii, p. 511 (1868). Borneo.

Var. *c.* Var. *nicobarensis*, Atkinson, Proc. A. S. B. p. 13, 1887). Nicobars.

Callidea eques, Mayr, Reise Novara, p. 24 (1866). Nicobars.

Var. *d.* *Callidea formosa*, Westwood. Hope, Cat. Hem. i, p. 15 (1837); Germar, Zeitschr. i (i) p. 113 (1839). China.

Callidea dorsalis, White in Gray's Zool. Misc. p. 80 (1842).

Var. *a.* Body ovate, above green: a band on the head between the antennæ emitting a branch up to the base and two small spots, deep black: dorsal line on thorax and four spots on each side (3, 1) deep black: scutellum large with eight deep black spots (2, 2, 2, 1) and the dorsal spot anteriorly bifid: abdomen black, margin green with black points: feet cœrulean (*C. eques*, Fabr.). Long, 11—13 mill.

Var. *b.* Head flat, smooth, green, with the ocular margin blue: the eyes and ocelli brown: antennæ black, very pubescent, the second joint only one-fifth the length of the following: pronotum a little punctured, except perhaps on the anterior angles; lateral margins much dilated, green or blue, disc golden: scutellum very tumid without a basal elevation, much punctured, principally near the anterior angles, a little flattened at the apex; colour green or golden red with a more or less large black spot at the extremity: deep violet beneath, middle of the venter black also the tarsi, or venter green with a large discal streak and small marginal spots, black. This variety has the following subvarieties:—

1. Black spots on the lateral angles of the pronotum.
2. In addition, a black spot on the anterior margin of the pronotum.

3. a T-shaped spot or two small lines on the disc of the scutellum.

4. Seven rather indistinct spots on the pronotum, scutellum with a small median line, two lateral and one anal spot.

5. Five rather distinct spots on the pronotum and five larger on the scutellum (*C. schwaneri*, Voll.).

Long, 11-12 mill.: all from Borneo.

Var. *c. nicobaricus*, mihi, is represented in the Indian Museum by a long series from the Nicobar islands.

Above shining green; eyes brown; antennæ black: pronotum with the lateral margins much dilated, semicircularly rounded, edged black; anteriorly with a transverse row of three black spots of which the median is largest, triangular, having its apex pointing hindward; three black spots arranged in form of a triangle at the posterior angles, sometimes but two, and then with the basal margin black, on which rests a median triangular spot with its apex turning forwards and meeting the triangular median spot of the anterior row: scutellum without a basal elevation, no discal spot, three black spots on each side and one at the apex: body beneath entirely brassy-green, tinted violet or steel blue, especially on the pectus, a small median transverse patch on the anterior margin of each segment, also the stigmata and base of anal segment violet black: feet of a steel blue, tibiæ internally sordid ferruginous. Long, 11-12 mill.

Mayr describes what is probably the ♂ of this variety, also from the Nicobars, as having the pronotum anteriorly with three black marks of which the median is largest, in the middle with two rounded black marks and near the posterior margin three like them, of which the median is connected by means of a black line with the median mark on the anterior border: scutellum shining green, bluish on both sides with three pair of blackish spots, of which the anterior and median pair are rounded, the posterior transverse; the median V-shaped mark is wanting and there is hardly any trace of the usual apical black spot: the basal segments of the abdomen are for the most part violet and somewhat green, the median are green with blackish-violet oblong streaks, stigmata violet and base of anal segment black.

Var. *d.* Brassy-green, pronotum with the sides reflexed, broader than the scutellum, spotted black and with two large, rounded dorsal spots, sanguineous; scutellum sanguineous; body beneath and feet brassy, the former spotted black, the stigmata deep blue (*C. formosa*, Westw.). Body long, 11-12 mill.

Reported from China.

Reported from Tranquebar, Malacca, Singapore, Banca, Sumatra, Java, Borneo. The Indian Museum has a long series of variety *c.* from the Nicobar Islands.

96. Chrysocoris dilaticollis, Guérin.

Scutellera dilaticollis, Guérin, Voy. La Coquille, Zool. ii, (2) p. 160, 164 (1830).
Chrysocoris stollii, Hahn (nec Wolff), Wanz. Ins. ii, p. 39, t. 44, f. 136 (1834).
Callidea abdominalis, Westwood, Hope, Cat. Hem. i, p. 15 (1837); Germar, Zeitschr. i (i) p. 112 (1839).
Galostha stockerus, Am. & Serv. Hist. Nat. Ins. Hèm. p. 34 (1843).
Callidea dilaticollis, Dallas, List Hem. i, p. 28 (1851); Walker, Cat. Het. i, p. 28 (1867): Vollenhoven, Faune Ent. l'Arch. Indo-Néer. p. 28 (1863).
Callidea stockerus, Stål, Ofvers. K. V.-A. Förh. p. 389 (1855).
Chrysocoris stockerus, Stål, Hem. Fabr. i, p. 12 (1868).
Var. *Callidea sumatrana*, Vollenhoven, l. c. p. 28, t. 2, f. 9 (1863).
C. (*Chrysocoris*) *dilaticollis*, Stål, En. Hem. iii, p. 21 (1873).

Above shining blue, more or less greenish: head broad, triangular; eyes prominulous; median longitudinal line, black: antennæ black, in ♂ at least as long as the body, in ♀ shorter, two last joints comparatively stout: thorax anteriorly as broad as the head, abruptly produced posteriorly in a small, fine, rounded dilatation on each side; no depression in front, broader than the scutellum and almost twice broader than long, surface smooth or very weakly punctured; with two rows of three round, rather large black spots, and the lateral dilatation, also, black in the middle: scutellum with seven round, black spots and a large triangular spot towards the base, very broad in front, a little emarginate on the sides and having in some specimens a small green line in the middle; the posterior spot is placed in the middle and near the tip: thorax beneath of a beautiful shining green, with small yellow lines, on the sutures: rostrum green, with the base orange: abdomen bright orange yellow, with a quadrate patch at the base and the anus black-blue; sides green with two rows of four black dots on each side: femora bright orange yellow with their tips, the tibiæ and tarsi blue-green *(Guérin)*. Long, 10—12; broad at the base of the scutellum, 5½—6 mill.

Reported from Java, Sumatra, Celebes, Timor, Malacca, Burma, India, China. The Indian Museum possesses specimens from Arakan in which the abdomen beneath is almost entirely dark brassy-green, the disc of the last three segments alone being orange yellow and in this respect approaches Var. *sumatrana*, Voll.

Genus Lamprocoris, Stål.

Hem. Afric. i, p. 34 (1864); Mayr, Reise Novara, Hem. p. 18 (1866): Stål, En. Hem. iii, p. 9, 22 (1873). Includes *Sophela*, Walker, Cat. Het. i, p. 17 (1867).

Stål distributes the species belonging to this genns amongst the subgenera *Lamprocoris* aud *Sophela*, both of which are represented in India. Third joint of the antennæ longer than the second; tibiæ cylindrical neither flat nor furrowed above: prostethium impressed behind the eyes within the anterior margin which is amplified betweeu the eyes and the sternum : anterior margin of the basal angles of the scutellum subreflexed ; ventral segments unarmed in the apical angles ; near the sides, anteriorly and posteriorly, somewhat convex or tumescent.

97. Lamprocoris lateralis, Guérin.

Scutellera lateralis, Guérin, Voy. La Coquille, Zool. ii (2) p. 159, 160 (1830).

Callidea lateralis, Dallas, List Hem. i, p. 28 (1851) ; Walker, Cat. Het. i, p. 28 (1867) : Vollenhoven, Faune Ent. l'Arch. Indo-Néerl. p. 32, t. 2, f. 11 (1863).

L. (Lamprocoris) lateralis, Stål, Berlin Ent. Zeitschr. x, p. 155 (1866); En. Hem iii, p. 22 (1873).

Head rounded at the tip, triangular, punctured, with two longitudinal grooves in the middle; green, shining, the sides and the space between the grooves of a rich Prussian blue: antennæ black : pronotum and scutellum bluish-green, the former very tumid and very broad behind, punctured, lateral posterior angles rather prominulous ; above and anteriorly, with two oblong black spots, placed transversely and trending a little obliquely, towards the tip of a median and longitudinal line of which the extremity reaches their level and whioh ends at the posterior margin; on each side of this line are three long oblique spots which do not reach the posterior margin: scutellum punctured, with three transverse rows of black marks, of which five are on the anterior margin in the form of a crescent, four towards the middle, of which the two median are much the largest, three behind these, almost united by a weak brown mark, two more behind these last and often a very small transverse spot at the posterior extremity : body beneath is of the same colour as above: abdomen with a broad red band, commencing close to the base and ending near the anus, it occupies half the first segment, the 2-4 and half the fifth segment, and has four black-brown stigmatic dots on the margin : feet concolorous : hemelytra brown ; wings transparent, tip alone infuscate (*Guérin*). Long, 9—10 ; broad, 6—6½ mill.

Reported from Java, Sumatra, Assam. The Indian Museum possesses a specimen from Sikkim.

98. Lamprocoris roylii, Westwood.

Callidea Roylii, Westwood, Hope, Cat. Hem. i, p. 16 (1837) : Germar, Zeitschr. i (i) p. 119 (1839) : Dallas, List. Hem. i, p. 28 (1851); Walker Cat. Het. i, p. 28 (1867).

Var. *Scutellera pulchella*, Westwood, Royle, Ill. Bot. Him. p. liv, t. 10, f. 6 (1839).

Lamprocoris roylii, Stål, En. Hem. iii, p. 22 (1873) : Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Rufous cupreous or golden, varied with black: pronotum with the dorsal line, three spots on each side and the humeral angle, black: scutellum with three basal and five apical spots, also a broad lunated band in the middle, black, margined green: body beneath greenish; abdomen with black band and on the margins rufous spots (*C. Roylii*, Westw.). Body long, 9½ mill.

Brassy or cœrulean-black, shining: disc of pronotum anteriorly and posterior margin tinted cupreous or brassy: scutellum, intensely green and gold, a transverse basal band and another median oblique (interrupted in the middle), and three rounded spots (posteriorly and arranged in form of a triangle), cœrulean black: scutellum covering the abdomen: two basal joints of antennæ short, equal, third almost twice as long as the second, last longest of all. Long, 10½; broad, 6¼ mill. (*S. pulchella*, Westw.)

Reported frcm the Himálaya, Bengal, Nepál, Assam. The Indian Museum has specimens from Sikkim and Mussoorie.

99. Lamprocoris obtusus, Westwood.

Callidea obtusa, Westw., Hope, Cat. Hem. i, p. 16 (1837); Germar, Zeitschr. i (i), p. 119 (1839): Voll., Faune Ent. l'Arch. Ind. Néerl. i, p. 32 (1863): Walker, Cat. Het. iii, p. 510 (1868).

L. (Lamprocoris) obtusus, Stål, En. Hem. iii, p. 22 (1873).

Golden-green: two anterior spots on the thorax, a dorsal line and four other oblique, black: eleven black spots on the scutellum: body beneath and the feet, black with a golden tinge; margin of abdomen, fulvous, stigmata black (*Westw.*). Long, 9½ mill.

Reported from Java.

100. Lamprocoris spiniger, Dallas.

Callidea spinigera, Dallas, Trans. Ent. Soc. v, p. 186, t. 19, f. 1 (1849).

Sophela spinigera, Walker, Cat. Het. i, p. 18 (1867).

Lamprocoris (Sophela) spinigera, Stål, En. Hem. iii, p. 22 (1873): Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Broadly ovate, rather convex; above brownish testaceous, with violet or brassy reflections, very thickly and finely punctured: head violet, shining, faintly punctured and transversely wrinkled, the tylus darker in colour; eyes brown, ocelli red: pronotum faintly punctured with the lateral angles produced into a small acute spine on each side, the anterior and lateral margins and in the ♂ the whole anterior portion, cupreous or violet, shining: on each side, towards the anterior margin, is a small transverse fovea, surrounded by a brassy green ring: scutellum very finely punctured and faintly wrinkled transversely, especially at the base which is brassy, cupreous or violet : hemelytra with the margins pale testaceous : margins of the abdomen projecting slightly beyond the scutellum, bright red, crenated, each segment bearing two small projections or tubercles; abdomen beneath, deep blue violet, very smooth and finely punctured, with a strong brassy-green reflection ; a violet line on the margin of each segment, running between the red tubercles ; anal apparatus red, violet at base in ♂ : pectus shining violet, punctured; the antero-lateral margins and the prominent lateral angles, reddish : legs shining violet, finely pilose; tarsi black: antennæ and rostrum black, the former covered with short hairs. *(Dallas.)* ♂, long with membrane 15 ; ♀, 16 mill.

Reported from N. India, Assam, Sikkim (Ind. Mus.) : varies somewhat in the colouring above and beneath : above often purplish nacreous, beneath the disc of abdomen shining red.

Div. Tetyraria, Stål.

En. Hem. iii, p. 3, 24 (1873).

Body beneath distinctly convex, generally above and below equally convex or below more convex: thorax and scutellum at the base conjointly gradually longitudinally convex, very rarely slightly convexly inclined, basal part of thorax somewhat produced backwards between the basal angles of the scutellum or the thorax posteriorly gradually rounded between the lateral angles, basal angles very obtuse or rounded: venter in both sexes with two stridulatory spots, longitudinally very densely and very finely strigose, oblong or elongate, extended through at least the fourth and fifth segments, sometimes difficult to distinguish, intermediate incisures straight on the disc or biundated, abruptly and obtusely subangulately curved at the sides of the disc: orifices very distinct (*Stål).*

Genus Hotea, Am. & Serv.

Hist. Nat. Ins. Hèm. p. 41 (1843) : Dallas, List Hem. i, p. 5, 39 (1851): Mayr, Reise Novara Hem. p. 15 (1866): Walker, Cat. Het., i, p. 55 (1867): Stål, Hem. Afric. i, p. 35, 53 (1864); En. Hem. iii, p. 24 (1873).

Body nude, above and beneath convex: head altogether convex, with a continued median lobe, bucculæ rather elevated before the middle: second and third joints of the antennæ subequal in length, or the second a little longer than the third : thorax sexangular, anterior lateral margins, distinctly sinuated, lateral angles produced, more or less acuminate, posterior angles rounded, posterior margin straight: scutellum as broad as the abdomen, rounded at the apex, not produced : prostethium dilated anteriorly, covering the base of the antennæ: sterna slightly sulcated: disc of venter with two sericeous-shining spots, last segment sinuated at the apex: feet somewhat robust, tibiæ above flat *(Stål)*.

101. Hotea curculionides, Herr. Schäff.

Pachycoris curculionides, Herr. Schäff., Wanz. Ins. iii, p. 106, t. 107, f. 331 (1835); Germar, Zeitschr. i (i) p. 106 (1839).

Pachycoris punctulatus, Germar, l. c. p. 105 (1839).

Hotea curculionides, Dallas, List Hem. i, p. 39 (1851); Walker, Cat. Hem. i p. 56 (1867); Vollenhoven, Faune Ent. l'Arch. Indo-Néer. p. 37 (1863).

Hotea (Tylonca) curculionides, Stål, En. Hem. iii, p. 25 (1873); Distant, J. A. S. B. xlviii (2) p. 37 (1879); A. M. N. H. (5 s.) iii, p. 44 (1879).

Ochraceous, deeply and thickly punctured brown or black, except on the vertex and anterior margins of the pronotum where the colour is more yellow: head beneath black, except the borders of the rostral groove: eyes and ocelli greyish yellow, the latter very small: two first joints of the antennæ yellow, the two next brownish and the last, brown: the feet are even more punctured than the body: the tibiæ reddish. This species varies much in the depth of its brown colour and the punctures more or less strong and black; Germar's *H. punctulata* is of a very deep brown; some specimens have three longitudinal lines on the head and thorax less punctured and lighter, and a zigzag transverse band on the scutellum, from the most advanced portion of which proceed three other light lines which reach the margins *(Voll.)*. Long, 8—9 mill.

Schäffer's figure shows the upper surface deep brown without spots. The Calcutta form has four longitudinal patches of a deeper colour proceeding from the anterior margin of the pronotum, the two median are continued obliquely inward almost to the posterior margin where they meet. The scutellum has on each side an oblique small oblong spot near the base on each side, and a large subquadrate patch on each side beyond the middle, and two at the apex, all of a darker colour. Specimens from Tavoy and Assam have the same spots more or less distinct.

Reported from Amboina, Java, Sunda, Celebes, Timor, Ternate, Sumatra, Assam. The Indian Museum possesses specimens from Tavoy, Calcutta and Sikkim.

102. Hotea nigrorufa, Walker.

Hotea nigrorufa, Walker, Cat. Het. i, p. 57 (1867).

Red, short-elliptical, thickly black-punctured, and with numerous small irregular black marks: head with five irregular red lines, and with two longitudinal furrows: antennæ black; first joint red; fourth red at the tip: thorax with a red longitudinal line; sides luteous; angles acute: scutellum with an apical patch, which is not varied with black: abdomen luteous along each side: legs red, black speckled; tarsi black: hemelytra brown; corium red, with black punctures: wings cinereous. Var. *a.* body red, with the exception of the punctures. Var. *b.* like var. *a*: punctures red, here and there black. (*Walker*). Body long, 10½ mill.

Reported from India.

103. Hotea(?) diffusa, Walker.

Hotea (?) *diffusa*, Walker, Cat. Het. i, p. 57 (1867).

Testaceous, elliptical very minutely punctured: head slightly rostriform, with two black longitudinal lines, which in the forepart are accompanied by two slight furrows: thorax somewhat rounded along the hind border, angular on each side, contracted in front; two slight and interrupted black lines; a transverse lanceolate ferruginous-bordered mark on each side near the fore border: scutellum with a short longitudinal streak on each side, composed of minute black speckles. (*Walker*). Body long, 9½ mill.

Reported from India.

Div. Odontotarsaria, Stål.

En. Hem. iii, p. 4, 26 (1873).

Head longer than broad or equally long and broad: anterior lateral margins of thorax anteriorly not, or but very slightly, rounded: propleura not, or but slightly, impressed near the lateral margins: orifices not distinguishable: second joint of antennæ straight.

Genus Alphocoris, Germar.

Zeitschr. i, p. 58 (1837): Dallas, List Hem. i, p. 5 (1851): Stål, Hem. Afric. i, p. 35, 60 (1844): Mayr, Reise Novara Hem. p. 13 (1866): Walker, Cat. Het. i, p. 59 (1867).

Body stout, especially beneath convex, narrowly oval or oblong, greyish-tomentose: head stout, not margined, very convex, bucculæ rather elevated: antennæ short, somewhat longer than the head: thorax sexangular, posterior angles obtusely rounded, lateral angles not prominent, obtuse: scutellum a little produced at the apex, the produced part sinuate or somewhat sinuate at the apex: prostethium somewhat dilated at the apex: sterna deeply sulcate: ventral incisures curved (*Stål*).

104. Alphocoris lixoides, Germar.

Alphocoris lixoides, Germar, Zeitschr. i, p. 59, t. i, f. 3 (1839): Am. & Serv., Hist. Nat. Ins. Hém. p. 44 (1843): Dallas, List Hem. i, p. 41 (1851): Stål, Hem. Afric. i, p. 60 (1864): En. Hem. iii, p. 26 (1873): Walker, Cat. Het. i, p. 59 (1867).

♂, ♀. Oblong, narrow, yellow-testaceous, beneath with feet (except ventral limbus) blackish: above, rather densely and distinctly punctulate, with four obsolete fuscous streaks; apex of scutellum subtruncate or slightly sinuate: disc of venter sometimes yellow-testaceous and adorned with two black streaks (*Stål*). Long, 9½—10; broad, 3—3½ mill.

Reported from North India, Senegal.

Div. Eurygastraria, Stål.

En. Hem. iii, p. 4, 29, (1873): *Eurygastridæ*, pt., Dallas, List Hem. i, p. 43 (1851).

Differs from *Odontotarsaria*, in having the orifices distinct: second joint of antennæ somewhat curved.

Genus Eurygaster, Laporte.

Subg. id. Ess. Hém. p. 69 (1832): *Eurygaster*, Stål, Hem. Afric. i, p. 61 (1864); Eu. Hem. i, p. 18 (1870); iii, p. 29, 30 (1873). Includes, according to Stål;—*Bellocoris*, pt., Hahn, Wanz. Ins. ii, p. 42 (1834):—*Eurygaster*, Spin., Ess. p. 365 (1837); Mulsant & Rey, Pun. Scut. p. 59 1865):—*Tetyra*, Germar, Zeitschr, i, (i) p. 72 (1839): Herr. Schäff. Wanz. Ins. v, p. 48 (1839):—*Eurygaster*, subg. *Platypleurus*, Mulsant & Rey, Pun. Scut. p. 59 (1865).

Body oval or ovate, a little convex above and beneath: head flat or very slightly convex; antennæ short, slender: thorax sexangular: scutellum with the sides parallel, much narrower than the abdomen, leaving the entire costal part of the hemelytra free: abdomen with the sides flattened broader than the thorax: orifices extended in a rather long furrow, abruptly abbreviated; sides of mesosternal furrow neither carinate nor rugose; tibiæ furrowed above. In the section to which *E. maurus*, Linn. belongs, the lateral margins of the pronotum are straight or somewhat so; the scutellum is marked on both sides at the base near the basal angles with an oblong callous spot and the smooth longitudinal line is not callous (*Platypleurus*, M. & R.).

105. Eurygaster maurus, Linnæus.

E. (Platypleurus) maurus, Stål, En. Hem. iii, p. 30 (1873).

Tetyra maura, Fallen, Hem. Suec. Cim., p. 12 (1828): Burm., Handb. Ent. ii, p. 390 (1835): Germar, Zeitschr. i, p. 73 (1839); Rambur, Fauna Andal. ii, p. 100 (1841).

Eurygaster maurus, Am. & Serv., Hist. Nat. Ins. Hém. p. 53 (1843); Dallas, List Hem. i, p. 48 (1851): Fieber, Eur. Hem. p. 370 (1861): Mulsant & Rey, Pun. France, p. 59 (1865): Walker, Cat. Het. i, p. 66 (1867): Stål, Hem. Fabr. i, p. 12 (1868): Douglas & Scott, Brit. Hem. i, p. 65 t. 2, f. 5 (1865): Saunders, Trans. Ent. Soc. p. 119 (1875): T. Sahlb., K. S. V.-A. Handl. xvi, 4, p. 14 (1878): Distant, Trans. Ent. Soc. p. 415 (1883).

Var. *a.*—*Cimex maurus*, Linn,, Fauna Suec., p. 246 (1761): Fabr., Syst. Ent., p. 99 (1775); Ent. Syst. iv, p. 87 (1794).

Tetyra maura, Fabr., Syst. Rhyng., p. 136 (1803).

Thyreocoris austriacus, Schranck, Fauna Boioc. ii, p. 68 (1801).

Odontotarsus maurus, Spin., Ess. Hém. p. 363 (1837).

Eurygaster cognatus, Westwood, Hope, Cat. Hem. i, p. 11 (1837).

Var. *b.*—*Tetyra picta*, Fabr., Syst. Rhyng. p. 136 (1803).

Odontotarsus pictus, Spin., Ess. Hém. p. 363 (1837).

Eurygaster orientalis, Westwood, Hope, Cat. Hem. i, p. 11 (1837).

This species varies much in size and colour from brownish tawny without markings to luteous with stripes and patches of brown.

Var. *a.*—Greyish or fuscous, scutellum at the base with two white spots (*Linn.*). Rufous-brunneous, punctured black: thorax with two diverging streaks, somewhat fuscous: scutellum with two minute basal, whitish spots, and an elevated median line, paler: beneath obscurely luteous, with a black spot before the anus (*E. cognatus*, Westw.). Long, 10½ mill.

Var. *b.*—Head and thorax obscure, a little irrorated with black: scutellum large, obscure; with two callous spots as in *T. maura*, two spots in the middle and a dorsal line bifurcated posteriorly, yellow: connexivum spotted fuscous on both sides (*T. picta*, Fabr.). Fuscous-rufescent, punctured black, variegated paler; a slender line from the head to the apex of the scutellum and two other oblique lines united to it (having the appearance of a triangular scutellum) and a pair of larger spots at the sides of the scutellum: beneath rufescent, punctured black, especially in the middle of the abdomen (*E. orientalis*, Westw.). Long, 9-10 mill.

Reported from Europe, Africa, India, Japan.

Div. Odontoscelaria, Stål.

En. Hem. iii, p. 4, 30 (1873).

Body setose or pilose: head transverse, somewhat semiorbicular, thorax anteriorly broader than the head, anterior lateral margins distinctly rounded: the scutellum very broad: propleura deeply impressed or excavated towards the lateral margins, the part lying beyond the depression a little deflexed: venter without stridulatory strigose spots; orifices not distinguishable (*Stål*).

Genus Arctocoris, Germar.

Pt., Zeitschr. i (i), p. 46 (1839): Stål, En. Hem. iii, p. 31 (1873). Includes, *Irochrotus*, Am. & Serv., Hist. Nat. Ins. Hém., p. 39 (1843); Fieber, Eur. Hem. p. 86, 377 (1861); Mayr, Reise Nov. Hem. p. 18 (1866).

Body thickly clothed with long hairs: lateral margins of thorax incised or sinuated behind the middle, between the sinus a deep transverse impression.

106. Arctocoris incisus, Stål.

Arctocoris incisus, Stål, En. Hem. iii, p. 31 (1873).

♂. Narrowly subobovate, punctulate, black, turning above into ferruginous, greyish-pilose and subtomentose: thorax before the middle slightly roundly-narrowed, transversely impressed very distinctly in the middle, lateral margins very deeply incised in the middle, anterior angles somewhat prominent forwards. The ♂ has on the ventral disc of 4th, 5th segments on both sides, a deep black opaque, subimpressed, oval spot. Allied to *A. lanatus*, Pallas, but differs in being smaller, narrower, subobovate, narrowed hindwards, thorax only narrowed at the apex, lateral margins very deeply incised, not obtusely sinuated, and with the bucculæ more elevated *(Stål)* Long 5, breadth of pronotum, 3 mill.

Reported from Bengal.

Species of uncertain position.

107. Callidea fascialis, White.

Callidea fascialis, White, Trans. Ent. Soc. iii, p. 86 (1842); Dallas, List Hem. i, p. 28 (1851); Walker, Cat. Het. i, p. 27 (1867); Stål, En. Hem. iii, p. 31 (1873).

Head short, in front rather blunt, with a large pinkish-violet spot, on the side of the two impressed præocular lines, the space between these, being green: first joint of the antennæ testaceous at base, green at the tip: rostrum reaching the posterior coxæ, black at the tip, yellow at the base: thorax with seven black spots; two distant anterior ones in front connected by a narrow slightly curved black line: five posterior ones, the median, largest, and square, apparently connected together at the base by an obscure band, which has a slight pinkish hue on the posterior blunt angle of the thorax: legs yellow, femora at tip, bluish green, tibiæ rufescent, ciliated: scutellum convex, posteriorly bent down, blunt at apex, with a semicircular impression at the base, deepest on the dorsum; at the base there is a narrow, transverse black band, sinuated on the posterior margin; a little before the middle there is another transverse black band, broadest in the middle beyond which are three spots, one of them subapical: abdomen beneath, yellow, sides tinged with pink, each segment being marked laterally with a black spot, the inner sides of which are tinged with green. (*White*). Body long, 11 mill.

Reported from India, Assam.

108. Callidea histeroides, Walker.

Callidea histeroides, Walker, Cat. Het. i, p. 28 (1867).

Blackish purple, short-elliptical, largely punctured: head with two longitudinal furrows which diverge between the eyes, space between the furrows somewhat ridged in front: antennæ black; second joint rather more than half the length of the first: thorax with two green stripes, very thinly punctured; punctures mostly along the fore border and along a transverse antemedial furrow; a fusiform, transverse, slightly depressed, ringlet on each side in front of the furrow: scutellum with a green band bordering a transverse furrow which is curved on each side to the fore border: abdomen beneath green, with a purplish band along the fore border of each segment and with a deeply dentate red stripe along each side: legs blackish green; tarsi black. (*Walker*). Long, 8—9 mill.

Reported from Cachar (Assam).

109. Callidea gibbula, Walker.

Callidea gibbula, Walker, Cat. Het. i, p. 29 (1867).

Purplish black, elliptical, thinly and roughly punctured: head with two longitudinal furrows, which diverge on the vertex: thorax with a very slight transverse furrow, which is curved on each side to the base: abdomen beneath, greenish at the tip, and with two deeply dentate lateral stripes, which do not extend to the base (*Walker*). Long, 8—9 mill.

Reported from the Panjab.

110. Callidea scripta, Walker.

Callidea scripta, Walker, Cat. Het. i, p. 29 (1867).

Purple, short-elliptical, largely punctured: head with two longitudinal furrows, which diverge towards the face and more towards the hind border: antennæ black; second joint nearly as long as the first: thorax with two golden green stripes, which are much abbreviated in front, and thence emit two oblique branches towards the hind angles; a fusiform transverse cupreous ringlet on each side in front: scutellum with a transverse furrow which is curved on each side to the fore border; four cupreous green-bordered bands: second, third and fourth bands connected on each side; second connected in the middle with the third, forked on each side, fourth apical: pectus blue: abdomen beneath blue; a purple band on the fore border of each segment; a dentate red stripe on each side: legs green; tarsi black *(Walker)*. Long, 9—10 mill.

Reported from Cachar (Assam), N. India.

111. Callidea contraria, Walker.

Callidea contraria, Walker, Cat. Het. i, p. 30 (1867).

Gilded green, short, stout, nearly elliptical, rather thinly and roughly punctured: head purple in front with two longitudinal furrows which diverge on the vertex: antennæ black; first joint purple; second more than half the length of the first: thorax with seven short purple stripes, in front of which there is a transverse purple spot on each side: scutellum with three purple spots near the base, and with three purple bands of which the second is interrupted; three hinder transverse spots, one on each side and one subapical: pectus purple: abdomen red; under side with a row of black dots along each side with a purple disc: legs bluish green; tarsi black *(Walker)*. Long, 10—11 mill.

Reported from N. India.

112. Fitha ardens, Walker.

Fitha ardens, Walker, Cat. Het. i, p. 45 (1867).

Gilded green, elliptical, largely punctured: head with two longitudinal furrows, which diverge between the eyes and converge slightly on the hind border; vertex purple between the furrows: antennæ 4-jointed (?), black; first joint reddish at the base: thorax and scutellum mostly brilliant reddish cupreous; the former with six purple spots; the latter with eight purple spots; three on each side; seventh elongated, on the disc near the base; eighth sub-apical: pectus with a transverse yellow streak on each side: abdomen beneath with a bright purple stripe along each side, and with a yellow patch on the disc: legs red; tibiæ and tips of femora blackish green; tarsi black: hemelytra black; space towards the base, except the costa, cinereous, nearly hyaline: wings cinereous, nearly hyaline *(Walker)*. Long, 8½ mill.

Reported from India.

113. Cœnina variolosa, Walker.

Cœnina variolosa, Walker, Cat. Het. i, p. 82 (1867).

Aeneous: head with a pale yellow spot on each side: antennæ yellowish, piceous towards the tips: thorax mostly yellowish, with a pale yellow border; an æneous band in front, containing two quadrate whitish spots, behind which there is an æneous spot; punctures æneous: scutellum yellowish, excepting the punctures and a patch on the disc, and three whitish spots on the fore border: legs whitish; femora at the base and coxæ black: corium yellowish, with æneous punctures *(Walker.)*. Body, long, 2 mill.

Reported from Burma.

Subfam. PENTATOMINA, Stål.

Hem. Afric. i, p. 32, 76 (1864); Ofvers. K. V.-A. Förh. (3), p. 31 (1872); En. Hem. v, p. 28 (1876).

(*a*). The primary and subtended veins of the hemelytra generally close to each other and diverging at the apex, parallel or somewhat so: hamus generally absent: scutellum varying in size, generally furnished with frena: entire basal margin of thorax touching base of the scutellum: rostral furrow anteriorly not or but very slightly narrowed.

(*b*). Rostrum extended behind the first pair of coxœ, of variable length, 1-2 joints elongate, the second entirely or to the greatest part extended behind the bucculæ.

(*c*). Scutellum generally reaching or extending beyond the middle of the abdomen, rarely short, and if so, narrow at the apex and only slightly or very slightly produced behind the frena: membrane moderate or small.

(*d*). Tarsi 3-jointed: tibiæ generally furrowed above.

(*e*). Rostrum slender, more or less remote from the labrum which is inserted below the apex of the tylus; rostral furrow anteriorly sometimes coarctate: bucculæ usually higher anteriorly, parallel, not united posteriorly.

The divisons of this large sub-family are still only tentative and cannot be satisfactorily arranged by any one working only in India away from the types. I only give when possible what may be considered a probable arrangement after consulting the very considerable literature on the subject.

Div. PODOPARIA, Stål.

En. Hem. v, p. 29 (1876).

Anterior lateral margins of the thorax produced in a tooth or spine before the lateral angles which on this account appear as if sinuate or emarginate: entire antenniferous tubercles or a great part prominulous beyond the lateral margins of the head, generally acutely produced outwards at the apex: first joint of the rostrum not extended behind the bucculæ which are everywhere equally high or posteriorly higher: eyes strongly prominulous or slightly stylate: frena sometimes occupying one-third the length of the scutellum which generally reaches the end of the abdomen.

Genus Scotinophara, Stål.

Ofvers. K. V.-A. Förh. p. 502 (1867): En. Hem. v, p. 33 (1876); Horvath, Wien Ent. Zeit. ii, p. 165 (1883).

Body ovate: head somewhat convex, more or less sinuate before the eyes; juga flattened, entirely distant, not narrowed before the anteocular sinus, not converging before the somewhat elevated tylus, rounded at the apex or roundly truncated: antenniferous tubercles placed below the lateral margins of the head and entirely prominulous beyond those margins, acutely produced outwards at the apex; bucculæ continued through, low, everywhere equally high: antennæ somewhat short, basal joint entirely visible from above, second joint distinctly shorter than the third, fifth joint scarcely or only a little stouter than the fourth elongate fusiform: rostrum reaching the last pair of coxæ: thorax transverse, furnished with a gular ring prominulous on both sides in a more or less acute tooth, and armed before the humeral angles with an acute tooth: scutellum large, longer than the corium, reaching the apex of the abdomen, slightly narrowed behind the base, the basal part with frena: prostethium furrowed, the furrow with elevated margins: second genital segment in ♂ entirely hidden, the third segment only visible. *(Horvath.)*

114. Scotinophara affinis, Haglund.

Scotinophara affinis, Haglund, Stettin Ent. Zeit. xxix, p. 153 (1868); Stål, En. Hem. v, p. 33 (1876).

♀. Fuscous-lurid, beneath blackish, densely and strongly punctured; rostrum, tibiæ (base excepted) and tarsi, rufescent; pronotum anteriorly with a very minute annulated tooth, sides subsinuate, lateral angles very slightly emarginate: scutellum distinctly truncate at the apex, extended to the apex of the abdomen. Closely allied to *S. lurida* Burm. from which it scarcely differs except in the anterior tooth on the pronotum being smaller, sides of thorax more distinctly sinuate, and thorax somewhat more impressed. Rostrum reaching the last pair of coxæ: membrane almost hyaline, margin fuscescent: second joint of antennæ rufescent *(Haglund)*. Long, 9; broad scarcely 5 mill.

Reported from Rangoon.

115. Scotinophara lurida, Burmeister.

Tetyra lurida, Burm., Nov. Act. Ac. Cæs. Leop. Car. Nat. Cur. xvi, Suppt. (i) p. 288 (1834).

Podops luridus, Germar, Zeitschr. i (i) p. 64 (1839); Dallas, List. Hem. i, p. 52 (1851); Walker, Cat. Het. i, p. 72 (1867).

Scotinophara lurida, Stål, En. Hem. v, p. 33 (1876); Scott, A. M. N. H. (4 s.) xiv, p. 289 (1874); (5 s.) Distant, iii, p. 44 (1879); Trans. Ent. Soc. p. 415 (1883).

Fuscous: head small; eyes free, almost stylate; clypeus produced forwards, with a distinct groove on each side, in which the antennæ lie: antennæ with 1-2 joints of equal length, half as long as the third, 3-5 joints of equal length, the last incrassate: pronotum narrowed forwards, on each side on the anterior angle a small acute spine, a similar one on each humeral angle, a weak, transverse furrow beyond the middle: scutellum a little shorter than the abdomen: rostrum, tibiæ, and feet reddish. *(Burm.)* Long, $10\frac{1}{2}$; broad, $6\frac{1}{4}$ mill.

Reported from Canton, Japan, Assam.

116. Scotinophara bispinosa, Fabricius.

Cimex bispinosus, Fabr., Ent. Syst. Suppt. p. 530 (1798).

Tetyra bispinosa, pt. Fabr., Syst. Rhyng. p. 138 (1803).

Scotinophara bispinosa, Stål, Hem. Fabr. i, p. 21 (1868); En. Hem. v, p. 33 (1876).

♀. Blackish; thorax behind the middle, scutellum, hemelytra and broad ventral limbus fuscous-flavescent, punctured ferruginous-black: antennæ, rostrum, tibiæ and tarsi greyish flavescent; last joint of antennæ, fuscous: spine of anterior and lateral angles of the thorax large, black, pallescent at the apex. Readily distinguished by the great spines of the thorax, almost equally long, pallescent at the apex and the anterior lateral margins of the thorax being straight. Head with the juga and tylus equally long, anteocular spine moderate: third joint of antennæ scarcely twice longer than the second: thorax slightly transversely impressed between the spines of the lateral angles; anterior angles with an acute spine turning outwards and forwards, subequal in length to the first joint of the antennæ; lateral angles with a spine turning outwards scarcely shorter than the spines of the anterior angles; anterior margin depressed, anterior lateral margins straight, entire, unarmed, somewhat callous behind the middle: scutellum reaching apex of abdomen, about 4th basal part somewhat narrowed hindwards, thence lateral margins subparallel, posteriorly rounded, apex obtuse, subsinuate: tubercle of apical angles of ventral segments distinct, pallid *(Stål)*. Long, 8; breadth of pronotum, $4\frac{1}{3}$ mill.

Reported from Tranquebar.

117. Scotinophara coarctata, Fabricius.

Cimex coarctatus, Fabr., Ent. Syst. Suppt., p. 530 (1798).
Tetyra bispinosa, pt. Fabr., Syst. Rhyng. p. 138 (1803).
? Podops bispinosus, Herr. Schäff., Wanz. Ins. v, p. 45, t. 158, f. 496 (1839) Dallas, List Hem. i, p. 53 (1851).
Scotinophara coarctata, Stål, Hem. Fabr., i, p. 21 (1868); En. Hem. v, p. 33 (1876).

Body oblong, entirely obscure: very slightly shining; head and anterior part of thorax, black: thorax on each side with two small teeth, one towards the apex, the other towards the base: scutellum coarctate on both sides in the middle (*Fabr.*).

♂ Differs from *S. bispinosa*, Fabr. in having the thorax anteriorly and the head more inclined, thorax scarcely transversely impressed in the middle, teeth of its anterior and lateral angles minute, equal in size; anterior lateral margins straight, slightly rounded anteriorly (*Stål*). Long, 7; broad, 4 mill.

Reported from Tranquebar, Ceylon.

118. Scotinophara tarsalis, Vollenhoven.

Podops tarsalis, Voll., Faune Ent. l'Arch. Indo-Néer. p. 42, t. 3, f. 8 (1863); Walker, Cat. Het. iii, p. 520 (1868).
Scotinophara tarsalis, Stål, En. Hem. v, p. 33 (1876); Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Body above rather deep brown, covered all over with an immense number of small black dots which have the effect of making it appear almost black: head and pronotum covered with a weak yellowish pubescence: tylus a little more tumid than the juga of which the further angles are weakly prolonged: the spine on the sides of the head rather robust: first joint of antennæ of an obscure brown, the rest of a light brown: eyes blackish; ocelli rather small: pronotum emarginate anteriorly and with two strong, broad spines at the anterior angles; lateral borders weakly widened in the middle, and the lateral angles end in an acute point followed by a small notch: scutellum rather flat, a little narrowed before the middle and oval at the apex, usually with two glossy yellow spots near the basal angles: body beneath, black, punctured, with a spare yellow pubescence: rostrum light brown: femora and four first tibiæ black, posterior with half of the tibiæ light brown which is the colour of all the tarsi: angles of ventral segments and margins are nodulose (*Voll.*). Long, 6 mill.

Reported from Java, Borneo, Assam. In Assam usually with legs luteous punctured with black.

119. SCOTINOPHARA OBSCURA, Dallas.

Podops obscurus, Dallas List Hem. i, p. 52 (1851); Voll., Faune Ent. l'Arch. Indo-Néer. p. 41, t. 3, f. 6 (1863); Walker, Cat. Het. i, p. 72 (1867).

Scotinophara obscura, Stål, En. Hem. v. p. 34 (1876); Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Above brown, obscure, thickly and rather finely punctured; head rather small, black, narrowed in front; juga longer than the tylus, but not meeting in front of it, a small spine on each side in front of the eyes: thorax blackish in front, with a short spine at each anterior angle, the antero-lateral margins nearly straight, and the lateral angles emarginate: scutellum reaching the apex of the abdomen, distinctly truncated at the apex, constricted a little before the middle: body beneath pitchy black, very thickly and finely punctured and sparingly clothed with short golden hairs: femora black with an indistinct pale band near the apex: tibiæ and tarsi pale brown: rostrum and antennæ pitchy (*Dallas*). Long, 7—8 mill.

Reported from Assam, Tenasserim, Borneo, Java.

120. SCOTINOPHARA NIGRA, Dallas.

Podops niger, Dallas, List. Hem. i, p. 53 (1851); Walker, Cat. Het. i, p. 72 (1867).

Scotinophara nigra, Stål, En. Hem. v, p. 34 (1876).

Pitchy black, somewhat obscure, thickly punctured, sprinkled with yellowish hairs: head rather long, with a strong spine before each eye; tylus as long as the juga, elevated into a tubercle about the middle: thorax gibbous in front, with a faint furrow across the middle; the antero-lateral margins reflexed, rounded; a long spine directed forwards, on each side at the anterior margin, and a small one at each lateral angle; scutellum as long as the abdomen, contracted before the middle, somewhat truncated at the apex, with a small pit in each basal angle: outer margin of the hemelytra and the edge of the abdomen pitchy red: legs concolorous; tarsi ferruginous: rostrum pitchy red, with the basal joint black: antennæ pitchy (*Dallas*). Long, $7\frac{1}{2}$-8 mill.

Reported from India?

121. SCOTINOPHARA SPINIFERA, Westwood.

Podops spinifera, Westwood, Hope, Cat. Hem. i, p, 16 (1837); Stål, En. Hem. v, p. 125 (1876).

Black, coarsely punctured; head anteriorly attenuated, subtruncate at the apex; a porrect spine on both sides before the eyes: pronotum scabrous anteriorly, abruptly elevated, sides acutely serrate and furnished with a lateral tooth; posterior angles of the abdominal segments, acute (*Westw.*). Long, 8½ mill.

Reported from Bengal.

122. Scotinophara limosa, Walker.

Podops limosus, Walker, Cat. Het. i, p. 72 (1867).

Tawny, punctured, piceous beneath: head carinated: pronotum with an obliquely porrect spine on each side in front; hind angles forming two acute teeth: scutellum extending almost to the tip of the abdomen, much narrower than the breadth of the abdomen which is tawny along each side, beneath: femora piceous (*Walker*). Long, 6-7 mill.

Reported from N. India: the colour distinguishes it from *S. nigra*, Dallas, with which it agrees in structure.

Genus Storthecoris, Horvath.

Wien. Ent. Zeit. ii, p. 296 (1883).

Body briefly oval: head transverse, slightly convex, gradually dilated forwards before the anteocular sinus: juga flattened, entirely distant, not converging before the somewhat elevated tylus: anteniferous tubercles produced outward in a conical spine placed in the same plane with the lateral margins of the head; bucculæ continued through, low, everywhere equally high: antennæ shortish, basal joint altogether visible from above, stoutish, second joint much shorter than the third, fourth joint somewhat shorter than the third, fifth joint a little stouter than the fourth, elongate-fusiform: thorax transverse, anterior lateral margins acute, irregularly serrated, furnished with a process behind the anterior angle, produced in an acutish tooth before the humeral angles, disc transversely impressed in the middle, anterior lobe somewhat rugose, furnished on each side with a transverse furrow behind the anterior margin which gradually disappears towards the anterior angles and there approaches the anterior margin: scutellum large, longer than the corium, reaching the apex of the abdomen (♂) or nearly reaching it (♀), slightly narrowed behind the base, thence slightly amplified; frena short: prostethium furrowed, furrow with moderately elevated margins: feet moderate; tibiæ furrowed: second genital segment in ♂ entirely hidden, only the third genital segment visible (*Horv.*). Differs from *Scotinophara*, Stål, in the shorter rostrum and the gular ring without a tooth on each side: from *Amauropepla*, Stål, in the head not being narrowed forwards before the anteocular sinus, in the tylus being somewhat elevated, and in the rostrum being longer.

123. Storthecoris nigriceps, Horvath.

Storthecoris nigriceps, Horv., Wien. Ent. Zeit. ii, p. 297 (1883).

♂, ♀. Fuscous-testaceous, rather densely punctured fuscous : head, pectus and a very large discal patch on venter, black : juga extending distinctly beyond the tylus, gradually a little dilated before the middle, obliquely roundly truncated at the apex : spine of the antenniferous tubercles, robust, straight, obliquely turning outwards and subacute at the tip : the anterior lateral margins of the thorax behind the triangular gular process, very slightly rounded and dilated, the obsolete intramarginal furrow parallel with the margins : the continued median line more or less obsolete on the thorax and three callous basal spots on the scutellum, pallid : scutellum truncated at the apex (♂), or rounded ♀ : membrane whitish-hyaline : lateral borders of metastethium and venter broadly yellow-testaceous, punctured black ; ventral spiracula and small basal spots on the connexivum, black ; rostrum, antennæ and feet, yellow-testaceous, variegated with black, sparingly greyish-pilose : third joint of the antennæ more than thrice longer than the second (*Horv.*). Long, 7 ; broad, 4 mill.

Reported from the Himálaya.

Genus Amauropepla, Stål.

Ofvers. K. V.-A. Förh. p. 502 (1867) ; En. Hem. v, p. 34 (1876).

Differs from *Scotinophara* in having the head gradually narrowed forwards before the anteocular sinus : the anterior lateral margins of the thorax rounded and denticulate : head somewhat flat : tylus not elevated.

124. Amauropepla denticulata, Haglund.

Amauropepla denticulata, Haglund, Stettin. Ent. Zeit. xxix, p. 151 (1868) : Stål, En. Hem. v, p. 34 (1876).

♂. Oblong, above lurid, beneath black-fuscous, entirely densely punctured black ; rostrum and feet sordid flavescent ; membrane and wings whitish-hyaline, external margin of membrane hardly flavescent ; thorax with the sides serrate and lateral angles boradly emarginate. Head with tylus shorter than the juga which are hiscent at the apex ; bucculæ elevated : eyes very prominent, almost pedunculate : ocelli placed a little behind an imaginary line drawn between the base of the eyes, twice more distant from each other than from the eyes : antenniferous tubercles externally spinose, entirely visible from above : first and second joints of the antennæ subequal, one half the length of the third : rostrum short, reaching the middle between the anterior and intermediate coxæ: sides of thorax slightly rounded, irregularly serrate or denticulate, transversely impressed on the disc; posterior margin, straight: scutellum large, reaching apex of abdomen, spathulate, with the sides sinuate, broadly rounded at the apex; frena short: abdomen densely punctured; minute tubercles behind the spiracula less distinct: feet moderate, tibiæ hardly sulcate externally towards the apex (*Haglund*). Long, 10; broad, 5; exp. hemi. 18 mill.

Reported from Rangoon.

Genus Melanophara, Stål.

Öfvers. K. V.-A. Förh. p. 503 (1867); p. 152 (1868); En. Hem. v, p. 34 (1876).

Differs from *Aspidestrophus*, Stål, in having the head very slightly convex behind the middle, somewhat concave towards the apex, margins acute; rostrum reaching the intermediate coxæ; body oval.

Melanophara dentata, Haglund.

Melanophara dentata, Haglund, Stettin Ent. Zeit. xxix, p. 152 (1868): Stål, En. Hem. v, p. 34 (1876).

♀. Black, opaque, above finely, remotely, abdomen more densely, punctured; briefly, palely pubescent; rostrum and tarsi, obscurely rufescent; thorax anteriorly elevated and marked with gyrated smooth impressions; impressed transversely in the middle; anterior angles with a very minute tooth, sides rounded and furnished with four small teeth, lateral angles with a large acute spine and behind it slightly emarginate. Head anteriorly rounded, very slightly emarginate; juga longer than the tylus, contiguous: ocelli situate behind an imaginary line drawn between the base of the eyes, twice more distant from each other than from the eyes: antenniferous tubercles broad, externally strongly dentate, altogether distinct from above: first and second joints of the antennæ equal, one half the length of the third: bucculæ much elevated, continued through: rostrum reaching the intermediate coxæ, third and fourth joints equally long, second subequal to them: thorax anteriorly with less distinct, smooth, gyrated or tortuous impressions; posterior margin, straight: scutellum broad, rounded at the apex, not reaching the apex of the abdomen; sides before the middle slightly sinuated; frena not reaching the middle; membrane slightly fuscescent: spiracula and minute tubercles behind the spiracula, distinct: tibiæ externally distinctly sulcate (*Haglund*). Long, barely 9; broad, $4\frac{1}{2}$ mill.

Reported from Rangoon.

Genus ASPIDESTROPHUS, Stål.

Ofvers. K. V.-A. Förh., xi, p. 232 (1854): Freg. Eug. Resa, Ins., Hem., p. 219 (1859); Ofvers. l. c., p. 503 (1867); En. Hem. v, p. 34 (1876).

Body somewhat broadly subovate, subpubescent: head subquadrate, rather convex, somewhat deflexed towards the apex, spinose on both sides before the eyes; juga scarcely longer than the tylus, obliquely truncate or sinuately truncate outwards at the apex, margins obtuse: rostrum reaching the posterior coxæ; antennæ as long as the head and thorax together: the thorax transversely, a little sinuate anteriorly, subtruncate posteriorly, sides slightly rounded, crenated: scutellum as long as the abdomen but half its breadth, slightly sinuate on both sides towards the base, broadly rounded at the apex: feet moderate, basal and apical joints of tarsi equal in length, the intermediate very small (*Stål*).

126. ASPIDESTROPHUS MORIO, Stål.

Aspidestrophus morio, Stål, Ofvers. K. V.-A. Förh. p. 232 (1854); Freg. Eug. Resa, Ins, Hem. p. 219, t. 3, f. 1 (1859); Vollenhoven, Faune Ent. l'Arch. Indo-Néer. i, p. 43 (1863); Walker, Cat. Het. i, p. 74 (1867). Stål, En. Hem. v, p. 34 (1876); Distant, A. M. N. H. (5 s.) iii, p. 44 (1879).

Aspidestrophus lineola, Vollenhoven, l. c. p. 44, t. 3, f. 10 (1863): Walker, l. c. iii, p. 521 (1868).

Black-piceous, roughly punctured, sordid ochraceous pubescent and silky; an almost apical ring on the femora and the tarsi, sordid yellow-testaceous (*Stål*). Long, $7\frac{1}{2}$; broad, $4\frac{3}{4}$ mill.

♂. Head square, rounded in front; head and pronotum punctured, of a very deep brown with a yellowish villosity, rather close: antennæ of the same colour: scutellum contracted obliquely on each side towards the base, pitchy brown, with a spare punctuation on the disc, closer towards the borders, weakly yellowish pilose: hemelytra of the same colour, rather strongly punctured, with some short, yellowish hairs towards the base of the costal border: beneath of a pitchy colour, the sternum with a yellowish villosity; abdomen punctured, sparingly pilose; each segment has a small round tubercle behind each stigma: feet of the same colour as the body, except a small patch beneath almost at the end of the femora, and the tarsi which are yellowish-white. (*Voll.*). Long, $7\frac{1}{2}$ mill.

Reported from Java, Borneo, Sumatra, Assam.

A. lineola, Voll. is smaller (6 mill.), of an almost black brown or black and is not so pubescent. A small line on the pronotum, a semicircular subapical spot on the femora and apex of antennæ, yellow.

Div. Halyaria, Stål.

En. Hem. v, p. 34 (1876):—Includes *Sciocorides* and *Halydes*, pt., Am. & Serv., Hist. Nat. Ins. Hém. p. 118, 103 (1843):—*Sciocoridæ* and *Halydidæ*, Dallas, List Hem. i, p. 130, 150 (1851).

Venter anteriorly on both sides with a short transversely rugose or strigose streak or with the venter furrowed: head long, rostrum reaching behind the last coxæ: antennæ remote from the eyes, third joint of the rostrum much longer than the fourth; eyes strongly prominulous.

Genus Mecidea, Dallas.

List Hem. i, p. 139 (1851); Stål, Hem. Afric. i, p. 79, 132 (1864); Ofvers. K. V.-A. Förh. p. 58 (1872); En. Hem. v, p. 34, 37 (1876): Walker, Cat. Het. i, p. 179 (1867). Includes *Erataulax*, Signoret, A. S. E. F. (2 s.), ix, p. 335 (1851).

Body somewhat elongate, somewhat depressed: head oblong-triangular, produced, somewhat convex, juga much longer than the tylus, anteriorly gradually narrowed and converging, or somewhat hiscent, lateral margins of the head not flattened; antenniferous tubercles entirely visible from above: bucculæ slightly elevated: eyes globose, rather prominulous; ocelli large, on a line with the base of the eyes: rostrum reaching the metasternum, inserted towards the apex of the head, second joint much longer than the third, about as long as the two apical taken together, third longer than the fourth: antennæ 5-jointed, stoutish, gradually stouter towards the base, first joint not reaching the apex of the head, second joint as long as or longer than the others, three-cornered and somewhat thickened towards the base, fourth joint longer than the fifth: anterior lateral margins of thorax obtuse, somewhat entire or very obsoletely crenulated, slightly sinuated: scutellum triangular, much narrowed at the apex, frena extended to a distance beyond the middle: hemelytra scarcely narrower than the abdomen; membrane with simple veins: mesosternum somewhat furrowed: feet moderate, femora unarmed at the apex; tibiæ somewhat furrowed; tarsi 3-jointed (*Stål.*).

127. Mecidea indica, Dallas.

Mecidea indica, Dallas, List Hem. i, p. 139, t. 3, f. 3 (1851); Trans. Ent. Soc. (n. s.) ii, p. 9 (1852); Walker, Cat. Het. i, p. 179 (1851): Stål, En. Hem. v, p. 38 (1876).

♀. Pale yellow, thickly and finely punctured; eyes black: scutellum very long: membrane transparent, whitish: ventral stigmata brown: rostrum with the tip black: antennæ with the second joint very long, more than twice the length of the third, dilated towards the base; 4-5 joints shorter than the second, but longer than the third; fourth longer than the fifth : antenniferous tubercles spinous on the outside (*Dallas*). Long, 10½ mill.

Reported from Bengal.

Genus Dalpada, Am. & Serv.

Hist. Nat. Ins. Hém. p. 105 (1843); Dallas, List Hem. i, p. 153 (1851) : Stål, Hem. Afric. i, p. 80, 101 (1864) : Walker, Cat. Het. i, p. 218 (1867) : Stål, Ofvers. K. V.-A. Förh. p. 508 (1867); En. Hem. v, p. 36, 43 (1876). Includes *Udana*, Walker, l. c. iii, p. 549 (1863).

Body oval or ovate : head scarcely or only very slightly convex : juga more or less distinctly sinuated at the apex outwards or obliquely truncated : bucculæ reaching the base of the head, angulated anteriorly, antennæ 5-jointed, slender, the first joint not or only very slightly extending beyond the juga, not longer than the marginal space of the head lying between the eyes and the place of insertion of the antennæ : eyes globose rather prominulous; ocelli in a line with the base of the eyes : rostrum extending a little beyond the last pair of feet, first joint not or only slightly extended beyond the bucculæ : anterior lateral margins of the thorax crenulated : membrane with about six simple, longitudinal veins : mesosternum carinated : venter slightly sulcated at the base : feet somewhat long; tibiæ broadly furrowed above, first pair sometimes dilated (*Stål*).

128. Dalpada oculata, Fabricius.

Cimex oculatus, Fabr., Syst. Ent. p. 703 (1775) ; Spec. Ins. ii, p. 347 (1781); Mant. Ins. ii, p. 285 (1787) ; Ent. Syst. iv, p. 99 (1794).

Halys oculata, Fabr., Syst. Rhyng. p. 181 (1803).

Dalpada aspersa, Ellenr., Nat. Tijdssk. v. Ned. Ind. xxiv, p. 140, f. 8 (1862).

Dalpada oculata, Dallas, List Hem. i, p. 184 (1851) ; Walker, Cat. Het. i, p. 218 (1867) ; Stål, Hem. Fabr. i, p. 22 (1868) ; En. Hem. v, p. 43 (1876) ; Distant, J. A. S. B. xlviii (2), p. 37 (1879) ; A. M. N. H. (5 s.) iii, p. 45 (1879).

Grey : antennæ usually as long as the body, fuscous, with two white rings ; head, fuscous, immaculate ; pronotum greyish or variegated fuscous-testaceous, furnished posteriorly with a small, obtuse prominence ; scutellum paler at the apex and at the base, on both sides with a very glabrous yellow spot : hemelytra concolorous ; wings black : beneath yellow with a lateral line, fuscous, and the margins of the abdomen variegated fuscous and ferruginous : femora scabrous, pallid, black at the apex ; tibiæ black (annulated yellow), first pair dilated at the apex ; tarsi pallid, black at the apex, four posterior feet pale, geniculæ black (*Fabr.*). Stål observes that the specimens usually found in collections are clouded with fuscous-æneous above, a large smooth spot at the basal angles and nearly the third apical part of the scutellum, flavescent, and the anterior tibiæ are dilated. Long, 15—18 mill.

Reported from China, Siam, Cambodia, Tenasserim, Assam, Silhat Malacca, Penang, Java, Borneo, Sumatra, Celebes, Bouru, Philippines. The Indian Museum has specimens from Sikkim, Assam, Arakan, Tavoy.

129. Dalpada versicolor, Herr. Schäffer.

Halys versicolor, Herr. Schäff. Wanz. Ins. v, p. 76, t. 169 f. 520 (1839); vii, p. 60 (1844).

Dalpada versicolor, Dallas, List Hem. i, p. 185 (1851); Walker, Cat. Het. i, p. 220 (1876); Stål, En. Hem. v, p. 43 (1876): Lethierry, Ann. Mus. Gen. xviii, p. 648 (1883).

Yellow-fuscous, variegated with bronze or steel-green patches: head elongate, tylus extending beyond the juga which form outwards two obtuse angles: eyes large: antennæ slender: sides of pronotum weakly serrated anteriorly, angles acute: two subminiaceous spots at base of scutellum of which the apex is long and slender; membrane with eight veins of which the outer on each side is indistinct: margin of abdomen yellow-ochreous with steel-green spots: beneath pale orange with greenish pulverulent outer border and a black longitudinal spot posteriorly. Long, 14 mill.

Reported from Java, India, Burma.

130. Dalpada clavata, Fabricius.

Cimex clavatus, Fabr., Ent. Syst. Suppt. p. 532 (1798).

Halys clavata, Fabr., Syst. Rhyng. p. 181 (1803).

Dalpada clavata, Dallas, List Hem. i, p. 184 (1851); Walker, Cat. Het. i, p. 219 (1867). Stål, Hem. Fabr. i, p. 22 (1868); En. Hem. v, p. 43 (1876); Distant, A. M. N. H. (5 s.) iii, p. 45 (1879).

Head porrect, unidentate on both sides: thorax not serrated but armed on both sides with a small dull-black clavate protuberance, two white dots at the apex: scutellum cinereous at the apex: hemelytra spotted fuscous: abdomen flavescent, margin black, spotted yellow (*Fabr.*).

Closely allied to *D. versicolor*, H. S., head a little longer, lateral angles of pronotum somewhat more obtuse, more thickened and flexed upwards; without the somewhat large, smooth, spot on the basal angles of the scutellum but at the base near the angles, a small smooth spot; dots more fuscous, less brassy (*Stål*). Long, 15—16 mill.

Reported from Tranquebar, Assam.

131. Dalpada pilicornis, Stål.

Dalpada pilicornis, Stål, En. Hem. v, p. 44 (1876).

♂. Stramineous; head, pronotum, hemelytra, and pectus, distinctly and irregularly punctured brassy, an indistinct median streak and the apex of the lateral angles of the pronotum less densely punctured, the lateral angles of the pronotum rather prominulous, neither tumid nor rugose; scutellum with a somewhat large, smooth, oval spot on the basal angles, third apical part and discoidal streak somewhat smooth, sparingly punctured; membrane greyish, veins fuscous: connexivum aeneous, segments banded with yellow; venter testaceous, sparingly punctured fuscous-aeneous, anteriorly subsulcate, extreme angles of segments, aeneous; antennæ, rostrum and feet pilose, the feet sprinkled with fuscous; second joint of the antennæ shorter than the third: rostrum somewhat extended beyond the last coxæ; tylus and juga equally long. ♂ with the genital segment strongly tri-impressed, costate between the impressions (*Stål*). Long, 10; broad, 5 mill.

Reported from the Nilgiris (Madras).

132. Dalpada concinna, Westwood.

Halys concinna, Westwood, Hope, Cat. Hem. i, p. 23 (1837).
Dalpada concinna, Stål, En. Hem. v, p. 44 (1876.)

Greyish-luteous, punctured with fuscous: two black lines between the eyes; thorax anteriorly serrate; posterior angles prominulous, black; basal angles of scutellum pallid; membrane hyaline, longitudinal veins fuscous, with some oblong dots scattered between; feet concolorous: sides of abdomen with black spots, a single small white spot in the middle. (*Westw.*). Long, body 14—14½ mill.

Reported from China, India. Dallas unites this with *D. clavata*, Fabr.

133. Dalpada nigricollis, Westwood.

Halys nigricollis, West:, Hope, Cat. Hem. i, p. 22 (1837) (♂).
Halys obscura, West. l. c. p. 22 (♀): Dallas, l. c. p. 184 (1851).
Dalpada nigricollis, Dallas, List Hem. i, p. 184 (1851); Walker, Cat. Het., i, p. 219 (1867). Stål, En. Hem. v, p. 44 (1876).

♀. Greyish luteous, everywhere punctured with brassy-black: slender, longitudinal, median line on the pronotum and four minute dots, luteous; sides of pronotum hardly serrate, posterior angles subprominulous; basal angles of scutellum, whitish: membrane pallid, with six fuscous longitudinal veins and the same number of intermediate longitudinal fuscous dots: feet luteous, dotted black: base of fourth and fifth joints of the antennæ, white. (*Westw.*). Long, 17—18 mill.

Reported from Bengal.

♂. Smaller than the ♀: the head and the thorax, blackish: antennæ fuscous, second joint incurved; sides of thorax entire, posterior angles subacute, prominulous, black: scutellum fuscous, punctured luteous, basal angles luteous; membrane whitish, the longitudinal veins slender with several fuscous dots strewed between them: abdomen fulvous with a broad lateral band fuscous, feet luteous, punctured fuscous (*Westw.*). Long, 12—13 mill.

Reported from Nepál, India.

134. Dalpada affinis, Dallas.

Dalpada affinis, Dallas, List Hem. i, p. 185 (1851); Walker, Cat. Het. i, p. 219 (1867); Stål, En. Hem. v, p. 44 (1876).

♀. Closely allied to *D. nigricollis*, Westw.; body broader, head longer, lateral angles of pronotum tuberculose, large, obtuse, whitish at the apex: scutellum immaculate at the base, somewhat broad at the apex: membrane fuscescent, veins more obscure: sides of the abdomen variegated with fulvous and black: antennæ fulvous, two last joints, fuscous (*Westw.*). Long, 17—18 mill.

Reported from N. India.

135. Dalpada varia, Dallas.

Dalpada varia, Dallas, List Hem. i, p. 185 (1851); Walker, Cat. Het. i, p. 220 (1867); Stål, En. Hem. v, p. 45 (1876); Distant, J. A. S. B. xlviii, (2) p. 37 (1879); A. M. N. H. (5 s.) iii, p. 45 (1879).

♂. Greyish-testaceous, punctured black; lateral angles of the pronotum subtuberculate; head, pronotum, scutellum, corium and margins of abdomen, variegated greenish-aeneous: scutellum with two whitish spots at the base; corium rufescent at the apex; membrane fuscescent, subhyaline, veins fuscous and the basal spot black: abdomen beneath, testaceous, sides punctured and subapical spot, black: feet and rostrum testaceous (*Westw.*). Long, 18-18½ mill.

Reported from Silhat, Assam: when the pubescene is removed the apex of the scutellum is broadly luteous. The Indian museum has a specimen from Tenasserim.

136. Dalpada alternans, Westwood.

Halys alternans, Westwood, Hope, Cat. i, p. 22 (1837).

Closely allied to *D. nigricollis* (♀), Westw.: differs especially in having the sides of the pronotum almost straight, oblique, posterior angles not prominulous: membrane with six longitudinal veins, fuscous, extended almost to the apex, the three internal connected at the base; internal space fuscous; feet with fuscous and luteous rings: sides of abdomen with abbreviated transverse, black striæ (*Westw.*). Long, 16—17 mill.

Reported from Bengal.

XIII.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator,' *Commander* ALFRED CARPENTER, R. N., *Commanding. No. 4. Description of a new Species of* Crustacea *belonging to the Brachyurous Family* Raninidæ.—*By* J. WOOD-MASON, ESQ., *Superintendent of the Indian Museum, and Professor of Comparative Anatomy and Zoology in the Medical College of Bengal, Calcutta.*

[Received and Read August 5th, 1885.]

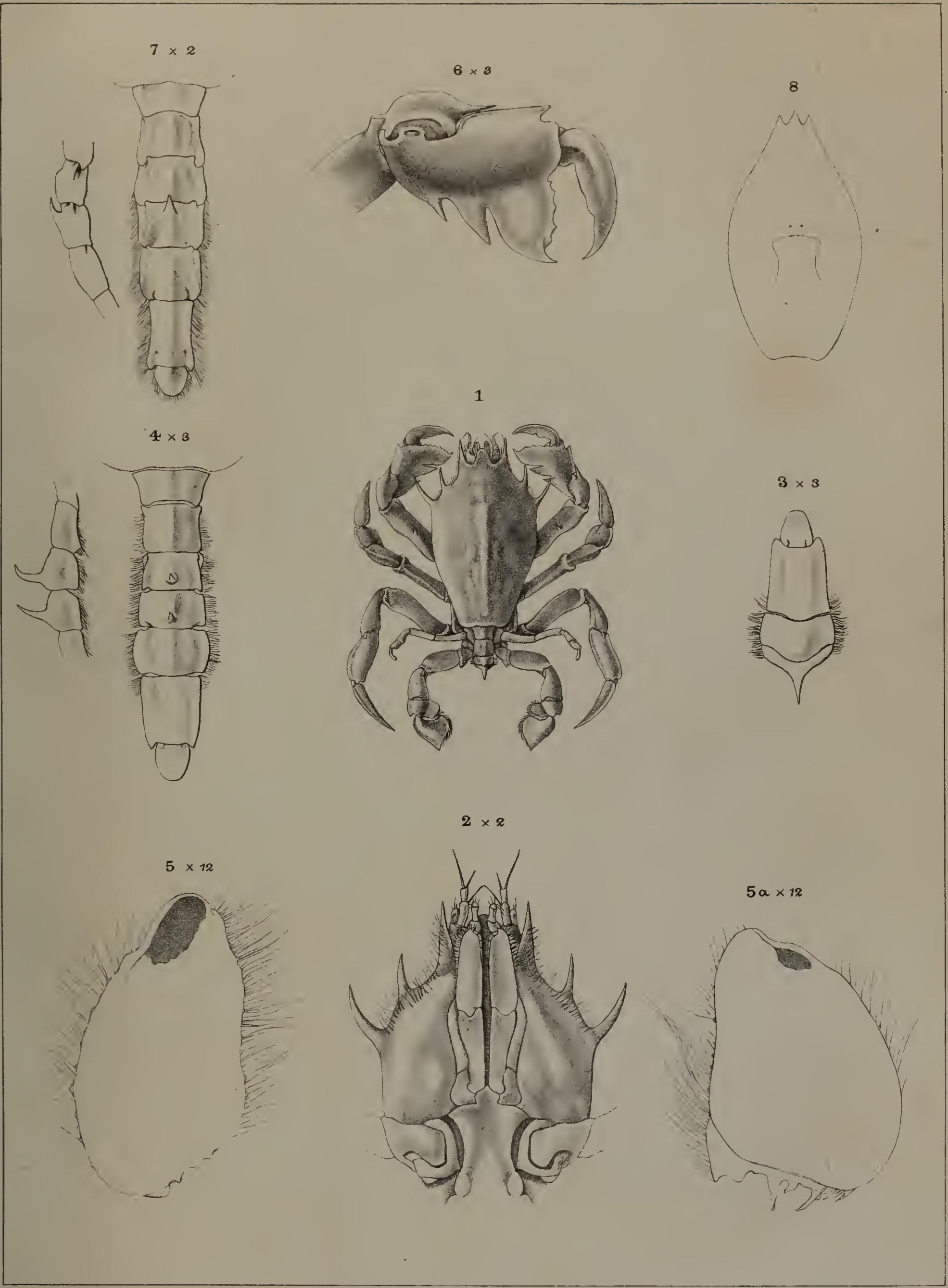
(With Plate I.)

LYREIDUS CHANNERI, n. sp.

Proc. Asiat. Soc. Bengal, August 1885, p. 104.

♂. Carapace transversely moderately convex, longitudinally bluntly carinate and slightly arched from near the posterior margin almost to the level of the spines marking the commencement of the antero-lateral margins, from which level to the end of the rostrum it is slightly concave; its antero-lateral margins armed with two pairs of long slender and acute outwardly and forwardly directed spines, of which the posterior are nearly twice the length of the anterior pair (the left one of which has been broken off early in life and is now only represented by a tubercular scar): its sides parallel from the larger pair of spines backwards to the insertion of the chelipeds, whence they gradually and regularly converge to the rounded angles of the concave-truncate posterior margin; and rapidly convergent from the same pair of spines forwards to about the level of the middle of the 3rd joint of the external maxillipeds, whence they suddenly run parallel to, or slightly divergent from, one another to the ends of the extraorbital spines. The rostrum is semi-oval, or, in other words, has the form of a triangle with the apex rounded and the opposite sides slightly arched, and, like the eye-peduncles, is surpassed by the long and acuminate extra-orbital spines.

Immediately in front of the two small crescentic muscular impressions near the middle of its length, the carapace is crossed by a faint depression, interrupted by the median carina and continued on the sides, passing immediately in front of the junction of the finely beaded postero-lateral lines with the *linea anomurica* some distance to the rear of the hinder pair of antero lateral spines, and deepening as it goes, to the buccal frame; in front of this depression the puncture of the surface is much coarser and thicker than behind it. The antero-lateral margin is finely granulated and, with the contiguous subhepatic and anterior pleural regions, slightly hairy. Two faint depressions, marking out a cardiac region, pass off from the posterior ends of the crescentic im-



Behari lal Dás, del.
Parker & Coward lith.

West, Newman & Co. imp.

pressions, extending rather more than half way to the posterior margin, and slightly converging as they go; and two oblique elevations, situated about midway between the median carina and the postero-lateral margins, with which they are parallel, are present on the posterior third of the carapace.

The eye-peduncles have the same form as those of *L. tridentatus*, and reach nearly to the level of the end of the rostrum, but the eyes they carry are in process of reduction to the condition of those of so many Reptant and Brachyurous Crustacea that inhabit the muddy depths of the sea, and, moreover, are unequally reduced on the two sides of the body, the left being represented by an oval and convex obsoletely faceted, thick, and opaque-yellow cornea, situated, as in the typical species of the genus, on the outer apex of the peduncles, with the subjacent pigment showing through the integument at its base as a dark lead-coloured circumferential band, while all that is to be seen in the corresponding part of the right eye is a smooth and very slightly convex area marked out by the transparence of the pigment of the subjacent ophthalmic tract.

The propodite of the chelipeds is armed below with two acute triangular spines, of which the distal is twice the size of the proximal; its low dorsal crest ends distally in a small tooth; the cutting process of its inner edge is divided into five irregular tooth-like lobules; and its tip is strongly hooked or incurved. The cutting edge of the dactylopodite is obsoletely two-toothed. The only armature of the carpopodite is a single long and acute spine, answering to the distal of the two in *L. tridentatus.* The meropodite bears a sharp spinule in the place of the tubercle seen in the typical species. The dactyli of the 1st and 2nd pairs of legs are shorter and broader, particularly those of the former, and the crests of the two preceding joints in the former also are all more lamellar, the dorsal ones being in addition distally produced to sharp teeth. No direct comparison of the 3rd pair of legs in the two species is possible, as these limbs are wanting in the only specimen of the Japanese form available for comparision, but, judging from DeHaan's figure, the two last joints would appear to be much more expanded in the Indian one. All the legs are slenderer.

The third and fourth abdominal terga each bear a very sharp recurved spine in the middle line.

Dr. Giles notes that the animal was in life, " except a little brown tint in front, of a uniform salmon colour;" and in the spirit-specimen all the upper surface of the carapace in front of the transverse impression, with the exception of the lateral spines, is still darker coloured than the rest of the body.

The unique example from which the foregoing description has been drawn up measures :—

	millims.
Length of carapace from tip of rostrum to posterior margin	25.0
" " " " to the middle of a straight line joining the bases of the posterior spines	8.5
Length of carapace from the posterior margin to the same straight line	16.5
Breadth of carapace across the parallel-sided part.................	14.3
Breadth of head between tips of extra-orbital spines.................	6.0
Distance between tips of posterior antero-lateral spines	18.0
Length of posterior antero-lateral spines..................................	5.0
" " anterior antero-lateral "	3.0
" " genital appendages	5.5
" " rostrum, measured from a straight line drawn tangentially to the bottom of the supra-obital emarginations,	2.0
" " extra-orbital angles, measured from the same straight line, ...	3.4

This interesting brachyuran may at once be distinguished from either of the three previously described species of its genus (*L. tridentatus*, DeHaan, Faun. Jap. Crust. 1850, p. 138, tab. XXXV, fig. 6, ♂, *L. elongatus*, Miers, Proc. Zool. Soc. Lond. 1879, p. 45, both from the seas of Japan, and *L. bairdii*, S. I. Smith, Proc. U. S. Nat. Hist. Mus. 1881, III, p. 420, from 100 fathoms, off the South Coast of New England) by the conspicuous armature of its carapace, by its bispinose abdomen, and by its partially aborted eyes.

A single male only of it was dredged up in the trawl from a depth of 405 to 285 fathoms with a bottom temperature of 48° to 50′ Fahr. in the 'swatch-of-no-ground,' a deep and narrow valley running northwards from the floor of the Bay of Bengal to within a short distance of the shoals lying off the conjoined mouths of the Ganges and Brahmaputra, in Lat. 21° 6′ 30″ N., Long. 89° 20′ E.

Explanation of Plate I.

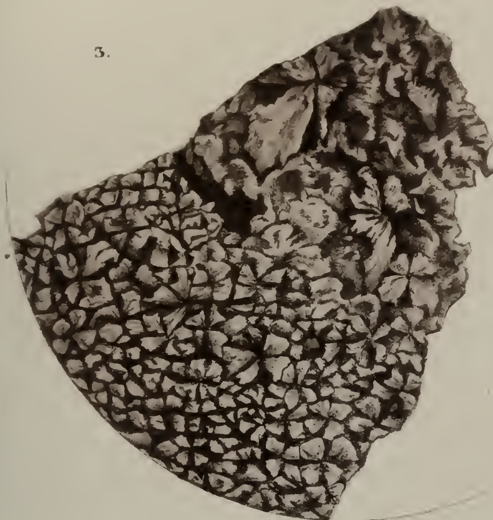
Fig. 1. *Lyreidus channeri*, W.-M., ♂. Natural Size.

" 2. Orbital, antennary, and buccal view. × 2.

" 3. Four terminal somites of abdomen, seen from below as they lie closely applied against the underside of the cephalothorax. × 3.

" 4. Dorsal view (to the right) of the abdomen, with side view (to the left) of its spinigerous 3rd and 4th terga. × 3.

" 5, 5*a*. Outline views from above, or optic sections in the plane of the fringing setæ, of the left and right eye-peduncles respectively, to show (*a*.) the setæ that fringe their two margins up to the corneal membrane on each side; (*b*.) the thickness and the relative development of the cornea, 3.



1.

4.

2.

B. L. Dás, del. et J.W.M. Photo.

which, opaque in both eyes, exhibits an obscure and degenerate faceting in the left, but is devoid of all traces of facets in the right, the shorter and the broader of the two; and (*c.*) the relative amount of pigment, represented by the dark shading. × 12. Zeiss' a*. Oc. 2. Abbe camera.

Fig. 6. The right chela. × 3.

,, 7. *Lyreidus stenops*, n. sp., ♀. Dorsal view (to the right) of the abdomen, with side view (to the left) of its spinigerous 4th tergum. × 2.

,, 8. The carapace of the same in outline. Natural Size.

This species may at once be distinguished from its congeners by its narrow metope, its unarmed carapace, and its decumbent abdominal spine. A single specimen of it, with a male and two females of another species identical with the specimen from Japan referred in the above description to *L. 3-dentatus*, has been received by me from Hongkong from Brigade-Surgeon Hungerford, since this paper was written.

XIV.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator,' *Commander* ALFRED CARPENTER, R. N., *Commanding. No.* 5. *On some Nodular Stones obtained by trawling off Colombo in* 675 *Fathoms of Water.—By* E. J. JONES, A. R. S. M., *Geological Survey of India.*

[Received February 2nd;—Read March 2nd, 1887.]

(With Plate II.)

These nodules were forwarded to the Superintendent of the Indian Museum, and by him passed on to the Director of the Geological Survey, by whom they were subsequently entrusted to me for examination.

The results of this investigation, though owing to want of time incomplete, are, as will be seen, of considerable interest; and I hope at some future time to be able to go into the subject more fully.

The nodules were obtained during a trawling operation off Colombo in water of 675 fathoms, and are stated to have been found associated with sand and mud, which formed a hard calcareous crust at the bottom of the sea, and a small quantity of which was forwarded with the specimens.

The stones are irregularly rounded, and vary in shape from almost spherical to roughly cylindrical with rounded ends. The specimens received varied in size from 1—4 inches in length and $1\frac{1}{4}$—$\frac{3}{4}$ inch in thickness. Externally, they are rough and mostly have one or two small excrescences of the size of a pin's head, and a few small pittings of about the same size; the colour is dirty light grey.

On breaking them open, the fractured surface has much the appearance of an ordinary slate without the cleavage, and is of a much darker colour than the exterior. Running along the central line of a long cylindrical one which I broke open, there is a narrow vein of a brownish colour.

A microscopic examination of a thin slice shewed merely a confused mass of aggregates resembling in their structure that of sphærulites, such as occur in the so-called sphærulitic lavas, with the remains of Foraminifera and Radiolaria disseminated throughout the mass. With ordinary light, little is to be seen except more or less radiating fibrous aggregates, but, as soon as the section is observed between crossed Nicol's prisms, the whole field is seen to be covered with little dark crosses with their limbs parallel to the planes of the prisms, and, on revolving the stage, the limbs of the crosses keep the same orientation whilst the section revolves.

It is when thus observed that the aggregates are seen to be entirely distinct from one another, as each cross keeps to its own aggregate, and the crosses do not overlap; so that, by revolving the stage, the limit of each aggregate can be determined by tracing the path of the outer end of one of the limbs of the crosses.

In the volcanic rocks in which this structure is known, it appears to be due to incipient crystallization in a glassy mass; and at first it might be supposed that these masses were of igneous origin. This idea, however, is untenable on account of the remains of Foraminifera (of several species, the most easily recognised of which are the globigerinæ) and Radiolaria which are sparsely scattered through the mass and, in some cases, enclose a sphærulitic aggregate.

An indeterminate greenish substance, which probably consists of glauconite, is also seen scattered through the mass.

The only difference that can be detected between the central vein and the portion between it and the exterior is that the aggregates in the central vein are much larger and the colour brown instead of green, and that it is unacted on by hydrochloric acid, which dissolves out some calcic carbonate from the other portion.

As mentioned by Mr. Daly in his letter forwarding the nodules, these are very heavy, having a sp. gr. of 3·77 at a temperature of 30° C. as against water of 4° C.

A qualitative analysis shewed the nodules to consist in great part of baric sulphate together with small quantities of calcic and strontic sulphates, small quantities of calcic and magnesic phosphates, aluminic silicate, calcic carbonate, and traces of iron, sodium, and manganese.

Not having the time to devote to a complete quantitative analysis, I made, in order to arrive at an approximate estimate of the proportion of baric sulphate present, a determination of the sulphuric acid. An average sample from two of the nodules powdered and dried at 100° C. gave 82·5 °/₀ of baric sulphate, the whole SO_2Ho_2 being calculated as SO_2Bao''.

This result is, however, of course too high, as a small quantity of the SO_2Ho_2 is combined with Ca. and Sr. in the form of calcic and strontic sulphates, though, from the results of the qualitative analysis, it is probably not much too high; and we may, I think, safely take 75°/₀ as the percentage of baric sulphate present.

In order to see whether the material was derived from the mud in which the nodules occur, and which also contained Foraminifera, I made a qualitative analysis of the mud, and found it to consist mainly of aluminic silicate, with small quantities of calcic carbonate, some iron, and a trace of manganese; there was also a trace of an alkaline earth which was not removed by boiling with hydrochloric acid and subsequent washing, but this, on spectroscopic examination, shewed itself to be lime.

In spite of the negative result of the analysis of the mud, I am inclined to think, from the presence of the Foraminifera both in the mud and enclosed in the nodules, that the latter have been formed at the bottom of the sea either at the spot where they were found or at no great distance therefrom, though it is difficult to imagine how the material was obtained, but it is possible that a careful analysis of a larger quantity of the mud would reveal a trace of Barium, for sea-water contains a slight trace of this element.

I cannot at present call to mind any instance of sphærulitic structure occurring without the aid of heat.

In volcanic lavas and in artificial glasses, it may be regarded as concretionary, or as resulting from incipient crystallisation or devitrification around certain points or nuclei. The nuclei when they exist consist either of a granule or a minute crystal or crystallite, but most commonly no nucleus is discernible.*

In this case, however, it would seem, that it must be due to slow segregative action; and, baric sulphate being very slightly soluble in water, the deposition would be very slow and may have been to some extent crystalline, at any rate sufficiently so to produce the same effect as incipient crystallisation from a glassy mass.

The execution of the accompanying plate has been kindly superintended by Mr. J. Wood-Mason.

* Rutley's Study of Rocks, p. 183.

Explanation of Plate II.

Fig. 1, 2. The external appearance, natural size, of some of the nodules.

Fig. 3. A thin slice treated with hydrochloric acid and seen between crossed Nicol's prisms; shewing the dark crosses and radiating structure of the aggregates.

Fig. 4. A thin slice shewing some of the enclosed Foraminifera as seen by ordinary light; from a microphotograph (Smith and Beck's 1½″ obj.) taken in the Biological Laboratory of the Indian Museum, Calcutta.

XV.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator', *Commander* Alfred Carpenter, R. N., *Commanding. No. 6. On Six new Amphipods from the Bay of Bengal.—By* G. M. Giles, M. B., F. R. C. S., *Surgeon-Naturalist to the Marine Survey.*

[Received and Read March 2nd, 1887.].

(With Plates III—VIII.)

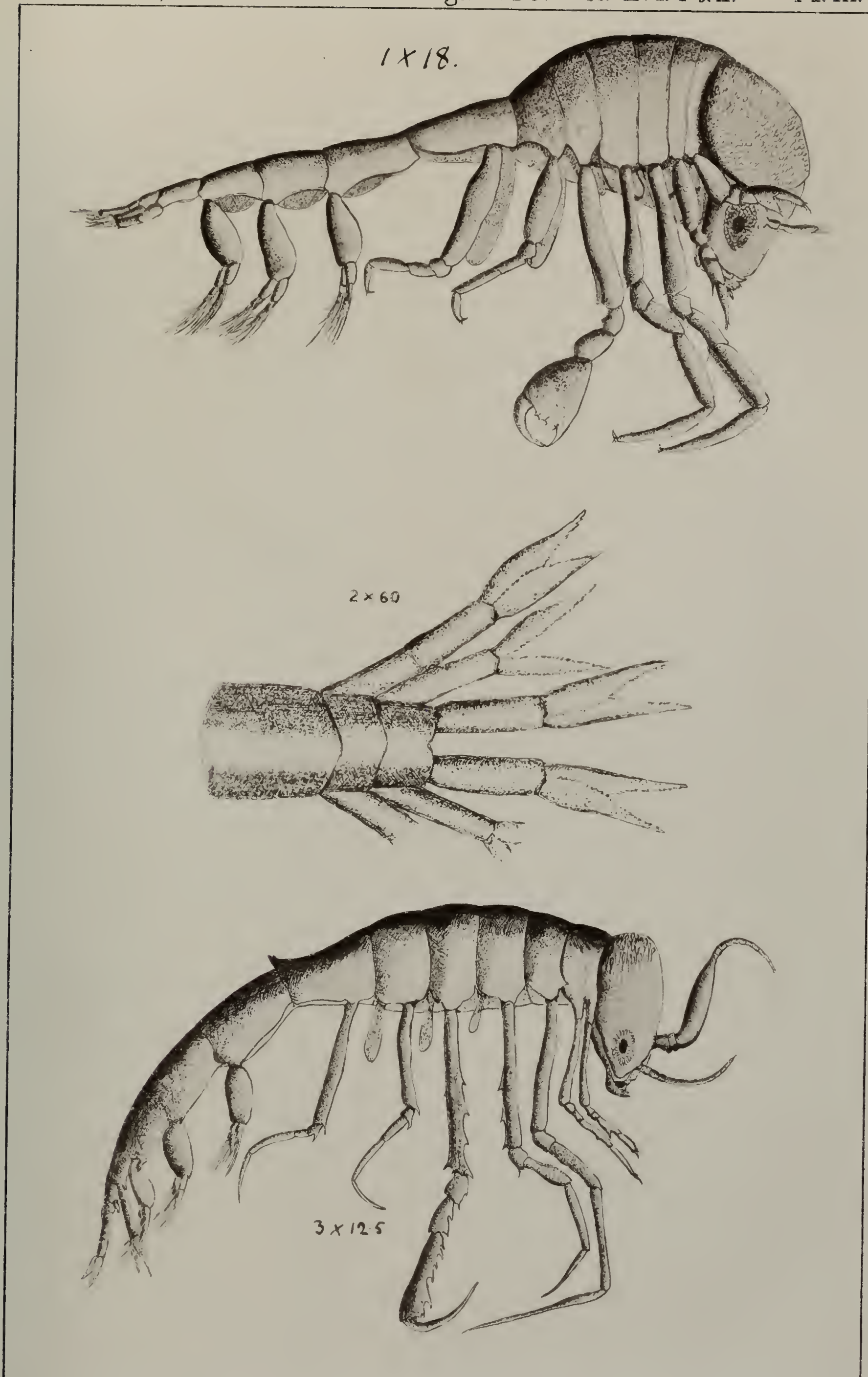
Contents.

§ 1. *A Description of two new Species of the Amphipod Family* Phronimidæ *with some Remarks on the Genera of the Family.*

The genus *Phronima* of the division *Hyperina* and family *Phronimidæ* is a very limited and peculiar one. The species that belong to it are remarkable for their bizarre form, and for the circumstance that the head is considerably prolonged downwards, like that of a quadruped, in a direction at right angles to the long axis of the body.

The number of joints in the legs appears to be less than the normal seven. This is due, on the one hand, to the coxal plates being fused with the pleuron of each segment, and, on the other, to the circumstance that the dactylopodite is in most instances very small or reduced to a mere rudiment. Spence Bate* gives as a generic character that the 6th thoracic appendage (third pereiopod) has the dactylopodite fused with the propodite. This is, however, I am inclined to believe, an error, arising probably from the want of fresh specimens. Such also appears

* Catalogue of Amphipodous Crustacea in the British Museum, p. 316.



G. M. G. del.

Autotype.

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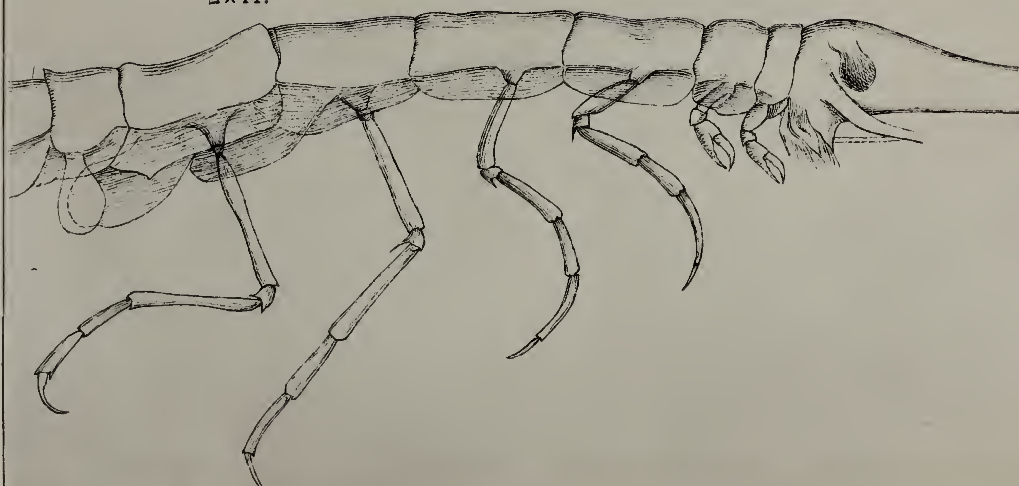

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G. M. G. del.

AUTOTYPE

G M G del.
Parker & Coward chr lith.
West Newman & Co imp.

G M G. del.

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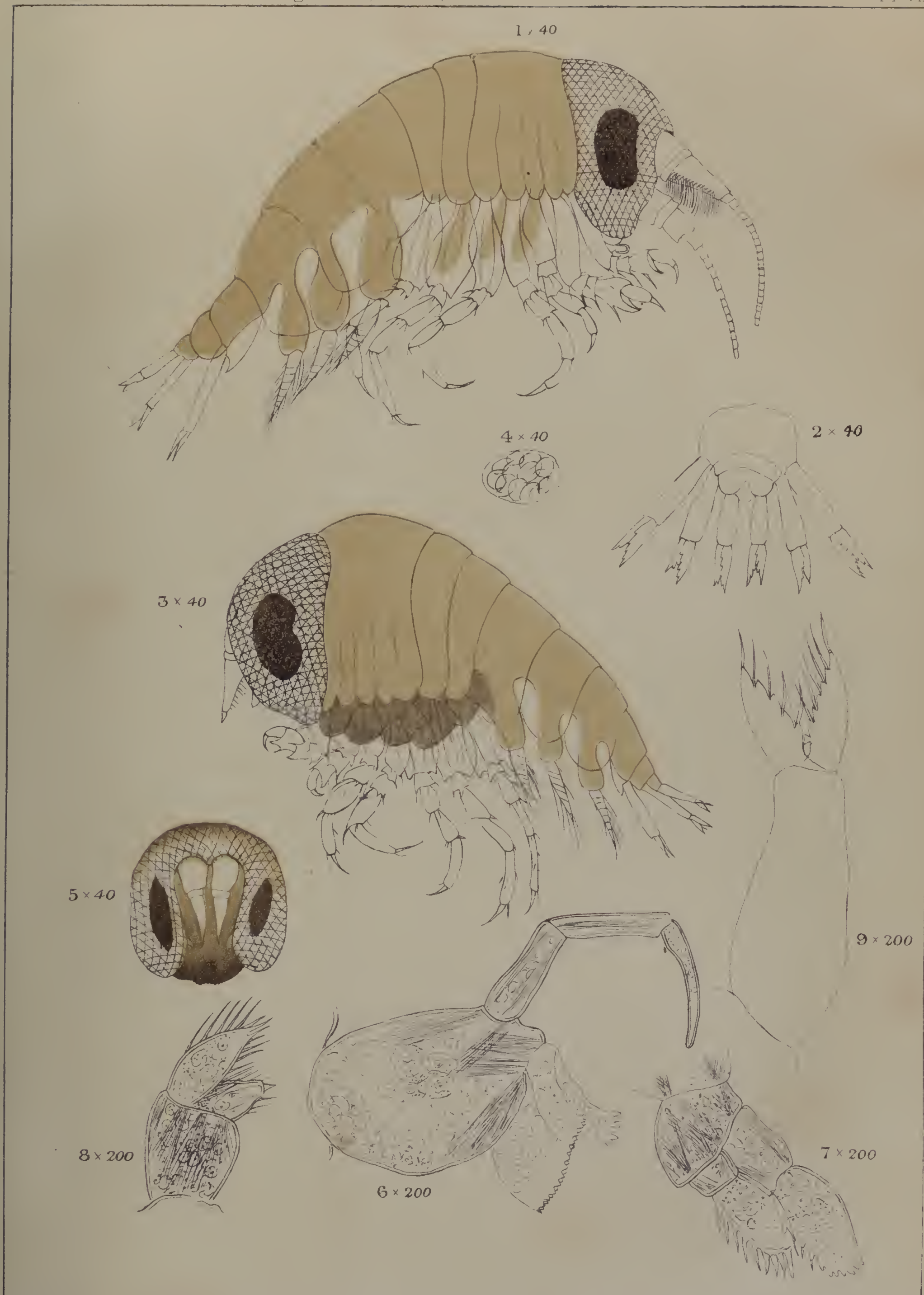

G.M.G. del.
Parker & Coward. chrom. lith.
West, Newman & Co. imp.

G.M.G. del. Parker & Coward lith. West, Newman & Co. imp.

to be the case not only in the sixth but in the two preceding appendages of one of the species described below. A careful examination, however, of various intermediate examples, furnished by the different appendages of the two species that have come under my notice, has satisfied me that the dactylopodite is neither absent nor fused with the propodite, but is, in such instances, represented by a minute spine-like body articulated to the distal extremity of the propodite, and usually flanked by a pair of tiny hairs, which appear again in a more developed form in the similarly placed "dactyloptera" which Spence Bate (*loc. cit.*) describes on the dactylo-propodital articulation of *P. sedentaria.*

Both my species were taken in the drift (surface) net,—the one that has been named *P. bucephala,* off the Mutlah light in a depth of 15 fathoms, the other, *Phronimella hippocephala,* in somewhat shallower water off the mouth of the Dhamrá river on the Orissa Coast. Both are perfectly colourless and transparent, so that most of the internal organs, muscles, &c., can be seen with the greatest facility through the integument. The circumstance of my only having obtained a single specimen of each in the surface-net appears to point to their not being normally surface organisms. While under observation, living in the tube of the net, although perfectly capable of swimming with considerable activity, they yet showed a tendency to sink to the bottom and rest there. For these reasons, it is probable, that their true habitat is the bottom in the localities and depths already mentioned.

In his recent monograph on the *Phronimidæ,** Claus divides the family into two sub-families—the *Phrosininæ* and the *Phroniminæ.* With the first we have nothing to do, as neither of the species to be described can be referred to this subfamily. Of the *Phroniminæ,* he enumerates four genera, of which *Phronima* Latr. is thus defined :—

" Body produced, with much narrowed and elongated last thoracic segment, with 3 pairs of styloid uropods. Head short, but elevated, with much produced vertico-oral axis. In the female the anterior antennæ two-jointed, and posterior antennæ represented by a globularly arched basal joint provided with a short bristle. The mandibular palps are wanting even in the male. Maxillipedes strongly compressed with lanceolate laminæ and a conical " tongue " (Zunge). Both pairs of gnathopoda slender, with weak, apposed subchelæ. The 5th pair of thoracic appendages provided with slender apposed shear-like forceps. Three pairs of gill-sacs on 4th, 5th, and 6th thoracic segments."

Now, the family, so far as it is known, is of such variable character that each new addition to its numbers appears to require a genus to

* Arbeit. aus d. zool. Inst. d. Univ. Wien u. d. zool. Stat. in Triest, 1879, II, 1.

itself; and to the genus, as thus limited, neither of my forms can be said perfectly to agree.

To the less limited genus of Spence Bate, however, one of them corresponds in every point, but it differs from the genus as defined by Claus in the following points:—1st., in my one female specimen, I can make out no trace whatever of inferior antennæ; 2nd., the subchela of the "5th" (6th) thoracic appendage cannot be said to be slender, the fixed ramus being very stout and almost quadrate; 3rd., there are two extra small gill-sacs on the 2nd and 3rd thoracic segments, a character extremely abnormal, but of the reality of which I carefully satisfied myself. To avoid, however, the necessity of manufacturing a new genus, I describe it as a member of the genus *Phronima*, as defined by Spence Bate, under the name of *P. bucephala.*

With the second of the species to be described the case is different, as it will not fit into any genus, whether the *Phronima* of Spence Bate, or the genera distinguished by Claus, namely, *Phronima*, *Phronimella*, *Phronimopsis*, and *Paraphronima.* Of these the species comes nearest to the definition of *Phronimella*, which is thus given by Claus:—

"Body much produced, entirely transparent, with but two pairs of style-shaped uropods, head short, with high-arched upper surface, vertico-oral axis much produced. The two front segments united without suture. Mandibular palps wanting even in the male. Tongue (Zunge) of the maxillipedes reduced to a wart-like excrescence. Both pairs of gnathopods slender with weak apposed subchelæ. The third pair of thoracic appendages somewhat smaller, the fourth much produced. The fifth pair of legs with a much produced apposed pair of subchelæ. Three pairs of gill-sacs on the 4th, 5th, and 6th thoracic segments."

With this definition, the specimen agrees in the very important detail of possessing but two pairs of style-shaped uropods, and in nearly every other item save in this that, in our species, the "3rd" (4th) thoracic appendages have the unfortunate peculiarity of being the longest and almost the largest of the whole series, instead of being smaller. A minor difference is that the two first thoracic segments, although united, shew signs of a short, but perfectly distinct, suture between their pleura.

On this account, one is reduced to the alternatives of either widening the range of *Phronimella* by cutting out the character referring to the third thoracic agpendage, or of making a new genus. The making of new genera is an expedient which should, I take it, be avoided whenever possible, so that I prefer to adopt the former alternative and to describe the species as *Phronimella hippocephala.*

I will now proceed to the description of the two species.

(i.) PHRONIMA BUCEPHALA, n. sp., Pl. III, Figs. 1 & 2.

Head large, and broad at the top, which is almost completely occupied by the regularly arranged series of components of the apical eyes. These latter, though essentially paired organs, very nearly blend in the middle line, so that only a small space in that situation is unoccupied by their visual cones. The dorsal aspect of the head forms a large, transversely oval shield, which is separated from the anterior and lateral surfaces by a distinct horizontal fold. The portion of the head below this forms a truncated cone, tapering from the shield like vertex to the mouth, which is placed on the truncate (ventral) aspect; the whole presenting a curious resemblance to the head of a buffalo, which is further heightened by the circumstance that the maxillipedes, lying along the posterior aspect of the truncated cone, present an outline much like the large fleshy fold behind the lower jaw of that animal. The lateral eyes are placed on the lateral aspect of the head, immediately below the fold that separates the lower truncate portion from the oval apical shield. Their component cones, like those of the apical eyes, are regularly arranged, but are somewhat widely separated, so that there is no true faceting, although a close approach to the true compound faceted eye is attained.

The *antennules* are short and two-jointed; the first joint about a quarter the length of the second, which is of clavate form, and terminated by a tuft of fine, short hairs: the entire length of the organ being a full third less than that of the conical portion of the head.

The *antennœ* are obsolete.

The *gnathites* are somewhat small and are articulated to the inferior or ventral aspect of the truncated cone. Only enough was seen of them to establish their being quite of the usual type, without any salient peculiarities, and that the mandibles are unprovided with any appendage. An unfortunate lurch of the ship spilled the portion of the dissection containing them as they were being separated for the purpose of drawing.

The *thorax*, as seen from above, forms with the cephalic shield a pear-shaped body; its five anterior dorsally visible segments being very broad, the penultimate tapering rapidly, and the last being very long and narrow. The first two are short and hard to distinguish from each other.

All the *thoracic appendages*, with the exception of the anterior gnathopoda, are provided with branchial sacs, but the last two of these greatly exceed the rest in size. 1st gnathopod about one-sixth the length of the body. The dactylopodite very minute and claw-shaped, its articulation with the propodite flanked by a pair of minute flattened hair-like bodies. The propodite is simple, slightly falciform, its posterior border fringed with fine, short, stiff setæ. It forms, in conjunction with the prolonged postero-inferior angle of the carpopodite, a somewhat incomplete subchelæ. The meropodite and ischiopodite are short and triangular, and the basipodite is stout and cylindrical, forming more than a third of the length of the appendage. The 3rd thoracic appendage, or 2nd gnathopod, is of generally similar form to the preceding, but is longer and slighter, equalling a fourth of the whole body length. The subchela, too, is even less perfect, the prolonged postero-inferior angle of the carpopodite amounting to little more than a stout spine. The 4th and 5th thoracic appendages, subequal and closely resembling each other, just equal the combined head and thorax in length, the anterior being slightly the longer and stouter. In both, the dactylopodite is minute and claw-like, propodite and carpopodite subequal and cylindrical, but stouter, and a third shorter than the two preceding joints, the ischiopodite short and triangular, and the basipodite long, cylindrical, swelling somewhat at its distal extremity, and forming quite a third of the length of the whole limb. The 6th thoracic appendage is by far the strongest of the series; it is, however, considerably shorter than 3rd and 4th, being as long only as the thorax. The dactylopodite is represented by a mere rudimentary spine. The propodite forms a stout curved claw which, in apposition with the inferior border of the carpopodite, forms a powerful subchela. The carpopodite is triangular, its inferior border being nearly as long as the lateral. The antero-inferior angle is prolonged into a powerful spine, and the inferior border is armed with three dentations, between which are a corresponding number of small, isolated tufts of hairs. The meropodite and ischiopodite are short and quadrangular, and the basipodite, forming fully half the length of the limb, is stout, cylindrical, and strengthened along its posterior border by a narrow buttress. The 7th and 8th thoracic appendages are alike in plan, the former being, however, decidedly the smaller, especially as to the basipodite, which is much longer and stouter in the 8th appendage. In both, the dactylopodites are minute and claw-like, the propodites of an elongated pyriform outline. The carpo- and meropodites cylindrical, the ischiopodites short and triangular, and the basipodites spindle-shaped.

Abdomen narrow, tapering, depressed rather than compressed, the first three segments long, diminishing from before backwards, the first nearly equalling the long last thoracic segment in length, the third being but half its length. The last three together only equal the 2nd in length.

The first three *abdominal appendages* are of the usual amphipod type, the first and third being subequal, the middle one slightly the longest. The last three abdominal appendages are alike in plan, and the fourth is the longest. They consist of a long cylindrical basal joint provided with a pair of lanceolate rami with serrate margins. The penultimate pair are the shortest of the three and the last but little inferior to the fourth in size. The basal joint of the fourth has the appearance of being composed of two joints; such an arrangement is, however, from a morphological point of view, so improbable, that, although it is represented in the drawing, I have hesitated to describe it as such. Both sides, however, appeared alike.

The *telson* appears obsolete.

The unique specimen is certainly a female, but the unlucky accident to the dissection prevented my dissecting out the generative organs.

Its actual length was 5·75 mm.

(ii.) Phronimella hippocephala, n. sp., Pl. III, Fig. 3.

The second species differs from the first in many important points. Speaking generally, it is, both as to body and limbs, if I may use the expression, a much more lanky species.

The *head* somewhat resembles that of a horse in shape, but the resemblance is not nearly so striking as that of the first species to the head of a bull. It is not so broad at the top, and no fold surrounds it; so that the appearance of a cephalic shield is not produced: its dorsal aspect is covered with a large, widely separated pair of apical eyes. The lateral eyes are situated low down laterally, of medium size, and of the same structure as in the first species.

Both *antennules* and *antennæ* are present; the former, much the larger, consist of a three-jointed peduncle and a flagellum of eight or ten short segments, total length equal to a third of the body exclusive of the head. The first two joints of the peduncle are short, while the third, of dilated spindle-shaped form, makes up more than half the length of the organ. Near the distal extremity it is provided with a few short, flattened hairs. The flagellum is quite naked with the exception of one or two small hairs on the last joint.

The *antennæ* are little more than half the length of the *antennules* and consist of a peduncle formed of three short joints and a naked tapering flagellum as long as that of the antennule, the proximal articulations of which are ill-marked.

Being unwilling to destroy my only specimen, the *gnathites* and *maxillipedes* were not closely examined: they appeared to resemble very closely those of the first species.

The *thorax* is long, narrow, depressed rather than compressed, the first two dorsally visible segments scarcely separable. The third has the inferior angle of its pleuron produced into a sort of triangular spine, overlapping the second. The fourth and fifth, of nearly equal length, form the widest portion of the body; the sixth longer and narrower than these; and the last, the longest and narrowest of all, is provided behind with a spine on either side of the middle line and has this posterior border considerably everted, so as to admit of hyperextension of the abdomen on the thorax.

The 5th, 6th, and 7th *thoracic appendages* are provided with branchial sacs, the hindermost being the largest. In the gnathopoda, the coxal extension of the pleura is considerable, and extends well below the level of any of the rest. The gnathopoda are on the same general plan as those of the first species, but are much longer and more slender, and their subchelæ are far less developed, being represented, in the anterior of the two, by a process some distance from the inferior extremity of the carpopodite, and, in the posterior, by a small projection half way along its length (this is if anything somewhat exaggerated in the drawing). The 4th is considerably the longest of all the appendages. It is, however, very slender, both the 5th and 6th exceeding it in stoutness. It equals in length the thorax and first two segments of the abdomen, and to all appearance consists of but five joints, the dactylopodite being represented only as a minute hair-like body. The propodite is very long and tapering, forming nearly a third of the length of the limb. The carpopodite, meropodite, and basipodite are long and cylindrical, and the ischiopodite is short and quadrangular. The 5th closely resembles the preceding, but is shorter than it by the length of the basipodite, the carpopodite being less than half as long as that of the 3rd. The postero-inferior angle of its ischiopodite is prolonged into a spine, and the posterior border of its much stouter basipodite is armed, along the distal half of its posterior border, with three strong serrate spines. The 6th is considerably the stoutest of the series, and equals the thorax and first segment of the abdomen in length. The dactylopodite is represented only by a minute hair-like body, the propodite, long and falciform, the carpopodite, a long flattened body, the opposible inferior border of which is but of small extent, is armed along its anterior border with six powerful serrations, so that the extremity much more resembles the sabre of a *Squilla* than a subchela. The mero- and ischiopodites are short and triangular, each having the anterior border armed with two serrations. The basipodite, cylindrical above, is three-sided below, each border ending in a strong spinous process, in addition to which the anterior border is armed with three stout, and the posterio with two smaller, serrations. The 7th and 8th are alike in all respects, save size, the hinder being the larger. With the exception of the short triangular ischiopodites, all the joints are cylindrical. The longer of the two barely equals the abdomen in length. In both the dactylopodites are minute and hair-like.

The *abdomen* is slightly shorter than the thorax, the segments diminishing in length from before backwards. The anterior extremity of the first segment, where it joins the thorax, is much constricted, the broadest part of the region being across the second segment. The last three segments together barely equal the third in length.

The three anterior *abdominal appendages* are of the usual type, the middle one being the largest and the hindermost, the smallest. The fourth consists of a cylindrical basal joint nearly as long as the third abdominal segment. It is provided with two lanceolate entire-margined rami, the outer of which is slightly the larger. The fifth is represented only by a short bud-like rudiment. The last closely resembles the fourth, but is somewhat shorter, and its rami are equal.

The *telson* is rudimentary.

A single specimen measuring about 7 mm. in length.

§ 2. Rhabdosoma investigatoris, n. sp, Pl. IV.

This species presents a close resemblance to *R. whitei* and *R. armatum*, forms which have recently been demonstrated to be male and female of one species by Claus,* by whom, as also by J. H. Streets,† they are well described. The two must accordingly now stand as *R. armatum* (Milne-Edwards).

After comparing the present species with the above descriptions, I am inclined to think that it is a distinct form, more especially as the animal was obtained, although at some distance from the land, from the shallow muddy water about the Palmyrus shoals. Still, the resemblances are so numerous that the shortest way of describing the new species will be to enumerate the differences from the above quoted descriptions of *R. armatum.*

Two specimens, one male and the other female, were obtained; the latter being that shown in the figure. It is probably an adult, as the brood-pouch, although empty, is well-marked and of considerable size.

The differences, described from the female as the more complete specimen, are as follows.—1. The head is shorter, not equalling (rostrum included) one half the total length of the body. 2. The mandibular

* Arbeit. aus d. zool. Inst. d. Univ. Wien. u. d. zool. Stat. Triest, 1879, II. 2.

† Proc. Acad. Sc. Phil., 1878, pp. 287—290.

palp is longer, exceeding in length considerably the first joint of the inferior antennæ. 3. Spence Bate (*Cat. Amphipodous Crust. Brit. Mus.* 1862) describes *R. whitei* as "having the coxa of first pair of gnathopoda produced to an obtuse point": this is wanting in our species. 4. All three of the authorities agree in describing considerable differences between the 1st and 2nd gnathopoda in size, length, and formation: in the present species these are subequal and very closely resemble each other. 5. Spence Bate describes the pereiopoda (last 5 thoracic appendages) as gradually increasing in length posteriorly, the fourth pair longest, the fifth obsolete. In our form, the third is longer than the fourth, aud the fifth, although either obsolete or destroyed in the male, is represented by a club-shaped basipodite in the female. 6. The same writer also gives the last three abdominal appendages as differing considerably in length, the last being the longest, while in our form they are subequal, the first being a trifle the longest.

Length of male 2·5 c. m., of female 4·9 c. m.

The male differs further in the inferior antennæ being much shorter, and the mandibular appendage correspondingly diminished.

I append a table of measurements from Claus of *R. armatum;* and a comparison of the corresponding measurements of the present species in an adjacent column is, I think, alone sufficient to establish the specific distinctness of the two forms. The measurements are in millimeters.

	R. armatum.						*R. investigatoris.*	
	♂	♂	♂	♂	♀	♀	♂	♀
Length of rostrum (broken)	15	18	20	36	24	28	$4\frac{1}{2}$	10
,, ,, head	$6\frac{1}{4}$	8	8	9	10	11	$4\frac{1}{4}$	8
,, ,, thorax	$6\frac{3}{4}$	9	9	9	$9\frac{1}{2}$	11	4	7
,, ,, 3 anterior abd. segs.	$7\frac{1}{2}$	$9\frac{1}{2}$	$9\frac{1}{2}$	10	10	12	5	7
,, ,, 4th abd. seg.	3	4	$3\frac{3}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	$2\frac{1}{7}$	$3\frac{1}{2}$
,, ,, 5th & 6th abd. segs.	$3\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{2}$	4	5	2	$3\frac{1}{2}$
,, ,, telson	6	9	8	10	18	$23\frac{1}{2}$	$3\frac{3}{4}$	6
,, ,, 1st caudal style	6	8	$7\frac{1}{2}$	8	10	11	$3\frac{1}{4}$	$5\frac{3}{4}$
,, ,, 2nd ,, ,, ...	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{2}$	3	—	4	—	$5\frac{1}{2}$
,, ,, 3rd ,, ,, ...	6	8	$7\frac{1}{2}$	9	—	18	—	$5\frac{1}{2}$

In the male specimen of our species the rostrum is very much broken, in the female it is nearly complete. The specimens are preserved in the Indian Museum.

§ 3. Amphipronoë longicornuta, n. sp., Pl. V.

Three specimens of the small amphipodous crustacean to be described below were taken in the drift-net in the clear but shallow water of the Mergui Archipelago.

It probably has its proper habitat at the surface, as it swims easily, though with no great speed. Its most salient peculiarity is the immense length of the rigid 5-jointed antennæ, which are much longer than in any form hitherto described, and are carried folded up and directed obliquely downwards and forwards in front of it.

The total length of the body is 6·5 mm., and the animal is opaque, of a pale pinkish brown tint, and plentifully sprinkled with deep madder-brown pigment spots, which are most numerous on the pleura and coxæ of the thorax, and on the entire surface of the 2nd and 3rd abdominal segments.

It is stoutly built, not markedly compressed.

The *head* is large, its length, depth, and breadth each equalling rather less than $\frac{1}{5}$th the body length; its entire upper and lateral surfaces occupied by the large regularly faceted eyes, and its anterior inferior aspect deeply hollowed for the reception of the antennules and of the first joint of the antennæ.

The *thorax* forms the broadest and deepest part of the body, but its segments are short, so that its entire length is but $\frac{2}{5}$th longer than the head. The coxal plates are united to the pleura, without any very obvious suture, and the first and the last two segments have their terga ankylosed.

The *antennæ* and *antennules* are formed on almost exactly the same plan as those of *Rhabdosoma.* On looking at the latter genus, one is inclined to be led to the conclusion that the curious antennæ have been evolved to enable the animal to reach out beyond the enormously prolonged rostrum and cephalon generally, which latter formation together with its generally slender form certainly suits the attainment of a high rate of speed. The present species, however, demonstrates the danger of such hasty deduction, as we have here the antennæ of even greater proportional length than in *Rhabdosoma,* while the head and body generally are short and stout and the entire plan of its structure is adapted for strength rather than speed.

The *antennules,* when at rest, are almost completely hidden within the depression of the antero-inferior face of the cephalon, the tip of the flagellum only being visible; they consist of a three-jointed peduncle of peculiar form (Fig. 2.) and a three-jointed flagellum (Figs. 2. & 3.). The basal joint is articulated to the recessed surface of the cephalon, close to the middle line, at a point about even with the middle of the eye. The first two joints are short and compressed and quadrate, directed obliquely downwards and forwards; the third joint is much larger, and is much compressed, so that, seen from below, it appears merely slightly clavate, viewed laterally, it is seen to be broad and of falciform outline, curving round, so that its distal border comes to be directed upwards and forwards. Its convex border is thickly clothed with a multitude of very fine, soft, flexible hairs, regularly arranged in distinct, but closely placed, transverse rows. The body of the joint is filled up by a large ganglionic mass, which appears to send off branches to the bases of the hairs. The flagellum (Fig. 3.) is extremely small in proportion to the peduncle, and consists of three joints, subequal in length, compressed, and diminishing progressively in breadth, so that the last joint is cylindrical; the first joint is provided with a circlet of soft clavate or spindle-shaped flattened hairs not so long as, but considerably broader than, those of the distal joint of the peduncles. The second has a similar pair of hairs springing from a depression on its distal aspect, while the last joint, which presents two slight constrictions in its length, is free from hairs, with the exception of three stiff tapering auditory bristles at its extremity. The entire organ is less than a millemeter in length and is so articulated as to be capable of flexion and extension only, no lateral play being practicable.

The *antennæ* take their origin a little behind, but much external to, the antennules, so that their first joint is placed close to the wall of the recess, and, in their habitual posture, they are completely hidden from the outside. The first joint reaches quite to the front of the recess, so that, to the casual observer, the second appears to be the first joint of the appendage, and to take its origin considerably in front of the antennules. The 2nd, 3rd, and 4th joints are carried folded sharply upon one another and the 2nd and 3rd of them are each half as long as the animal exclusive of the last two abdominal segments; the fourth is slightly shorter and the fifth very short: the proportional length of the 5 joints being as 25 : 67 : 67 : 60 : 3; and the whole length of the organ being a little over 9 m.m., or about $1\frac{1}{2}$ times the length of the body. Each joint is thickly clothed with extremely fine short hairs, too small to be visible except under very high amplification. The musculature of their appendages is peculiar. In the first joint, a pair of powerful muscles, flexor and extensor, are located in its proximal two-thirds, and act by means of two distinct tendons on the second joint. In the remaining articulations, the muscles are confined to a small part of the distal extremities, which are dilated for their reception, the muscles in each case being in pairs so that no lateral motion is obtainable.

The *mouth-organs* appeared to be very rudimentary, but were not closely examined.

The 2nd and 3rd *thoracic appendages* (gnathopoda) are short and stout and can scarcely be made out in the usual position of the animal, being carried folded closely against the ventral surface of the body. They closely resemble each other, differing only in the more anterior being stouter with its basipodite shorter than in the hinder; they are provided with a curious complex subchela (Fig. 7.). The dactylopodite forms a stout sharp claw and is articulated to the propodite by a movable joint acted on by powerful muscles. The propodite consists of a stout cylindrical curved body so bent that its posterior border is apposed to the prolonged inferior border of the carpopodite. This posterior border is armed with a strong flat plate provided with a toothed cutting edge. The carpopodite is stout, compressed, and quadrangular, and has its infero-posterior angle prolonged into a sharp process. The posterior half of this border is formed by a thin plate with a toothed edge, opposable to the smaller plate on the propodite. In extreme flexion, these two plates overlap each other, the carpopodital plate passing inside that of the propodite; all the remaining articulations are compressed, but broad and strong, the meropodites are short and triangular, the ischiopodites short and quadrangular. The basipodite of the 2nd gnathopoda is as long as all the other articulations together, while that of the first is but $\frac{2}{3}$ as long; in both, the articulations are curved forwards and extremely stout. A cord-like glandular body runs through the middle of each of these appendages ending in the base of the propodite. It is difficult to be certain as to the point of exit of its duct, but this was doubtfully made out as opening near the angle between the two limbs of the subchela. The muscles of these appendages are large and distinct, each joint being provided with a flexor and extensor; in the two distal articulations, the flexor is by far the more powerful, but in the next the two are nearly of equal strength, while, of the muscles contained in the basipodite, the extensor is the more powerful, and its tendon, passing through the ischiopodite, is inserted into the base of the meropodite, being reinforced by only a small slip taking origin from the former joint, while only a small accessory slip of the extensor contained in the basipodite is inserted into the ischiopodite. The 4th and 5th thoracic appendages are cylindrical and of the usual ambulatory type; they are subequal, slightly exceeding the thorax in length, but the fifth is slightly the stouter of the two. The 6th and 7th are like the two preceding appendages, save that their basipodites are strengthened by strong buttress-like developments of their anterior and posterior borders; the 7th but little exceeds the 5th in length; but the 6th is the longest of all the thoracic appendages, equalling the thorax and the first abdominal segment in length. The 8th thoracic appendage is peculiar, its basipodite is formed on the same plan as those of the sixth and seventh, but is shorter, and if anything broader, so that its outline approaches the circular, and its remaining joints are so short that together they do not equal the breadth of the basipodite.

The first three *abdominal appendages* are subequal and are of quite the usual amphipod type, but are rather short. The three remaining (Fig. 8) abdominal appendages differ greatly in length; the 1st has the protopodite as long as the basipodite of the longest thoracic appendage; its two rami are foliaceous, the inner slightly exceeding the outer ramus. The 5th is but half the size of the 4th, and the irregularity of its rami is more marked, while the last appendage is but half the length of the penultimate and has its inner ramus nearly twice as long as the outer.

The animal agrees well with all the characteristics of the genus as given in Spence Bate, though the 8th thoracic appendage would perhaps be better described as stunted than as rudimentary.

§ 4. Lestrigonus bengalensis, n. sp., Pls. VI. & VII.

In looking over the literature referring to the genera *Lestrigonus* and *Hyperia*, it becomes increasingly apparent that Spence Bate's suspicion as to the doubtful value of the latter genus was well founded. One after another species of *Lestrigonus* have been paired off as males with *Hyperia* females, so that the latter genus must, in all probability, be entirely abandoned, as its retention could only be justified by the discovery of a form whose males retain permanently the character of the genus.

The present species is one of the commonest surface organisms of the Bay of Bengal, and is especially so in the more truly pelagic portion of its area.

I was on this account able to obtain a large number of specimens,—including (*a*) females of *Hyperia* form, but with rudimentary inferior antennæ; (*b*) immature males of *Hyperia*-form; and (*c*) 9 mature males of *Lestrigonus* form,—amongst which all stages between the two latter conditions were observable.

I notice that the pelagic *Lestrigoni* are very generally credited with being parasitic on medusæ, &c. In the present species, this is not the case. I have occasionally seen them ensconced in the cavity of a Salpa, but believe this to have been an accidental circumstance, as by far the larger number were captured swimming freely.

The specimen figured (Pl. VI.) was taken in the drift-net about 100 miles from land in the Bay of Bengal, the depth of the water in the locality being 850 fathoms. Seven specimens were obtained on this occasion and some hundreds have since been taken.

As all specimens of the *Lestrigonus*-form are of nearly equal size, and all the appendages are fully developed, it is probable that they are, in spite of their small size, adult animals. The greater part of the surface of the body and appendages is liberally besprinkled with patches of black pigment, so that, seen in the water, they appeared of a dark reddish grey tint. The pigmentation is deepest on the pleura of the thoracic segments, on the basipodites of their appendages, and on the abdomen. The lower part of the cephalon, too, including the gnathites, is so deeply pigmented, that it is extremely difficult to make out the arrangement of the parts, as they are almost opaque to transmitted and nearly impossible to be illuminated by direct light. The entire length of the animal is 2·5 m.m.

The only two of the members of the genus enumerated in Spence Bate and elsewhere which approach it in size are *L. ferus* and *L. fuscus*, though both of these are considerably larger than any of my specimens. Moreover, in the present species, the seventh thoracic appendage (fourth pereiopod) is considerably larger than the preceding and succeeding appendages, whereas in *L. ferus* all three are described as subequal, and in *L. fuscus* the third pereiopod is stated to be longer than the fourth.

It differs also from the description and figures of these species in several other particulars. I would, therefore, propose to name it *L. bengalensis.*

In swimming, it progresses by a series of jerks, lying on its side and moving in small circles.

The *head* is the broadest portion of the animal, the two immense eyes projecting considerably beyond the very narrow thorax when seen from above. The eyes are of large size and distinctly faceted, the anterior faceted membrane being easily separable, and they cover the entire upper and lateral aspects of the head, the anterior aspect of which is deeply excavated for the reception of the antennæ.

The *thorax* is composed of seven distinct, but very short, segments; the junction between the pleura and the coxal plates being hard to make out, as also are the junctions of the terga of the first 5 thoracic segments. The segments increase in length slightly from before backwards, but not to any very marked extent; the entire thorax forming less than a third of the entire length of the animal.

The first three *abdominal segments* are of very large size, especially the first two, either of which is as long as any three of the thoracic segments. The fourth abdominal segment is much shorter and narrowed in front, so as to be freely movable under the much excavated posterior border of the third. The fifth and sixth abdominal segments are very small, and the latter is united without suture to the short, accurately semicircular telson.

The *antennules* are as long as the entire body of the animal *plus* the protopodite of the sixth abdominal appendage. Their peduncles consist of three joints, of which the first is large and globular and filled with a number of muscular bands, that are evidently capable of moving its articulation with the second in all directions. It contains also a small antennular gland. The second is extremely short, and the third, which is pear-shaped, is provided, along its inferior border, with a number of closely set exceedingly fine hairs. The flagellum consists of between 20 and 30 long, narrow articulations, longest in the middle of the organ, the first being exceptionally short. Each joint carries two or three exceedingly fine hairs, and the last, a pair of blunt, cylindrical hairs of uniform thickness throughout.

The *antennæ* are shorter than the antennules, equalling in length only the head, thorax, and first two abdominal segments; and, like these, their peduncles are three-jointed, the third joint being considerably longer than the two first. The flagellum is also closely similar, but differs in the first joint being long and conical, and in the armature of the terminal joint, which is provided with a pair of bifid (or, possibly, four) tapering hairs.

The dissection of the *gnathites* was attended with considerable difficulty no less on account of their extreme minuteness than because of their dense pigmentation, so that I am even now by no means satisfied as to the exact relative position of the parts in this stage of the animal. The mandibles (Fig. 6.) are stout and provided with a long three-jointed naked palp. Their masticatory plate (shown separately in Fig. 7) is peculiarly well developed, being provided with several rows of regularly arranged conical teeth. The maxillæ are liberally toothed and the maxillipedes have one of their lobes terminated by a biramous jointed appendage.

The second of the *thoracic appendages* is short and stout and provided with a somewhat incomplete subchela. The third, longer and somewhat slighter, has the subchela very well developed, the opposable prolongation of their carpopodites being distinctly hollowed out for the reception of the cylindrical propodite. The remaining thoracic appendages are of the usual type, increasing regularly in size to the seventh, which is largest; the sixth and eighth being subequal. The eighth has its posterior border provided with a strong buttress-like plate. Some of the posterior thoracic appendages are provided with gill-sacs, but I was unable to satisfy myself as to their exact number and position in this stage of the animal, although they are probably identical with those of the *Hyperia*-stage.

The first three *abdominal appendages* are subequal, and on the usual amphipod plan. The remaining three have long protopodites and small equal rami, the first two being subequal, while the last is a quarter shorter than the preceding two pairs.

The form (the *Hyperia*-stage) figured on Pl. VI. was obtained on the same occasion as the *Lestrigonus bengalensis*. The specimens were about equally divided between the sexes; and I have little doubt that the males (Fig. 1.) are merely a young stage of this species, as they agree in all essential particulars save the smaller development of the flagella of the antennæ. Even here the difference lies only in the smaller length of the individual joints and not in their number. Seen apart from the more fully developed forms, they would certainly be assigned to the genus *Hyperia*, especially some specimens, smaller than that figured, in which the antennæ are even shorter. If this supposition be correct, distinctions between *Hyperia* and *Lestrigonus* can hardly, as already advanced, be of generic value. Whether or not all male *Hyperia* ultimately develop a long flagellum is of course doubtful, but there can be little doubt that all *Lestrigonus* pass through an *Hyperia*-stage. Speaking generally, the *Hyperia*-stage is shorter and stouter and more like the female (Fig. 3.) described below. In this specimen, I could clearly make out three gill-sacs attached to the 4th, 5th, and 6th thoracic segments. I was more fortunate, too, in the dissection of the gnathites in the younger than in the adult specimen; and a glance at the incomplete figures of those of the adult form as compared with those of the more completely figured *Hyperia*-stage confirms the opinion as to the identity of the two forms. With the exception of the antennæ, the appendages are practically identical in both, save that in the younger form they are proportionally a trifle shorter than in the adult.

The female, in general form, closely resembles the young male; she is, however, shorter, but more stoutly built, the very short thoracic segments being of remarkable depth. The principal external difference between the sexes lies in the antennæ, which, in the female, are remarkably ill developed. In the *antennules*, there is a three-jointed peduncle, practically identical with that of the male, but the flagellum is reduced to a rudimentary first joint. The *antennæ* are reduced to a rudiment of the basal joint of the peduncle. All the females collected carried in a well-developed brood-pouch a number (about 18 or 20) of largish (6·25 m.) ova, none of which had gone beyond the stage of segmentation. The length of the specimen figured is 1·75 m.m.

§ 5. Eurystheus hirsutus, n. sp., Pl. VIII.

The species described below was taken on the same occasion as *Lestrigonus bengalensis*. It is nearly transparent and, saving a few scattered patches of reddish brown pigment, colourless. Only a single specimen was obtained.

The animal is 4 m.m. long.

The *head* is $\frac{3}{20}$ths of the total length, irregularly quadrate and smooth; it is produced anteriorly into a small blunt rostrum, and the small eye, which is pigmented red brown and consists of numerous ocelli, is placed opposite to the root of the antennules.

The *thorax* and *abdomen* are of equal length and of nearly the same depth and breadth throughout. In the thorax, the segments increase regularly in length from before backwards, while the first two of the abdomen are subequal to the hinder thoracic segments and the third is much longer than any other segment, the last three decreasing rapidly in length.

The *antennules* are rather more than half as long as the body; the peduncle forms the larger half of their length and consists of three stout joints, the distal two of which are fringed on their lower surface by a number of very long flexible hairs, the proximal joint is beset with extremely fine short hairs only, the secondary appendage is small and consists of four short joints well provided with short stiff hairs, and the flagellum consists of about eleven short articulations liberally fringed below with short fine hairs.

The *antennæ* are somewhat shorter, slightly less than half the body length; their peduncle consists of five joints, of which the first two are extremely short, the second being armed with a strong downwardly produced spine, the third joint is longer and stouter than either of those of the antennules and the fourth and fifth subequal in length and considerably longer; as in the antennules, the two distal joints are liberally fringed below with long flexible hairs; the flagellum is short, barely equalling the last joint of the peduncle in length; it consists of seven short joints all well provided with hairs, the last joint carrying, in addition, a pair of peculiar stout bifid hairs.

The *gnathites* could not be examined, with the exception of the maxillipedes, which are remarkably long and pediform.

All the *thoracic appendages* are remarkably hirsute, being covered, in addition to the large stout hairs, shewn in the figure, with a perfect coat of fine hairs visible only under considerable amplification. The second and third are very weakly subchelate, the propodites being merely dilated and not produced into an opposible member. The first is much smaller and slenderer than the second, but both are on the same general plan, the dactylopodites being barely serrated and the propodites armed only with one or two stout spines. The fourth and fifth are subequal, the fourth slightly the longer and stouter; they slightly exceed the second in length and are of the usual ambulatory type. The sixth, seventh, and eighth thoracic appendages agree in having their basipodites very large and strengthened by large anterior and posterior buttress-like plates; they differ, however, considerably in length, the fifth being the shortest of all the thoracic appendages, while the sixth and seventh much exceed the anterior ones, the seventh being more than half as long as the body, and the eighth even longer.

The first three *abdominal appendages* are rather long and slender, but are quite of the usual type. The last three are short and cylindrical, having both their protopodites and rami armed with a number of short very stout spines; they decrease regularly in length from before backwards, the fourth being as long as the fifth and sixth together, and the sixth, very short. The *telson* is a short compressed lamina armed with a number of short tooth like spines similar to those on the posterior abdominal appendages.

EXPLANATION OF THE PLATES.

Plate III.

Fig. 1. *Phronima bucephala*, n. sp., male. × 18. Fig. 2. Last three abdominal segments of the same with their appendages. × 60. Fig. 3. *Phronimella hippocephala*, n. sp. × 12·5.

Plate IV.

Fig. 1. *Rhabdosoma investigatoris*, n. sp., female, as seen by dark ground illumination. × 3·8. Fig. 2. Thorax with appendages of the same. × 14. Fig. 3. End of an antennule. × 200.

Plate V.

Fig. 1. *Amphipronoë longicornutus*, n. sp., male. × 17. Fig. 2. Antennule. × 39. Fig. 3. Flagellum of antennule. × 180. Fig. 4. An antenna. × 7. Fig. 5. First joint of an antenna. × 40. Fig. 6. Head seen from below (diagrammatic). Fig. 7. 2nd thoracic appendage. × 110. Fig. 8. Last three abdominal segments. × 25.

Plate VI.

Fig. 1. *Lestrigonus bengalensis*, n. sp., male. × 40. Fig. 2. Last joint of antennule. × 400. Fig. 3. Last joint of an antenna. × 400. Fig. 4. Peduncle of antennule. × 100. Fig. 5. Peduncle of antenna. × 100. Fig. 6. Mandible and its appendage. × 200. Fig. 7. Masticatory plate of mandible. × 200. Fig. 8. The maxillæ. × 200. Fig. 9. Portion of maxilipede. × 100. *Fig.* 10. Last three segments of abdomen with their appendages, seen from above. × 60.

Plate VII.

Fig. 1. *Lestrigonus bengalensis*, n. sp., immature male. × 40. Fig. 2. Last three segments, seen from below. × 40. Fig. 3. *Lestrigonus bengalensis*, female. × 40. Fig. 4. An ovum from her brood-pouch. × 40. Fig. 5. Head of female, front view. × 40. Fig. 6. Mandible and its appendages. × 200. Fig. 7. 1st maxilla. × 200. Fig. 8. 2nd maxilla. × 200. Fig. 9. Maxillipede. × 200.

Plate VIII.

Eurystheus hirsutus, n. sp. × 40.

XVI.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator,' *Commander* Alfred Carpenter, R. N., *Commanding. No. 8. The Mean Temperature of the Deep Waters of the Bay of Bengal. By Commander* Carpenter, R. N., D. S. O., F. R. Met. Soc., F. Z. S.—*Communicated by* The Superintendent of the Indian Museum.

[Received August 1st;—Read August 3rd, 1887.]

(With Plate X.)

The temperature curves of the deep sea at different points in the Bay of Bengal vary but little at depths greater than 100 fathoms. The larger number of observations have naturally been made in shallow waters, that is to say, in less than 300 fathoms; but, still, more than one observation has now been obtained for every 100 fathoms down to 1900 fathoms. The greatest depth at which the temperature has been obtained is 2,105 fathoms, off the east coast of Ceylon, at which depth a Casella-Miller thermometer shewed 33°.7 Fahr. corrected for pressure, the correction being 0°·8 subtractive. As will be seen by the following example, the uniformity of temperature comes to be a check on the accuracy of the thermometers and, *vice versâ*, on the accuracy of the depth found.

Date.	No. of Thermometer used.	Depth in Fathoms.	Corrected temperature.	Locality.
3. I. 1885......	31478	675	41°·7	Near the head of the Bay of Bengal.
29. IV. 1886......	19042	675	42·1	East of Little Andaman Island.
5. V. 1886......	32096	675	41·8	Off Colombo, Ceylon.

Here we see only a variation of half a degree at the same depth in widely different places, and the error of reading off absorbs quite half of that. Unfortunately, the scale is not cut on the thermometer tube but on porcelain at the side; and, as the bent tube of the Miller-Casella admits of a small movement, care has to be taken to hold the tube firmly against the scale, so that both mercury ends shew similar readings, before taking the reading of the minimum index, which has been pushed up the tube to some lower temperature whilst under water. The uni-

Depth in Fathoms. Bay of Bengal.

Lith. & Printed by W. Newman & Co. Ld. Calcutta

formity of temperature also shows a uniform origin, for the change of temperature in large bodies of water is slow. The submarine inflow which must come from the southward to make up for the great evaporation of the bay, is therefore probably uniform in temperature and widely spread. It should be mentioned, however, that the observations have been entirely made in the fine season between November and May; and, although surface disturbance by wind would be unlikely to affect deep currents, yet it is just possible that the great climatic difference between the two monsoons may upset the balance in other ways and so alter the rate of submarine inflow.

Slow-moving deep currents such as would exist at the bottom of the Bay of Bengal cannot be accurately tested by any means yet devised. It is true that the United States Coast Survey have lately detailed a vessel specially to take the strength and direction of the Gulf Stream in the Straits of Florida, and that a careful section was obtained, by means of special fittings, of the strength and volume of the stream in that its narrowest portion. But even there, where considerable movement might have been expected, it never exceeded one mile an hour at the bottom, which was only some 400 fathoms deep. It is then unlikely that the same instrument, ingenious as it is, would be of any service at the greater depths owing to the far greater sources of error and the very much slower movement.

Whatever current-meter is used will have to be very sensitive, and must be anchored at the bottom for at least thirty hours, without being fouled by fish or weed, to minimise errors of lowering it down, pressure, hauling up, &c.

Surface currents are, however, guaged with comparative ease, and the depth of these as yet found by the "Investigator" range from 80 fathoms to 175 fathoms in the open waters of the bay.

Off the Rivers Hughli and Ganges, a higher temperature was frequently found at five to ten fathoms than at the surface, and this probably occurs when the fresh water of the rivers brings down a lower temperature, and temporarily overlies the salt water.

Future observations of temperature will be unlikely to vary more than one degree Fahr. from the mean curve given in the accompanying plate for depths greater than 100 fathoms; but at depths between 10 and 100 fathoms they may vary 5° either way.

A remarkable verification of depth by aid of the thermal reading was made in March last. When tabulating the mean temperatures last January, I noticed that the temperature shewn at a cast of 1400 fathoms, made in 1885, in Lat. 19°.34′ N., Long. 91°.07′ E., was far more suitable to a depth of 1000 fathoms. Upon reference to the Sounding

Record Book, it was seen that the cast was given a value of only "fair," whilst a remark was made that "the wire appeared to have lain on the bottom," too light a weight having been used to shew the instant of contact. The opportunity offered soon after of making another cast on the same spot with an improved sounding machine, when a depth of 912 fathoms was obtained with a temperature differing only one degree from that of the former cast.

Whilst taking some soundings east of the Andaman Islands in November last, I found that there were two abnormal temperatures, one of 41°.7 at 782 fathoms instead of 40°.5, which is the mean at that depth, and one of 41°.2 at 1010 fathoms instead of 37°.7. Both of these temperatures point to the water having been warmed by passage over some shallower ridge of about 740 fathoms (*see* accompanying plate).

If we look at a chart of the east side of the Bay of Bengal, we see that there are three inlets into this partly enclosed sea. One is only 150 fathoms deep, *viz.*, Preparis Channel; one is not marked with any depth, *viz.*, the Ten Degree Channel; and one has 760 fathoms marked nearly on the ridge between Acheen Head and Great Nicobar. The two high temperatures at 782 fathoms and 1010 fathoms seem to prove, so far as two observations can be a proof, that no greater depth than 740 fathoms exists on the ridges between Acheen Head and Great Nicobar and in the Ten Degree Channel.

A glance at the curve will show that a striking change occurs at 150 fathoms, and that below that depth the diminution of temperature is much more gradual.

This agrees with our observations of the depth of the surface currents, that is to say, of the quick-moving portion of this ocean. After 1200 fathoms the change of temperature becomes very slow. A line joining Sandoway in Arrakan with Calingapatam on the Orissa coast forms the southern limit of the 1200 fathom contour of the bottom of the Bay. Down to 1200 fathoms the thermometer is a check on the depth obtained, but deeper than that there is too little change.

The mean temperature of the first 150 fathoms being a moving variable* may have some influence on the climatic conditions of the Bay.

A warm surface current was met with in April in Lat. 17°.34′ N., Long. 88° E., where the water down to 120 fathoms was all 4 to 7 degrees above the mean, the greatest difference being at 60 fathoms. It was then setting to the E. N. E.

* By 'a moving variable' I mean that that portion of the ocean which moves most rapidly has also the most varying temperature.

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XVII.—*On the* Chiroptera *of Nepal.*—*By* J. Scully.

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The local distribution of our Indian Mammalian fauna is not only of special interest to naturalists in this country, but is also important to those who are mainly concerned with questions of general geographical distribution. To be of real use, local lists should be founded on specimens actually captured in the region under review; less direct evidence should rarely be accepted. And nowhere, perhaps, in this great country is greater precision required in assigning a station to the forms which inhabit it than in the case of the Himalayas. For not only does the fauna of these mountains differ markedly according to the elevation above sea-level, but it also varies strikingly as we proceed from east to west in them. We have, moreover, in the Himalayas a meeting ground of Palæarctic, Indian, and Malay forms; and, for the elucidation of the complex questions of station and habitat of species, strict accuracy is required in lists of forms inhabiting merely political divisions of the Himalayas.

In view of the considerations above mentioned, the expression so often affixed to a species of "Habitat, Nepal" might be only a degree less vague than "Habitat, Himalayas," were it not for what may be called an accident. The term "Nepal" may mean either the whole State of Nepal, or a very small part of it, the Nepal Valley. The State of Nepal is about 500 miles in length, and has an average breadth of about 100 miles; part of this country differs in no way from the adjoining plains of India, but most of it is highly mountainous, and in it, indeed, is found the highest mountain in the world. The Nepal Valley, the true "Nepal" of the natives, is a small tract, some 20 miles in length by 15 in breadth, at an elevation of from 4050 to 4500 feet above sea-level, in which is situated the capital of the state, Kathmandu. But the Nepal Valley is the only part of the state which has been efficiently explored zoologically, and, consequently, we may be pretty certain that, when the term Nepal only is used to denote the station of a species, the Nepal Valley is what is really meant.

I once lived for two years in the Nepal Valley, and while there made large collections of zoological specimens. Amongst these, I preserved 40 specimens of bats, and, on my return to England, I spent some time on a careful identification of them, by reference to published descriptions and by comparison with specimens in the British Museum. In this way, I ascertained that the whole of my specimens were referable to only 10 species, and the next step was to find out whether the forms I had secured were previously known to occur in Nepal. This task proved much more difficult than the mere identification of the species; the information available about the species of Chiroptera actually inhabiting Nepal being somewhat vague and confused.

In order to show why the matter lacks precision, it is necessary to trace the source of our information on the subject.

Mr. Brian H. Hodgson, to whose labours zoological science is so largely indebted, lived for more than twenty years in the Nepal Valley; and during this time he made very extensive zoological collections, and described many new forms. He discriminated altogether *twelve* species of bats from Nepal, and to every one of these he gave a new scientific name. Unfortunately, however, he did not describe all the species whose names he published, and some of the descriptions he gave were not sufficiently full to fix the species intended without doubt. Mr. Hodgson presented most of his specimens from Nepal to the British Museum, and he also gave a few to the Asiatic Society of Bengal. This led to Dr. J. E. Gray and Mr. Ed. Blyth identifying some of Hodgson's species with others previously named by different authors, and in some cases to more extended description of the Nepalese specimens. Some doubt and error were in this way introduced, as will be explained further on; the doubt hanging over the species named by Mr. Hodgson but never described by him.

Mr. Hodgson left Nepal in 1844. He never returned to that country, but, after a visit to England, he settled for some years at Darjiling, in the Sikkim Himalayas east of Nepal, and collected zoological specimens there largely. These spoils he also gave to the British

Museum and to the museum of the East India Company in London. Mr. Hodgson's name had, however, become so firmly connected with Nepal in the minds of English zoologists, that some portion of his collections in Sikkim were wrongly assigned by them to Nepal. So that, mainly by Dr. Horsfield, Hodgson's additions of Chiroptera from Darjiling were published as coming from the former country. Owing to this confusion, at least half a dozen species of bats frcm Sikkim, never obtained by Hodgson in Nepal, were credited to the latter country on the strength of that naturalist having collected them.

In 1876 and 1878, Dr. Dobson's two admirable works on the Chiroptera appeared. The task this author had on hand was too extensive to permit his paying particular attention to a relatively small question like the station of certain species in Nepal; he had, moreover, to be guided to some extent by previous writers, and to rely on museum labels, which are not always accurate. He has in consequence given in his works some species as from Nepal which were not obtained there by Hodgson or any one else, and has altogether omitted mention in his synonymy of two names given by Hodgson to Nepalese species.

In short, without much balancing of evidence, it was impossible to draw up a correct list of the bats of Nepal from the writings of the authors I have referred to; and I consequently determined to investigate the whole question with the aid of the specimens I had myself collected. The result of my enquiry is set forth in this paper.

I have already mentioned Mr. Hodgson's collection of bats from Nepal. This forms the foundation of our knowledge on the subject, and the subsequent additions of material can be readily indicated. In 1871, a collector of the Indian Museum obtained 3 specimens of bats, representing two species, at Kathmandu; and the third and last collection of Nepalese Chiroptera is my own.

Mr. Hodgson named 12 species from Nepal, but some of his specimens in the British Museum show that he really obtained 13 species in that country. The collector of the Indian Museum did not, I think, add anything to Hodgson's list, although one of his specimens was described as a new species by Dr. Dobson (see p. 253). Of the 10 species which I obtained, no less than 5 were never secured by Mr. Hodgson in Nepal. The inference I draw from this is that the list of species of Chiroptera now actually known to occur in the Nepal Valley does not completely represent the forms to be found there. A considerably extended list must be the reward of future workers in that country.

As regards a list of bats inhabiting the whole State of Nepal, that would certainly include a very large number of species not to be found in the Nepal Valley; for anything I know to the contrary nearly every species of bat found in India *may* occur in Nepal territory. That must be mere matter of conjecture, for, as I have mentioned, we have only certain knowledge of the majority of forms which occur in and near the Nepal Valley.

In the following list reference is made under every species to the ample descriptions given in Dr. Dobson's works. Detailed descriptions would therefore be quite superfluous in this paper; but I have endeavoured to include such information as is available, from Indian sources, regarding the habits of the animals. It is matter for regret that our knowledge of the habits of bats is so scant.

I. Pteropus medius.

Pteropus medius, Temminck, Monogr. Mammal. i, p. 176 (1827); Dobson, Monogr. Asiat. Chiroptera, p. 18 (1876); Cat. Chir. Brit. Mus. p. 51 (1878).

Pteropus leucocephalus, Hodgson, J. A. S. B. vol. iv, p. 700 (1835).

Mr. Hodgson appears to have obtained a number of specimens of this bat in Nepal, as he presented four examples collected there to the British Museum. The type of *Pteropus leucocephalus* measured, length of head and body 10 inches, and expanse 46; the weight of the animal was 22 ounces. Dr. Dobson mentions that all these Nepalese examples have the head and under surface paler than usual, and that one specimen has an abnormal additional upper molar, immediately behind the third molar.

Mr. Hodgson informs us that this species never appears in the central region of Nepal save in autumn, when it comes in large bodies to plunder the ripe fruit in gardens. So far as the Nepal Valley is concerned, this remark hardly accords with my two years' experience of that portion of the country; for I was never able to obtain a specimen of *Pteropus medius* there. Of late years, at all events, this animal can only be regarded as a straggler to the Nepal Valley, and, whenever it does make its appearance there, I have little doubt that it merely travels about a dozen miles from the low and hot valley of the Trisul Ganga, immediately to the north-west of Nepal. Its route to a point so far in the interior of the Nepal mountains would naturally be along the easy gradient offered by the valley of the Gandak river, and its eastern-branch up to Nowakot (or Nayakot).

An interesting note will be found in Dr. J. Anderson's 'Catalogue of the Mammalia in the Indian Museum' (1881, p. 101) on some semi-migratory movements of *Pteropus medius*, in immense numbers, during autumn.

2. Cynonycteris amplexicaudata.

Pteropus amplexicaudatus, Geoffroy, Ann. du Mus. xv, p. 96 (1810).

Pteropus pyrivorus, Hodgson, Journ. Asiat. Soc. Beng. vol. iv, p. 700 (1835).

Cynonycteris amplexicaudata, Dobson, Mon. Asiat. Chir. p. 29 (1876); Cat. Chir. Brit. Mus. p. 72 (1878).

Mr. Hodgson's description of his *Pteropus pyrivorus* from Nepal leaves little doubt that he was referring to *Cynonycteris amplexicaudata:* he gives, length of head and body 6 inches, tail 0·5, expanse 24; weight 5 ounces. And Dr. Dobson's examination of the type specimen in the British Museum settles the question. Mr. Hodgson says that these bats only appear in Central Nepal in autumn, and at midnight, when they come in large bodies to plunder the fruit-gardens. As the animal was considered a perfect pest from the havoc it made among the ripe pears, he called it *pyrivorus.* He adds that when these bats appear in Central Nepal they must necessarily come from a very considerable distance, and that in the plains it is noted of them that they will travel 30 or 40 miles, and as many back, in a single night, in order to procure food.

These remarks of Mr. Hodgson as to the habits of *Pteropus pyrivorus* have been repeatedly misapplied to a totally distinct species of bat. Dr. J. E. Gray wrongly placed *Pt. pyrivorus* as a synonym of *Cynopterus marginatus* in his List of 'Mammalia in the British Museum' published in 1843. In 1844, Blyth confidently asserted that *Pteropus pyrivorus* was the same as *Cynopterus marginatus* (J. A. S. B. XIII, p. 479); it does not appear that he had seen an example named by Hodgson, but Gray certainly had two Nepalese specimens before him which are still in the collection of the British Museum. Horsfield, Hodgson himself, Hutton, and Dobson followed suit in this wrong determination. Hutton (P. Z. S. 1872, p. 693), under the head of *C. marginatus*, quotes Hodgson's account of *Pt. pyrivorus* and makes some remarks about the (supposed) wonderful feat accomplished by this bat in travelling from the plains to the Nepal Valley, and back again, in a single night. Dr. Dobson gives *Pt. pyrivorus* as a synonym, and quotes a portion of Hutton's remarks, in his article on *Cynopterus marginatus* in the Monograph of Asiatic Chiroptera (p. 26). But in the 'Catalogue of Chiroptera in the British Museum,' published two years later, he finds that *Pteropus pyrivorus* is undoubtedly *Cyn. amplexicaudata*, and gives Mr. Hodgson's remarks about its habits, correctly, under the description of the latter animal. The proverbial immortality of error, however, asserts itself, for, in the work last mentioned, we find the article on *Cynopterus marginatus* transcribed from the Monograph without excision of the references to *Pteropus pyrivorus.* The latter title is given as a synonym with a reference to P. Z. S. 1836, p. 36 ; and, at page 83, Capt. Hutton's misapplied remarks about *C. marginatus* being a perfect pest in Nepal &c. is repeated. It is easy to show that both these entries are erroneous. There is no mention of any bat on page 36 of the Proceedings of the Zoological Society for 1836 ; the page should be 46, and there will be found the name only of *Pteropus pyrivorus*, whose characters have to be sought for in the 'Journal of the Asiatic Society of Bengal,' that is to say, in Hodgson's original description in Vol. IV, 1835. Moreover, Dr. Dobson does not find any specimen of *Cynopterus marginatus* from Nepal in the British or Indian Museums, Mr. Hodgson never having obtained any example of it in that country. As to Captain Hutton's remarks on the habits of (so-called) *Cynopterus marginatus* in Nepal, that writer of course knew nothing of the bats of Nepal beyond what he derived from Hodgson's published accounts, and he merely followed Blyth and others in supposing that *Pt. pyrivorus* was a synonym of *C. marginatus.*

About the great distances supposed to be traversed by *C. amplexicaudata* in a single night in search of food, I think there is a misconception—at least so far as relates to the Nepal Valley. At the time Mr. Hodgson wrote his account of this species, he was probably not familiar with the Nowakot (or Nayakote) district, about 16 miles only in a direct line from Kathmandu. This part of the country, although situated to the north-west of the Nepal Valley, is more than 2000 feet lower than the latter ; one part of it, at Devighat, being less than 2000 feet above sea-level. The climate, vegetation, and fauna of this district naturally differ strikingly from those of the Nepal Valley, and here certainly we may expect to find both *Pteropus medius* and *Cynon. amplexicaudata* quite at home. A glance at any recent large scale map of India will show the broad valley of the Gandak river stretching from the plains into the Nepal hills, and Nowakot in the valley of the Trisul Ganga, the eastern affluent of the Gandak. Although so far in the interior of the hills, it will readily be understood that, in such hot malarious valleys, we have a direct continuation of the climate and flora suited to *C. amplexicaudata.* It is no wonder then that this bat should stray from the Nowakot district into the Nepal Valley in search of food, at suitable seasons ; and the supposition of its travelling 40 miles in a direct line over hill and dale, to visit the Nepal Valley at midnight, may be dismissed as improbable.

Three examples of this species, from Nepal, were presented by Mr. Hodgson to the British Museum, and these were probably the only specimens he obtained in that country.

3. Cynopterus marginatus.

Pteropus marginatus, Geoffroy, Ann. du Mus. xv, p. 97 (1810).

Cynopterus marginatus, Dobson, Mon. Asiat. Chir. p. 24 (1876); Cat. Chir. Brit. Mus. p. 81 (1878).

I obtained only two specimens of this species in Nepal, one from the Nowakot district about 16 miles north-west of Kathmandu; and another just within the Nepal Valley, which had evidently strayed there from the Nowakot district. The captures were effected on the 13th and 27th of July. The first example obtained is a female, evidently an old animal, as the molars are much worn, and the second is a male, apparently full grown, but not old.

The following are measurements taken from these specimens after preservation in alcohol :—

	♀	♂
Length, head and body	3·6	3·2
,, tail	0·45	0·45
,, head	1·3	1·25
,, ear (anteriorly from notch)	0·7	0·7
Breadth, ear	0·47	0·45
Length, ear to tip of nostril	1·1	1·1
,, eye to tip of nostril	0·5	0·47
,, forearm	2·5	2·43
,, thumb and claw	0·9	1·03
,, third finger	4·1	3·9 5
,, fifth finger	3·1	2·9
,, tibia	0·95	0·86
,, foot and claws	0·6	0·55
Expanse	16·0	16·0

The dental formula of these two specimens is :—

Incisors $\frac{4}{4}$, canines $\frac{2}{2}$, premolars $\frac{4}{6}$, molars $\frac{4}{4}$ = 30.

Ears margined with white; wing-membrane from basal half of first toe; fur olive-brown above, pale fulvous beneath. Claws black, with white tips. Compared with specimens of *C. marginatus* in the British Museum, I could not detect any difference except in size, the Nepalese examples being decidedly small and having short ears. My measurements accord best with those of *C. brachyotus*, from S. Andaman Island, given by Dobson in the Monograph of Asiatic Chiroptera; but, as this variety does not even figure as a synonym in the Catalogue of Chiroptera published by him later, it is to be presumed that *C. marginatus* must be regarded as a species which varies greatly in all dimensions.

Mr. Hodgson did not obtain this species in Nepal, and, although it has often been quoted as from that country on his authority, it has been shown, under the head of *Cynonycteris amplexicaudata*, that this was founded on error. Consequently, the present notice is the first authentic record of the occurrence of *C. marginatus* in Nepal.

4. Rhinolophus luctus.

Rhinolophus luctus, Temminck, Monogr. Mammal. ii, p. 24 (1835); Hutton, Proc. Zool. Soc. Lond. 1872, p. 694; Dobson, Mon. Asiat. Chir. p. 39 (1876); Cat. Chir. Brit. Mus. p. 105 (1878).

Rhinolophus perniger, Hodgson, Journ. As. Soc. Beng. vol. xii, pt. i, p. 414 (1843.)

There seems to be no doubt now that the species described by Hodgson, from Nepal, under the name of *Rhinolophus perniger* is, as Blyth first stated, the same as *Rh. luctus*, Temminck. Mr. Hodgson gives the following measurements of the type of *Rh. perniger*, a female: length of head and body 3·25 inches, tail 1·12, head 1·31, expanse 17, ear from anteal base 1·68, ear from crown of head or posteal base 1·37, radius 2·62, third finger 4·0, tibia 1·37, foot 0·81. Captain Hutton gives, for *Rh. luctus* from Masuri, head and body 3·5 to 4·6 inches, tail 1·95 to 2·12, ear 1·5, expanse 17·12 to 18·5, radius 2·75 to 3, third finger 4·5.

Mr. Hodgson did not present any example of *Rh. perniger* to the British Museum, but he gave a skeleton of the species to the Asiatic Society in 1842, which is at present in the collection of the Indian Museum. Dr. Dobson enters this example in the catalogue appended to his 'Monograph of Asiatic Chiroptera' (p. 194), and under the heading of locality he puts "Nipal?" There can, however, be no doubt that this specimen having been received from Mr. Hodgon in 1842 must have come from Nepal and no other country. I have not been able to trace any other authentic record of a Nepalese specimen of the species.

Concerning the habits of this bat in Nepal, Mr. Hodgson says that it is shy and never approaches houses or cultivated country; and that it dwells in the deep forests and caves of the more precipitous mountains. On this Captain Hutton remarks that such are not the habits of *Rh. luctus* at higher elevations in the Himalayas further west than Nepal. I am disposed to think that Hodgson's observation is correct, so far as Nepal is concerned. I never obtained a specimen in the valley during my residence there, and, if it had anything like the habits of *Rh. minor* or of the different species of *Phyllorhina* in Nepal, I could not have failed to secure such a fine and conspicuous species as *Rh. luctus*.

As Mr. Hodgson obtained very few specimens of it in Nepal (perhaps only one), and judging from my own want of success, I believe this species to be rare in that locality. It probably affects higher elevations than the Nepal Valley. Captain Hutton has given a very interesting account of the habits of *Rh. luctus ;* this has been quoted in Dr. Dobson's Monograph and, being therefore readily accessible, need not be reproduced here.

5. Rhinolophus macrotis.

Rhinolophus macrotis, Hodgson, Blyth, Journ. As. Soc. Beng. vol. xiii, pt. i, p. 485 (1844); Hutton, Proc. Zool. Soc. Lond. 1872, p. 699 ; Dobson, Mon. As. Chir. p. 45 (1876), Cat. Chir. Brit. Mus. p. 110 (1878).

This species, which is only known with certainty to occur in Nepal and Masuri, was first described by Mr. Hodgson from the former locality in 1844. He presented a specimen of it to the British Museum, and another to the Asiatic Society which is now in the collection of the Indian Museum. These are the only two known examples of the species from Nepal. Mr. Hodgson mentions that *Rhinolophus macrotis* has no pubic false teats, and he gives the weight of his type specimen as one-third of an ounce.

In the following table, measurements of examples of this species from various sources are contrasted. In column I. are entered Mr. Hodgson's original measurements, II. contains those given by Mr. Blyth of a female example sent by Mr. Hodgson to the Asiatic Society, III. shows Captain Hutton's results for recent examples captured at Masuri, and IV. contains Dr. Dobson's measurements of an adult male sent by Captain Hutton from Masuri to the Asiatic Society. Dimensions in inches.

	I.	II.	III.	IV.
Head and body	1·75	1·62	2·37 to 2·5	1·7
Head..	0·75	0·63	—	0·75
Ear from anteal base...	0·93	0·62	1·0	0·85
Interval of ears...	0·25	—	—	—
Tail..	0·75	0·63	0·87	0·8
Humerus..	1·0	—	—	—
Radius...	1·5	1·62	1·7	1·6
Third finger..................................	2·3	2·25	2·37	2·2
Femur..	0·62	—	—	—
Tibia..	0·62	0·63	0·7 to 0·75	0·7
Expanse...	9·75	—	9	
Foot..	—	0·37	—	0·35

It will be seen that Captain Hutton's dimensions considerably exceed those given by the other authorities. The most noteworthy divergence is in the length of the head and body, but Hutton expressly says that his measurements are taken from fresh specimens, so that part at least of the discrepancy may be accounted for by the shrinking of specimens preserved in alcohol.

Mr. Hodgson does not give any particular account of the habits of this species in Nepal. Hutton's note about the manners of these bats in Masuri is this, "They come out of the caves in the earlier twilight hours, and may be seen flitting rapidly at some height in the air, chasing the small flies and beetles which abound during the rainy season."

Dr. Dobson mentions that the type of *Rhinolophus macrotis* is in the collection of the Indian Museum. There are three specimens of this species in that collection, an adult female in alcohol presented by Mr. Hodgson in 1842, from Nepal, which has been mentioned above ; and two adult males in alcohol from Masuri, presented by Captain Hutton in 1852. The Nepal specimen is therefore doubtless the type as understood by Dr. Dobson, but this fact is not mentioned in the catalogue appended to his Monograph, nor in Dr. Anderson's 'Catalogue of Mammalia in the Indian Museum' (1881).

6. Rhinolophus affinis.

Rhinolophus affinis, Horsfield, Zool. Research. Java, (1824); Dobson, Mon. As. Chir. p. 47 (1876); Cat. Chir. Brit. Mus. p. 112 (1878).

This species is entered here with considerable doubt. The only ground for its inclusion is an entry in the 'Catalogue of Chiroptera in the British Museum' of a specimen of *Rh. affinis* from "Nipal," presented by Mr. Hodgson. It is quite possible that the locality quoted merely rests on the evidence of an erroneous museum label, and that the specimen was really procured by Mr. Hodgson in Darjiling, where *Rh. affinis* appears to be common. No synonym is quoted under the entry of this particular specimen to show that it ever bore a name bestowed by Mr. Hodgson ; and specimens of *V. mystacinus*, *Megaderma lyra*, and *Plecotus auritus*, certainly obtained by Mr. Hodgson in Darjiling or the Sikkim Tarai, and never in Nepal, are in that work entered as from Nepal.

A reference to the register of the British Museum would settle the question ; for, if the specimen of *Rh. affinis* presented by Mr. Hodgson was only received in 1847, or on any subsequent date, it could not have been collected in Nepal.

However, the species is very likely to be found in Nepal, as it occurs both east and west of that country in the Himalayas, at Darjiling and Masuri.

7. Rhinolophus minor.

Rhinolophus minor, Horsfield, Zool. Res. Java (1824); Dobson, Mon. As. Chir. p. 50 (1876), Cat. Chir. Brit. Mus. p. 114 (1878).

Rhinolophus subbadius, Hodgson, Blyth, Journ. As. Soc. Beng. vol. xiii, pt. i, p. 486 (1844).

In a catalogue of the mammals of Nepal by Mr. Hodgson, printed in Journ. As. Soc. Bengal, Vol. X. Pt. II, p. 909 (1841), a species called *Vespertilio subbadia* is mentioned. The description of this form as *Rhinolophus subbadius* only appeared three years later, as cited in the above synonymy. Dr. Dobson does not notice the title of *Rhinolophus subbadius* at all, either in his 'Monograph' or 'Catalogue of Chiroptera in the British Museum.' It will be useful to recall the descriptions and measurements given by Hodgson and by Blyth of *Rh. subbadius.* The account given by the former author is too vague to fix the species, but he fortunately sent a specimen of it to the Asiatic Society, which Blyth described in the paper in which Hodgson's diagnosis appeared.

Hodgson says that, in his species, the ears are not longer than the head, are truncated at the tip [or somewhat obtusely pointed], and ovoid. Nasal appendage quadrate, not salient, with a transverse bar nearly surmounting it towards the head. Blyth's diagnosis is, Anterior nose leaf very small, oblong, rounded above. Vertical membrane conspicuously developed, and pointed posteriorly. Behind vertical membrane a short and broad transverse membrane, divided into two lateral lobes. Hindmost angular peak with sides slightly emarginated towards the point. Nostrils not externally fringed with membrane. Over the lip is the usual horse-shoe. The following are the measurements given *(a)* by Hodgson and *(b)* by Blyth of this Nepalese species.

	(*a*)		(*b*)
Length, head and body......	1·5	...	1·25
,, tail....................	1·25	...	0·62
,, head....................	0·62	...	0·62
,, ear.....................	0·62	...	0·5
,, forearm	1·25	...	1·37
,, third finger	2·25	...	1·88
,, tibia...................	—	...	0·62
,, foot....................	0·37	...	0·31
Expanse....................	7·5	...	—

No specimen of *Rh. subbadius* was presented by Hodgsou to the British Museum; the example he gave to the Asiatic Society was entered in Blyth's Catalogue (p. 25) as No. 69 A. This number seems to have been accidentally removed from the specimen, and it cannot now be traced with certainty. I shall refer to this specimen later on.

I obtained an example of this species in the Nepal Valley which gave the following measurements. Length head and body 1·5 inch, tail 0·75, head 0·7, ear, 0·65, nose-leaf 0·44 × 0·28, forearm 1·4, thumb 0·23, third finger, metacarpal 1·1, first phalanx 0·43, second phalanx 0·65, fifth finger, metacarpal 1·13, first phalanx 0·36, second phalanx 0·45, tibia 0·62, foot and claws 0·3.

Ears subacutely pointed; antitragus separated by a deep angular notch. Posterior connecting process acutely pointed, considerably exceeding the vertical process of the sella in height. Terminal process of posterior nose leaf narrow and emarginate. Lower lip with three vertical grooves. Second lower premolar in the tooth row. Second upper premolar rather widely separated from the canine, and the first upper premolar standing in the tooth row. Wing membrane to tibia, 0·1 above ankle-joint.

I have no doubt that this specimen represents *Rh. subbadius* of Hodgson, and I think it is also certainly an example of the variable *Rh. minor* of Horsfield. I have compared my Nepalese specimen with examples of *Rh. minor* in the British Museum, named by Dr. Dobson. The sella is exactly the same shape, but the ears are rather larger and the horizontal nose-leaf, or horse-shoe, is slightly larger, and conceals the lip more. These slight differences are not of much importance, and I believe *Rh. subbadius*, Hodgson, may be safely considered a synonym of *Rh. minor*.

With regard to the original specimen received by the Asiatic Society from Mr. Hodgson, I have already said that it cannot be traced with certainty. In the catalogue of specimens appended to Dr. Dobson's Monograph, No. 69A of Blyth's Catalogue is not accounted for; but three specimens of *Rh. minor* are entered of which the locality, date, and donor are unknown. These bats came to the Indian Museum from the Asiatic Society, and of one of them Dr. Dobson notes that the sex is undeterminable, and that it is in a dilapidated condition. It is possible that this specimen is the type of *Rhinolophus subbadius*, received from Mr. Hodgson in 1832. In noticing these three specimens of *Rh. minor*, Dr. J. Anderson mentions that they are *types* (Cat. Mamm. Ind. Mus. 1881, p. 110).

This species does not appear to be common in the Nepal Valley; I noticed it only on a few occasions, and Mr. Hodgson does not furnish any notes about its habits. Captain Hutton records it from Masuri, but the measurements he gives of his specimens are not reconcilable with the known dimensions of *Rh. minor*. He gives the length of head and body as from 3 inches to 3·25, &c. I think the specimens whose dimensions he records could not have been *Rh. minor*.

8. Rhinolophus ferrum-equinum.

Vespertilio ferrum-equinum, Schreb., Säugeth. i, p. 174 (1775).

Rhinolophus tragatus, Hodgson, Journ. As. Soc. Beng. vol. iv, p. 699, (1835).

Rhinolophus ferrum-equinum, Dobson, Mon. As. Chir. p. 53 (1876); Cat. Chir. Brit. Mus. p. 119 (1878).

This species is fairly common in Nepal. The following particulars are extracted from Mr. Hodgson's original description of his *Rh. tragatus*, obtained in the Nepal Valley :—Length of head and body 2·62 inches, tail 1·87, expanse 15·5, weight 2 ounces. The pubic false teats are strikingly developed, and have the same shape as the true pectoral teats, bnt even exceed them in size. The ears are "tremblingly alive all over" and capable of considerable movement and compression. "So soon as it is dark, they come forth from the cavities of rocks, in groups, to skim the surface of standing crops, or to glide around and between umbrageous trees, in search of nocturnal insects, which constitute their sole food. They make their exit rather sooner than the true bats [*Vespertilionidæ*], and always in considerable numbers. They are not migratory, nor subject to hibernation. They breed once a year, towards the close of summer, and produce two young, differing from the parents chiefly in the very restricted development of the nasal appendages."

These remarks on habits must of course be understood as applying only to Nepal and regions having a similar climate. In Gilgit, for instance, where the winter is much colder than in the Nepal Valley, *Rh. ferrum-equinum* certainly hibernates [*see* my paper on the Mammals of Gilgit, P. Z. S. 1881, p. 199].

9. Phyllorhina armigera.

Rhinolophus armiger, Hodgson, Journ. Asiat. Soc. Beng. vol. iv, p. 699 (1835).

Phyllorhina armiger, Dobson, Monogr. Asiat. Chir. p. 64 (1876); Cat. Chir. Brit. Mus. p. 135 (1878).

Mr. Hodgson was the first to name and describe this bat, from specimens obtained by him in Nepal, of which he presented three to the British Museum. This fine species is very common in the Nepal Valley at all seasons. Owing to its large size and peculiar method of hunting for its prey, its habits can be readily observed. In the following table detailed measurements of eleven examples which I preserved are set forth. It is somewhat remarkable that more than four-fifths of the total number secured should have been females.

	♂	♂	♀	♀	♀	♀	♀	♀	♀	♀	♀
Length, head and body.........	4·0	4·1	3·8	4·1	3·65	3·63	3·7	3·9	3·6	4·0	4·0
,, tail..	—	2·25	2·35	2·1	2·2	2·4	2·4	2·3	2·4	2·4	1·9
,, head....	1·27	1·34	1·34	1·3	1·34	1·3	1·3	1·3	1·3	1·28	1·4
,, ear (anteriorly)	1·17	1·15	1·17	1·2	1·2	1·1	1·1	1·15	1·16	1·25	1·23
Breadth of ear (anteriorly)..	0·94	0·9	0·95	I·1	0·95	0·94	0·93	1·0	0.96	1·0	1·0
Length, forearm..	3·45	3·45	3·5	3·4	3·5	3·43	3·56	3·6	3·45	3·4	3·6
,, thumb and claw....	0·47	0·54	0·55	0·55	0·54	0·55	0·53	0·55	0·53	0·55	0·55
,, third finger	4·53	4·7	4·7	5·3	4·65	4·67	5·2	4·9	4·75	4·65	4·95
,, fifth finger...	3·68	3·7	3·65	3·75	3·8	3·73	3·8	3·85	3·7	3·65	3·85
,, tibia.......	1·5	1·5	1·4	1·45	1·4	1·4	1·53	1·42	1·44	1·43	1·56
,, calcaneum	—	0·87	0·93	0·82	0·85	0·83	0·8	0·87	0·8	0·82	0·97
,, foot and claws....	0·65	0·7	0·7	0·72	0·65	0·73	0·74	0·73	0·67	0·65	0·7
Expanse	21·4	—	23·3	21·5	21·0	21·3	22·0	22·3	21·5	21·0	2·02

In all the specimens the glandular frontal sac is distinct, but is smaller in the females than in the males. The wing-membrane is attached to the tibia above the ankle-joint, and the distal end of the calcaneum is distinctly marked in all. Pubic warts are present in six of the females, but are absent in the three remaining examples of this sex; in one case a pubic wart measures 0·28 inch in length. Hodgson found the weight of his type specimen (a male) to be 3 ounces; in the only specimen I weighed, an adult female, I found the weight 1·5 oz. or just half the figure Mr. Hodgson gives.

This bat usually harbours during the day in caves, or commonly in lofts, out-houses, and sheds that are little used; in the latter localities it suspends itself, by the claws of the feet, from the rafters. When attaching itself in this way to the edge of a beam or rafter, the animal sways, pendulum-like, a few times until the impetus given during flight is exhausted; and it then hangs motionless with its wings folded close to the body. If slightly alarmed by the opening of a door, or any unusual noise in the room it occupies, the head is thrust out and turned carefully in various directions, as if for the purpose of finding out the cause of disturbance. On such occasions I have purposely dropped a heavy book on the floor so as to alarm the bat thoroughly. The animal would at once fly off and either take several turns round the room, or else leave it; but it invariably returned quickly and attached itself to the spot it had previously occupied.

It comes out for the capture of its prey about sunset, and its hunting grounds are gardens, orchards, cleared spaces in woods, or avenues of trees ; somewhere near trees always. It is sometimes found flying on a level with the tops of the trees, but more commonly nearer the ground; a very characteristic movement it has is a slow but steady sweep round a leafy tree, or clump of trees, in search of insects which frequent the lower branches. While it was intently occupied in this circular flight I have been nearly touched on the face by this bat, as I walked across the grounds attached to my house in Nepal. And in passing so close to one it could be distinctly heard crunching the hard-bodied insects it had caught, between its strong teeth.

Sometimes these bats seem to come out of their day retreat before the insects they are in search of are to be found in plenty. On the 25th August about 6 P. M., I noticed an example of *Phyllorhina armigera* flying close to a tree. It circled twice round the tree while I was watching it, keeping about three feet above the ground. Apparently finding that none of the insects it wanted were about, it suspended itself to a small horizontal branch of the tree, just 3½ feet above the ground, and so remained for some time. It was probably waiting for a more propitious hour. Whether this was really the explanation of the pause in its flight or not, it seems certain that this bat does not ordinarily remain very long on the wing. I have often observed that in the early part of the night it alternated its pursuit of insects with short periods of repose in an out-house. On one occasion, I observed a bat of this species return three times during the evening (from about 8 to 10 P. M.) to a room I happened to be occupying ; and curiously enough it always attached itself to precisely the same part of the ceiling. That part of the room, however, was the point furthest away from me, and my presence may have influenced the bat in its selection of the most quiet spot.

On another occasion, one of these bats had suspended itself to the ceiling of my study late at night, and it first attracted attention by the pattering of its droppings on the floor. On being alarmed at some noise I made in moving books, it quitted its perch and flew lumberingly round the small room. It soon ended by knocking itself violently against a wall and then fell on the floor, apparently exhausted and stunned. When I approached it, however, it flew up and once more hooked on to a beam exactly where it had been before. It does not enter lighted rooms in houses so commonly as so many other species of bats do. Indeed, on the rare occasions when I have found it in this way, its object in coming in was evidently for rest merely, either temporarily or for the night.

When captured alive (a large butterfly-net answers for this purpose), this bat has a fierce and forbidding aspect owing to its depressed muzzle and prominent canine teeth ; the ears are kept in quick tremulous motion, and there is also frequent but slight movement of the facial crests. The animal is easily shot during its flight, and most of my specimens were obtained in this way.

Hodgson says that *Phyllorhina armigera* breeds once a year, towards the close of summer, and produces two young, differing from the parents chiefly in the very restricted development of the nasal appendages. I made no observations on this point, but I note that in a female specimen captured on the 27th July, the pectoral teats, which are situated near the anterior margin of the axilla, are enlarged.

10. Phyllorhina fulva.

Hipposideros fulvus, Gray, Mag. Zool. and Bot. ii, p. 492 (1838).

Phyllorhina fulva, Dobson, Monogr. Asiat. Chir. p. 71 (1876) ; Cat. Chir. Brit. Mus. p. 149 (1878).

The following particulars are derived from three examples of this bat captured in the Nepal Valley on the 21st and 22nd August, and the 10th of January :

	♀	♀	♂
Length, head and body	2·0	2·1	1·9
,, tail............ ...	1·2	1·4	1·35
,, head......	0·75	0·75	0·75
,, ear.....	0·85	0·82	0·9
,, forearm...	1·6	1·64	1·6
,, third finger.	2·45	2·5	2·4
,, fifth finger......	2·15	2·14	2·0
,, tibia...	0·73	0·75	0·72
,, foot...............	0·33	0·34	0·3
,, calcaneum	0·35	0·4	0·37
Expanse	10·2	10·0	—

Nothing in the coloration of these specimens recalls Mr. Blyth's remark (J. A. S. B. XIII, Pt. i, p. 489, 1844) that this species is perhaps the most vividly coloured of the whole class of mammalia. The fur is long, dense, and soft, above smoky brown, the hairs white at their bases ; below paler, especially on the throat. Ears and membrane dusky. Wing-membrane from the tarsus.

These examples agree well with specimens of *Phyllorhina fulva* in the British Museum, named by Dr. Dobson. That author considers that *Ph. fulva* is only a variety of *Ph. bicolor*, and on this point I cannot offer any useful opinion. But *Ph. amboinensis*, which he also regards as a variety of *Ph. bicolor*, seems to me quite distinct from *Ph. fulva*.

This species is not uncommon in the Nepal Valley, although Mr. Hodgson never obtained it. It often comes into lighted rooms at night to hunt for insects. While being pursued in a room, it constantly flies very low down, not more than a couple of feet from the floor. It is a permanent resident in Nepal and does not hibernate there.

11. Phyllorhina amboinensis.

Phyllorhina amboinensis, Peters, M. B. Akad. Berl. 1871, p. 323; Dobson, Mon. Asiat. Chir. p. 72 (1876); Cat. Chir. Brit. Mus. p. 150 (1878).

Phyllorhina micropus, Hutton, Proc. Zool. Soc. 1872, p. 703.

I captured two specimens of this bat in the Nepal Valley on the 22nd of October; the animals had entered a lighted room on the ground floor about 9 o'clock in the evening.

The following are dimensions of these examples—both females—in inches:—

	1	2
Length, head and body	1·6	1·7
,, tail......	1·03	1·0
,, head.............	0·65	0·65
,, ear................	0·63	0·62
Length, forearm...	1·40	1·37
,, third finger...........	2·0	2·1
,, fifth finger...........	1·8	1·78
,, tibia.......	0·58	0·57
,, foot.....................	0·27	0·27
,, calcaneum...	0·26	0·3
Expanse...........	8·9	8·9

These specimens agree well with a bat in the collection of the British Museum, from Lingasugur in the Deccan, which had been compared with the type of *Phyllorhina amboinensis* in the Berlin Museum by Dr. Dobson. In the Nepalese specimens the wing-membrane is attached to the tarsus.

Mr. Hodgson never obtained this species in Nepal.

Captain Hutton observes that it occurs in the summer months both in the lower hills near Masuri and in the Dehra Doon. He adds that one was taken on a warm evening in September, having flown in to the lights in a room, and another was taken at the foot of the hills, in the same way, in October; but that it is by no means common.

12. Vesperugo noctula.

Vespertilio noctula, Schreb., Säugeth. i, p. 166 (1775).

Vespertilio labiata, Hodgson, Journ. Asiat. Soc. Beng. vol. iv, p. 700 (1835).

Vesperugo noctula, Dobson, Mon. Asiat. Chir. p. 88 (1876) ; Cat. Chir. Brit. Mus. p. 212 (1878).

Mr. Hodgson appears to have obtained only one specimen of this bat in Nepal, the type of his *Vespertilio labiata*, now in the collection of the British Museum. In his description, he says that the colour of the fur is saturate brown throughout and that of the skin, wherever uncovered by hair, purpurascent. His measurements are, length of head and body 3 inches, tail 2, and expanse 15.

I only secured a single specimen of *Vesperugo noctula* in the Nepal Valley, on the 2nd of July, in the following manner. About 8 o'clock in the evening, I heard the very shrill scream of some small animal in my bedroom, and, on going into the room, I found this bat attached to the mosquito-net covering my bed. In its flight, it had apparently alighted on the net, and there got its claws so firmly entangled that it could not escape.

The following are the measurements of this specimen:—length, head and body 3·1, tail 2·1, head 0·9, ear 0·75 × 0·6, tragus 0·3 × 0·13, forearm 2·05, thumb 0·34, third finger 3·65, fifth finger 2·2, tibia 0·75, calcaneum 0·7, foot and claws 0·45 ; expanse 15·0.

The colour of the fur above is rich olive-brown, beneath paler brown, and the fur on the membranes is buff. Ears and membranes dusky.

Vesperugo noctula is, I think, not common in the Nepal Valley. Mr. Hodgson says that it is found there throughout the year, does not hibernate, and quests for food solitarily.

13. Vesperugo abramus.

Vespertilio abramus, Temminck, Monogr. Mammal. ii, p. 232 (1835).

Scotophilus fuliginosus, Gray, Cat. Hodgson's Collect. Brit. Mus. p. 4 (1845).

Vesperugo abramus, Dobson, Mon. Asiat. Chir. p. 97 (1876) ; Cat. Chir. Brit. Mus. p. 226 (1878).

This is a very common species in the Nepal Valley, where it is to be found at all seasons. It is very active in hunting over gardens and woods, and its flight is quick. It often enters houses at night, in pursuit of insects attracted by lights. The breeding season would appear to be in the cold weather; for none of the adult specimens captured from May to August showed any sign of rutting, but a male secured in November was evidently in rut.

The following are dimensions and some particulars of the specimens preserved :—

	♂	♂	♂	♀	♀	♂	♀
Length, head and body....	1·73	1·8	1·8	1·9	1·8	1·79	1·82
„ tail......	1·45	1·4	1·5	1·63	1·55	1·37	1·55
„ head....	0·6	0·64	0·6	0·63	0·65	0·63	0·63
„ ear......	0·5	0·5	0·5	0·58	0·55	0·5	0·53
„ tragus..	0·22	0·21	0·22	0·25	0·21	0·23	0·22
„ forearm..	1·29	1·28	1·3	1·3	1·3	1·28	1·3
„ thumb..	0·25	0·25	0·3	0·25	0·24	0·24	0·27
„ third finger....	2·35	2·4	2·4	2·55	2·45	2·3	2·5
„ fifth finger	1·6	1·7	1·7	1·77	1·75	1·65	1·8
„ tibia..............	0·52	0·5	0·5	0·6	0·51	0·5	0·53
„ foot and claws	0·26	0·26	0·27	0·3	0·26	0·27	0·25
Expanse........	8·8	9·0	10·0	10·1	9·0	8·9	9·7

Fur above dark olive-brown, below paler and rather rufous brown; basal part of fur above and below blackish. Membranes dusky. In a male captured on the 8th November the testes appear in the form of oval bodies, 0·3 inch in length, placed on each side of the base of the tail, below, in a temporary scrotum. Iu this specimen, the colour of the fur differs perceptibly from that of the other examples. The fur above is a rich brown, with a wash of gold-colour in parts, due to the hairs being pale-tipped; below, the colour is sandy brown. The tips of the claws are pure white. On comparing these Nepalese examples with specimens of *V. abramus* in the British Museum, I could not detect any appreciable differences in the shape or position of the teeth, or in any other specific characters.

Mr. Hodgson presented five examples of *Vesperugo abramus*, obtained in Nepal, to the British Museum; but he does not appear to have discriminated the species, as he gave no name to it. The specimens were entered in the Catalogue of Hodgson's collection, by Dr. J. E. Gray, as *Scotophilus fuliginosus*, with *Vespertilio fuliginosus*, Hodgson, as a synonym. The latter title is really a synonym of *Miniopterus schreibersii*, as is proved by Hodgson's original description.

14. Harpyiocephalus leucogaster.

Murina leucogaster, Alph. Milne-Edwards, Nouv. Arch. Mus. vii, Bull. p. 91 (1871); Mammif. du Tibet. p. 250 (1872).

Harpiocephalus leucogaster, Dobson, Monogr. Asiat. Chir. p. 157 (1876); Cat. Chir. Brit. Mus. p. 283 (1878).

I obtained a single specimen of this bat in the Nepal Valley, on the 2nd of September. It was found dead in my room, early in the morning, and had probably killed itself by dashing against a wall.

Length, head and body 1·85 inch, tail 1.4, head 0·7, ear 0·6, tragus 0·3, forearm 1·25, thumb 0·4, third finger 2·4, fifth finger 1·85, tibia 0·65, foot aud claws 0·33 ; expanse 9·3.

Ears oval, broadly rounded above ; the inner margin convex, with a distinct spur-shaped process near its base, which projects forwards towards the posterior angle of the eye ; outer margin convex.

Wing-membrane to base of distal phalanx of outer toe. Interfemoral membrane angularly emarginate at termination of calcaneum ; extreme tip of tail projecting.

Fur golden-orange on head, the base of the hairs greyish ; on the back pale rufous brown, grey at the base. Fur on membranes bright ferruginous, the upper surface of the interfemoral membrane and toes being well covered. Beneath, the fur is white throughout on the chin and throat, the rest of the lower parts having bicoloured fur—grey at the base with white tips.

Upper inner incisor longer than outer incisor and not touching the canine at the base ; from the outer side of its base a cusp projects inwards. First upper premolar in the same plane as the canine and second premolar, about equal to the latter in vertical height and about three-fourths of its size in cross section.

Nose, lower lip, and sides of head to ears, nude and dark fleshy ; membranes brownish black, but orange-coloured along forearm. Compared with a specimen of *H. leucogaster* in the British Museum, from Tibet, the ears, teeth, and thumb and claw are of the same size and shape. The only difference observable is in the colour of the fur, which is very ferruginous above in the Nepal specimen and brown in the animal from Tibet. As the two specimens must certainly be referred to the same species, it would seem that the colour of the fur is no more a reliable character in this species of *Harpyiocephalus* than in other Chiroptera (*cf.* Dobson, Cat. Chir. Brit. Mus. p. 284).

Mr. Hodgson did not obtain this species in Nepal. Of its habits in the north-west Himalayas, Captain Hutton says that it occurs at an elevation of about 5,500 feet, but does not appear to be common in the hills, the Dehra Doon being probably its true locality there. An example which flew into a room at Jeripani (below Masuri), at night, kept low down in its flight, instead of soaring towards the ceiling, passing under the tables and chairs, as if afraid to emerge into the broad glare of the lamps. " This likewise is the mode of flight when searching for insects in the open fields, where it skims closely and somewhst leisurely over the surface of the crops and grass" (P. Z. S. 1872, p. 712).

15. Vespertilio nipalensis.

Vespertilio pallidiventris, Hodgson, Calc. Journ. Nat. Hist. vol. iv, p. 286 (1844), (name only); Gray, Cat. Hodgson's Collect. Brit. Mus. p. 4 (1846) (not described).

Vespertilio pallidiventer, Gray, Cat. Hodgson's Collect. Brit. Mus. 2nd Ed. p. 2 (1863) (name only).

Vespertilio nipalensis, Dobson, Proc. Asiat. Soc. Beng. 1871, p. 214; Mon. Asiat. Chir. p. 141 (1876); Cat. Chir. Brit. Mus. p. 302 (1878).

The name *Vespertilio pallidiventris* first occurs in a list of the mammals of Nepal by Mr. Hodgson, published in the 'Calcutta Journal of Natural History' in 1844. Although the name given by Mr. Hodgson to this Nepalese species of bat appears in several lists subsequent to that date, he never gave any description of the animal. As he did not present any examples of it to the British Museum or the Asiatic Society, I imagine that he only obtained one specimen, which must have been lost, somehow, after it was figured. There is a well executed figure of *V. pallidiventris* in the collection of plates of Mammals of Nepal presented by Mr. Hodgson to the Zoological Society of London.

In 1871, a collector of the Indian Museum obtained a bat in Kathmandu, which Dr. Dobson described as a new species under the name of *V. nipalensis*, the type and only known specimen being an adult female example, preserved in spirit, and now in the Indian Museum, Calcutta. I have carefully examined Hodgson's original plate of *V. pallidiventris*, with Dr. Dobson's description and figure of *V. nipalensis* before me, and, so far as any conclusion can be arrived at on such data, I believe that both these names apply to the same species. The plate of *V. pallidiventris* represents a true *Vespertilio*, as evidenced by the shape of the ear and by the narrow, acutely pointed tragus; and the whole lower surface of the animal is coloured *pure white.* This white colour of the under-parts is perhaps the most marked feature in *V. nipalensis.* And, Dr. Dobson's type specimen having come from the very place where Mr. Hodgson obtained his *V. pallidiventris*, there can be no reasonable doubt about Hodgson's title having priority. But as the latter naturalist never defined his species by any description however short, or was helped to a definition by any writer before the name *V. nipalensis* was published, *V. pallidiventris* must be regarded as a synonym merely, under the accepted rules of zoological nomenclature.

Nothing is recorded about the habits of *V. nipalensis.* It appears to be restricted to Nepal, and, from what has been said above, it would seem that it is not common even in its only known habitat. A full description of the animal, with measurements of the type, is given in Dr. Dobson's works above cited.

16. Vespertilio formosus.

Vespertilio formosa, Hodgson, Journ. As. Soc. Beng. vol. iv, p. 700 (1835).

Vespertilio formosus, Dobson, Mon. Asiat. Chir. p. 140 (1876); Cat. Chir. Brit. Mus. p. 311 (1878).

In his original description of this species from Nepal, Mr. Hodgson gives the following measurements of the type specimen: length of head and body 2·5 inches, tail 2, expanse 12·5. He notes that the animal has a sharp visage, and that the nasal bones are slightly convexed and unite easily with a low forehead, in this respect contrasting with his *Vespertilio fuliginosa (Miniopterus schreibersii).*

Of the habits of *V. formosus* in the Nepal Valley, Mr. Hodgson merely records that it remains there throughout the year and does not hibernate; and that it quests for food solitarily.

In the Himalayas, this bat seems to be common at Darjiling, and in Dehra Doon, and Lower Masuri; but I think it does not occur plentifully in the Nepal Valley, as only one example appears to have been obtained by Mr. Hodgson (the type, now in the British Museum), and I never secured a specimen there.

17. Vespertilio mystacinus.

Vespertilio mystacinus, Leisler, Kuhl, Deutsch. Flederm. Ann. Wetterau. Naturk. iv, p. 55 (1819); Dobson, Monogr. Asiat. Chir. p. 133 (1816); Cat. Chir. Brit. Mus. p. 314 (1878).

This is one of the commonest bats in the Nepal Valley. It may be seen every evening throughout the year, flying rather high in the air; and it frequently enters houses at night for a short hunt near lamps or other lights. On such occasions, two individuals are often found associated. Ten examples were secured from June to November. Of these eight are adult (5 ♂, 3 ♀), and, though they were captured in the months of June, July, August, September, and October, they do not show any sign of breeding. In none of the males are the testes descended, and in the females the mammæ are not enlarged. An immature female was obtained on the 30th June, and a very young male, just able to fly, on the 3rd July. The following table shows the dimensions of the adult specimens:—

	♂	♂	♂	♂	♂	♀	♀	♀
Length, head and body ...	1·9	1·8	1·7	1·5	1·5	2·0	1·95	1·9
„ tail..................	1·4	1·55	1·6	1·5	1·55	1·5	1·45	1·6
„ head...............	0·6	0·6	0·6	0·58	0·6	0·63	0·6	0·61
„ ear.................	0·5	0·5	0·57	0·5	0·5	0·51	0·53	0·52
„ tragus..............	0·27	0·23	0·26	0·25	0·25	0·24	0·24	0·26
„ forearm............	1·38	1·34	1·4	1·32	1·35	1·4	1·35	1·43
„ thumb..............	0·28	0·29	0·27	0·28	0·26	0·27	0·27	0·27
„ third finger.. ...	2·25	2·26	2·2	2·17	2·2	2·15	2·27	2·3
„ fifth finger.......	1·74	1·7	1·7	1·73	1·7	1·75	1·75	1·8
„ foot and claws ..	0·3	0·34	0·37	0·4	0·34	0·37	0·36	0·4
„ calcaneum......	0·6	0·6	0·57	0·57	0·55	0·55	0·6	—
Expanse....................	9·5	—	9·4	9·3	9·5	9·5	9·7	10·0

Fur above dark brown; beneath ashy, the basal part of the hairs being black. Muzzle, ears, and membranes dusky, with a purplish tint. The specimen whose dimensions are entered in the third column above differs from all the others in having the forehead rather abruptly raised above the face line, the ears longer, and the third finger differently proportioned. The metacarpal bone is longer than in any of the other examples, but the first phalanx of the third finger is shorter, measuring 0·4, while in the other specimens it varies from 0·5 to 0·55. On a comparison of specimens at the British Museum, I find an example of *V. mystacinus* in that collection with the third finger proportioned as in this abnormal individual; and all these Nepalese bats agree perfectly with the common *V. mystacinus* in shape of ear and tragus, and in other essential characters.

Considering how common this bat is in Nepal, it is very singular that Mr. Hodgson never seems to have obtained a specimen of it there. His first acquaintance with the species was made years after he left Nepal, when he procured it at Siligori, in the Sikkim Tarai, and named it *Vespertilio siligorensis*.

18. Vespertilio muricola.

Vespertilio muricola, Hodgson, Journ. Asiat. Soc. Beng. vol. x, pt. ii, p. 908 (1841) (name only); Gray, Cat. Hodgson's Collect. Brit. Mus. p. 4 (1846); Dobson, Monogr. Asiat. Chir. p. 134 (1876); Cat. Chir. Brit. Mus. p. 316 (1878).

Vespertilio adversus, *apud* Hutton, Proc. Zool. Soc. Lond. 1872, p. 710.

This is another species from Nepal which Mr. Hodgson named but never described. He presented three examples of it, obtained in the Nepal Valley, to the British Museum, and of these Gray noted in the catalogue above quoted, "Feet large, elongate, half free; tragus elongate, lanceolate, subfalcate;" no measurements or other diagnostic particulars are given. It is difficult to see how this can be considered a definition of the species, and yet I believe it is the only description we had of Hodgon's *V. muricola* before the appearance of Dr. Dobson's 'Monograph.' That author has satisfied himself that the title *Vespertilio caliginosus* of Tomes, dating from 1859, as well as three or four other defined names published before the appearance of his monograph, really apply to the species named, but not described, by Hodgson as *V. muricola.* Under these circumstances it seems doubtful whether Hodgson's title can be retained for the species; but, as Dr. Dobson has used the name of *V. muricola* in his two important works, and changes in nomenclature are to be deprecated, I have here followed his example.

On a comparison of specimens, *V. muricola* is readily distinguished from *V. mystacinus* by the shape of the tragus. In the former, the tragus is concave on its inner margin, and is decidedly inclined inwards and rather forwards; while in *V. mystacinus* the tragus is more erect and has a straight inner margin.

Nothing is recorded about the habits of this species in Nepal, but Captain Hutton writes, "This is a common species at Mussooree and in the Dehra Doon. It is early on the wing, coming out of caves and hollow trees, flying high, and is very rapid in its movements."

19. Miniopterus schreibersii.

Vespertilio schreibersii, Natterer in Kuhl, Deutsch. Flederm. Wetterau. Ann. iv p. 41 (1819).

Vespertilio fuliginosa, Hodgson, Journ. Asiat. Soc. Beng. vol. iv, pp. 700 and 701 (1835).

Miniopterus schreibersii, Dobson, Monogr. Asiat. Chir. p. 160 (1876); Cat. Chir. Brit. Mus. p. 348 (1878).

Mr. Hodgson, in describing his *Vespertilio fuliginosa*, says that in size it is somewhat smaller than *Vespertilio formosa*, and with the ears, lips, and muzzle as in the latter species. The face is sharp, but the rostrum is somewhat recurved, owing to the concave bend of the nasal bones which join a high forehead with a considerable curve. He notes that the dentition of *V. fuliginosa* is $\frac{2-2}{6}$, $\frac{1-1}{1-1}$, $\frac{5-5}{6-6}$, thus differing from *V. formosa* and *V. labiata* (= *V. noctula*), in which the molar series is $\frac{6-6}{6-6}$. The colour, he says, is wholly sooty brown.

This description is sufficient to show that Hodgson was referring to *Miniopterus schreibersii.* In Gray's 'Catalogue of Hodgson's collection in the British Museum' (1846, p. 4), six specimens of bats from Nepal are entered under the name of Sooty Scotophile (*Scotophilus fuliginosus*), with a remark that the feet are very small, in the wing to the base of the toes. This attachment of the wing-membrane would not apply to *M. schreibersii*, in which that membrane only reaches the ankle; but Dr. Gray appears to have suspected that he was including two species under one name, for he adds, "*a.—e.* Specimens in spirit. *f.* A specimen with a rather larger tragus, without any small lobe at the outer side of its base." The last-mentioned specimen was probably the type of Hodgson's *V. fuliginosa*, and I am rather surprised not to find it figuring in the list of specimens of *M. schreibersii* in the latest catalogue of bats in the British Museum. As has before been mentioned, the first five specimens called by Dr. Gray *Scotophilus fuliginosus* are really examples of *Vesperugo abramus.*

I obtained a single specimen of *M. schreibersii* in the Nepal Valley, on the 8th of February, which gave the following measurements:—

Length, head and body 2·2 inches, tail 2·2, head 0·7, ear 0·52, tragus 0·24, forearm 1·9, thumb 0·3, third finger 3·52, first phalanx of third finger 0·45, fourth finger 2·6, fifth finger 2·1, tibia 0·75, foot and claws 0·4, calcaneum 0·55; expanse 13·5.

The fur is rich dark brown above, and pale brown on the lower surface; the basal part of the fur being everywhere blackish brown. This example was secured in a curious way. I shot a crow *(Corvus splendens)* one evening in my garden, and as it fell a bat dropped from its claws, which proved to be *M. schreibersii.* The bat had evidently just been captured and killed by the crow, probably out of sheer mischief.

Mr. Hodgson says that this species remains in Nepal throughout the year and does not hibernate, and that it is solitary in habit when hunting for its prey. Captain Hutton mentions that in Masuri it is found in caves and caverns, and even in crevices of rocks, and is occasionally attracted to the lamps in a room. This no doubt means that the light of lamps attracts insects, and in pursuit of these the bat enters rooms.

It will be seen that, in the foregoing list, 19 species of bats are admitted as occurring in Nepal. One of these (*Rhinolophus affinis*) is included with doubt, the specimen of that species presented by Mr. Hodgson to the British Museum having possibly been obtained in Darjiling, and not in Nepal. Of the total 19 species, 3, namely, *Pteropus medius*, *Cynonycteris amplexicaudata*, and *Cynopterus marginatus*, are certainly not part of the fauna of the Nepal Valley. They have been found there as mere stragglers from a neighbouring tract of the country which differs essentially, in point of elevation and of fauna and flora, from our valley. These three bats extend all along the Himalayas, in the low and hot portions adjoining the plains; and they only penetrate into the hills for considerable distances, in suitable localities, up low-lying river valleys.

Of the 15 or 16 species of Chiroptera properly belonging to the Nepal Valley, only *one* (*Vespertilio nipalensis*) is, so far as known, peculiar to this small part of the Himalayas. Another species (*Rhinolophus macrotis*) is only known to occur in Nepal and at Masuri further west in the Himalayas. All the rest have a more or less wide range in the Himalayas, both east and west of Nepal.

A few words remain to be said about certain species which have been hitherto wrongly attributed to Nepal by various authors. The number amounts to six or seven, and these I will now briefly notice.

1. As already shown, *Cynopterus marginatus* has been included in the Nepal list by many writers owing to a misidentification of *Pteropus pyrivorus*, Hodgs.

2. *Megaderma lyra* is said to be represented by specimens in the British Museum from Nepal, in Dr. Dobson's 'Catalogue of Chiroptera' (p. 157). This is erroneous, as the specimens referred to were presented by Mr. Hodgson, and he first obtained the species in the Siligori Bungalow, Sikkim Tarai, in 1847, long after he had permanently left Nepal.

3. *Synotus darjilingensis* is given by Dr. Horsfield (P. Z. S. 1856, p. 395) as from Nepal, under the names of *Barbastellus communis* and *Plecotus darjilingensis*, Hodgs. This is clearly wrong, as the title given by Hodgson sufficiently shows.

4. *Plecotus auritus* is indicated by Dr. Dobson (Cat. Chir. Brit. Mus. p. 179) as from Nepal, on the evidence of the type specimen of *Plecotus homochrous*, Hodgson. That type, however, was obtained by Hodgson in Darjiling (Gray, Cat. Hodgson's Coll. 1863, p. 2), and he never got the species in Nepal.

5. Dr. Horsfield states (P. Z. S. 1856, p. 394) that *Murina suillus* (= *Harpyiocephalus harpia*) was obtained by Hodgson in Nepal. This is not so: the species was called *Noctulinia lasyura* by Hodgson, and was obtained by him in Darjiling (Gray, Cat. Hodgson's Coll. 1863, p. 3).

6. *Vespertilio mystacinus* has been stated by more than one writer to have been procured by Hodgson in Nepal. This is a mistake: he first obtained the species in the Siligori Tarai, and named it *V. siligorensis*. *Vespertilio darjilingensis* is also attributed by Horsfield (loc. cit.) to Nepal; it is probably the same as *V. mystacinus*, and if Hodgson got it in Nepal he must have named it on the model of *lucus a non lucendo*.

Printed from a transfer to stone in the Lithographic Office, Survey of India Department, Calcutta, October 1887.

7. Lastly, *Nycticejus nivicolus* Hodgs. is said by Dr. Horsfield (loc. cit. p. 395) to be from Nepal. I am not certain as to what this species really is; it is possibly *Harpyiocephalus harpia*, before mentioned, but, whatever it may be, Hodgson did not get it in Nepal. The correct locality for the type is, "Sikkim Himalaya, northern region, near snow" (Gray, Cat. Hodgson's Coll. 1863, p. 3).

Considering that the list of Nepal bats is a short one, the number of errors that have collected about it is more than usually large.

XVIII.—*Notes on some recent Neolithic and Palæolithic Finds in South India.—By* R. Bruce Foote, F. G. S., *Superintendent of the Geological Survey of India, Fellow of the University of Madras.—Communicated by* the Superintendent of the Indian Museum.

[Received and Read August 3rd, 1887.]

(With a Map—Pl. XI.)

Contents.

§ 1. So many communications have been made to this Society on the subject of prehistoric stone implements of various ages, discovered in different parts of India and its dependencies, that I should hesitate before making a further one, did I not believe that I have really fresh matter of great interest to lay before you, having during the last few years made various finds which determine the age of a hitherto uncertain group of remains, and throw light on the connection of the Neolithic and Iron periods. The mere discovery of important centres of manufacture of Neolithic or polished stone implements is by itself a point of great interest, and I have the pleasure of informing you of the discovery of several centres of the kind.

Most archæologists regard it as a well-established fact that our ancestors, to speak of mankind generally, passed through at least three, and in some countries four, grades of progressive civilization indicated by the character and material of their weapons and domestic implements.

In South India, up to the present day, three of these grades, or periods, are known to have been passed through by the old inhabitants; the Rude Stone Period, the Polished Stone Period, and the Iron Period. A Bronze or Copper Period has not, so far, been traced in the south, and iron had been introduced among the people living in the Southern Deccan, and was probably manufactured by them at the same time that they were still using and making implements of polished stone.

I have used the terms Palæolithic and Neolithic not only because they are extremely convenient, but because, so far as South India is concerned, they are, so far as our present knowledge goes, very fit and suitable terms. Abundant geological evidence exists in the south that a great period of time elapsed between the era of the old Stone-chippers and that of the Stone-polishers.

Whether the latter were descendants of the former is at present impossible to say, for no evidence has been yet found to prove or disprove the idea.

§ 2. The former existence of the old Stone-chippers in South India was unknown till 1863, when I had the good fortune to discover the first chipped implement in a lateritic gravel at Palaveram a few miles south of Madras. A few months later, Dr. King and I had the further good fortune to come upon another lateritic gravel some forty miles north-west of Madras, where implements, all made of quartzite, occurred *in situ* and abundantly. A fine series of these, including many of the type specimens figured in my papers in the Madras Literary Society's Journal and the volume of the Norwich Prehistoric Congress (1868), is now in the Indian Museum.

At that time, no discovery of Neolithic or polished implements had been published, nor, so far as I know, had any been made, and it fell to me to make the first discovery of such during the course of the following year, 1864. This find (a ring-stone) was noticed in my paper on the Palæolithic implements published in the Madras Journal of Literature, and is now in the Indian Museum. Not very long after, I found a good celt near the Arconum junction of the Madras Railway, which was also recorded in the same paper.

In 1865, it became known that celts of diverse shapes and sizes and in large numbers were to be seen in little shrines, or stuck up on end round the foot of sacred trees, close to many of the temples on the Shevaroy hills in Salem District. Considerable numbers of these were procured, and some found their way into the British Museum, but, so far as I know, nothing was published about them. In the same year, I found a small, but very well made, celt about eleven miles south of Nellore.

A solitary celt was reported as found on a hill near Mercara in Coorg, and the find, which was communicated to this Society in 1868 by Mr. H. A. Mangles, has repeatedly been quoted by various writers, Mr. W. T. Blanford, Mr. V. Ball, and Mr. John Cockburn amongst them, as the first made in South India, my Arconum celt being ignored, though published in 1865.

§ 3. The next Neolithic discovery in the south was made by the late Mr. William Fraser, M. I. C. E., about 1872, when he was District Engineer of Bellary. I first heard of his discovery from himself towards the end of that year. He had found numerous celts and chisels in various stages of manufacture and use, together with corn-crushers and mealing-stones, and much broken antique pottery on two hills, the North Hill at Bellary and the Peacock Hill five miles to the north-east. Mr. Fraser very kindly took me to both hills, and afforded me the pleasure of finding some specimens for myself, to which he added a few more from his own small but choice collection.

On taking leave of him, I urged him strongly to communicate his discovery to some scientific society, which he promised to do, but unfortunately never did. He died suddenly a few months later, and his collection of celts was lost, probably thrown away in ignorance of its value. It included some good celts and several remarkably good specimens of the long narrow chisel type, a form which, so far as I know, has not yet been found in other parts of India.

On my way from Bellary to Gadak, I passed a notable conical mound of slaggy cinders which stands in the middle of a small pass, the Budi Kanama, across a line of hills about sixteen miles west of Bellary, and has been described several times by various writers many years ago, among them by no less excellent an observer than the late Captain Newbold. It has been held to be of volcanic origin, and the natives regard it as the funereal mound of some great Rakshas or demon. I had only a few minutes to devote to looking over it, as I was on the march and much pressed for time. Brief as my search was, I found one celt and some mealing-stones and corn-crushers in the little rain-gullies cut in the sides of the mound, and on several lumps of slag found the impressions of stalks of coarse straw; this sufficed to disprove the volcanic cone theory, so I went on. At Hampasagra, sixty miles west of Bellary, I found a good celt lying on the top of the bank of the Tungabhadra. In the South Mahratta country, I had made a few good finds in the two previous years, the best being some seven or eight good celts of medium size on the top of a small hill fifteen miles south-west of Kaladgi. I did not publish any separate notice of these finds beyond a brief reference to them in a letter to the Geological Magazine, in which I also drew attention to Mr. Fraser's discovery. This letter appeared in April 1873. Some of these (with my Bellary specimens and a very fine collection of Palæolithic implements that I discovered in fluviatile gravels in the banks and beds of the Malprabha river and its main southern affluent, the Benihalla), I exhibited at the Vienna International Exhibition in 1873. My collection was much admired by the Austrian archæologists, and I was strongly pressed to sell it, but declined, and afterwards presented it to the Geological Survey Museum, to which it was sent from Vienna. In 1882, it was made over to the Archæological section of the Indian Museum, together with all the other collections of Palæolithic and Neolithic implements.

§ 4. Among the number of those who saw and examined my specimens in the Vienna Exhibition was Mr. Valentine Ball, then of the Geological Survey of India, a gentleman who had made various communications to this Society on the subject of stone implements in India. In 1878, Mr. Ball read a paper before the Royal Irish Academy, with elaborate tables showing the distribution, in India, Burmah, and parts of the Indian Archipelago, of stone implements of all kinds. Mr. Ball forgot my Bellary specimens, overlooked my letter to the Geological Magazine, and ignored the various references to Neolithic finds made in my various papers on Stone Implements in South India. The Shevaroy hill celts he had not heard of, and he assumed Mr. Mangles' Coorg celt to be the only Neolithic implement ever found in South India. On this very slender foundation, Mr. Ball built up a decidedly bold, if not hazardous, theory that the occurrence of polished celts only in the north-eastern quarter of India and in Burmah, of only chipped implements in the southern half of India, and of only cores and flakes in the north-western quarter of the country, was due to the different implements having been made by different races of men occupying these three distinct provinces, which met and slightly overlapped each other in Central India. Here and there, it was true, a few implements characteristic of one province occurred well within the limits of another, but such an occurrence was to be treated as what is geologically termed an "outlier", and held not to affect the general validity of the theory. Mr. Ball rejected the terms Neolithic and Palæolithic for India as conveying erroneous ideas of progression. He says in the paper referred to, "The different forms of implements seem to be rather indices of race than time." The early inhabitants of South India, according to this theory, attained only to a much lower platform of civilization than did those of North-eastern India.* While passing his paper through the press, Mr. Ball became acquainted with the collection of Shevaroy hills celts in the British Museum, which seems to have staggered him somewhat, but he still stuck to his theory and merely added a note in the press to this effect: "If the locality" (the Shevaroy hills) "is authentic, we have another instance of an outlier. Such exceptions to the main features of distribution will possibly be from time to time discovered, but they must become very numerous before they can be considered to outweigh the facts upon which the general conclusions in this paper have been founded."

Mr. Ball's paper remained unknown to me for more than six years after its publication, else I should have written at once to show how ill-founded it was, in view even of the knowledge of Neolithic remains then existing. When I did become acquainted with it, rather more than three years ago, I was making almost daily fresh discoveries of Neolithic remains in the South, and had not time to write a paper in reply, but mentioned it in a letter to Dr. John Evans, F. R. S., the greatest living authority on stone implements, and he communicated this letter and some others about my new finds to the Anthropological Society, in whose Journal for August 1886 an abstract of them was published.

§ 5. The Shevaroy Hill celts constituted the earliest Neolithic find made south of the latitude of Madras, and twelve years elapsed before any further discoveries were made in that direction. In 1878, I found the cutting half of a small celt at Uta Kovil four miles north-east from Arrizur in Trichinopoly District. Tanjore District yielded no Neolithic implements, and Madura District was also very unprolific, the only specimens found being two chert cores and a chert flake with a serrated edge formed by 7 consecutive small notches in close apposition. These were found on the surface of gravels of very recent formation.

* The question of the distinctness of the two stone ages will be referred to again later.

Of uncertain age, but probably Neolithic, is a carved bone pendant that I obtained in 1883 out of the mud of a very interesting submerged forest at the west end of Valimukkam Bay on the south coast of the Ramnad zamindari. This is the only piece of worked bone that I know of as having been found in South India, excepting some cut bones discovered in the ossiferous caves of Billa Surgam in Karnul District. The pendant was in all probability used as an ear ornament. It is pierced at the thinner end by a small well-drilled hole, and shows four incised lines going clean round it, one a little below the perforation, the other about ¼″ above the round, thicker (lower) end. It was probably well-polished, and, though weathered, is still smooth enough to be rather glossy. I had hoped to find much of value in the Valimukkam submerged forest, my first visit of a few minutes duration having given me the bone pendant, but, on re-visiting it last year, I found that the action of a small river which opens into the bay close by, combined with a heavy surf, had covered over the greater part of the old forest area with a broad sandbank, while the surf had removed a large number of the old tree stumps which had been visible at low tide at the time of my first visit. I had a long tramp about over the peaty mud flat still remaining, but found nothing more than a piece of old pottery too much rolled to show its real character.

At my first visit to Cape Comorin in 1869, I was struck by the large consumption of shellfish made by the fisher-folk living in the coast villages, speculating that their ancestors might have had similar tastes, and I hoped that an examination of the coast would show the existence of middens, such as proved so wonderfully rich in prehistoric remains on the coasts of Jutland and Schleswig. In 1881, 1882, and 1883, I carried out the geological survey of South Travancore, Tinnevelly, and Madura, but unfortunately found no true kitchenmiddens, and fear that none will be found there, for my work, though not absolutely exhaustive, was very close in many places where such remains might have been expected. The remains of shellfish, chiefly of a large species of *Mytilus*, lie about in great quantities in many places near the coast and, here and there, at places far inland, but they do not occur in sufficiently great accumulations to deserve the name of middens, or to hide any prehistoric remains.

The Neolithic remains I obtained in Tinnevelly (in 1883) were cores and flakes of a chert foreign to that part of the country. They were found at the south end of the red sandhills forming the "teri" west of Sawyerpuram, a well-known station of the Gospel Propagation Society's Mission, eleven miles south-west of Tutikorin. The south end of the teri had been largely denuded by wind action, which had removed the fixed red sand to a depth of 15 or 16 feet, and exposed a dark red surface of hard sandy loam over an area of several acres. On this surface, I noticed some flakes of a brown chert I had seen nowhere in the South, and these flakes led me to search closer, and I soon found several well-made cores of the Jabalpur type. With the chert flakes were a few of limpid quartz, also a foreign stone in that immediate neighbourhood. A number of fragments, mostly small, of antique red pottery accompanied the chert implements and showed strong signs of having had their edges much worn by the action of "sand blast" at some previous time when the teri* was in a moving condition.

The northern part of the Carnatic had previously yielded me a few Neolithic implements, a small but perfect celt eleven miles south of Nellore (1865) and half of a large ring-stone the drilling of which had never been quite completed. This ring-stone, or perforated hammer, was found in 1875 at Vemavaram ten miles north-east of Ongoze and close to the northern boundary of Nellore district.

Some four miles to the east of the famous Amravati tope, I found (close to the village of Vayikunthipuram, on the south bank of the Kistna) what appears to be the body of a good-sized celt minus the cutting edge. This was made of a buff and purple mottled sandstone of upper Gondwana age. The only other implement made of this material was a cylindrical fragment (wanting both ends) of doubtful use, unless it may be regarded as part of a prehistoric "rolling pin." This I got on the site of a Neolithic settlement at Jerlacherru, nine miles W. of Kammamet in the Nizam's territory. The settlement had existed between two granite-gneiss hills, and the fields all round were covered thickly with fragments of high class antique pottery. I could only mourn the hard fate which denied me time to examine this very promising locality.

Another Neolithic site, on the left bank of the Umni-ern, 3 or 4 miles south of Kammamet, that I could only pass by on the march looked also very promising.

I must not forget to mention that I picked up the pointed end of a celt just south of the village of Matur, 27 miles south-east of Kammamet.

Proceeding westward, I came across a small hill of granite-gneiss south of Poolloygooda (21 miles east by south of Bonagiri), where were a considerable number of highly polished deep grooves worn into the hard rock. From their shape and size, I inferred they must have been

* Teri is the name given by the Tamil people exclusively to the great drifts of red sand which form so remarkable a feature along the eastern side of Tiinnevelly District.

made in grinding the cutting edges of celts, and my inference has since been confirmed by finding similar polished grooves on granitoid hills in the Bellary country which were great centres of the celt manufacture. The grooves were about 10 to 14 inches long, about $1\frac{1}{2}$ wide in the middle, and tapered off to a sharp point at either end. The greatest depth of the groove was at the centre and varied from $1\frac{1}{2}$ to nearly 2 inches. The polish was best preserved in the grooves that had been filled up with soil washed in by rain.

A few miles west of this place, I came on a large dyke of very fine grained greenstone, the surface of the western end of which, near the village of Arur, had been considerably broken up and yet showed no signs of ordinary quarry work ; a large quantity of débris of an uncommon character lay about, which struck me as having possibly been produced in the manufacture of stone implements; some of the fragments being very shapely flakes. A few minutes' search gave me a well-shaped celt in the first or rough stage. Further search would I feel sure have produced more evidence as to this having been a celt factory, but I had not the time to spare for it.

§. 7. In October 1883, I had the pleasure of making a very interesting find at Pátpád, a small village 4 miles west of Banaganpalli, in Karnul District. The spot on which the find was made is a piece of slightly irregular ground, triangular in shape, and enclosed between the high road, the end of a small limestone ridge, and a small stream which runs south-east into the Suru river, a confluent of the Peneru, or Northern Pinakini. Near the centre of the ground, I noticed a few fragments of bright red antique pottery sticking in the sides of a tiny rain-gully. Being greatly taken up with excavations in a large cave some distance off, I thought no more about them; but, a few days later, having found some interesting prehistoric pottery at some depth in excavating in one of the passages of my cave, and taken a great deal of trouble in getting all the pieces and sticking them together, my head servant, a bright and observant little Madrassee, excavated some of the broken pottery I had seen in the rain-gully just referred to and pieced it together into a very shapely bowl. After that, he dug over several square yards of the adjacent ground, under my superintendence, and we unearthed a considerable number of articles of pottery of various shapes and sizes, but all broken more or less. They were buried only 5 or 6 inches below the surface, and the place where they lay was just in the regular track of the village cattle to their drinking place and thus crossed every day several times by large herds. The wonder was everything had not been reduced to powder.

The different vessels found are mostly of admirable shape, several of them really elegant. They are of the typical glazed red and black earthen-ware so characteristic of the prehistoric graves of Coimbatoor and the Nilgiris. Two forms are, so far as I know, peculiar to that find, the one is like a flower-pot with an extremely small base, the other is conical with slightly excavated sides and no base, so that it must have been perched on a ring-stand when in use, and not held in the hand. Several such rings fitted for larger vessels were found there. In the soil which had filled some of the vessels, I found several good agate and chert cores, and a few iron implements of (with one exception) small size; long arrow-heads with strong barbs, one of which is now in the Indian Museum collection, and other forms. With these were several green-stone corn-crushers, a large stone pestle with polished sides, and a highly polished slyking-stone, or slickstone, made of a hornblendic rock. There were also a small number of point bones too much broken to identify. In addition, I found a small white bead made out of some shell, a human premolar, a shell-scraper made by grinding away the lower half of one valve of a unio shell, and, lastly, a pottery spindle-whorl. The surface of the ground a few yards to the east, which was freely scattered over with broken antique pottery, yielded a good number of agate and chert cores and flakes, all of the Jabalpur type, also a variety of larger flakes, and several small but well worked scrapers. One of these latter is an exact match to an old flint scraper from Yorkshire which I have in my collection. A large quantity of mostly bright-coloured pieces of chert, agate, jasper, quartzite, and lydian stone was also collected on the same bit of ground; having doubtless been brought there to be used in making flakes; all these stones are foreign to that immediate neighbourhood, and the agates and lydian stones must have come from a distance of 40 miles at the very least. Some of the pottery found in the Yerizari-gabbi (cave) is ornamented in precisely the same way as the large fragment of a pot (found lately at Quetta together with a very fine ringstone and a jasper corn-crusher) which Mr. Wood-Mason is exhibiting to-night.* No celts were found at Pátpád, but I got a broken cylindrical hammer on the path leading to the Yerrazari-gabbi, and, as I shall show presently, cores and flakes and the prehistoric red and black glazed pottery occur largely, together with celts and a variety of other typical Neolithic implements, in various places to the west of Pátpád; such being the case, I do not hesitate in regarding the Pátpád find as late Neolithic overlapping into the Iron Age. The whole find was pre-

* Pottery with the same peculiar ornament has also been found on the North Hill Bellary and at Palavaram close to Madras.—Identically the same ornament appears also on pottery figured by Sir William Dawson from the old Red Indian city of Hochelagas in Canada.

sumably a cache rather than a burying place. A very fine chert flake, with an excellent core of the same material, was found at Paspalla, a village some 9 miles west of Pátpád.

§ 8. I come now to the most interesting and important part of my subject, the occurrence of numerous Neolithic settlements in the Bellary-Anantapur country, to which I proceeded at the end of 1884 to take up the geological survey of that region. Ever since my expeditions with Mr. Fraser to the North Hill and the Peacock Hill, I had been longing to revisit that quarter, and my desire had been much increased by my great find at Pátpád.

I was most anxious also to settle if possible the real nature of the great cinder-mound at Budikanava which I have already referred to above.

I revisited the North-hill at Bellary with much success and initiated a friend, Mr. Justin Boys, the Agent of the Madras Branch Bank at Bellary, into the delights of celt-hunting, which he has since followed up with a very satisfactory result, namely, the discovery that the north and east sides of the Bellary Fort Hill were also at one time inhabited by the Stone-folk.

At the first possible opportunity, I revisited the Peacock Hill, or Kapgallu as it is called by the country people. Mr. Fraser had taken me up and about the southern side of Kapgal, and we had secured but a small quantity of implements, mostly celts and chisels, but noticed no special signs of manufacture. On my second visit, I explored the whole hill, and, on the northern side, near the summit, found abundant traces of the manufacture of implements and of the residence of the manufacturers. Kapgal had evidently been a settlement of the Stone-folk for a considerable period and an important centre of celt manufacture. The traces of residence were very numerous in the shape of small terraces revetted with rough stone walls, great accumulations of made ground full of ashes and broken pottery and containing many implements of all sorts, a large proportion of them damaged, many so much so that they had evidently been rejected as useless. Bones of bullocks, chiefly broken, occur pretty numerously and especially in the ashy parts of the made ground. Other traces of residence were small tanks made by damming up the little stream which drained the northern side of the ridge. Large blocks of the local granite-gneiss had been hollowed for some purpose or other and so well worn by use, or purposely fine-tooled, that their inner surface was all but polished. A number of these had evidently stood close to the structures that I assume to have been tanks. Some still remain there as if ready for use, but many have been broken, and their fragments lie close by. These block-troughs were not deep enough to hold any quantity of water, but may very likely have been used for mixing some kind of dough, for which they were very well adapted. A few blocks showed very shallow hollows, and such hollows are very common on rock surfaces, both in the open and under rock-shelters. Some of these I believe to have been mealing-troughs in which the grain the people used was finely mealed with mealing-stones after having been roughly bruised with smaller and lighter corn-crushers. Both of these kinds of implements are met with in great numbers here and in almost every one of the many settlements of the folk that I examined in the Bellary-Anantapur country, and are especially numerous where great accumulations of ashes and other kitchen stuff are met with.

The signs of manufacture of implements I found on Kapgal consisted of large numbers of unfinished celts in all possible states of completion and great quantities of flakes struck off from the selected fragments of rock in the process of fabrication. In the case of Kapgal settlement, the stone to be worked was procurable on the hill. It is a fine grained pale greenstone (diorite ?), which occurs here and there in irregular bands of some thickness within the mass of a huge dyke of coarse black diorite that runs along the northern slope of the hill parallel with its axis. In other settlements, the celts were found to be made from pieces of greenstone of convenient shape collected from dykes which in many cases occurred only at considerable distances; and, in these cases, the makers often worked up pieces whose exterior was greatly pitted by weather action and did not take the trouble to remove the weathered part except where the cutting edge was made. In some few instances, pebbles were selected and so chipped as to utilize one or other of them naturally. At Kapgal, this was not the case, and consequently the celts there found have a much more recent look than those from many of the other settlements.

There is a great variety also in size and shape among the celts and chisels, especially the former. This was doubtless intentional to suit special purposes, but to some extent the makers evidently accommodated themselves to the shape of the rough stone selected for treatment. This cannot fail to strike the eye when a large series of the implements is examined. Great differences in skill, in taste, and in patience must have existed among the workers; the beauty of shape and finish of the implements varying so very greatly. Some are really elegant in shape and others downright clumsy. The stages of manufacture through which the more or less carefully chosen rough stones passed were certainly four in number, — chipping and picking, grinding and polishing. The first stage, the chipping, was in all probability done by means of stone strikers, hammers, in fact, without handles, of which large numbers of all sizes and weights occur in all the settlements in which the manufacture was carried on. In the second stage, the surface of the chipped implement was picked or "pecked" over with a sharp-pointed striker (by which all the little ridges between the numerous chipped out surfaces were broken down and the surface rendered approximately even), and great labour saved to the grinder, who put the implement through the third stage of progress, and gave it a good sharp and even cutting edge. The fourth and final stage consisted in polishing the implement all over.

The grinding and polishing was done by rubbing the implements backwards and forwards on the surface of the granite rocks, or of big blocks, which became worn into the shallow elliptical troughs above referred to, and of which several were met with on the Kapgal hill; on some of the other settlements, these are very numerous and occur in groups where the grinders had sat together sociably over their work. On the Budihal Hill, in Anantapur District, 8 miles south-east of Bellary, are several remarkable groups of these polishing places. They are placed on high rock terraces, regular coigns of vantage commanding good views over the country where the operators could work and watch with great ease. On one rock terrace, twenty are to be seen in a space just 15 yards square. Other polishing troughs are found well under cover of great rock shelters, or in small caves, where perfect shade was obtainable during the heat of the day.

The implements lay about exposed on the surface or partly imbedded in the made ground, and some were found at a depth of 2 or 3 or more feet, where rain-gullies had cut deeply into the made ground. In every case in which I obtained numerous implements, the quantity of broken pottery was also very great, and I hardly ever got the one without the other; and now, whenever I come across fragments of antique black and red pottery, I make a special search for implements, and very rarely fail in finding something of interest.

The most numerous implements are strikers and corn-crushers, next to them numerically come the mealing-stones, then celts and chisels, the last being very rare. Less common than celts, but less rare than chisels, are worked scrapers of the Esquimaux type. Cores and core-flakes are also rare, but I imagine many more would be found, if regular excavations of the made ground of the built, or natural, terraces were carried out and the material all carefully sifted. This I had no opportunity of doing in any case, as my geological work did not admit of my devoting sufficient time for close research. In many of the settlements, numerous small stones differing in kind from the local rock were found, such as agates, chert, jasper, lydian stone, and quartz of different kinds; these had doubtless been collected to be converted into flakes and small scrapers, or, possibly, simply because of their bright and pleasing colours. In three places, stone beads of good workmanship were found; of these two were of reddish carnelian, two of delicate green quartzite of extremely fine texture, and one of shell. Lastly, I must not omit to mention several pieces of tolerably soft deep red hæmatite which had been rubbed down to smooth surfaces on one or more sides and in all probability been so rubbed down to furnish a pigment for decorative purposes, very likely as rouge for the cheeks of the Neolithic ladies. The North Hill at Bellary yielded several of these, and I noticed other pieces of hæmatite which had evidently been brought from a distance for some similar purposes, but had never been used.

Of the dwellings of the Neolithic folk, no positive traces remain; from which it may reasonably be inferred that they were of rather perishable character, like the thatched huts with mud walls of so large a proportion of the lower classes among the present inhabitants of the Southern Deccan. It is useless to speculate about what they may have been like. Small roofless huts, with rough mud and stone walls, exist in plenty at some of the many settlements, but in each case there were manifest signs of comparatively recent occupation of the place, and in no case did I find any implement or fragment of antique pottery inside such huts, although I carefully searched many of them.

Mr. Fraser discovered two settlements of the Neolithic people, those of the North Hill at Bellary and the south side of the Peacock Hill; and, since December 1884, I have found over forty others, large and small. Of these, I have prepared a list, which will be found further on. I have indicated the principal ones on the map accompanying this paper, from which will be seen how they cluster together chiefly in the neighbourhood of Bellary. Of the forty odd I have enumerated, ten, judging them by the number of implements they yielded, may be reckoned as first class, eight, as second class, and the remainder, as third class.

The respective positions of these different settlements are of importance and show that the old Stone-folk had a very decided preference for occupying commanding positions which were defensible against their enemies. These they seem to have found preferably on the granite-gneiss hills so numerously met with in the Bellary-Anantapur country. Not a single one of their settlements is found on the non-granitoid hills in the immediate neighbourhood, though many of these are as lofty, or much more so. I have given much careful consideration to this important point, and think that four good and sound reasons appear to have prevailed with the stone-folk when selecting the sites for their settlements. Doubtless, other considerations may have influenced them, but they are not so obvious. The four which seem to have mostly influenced them were :—1. The more perfect isolation of the granite-gneiss hills, which mostly rise singly out of the plains, or, if in clusters, are yet individually detached and therefore more suitable for defence than posts on continuous ridges, such as are generally formed by the schistose rocks. Some of the granite-gneiss hills are nearly perfectly castellated by the disposition of the rock masses. 2. Rock shelters of great efficiency and comfortable terraces are to be found in numbers on many of the granitoid hills, but hardly ever on the schistose hills. 3. The collection of rain water and its storage would, from the nature of the ground, be much easier on the average granitoid rock than on the average schistose hill. 4. The schistose hills are, in very many cases, generally, in fact, surrounded by a heavy and broad talus most detrimental to easy agricultural work. The granitoid hills, on the contrary, form, as a rule, no great talus, but rise up straight out of the great cotton-soil plains, so that the Neolithic field labourers could have been quite close to places of refuge in case of attack from other tribes, and yet have been able to carry on their agricultural work.

I only know one *bonâ fide* settlement situated on the schistose rocks, and this is in the open plain far away from any hill. This is near Sanawaspuram 16 miles N. by E. of Bellary.

Yet another reason in favour of the granitoid hills is that, from the many bare sheets and scarps of rock which they show, they do not bear continuous slopes of long grass capable of being burnt over, as are the uninterrupted slopes of the schist hills. The absence of these great grass spreads was a great element of safety for the thatched huts on the hills.

I referred above to the remarkable mound of slaggy cinders occurring on the Budi Kanama pass, 16 miles west of Bellary, which mound had been described by various writers 40 or 50 years ago, one of them supposing it to be a volcanic ash cone ! Captain Newbold, the most eminent amateur geologist and archæologist that South India has known, was another of these writers, and he favoured one of the native theories accounting for the origin of the mound, namely, that it was the result of a great funeral pyre on which all the dead killed in some great local battle had been cremated. Another native legend ascribes this mound to the death of Edimbassurah, a great Rakshas, or giant, killed by Bhimasainah, one of the Panch Pandus. Captain Newbold rather opposed another hypothesis that the mound might be due to the celebration of some great holocaust of animals offered on the occasion of some great religious celebration. The proper way to test the real origin of this much debated mound would of course be to cut a section through it, a work which ought to be executed by the Archæological Survey. The mound is certainly not the product of one huge burning, the cinder occurring in distinct layers 2′—4′ thick with thin layers of made ground between them. It was from these that the celts and various mealing-stones and corn-crushers I found there were washed down by action of rain. I noticed no other traces of residence, nor any at all of a manufacture of celts. I cannot help inclining to the holocaust theory, for, in other cases (notably at the important settlement on Kuri Kuppi hill and at the quadrangular cinder camp west of Sanawaspura 61 miles N. by E. of Bellary), the number of mealing-stones and corn-crushers was very large, many of them being imbedded in the cindery mass. Bones of animals, too, mostly bovine, occur frequently. Fragments of pottery too are very numerous. Many of the marrow bones had been broken as if to extract the marrow. I did not notice a single human bone in any one case, or any evidence pointing to a ceremonial cremation.

The cinder mounds at Sanawaspur, and the larger of the two west of Halakundi and near the foot of the Copper Mountain, form quadrangles about sixty yards square by external measurement, the sides making a low breastwork much trodden down and cut by rain action. I do not think they exceed 5 feet in height above the general level, for I noticed no places that I could not overlook.

Except in the absence of the signs of manufacture of implements, these two quadrangular camp-like piles of cinder showed much the same style of things as occurred on many of the larger ash-covered terraces in the typical hill settlements. Celts and chisels were probably less numerous in the camps than on the hill terraces, but mealing-stones and corn-crushers are quite as common, and broken pottery is not rare. At the Sanawaspuram camp, I obtained fragments of two small bottle-shaped earthenware vessels.

At the North Hill, Bellary, and several other settlements, I found numerous lumps of hæmatite which did not appear to have been collected for conversion into any implement, for which purpose they were evidently unfit either from their small size or softness, and with them, here and there, were pieces of iron slag, which may not improbably be traces of the local manufacture of iron. Similar indications of an iron-smelting industry were found in considerable quantity by my friend Mr. C. Cardew, Superintendent, Locomotive Department, Bellary-Kistna State Railway, in the great Neolithic settlement which formerly existed on the high ground south-west of the Guntakal Railway junction. Strongly confirmative of the existence of the iron industry at Bellary is to my apprehension the existence of a small brown earthenware tuyere which I found on the east side the Fort Hill at Bellary among a large quantity of broken pottery. This tuyere is now in my collection.

Of special interest are two implements found respectively by my friends Messrs. Boys and Cardew, the first a ring-stone found on Bellary Fort Hill, the second a wooden comb excavated from a thick bed of pure white ash in the Guntakal settlement.

The ring-stone, of which Mr. Boys found one half, was a very large one of rather oval shape externally, but the well-drilled central hole is perfectly circular.

A very fine collection of celts in various stages of manufacture and of other implements was made by another friend, Mr. Henry Gompertz, Deputy Superintendent, Madras Revenue Survey, on the north side of the Bellary Fort Hill, and on the Sangankal hills between the Bellary hills and Kapgul Hill.

Up to the present, no celt has been found in South India which has been drilled for the insertion of a handle, as were many European-made axes and hammer-heads. A very fine celt (in my collection) which was found on the Shevaroy hills shows, however, the commencement of a drill-hole on each of the broad sides. These holes are exactly opposite each other and an inch or more from the middle towards the cutting edge of the implement. The Celt-folk were, however, well acquainted with the art of drilling small objects in hard stone, as is shown by the well executed perforations of the carnelian and quartzite beads already mentioned.

A specimen (also in my collection) from one of the Bellary settlements shows the general outline of a typical celt, but the broad end has been left quite thick instead of being ground to an edge, while the pointed end has been ground to a narrow chisel edge transverse in direction to that which should have been the broad cutting edge. There are no signs of use on this specimen, which, so far as I know, is quite unique; and I am unable to imagine for what special purpose it may have been prepared.

A few specimens of whetstones, or hones, have been found in the Bellary settlements, which may perhaps have been used to give the last final edge to specially choice celts. I have two such in my collection which show strong marks of use. The marks are rather semicircular, and just such as would be produced by whetting the rather rounded edge of a celt. Mr. H. Gompertz found such a stone of rather flat shape lying on a piece of rock under a good rock shelter on the north side of Bellary Fort Hill. On the whetstone lay a small celt exactly as if it had been put down suddenly and never taken up again by the workman.

At Koganur, 7 miles E. S. E. of Davangere in Mysore, I picked up from the surface a large lump of stone (quartzite, if I recollect right) one end of which had been deeply ground into with such semicircular strokes. The stone had also been very well drilled right through the centre with a narrow hole a little more than an inch in diameter. No other traces of Neolithic remains accompanied this hammer, which, if fixed to a strong handle, must have formed a most formidable weapon, as the head weighs several pounds. By whomsoever it may have been made, the artificer had a very good knowledge of the manner in which to drill a very hard stone.

A remarkable fact with reference to the varieties of weapons and tools made by the Neolithic people of South India is the absence hitherto of any traces of their having manufactured stone arrow-heads, such as are frequently found in other countries occupied by tribes who had attained to a very similar grade of civilization. It is hard to imagine that the Neolithic people of the Deccan were unacquainted with the use of the bow prior to the first introduction of iron. That they used brass after becoming acquainted with iron is clearly proved by the discovery of unquestionable iron arrow-heads in the Pátpád cache and in many prehistoric graves in the South. With an abundance of stone, such as agate, chalcedony, lydian stone, jasper, and chert, fit for making arrow-heads, it is certainly most remarkable that no true worked arrow-heads have yet been found, and it is most desirable that all prehistoric explorers in India should pay special attention to this point. I have found some few flakes of chert and jasper that might have been used to tip an arrow, but I have found and seen none that were obviously prepared for that purpose.

I give here a list of the localities in the Bellary-Anantapur country at which the Neolithic folk have left traces of their residence and modes of life.

List of Settlements with their direct distances from Bellary Fort.

First Class.

1.	Kapgal, N. side of hill...	5	miles	N. E.	of	Bellary.
2.	Guntakal Junction	30	,,	E.	of	do.
3.	Budihal Hill................	24½	,,	S. E.	of	do.
4.	Iddapinkal Fort Hill	19	,,	S. E.	of	do.
5.	Ditto Main Hill....	18½	,,	S. E.	of	do.
6.	Yelapadugu Hill	20½	,,	S. E.	of	do.
7.	Daroji Hill	18	,,	N.W. by W.	of	do.

8.	Kuri Kuppa Hill	18 miles	W. N. W. of	Bellary.
9.	Gadiganur Hill, foot of	21½ „	W. N. of	do.
10.	Latwaram Hill............	28 „	S.E. by E. of	do.

Second Class.

11.	Bellary North Hill	—	— —	—
12.	Bellary Fort Hill	—	— —	—
13.	Saudamma Konda (hill)	3½ „	N. E. of	do.
14.	Sanarasama Konda (hill)	3¾ „	N. E. of	do.
15.	Ram Durg Fort and Hill	24 „	E. N. E. of	do.
16.	Karamukalu Hill	18½ „	S. E. by E. of	do.
17.	Tornagul Hill..............	16 „	W. by N. of	do.

Third Class.

18.	Kapgal S. E. side of hill	5 miles	N. E. of	Bellary.
19.	Halakoté N. Fort Hill ...	31½ „	N. of	do.
20.	Ditto South Hill	31 „	„ of	do.
21.	Manakurti Hill	33 „	N. E. 3° N. of	de.
22.	Hospett Hill (Alur Taluq)	26 „	N. E. 5° N. of	do.
23.	Hatti Bellagul Hill	24 „	N. E. of	do.
24.	Nagaradoni fort Hill......	25 „	E. N. E. of	do.
25.	Chippagiri Hill............	27 „	E. by N. of	do.
26.	Yerragudi Hill.............	42 „	E. by 5° S. of	do.
27.	Wajra Karur (low hill) W. of....................	31½ „	E. S. E. of	do.
28.	Hill east of great dyke east of Urava Konda	32 „	S. E. by E. of	do.
29.	Urava Konda (hill)	26½ „	S. E. by E. of	do.
30.	Koté Koté West Hill ...	16½ „	E. S. E. of	do.
31.	Beder Bellagal Hill	6 „	W. by 5° S. of	do.
32.	Kolagal East Hill.........	3½ „	N. W. of	do.
33.	Ditto West Hill	6 „	N. W. of	do.
34.	Hill N. of Badanhatti...	13 „	N. N. W. of	do.
35.	Elgunda Hill...............	24 „	E. S. E. of	do.
36.	Rupangudi Fort Hill ...	13 „	S. E. of	do.

List of Cinder Mounds and Camps.

37.	Budi Kanama or Budigunta	13½ miles	W. 5° N. of	Bellary.
38.	Hala Kandi Camp and 1 mound	5 „	S. W. by S. of	do.
39.	Sanawaspuram Camp...	20 „	N. 5° E. of	do.

Smaller Cinder heaps.

40.	Rocks S. of Kapgal... ...	4½ miles	N. E. of	Bellary.
41.	Kurikuppa Hill...........	18 „	W. N. W. of	do.
42.	Kakballa hill fort of	25 „	W. 5°N. of	do.
43.	Ditto do. Saddle			

Captain Newbold mentions some cinder mounds on Kapgal Hill which if still in existence escaped my attention. The great cinder mound at Nimbapuram a little to the N. E. of the ruins of Hampi (Vijayanagar), I have not yet visited. Like the Budikanama mound, it is regarded by the natives as the cremation heap of one of the great Rakshasas. It is singular that Newbold, though so keen an observer in many branches of science, should have so completely overlooked the celts and many other Neolithic implements lying so freely scattered about on Kapgal Hill and not unfrequently at Budikanama. It is more than probable, from his descriptions of the geology of the Bellary country, that he must have examined pretty closely many of the other hills in that quarter where the Neolithic settlements now referred to occur. Only one explanation seems possible to account for so able an archæologist missing these finds, namely, that, his eye being untrained and his attention not being awake to this class of prehistoric facts, he passed them by unheeded. It was not till many years after his time that the great stir in the scientific world caused by the recognition (by Lyell, Prestwich, Evans, Falconer, and the great leaders among French and German geologists) of the true value of Boucher des Perthes Palæolithic finds extended to India, and was followed by the discovery of the Palæolithic quartzite implements of Palavaram and the Attrampakkam nullah, which really started prehistoric research in this country.

The following list enumerates the varieties of implements made of stone which have been found in the Bellary-Anantapur Neolithic settlements.

1. Celts...... *a.* body narrow and round—butt end pointed.
   - *b.* do. do. and do. do. blunt.
   - *c.* do. do. and flat do. broad.
   - *d.* do. broad and round do. pointed.
   - *e.* do. do. and flat do. broad.
   - *f.* battle-axe type do. blunt.
   - *g.* cutting edge, an abrupt wedge.
   - *h.* do. a rounded wedge.
   - *i.* whole body worked square.
2. Chisels... *a.* body long and narrow.
   - *b.* do. much wider than cutting edge.
   - *c.* do. increasing backward to a thick butt; edge transverse to general plane of body.

3.	Hammers	*a.* round.
		b. square.
4.	Ring-stones.	
5.	Pestles.	
6.	Corn-crushers, ...	globular, $1\frac{1}{2}''$—$2\frac{1}{8}''$ diameter.
7.	Bone-crushers, ...	do. $3\frac{1}{2}''$—$5''$ do.
8.	Strikers, ...	*a.* thick type.
9.	Mealing-stones, ...	*b.* flat type.
10.	Slyking-stones, ...	(slick-stones).
11.	Sharpening-stones,...	(hones).
12.	Scrapers, ...	*a.* heavy.
		b. light.
		c. circular.
13.	Worked flakes.	
14.	Unworked flakes, ...	triangular, "knife type," &c., &c.
15.	Cores, small, ...	Jabalpur type.
16.	Flakes from small cores.	
17.	Beads.	
18.	Reddle-stones.	
19.	Stone vessels, ...	bowl-shaped.
20.	Mealing places, ...	deep, on rocks or detached blocks.
21.	Polishing places, ...	do. do.
22.	Edging grooves, ...	do. do.

The variety of stone selected for different purposes was considerable as will be seen by the following lists.

Varieties of stone selected for use.

Granite...	for	mealing-stones and corn-crushers.
Granite gneiss...	,,	mealing-stones, mealing-troughs, polishing and edging places on the rocks, deep troughs for water.
Epidote granite...	,,	corn-crushers } these were evidently very favourite stones and often fetched from long distances.
Gneiss (green)...	,,	mealing-stones } these were evidently very favourite stones and often fetched from long distances.
Greenstone of several varieties.........	,,	celts, scrapers, mealing-stones, corn-crushers, strikers, hammers, pestles, flakes.
Quartz very rarely used...	,,	corn-crushers and scrapers.
Siliceous breccia of Dharwar age, very rarely used	,,	mealing-stones.

Hornblende schist (a very silky variety)...	for	celts of the flat type, very commonly at Gadiganur, elsewhere very rarely. Pestles.
Quartzite...	,,	Sharpening stones, mealing-stones, beads (very rarely).
Hæmatite, jaspery, ...	,,	mealing-stones, corn-crushers.
Jasper, red........	,,	cores (rare).
Hæmatite, earthy red...	,,	pigment.
Agate............ ....,	,,	cores and flakes.
Carnelian......	,,	beads.
Chert mostly of Lower Vindhyan age... ...	,,	cores, flakes, flake knives, scrapers, strikers.
Lydian stone. ...	,,	flakes and scrapers.

The bulk of the neolithic pottery is of very high class for Indian pottery, for, though it will not at all compare with Etruscan and Greek pottery, yet many specimens have been met with showing great elegance of form with very superior quality of the clay worked. As it is impossible to enlarge intelligibly on such subjects, unless they could be illustrated by well-executed illustrations, I will make my remarks on this subject very brief, reserving a full account of my pottery finds till some future time when I shall have had them built up into shape and figured. The quantity of broken pottery found lying about in the old settlements is very great, and affords in many cases abundant proof either that the population was very large, or else that the period of residence represented was of great duration. I think all the pottery collected or examined by me at the different settlements was wheel-made. In point of size and shape, the articles found can only be described as legion. The patterns of ornament employed were also extremely numerous. I have lately begun to collect fragments of sufficiently large size to show the special patterns ornamenting them, and I can only express my surprise at the great variety of patterns the old potters had invented. It is the exception rather than the rule to find the same pattern used twice over. Many of the patterns are so pretty as to cause very great regret that they are known from fragments only.

None of the vast number of specimens I have examined belonged to angular mouthed vessels; all without exception were round, but, with that limitation, they represented all possible varieties of shape, from extremely shallow plates up to rather elongated oval vessels of great size and thickness of walls, and to narrow-necked bottles.

I noticed no vessel with handles either external or internal,* but

* The internal handles for suspending vessels over a fire without risk of the flames touching the suspending ropes, such as were used by the North American

a tolerable number were found which were furnished with legs, probably three or four in number. In many settlements, I found fragments of flat saucer-like vessels perforated with many holes placed close together. These had evidently constituted strainers of some kind.

I found several small, rather rudely circular, flat discs of pottery about 2 inches in diameter, the edges of which had been coarsely ground. These were very probably lids to lay upon the mouths of vessels requiring to be closed; such discoid lids are used occasionally now-a-days for the same purpose.

The pots ornamented with a raised fillet marked with impressions greatly resembling those to be made by a human finger* found in the Yerra Zari Gaffi (Cave) struck the diggers whom I employed as very strikingly different from the pottery made locally at the present time, and they remarked upon this very intelligently. Indeed, the new and strange patterns of the old pottery called forth many more remarks than any of the other finds we made in that quarter.

In no case did I find any sign of the localities where the potters had followed their trade. These were probably well removed from the settlements (whether the latter stood on the hills or in the plains), near to the rivers, where suitable clays would be likely to be found.

§. 9. While camped at Halakundi 5 miles south of Bellary along the Bangalore road in December 1884, I obtained some 20 or 30 chipped Palæolithic implements made of jaspery hæmatite schist; they are all of rather small size but of the typical shapes, oval, pointed oval with two or three of the square-edged hatchet-shape so specially characteristic of the south of India. They were collected from the surface of a ploughed field which lies on a great fan or cone of dejection of detritus (chiefly hæmatite and hornblendic schists) formed by one of the numerous torrents coming down from the north-eastern flank of the Sugadevi belta or Copper mountain, the highest part of the band of Dharwar rocks lying south of Bellary. I am unable to offer any further evidence as to their origin at present, but they are in type utterly different from the rudest of the Neolithic implements, and they do not occur intermixed in any place that came under my notice.

Similar implements occur at distant intervals in the talus fans along the Copper mountain ridge westward. Two good specimens were

Indians, have not yet been found by me, but they may have been used. I have one piece of thick pottery which might have served in such capacity. It would be most interesting if it were to be established that the old potters of the two continents had both hit on this most ingenious expedient.

* I am doubtful whether the impressions in question are really those of human fingers, for in none could I detect the impression of the edge of the nail.

obtained at Joga, a small village at foot of the northern ridge of the Sandur basin, 24 miles west of Bellary. The majority of the specimens have been a good deal worn by rolling. I have had no opportunity of studying the circumstances under which they occur in the gravel fans in question, and merely wish to record the finds.

The theory has been advanced that the implements of rude Palæolithic type are really the agricultural tools of the people, who, for other domestic or warlike purposes, manufactured the various wholly or partially polished implements generally classed as Neolithic. This theory will, however, not fit in with the facts observed in the Neolithic settlements above described. Nearly all the implements of Palæolithic type found in the Bellary country consist of jasperyhæmatite, only a very few of quartzite. Implements of these materials and of the older type are extremely rare in the various settlements I have searched; only two or three in all were found to the hundreds and hundreds of specimens of the newer types. It is impossible that the manufacture of hæmatitic jasper and quartzite implements should have been carried on to even a very moderate extent without leaving behind piles of splinters and flakes of the red and purple and brown stones of which they were made. These flakes and splinters would be quite as conspicuous on the granitoid hills as the green and black ones left in the preparation of the celts, chisels, and hammers made of greenstone of different kinds. The latter kind of splinters and flakes occur very largely, the former not at all. Furthermore, if the hæmatite and quartzite implements of the so-called Palæolithic type were the agricultural tools of the Neolithic people, how comes it that the former are not found largely in broken or at least used condition around the hills inhabited by their makers? It is most unlikely that the people left the rich black soil tracts around their strong places uncultivated, and yet, if these were cultivated by the particular form of tools they are assumed to have used, remains of the latter must assuredly be met with here and there near the strong places in question. As a matter of fact they have not been found in such localities, and, from their absence, only one inference seems reasonable, namely, that they were not used as supposed by the Neolithic people, but belonged to another and older race. In none of the different lateritic gravels and other deposits which have yielded typical Palæolithic implements in the South has the faintest trace of any polished implement of any kind, or of any pottery, however coarse, been found. While the deposits in which the Neolithic remains occur cannot by any possibility be treated as geological formations—they are all of them manifestly accumulations of matter entirely due to direct human agency,—and, geologically speaking, date only from yesterday.

To my mind nothing can be clearer than the existence of a great break in time between the Palæolithic and Neolithic Periods in South India. Whether this great break will ever be closed in by future archæological discoveries remains to be seen.

XIX.—*E'tude sur les Arachnides de l' Asie méridionale faisant partie des collections de l' Indian Museum (Calcutta).—Par* M. E. Simon, *de Paris. Communicated by* The Superintendent of the Indian Museum.

[Received September 22nd;—Read November 2nd, 1887].

II.

Arachnides recueillis aux Iles Andaman par M. R. D. Oldham.

Fam. **Attidæ.**

1.—Cytæa albolimbata, *sp. nov.*

♀. Long. 7*mm.* Cephalothorax crassus convexus postice attenuatus lævis, niger, in medio dilutior et rufescens, obscure rufulo-pubescens, vitta marginali latissima postice interrupta crasse albo-pilosa cinctus, parte cephalica in medio fulvo albidoque pilosa et parte thoracica vitta media postice abbreviata et acuta alba notatus. Oculorum pili supra fulvi infra oculos albidi. Pili clypei crassissimi albidi. Oculi antici parum disjuncti in linea parum recurva. Oculi ser. 2æ vix ante medium (inter oculos laterales anticos et medios posticos) siti. Oculorum series 3a cephalothorace haud vel vix angustior. Abdomen oblongum, supra nigrum et squamulis micantibus parce ornatum, in parte basilari sinuosa albo-marginatum et lineis mediis quatuor albidis sinuosis et fere inordinatis notatum et pone medium linea transversa alba valde dentata sectum, venter simpliciter fulvo-pubescens. Pedes, præsertim antici, breves et robusti, fulvo-ravidi, femoribus tibiisque ad basin atque ad apicem, patellis metatarsisque ad apicem nigro fulvove annulatis, partibus fulvis crasse albo-pilosis, tibiis anticis patellis non multo longioribus, aculeis validis et numerosis: patellis cunctis biaculeatis, tibiis metatarsisque anticis aculeis inferioribus et lateralibus instructis. Chelæ robustæ fusco-rufulæ, læves, albido-hirsutæ, margine inferiore sulci dentibus geminatis binis instructo. Vulvæ plaga antice fovea parva semicirculari, postice plagula rufula lævi et plana, recte transversa et utrinque rotunda notata.

Port Blair.

C. sinuatæ Dolesch. et *C. alburnæ* Keys. sat affinis, differt cephalothorace crassiore pube ad maximam partem simplici, pictura cephalothoracis et abdominis, etc.

Nota.—Le genre *Cytæa* Keyserling (in L. Koch, *Arachn. Austral.*, 1882, p. 1380) se rapproche des genres *Euryattus* Thorell, *Scœa* L. Koch,* *Hasarius* E. Sim. (emend. *H. adansoni*), *Ptocasius* E. Sim., *Ascyltus* Karsch, *Cocalus* C. Koch, par l'armature de la marge inférieure des chélicères, qui offre deux dents géminées ou mieux une dent très comprimée cariniforme et échancrée au sommet avec les angles formant deux pointes aigués.—Il se distingue du genre *Euryattus* Th., par l' aire oculaire parallele, nullement dilatée en arrière, des genres *Scœa* L. K., *Hasarius* et *Ptocasius* E. S., par sa pubescence squameuse et la marge superieure des chélicères pourvue de 2 ou 4 dents, tandis qu'elle n' en offre que deux chez les genres cités.—Il diffère du genre *Ascyltus* Karsch, par le céphalothorax non dilaté *ni conique aux angles* antérieurs et les tibias antérieurs pourvus d' épines dorsales et latérales externes. Enfin, il se distingue du genre *Cocalus* C. Koch† par les yeux antérieurs en ligne recourbée, les yeux de la 3e ligne évidemment plus petits que les latéraux de la première, les chélicères médiocres et verticales dans les deux sexes.

Indépendamment des espèces decrites par Keyserling dans l' ouvrage de L. Koch, le genre *Cytæa* renferme encore le *S. sinuatus* Doleschall, classi par Thorell dans le genre *Plexippus*, le *Plexippus laticeps* Thorell, et peut-être aussi les *P. expectans*, *ruber* (Walck.), *argentosus*, *severus*, *nimbatus*, *frontaliger*, *ochropis*, *pupulus* Thorell (Rag. Mal. etc. 111) de Nouvelle Guinée, l' auteur ne décrit malheureusement pas pour toutes ces espèces l' armature des chélicères.

2.—Cyllobelus‡ miniaceomicans, *sp. nov.*

♀. Long 5·6*mm.* Cephalothorax niger pube subsquamosa pallide

* *Scœa* L. Koch 1879, nom préoccupé que nous proposons de remplacer par celui de *Servœa*.

† Le type du genre *Cocalus* est le *C. concolor* C. Koch, de Malaisie, qui nous paraît être la même espèce que le *Salticus* (*Attus*) *forceps* Doleschall; cet auteur a bien figuré la bifurcation de la dent principale des chélicères. Le *Plexippus erythrocephalus* C. Koch, de Java, appartient probablement au même genre, le *Cocalus cyaneus* C. Koch, de Surinam, pour lequel C. Koch a plutard proposé le genre *Psecas* s' en éloigne au contraire beaucoup et paraît plus voisin des *Mœvia*.—Plusieurs des espèces décrites par Thorell sous le nom generique de *Cocalus* sont très douteuses pour le genre (*C. salax*), par contre plusieurs de ses *Plexippus* pourraient lui appartenir (*P. aper*, *catellus*).

‡ Pour le genre *Cyllobelus*, cf. E. Sim., *Ann. Soc. ent. Fr.* 1885, p. 390. Le *Salticus collingwoodi* Cambr. (Proc. Zool. Soc. Lond. 1871, p. 621, pl. xliv f. 5) de Labuan, appartient peut-être à ce genre; il se rapproche de *C. miniaceomicans* par son système de coloration.

cinereo-viridi nitida obtectus, parte cephalica inter oculos posticos vitta transversa lata leviter arcuata, parte thoracica maculis binis latis obliquis et vitta submarginali lata postice interrupta læte miniaceo-pilosis ornatis. Oculorum pili faciei supra aurantii infra oculos albidi. Clypeus subglaber paululum retro obliquus et in medio depressus, oculis anticis tantum $\frac{1}{3}$ angustior. Oculi antici contigui, in linea recta. Oculi ser. 2æ fere in medio inter laterales anticos et posticos siti. Oculorum series postica cephalothorace haud augustior. Abdomen ovatum, postice acuminatum, splendide viridi-metallico squamulatum, antice maculis binis magnis, pone medium vitta transversa latissima medio triangulariter dilatata miniaceo-pubescentibus et vittis transversis angustioribus pallide cinereo-viridibus decoratum. Venter antice et in medio subglaber utrinque et præsertim postice squamulis splendide violaceo-micantibus ornatus. Sternum nigrum albo-squamulatum. Pedes longi fulvi, valde nigro-lineati, femoribus anticis fere omnino nigris. Pedes-maxillares luridi, femore infuscato.

Port Blair.

Fam. **Lycosidæ.**

3.—Sphedanus* marginatus, *sp. nov.*

♀. Long. 19·5*mm.* Cephalothorax oblongus fusco-rufescens, pilis plumosis fulvis albisque mixtis vestitus, vitta submarginali latissima valde flexuoso-dentata atque in parte cephalica lineis trinis (media recta lateralibus arcuatis) albo-pilosis ornatus. Oculi medii subæquales, aream evidenter longiorem quam latiorem et antice quam postice angustiorem occupantes. Oculi quatuor antici appropinquati subæquales lineam leviter recurvam formantes. Clypeus oculis anticis non multo latior. Abdomen longe oblongum fuscum, supra pilis plumosis fulvo-nitidis subtus pilis simplicibus albidis dense vestitum. Chelæ fulvo-rufescentes albido-setosæ, margine inferiore sulci dentibus æquis trinis, superiore dentibus trinis medio majore instructis. Sternum olivaceum albo-pilosum. Pedes lutei, aculeis nigris longis et numerosis ut in *S. undato* Th. valde instructi (vulva haud plane adulta).

Port Blair.

A *S. undato* Thorell praesertim differt cephalothorace longiore et albo-variegato, arca oculorum mediorum evidentius longiore, etc.

Fam. **Epeiridæ.**

4.—Gasteracantha annamita, E. Sim., *Act. Soc. Linn. Bord.* 1886.
Commun aux Iles Andaman: Port Blair, Havelock.

* Sur le genre *Sphedanus*, cf. Thorell, *Studi s. Ragni Malesi et Papuani*, I, p. 182, Gênes, 1877.

Nota.—*Stanneoclavis canningensis* Stol., qui m' a été communiqué en même temps que le précedent par l' *Indian Museum*, paraît très commun à Barren Island (Baie de Bengale). Contrairement aux conclusions que nous avons donnée précedemment, cette espèce pourraît n' être qu' une variété de *S. brevispina* Doleschall. Les caractères que nous avons indiqués pour séparer les deux formes s' effacent considérablement chez les exemplaires du Barren Island.

5.—Cyclosa albisternis, *sp. nov.*

♀. Long. 7·5*mm.* Cephalothorax pallide luridus, longe albo-pilosus, anguste nigro-marginatus, parte cephalica postice maculis geminatis binis divaricatis albo-opacis notata, ovato-elongatus, parte cephalica parum convexa haud constricta. Area oculorum mediorum longior quam latior, oculi postici majores juxte contigui, antici anguste separati. Oculi laterales a mediis sat late remoti utrinque contigui et subæquales. Clypeus oculis mediis anticis haud latior. Abdomen altissimum, oblongum, antice valde prominens, simpliciter et obtuse acuminatum, prope medium obtusissime vix distincte bituberculatum, postice attenuatum et sat longe productum, apice obtuse trifidum, mucrone medio reliquis longiore et graciliore, testaceum pallide flavo-aureo-guttulatum, utrinque leviter nigro-variagatum et striolatum. Mammillæ nigræ. Sternum albo-opacum. Oris partes pallide testaceæ. Chelæ fulvæ. Pedes breves, luridi, femoribus annulo submedio angusto et macula superiore subapicali, tibiis metatarsisque annulo apicali angusto nigricantibus notati, tibiis aculeis brevibus paucis munitis, metatarsis muticis. Vulvæ uncus rufulus acute triquetrus, supra ad apicem sulcatus, scapum fuscum transversum utrinque rotundum, in medio depressum et plagula media rufula cordiformi notatum.

♂. Long. 4·6*mm.* Cephalothorax paulo latior et humilior, fuscus, parte thoracica in medio late dilutiore et rufula, subtiliter coriaceus, parte thoracica in medio depressa et sulco longitudinali abbreviato secta. Abdomen minus et præsertim angustius, postice breviter productum et simpliciter obtusum, fusco-olivaceum, in parte fasali lineis longitudinalibus albis quatuor, medianis rectis postice divaricatis, lateralibus arcuatis, in parte apicali punctis albidis biseriatim ordinatis ornatum. Venter nigricans. Sternum fusco-rufulum, maculis marginalibus dilutioribus ornatum. Pedes, præsertim antici, longiores, coxis anticis fuscis, patellis fuscis, reliquis articulis luridis, annulo medio angusto et annulo apicali lato fuscis ornatis, tibiis metatarsisque anticis parce aculeatis. Tibia paris 2æ tibia paris 1æ leviter robustior et levissime arcuata, intus aculeis robustioribus et brevibus biseriatis 6—4 armata (serie inferiore dimidium apicalem articuli tantùm occupante). Pedes-maxillares breves et robusti fusco-rufuli, bulbo maximo, transversim late ovato, apice apophysibus tribus munito, apophysi superiore depressiuscula late rotunda, media gracili sed obtusa, inferiore styliformi longe bifida.

Var. ♀. Abdomen supra vitta longitudinali rosea anguste argenteo fuscoque marginata læte decoratum.

Port Blair. Havelock.

C. anseripedi Walck. affinis, imprimis differt in femina cephalothorace lurido sterno albo, oculis lateralibus a mediis remotioribus, pedibus anticis brevioribus angustius annulatis, vulvæ unco acutiore et rufulo, etc.

Nota.—nous possedons aussi cette espèce de Ramnad (Hindoustan méridional).

6.—Tetragnatha gracilis Stoliczka, *Journ. Asiat. Soc. Beng.* XXXIII. Pt. II, 1869, p. 244, pl. XIX, f. 2 (sub *meta*).

Saddle Hill (North Andaman Island) ; Havelock.

Paraît commun. Décrit par Stoliczka des environs de Calcutta sous le nom générique de *Meta*.

Fam. **Avicularidæ.**

Genus Satzicus *nov.*

Cephalothorax humilis subplanus haud vel vix longior quam latior sed antice valde attenuatus et fronte angusta, fovea thoracica pone medium sita valde recurva. Area oculorum a margine antico parum remota, saltem $\frac{1}{3}$ latior quam longior. Oculi quatuor antici in linea validissime procurva semicirculari, medii lateralibus saltem duplo majores et a lateralibus quam inter se remotiores. Oculi postici minutissimi utrinque contigui atque a mediis anticis parum distantes. Spatium inter oculos laterales anticos et posticos latissimum. Chelæ parvæ, subverticales, muticæ. Pars labialis coxæque omnino muticæ. Pars labialis paulo latior quam longior. Sternum sat latum sed antice valde attenuatum. Pedes (♂) sat longi 4, 1, 2, 3, aculeis paucis gracilibus muniti, tarsis metatarsisque anticis longe sed parum dense scopulatis, posticis setosis sed tarsis cunctis fasciculis unguicularibus validis munitis. Ungues bini graciles et (saltem posteriores) mutici. Patellæ anticæ tibiis non multo breviores. Trochanter paris 4æ longus et teres, coxa non multo brevior.

Generi *Sarpedoni* Cambr. (gen. mihi ignoto) sat affinis, differt imprimis oculis mediis anticis lateralibus saltem duplo majoribus (in *Sarpedone* paulo minoribus) et fovea thoracica valde recurva (in *Sarpedone* recte transversa).

Nota.—Le genre *Sarpedon* Cambr. (Proc. Zool. Soc. Lond., 1883, p. 353), qui nous est inconnu en nature, a été comparé par l' auteur au genre *Moggridgea*, dont il paraît cependent diffèrer grandement, ce dernier appartenant à la série des *Avicularidæ trionichi.*

Il est selon nous beaucoup plus voisin du genre *Leptopelma* Ausserer; l' auteur ne parle pas des chélicères, qui d'après la figure (loc. cit., pl. xxxvi, f. 1) paraissent mutiques.

7.—SATZICUS ANDAMANICUS, *sp. nov.*

♂. Ceph.-th. long. 5 *mm.*; lat. 4·8 *mm.* Pedes I 15·7 *mm.*; III 15·2 *mm.*; IV 17·3 *mm.*

Cephalothorax fulvo-rufescens sublevis fulvo-nigroque longe setosus, area oculorum nigra. Abdomen breviter ovatum, fusco-testaceum longe et crebre fulvo-sericeo hirsutum. Chelæ, sternum, pedes-maxillares, pedesque fulva, pedes extremitates versus obscuriores. Pedes 1 tibia patella non multo longiore haud incrassata, intus prope apicem calcare unico simplici ad basin crasso ad apicem abrupte graciliore, leviter uncato armata, inferne ad marginem exteriorem aculeis trinis gracilibus uniseriatis munita. Metatarso mutico. Pedes postici fere mutici.

Port Blair.

Un seul exemplaire mâle en très mauvais état auquel manquent les pattes-mâchoires et les pattes de la troisième paire.

NOTA.—La collection renferme en outre un certain nombre de jeunes araignées, qui ne sout pas en état d' être décrites. Ces espèces appartiennent aux genres *Homalattus* Wh., *Oxyopes* Latr., *Argiope* Sav., *Nephila* Leach, *Epeira* Walck., *Meta* C. Koch, *Hersilia* Sav., *Chiracanthium* C. Koch.

XX.—*A Memoir on Plane Analytic Geometry.*—*By* Asutosh Mukhopadhyay, M. A., F. R. A. S., F. R. S. E. *Communicated by* The Hon'ble Mahendralal Sircar, M. D., C. I. E.

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(With three Wood-cuts.)

Contents.

§. 1. *Introduction.*

§. 1. **Object and Scope.**—It is my object in the present paper to bring together a number of theorems in plane analytic geometry which have accumulated in my hands during my study of that subject. Some of the simpler of these theorems have already been given in my Lectures on Plane Analytic Geometry, now in course of delivery at the Indian Association for the Cultivation of Science; a few have been enunciated elsewhere without demonstration; most of the propositions, however, are here published for the first time. I believe that either the theorems themselves, or the methods of establishing them are original; and, except in a very few instances where I have inserted well-known results for the sake of avoiding disconnectedness, I have considered them either for the purpose of giving a proof simpler and more complete than that usually given, or with a view to throw light on the connection between the various parts of the subject. As the different sections of this paper are, to a great extent, practically independent of each other, for the sake of facility of reference, an outline of the principal topics discussed is added above.*

§. 2. *Basis of Analytical Geometry.*

§. 2. **Analysis and Geometry.**—The notion of either space or number, or of both, lies at the root of every department of mathematics. Analysis is the science of number; geometry is the science of space; but, as space is homogeneous, and, as every homogeneous substance can, by the choice of a unit, be represented by a number, space can be, for mathematical purposes, represented by numbers; hence, the *possibility* of applying analytical methods to geometrical investigations, and of founding a science of analytical geometry. This possibility was first *realized* into practice by the illustrious French mathematician René Descartes, who invented the method of coordinates. With respect

* For a full analysis of this paper, see the Proceedings for 1887, pp. 232-235.

to this method, there are two points which ought to be most carefully noticed. In the first place, to determine the position of any point, we must choose an origin, and, then, fix the position of the point by its coordinates, which may be defined to be independent quantities of the same order which fix the position of a point; we see, then, that the two essentially distinct ideas of origin and coordinates are fundamental in this theory; and, if we consider the matter for a moment, we find that the same two ideas are ever present in every system of coordinates that we may choose. Thus, looking to a comparatively modern part of the subject, the theory of Elliptic Coordinates, we see that the position of any point is determined by the lengths of the semi-axes of the conics which can be drawn through that point confocal to a given conic, called the primitive conic; here, then, the point-origin of the Cartesian system has been replaced by the fundamental conic, and the ordinate and abscissa have been replaced by the semi-axes of two conics. Hence, we conclude that in every system, we must have an origin, which is, as it were, a unit or symbol of reference, and which may be a point or a conic, or any other figure, according to the system we choose; and, having fixed our origin, we determine the position of a point by coordinates, which may be lines straight or curved, or any other geometrical figure; the only essential ideas being those of a symbol of reference, and of the independence of the quantities which fix the position of the point relatively to that origin or symbol of reference.

Having thus fixed the position of a point, we next consider how to represent a curve. A curve is defined to be an assemblage of points arranged according to a definite law; the equation of a curve, therefore, is the analytical representation of that geometrical relation which must subsist between the coordinates of a point, in order that that point may be on the given curve. In other words, the equation of a curve may be defined to be the analytical representation of some geometrical property of the curve; and, as a curve has an infinite number of geometrical properties, the question naturally suggests itself whether the analytical representation of each of these properties will give a different equation of the curve. As a matter of fact, we do know that, in whatever way we may derive the equation of a curve, we are led to equations which are apparently different from each other, but which are really not distinct, and which may all be made to coincide by suitable transformations. Indeed, if the reverse had been the case, it would have been manifestly impossible to create a science of analytic geometry; and the reason why all the equations of a curve are really identical is a simple outcome of the fact that all the innumerable geometrical properties of any curve are dependent on each other: the truth of any one being assumed, the others can be deduced from it as necessary mathematical consequences. We see, therefore, that though a curve has an infinite number of geometrical properties, it can have only one equation, and this accords with the great Law of Nature that, *in every natural system, there can be only one relation between the component parts.* This, then, is the second fact which made possible the very existence of Analytical Geometry.

From what has been pointed out above, it is evident that the equation of a curve is, as it were, a convenient repository of all theorems connected with it, and all its properties may be established by algebraic transformation of the equation. From this, as well as from the fundamental relation between analysis and geometry noted above, it is clear that, to every algebraic transformation, there corresponds a geometrical fact, and *vice versâ.* Take, for example, the subject of the transformation of coordinates. We all know that transformation is of two kinds; it may be a change to new axes, parallel to the old ones, through a new origin, which may conveniently be termed **Translation-transformation**; or, again, the transformation may be to new axes, inclined to the old ones, through the old origin, which may be called **Rotation-transformation**; if, in any case, both these kinds are combined, we may call it **Compound-transformation**; and from the known algebraical formulæ for compound transformation, it is clear that this geometrical process is nothing but the exact counterpart of the algebraic process of linear transformation. Similarly, it may be remarked that the problem of inversion is a case of quadric transformation.

§§. 3—5. *The Right Line.*

§. 3. **The Line at Infinity.**—The equation of any line being

$$\frac{x}{a}+\frac{y}{b}=1,$$

where a, b are the intercepts on the co-ordinate axes, the equation of the line which is at an infinite distance from the origin is obtained by substituting herein

$$a=b=\infty,$$

which gives

$$1=0.$$

Without any real change of generality, we may write this

$$\lambda=0$$

where λ is any constant; this, then, is the equation of the line at infinity; it will be of use in determining the asymptotes of the conic given by the general equation of the second degree (§. 12).

§. 4. **Coordinates of intersection of two lines.** The following method of investigating the condition that the general equation of the second degree

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

may represent two right lines, is shorter than the proofs usually given, and has, besides, the advantage of furnishing at once the coordinates of the point of intersection of the lines represented by the equation.

Let (x', y') be the point of intersection of the lines; removing our origin to this point, the equation becomes

$$ax^2 + 2hxy + by^2 + 2g'x + 2f'y + c' = 0 \quad \text{............} \quad (1)$$

where

$$g' = ax' + hy' + g,$$

$$f' = hx' + by' + f,$$

$$c' = ax'^2 + 2hx'y' + by'^2 + 2gx' + 2fy' + c.$$

But the equation (1) now represents a pair of lines through the origin, and, as such, it ought to be homogeneous in the second degree; therefore, each of the quantities g', f', c' must vanish separately, which gives

$$ax' + hy' + g = 0 \quad \text{............} \quad (2)$$

$$hx' + by' + f = 0 \quad \text{............} \quad (3)$$

$$ax'^2 + 2hx'y' + by'^2 + 2gx' + 2fy' + c = 0 \quad \text{............} \quad (4)$$

Multiplying (2) by x', (3) by y', and subtracting the sum of the products from (4), we get

$$gx' + fy' + c = 0 \quad \text{............} \quad (5)$$

From (2) and (3), we have

$$x' = \frac{hf - bg}{ab - h^2}, \quad y' = \frac{hg - af}{ab - h^2}, \quad \text{............} \quad (6)$$

which are, accordingly, the coordinates of the point of intersection of the lines represented by the given equation. Eliminating x', y', from (2), (3), (5), we have the condition that the discriminant must vanish in order that the equation may represent two right lines, *viz.*,

$$\begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix} = 0 \quad \text{............} \quad (7)$$

As the equation

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

is transformed to

$$ax^2 + 2hxy + by^2 = 0$$

when the axes are removed to the point of intersection of the lines, it follows that, as the angle between the lines is not altered in magnitude by the transformation, the angle between the lines given by the general equation of the second degree is the same as that between the lines

$$ax^2+2hxy+by^2=0.$$

The quantity c', which occurs in this investigation, may be called the point-function of the conic.

Definition.—The **point-function** of any curve with respect to any point is the function which is obtained by substituting the coordinates of that point in the expression the vanishing of which gives the equation of the curve. It is clear that the point-function with respect to any point on the curve itself is zero, while the point-function with respect to the origin is the absolute term in the equation of the curve.

§. 5. **Area of a Triangle.**—If the general equation of the second degree

$$ax^2+2hxy+by^2+2gx+2fy+c=0 \qquad \text{............ (8)}$$

represents a pair of right lines, to investigate the area of the triangle formed by these two lines with the line

$$lx+my=n. \qquad \text{............ (9)}$$

Remove the origin to the point

$$\left(\frac{hf-bg}{ab-h^2}, \ \frac{hg-af}{ab-h^2}\right),$$

which is the point of intersection of the pair of lines represented by (8). The two equations then become

$$ax^2+2hxy+by^2=0 \qquad \text{............ (10)}$$

and

$$l\left(x+\frac{hf-bg}{ab-h^2}\right)+m\left(y+\frac{hg-af}{ab-h^2}\right)=n,$$

or

$$lx+my=p, \qquad \text{............ (11)}$$

where

$$p=\frac{l(hf-bg)+m(hg-af)+n(h^2-ab)}{h^2-ab} \text{............ (12)}$$

Now, suppose that the lines in (10) are made up of the two

$$y-m_1x=0, \ \ y-m_2x=0, \qquad \text{............ (13), (14)}$$

so that

$$m_1+m_2=-\frac{2h}{b} \qquad \text{............ (15)}$$

$$m_1 \ m_2 = \ \frac{a}{b} \qquad \text{............ (16)}$$

whence

$$m_1^2+m_2^2=\frac{4h^2-2ab}{b^2} \qquad \text{............ (17)}$$

The coordinates of the point of intersection of (11) with (13) are given by

$$x=\frac{p}{l+mm_1},\ y=\frac{m_1 p}{l+mm_1}.$$

If, therefore, δ_1 is the length of the line intercepted between the new origin (which is the point of intersection of the pair of lines) and the point of intersection of (11) with (13), we have

$$\delta_1{}^2=\frac{p^2(1+m_1{}^2)}{(l+mm_1)^2} \qquad \text{............ (18)}$$

Similarly, if δ_2 be the length of the line intercepted between the new origin and the point of intersection of (11) with (14), we have

$$\delta_2{}^2=\frac{p^2(1+m_2{}^2)}{(l+mm_2)^2} \qquad \text{............ (19)}$$

Hence, from (18) and (19), we get

$$\delta_1{}^2\delta_2{}^2=\frac{p^4\left\{1+(m_1{}^2+m_2{}^2)+m_1{}^2m_2{}^2\right\}}{\left\{l^2+lm(m_1+m_2)+m^2.m_1m_2\right\}^2}.$$

Therefore, substituting for m_1, m_2 from the system of equations (15), (16), (17), we get

$$\delta_1\delta_2=\frac{p^2\sqrt{\left\{4h^2+(a-b)^2\right\}}}{am^2-2hml+bl^2}. \qquad \text{............ (20)}$$

But, if ϕ be the angle between the lines given by (10), we have

$$\tan\phi=\frac{2\sqrt{h^2-ab}}{a+b},$$

whence

$$\sin\phi=\frac{2\sqrt{h^2-ab}}{\sqrt{\left\{4h^2+(a-b)^2\right\}}},$$

so that the area of the triangle in question is

$$=\tfrac{1}{2}\,\delta_1\,\delta_2\sin\phi$$

$$=\frac{p^2\sqrt{h^2-ab}}{am^2-2hml+bl^2}$$

$$=\frac{\left\{l(hf-bg)+m(hg-af)+n(h^2-ab)\right\}^2}{(h^2-ab)^{\frac{3}{2}}\,(am^2-2hml+bl^2)},$$

by substituting for p from (12). Hence, finally, using the determinant notation, and altering the sign of n, we have the general

Theorem.—If the general equation of the second degree

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

represents a pair of right lines, the area of the triangle formed by this pair with the line

$$\lambda x + \mu y + \nu = 0$$

is

$$\frac{\begin{vmatrix} a & h & \lambda \\ h & b & \mu \\ g & f & \nu \end{vmatrix}^2}{\begin{vmatrix} h & b \\ a & h \end{vmatrix}^{\frac{3}{2}} \begin{vmatrix} h & b & \mu \\ a & h & \lambda \\ \lambda & \mu & 0 \end{vmatrix}} \quad \ldots (21)$$

The length of the portion of $\lambda x + \mu y + \nu = 0$ which is intercepted between the pair of lines is also easily found; for, from (12), the perpendicular from the point of intersection of the pair of lines on

$$\lambda x + \mu y + \nu = 0$$

is at once seen to be

$$\frac{\begin{vmatrix} a & h & \lambda \\ h & b & \mu \\ g & f & \nu \end{vmatrix}}{\left\{(h^2 - ab)(\lambda^2 + \mu^2)\right\}^{\frac{1}{2}}} \quad \ldots\ldots\ldots\ldots (22)$$

Hence, the length of the intercepted portion is

$$2\,\frac{\begin{vmatrix} \lambda & -\mu \\ \mu & \lambda \end{vmatrix}^{\frac{1}{2}}}{\begin{vmatrix} h & b \\ a & h \end{vmatrix}^{\frac{1}{2}}} \cdot \frac{\begin{vmatrix} a & h & \lambda \\ h & b & \mu \\ g & f & \nu \end{vmatrix}}{\begin{vmatrix} h & b & \mu \\ a & h & \lambda \\ \lambda & \mu & 0 \end{vmatrix}} \quad (23)$$

The product of the two sides is, by a glance at (20), written down to be

$$\frac{\begin{vmatrix} 2h & a-b \\ b-a & 2h \end{vmatrix}^{\frac{1}{2}} \begin{vmatrix} a & h & \lambda \\ h & b & \mu \\ g & f & \nu \end{vmatrix}^2}{\begin{vmatrix} h & a \\ b & h \end{vmatrix}^2 \begin{vmatrix} h & b & \mu \\ a & h & \lambda \\ \lambda & \mu & 0 \end{vmatrix}} \quad \ldots (24)$$

As an application of the formula in (21), we can find the area of the parallelogram formed by the two lines

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

with

$$ax^2 + 2hxy + by^2 = 0$$

which are two lines through the origin parallel to the first pair. By subtracting the equations, we see that

$$2gx + 2fy + c = 0$$

represents that diagonal of the parallelogram which does not pass through the origin. The area of the triangle formed by this diagonal with the first pair is

$$\frac{\left\{2g\ (hf-bg)\ +2f\ (hg-af)-c\ (h^2-ab)\right\}^2}{4(h^2-ab)^{\frac{3}{2}}\ (af^2-2fgh+bg^2)},$$

and that formed with the second pair is

$$\frac{c^2\ (h^2-ab)^2}{4(h^2-ab)^{\frac{3}{2}}\ (af^2-2fgh+bg^2)}.$$

But, since the discriminant vanishes, it is clear that

$$2g(hf-bg)+2f\ (hg-af)-2c\ (h^2-ab)=0$$

$$af^2-2fgh+bg^2=c\ (ab-h^2).$$

Hence, adding the above expressions, the area of the quadrilateral in question is found to be

$$\frac{1}{2}\frac{c}{\sqrt{h^2-ab}}.$$

It may be noted that this expression is only apparently independent of f, g, for the vanishing of the discriminant shews that a, b, c, h are functions of f and g.

§§. 6—7. *The Circle.*

§. 6. **Meaning of the Constants in the Equation of a Circle.**— The equation of a circle

$$x^2+y^2+2gx+2fy+c=0$$

being thrown into the form

$$(x-g)^2+(y-f)^2=g^2+f^2-c,$$

the quantities $-g$, $-f$ are seen to be the coordinates of the centre, while, if r be the radius, we have

$$r^2=g^2+f^2-c.$$

To determine the geometric meaning of c, let δ be the distance of the centre from the origin, and t, either of the tangents drawn from the origin to the circle; then,

$$\delta^2=r^2+t^2$$

and, also,

$$\delta^2=f^2+g^2$$

$$r^2=f^2+g^2-c$$

which give

$$c=t^2. \qquad \ldots\ldots\ldots\ldots (25)$$

Hence, c denotes the square of the tangent drawn from the origin to the circle. We thus infer that, if the equations of a system of circles agree in either f or g, the locus of their centres is a right line parallel to a given line at a given distance from it, and their common chords are parallel, being all perpendicular to this given line; if both f and g are the same in all the equations, the system is concentric; if c alone is the same in all the equations, the circles are such as can be intersected orthogonally by a circle of radius $\sqrt{c}$, described round the origin as centre; and this shews at once that as a system of co-axal circles can be orthogonally intersected, their equations must necessarily be of the form

$$x^2+y^2-2kx=\pm\delta^2,$$

where δ is constant, but k variable.

The geometric meaning of c also furnishes the length of the tangent drawn from any point to a circle, for, the equation of the circle being

$$x^2+y^2+2gx+2fy+c=0,$$

and the point from which tangents are drawn being (x', y'), remove the origin to this point; then, the new absolute term is clearly the point-function of the circle with respect to the point (x', y'), and this, therefore, is the length of the tangent sought. It follows as a consequence of this, that the geometric meaning of the equation of the circle is that, if the length of the tangent drawn from any point to a circle vanishes, that point must be on the curve itself.

§. 7. **Chords and Tangents of Circles and Conics.**—The following equation of the chord joining the two points (x', y'), $(x'', y'',)$ on the circle

$$x^2+y^2=r^2 \qquad \ldots\ldots\ldots\ldots (26)$$

is due to Professor Burnside, (Salmon's *Conics*, §. 85, Ed. 1879, p. 80),

$$(x-x')(x-x'')+(y-y')(y-y'')=x^2+y^2-r^2. \ldots\ldots\ldots\ldots (27)$$

It is easily verified that this is actually the equation of the chord; the following geometrical interpretation, however, shews the genesis of the equation.

On the line joining the points (x', y'), (x'', y'') as diameter, describe a circle; any point (x, y) on this circumference is such that the lines joining (x, y), (x', y'), and (x, y), (x'', y''), include a right angle; this condition, expressed analytically, gives for the equation of the circle

$$(x-x')(x-x'')+(y-y')(y-y'')=0 \quad \ldots\ldots\ldots\ldots (28)$$

The chord in question may now be regarded as the common chord of the two circles represented by (26) and (28); and then, from the elementary principle that $S+kS'=0$ represents any locus through the common points of $S=0$, $S'=0$, we at once write down Burnside's equation (27), the proper value of k being easily seen to be given by

$$1+k=0.$$

The generalisation to the conic given by the general equation

$$ax^2+2hxy+by^2+2gx+2fy+c=0 \quad \ldots\ldots\ldots\ldots (29)$$

is easy, *viz.*,

$$a(x-x')(x-x'')+2h(x-x')(y-y'')+b(y-y')(y-y'')=0 \quad (30)$$

represents any conic through (x', y'), (x'', y''), which may, it is useful to notice, satisfy three other conditions: and the chord in question, being the common chord of (29) and (30), must have for its equation

$$a(x-x')(x-x'')+2h(x-x')(y-y'')+b(y-y')(y-y'')$$
$$=ax^2+2hxy+by^2+2gx+2fy+c \quad \ldots\ldots\ldots\ldots (31)$$

I have not, however, been able to find if the conics (29) and (30) are connected by any very special or peculiar relation: their centres are not coincident; the centre of (30) is not on the chord whose equation is required; their asymptotes, however, include equal angles, and their axes are parallel; in fact, they are similar and similarly situated, and, therefore, necessarily equi-eccentric.

The equation of the tangent *at* any point may be deduced, as usual, from the equation of the chord; or we may first obtain by Joachimsthal's method the equation of the pair of tangents *from* an external point, and thence obtain the equation of the tangent *at* any point of the curve. The same equation, however, may be obtained by transformation, if we know the equation of the tangents from the origin; thus, the conic being

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

and (x', y') the external point, remove the origin to this point, so that the conic becomes

$$ax^2+2hxy+by^2+2g'x+2f'y+c'=0,$$

where the values of f', g', c' are the same as in §. 4. If now $y=mx$ be any line through the new origin, it will touch the conic if the quadratic in x,

$$(a+2hm+bm^2)x^2+2(g'+f'm)x+c'=0,$$

has equal roots, which condition gives

$$c'(a+2hm+bm^2)=(g'+f'm)^2,$$

and by substituting

$$m=\frac{y}{x},$$

we have for the equation of the tangents, referred to the new origin,

$$c'(ax^2+2hxy+by^2)=(g'x+f'y)^2,$$

which may be written

$$c'(ax^2+2hxy+by^2+2g'x+2f'y+c')=(g'x+f'y+c')^2.$$

Reverting to our old axes, we have at once the equation in the form

$$(\text{Conic})\times(\text{Point-function})=(\text{Polar})^2,$$

which is, of course, the same equation as that obtained by Joachimsthal's method.

§§. 8—15. *The General Equation of the Second Degree.*

§. 8. **Preliminary.**—The discussion of the general equation of the second degree deservedly occupies an important position in the application of analytical geometry to the theory of lines of the second order; for, in analytical geometry properly so called, the question of degree or class is of fundamental importance, and the curves of the second degree should be called lines of the second order, and not conic sections, the proper point of view from which their properties ought to be studied being the fact that the equation representing them is of the second degree, and not the other fact that they are sections of a cone and have foci and directrices. The truly logical order of treating the subject is first to have a chapter on the equation of the first degree, containing the properties of right lines, then a chapter on the general equation of the second degree, and, as distinctly subsidiary to this, chapters on the circle, the ellipse, and the other conics. We proceed, then, to give the barest outline of such a systematic discussion as is indicated here. It may usefully be noted that the object of the discussion is twofold, *viz.*, in the first place, the problem is how to transform the equation to its simplest forms, and thus to classify the different kinds of conics; in the second place, we obtain some general formulæ for such properties as are common to all conics.

§. 9. **Transformation of the Equation.**—The general equation of the second degree being

$$S = ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0, \quad \ldots\ldots\ldots\ldots \quad (32)$$

first change the origin to (x', y'), so that the equation becomes

$$ax^2 + 2hxy + by^2 + 2g'x + 2f'y + c' = 0$$

where

$$g' = \left(\frac{dS}{dx}\right)_{\substack{x=x' \\ y=y'}} = ax' + hy' + g$$

$$f' = \left(\frac{dS}{dy}\right)_{\substack{x=x' \\ y=y'}} = hx' + by' + f$$

$$c' = \text{Point-function.}$$

If, then, we make $g' = f' = 0$, that is, if we have for the coordinates of the new origin

$$x' = \frac{hf - bg}{ab - h^2}, \quad y' = \frac{hg - af}{ab - h^2}, \quad \ldots\ldots\ldots\ldots \quad (33), (34)$$

the transformed equation is

$$ax^2 + 2hxy + by^2 + \frac{\Delta}{ab - h^2} = 0 \quad \ldots\ldots\ldots\ldots \quad (35)$$

where Δ is the discriminant (§. 4). In order that this transformation may be real and possible, we must have $(ab - h^2)$ different from zero.

The first point of departure, then, in the classification of conics, depends on the equation

$$ab - h^2 > \text{ or } < 0.$$

The case in which $h^2 = ab$ does not admit of the above transformation, and it must be treated separately (see Carr's Synopsis of Pure Mathematics, §§. 4430—4443). In the case where $(ab - h^2)$ does not vanish, we proceed further, as follows. Turn the axes about the new origin through an angle θ, where θ is given by

$$\tan 2\theta = \frac{2h}{a-b}, \qquad \text{............ (36)}$$

and the new equation becomes

$$Ax^2 + By^2 + \frac{\Delta}{ab - h^2} = 0 \qquad \text{............ (37),}$$

where A, B are certain constants to be determined hereafter. This equation may be put into the form

$$\frac{x^2}{\alpha^2} + \frac{y^2}{\beta^2} = 1 \qquad \text{............ (38)}$$

if

$$\frac{1}{\alpha^2} = -\frac{A}{Q}, \quad \frac{1}{\beta^2} = -\frac{B}{Q} \qquad \text{............ (39), (40)}$$

and

$$Q = \frac{\Delta}{ab - h^2}. \qquad \text{............ (41)}$$

Definition.—The quantity which we have denoted here by Q, we will call the **Asymptotic Constant,** the reason for which name will appear in §. 12. The quantities α, β are called the semi-axes of the conic.

§. 10. **Invariants.**—In the last section, we transformed the general equation of the second degree to its simplest form (38); but, we did not calculate the quantities α, β which depend on A, B. As a rule, the calculation of these quantities in every particular case is a laborious task; we, therefore, find out some functions of the coefficients which remain unaltered by transformation, and which are, accordingly, called Invariants of the conic. These invariants may be of different classes; thus, there are certain quantities which remain unaltered for a translation-transformation, and which may appropriately be called **Translation-invariants**; to this class belong a, h, b. Again, there are certain quantities which remain unaltered for a rotation-transformation, and which may, accordingly, be called **Rotation-invariants**; thus, the absolute term is a rotation-invariant; but the most important of these invariants are embodied in Dr. Boole's theorems that the quantities

$$\frac{a + b - 2h\cos\omega}{\sin^2\omega}, \quad \frac{ab - h^2}{\sin^2\omega} \qquad \text{............ (42), (43)}$$

belong to this class (Salmon's *Conics*, §. 159, Ed. 1879, p. 159). Again, as we have seen that a, b, h are translation-invariants, it follows that

$$\frac{a+b-2h\cos\omega}{\sin^2\omega}, \quad \frac{ab-h^2}{\sin^2\omega}$$

are invariants for the compound transformation as well, and may, accordingly, be called **General Invariants.** We shall now proceed to investigate, by a process analogous to that employed by Dr. Boole, certain invariants which include as particular cases those noticed above.

Suppose that by a rotation-transformation the equation

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

assumes the form

$$AX^2+2HXY+BY^2+2GX+2FY+C=0.$$

Then, by the same transformation

$$x^2+y^2+2xy\cos\omega$$

is altered into

$$X^2+Y^2+2XY\cos\Omega,$$

because each of these expressions denotes the distance of the same point from the fixed origin. Hence, we have

$$(a+\lambda)x^2+2(h+\lambda\cos\omega)xy+(b+\lambda)y^2+2gx+2fy+c$$
$$=(A+\lambda)X^2+2(H+\lambda\cos\Omega)XY+(B+\lambda)Y^2+2GX+2FY+C.$$

Each side of this identity will resolve itself into linear factors for the same value of λ; hence, equating the discriminant of each side to zero, we have the two equations

$$c\sin^2\omega.\,\lambda^2+\left\{c(a+b-2h\cos\omega)-(f^2+g^2-2fg\cos\omega)\right\}\lambda$$
$$+abc+2fgh-af^2-bg^2-ch^2=0$$
$$C\sin^2\Omega.\,\lambda^2+\left\{C(A+B-2H\cos\Omega)-(F^2+G^2-2FG\cos\Omega)\right\}\lambda$$
$$+ABC+2FGH-AF^2-BG^2-CH^2=0.$$

As these quadratics in λ must be identical, we have, by equating the coefficients of corresponding terms, the two relations

$$\frac{a+b-2h\cos\omega}{\sin^2\omega}-\frac{f^2+g^2-2fg\cos\omega}{c\sin^2\omega}$$
$$=\frac{A+B-2H\cos\Omega}{\sin^2\Omega}-\frac{F^2+G^2-2FG\cos\Omega}{C\sin^2\Omega}, \quad \text{.........} \quad (44)$$

$$\frac{abc+2fgh-af^2-bg^2-ch^2}{c\sin^2\omega}=\frac{ABC+2FGH-AF^2-BG^2-CH^2}{C\sin^2\Omega}. \quad (45)$$

If $f=0$, $g=0$, these equations furnish Dr. Boole's invariants. As we have noticed that c is a rotation-invariant, these results shew that the functions

$$\left\{c(a+b-2h\cos\omega)-(f^2+g^2-2fg\cos\omega)\right\}\div\sin^2\omega \quad \text{.........} \quad (46)$$

$$\frac{\Delta}{\sin^2\omega}. \qquad \text{............} \quad (47)$$

are rotation-invariants.

In order to see if any of these is a general invariant, we must examine whether they are translation-invariants. It will be found on examination that the first is not a translation-invariant, while for the second we know that, by a translation-transformation, the equation

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

is transformed into

$$a'x^2+2h'xy+b'y^2+2g'x+2f'y+c'=0,$$

where

$$a'=a,\ h'=h,\ b'=b,$$

which, by the way, shews that the part of the second degree in the general equation is a covariant for translation-transformation,

and
$$g'=ax'+hy'+g$$
$$f'=hx'+by'+f$$
$$c'=\text{Point-function},$$

from which, by actual calculation, we find that the coefficients of x^2, xy, y^2, x, y in

$$a'b'c'+2f'g'h'-a'f'^2-b'g'^2-c'h'^2$$

all vanish, and the absolute term is Δ. Hence, we infer that Δ is a translation-invariant, and so also is

$$\frac{\Delta}{\sin^2\omega},$$

since ω is unaltered by translation-transformation; thus, from what precedes, we have finally that

$$\frac{\Delta}{\sin^2\omega}$$

is a general invariant of the conic. To sum up, we enumerate below the principal invariants of the general conic.

I. Translation-invariants.

(i). a. (ii). h. (iii). b. (iv). Δ.

II. Rotation-invariants.

(i) Absolute term. (ii) $\dfrac{a+b-2h\cos\omega}{\sin^2\omega}$

(iii) $\dfrac{ab-h^2}{\sin^2\omega}$

(iv) $\dfrac{a+b-2h\cos\omega}{\sin^2\omega}-\dfrac{f^2+g^2-2fg\cos\omega}{c\sin^2\omega}$

(v) $\dfrac{\Delta}{\sin^2\omega}$. (vi) $\dfrac{f^2+g^2-2fg\cos\omega}{c\sin^2\omega}$.

III. General invariants.

(i) $\dfrac{a+b-2h\cos\omega}{\sin^2\omega}$ (ii) $\dfrac{ab-h^2}{\sin^2\omega}$

(iii) $\dfrac{\Delta}{\sin^2\omega}$.

It is clear that since any function of an invariant is an invariant, various invariants may be deduced from these by combining them in different ways or by imposing limiting conditions on them. Thus, for rectangular axes, Δ is a general invariant; and, if we examine the equation

$$ax^2+2hxy+by^2+2fy=0,$$

which denotes a conic referred to a tangent and normal as coordinate-axes, we see that it has the three general invariants, $(a+b)$, $(ab-h^2)$, af^2.

We have shewn above, *by actual calculation*, that the discriminant is a translation-invariant; it is interesting to note that the same result may be obtained as an illustration of Dr. Boole's method. Thus, if by translation-transformation the equation

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

is transformed into

$$a_1X^2+2h_1XY+b_1Y^2+2g_1X+2f_1Y+c_1=0,$$

the same transformation changes

$$x^2+y^2+2xy\cos\omega$$

into

$$(X-x_1)^2+(Y-y_1)^2+2(X-x_1)(Y-y_1)\cos\omega,$$

whence we have

$$ax^2+2hxy+by^2+2gx+2fy+c+\lambda(x^2+y^2+2xy\cos\omega)$$
$$=a_1X^2+2h_1XY+b_1Y^2+2g_1X+2f_1Y+c_1$$
$$+\lambda\left\{(X-x_1)^2+(Y-y_1)^2+2(X-x_1)(Y-y_1)\cos\omega\right\}.$$

Equating the discriminant of the left hand side to zero, we have

$$c\sin^2\omega.\,\lambda^2+\left\{c(a+b-2h\cos\omega)-(af^2+bg^2-2fg\cos\omega)\right\}\lambda$$
$$+\Delta=0 \qquad \ldots\ldots\ldots\ldots \ (48)$$

If we equate to zero the discriminant of the right hand side, the equation in λ apparently comes out to be a cubic; but the coefficient of λ^3 is found on calculation to be zero, while, in the coefficient of λ^2, the terms involving x_1^2, x_1y_1, y_1^2, x_1, y_1 separately vanish, and the constant is $c\sin^2\omega$; hence the equation may be written

$$c\sin^2\omega.\,\lambda^2+R\lambda+\Delta_1=0. \qquad \ldots\ldots\ldots\ldots \ (49).$$

Therefore, equating coefficients, we have

$$\Delta=\Delta_1,$$

which shews, as before, that Δ is a translation-invariant. It may be noted that, from a comparison of (48) and (49), it is clear that the value of R in (49) is

$$\left\{ c(a+b-2h\cos\omega)-(af^2+bg^2-2fg\cos\omega) \right\},$$

as, indeed, may be verified by direct calculation.

§. 11. **Lengths of axes and area of conic.**—We have shewn above that the semi-axes α, β of a conic are given by (39) and (40), *viz*,

$$\frac{1}{\alpha^2}=-\frac{A}{Q},\quad \frac{1}{\beta^2}=-\frac{B}{Q},$$

and, from the theory of invariants explained above, we have further

$$A+B=\frac{a+b-2h\cos\omega}{\sin^2\omega},\quad AB=\frac{ab-h^2}{\sin^2\omega}\quad \text{.........}\ (50),\ (51).$$

Hence, if ρ be a semi-axis, we have

$$\rho^4-(\alpha^2+\beta^2)\rho^2+\alpha^2\beta^2=0\quad \text{............}\ (52)$$

where

$$\alpha^2+\beta^2=-Q\left(\frac{1}{A}+\frac{1}{B}\right),\quad \alpha^2\beta^2=\frac{Q^2}{AB}.$$

Substituting in (52) from (50) and (51), and putting from (41)

$$Q=\frac{\Delta}{ab-h^2},$$

we get

$$\rho^4+\frac{\Delta(a+b-2h\cos\omega)}{(ab-h^2)^2}\rho^2+\frac{\Delta^2\sin^2\omega}{(ab-h^2)^3}=0,\quad \text{......}\ (53)$$

which is, accordingly, the equation furnishing the semi-axes of the given conic; and, as it is a quadratic in ρ^2, it shews that there are *four* semi-axes, which may be grouped into two pairs, the two axes in each pair being equal in magnitude but opposite in direction. It follows from (53) that, if $\rho_1{}^2$, $\rho_2{}^2$ be the roots of the quadratic in ρ^2, the area of the conic is

$$\pi\rho_1\rho_2=\frac{\pi\Delta\sin\omega}{(ab-h^2)^{\frac{3}{2}}}\quad \text{............}\ (54)$$

Again, it is clear that A and B will have the same sign or different signs, according as AB is positive or negative, that is, according as AB is greater or less than zero; hence, since A and B in the equation (37)

$$Ax^2+By^2+\frac{\Delta}{ab-h^2}=0$$

are connected by the relation (51)

$$AB=\frac{ab-h^2}{\sin^2\omega},$$

it follows that A and B, and thence necessarily α^2, β^2 in the equation (38)

$$\frac{x^2}{\alpha^2}+\frac{y^2}{\beta^2}=1,$$

will have the same sign or opposite signs, according as $(ab - h^2) \gt$ or $\angle 0$, or according as the curve is an ellipse or hyperbola. This completes the classification of conics. (§. 9).

§. 12. **Asymptotes.**—In the ordinary text-books (cf. Smith's *Conics*, §. 174, Ed. 1882, p. 187), the method of finding the equation of the asymptotes of the general conic is given as follows: it is first proved that the asymptotes of the conic in the particular case

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

are given by

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 0,$$

and thence it is inferred that, in the general case, the equations of the conic and asymptotes must differ only by a constant; the logic of this reasoning is, to say the least, hardly satisfactory; the following method is both easy and rigorously logical.

The asymptotes being tangents to the conic at infinity, they may be regarded as a pair of lines passing through the points of intersection of the conic and the line at infinity. Now, the equation of the conic being

$$S \equiv ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0,$$

and that of the line at infinity having been shewn (§. 3) to be

$$\lambda = 0,$$

any conic through their common points is

$$S + \lambda = 0;$$

and, in order that this may be a pair of lines, its discriminant must vanish, whence, as usual,

$$\lambda = -Q = -\frac{\Delta}{ab - h^2},$$

and the asymptotes are given by

$$S = Q,$$

which shews that the **asymptotic constant** in (41) is a constant which must be equated to S, to furnish the equation of the asymptotes.

The above process may be represented in a modified form as follows; the conic

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

being transformed to the centre, becomes

$$ax^2 + 2hxy + by^2 + \frac{\Delta}{ab - h^2} = 0,$$

whence it at once follows that the quantity to be added to the right hand side of this equation to give the asymptotes is the asymptotic constant. Now, if we transform back to our old axes, the left hand side becomes

$$ax^2+2hxy+by^2+2gx+2fy+c,$$

while, Δ and $(ab-h^2)$ being translation-invariants, the right hand side remains unaltered, and the equation sought is accordingly

$$S=\frac{\Delta}{ab-h^2}. \qquad \ldots\ldots\ldots\ldots (55)$$

It follows from (6) that the point of intersection of the asymptotes in (55) coincides with the centre of the conic, and that, accordingly, the centre is the pole of the line at infinity. It is also clear that the asymptotes will be at right angles to each other and the conic will be a rectangular hyperbola, if $(a+b)=2h\cos\omega$, in oblique coordinates, and $(a+b)=0$ in rectangular coordinates.

§. 13. **Eccentricity.**—The eccentricity may be calculated in different ways according to the definition we employ.

First method.

$$e^2=\frac{\alpha^2-\beta^2}{\alpha^2},$$

where α, β are the semi-axes of the conic. We have

$$2-e^2=\frac{\alpha^2+\beta^2}{\alpha^2},$$

$$1-e^2=\frac{\beta^2}{\alpha^2},$$

which give

$$\frac{(2-e^2)^2}{1-e^2}=\frac{(\alpha^2+\beta^2)^2}{\alpha^2\beta^2},$$

and this, by substitution from (39) and (40), becomes

$$\frac{(2-e^2)^2}{1-e^2}=\frac{(A+B)^2}{AB}. \qquad \ldots\ldots\ldots\ldots (56)$$

But, from the invariants (42) and (43), we have

$$A+B=\frac{a+b-2h\cos\omega}{\sin^2\omega},$$

$$AB=\frac{ab-h^2}{\sin^2\omega},$$

so that equation (56) becomes

$$\frac{(2-e^2)^2}{1-e^2}=\frac{(a+b-2h\cos\omega)^2}{(ab-h^2)\sin^2\omega}, \qquad \ldots\ldots\ldots\ldots (57)$$

which is the familiar equation. It is clear from (57) that $(1-e^2)$ and $(ab-h^2)$ are simultaneously positive, zero, or negative; hence, we have

$$e^2 \angle = \urcorner\, 1$$

according as

$$h^2 \angle = \urcorner\, ab,$$

or according as the conic is an ellipse, a parabola, or an hyperbola. In the equilateral hyperbola, we have

$$a+b-2h\cos\omega=0,$$

whence $$e=\sqrt{2}.$$

Second method.

$$e=\sec\frac{\phi}{2},$$

where ϕ is the angle between the asymptotes. The equation of the asymptotes from (55) being

$$ax^2+2hxy+by^2+2gx+2fy+c=\frac{\Delta}{ab-h^2},$$

we have

$$\tan\phi=\frac{2\sin\omega.\sqrt{h^2-ab}}{a+b-2h\cos\omega}. \quad \ldots\ldots\ldots\ldots (58)$$

But $$\sec^2\phi=\left(2\cos^2\frac{\phi}{2}-1\right)^{-}$$

$$=\left[\frac{\sec^2\frac{\phi}{2}}{2-\sec^2\frac{\phi}{2}}\right]^2=\left(\frac{e^2}{2-e^2}\right)^2,$$

whence we have

$$\tan^2\phi=\sec^2\phi-1=\left(\frac{e^2}{2-e^2}\right)^2-1=\frac{4(e^2-1)}{(2-e^2)^2}.$$

Therefore, from equation (58),

$$\frac{e^2-1}{(2-e^2)^2}=\frac{(h^2-ab)\sin^2\omega}{(a+b-2h\cos\omega)^2},$$

which is the same equation as (57).

Third method.

The eccentricity may be defined to be the ratio of the distance of any point on the conic from a focus to its distance from the corresponding directrix; the calculation on the basis of this method will come in most appropriately when we presently deal with Laplace's Linear Equation of a Conic (§§. 16—20; see, in particular, §. 20).

§. 14. **Director-circle.**—The director-circle of

$$S\equiv ax^2+2hxy+by^2+2gx+2fy+c=0$$

being the locus of intersection of orthogonal tangents, its equation in rectangular coordinates is known to be

$$(ab-h^2)(x^2+y^2)+2(gb-fh)x+2(fa-hg)y$$
$$+c(a+b)-f^2-g^2=0, \quad \ldots\ldots\ldots\ldots (59)$$

which may also be written in the form

$$D\equiv(a+b)S-(ax+hy+g)^2-(hx+by+f)^2=0 \quad \ldots\ldots\ldots\ldots (60)$$

The centre of the director-circle is seen from (59) to be the point

$$\left(\frac{fh-bg}{ab-h^2}, \frac{hg-af}{ab-h^2}\right),$$

which coincides with the centre of the conic; and, if R be the radius, we have

$$R^2 = \frac{(fh-bg)^2}{(ab-h^2)^2} + \frac{(hg-af)^2}{(ab-h^2)^2} - \frac{c(a+b)-(f^2+g^2)}{ab-h^2}$$
$$= \frac{-(a+b)\,\Delta}{(ab-h^2)^2},$$

which shews that in rectangular axes the square of the radius of the director-circle is equal to the sum of the squares of the semi-axes of the conic given in equation (53).

That the same propositions hold for oblique coordinates may easily be shewn, *viz.*, the equation of the tangents to the conic from (x', y') being

$$(ax^2+2hxy+by^2+2gx+2fy+c)\times$$
$$(ax'^2+2hx'y'+by'^2+2gx'+2fy'+c)$$
$$=\left\{(ax'+hy'+g)x+(hx'+by'+f)y+gx'+fy'+c\right\}^2,$$

the condition that these lines may include a right angle, gives for the locus of (x', y') the circle

$$(ab-h^2)(x^2+y^2+2xy\cos\omega)$$
$$+2\left\{(gb-fh)+(fa-gh)\cos\omega\right\}x$$
$$+2\left\{(fa-gh)+(gb-fh)\cos\omega\right\}y$$
$$+c(a+b)-(f^2+g^2)+2(fg-ch)\cos\omega=0$$

Comparing this with the standard form

$$(x-\alpha)^2+2(x-\alpha)(y-\beta)\cos\omega+(y-\beta)^2=r^2,$$

or

$$(x^2+y^2+2xy\cos\omega)-2(\alpha+\beta\cos\omega)x-2(\beta+\alpha\cos\omega)y$$
$$+\alpha^2+\beta^2+2\alpha\beta\cos\omega-r^2=0,$$

we have at once

$$\alpha=\frac{fh-bg}{ab-h^2},\quad \beta=\frac{hg-af}{ab-h^2},$$

which give the same coordinates of centre as before, while we have for the radius

$$r^2=\alpha^2+2\alpha\beta\cos\omega+\beta^2$$
$$-\frac{c(a+b)-(f^2+g^2)+2(fg-ch)\cos\omega}{ab-h^2}$$
$$=\Big[(fh-bg)^2+(hg-af)^2-(ab-h^2)\left\{c(a+b)-(f^2+g^2)\right\}$$
$$+2\left\{(fh-bg)(hg-af)-(fg-ch)(ab-h^2)\right\}\cos\omega\Big]\div(ab-h^2)^2$$

$$= \left[-(a+b)\,\Delta + 2h\cos\omega.\ \Delta \right] \div (ab-h^2)^2$$

$$= \frac{-(a+b-2h\cos\omega)\,\Delta}{(ab-h^2)^2},$$

which, by a glance at (53), is seen to represent, as before, the sum of the squares of the semi-axes. From the value of the radius given above, it is clear that, when the conic is an equilateral hyberbola, the radius vanishes, and the director-circle is a circle of infinitesimal radius, *viz.*, it is the centre of the conic itself, and the asymptotes, therefore, are the only tangents of the equilateral hyperbola which are at right angles to each other.

§. 15. **Hyperbola referred to the asymptotes.**—In this section, we purpose to investigate what form the general equation assumes when the axes of coordinates are transformed to the asymptotes; two methods will be given, the first very direct and elementary, the second partly geometrical and requiring a knowledge of the invariants given above.

First method.

Let the general equation of the second degree be

$$ax^2+2hxy+by^2+2gx+2fy+c=0.$$

Transfer the coordinate axes to the centre of the conic, which is also the point of intersection of the asymptotes; the conic then becomes

$$ax^2+2hxy+by^2+\frac{\Delta}{ab-h^2}=0 \quad \text{.........} \quad (61)$$

and the asymptotes are given by

$$ax^2+2hxy+by^2=0. \quad \text{............} \quad (62)$$

Now the equation of either asymptote may be taken to be $y=mx$, so that the two values of m are found, by substitution in (62), to be the roots of the quadratic

$$bm^2+2hm+a=0. \quad \text{............} \quad (63)$$

Hence, if α, β be the angles which the two asymptotes make with the axis of x, both $\tan\alpha$ and $\tan\beta$ must satisfy (63), so that we have

$$b\tan^2\alpha+2h\tan\alpha+a=0$$

or

$$b\sin^2\alpha+2h\sin\alpha\cos\alpha+a\cos^2\alpha=0 \quad \text{......} \quad (64)$$

and similarly,

$$b\sin^2\beta+2h\sin\beta\cos\beta+a\cos^2\beta=0 \quad \text{............} \quad (65)$$

Now, the angle between the original axes being $\omega=\frac{\pi}{2}$, the ordinary formulæ for the transformation of coordinates (Salmon's *Conics*, §. 9, Ed. 1879, p. 7) become in this case

$$y\sin\omega=X\sin\alpha+Y\sin\beta.$$

$$x\sin\omega=X\cos\alpha+Y\cos\beta.$$

Substituting these in (61), and arranging, we have for the equation of the conic

$$(a\cos^2\alpha+2h\cos\alpha\sin\alpha+b\sin^2\alpha)X^2$$
$$+(a\cos^2\beta+2h\cos\beta\sin\beta+b\sin^2\beta)Y^2$$
$$+2\Big[a\cos\alpha\cos\beta+h.\sin(\alpha+\beta)+b\sin\alpha\sin\beta\Big]XY$$
$$+\frac{\Delta}{ab-h^2}=0.$$

But, by (64) and (65), the coefficients of X^2 and Y^2 vanish, and the equation becomes

$$2Hxy+\frac{\Delta}{ab-h^2}=0, \qquad \ldots\ldots\ldots\ldots (66)$$

where H is the quantity to be calculated. For this purpose, we note that, if m_1, m_2 be the two roots of the quadratic in m given by (63), we have

$$m_1+m_2=-\frac{2h}{b}, \quad m_1 m_2=\frac{a}{b}.$$

Now, we see that

$$H=\cos\alpha\cos\beta\Big\{a+h(\tan\alpha+\tan\beta)+b\tan\alpha\tan\beta\Big\}$$
$$=\frac{2(ab-h^2)}{b}\cos\alpha\cos\beta,$$

where

$$\cos^2\alpha\cos^2\beta=\Big\{(1+m_1^2)(1+m_2^2)\Big\}^{-1} \because m_1=\tan\alpha,\ m_2=\tan\beta.$$
$$=\Big[(m_1+m_2)^2+(1-m_1m_2)^2\Big]^{-1}$$
$$=\frac{b^2}{(a-b)^2+4h^2}.$$

Therefore, $H=\pm\dfrac{2(ab-h^2)}{b}\cdot\dfrac{b}{\sqrt{\Big[(a-b)^2+4h^2\Big]}}$

and, finally, the equation (66) becomes

$$xy=\pm\frac{\Delta}{4}\cdot\frac{\sqrt{\Big[(a-b)^2+4h^2\Big]}}{(ab-h^2)^2}, \quad \ldots\ldots (67)$$

which is, accordingly, the equation of the hyperbola referred to its asymptotes, which was sought.

Second method.

The same result may also be obtained as follows. The equation of the conic, referred to its centre, being, as before,

$$ax^2+2hxy+by^2+\frac{\Delta}{ab-h^2}=0, \qquad \ldots\ldots\ldots\ldots (68)$$

and remembering that the absolute term is a rotation-invariant, we see that, when referred to the asymptotes, the equation must assume the form

$$Ax^2+2Hxy+By^2+\frac{\Delta}{ab-h^2}=0 \qquad \dots\dots\dots\dots (69)$$

Now, in this equation, the axis of x being an asymptote, one value of x must be infinite, and, therefore, in this equation, regarded as a quadratic in x, we must have $A=0$; similarly, the axis of y being the other asymptote, we must have $B=0$; so that (69) reduces to

$$2Hxy+\frac{\Delta}{ab-h^2}=0. \qquad \dots\dots\dots\dots (70)$$

To calculate H, we remark that, since the original axes are at right angles, we have $\omega=\frac{\pi}{2}$, and, as also $A=0$, $B=0$, the invariant relation

$$\frac{ab-h^2}{\sin^2\omega}=\frac{AB-H^2}{\sin^2\Omega}$$

reduces to

$$-H^2=(ab-h^2)\sin^2\Omega, \qquad \dots\dots\dots (71)$$

where Ω is the angle between the asymptotes,

$$ax^2+2hxy+by^2=0. \qquad \dots\dots\dots\dots (72)$$

But, α, β being the angles which the asymptotes make with the axes, we have $\Omega=\alpha-\beta$, and, from equation (72),

$$\tan\Omega=\frac{2\sqrt{h^2-ab}}{a+b},$$

$$\sin\Omega=\frac{2\sqrt{h^2-ab}}{\sqrt{\left\{(a-b)^2+4h^2\right\}}},$$

so that (71) becomes

$$H^2=\frac{4(ab-h^2)^2}{(a-b)^2+4h^2},$$

and (70) gives for the required equation

$$xy=\pm\frac{\Delta}{4}\cdot\frac{\sqrt{\left\{(a-b)^2+4h^2\right\}}}{(ab-h^2)^2},$$

which is the same result as that obtained before. It may be noted that the value of H might have been obtained with equal ease by using the other invariant relation

$$\frac{a+b-2h\cos\omega}{\sin^2\omega}=\frac{A+B-2H\cos\Omega}{\sin^2\Omega}.$$

The geometrical meaning of this equation of the hyperbola is easily seen, *viz.*, taking ρ_1^2, ρ_2^2 for the squares of the semi-axes of the conic, and remembering that our original axes were rectangular, we have from (53),

$$\rho_1^2+\rho_2^2=\frac{-\Delta\ (a+b)}{(ab-h^2)^2}$$

$$\rho_1^2\ \rho_2^2=\frac{\Delta^2}{(ab-h^2)^3},$$

so that

$$(\rho_1^2-\rho_2^2)^2=(\rho_1^2+\rho_2^2)^2-4\ \rho_1^2\ \rho_2^2$$

$$=\frac{\Delta^2\left\{(a-b)^2+4h^2\right\}}{(ab-h^2)^4}.$$

The equation (67), therefore, may be written

$$xy=\tfrac{1}{4}\ (\text{Difference of squares of semi-axes}),$$

which is a well-known result.

If the conic had been originally referred to axes inclined at an angle ω, the equation of the hyperbola referred to the asymptotes would have been

$$xy=\pm\frac{\Delta}{4\ (ab-h^2)^2}\left[(a-b)^2+4h^2-4\cos\omega\left\{h\ (a+b)-ab\cos\omega\right\}\right]^{\frac{1}{2}}$$

and the right hand side may be proved to be the difference of the squares of the semi-axes given by (53).

§§. 16—20. *Laplace's Linear Equation.*

§. 16. **Genesis of Laplace's Equation.**—The theorem that

$$\rho=Ax+By+C,$$

where ρ is the distance of any point on the curve from a fixed coplanar point, represents a conic is first due, substantially, to Laplace (*Mécanique Céleste*, Ed. 1878, t. I. p. 177). In integrating the equations for elliptic motion, he gets

$$dr=\lambda dx+\gamma dy,$$

which leads to

$$r=\frac{h^2}{\mu}+\lambda x+\gamma y\,;$$

Laplace then explicitly adds that "Cette équation, combinée avec celles-ci,

$$z=ax+by,\ r^2=x^2+y^2+z^2$$

donne une équation du second degré." It is proposed to examine here the geometrical meaning of the arbitrary constants in what I have called Laplace's Linear Equation to a conic.

§. 17. **Meaning of the Constants.**—That this equation represents a conic may be shewn in various ways, and some additional information regarding the constants may be gained from each standpoint of view. Thus, squaring the equation and putting

$$\rho^2=x^2+y^2,$$

we see that it is the equation to a conic which is an ellipse, a parabola, or an hyperbola according as

$$A^2+B^2 \angle = \urcorner 1.$$

Now, knowing that the curve is a conic, we may next compare its equation with the focal polar equation

$$l=\rho\ (1+e \cos\theta).$$

Remembering that ρ is a function of x and y, we conclude that the absolute terms in the two equations must be identical, whence

$$C=l=\text{semi-latus-rectum}.$$

Again, as the equation may be written in the form

$$\rho \div \left\{ \frac{Ax+By+C}{\sqrt{A^2+B^2}} \right\} = \sqrt{A^2+B^2},$$

where ρ is the distance of any point on the curve from a fixed point, and

$$\frac{Ax+By+C}{\sqrt{A^2+B^2}}$$

is the perpendicular on the line $Ax+By+C=0$, we see, by attending to the focus-directrix method of generating conics, that the curve is a conic of which the directrix is

$$Ax+By+C=0,$$

and the eccentricity is given by

$$e^2=A^2+B^2.$$

§. 18. **Elliptic Motion.**—In order to represent these properties geometrically, and to shew their relation to elliptic motion, it is convenient to begin with the following method of integrating the equations of motion. We have, as usual,

$$\frac{d^2x}{dt^2} = -\frac{\mu x}{r^3},$$

$$\frac{d^2y}{dt^2} = -\frac{\mu y}{r^3},$$

$$x\frac{dy}{dt} - y\frac{dx}{dt} = h,$$

$$r^2\frac{d\theta}{dt} = h.$$

Now $$\frac{x}{r} = \cos\theta,\ \frac{y}{r} = \sin\theta;$$

therefore $$\frac{d}{dt}\left(\frac{x}{r}\right) = -\sin\theta . \frac{d\theta}{dt} = -\frac{y}{r^3} . h,$$

whence $$\frac{y}{r^3} = -\frac{1}{h}\frac{d}{dt}\left(\frac{x}{r}\right),$$

and, similarly, $$\frac{x}{r^3} = \frac{1}{h}\frac{d}{dt}\left(\frac{y}{r}\right).$$

The equations of motion, therefore, become

$$\frac{d^2x}{dt^2} = -\frac{\mu}{h}\frac{d}{dt}\left(\frac{y}{r}\right),$$

$$\frac{d^2y}{dt^2} = \frac{\mu}{h}\frac{d}{dt}\left(\frac{x}{r}\right).$$

Integrating, we get

$$\frac{dx}{dt} = -\frac{\mu}{h}\left(\frac{y}{r} - \gamma\right),$$

$$\frac{dy}{dt} = \frac{\mu}{h}\left(\frac{x}{r} - \lambda\right),$$

and since

$$x\frac{dy}{dt} - y\frac{dx}{dt} = h,$$

we have

$$\frac{\mu x}{h}\left(\frac{x}{r} - \lambda\right) + \frac{\mu y}{h}\left(\frac{y}{r} - \gamma\right) = h,$$

which leads to

$$r = \frac{h^2}{\mu} + \lambda x + \gamma y,$$

which is Laplace's equation. Comparing this with the form

$$\rho = Ax + By + C,$$

we find, as it ought to be,

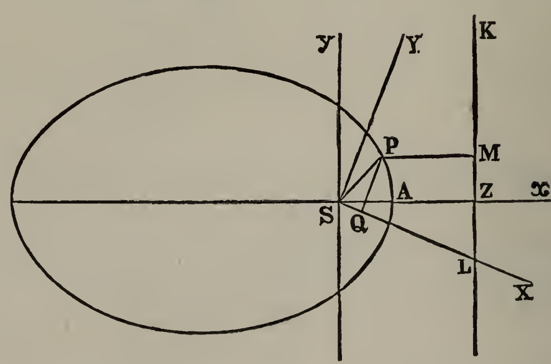
$$C = \frac{h^2}{\mu} = \text{semi-latus-rectum}.$$

This shews why, in integrating the equation

$$dr = \lambda dx + \gamma dy,$$

Laplace at once puts $\frac{h^2}{\mu}$ for the constant of integration.

§. 19. **Geometric interpretation.**—The subject may be made still clearer by the help of a diagram. The ellipse is originally referred to rectangular axes through the focus S; suppose that the coordinate axes revolve round the origin, making an angle XSx $(=\theta)$ with the former position. Then, we have



$$e.\ \mathrm{PM}=\mathrm{PS},$$

whence

$$e^2.\ \mathrm{PM}^2=\mathrm{PS}^2=\mathrm{SQ}^2+\mathrm{QP}^2$$
$$=x^2+y^2.$$

But, as PM is parallel to SZ, we have

$$\mathrm{PM}=p-x\cos\theta-y\sin\theta,$$

which gives

$$(ep-ex\cos\theta-ey\sin\theta)^2=x^2+y^2,$$

as might also have been obtained, but not so easily, by putting

$$x=\ \ \mathrm{X}\cos\theta+\mathrm{Y}\sin\theta$$
$$y=-\mathrm{X}\sin\theta+\mathrm{Y}\cos\theta$$

in the equation

$$\frac{(x+ae)^2}{a^2}+\frac{y^2}{b^2}=1.$$

Comparing this with the equation

$$(\mathrm{C}+\mathrm{A}x+\mathrm{B}y)^2=\rho^2=x^2+y^2,$$

we get

$$\mathrm{C}=ep,\ \mathrm{A}=-e\cos\theta,\ \mathrm{B}=-e\sin\theta,$$

whence, as before,

$$e^2=\mathrm{A}^2+\mathrm{B}^2.$$

Also $$\tan\theta=-\frac{\mathrm{B}}{\mathrm{A}},$$

and $$p=\frac{\mathrm{C}}{e}=\frac{\mathrm{C}}{\sqrt{\mathrm{A}^2+\mathrm{B}^2}}.$$

Now, when $\theta=0$, the new axis of X coincides with the major axis of the ellipse; but, when $\theta=0$, we have also $\mathrm{B}=0$, by virtue of the relation

$$\tan\theta=-\frac{\mathrm{B}}{\mathrm{A}};$$

therefore

$$(\mathrm{C}+\mathrm{A}x)^2=x^2+y^2,$$

and, putting $x=0$, this gives, as before,

$$y=\mathrm{C}=\frac{h^2}{\mu}.$$

Again, the equation of the directrix is

$$x\cos\theta+y\sin\theta=p,$$

which, by substituting for θ and p, gives

$$\mathrm{A}x+\mathrm{B}y+\mathrm{C}=0,$$

and this agrees with our previous result.

It may be noticed that Gauss uses this form of the equation of a conic, and calls it the "*characteristic equation*" (*Theoria Motus*, §. 3). It is easy to see that when $\mathrm{B}=0$, we have $\mathrm{A}=e$, and

$$\rho = C + ex,$$

which is the form finally adopted by Gauss. Since $x = \rho \cos \theta$, we have

$$\rho = \frac{C}{1 - e \cos \theta},$$

which is the ordinary polar equation. If $A = B = 0$, we have

$$\rho = \frac{h^2}{\mu},$$

which is the circle. The whole theory of lines of the second order may be based on the form

$$\rho = C + ex,$$

and, by means of this equation, Gauss has deduced the most complicated properties of elliptic motion with remarkable ease and elegance.

§. 20. **Eccentricity.**—If we square the equation

$$\rho = Ax + By + C,$$

and compare the result with the standard form

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0,$$

we have, by equating coefficients,

$$\frac{a}{c} = \frac{A^2 - 1}{C^2}, \quad \frac{h}{c} = \frac{AB}{C^2}, \quad \frac{b}{c} = \frac{B^2 - 1}{C^2}.$$

Therefore

$$\frac{(a-b)^2 + 4h^2}{c^2} = \frac{(A^2 - B^2)^2}{C^4} + \frac{4A^2B^2}{C^4} = \frac{(A^2 + B^2)^2}{C^4} = \frac{e^4}{C^4},$$

and

$$\frac{ab - h^2}{c^2} = \frac{(A^2 - 1)(B^2 - 1) - A^2B^2}{C^4} = \frac{1 - e^2}{C^4},$$

which lead to

$$e^4 + \frac{(a-b)^2 + 4h^2}{ab - h^2}(e^2 - 1) = 0,$$

and this is the well-known equation for the eccentricity (§. 13).

The value of the eccentricity in oblique axes may also be obtained from Laplace's equation; for, if p be the perpendicular on the directrix from any point on the curve

$$\rho = Ax + By + C,$$

we have
$$\rho = ep,$$

and
$$p = \frac{(Ax + By + C) \sin \omega}{\sqrt{A^2 + B^2 - 2AB \cos \omega}},$$

whence

$$e^2 = \frac{A^2 + B^2 - 2AB \cos \omega}{\sin^2 \omega}. \qquad \text{............} \ (73)$$

Now, squaring Laplace's equation, and substituting for ρ^2, remembering that in oblique axes

$$\rho^2 = x^2 + y^2 + 2xy \cos \omega,$$

we get

$$(A^2-1)\,x^2+2\,(AB-\cos\omega)\,xy+(B^2-1)\,y^2+2ACx+2BCy+C^2=0,$$

a comparison of which with the standard equation

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

gives

$$\frac{a}{c}=\frac{A^2-1}{C^2},\ \frac{h}{c}=\frac{AB-\cos\omega}{C^2},\ \frac{b}{c}=\frac{B^2-1}{C^2},$$

whence

$$\frac{a+b-2h\cos\omega}{c}=\frac{A^2+B^2-2AB\cos\omega-2\sin^2\omega}{C^2}$$
$$=\frac{(e^2-2)\sin^2\omega}{C^2},$$

and

$$\frac{ab-h^2}{c^2}=\frac{\sin^2\omega-(A^2+B^2-2AB\cos\omega)}{C^4}$$
$$=\frac{(1-e^2)\sin^2\omega}{C^4},$$

by substitution from the value of e^2 in (73). These lead to the familiar result

$$\frac{(e^2-2)^2}{1-e^2}=\frac{(a+b-2h\cos\omega)^2}{(ab-h^2)\sin^2\omega}.$$

§. 21. *Area of a triangle.*

§. 21. **Triangle formed by two tangents.**—We now proceed to investigate the area of the triangle formed by two tangents drawn from any point to the general conic, and the chord of contact. For this purpose, we will first confine our attention to the simple case when the tangents are drawn from the origin, and then an easy application of invariants will smoothly lead to the solution of the general problem.

The tangents which can be drawn from the origin to the conic

$$S\equiv ax^2+2hxy+by^2+2gx+2fy+c=0$$

are given by (Salmon's *Conics*, §. 147, Ed. 1879, p. 149)

$$(ac-g^2)\,x^2+2\,(ch-gf)\,xy+(bc-f^2)\,y^2=0, \quad \ldots (74)$$

and the chord of contact being the polar of the origin is

$$gx+fy+c=0. \quad \ldots\ldots\ldots\ldots (75)$$

The area of the triangle formed by the intersection of the lines in (74) and (75) is at once written down by substitution in (31), *viz.*,

$$(\text{Area})^2=-\frac{c^3\,(af^2+bg^2+ch^2-2fgh-abc)}{af^2-2fgh+bg^2},$$

which may be written

$$\text{Area}=\frac{c\sqrt{-c\,\Delta}}{\{(ab-h^2)\,c-\Delta\}} \quad \ldots\ldots\ldots (76)$$

Now, if the tangents are drawn from any point (x', y') to the conic S, we may make that point our new origin, and by this transformation we know that c is changed into the point-function S′, while Δ and $(ab-h^2)$, being translation-invariants, remain unaltered by the transformation; hence, as a generalization of (76), we are able to enunciate the following general

Theorem.—If from any point (x', y'), tangents are drawn to the conic

$$ax^2+2hxy+by^2+2gx+2fy+c=0$$

the area of the triangle formed by the two tangents with their chord of contact is

$$\frac{S'\sqrt{-\Delta S'}}{(ab-h^2)\ S'-\Delta}, \qquad \ldots\ldots\ldots\ldots (77)$$

where Δ is the discriminant and S′ the point-function of the conic.

A variety of particular theorems may be deduced from this general formula; thus, if the curve is a parabola, the area in question is

$$S'\sqrt{-\frac{S'}{\Delta}};$$

and, if, further, the point from which the tangents are drawn be the origin, we have the theorem that, if the general equation of the second degree represents a parabola, and two tangents be drawn from the origin to the curve, the area of the triangle formed by the two tangents and the chord of contact is

$$\frac{c\sqrt{c}}{\sqrt{a} \backsim g\sqrt{b}}.$$

Again, the chord of contact being the polar of (x', y') with respect to the conic, has for its equation

$$(ax'+hy'+g)\ x+(hx'+by'+f)\ y+gx'+fy'+c=0,$$

and, therefore, if p be the perpendicular let fall on this chord from (x', y'), we have easily

$$p^2=\frac{S'^2}{(ax'+hy'+g)^2+(hx'+by'+f)^2} \qquad \ldots\ldots (78)$$

But, if $D \equiv 0$ be the equation of the director-circle of the conic, and, therefore, D′ its point-function, we have from (60)

$$(ax'+hy'+g)^2+(hx'+by'+f)^2=(a+b)\ S'-D'.$$

Hence (78) gives

$$p^2=\frac{S'^2}{(a+b)\ S'-D'}. \qquad \ldots\ldots\ldots\ldots (79).$$

It is now easy to find the length of the chord intercepted between the points of contact of the tangents, for if λ be the length sought, we have

$$\lambda = \frac{2(\text{Area of triangle})}{p},$$

which, by the help of equation (77), reduces to

$$\lambda = \frac{2\sqrt{\{\Delta S' D' - (a+b)\ \Delta S'^2\}}}{(ab-h^2)\ S' - \Delta}.$$

Hence, we have the

Theorem.—If from any point (x', y') two tangents be drawn to a conic given by the general equation, the length of the chord of contact is

$$\frac{2\sqrt{\{\Delta S' D' - (a+b)\ \Delta S'^2\}}}{(ab-h^2)\ S' - \Delta}, \qquad \ldots\ldots (80)$$

where S′, D′ are the point-functions of the conic and of its director-circle, respectively.

Various particular cases may be deduced from the general formula in (80). Thus, if the tangents be drawn from any point on the director-circle, that is, if the tangents be orthogonal, the length of the chord of contact is

$$\frac{2S'\sqrt{-(a+b)\ \Delta}}{(ab-h^2)\ S' - \Delta}.$$

Again, if two tangents be drawn from the directrix of a parabola to the curve, the length of the chord is

$$2S'\sqrt{-\frac{a+b}{\Delta}} = 2S'.\frac{\sqrt{a+b}}{f\sqrt{a} - g\sqrt{b}}.$$

If the curve is an equilateral hyperbola, the director-circle degenerates into the centre of the conic, and the chord in question, being the line at infinity, is of infinite length; this also follows from (80), for in this case

$$D' = 0,\ S' = \frac{\Delta}{ab-h^2},\ a+b=0,$$

so that the numerator becomes the square root of a zero-quantity, while the denominator also vanishes, and, therefore, the limiting value of the apparently indeterminate expression is really infinite.

Again, we can easily find the area of the triangle formed by the chord of contact with the lines joining the centre to the points of contact. For the chord of contact, being the polar of (x', y'), is

$$(ax'+hy'+g)x + (hx'+by'+f)y + gx'+fy'+c = 0, \quad \ldots (81)$$

and the centre being

$$\left(\frac{hf-bg}{ab-h^2}, \frac{hg-af}{ab-h^2}\right),$$

the perpendicular from the centre on the line in (81) is given by

$$\left\{(ax'+hy'+g)(hf-bg)+(hx'+by'+f)(hg-af)+(gx'+fy'+c)(ab-h^2)\right\}$$
$$\div (ab-h^2)\left\{(ax'+hy'+g)^2+(hx'+by'+f)^2\right\}^{\frac{1}{2}}.$$

If, therefore, p_1 be the length of the perpendicular in question, this reduces to

$$p_1 = \frac{\Delta}{(ab-h^2)\sqrt{\left\{(a+b)S'-D'\right\}}} \quad \ldots\ldots\ldots (82)$$

Hence, as the length of the chord is given in (80), the area of the triangle is written down to be

$$\tfrac{1}{2}p_1\lambda = \frac{\Delta\sqrt{-\Delta S'}}{(ab-h^2)\left\{(ab-h^2)S'-\Delta\right\}} \quad \ldots\ldots\ldots (83)$$

It must be carefully noticed that the two triangles whose areas are given in (77) and (83), being on opposite sides of the chord of contact, are affected with opposite signs; hence their algebraic sum establishes the truth of a property enunciated by Prof. Nash, *viz.*, we have the following

Theorem.—If two tangents are drawn from any point (x', y') to the conic

$$ax^2+2hxy+by^2+2gx+2fy+c=0,$$

the area of the quadrilateral formed by the two tangents and the two lines joining the centre to the points of contact is

$$\frac{\sqrt{-\Delta S'}}{ab-h^2}, \quad \ldots\ldots\ldots\ldots (84)$$

where S′ is the point-function of the conic.

It is easy to remark that the geometrical meaning of the equation of the conic is that, when the area of the quadrilateral vanishes, the locus of the point must be the curve itself. Again, since we know from geometry that the area of the quadrilateral is real or imaginary according as the point is outside or inside the curve, we infer from (84) that any given point is inside or outside the curve according as $\Delta S'$ is positive or negative, which is equivalent to the statement that the point is inside or outside according as the discriminant and the point-function have the same or different signs, and the same result, of course, also follows from the formula in (77). Here we may add that if from any point two tangents be drawn to a conic, the angle between the two tangents will be real, only if a certain relation holds amongst the coefficients in the equation of the conic; thus, first taking the simple case when the tangents are drawn from the origin, we have the tangents given by equation (74), *viz.*

$$(ac-g^2)x^2+2(ch-fg)xy+(bc-f^2)y^2=0,$$

and clearly the angle between these two lines will be real, if

$$(ch-fg)^2 > (ac-g^2)(bc-f^2)$$

or

$$\Delta < 0.$$

Hence, remembering that the discriminant is a translation-invariant, we can at once generalize the theorem to the case where the tangents are drawn from any point, *viz.*, the angle between the tangents is real, if the discriminant is negative; but we have shewn that, if the tangents are real and the point outside the curve, the discriminant and the point-function must have different signs, so that, as the discriminant is negative, the point-function must be positive; hence, finally, we have the very simple

Theorem.—Any point is outside a conic, on the curve, or inside it, according as the point-function is positive, zero, or negative.

§§. 22—23. *Inclinations of tangents to conics.*

§. 22. **Theorem.**—We shall now prove a theorem which shews how some well-known properties of the circle and the ellipse are correlated.

Consider the conic

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1 \qquad \text{............ (85)}$$

where b^2 is essentially indeterminate in sign and value. The tangents at any two points (x_1, y_1), (x_2, y_2) are

$$\frac{xx_1}{a^2}+\frac{yy_1}{b^2}=1 \qquad \text{............ (86)}$$

$$\frac{xx_2}{a^2}+\frac{yy_2}{b^2}=1, \qquad \text{............ (87)}$$

and their chord of contact is

$$\frac{x\ (x_1+x_2)}{a^2}+\frac{y(y_1+y_2)}{b^2}=\frac{x_1x_2}{a^2}+\frac{y_1y_2}{b^2}+1 \qquad \text{......... (88)}$$

Hence, if θ, ϕ, ψ be the angles of inclination of the two tangents and of their chord of contact to a directrix, we have

$$\tan\ \theta=-\frac{a^2}{b^2}\cdot\frac{y_1}{x_1} \qquad \text{............ (89)}$$

$$\tan\ \phi=-\frac{a^2}{b^2}\cdot\frac{y_2}{x_2} \qquad \text{............ (90)}$$

$$\tan\ \psi=-\frac{a^2}{b^2}\cdot\frac{y_1+y_2}{x_1+x_2} \qquad \text{............ (91)}$$

Substituting for y_1, y_2 from (89) and (90) in

$$\frac{x_1^2}{a^2}+\frac{y_1^2}{b^2}=1,\ \ \frac{x_2^2}{a^2}+\frac{y_2^2}{b^2}=1,$$

we have

$$x_1=\frac{a^2}{\sqrt{a^2+b^2\tan^2\theta}},\quad x_2=\frac{a^2}{\sqrt{a^2+b^2\tan^2\phi}} \qquad \text{...... (92), (93)}$$

But, substituting for y_1, y_2 from (89) and (90) in (91), we have

$$\tan\psi=\frac{x_1\tan\theta+x_2\tan\phi}{x_1+x_2} \qquad \dots\dots\dots\dots (94)$$

Now, assume

$$a^2+b^2\tan^2\theta=\frac{a^2\lambda^2}{\cos^2\theta},$$

$$a^2+b^2\tan^2\phi=\frac{a^2\mu^2}{\cos^2\phi},$$

so that

$$\lambda^2=1-e^2\sin^2\theta,\ \mu^2=1-e^2\sin^2\phi,$$

and
$$x_1=\frac{a\cos\theta}{\lambda},\ x_2=\frac{a\cos\phi}{\mu}.$$

Substituting these values in (94), we arrive at the following symmetrical theorem, *viz.*, if θ, ϕ, ψ be the angles of inclination of any two tangents to a conic and of their chord of contact to a directrix, we have

$$\tan\psi=\frac{\lambda^{-1}\sin\theta+\mu^{-1}\sin\phi}{\lambda^{-1}\cos\theta+\mu^{-1}\cos\phi},$$

where the eccentricity of the conic is given by

$$e^2=\frac{1-\lambda^2}{\sin^2\theta}=\frac{1-\mu^2}{\sin^2\phi}.$$

(See *Educational Times*, November 1885, my Ques. 8337).

§. 23. **Applications.**—To verify the truth of this theorem, we proceed to some applications. In the parabola, $e=1$, so that

$$\lambda=\cos\theta,\ \mu=\cos\phi,$$

which give

$$2\tan\psi=\tan\theta+\tan\phi,$$

a result which can be proved independently, and is often useful in the elementary theory of projectiles. The particular case of the circle is specially interesting. Here $e=0$, and $\lambda=\mu=1$, whence

$$\tan\psi=\frac{\sin\theta+\sin\phi}{\cos\theta+\cos\phi}=\tan\frac{\theta+\phi}{2},$$

and
$$2\psi=\theta+\phi,$$
$$\text{or}\quad \psi-\theta=\phi-\psi.$$

To see the geometric meaning of this analytic condition, observe that, in the circle, the foci coincide with the centre, and the position of the axes becomes essentially indeterminate, while the directrix is situated at an infinite distance. Now draw any two tangents OA, OB to a circle, and let OA, OB, BA intersect the line at infinity in the points C, D, E; $\angle OCD=\theta$, $\angle ODC=-\phi$, $\angle BEC=\psi$, ϕ being taken negative as it is measured in a direction opposite to that in which θ, ψ are measured;

hence we have

$$\angle OAB = \angle CAE = \theta - \psi$$
$$\angle OBA = \psi - \phi.$$

Therefore $\angle OAB = \angle OBA$, and $OA = OB$, just as it should be, so that the geometric meaning is the equality of two tangents to a circle drawn from any external point. Lastly, if we draw any two tangents OA, OB to any conic, and, if OA, OB, BA intersect a directrix at C, D, E, we have as before

$$\angle OAB = \theta - \psi, \ \angle OBA = \psi - \phi.$$

Now draw through the centre two radii-vectores of the curve (ρ_1, ρ_2), making angles θ, ϕ with the conjugate axis; then, from the polar equation to the curve, we have

$$\rho_1^2 = \frac{b^2}{1 - e^2 \sin^2\theta}, \ \rho_2^2 = \frac{b^2}{1 - e^2 \sin^2\phi},$$

so that

$$\rho_1 = \frac{b}{\lambda}, \ \rho_2 = \frac{b}{\mu},$$

which furnish the geometrical meanings of the symbols λ, μ in the statement of the theorem. Substituting for λ, μ in our original equation, we have

$$\tan \psi = \frac{\rho_1 \sin \theta + \rho_2 \sin \phi}{\rho_1 \cos \theta + \rho_2 \cos \phi},$$

whence

$$\frac{\rho_1}{\rho_2} = \frac{\sin (\psi - \phi)}{\sin (\theta - \psi)} = \frac{OA}{OB},$$

and this asserts that the tangents OA, OB are proportional to the central radii-vectores which are obviously parallel to them. In the case of the circle, the indeterminateness in the position of the axes makes all the radii-vectores equal, so that, as shewn before,

$$OA = OB, \ \psi - \phi = \theta - \psi.$$

It may be remarked that we might have started from the polar instead of the Cartesian equations, as just shewn, and thus worked up to the value of $\tan \psi$ given above; it is also useful to notice that, though the theorem was obtained from a very particular form of the equation of a central conic, it is perfectly true for the general conic, inasmuch as the eccentricity only appears in the final result.

§. 24. *Similar Conics.*

§. 24. **Generation of Similar Conics.** Given any conic, any other conic which is concentric with it, and similar and similarly situated, may be generated as the locus of a point through which any two chords of the conic being drawn at right angles to each other, the sum of the reciprocals of the rectangles under the segments of each chord is constant, the variation of this constant furnishing the different members of the family of similar conics.

Let

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0 \quad \ldots\ldots\ldots\ldots (95)$$

be the primitive conic, and (x', y') the point through which the chords are drawn at right angles to each other and whose locus we seek. Transferring the origin to this point, the conic becomes

$$ax^2 + 2hxy + by^2 + 2g'x + 2f'y + c' = 0 \quad \ldots\ldots\ldots\ldots (96)$$

where c' is the point-function. The polar form of this equation is

$$(a \cos^2\theta + 2h \cos\theta \sin\theta + b \sin^2\theta)\,\rho^2 + 2(g' \cos\theta + f' \sin\theta)\,\rho + c' = 0 \ \ldots \ (97)$$

Hence, if ρ_1, ρ_2 be the segments of the chord drawn through the new origin, inclined at an angle θ to the axis of x, and ρ_3, ρ_4 the segments of the chord at right angles, we have, from (97),

$$\rho_1\,\rho_2 = \frac{c'}{a\cos^2\theta + 2h\cos\theta\sin\theta + b\sin^2\theta},$$

$$\rho_3\,\rho_4 = \frac{c'}{a\sin^2\theta - 2h\sin\theta\cos\theta + b\cos^2\theta}$$

so that

$$\frac{1}{\rho_1\,\rho_2} + \frac{1}{\rho_3\,\rho_4} = \frac{a+b}{c'},$$

which shews that the sum of the reciprocals of the rectangles is independent of the direction of the chord, and for any given value of this sum, say $\frac{1}{k^2}$, the locus of (x', y') is given by

$$\frac{a+b}{c'} = \frac{1}{k^2},$$

which may be written

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = k^2\,(a+b) \quad \ldots\ldots\ldots\ldots (98)$$

and this, of course, represents a conic concentric with the primitive one given by (95), and similar and similarly situated; and we get a family of similar conics by assigning all possible values to k. It is interesting to remark that the property established here is general in a twofold sense, *viz.*, if the sum of the reciprocals of the rectangles under the segments is to be constant, the point may be any point on the conic given by (98), and the chords may be inclined at any angle to the axis of x, provided they include a right angle. The same results, of course, could have been obtained by applying the process to each of the conics separately, *viz.*, if we have the central conic

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1,$$

the value of

$$\frac{1}{\rho_1 \rho_2}+\frac{1}{\rho_3 \rho_4}$$

is found to be

$$\frac{\frac{1}{a^2}+\frac{1}{b^2}}{\frac{x'^2}{a^2}+\frac{y'^2}{b^2}-1},$$

and the locus in question is

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=k^2\left(\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{k^2}\right).$$

Similarly, if we have the parabola

$$y^2=4ax,$$

the value of

$$\frac{1}{\rho_1 \rho_2}+\frac{1}{\rho_3 \rho_4}$$

is

$$\frac{1}{y'^2-4ax'},$$

and the locus sought is

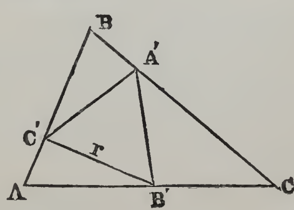
$$y^2-4ax=k^2.$$

Lastly, as in the equilateral hyperbola, we have $(a+b)=0$, the required conic-locus is the given conic itself, and we have the following

Theorem.—If through a given point P in the plane of any conic, any two chords be drawn mutually at right angles, the sum of the reciprocals of the rectangles under the segments is constant; and, for different values of this constant, the locus of P is a family of concentric, similar and similarly situated conics, which, however, all merge into the primitive conic when it is an equilateral hyperbola. (Cf. Salmon's *Conics*, §. 181, Ex. 2, Ed. 1879, p. 175).

§. 25. *Theory of Envelopes.*

§. 25. **On Three Parabolic Envelopes.**—As an illustration of the theory of envelopes, we proceed to discuss the envelopes of the sides of all equilateral triangles inscribed in a given triangle.



Let ABC be the given triangle, and A'B'C' an equilateral triangle inscribed in it; let r be the side of this equilateral triangle, and let $\angle AC'B'=\frac{\pi}{3}+\theta$, so that $\angle A'C'B=\frac{\pi}{3}-\theta$, $\angle BA'C'=\frac{2\pi}{3}+\theta-B$,

$\angle AB'C' = \frac{2\pi}{3} - \theta - A$. Then, in order to find the envelope of B′C′, take AC, AB as the axes of x and y respectively, so that the equation of B′C′ is

$$\frac{x}{AB'} + \frac{y}{AC'} = 1 \qquad \text{............ (99)}$$

Now, we have from the geometry of the figure

$$AC' = \frac{r}{\sin A} \sin\left(\frac{2\pi}{3} - \theta - A\right), \qquad \text{............ (100)}$$

$$AB' = \frac{r}{\sin A} \sin\left(\frac{\pi}{3} + \theta\right), \qquad \text{............ (101)}$$

while

$$c = AB = AC' + C'B$$

gives

$$\frac{c}{r} = \frac{\sin\left(\frac{2\pi}{3} - \theta - A\right)}{\sin A} + \frac{\sin\left(\frac{2\pi}{3} + \theta - B\right)}{\sin B}$$

$$= \left\{\frac{\sin\left(\frac{2\pi}{3} - A\right)}{\sin A} + \frac{\sin\left(\frac{2\pi}{3} - B\right)}{\sin B}\right\} \cos\theta$$

$$+ \left\{\frac{\cos\left(\frac{2\pi}{3} - B\right)}{\sin B} - \frac{\cos\left(\frac{2\pi}{3} - A\right)}{\sin A}\right\} \sin\theta,$$

which may be written in the form

$$\frac{c}{r} = P\cos\theta + Q\sin\theta, \qquad \text{............ (102)}$$

where

$$P = 1 + \frac{\sqrt{3}}{2}(\cot A + \cot B) \qquad \text{............ (103)}$$

$$Q = \tfrac{1}{2}(\cot A - \cot B) \qquad \text{............ (104)}$$

The equation of B′C′ in (99), therefore, reduces to

$$\frac{\sin A}{\sin\left(\frac{\pi}{3} + \theta\right)} x + \frac{\sin A}{\sin\left(\frac{2\pi}{3} - \theta - A\right)} y = r,$$

which may be written

$$\left\{x \sin\left(\frac{2\pi}{3} - A\right) + y \sin\frac{\pi}{3}\right\} \cos\theta + \left\{y \cos\frac{\pi}{3} - x\cos\left(\frac{2\pi}{3} - A\right)\right\} \sin\theta$$

$$= \frac{r}{\sin A}. \ \sin\left(\frac{\pi}{3} + \theta\right) \sin\left(\frac{2\pi}{3} - \theta - A\right)$$

$$= \frac{r}{2\sin A}\left\{\cos\left(\frac{\pi}{3} - 2\theta - A\right) + \cos A\right\},$$

and this may be written

$$r\left\{\cos A+\cos\left(\frac{\pi}{3}-A-2\theta\right)\right\}=E\cos\theta+F\sin\theta, \quad \ldots \quad (105)$$

where

$$E=2\sin A\left\{x\sin\left(\frac{2\pi}{3}-A\right)+y\sin\frac{\pi}{3}\right\} \quad \ldots\ldots\ldots\ldots \quad (106)$$

$$F=2\sin A\left\{y\cos\frac{\pi}{3}-x\cos\left(\frac{2\pi}{3}-A\right)\right\} \quad \ldots\ldots\ldots\ldots \quad (107)$$

Eliminating r between (102) and (105), we have

$$2c\left\{\cos A+\cos\left(\frac{\pi}{3}-A-2\theta\right)\right\}$$

$$=PE.\,2\cos^2\theta+QF.\,2\sin^2\theta+(QE+PF).\,2\sin\theta\cos\theta.$$

Assuming, therefore, $2\theta=\phi$, this may be written

$$2c\cos A+2c\cos\left(\frac{\pi}{3}-A-\phi\right)$$

$$=PE+QF+(PE-QF)\cos\phi+(QE+PF)\sin\phi$$

Expanding $\cos\left(\frac{\pi}{3}-A-\phi\right)$, and arranging the coefficients of $\sin\phi$ and $\cos\phi$, this may be written

$$M\sin\phi+N\cos\phi=K \quad \ldots\ldots\ldots\ldots \quad (108)$$

where

$$M=QE+PF-2c\sin\left(\frac{\pi}{3}-A\right) \quad \ldots\ldots\ldots\ldots \quad (109)$$

$$N=PE-QF-2c\cos\left(\frac{\pi}{3}-A\right) \quad \ldots\ldots\ldots\ldots \quad (110)$$

$$K=2c\cos A-PE-QF \quad \ldots\ldots\ldots\ldots \quad (111)$$

The envelope of (108) is obviously

$$M^2+N^2=K^2,$$

and this, being written in the form

$$M^2=(K+N)(K-N),$$

leads, on substitution from (109), (110), and (111), to the equation

$$(QE+PF)^2-4c\sin\left(\frac{\pi}{3}-A\right).\,(QE+PF)+4c^2\sin^2\left(\frac{\pi}{3}-A\right)$$

$$=4c^2\left\{\cos^2 A-\cos^2\left(\frac{\pi}{3}-A\right)\right\}$$

$$-4c\left\{\left[\cos A-\cos\left(\frac{\pi}{3}-A\right)\right]PE+\left[\cos A+\cos\left(\frac{\pi}{3}-A\right)\right]QF\right\}$$

$$+4\,PQEF,$$

which may be written

$$(QE-PF)^2-4c\left[Q.\sin\left(\frac{\pi}{3}-A\right)+P\left\{\cos\left(\frac{\pi}{3}-A\right)-\cos A\right\}\right]E$$
$$-4c\left[P\sin\left(\frac{\pi}{3}-A\right)-Q\left\{\cos\left(\frac{\pi}{3}-A\right)+\cos A\right\}\right]F+4c^2\sin^2 A=0.$$

As E and F are linear functions of x and y, while P and Q are constant quantities, it is clear that this equation of the required envelope represents a parabola, and a diameter of this parabolic envelope is given by

$$QE=PF,$$

which is equivalent to

$$\left\{P.\cos\left(\frac{2\pi}{3}-A\right)+Q\sin\left(\frac{2\pi}{3}-A\right)\right\}x-\left\{P\cos\frac{\pi}{3}-Q\sin\frac{\pi}{3}\right\}y=0,$$

or, since

$$P\cos\left(\frac{2\pi}{3}-A\right)+Q\sin\left(\frac{2\pi}{3}-A\right)=\frac{\sin\left(\frac{\pi}{3}+C\right)}{\sin B},$$

and

$$P\cos\frac{\pi}{3}-Q\sin\frac{\pi}{3}=\frac{\sin\left(\frac{\pi}{3}+B\right)}{\sin B},$$

the equation of the diameter may be written

$$x\sin\left(\frac{\pi}{3}+C\right)-y\sin\left(\frac{\pi}{3}+B\right)=0.$$

The diameter can be geometrically constructed as follows, *viz.*, on BC describe externally an equilateral triangle BDC, and join AD; then AD is the diameter; for, if the point D be (x, y), we have

$$\frac{DC}{y}=\frac{\sin A}{\sin\left(\frac{\pi}{3}+C\right)},\quad \frac{DB}{x}=\frac{\sin A}{\sin\left(\frac{\pi}{3}+B\right)},$$

so that the equation of AD is

$$x\sin\left(\frac{\pi}{3}+C\right)=y\sin\left(\frac{\pi}{3}+B\right),$$

which is also the equation of the diameter.

Again, if we consider the envelopes of the other two sides, they also will be parabolas, and their diameters will be obtained by joining B and C to the remote vertices E and F of the equilateral triangles described externally on the opposite sides; and, since, from elementary geometry, AD, BE, CF intersect in a point, it can easily be shewn, from Euc. III. 22, that the acute angle between any two of them is $\frac{\pi}{3}$. Thus, finally, we have the

Theorems.—The envelopes of the sides of the equilateral triangles which can be inscribed in any given triangle ABC, are three parabolas;

the acute angle between every pair of the three axes is $\frac{\pi}{3}$; if, through the vertices of the given triangle, diameters of the parabolas be drawn, they intersect in a fixed point which may be determined geometrically, *viz.*, if equilateral triangles BDC, CEA, AFB be described externally on the sides, the lines AD, BE, CF are diameters of the enveloping parabolas and meet in a point, the acute angle between each pair being $\frac{\pi}{3}$.

§§. 26—27. *Reciprocal Polars.*

§. 26. **Reciprocal of Central Conic.**—It is well-known that the first focal pedal of a conic, being the locus of the foot of the perpendicular dropped from a focus on any tangent, is, in the case of central conics, the circle described on the axis-major as diameter; hence, as the reciprocal of any curve is the inverse of its pedal, it is clear that the inverse of pedal of the first focal pedal of any central conic is the reciprocal polar of a circle, which reciprocal is known to be a conic; hence it follows that the second pedal of a conic with respect to a focus is the inverse of a conic whose position and magnitude may be determined geometrically. For we know that the reciprocal of a circle of radius a, with respect to a circle of radius k, is a conic which is an ellipse if the origin of reciprocation lies within the given circle, the focus of the conic is at the origin of reciprocation, the semi-latus-rectum is $\frac{k^2}{a}$, the eccentricity is $\frac{c}{a}$, where c is the distance between the centres of the given circle and the circle of reciprocation, and the directrix is a line at right angles to the central line drawn at a distance $\frac{k^2}{c}$ from the origin of reciprocation. Now, in the question under consideration, we have to find the reciprocal of the circle described on the major axis as diameter, with a focus as origin of reciprocation; hence the conic is an ellipse, a focus of which is the focus of the given conic, the semi-latus-rectum is $\frac{k^2}{a}$, the eccentricity is equal to the eccentricity of the given conic, and the directrix is a line at right angles to the axis-major of the given conic, at a distance $\frac{k^2}{ae}$ from the given focus.

These results are easily verified analytically, for the given conic being

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,$$

remove the origin to the focus, say the negative one; then the conic is

$$\frac{(x-ae)^2}{a^2}+\frac{y^2}{b^2}=1,$$

and the first pedal, being the circle on the major axis as diameter, is

$$(x-ae)^2+y^2=a^2,$$

the coordinates of any point on which may be expressed by means of a single parameter, *viz.*,

$$x=a\ (e+\cos\phi),$$
$$y=a\sin\phi,$$

and hence the equation of any tangent may be thrown into the form

$$(x-ae)\cos\phi+y\sin\phi=a.$$

A line at right-angles to this through the origin (which is now the focus) is

$$x\sin\phi-y\cos\phi=0,$$

and, as the second pedal of the conic, or the first pedal of the circle, is the locus of the intersection of the two lines, we have, by solving for $\sin\phi$ and $\cos\phi$,

$$\sin\phi=\frac{ay}{x^2+y^2-aex},\ \cos\phi=\frac{ax}{x^2+y^2-aex},$$

where (x, y) is, of course, a point on the pedal, *viz.*, the actual equation is

$$a^2\ (x^2+y^2)=(x^2+y^2-aex)^2,$$

which quartic, therefore, is the second pedal of the given conic with respect to a focus. To see that this is the inverse of a conic, we have only to take its inverse, *viz.*, substituting for x and y

$$\frac{k^2x}{x^2+y^2},\ \frac{k^2y}{x^2+y^2}$$

respectively, the second-pedal-quartic is seen to be the inverse of

$$a^2\ (x^2+y^2)=(k^2-aex)^2,$$

which is, of course, a conic, *viz.*, this may be written

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=\frac{k^4}{a^2b^2}-\frac{2k^2ex}{ab^2},$$

which is equivalent to

$$\left(\frac{x}{a}-\frac{k^2e}{b^2}\right)^2+\frac{y^2}{b^2}=\frac{k^4}{b^4}.$$

It may be noted that any two conics having a common focus have two of their common chords passing through the intersection of their directrices; in the present case, therefore, two of the chords of intersection of this conic and the given conic are parallel to the directrices; one of these chords is found, by subtracting the equations of the conics, to be the line

$$x=\frac{k^2-b^2}{2ae}.$$

§. 27. **Reciprocal of Evolute of Conic.***—We now purpose to investigate the reciprocal polars of evolutes of conics; but as all central conics are included in the equation

$$\left(\frac{x}{a}\right)^m + \left(\frac{y}{b}\right)^m = 1, \qquad \text{.........} \quad (112)$$

we will discuss the problem with regard to this general case. Since the reciprocal is the inverse of the pedal, and as the pedal of the evolute is the locus of the intersection of the normal and the line drawn at right angles to it through the origin, it is clear that the reciprocal polar of the evolute is the inverse of the locus of the point of intersection of the normal at any point of the curve, and the right line dropped perpendicular to it from the origin. Now, the normal at any point (x, y) of the curve in (112) is

$$\frac{m}{a}\left(\frac{x}{a}\right)^{m-1}(Y-y) = \frac{m}{b}\left(\frac{y}{b}\right)^{m-1}(X-x),$$

where X, Y being the current coordinates, the equation may be written

$$\frac{x^{m-1}}{a^m}Y - \frac{y^{m-1}}{b^m}X = xy\left(\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right). \qquad \text{.........} \quad (113)$$

The straight line through the origin at right angles to this, is

$$\frac{y^{m-1}}{b^m}Y + \frac{x^{m-1}}{a^m}X = 0 \qquad \text{.........} \quad (114)$$

At the common point of intersection of the two lines given by (113) and (114), we have

$$\left\{\frac{x^{2(m-1)}}{a^{2m}} + \frac{y^{2(m-1)}}{b^{2m}}\right\}X = -xy\left(\frac{y^{m-1}}{b^m}\right)\left(\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right) \quad (115)$$

$$\left\{\frac{x^{2(m-1)}}{a^{2m}} + \frac{y^{2(m-1)}}{b^{2m}}\right\}Y = xy\left(\frac{x^{m-1}}{a^m}\right)\left(\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right). \quad (116)$$

If (ξ, η) be the inverse of the point whose coordinates are given by (115) and (116), and k^2 the constant of inversion, we have

$$\xi = \frac{k^2 X}{X^2+Y^2} = -\frac{k^2 y^{m-1}}{xy.\, b^m\left(\dfrac{x^{m-2}}{a^m} - \dfrac{y^{m-2}}{b^m}\right)}. \qquad \text{.........} \quad (117)$$

* The theorems established in this section were discovered by me about three years ago, and were, on the 29th August, 1885, communicated to Mr. W. J. C. Miller, Mathematical Editor of the *Educational Times*, with a view to their publication in that journal. They have since been published as questions 8571, 8707, 8773, 8993, 9049, 9074, 9148, 9162, 9163, 9204; but, while some of these questions have appeared under my name, the others have been, for reasons best known to Mr. Miller himself, ascribed to different gentlemen who had, perhaps, just as much to do with the theorems with which they have been credited, as the proverbial man in the moon.

$$\eta = \frac{k^2 Y}{X^2+Y^2} = \frac{k^2 . x^{m-1}}{xy . a^m \left(\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right)} \qquad \text{............ (118)}$$

If, now, we eliminate x and y between the equations (117) and (118) by virtue of the relation

$$\left(\frac{x}{a}\right)^m + \left(\frac{y}{b}\right)^m = 1,$$

we shall obtain the equation of the locus sought. For this purpose, we find that

$$\left(\frac{\xi}{+a}\right)^{\frac{m}{m-1}} + \left(\frac{\eta}{-b}\right)^{\frac{m}{m-1}}$$

$$= \left\{\frac{-k^2}{abxy\left[\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right]}\right\}^{\frac{m}{m-1}} \qquad \text{............ (119)}$$

and

$$(b\eta)\left(\frac{\xi}{+a}\right)^{\frac{1}{m-1}} + (a\xi)\left(\frac{\eta}{-b}\right)^{\frac{1}{m-1}}$$

$$= k^2 \left\{\frac{-k^2}{abxy\left[\frac{x^{m-2}}{a^m} - \frac{y^{m-2}}{b^m}\right]}\right\}^{\frac{1}{m-1}} \qquad \text{............ (120)}$$

Therefore, finally, replacing (ξ, η) by (x, y), we find from (119) and (120) the

Theorem.—The reciprocal polar of the evolute of

$$\left(\frac{x}{a}\right)^m + \left(\frac{y}{b}\right)^m = 1$$

is the curve

$$k^2 \left\{\left(\frac{x}{+a}\right)^{\frac{m}{m-1}} + \left(\frac{y}{-b}\right)^{\frac{m}{m-1}}\right\}^{\frac{1}{m}}$$

$$= (by)\left(\frac{x}{+a}\right)^{\frac{1}{m-1}} + (ax)\left(\frac{y}{-b}\right)^{\frac{1}{m-1}}, \qquad \text{............ (121)}$$

where k is the radius of the circle of inversion.

A host of interesting results may be obtained by assigning particular values to m and k in (121); a few are noted below.

If $m=2$, $k^2=a^2\mp b^2$, we see that the reciprocal polar of the evolute of the conic

$$\frac{x^2}{a^2}\pm\frac{y^2}{b^2}=1,$$

with regard to the circle described on the line joining the foci as diameter, is the curve

$$\frac{a^2}{x^2}\pm\frac{b^2}{y^2}=1 \qquad \text{............ (122)}$$

which, when the hyperbola is equilateral, becomes

$$\frac{1}{x^2}-\frac{1}{y^2}=\frac{1}{a^2}. \qquad \text{............ (123)}$$

Again, if $m=\frac{2}{3}$, $k=1$, we see that the reciprocal polar of the evolute of the hypocycloid

$$\left(\frac{x}{\alpha}\right)^{\frac{2}{3}}+\left(\frac{y}{\beta}\right)^{\frac{2}{3}}=1$$

is the curve

$$\left(\frac{x^2}{\alpha^2}+\frac{y^2}{\beta^2}\right)^3=\left(\frac{x^4}{\alpha^2}-\frac{y^4}{\beta^2}\right)^2, \qquad \text{............ (124)}$$

the radius of the circle of inversion being unity; if $\alpha=\beta$, the polar equation of the reciprocal polar becomes

$$r=\alpha\sec 2\theta. \qquad \text{............ (125)}$$

Again, since the evolute of the conic

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

is

$$\left(\frac{x}{\alpha}\right)^{\frac{2}{3}}+\left(\frac{y}{\beta}\right)^{\frac{2}{3}}=1,$$

where

$$\alpha=\frac{a^2-b^2}{a},\ \beta=\frac{a^2-b^2}{b},$$

we see, by putting $m=\frac{2}{3}$, $k^2=a^2-b^2$, that the reciprocal polar of the evolute of the evolute of the conic

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,$$

with respect to the circle described on the line joining the foci as diameter, is the curve

$$\left(\frac{a^2}{x^2}+\frac{b^2}{y^2}\right)^3=(a^2x-b^2y)^2 \qquad \text{............ (126)}$$

Again, by putting $m=-2$, and attending to equation (122), it is clear that the reciprocal polar of the evolute of the reciprocal polar of the evolute of the conic

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,$$

with regard to the circle described on the line joining the foci as diameter, is the curve

$$\left\{\left(\frac{x}{a}\right)^{\frac{2}{3}}+\left(\frac{y}{b}\right)^{\frac{2}{3}}\right\}\left\{\left(\frac{x}{y}\right)^{\frac{1}{3}}\left(\frac{x}{b}\right)^{\frac{2}{3}}-\left(\frac{y}{x}\right)^{\frac{1}{3}}\left(\frac{y}{a}\right)^{\frac{2}{3}}\right\}^2=\left(\frac{a}{b}-\frac{b}{a}\right)^2 \quad (127)$$

Here we may remark in passing that since the reciprocal polar of the evolute of the reciprocal polar of any curve can be geometrically proved to be the locus of the extremity of the polar subtangent, it is clear that the curve in (127) is the locus of the extremity of the polar subtangent of the evolute of the conic

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1.$$

Hence, transforming to polar coordinates, we have the

Theorem.—The locus of the extremity of the polar subtangent of the curve

$$\left(\frac{1}{r}\right)^{\frac{2}{3}}=\left(\frac{a\cos\theta}{a^2\cdot\ b^2}\right)^{\frac{2}{3}}+\left(\frac{b\sin\theta}{a^2-b^2}\right)^{\frac{2}{3}},$$

which is, of course, the evolute of the conic, is the curve

$$\left(\frac{a}{b}-\frac{b}{a}\right)^2\frac{1}{r^2}=\left\{\left(\frac{\cos\theta}{a}\right)^{\frac{2}{3}}+\left(\frac{\sin\theta}{b}\right)^{\frac{2}{3}}\right\}\times$$

$$\left\{\cot\theta.\left(\frac{\cos\theta}{b}\right)^{\frac{2}{3}}-\tan\theta\left(\frac{\sin\theta}{a}\right)^{\frac{2}{3}}\right\}^2 \quad \text{............} \quad (128)$$

which is, of course, the polar form of the equation (127).

Again, by putting $m=\frac{1}{2}$, $k^2=ab$, we find that the reciprocal polar of the evolute of the parabola

$$\left(\frac{x}{a}\right)^{\frac{1}{2}}+\left(\frac{y}{b}\right)^{\frac{1}{2}}=1,$$

with respect to a circle of radius $\sqrt{ab}$, is the cubic curve

$$\frac{y}{x}.\ \frac{a-y}{b}+\frac{x}{y}.\ \frac{b-x}{a}=2. \quad \text{............} \quad (129)$$

By the application of the same process to the parabola, a variety of new theorems may be obtained, *viz.*, taking the parabola of the n^{th} degree,

$$y=\lambda x^n, \quad \text{............} \quad (132)$$

the normal at any point (x, y) is

$$\lambda n x^{n-1}.\ \mathrm{Y}+\mathrm{X}=x\left(1+\lambda n y x^{n-2}\right), \quad \text{............} \quad (131)$$

while the line at right angles to this through the origin is

$$Y - \lambda n x^{n-1} X = 0, \qquad \text{............ (132)}$$

so that, at the point of intersection of the lines given by (131) and (132), we have

$$\left\{1 + \lambda^2 n^2 x^{2(n-1)}\right\} Y = \lambda n x^{n-1}. x. (1 + \lambda n y x^{n-2}), \qquad \text{...... (133)}$$

$$\left\{1 + \lambda^2 n^2 x^{2(n-1)}\right\} X = \qquad x\ (1 + \lambda n y x^{n-2}), \qquad \text{...... (134)}$$

and the inverse of the X, Y is given by

$$\xi = \frac{k^2 X}{X^2 + Y^2} = \frac{k^2}{x\,(1 + \lambda n y x^{n-2})} \qquad \text{............ (135)}$$

$$\eta = \frac{k^2 Y}{X^2 + Y^2} = \frac{k^2. \lambda n x^{n-1}}{x\,(1 + \lambda n y x^{n-2})} \qquad \text{............ (136)}$$

where ξ, η are the coordinates of a point on the locus sought; hence, eliminating x, y between the equations (135) and (136), by virtue of the relation in (130), we have, after replacing ξ, η by x, y respectively, the

Theorem.—The reciprocal polar of the evolute of the parabola of the n^{th} degree

$$y = \lambda x^n$$

is the curve

$$y x^{n-2} \left(1 + \frac{1}{n}. \frac{y^2}{x^2}\right)^{n-1} = \lambda n k^{2(n-1)} \qquad \text{............ (137)}$$

where k is the constant of inversion.

As before, by assigning particular values to λ and n in this equation, we may deduce various theorems.

Thus, the reciprocal polar of the evolute of the parabola

$$y^2 = 4ax,$$

with regard to a circle whose diameter is equal to the latus-rectum, is the cubic curve

$$r\ (\cos^2\theta + \cot^2\theta) = 4a \cos\theta, \qquad \text{............ (138)}$$

of which $x = 2a$ is an asymptote.

Again, the reciprocal polar of the evolute of the parabola

$$y^2 = 4ax,$$

with respect to a circle of radius a, is the cubic

$$x^3 = y^2\ (a - 2x), \qquad \text{............ (139)}$$

of which $x = \frac{a}{2}$ is an asymptote.

Again, the reciprocal polar of the evolute of the parabola

$$y^2 = 4a\ (x + a),$$

the focus being now the origin, with regard to a circle whose diameter is equal to the semi-latus-rectum, is the curve

$$r \cot\theta = a \sin\theta, \qquad \text{............ (140)}$$

which represents a circular cubic, of which $x=a$ is an asymptote, and the point at infinity a point of inflexion.

Again, the reciprocal polar of the evolute of the evolute of the parabola

$$y^2=4a\ (x+2a),$$

the origin now being the centre of curvature at the vertex, with respect to a circle of radius a, is the quartic

$$y^2\ (3x^2+2y^2)=a^3\,x^3. \qquad \text{............ (141)}$$

Similarly, the reciprocal polar of the evolute of the parabola

$$y^2=4a\ (x+2a),$$

with respect to a circle of radius k, is the cubic

$$ax^3=k^2y^2.$$

It is useful to notice that if we are given any curve

$$u=f\ (x,\ y)=0, \qquad \text{............ (142)}$$

the normal at any point $(x,\ y)$ is

$$(\mathrm{Y}-y)\ \frac{du}{dx}=(\mathrm{X}-x)\ \frac{du}{dy}, \qquad \text{............ (143)}$$

while the line at right angles to this through the origin is

$$\mathrm{X}\ \frac{du}{dx}+\mathrm{Y}\ \frac{du}{dy}=0. \qquad \text{............ (144)}$$

At the common point of intersection of these two lines, we have

$$\left\{\left(\frac{du}{dx}\right)^2+\left(\frac{du}{dy}\right)^2\right\}\mathrm{X}=-\frac{du}{dy}\left(y\ \frac{du}{dx}-x\ \frac{du}{dy}\right), \qquad \text{............ (145)}$$

$$\left\{\left(\frac{du}{dx}\right)^2+\left(\frac{du}{dy}\right)^2\right\}\mathrm{Y}=\ \frac{du}{dx}\left(y\ \frac{du}{dx}-x\ \frac{du}{dy}\right), \qquad \text{............ (146)}$$

whence it follows that if $(\xi,\ \eta)$ be the point inverse to (X, Y), the coordinates are given by

$$\xi=\frac{k^2\,\mathrm{X}}{\mathrm{X}^2+\mathrm{Y}^2}=-k^2.\frac{\dfrac{du}{dy}}{y\ \dfrac{du}{dx}-x\ \dfrac{du}{dy}} \qquad \text{............ (147)}$$

$$\eta=\frac{k^2\,\mathrm{Y}}{\mathrm{X}^2+\mathrm{Y}^2}=\ k^2.\frac{\dfrac{du}{dx}}{y\ \dfrac{du}{dx}-x\ \dfrac{du}{dy}} \qquad \text{............ (148)}$$

Therefore, the equation of the reciprocal polar of the evolute of the curve given by (142) is obtained by eliminating x and y from the three equations (142), (147), (148); and, the general theory being thus given, the question is reduced to one of elimination.

It is interesting to note that if the coordinates of any point on the given curve can be expressed in terms of a single variable parameter ϕ, the coordinates of the corresponding point on the reciprocal polar of the evolute, may be similarly expressed. For, remembering that

$$\frac{\frac{du}{dx}}{\frac{du}{dy}} = -\frac{dy}{dx},$$

the formulæ in (147) and (148) may be written

$$\xi = k^2 . \frac{1}{y\frac{dy}{dx}+x} = k^2 . \frac{\frac{dx}{d\phi}}{y\frac{dy}{d\phi}+x\frac{dx}{d\phi}}$$

$$\eta = k^2 . \frac{\frac{dy}{dx}}{y\frac{dy}{dx}+x} = k^2 . \frac{\frac{dy}{d\phi}}{y\frac{dy}{d\phi}+x\frac{dx}{d\phi}},$$

so that, if the coordinates of any point on the given curve be given by

$$x = f_1(\phi)$$
$$y = f_2(\phi),$$

we see at once that the coordinates of the corresponding point on the reciprocal polar of the evolute are given by the system

$$\xi = k^2 . \frac{f'_1(\phi)}{f_1(\phi)f'_1(\phi)+f_2(\phi)f'_2(\phi)}.$$

$$\eta = k^2 . \frac{f'_2(\phi)}{f_1(\phi)f'_1(\phi)+f_2(\phi)f'_2(\phi)}.$$

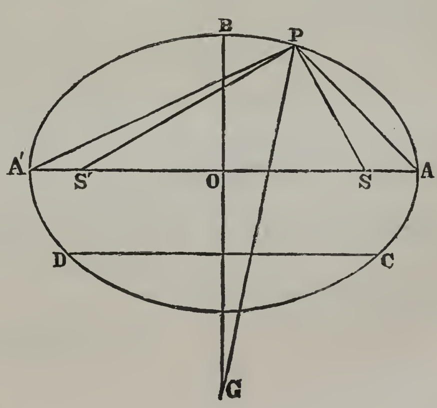
It is clear that the coordinates of any point on the n^{th} "reciprocal polar of evolute" may be obtained from this system; and the coordinates of points on the curves given above may also be expressed by means of a single variable parameter.

§§. 28—29. *Theorems on Central Conics.*

§. 28. **Properties of the Ellipse.**—In this section we shall investigate the truth of some theorems on the ellipse.

I. Let ϕ be the eccentric angle at any point P on the ellipse

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,$$



so that, if A, A′ are the vertices and S, S′ the foci, the coordinates of A, A′, S, S′, P are (a, o), $(-a, o)$, (ae, o), $(-ae, o)$, $(a\cos\phi, b\sin\phi)$, respectively. The equations to PA, PS, PS′, PA′ are easily found, *viz.*,

PA is $\dfrac{x-a\cos\phi}{y-b\sin\phi}=\dfrac{a\cos\phi-a}{b\sin\phi},$

$$\text{or}\qquad y=\frac{b}{a}\frac{\sin\phi}{\cos\phi-1}x-\frac{b\sin\phi}{\cos\phi-1} \qquad\ldots\ldots\ldots\ldots (149)$$

PS is $\dfrac{x-a\cos\phi}{y-b\sin\phi}=\dfrac{a\cos\phi-ae}{b\sin\phi},$

$$\text{or}\qquad y=\frac{b}{a}\frac{\sin\phi}{\cos\phi-e}x-\frac{be\sin\phi}{\cos\phi-e} \qquad\ldots\ldots\ldots\ldots (150)$$

PS′ is $\dfrac{x-a\cos\phi}{y-b\sin\phi}=\dfrac{a\cos\phi+ae}{b\sin\phi},$

$$\text{or}\qquad y=\frac{b}{a}\frac{\sin\phi}{\cos\phi+e}x+\frac{be\sin\phi}{\cos\phi+e} \qquad\ldots\ldots\ldots\ldots (151)$$

PA′ is $\dfrac{x-a\cos\phi}{y-b\sin\phi}=\dfrac{a\cos\phi+a}{b\sin\phi},$

$$\text{or}\qquad y=\frac{b}{a}\frac{\sin\phi}{\cos\phi+1}x+\frac{b\sin\phi}{\cos\phi+1} \qquad\ldots\ldots\ldots\ldots (152)$$

Let p, q be the intercepts made by PA, PA′, and r, s those made by PS, PS′, on the minor axis. Then we have

$$p=\frac{b\sin\phi}{1-\cos\phi},\quad q=\frac{b\sin\phi}{1+\cos\phi},$$

$$r=\frac{be\sin\phi}{e-\cos\phi},\quad s=\frac{be\sin\phi}{e+\cos\phi};$$

so that we get

$$p+q=\frac{2b}{\sin\phi},\quad pq=b^2,\quad \frac{1}{p}+\frac{1}{q}=\frac{2}{b\sin\phi}.$$

$$r+s=\frac{2be^2\sin\phi}{e^2-\cos^2\phi},\quad rs=\frac{b^2e^2\sin^2\phi}{e^2-\cos^2\phi},\quad \frac{1}{r}+\frac{1}{s}=\frac{2}{b\sin\phi}.$$

This shews that the sum of the reciprocals of the intercepts made by PA, PA′ on the minor axis is equal to the sum of the reciprocals of the intercepts made by PS, PS′ on the same axis; it also follows that, since $pq=b^2$, the rectangle under the intercepts made by PA, PA′ is always constant and equal to the square of the semi-axis-minor. Again, p, q are the roots of the quadratic

$$z^2-2b\operatorname{cosec}\phi.\,z+b^2=0. \qquad\ldots\ldots\ldots\ldots (153)$$

Similarly, r, s are the roots of the quadratic

$$z^2-2b\lambda^2\operatorname{cosec}\phi.\,z+b^2\lambda^2=0 \qquad\ldots\ldots\ldots\ldots (154)$$

where λ^2 satisfies the equation

$$\lambda^2=\frac{e^2\sin^2\phi}{e^2-\cos^2\phi},$$

which is equivalent to

$$\frac{\sin^2\phi}{e^2-1}=\frac{\lambda^2}{e^2-\lambda^2}.$$

Again, since the equations of all the four lines PA, PA′, PS, PS′, are known, the angle between any two of them may be found, *viz.*,

$$\tan \text{APA}' = \frac{2\,ab}{(a^2-b^2)\sin\phi} \quad \text{............ (155)}$$

$$\tan\ \text{SPS}' = \frac{2be}{a}.\ \frac{\sin\phi}{1-e^2\ (1+\sin^2\phi)} \quad \text{............ (156)}$$

$$\cot\ \text{SPA} = -\frac{a}{b}.\frac{1+e}{1-e}\left\{\tan\frac{\phi}{2}-\frac{e^2}{1+e}\sin\phi\right\} \quad \text{......... (157)}$$

$$\cot\ \text{S}'\text{PA}' = \frac{a}{b}.\frac{1+e}{1-e}\left\{\cot\frac{\phi}{2}-\frac{e^2}{1+e}\sin\phi\right\}. \quad \text{......... (158)}$$

We have shewn above that

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{r}+\frac{1}{s}=\frac{2}{b\sin\phi}=\frac{2}{\text{ordinate of P}},$$

whence the ordinate of P is a harmonic mean as well between r and s as between p and q. Again, it is evident that the theorem holds, even if S, S′ are not the foci, but any two points on the major axis equidistant from the centre; for, in that case, instead of putting $\text{OS}=ae$, we have to put $\text{OS}=ak$, where k is a certain constant; thus, we have the theorem that the ordinate of any point P is a harmonic mean between the intercepts made on the minor axis by the two lines joining P to two points on the major axis equidistant from the centre.

In order to see whether the formulæ

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{r}+\frac{1}{s}=\frac{2}{y},$$

$$pq=k^2,$$

hold for any curve other than the conic, let us take the inverse question in a more general form, *viz.*, take O as the origin of coordinates, and BOA, OQP any two lines through it, A, B being fixed points; then, if BQ and AP intersect in R, required the locus of R, when

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{r}+\frac{1}{s}=\frac{2}{y},$$

$$pq=k^2,$$

where $\text{OP}=p$, $\text{OQ}=q$. Let α, β be the coordinates of R; $\text{OA}=a$, $\text{OB}=-b$; then

$$\text{RA is } \frac{x-\alpha}{y-\beta}=\frac{a-\alpha}{\beta},$$

$$\text{RB is } \frac{x-\alpha}{y-\beta}=\frac{\alpha+b}{\beta}.$$

But, since $OP = p$, $OQ = q$, we have

$$\frac{-a}{p-\beta} = \frac{\alpha - a}{\beta}, \quad \frac{-a}{q-\beta} = \frac{\alpha + b}{\beta},$$

whence

$$p = \frac{a\beta}{a-\alpha}, \quad q = \frac{b\beta}{\alpha + b}, \qquad \text{............ (159), (160)}$$

so that

$$\frac{1}{p} + \frac{1}{q} = \frac{2}{\beta} + \frac{\alpha\,(a-b)}{ab\,\beta}.$$

Hence the theorem that the ordinate is a harmonic mean between the intercepts holds only when $a = b$, that is, when the line on which the intercepts are made is equidistant from the fixed points; thus, we have the

Theorem.—Given two points and a line equidistant from them; then, taking for axes the given line and the line joining the points, the ordinate of any point is a harmonic mean between the intercepts which the lines joining the point to the given points make on the given line.

Again, if $pq = k^2$, we must have, changing α, β into x, y in (159) and (160),

$$\frac{ay}{a-x} \cdot \frac{by}{x+b} = k^2,$$

which may be written

$$\frac{x^2}{ab} + \frac{y^2}{k^2} + \left(\frac{1}{a} - \frac{1}{b}\right) x = 1,$$

shewing that the theorem holds only when P lies on a conic. In the particular case when the given line is equidistant from the given points, we have $a = b$, and the conic is

$$\frac{x^2}{a^2} + \frac{y^2}{k^2} = 1.$$

If the two lines are also at right angles, they are the axes of the conic, and the given constant k is the semi-axis-minor.

II. To determine the position of a point P on an ellipse such that, if the normal at P intersects the minor axis produced in G, the polar of G may subtend a right angle at P.

Using the same diagram, let the ellipse be

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1,$$

and P the required point where the eccentric angle is ϕ, so that the coordinates of P are $a \cos \phi$, $b \sin \phi$. Then the normal at P is

$$\frac{ax}{\cos \phi} - \frac{by}{\sin \phi} = c^2,$$

so that G is

$$\left(0, -\frac{c^2 \sin \phi}{b}\right).$$

Let CD be the polar of G with respect to the conic, so that CD is parallel to the axis-major and has for its equation

$$y = -\frac{b^3}{c^2 \sin \phi}.$$

Transfer the origin to P, and take the new axes parallel to the old; then the ellipse is

$$\frac{(x+a\cos\phi)^2}{a^2} + \frac{(y+b\sin\phi)^2}{b^2} = 1$$

or $$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{2\cos\phi}{a}x + \frac{2\sin\phi}{b}y = 0 \quad \text{.........} \quad (161)$$

The line CD is

$$y + b\sin\phi = -\frac{b^3}{c^2\sin\phi},$$

or $$y = \lambda \quad \text{.........} \quad (162)$$

where $$\lambda = -\frac{b}{c^2\sin\phi}(a^2\sin^2\phi + b^2\cos^2\phi) \quad \text{.........} \quad (163)$$

Now, PD, PC are two lines through the new origin, and through the intersection of the conic with the line; their equation, therefore, must be

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{2\cos\phi}{\lambda a}xy + \frac{2\sin\phi}{\lambda b}y^2 = 0 \quad \text{.........} \quad (164)$$

These will be at right angles, if

$$\frac{1}{a^2} + \frac{1}{b^2} + \frac{2\sin\phi}{\lambda b} = 0.$$

Substituting for λ from (163) and simplifying, we have

$$\sin^2\phi = \left(1 - \frac{1}{e^2}\right)\left(1 - \frac{2}{e^2}\right) \quad \text{.........} \quad (165)$$

which determines the value of ϕ, and, therefore, of P; it is remarkable that the result is dependent simply on the eccentricity.

III. A very interesting point arises, if we seek the envelope of the sides of any triangle PSS′ having its vertex P at any point on the ellipse, and its base-ends any two points S, S′ on the axis-major, equidistant from the centre, so that OS = OS′ = k. Then, from (150), the equation of PS is

$$y = \frac{b}{a}\cdot\frac{\sin\phi}{\cos\phi - k}x - \frac{bk\sin\phi}{\cos\phi - k},$$

which may be written

$$(bx - akb)\sin\phi - ay\cos\phi = -aky,$$

and the envelope of this for different values of ϕ is

$$(bx - akb)^2 + a^2y^2 = a^2k^2y^2, \quad \text{.........} \quad (166)$$

which is equivalent to

$$b^2(x - ak)^2 = a^2(k^2 - 1)y^2 \quad \text{.........} \quad (167)$$

or $$b(x - ak) = \pm a\sqrt{k^2 - 1}\,y;$$

apparently, therefore, the envelope is a pair of right lines passing through the fixed point (ak, o), and real only if k is greater than unity, that is, if the point S is outside the ellipse. But, looking to the geometry of the figure, it is clear that the envelope must be the given point S, so that the analytical solution furnishes, apparently, a whole line for the envelope, while geometrically only one definite point on that line satisfies the demand of the problem; the discrepancy, however, is only apparent, *viz.*, the equation (167) may be written

$$b^2 (x - ak)^2 + a^2 \left(\sqrt{1 - k^2}\right)^2 y^2 = 0,$$

so that this must be equivalent to

$$\left.\begin{array}{l} x = ak \\ y = 0 \end{array}\right\},$$

which is, of course, the point in question. Such instances of degenerate envelopes are by no means rare.

§. 29. **Properties of Confocals.**

I. Given a system of confocal ellipses, to find the locus of points where the tangents cut off a constant area from the axes.

Any conic of the system is

$$\frac{x^2}{A^2} + \frac{y^2}{B^2} = 1, \qquad \text{............} \quad (168)$$

where, for the moment,

$$A^2 = a^2 + \lambda^2,\ B^2 = b^2 + \lambda^2,\ c^2 = A^2 - B^2 = a^2 - b^2.$$

Take a point (ξ, η) on this ellipse where the eccentric angle is ϕ; the tangent is

$$\frac{x}{A} \cos \phi + \frac{y}{B} \sin \phi = 1,$$

and the intercepts made on the axes are

$$\frac{A}{\cos \phi},\ \frac{B}{\sin \phi},$$

so that, if h^2 be double the constant area in question, we have

$$\frac{AB}{\sin \phi \cos \phi} = h^2 \qquad \text{............} \quad (169)$$

Hence we get the system

$$\xi^2 = A^2 \cos^2 \phi = (a^2 + \lambda^2) \cos^2 \phi, \qquad \text{............} \quad (170)$$

$$\eta^2 = B^2 \sin^2 \phi = (b^2 + \lambda^2) \sin^2 \phi, \qquad \text{............} \quad (171)$$

and from (169)

$$(a^2 + \lambda^2)(b^2 + \lambda^2) = h^4 \sin^2 \phi \cos^2 \phi. \qquad \text{............} \quad (172)$$

The elimination of λ, ϕ from these three equations will lead us to the equation of the locus. For this purpose, observe that from (170) and (171),

$$\xi^2 \eta^2 = (a^2 + \lambda^2)(b^2 + \lambda^2) \sin^2 \phi \cos^2 \phi = h^4 \sin^4 \phi \cos^4 \phi,$$

so that

$$\xi\eta = h^2 \sin^2\phi \cos^2\phi. \qquad \ldots\ldots\ldots\ldots (173)$$

Again, from (170) and (171),

$$\frac{\xi^2}{\cos^2\phi} - \frac{\eta^2}{\sin^2\phi} = a^2 - b^2 = c^2,$$

or

$$\xi^2 \sin^2\phi - \eta^2 \cos^2\phi = c^2 \sin^2\phi \cos^2\phi = \frac{c^2\,\xi\eta}{h^2},$$

from (173).

This may be written

$$\xi^2 \sin^2\phi - \eta^2 (1 - \sin^2\phi) = \frac{c^2}{h^2}\,\xi\eta,$$

whence

$$\sin^2\phi = \frac{\eta^2}{\xi^2+\eta^2} + \frac{c^2}{h^2}\,\frac{\xi\eta}{\xi^2+\eta^2}, \qquad \ldots\ldots\ldots\ldots (174)$$

$$\cos^2\phi = \frac{\xi^2}{\xi^2+\eta^2} - \frac{c^2}{h^2}\,\frac{\xi\eta}{\xi^2+\eta^2}. \qquad \ldots\ldots\ldots\ldots (175)$$

Substituting for $\sin\phi$ and $\cos\phi$ from (174) and (175) in (173), and simplifying, we have

$$(c^2\xi + h^2\eta)(h^2\xi - c^2\eta) = h^2\,(\xi^2+\eta^2)^2,$$

which is the equation of the locus in question. Hence, we have the theorem that the locus of points on a system of confocal ellipses where the tangents cut off a constant area from the axes is the bicircular quartic through the origin

$$(c^2x + h^2y)(h^2x - c^2y) = h^2\,(x^2+y^2)^2, \qquad \ldots\ldots\ldots\ldots (176)$$

where c is half the distance between the foci, and h^2 double the given constant area.

It is not difficult to see that this quartic-locus is the inverse of a central conic, for, substituting for x and y

$$\frac{k^2x}{x^2+y^2}, \text{ and } \frac{k^2y}{x^2+y^2}$$

respectively, we find that the bicircular quartic is the inverse of the conic

$$(c^2x + h^2y)(h^2x - c^2y) = h^2 k^4, \qquad \ldots\ldots\ldots\ldots (177)$$

where k is the radius of inversion; it is easy to see that this conic is an equilateral hyperbola concentric with the confocal ellipses, and, if θ be the inclination of its transverse axis to the line joining the foci of the confocal family, we have

$$\tan 2\theta = \tfrac{1}{2}\left(\frac{h^2}{c^2} - \frac{c^2}{h^2}\right),$$

which furnishes for $\tan\theta$ the two values

$$\frac{h^2-c^2}{h^2+c^2},\ \frac{c^2+h^2}{c^2-h^2}.$$

II. To investigate the locus of points on a system of confocal ellipses, where the eccentric angle has a constant value.

Let any one of the confocal system be

$$\frac{x^2}{A^2}+\frac{y^2}{B^2}=1$$

where $A^2=a^2+\lambda^2$, $B^2=b^2+\lambda^2$; then, if ϕ be the eccentric angle at any point (ξ, η), we have

$$\xi^2=A^2\cos^2\phi=(a^2+\lambda^2)\cos^2\phi,$$
$$\eta^2=B^2\sin^2\phi=(b^2+\lambda^2)\sin^2\phi,$$

so that the locus in question is the hyperbola

$$\frac{\xi^2}{\cos^2\phi}-\frac{\eta^2}{\sin^2\phi}=a^2-b^2=c^2, \quad \text{............} \quad (178)$$

and this is evidently a member of the confocal family; hence it follows that, given a system of confocal ellipses, the locus of points where the eccentric angle has a constant value is one of the confocal hyperbolas which intersect the system orthogonally; in other words, given a confocal system of ellipses and hyperbolas, each hyperbola intersects the ellipses at points where the eccentric angle has a constant value, and, by variation of this constant value, we get all the hyperbolas of the system, and, from a known theorem, the envelope of all these hyperbolas is an imaginary quadrilateral.

Similarly, if we have the hyperbola

$$\frac{x^2}{a^2+\lambda^2}-\frac{y^2}{b^2+\lambda^2}=1,$$

which is one of a confocal system, and ϕ the eccentric angle at any point (ξ, η), we have

$$\xi^2=(a^2+\lambda^2)\sec^2\phi,$$
$$\eta^2=(b^2+\lambda^2)\tan^2\phi,$$

so that, if the eccentric angle has a constant value, the locus is

$$\frac{\xi^2}{\sec^2\phi}-\frac{\eta^2}{\tan^2\phi}=a^2-b^2=c^2 \quad \text{............} \quad (179)$$

and the envelope of this, for different values of the eccentric angle, is the parallelogram formed by the four lines

$$(c^2+y^2-x^2)^2=4c^2y^2, \quad \text{............} \quad (180)$$

viz., the four lines are

$$-c+y+x=0,\ c-y+x=0,\ c+y-x=0,\ c+y+x=0.$$

§§. 30—31. *Theorems on the Parabola.*

§. 30. **A Dynamical Problem.**—Take the parabola

$$y^2=4ax,$$

which, when the origin is removed to a point on the principal axis at a distance na from the vertex, becomes

$$y^2=4a(x+na). \quad \text{............} \quad (181)$$

Imagine a particle to describe the parabola under the action of a force directed to the new origin as centre; and suppose it to be started from the apse with the velocity in a circle at the same distance. Then

$$2y\frac{dy}{dt}=4a\frac{dx}{dt},$$

and
$$\left(\frac{dy}{dt}\right)^2+y\frac{d^2y}{dt^2}=2a\frac{d^2x}{dt^2}.$$

But
$$x\frac{dy}{dt}-y\frac{dx}{dt}=h,$$

so that
$$x\frac{dy}{dt}-\frac{y^2}{2a}\frac{dy}{dt}=h,$$

whence
$$(x+2na)\frac{dy}{dt}=-h.$$

Therefore
$$\frac{h^2}{(x+2na)^2}-\text{P}\frac{y^2}{r}=-2a.\ \text{P}.\ \frac{x}{r},$$

where P is the central force.

This may be written

$$\frac{h^2}{(x+2na)^2}=\frac{\text{P}}{r}(y^2-2ax)=\frac{\text{P}}{r}.\ 2a\ (x+2na),$$

which gives

$$\text{P}=\frac{h^2}{2a}\frac{r}{(x+2na)^3}. \qquad \text{............ (182)}$$

But
$$x^2+y^2=r^2$$
$$y^2=4a\ (x+na).$$

Eliminating y, this gives a quadratic for x, whence we derive

$$x+2na=2a\ (n-1)+\left\{r^2+4a^2(1-n)\right\}^{\frac{1}{2}}.$$

Substituting in (182), we get

$$\text{P}=\frac{h^2}{2a}\frac{r}{\left\{2a\ (n-1)+\sqrt{r^2+4a^2\ (1-n)}\right\}^3} \qquad \text{............ (183)}$$

which gives the law of force in terms of the radius vector. For an interesting discussion of a kinetic difficulty in connection with this dynamical problem, see a note by Dr. Besant in the *Quarterly Journal of Mathematics*, t. XI, 38.

§. 31. **Geometrical Applications.**—Thus far we have solved a purely dynamical question; we now proceed to obtain some interesting geometrical properties of the parabola. We have

$$\text{P}=\frac{h^2}{p^3}\frac{dp}{dr}=-\frac{h^2}{2}\frac{d}{dr}\left(\frac{1}{p^2}\right).$$

Hence, from (183), we get

$$-\frac{a}{p^2}=\int\frac{rdr}{\left\{2a\,(n-1)+\sqrt{\left[r^2+4a^2\,(1-n)\right]}\right\}^3}.$$

If, therefore, we take p for all values of r from $+\infty$ to $-\infty$, we have

$$\Sigma\left(-\frac{a}{p^2}\right)=2\int_{\infty}^{na}\frac{rdr}{\left\{2a\,(n-1)+\sqrt{\left[r^2+4a^2\,(1-n)\right]}\right\}^3} \quad (184)$$

To evaluate this definite integral, let us first take the indefinite form. Put

$$r^2=4a^2\,(1-n)\,\tan^2\phi, \quad \ldots\ldots \quad \ldots \quad (185)$$

$$r=2a\sqrt{1-n}\,\tan\phi,$$

$$dr=2a\sqrt{1-n}\,\sec^2\phi\,d\phi,$$

$$r^2+4a^2\,(1-n)=4a^2\,(1-n)\,\sec^2\phi.$$

If, therefore, I be the indefinite integral, we have

$$\mathrm{I}=\int\frac{4a^2\,(1-n)\,\tan\phi\,\sec^2\phi\,d\phi}{\left\{2a\,(n-1)+2a\sqrt{1-n}\,\sec\phi\right\}^3}$$

$$=\int\frac{4a^2\,(1-n)\,\sin\phi\,d\phi}{\left\{2a\sqrt{1-n}-2a\,(1-n)\,\cos\phi\right\}^3}$$

$$=\int\frac{4a^2\,(1-n)\,\sin\phi\,d\phi}{8a^3\,(1-n)^{\frac{3}{2}}\left\{1-\sqrt{1-n}\,\cos\phi\right\}^3}$$

$$=-\frac{1}{2a\sqrt{1-n}}\int\frac{d\,(\cos\phi)}{\left\{1-\sqrt{1-n}\,\cos\phi\right\}^3}$$

$$=\frac{1}{4a\,(n-1)}\,\frac{1}{\left\{1-\sqrt{1-n}\,\cos\phi\right\}^2}. \quad \ldots\ldots \quad (186)$$

Now, $\sec^2\phi=1+\tan^2\phi=1+\dfrac{r^2}{4a^2\,(1-n)}$, from (185).

Therefore

$$\cos^2\phi=\frac{4a^2\,(1-n)}{r^2+4a^2\,(1-n)},$$

and, when $r=na$, this gives

$$\cos^2\phi=\frac{4\,(1-n)}{(2-n)^2}$$

and, when $r=\infty$,

$$\cos^2\phi=0.$$

These give the limits of the transformed integral; if, therefore, Q be the value of the definite integral, we have

$$Q = -\frac{1}{an^2},$$

so that, from (184), we have

$$a\,\Sigma\left(-\frac{1}{p^2}\right) = 2Q = -\frac{2}{an^2},$$

whence, finally,

$$\Sigma\left(\frac{1}{p^2}\right) = \frac{2}{a^2n^2}. \qquad \text{...........} \quad (187)$$

Hence we have the theorem that, if we take any point on the axis of a parabola whose distance from the vertex is na, the sum of the squares of the reciprocals of all the perpendiculars dropped from this point on successive tangents to the parabola is equal to $\frac{2}{n^2a^2}$. It is obvious that these perpendiculars are the radii-vectores of a pedal of the parabola; hence, the following theorems may be ennunciated.

Theorem I.—A is the vertex and S_1 the focus of a parabola whose latus-rectum is $4a$; points $S_2, S_3, \ldots\ldots S_\infty$ are taken on the principal axis such that $AS_1 = S_1 S_2 = \ldots = a$; the sum of the squares of the reciprocals of the radii-vectores of the pedal of the parabola with regard to S_n is $\frac{2}{n^2a^2}$. (188)

Theorem II.—The sum of the squares of the reciprocals of the radii-vectores of all the pedals of the parabola with regard to $S_1, S_2 \ldots S_\infty$ is

$$= \frac{2}{a^2}\left(\frac{1}{1^2} + \frac{1}{2^2} + \ldots\ldots\right) = \frac{1}{3}\left(\frac{\pi}{a}\right)^2 \qquad \text{.........} \quad (189)$$

Theorem III.—If we take only the odd pedals, the sum of the squares of the reciprocals of all the radii-vectores is

$$= \frac{2}{a}\left(\frac{1}{1^2} + \frac{1}{3^2} + \ldots\ldots\right) = \frac{1}{4}\left(\frac{\pi}{a}\right)^2 \qquad \text{.........} \quad (190)$$

Theorem IV.—If we take only the even pedals, the sum of the squares of the reciprocals of all the radii-vectores is

$$= \frac{2}{a}\left(\frac{1}{2^2} + \frac{1}{4^2} + \ldots\ldots\right) = \frac{1}{12}\left(\frac{\pi}{a}\right)^2 \qquad \text{.........} \quad (191)$$

§. 32. *A Geometrical Locus.*

§. 32. **General Theorem on Conics.**—If from any point P two tangents be drawn to the conic

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, \qquad \text{...............} \quad (192)$$

to investigate the locus of the middle point of the chord of contact when

P is constrained to move on any curve

$$F\ (x, y) = 0. \qquad \ldots\ldots\ldots\ldots\ldots \quad (193)$$

Let θ, ϕ be the eccentric angles at the points of contact of the tangents; then the tangents are

$$\frac{x}{a} \cos\theta + \frac{y}{b} \sin\theta = 1,$$

$$\frac{x}{a} \cos\phi + \frac{y}{b} \sin\phi = 1,$$

and, if X, Y be the coordinates of P, we have

$$X = a. \frac{\cos\frac{\theta+\phi}{2}}{\cos\frac{\theta-\phi}{2}}.$$

$$Y = b. \frac{\sin\frac{\theta+\phi}{2}}{\cos\frac{\theta-\phi}{2}}.$$

If, further, ξ, η be the coordinates of the middle point of the chord of contact the locus of which is sought, we have

$$\xi = \frac{a}{2} (\cos\theta + \cos\phi) \qquad \ldots\ldots\ldots\ldots \quad (194)$$

$$\eta = \frac{b}{2} (\sin\theta + \sin\phi) \qquad \ldots\ldots\ldots\ldots \quad (195)$$

The locus is obtained by eliminating θ, ϕ between these and

$$F \left\{ a \frac{\cos\frac{\theta+\phi}{2}}{\cos\frac{\theta-\phi}{2}},\ b \frac{\sin\frac{\theta+\phi}{2}}{\cos\frac{\theta-\phi}{2}} \right\} = 0 \quad \ldots \ (196)$$

From (194) and (195), we have

$$\frac{\xi}{a} = \cos\frac{\theta+\phi}{2} \cos\frac{\theta-\phi}{2}$$

$$\frac{\eta}{b} = \sin\frac{\theta+\phi}{2} \cos\frac{\theta-\phi}{2}.$$

whence, squaring and adding,

$$\cos^2\frac{\theta-\phi}{2} = \frac{\xi^2}{a^2} + \frac{\eta^2}{b^2}. \qquad \ldots\ldots\ldots\ldots \quad (197)$$

Also, by division, from (194) and (195),

$$\tan\frac{\theta+\phi}{2} = \frac{a\eta}{b\xi}$$

whence

$$\sin\frac{\theta+\phi}{2} = \frac{a\eta}{\sqrt{b^2\xi^2 + a^2\eta^2}}, \quad \cos\frac{\theta+\phi}{2} = \frac{b\xi}{\sqrt{b^2\xi^2 + a^2\eta^2}} \quad \ldots\ldots\ldots \ (198), (199)$$

Substituting from (197), (198), and (199) in (196), the equation of the locus sought is found to be

$$F\left(\frac{a^2b^2\xi}{b^2\xi^2+a^2\eta^2},\ \frac{a^2b^2\eta}{b^2\xi^2+a^2\eta^2}\right)=0. \quad \text{..........} \quad (200)$$

We have, therefore, the

Theorem.—If from any point P, tangents are drawn to the conic

$$S \equiv \frac{x^2}{a^2}+\frac{y^2}{b^2}-1=0,$$

and P is constrained to move on any curve

$$F(x, y)=0,$$

the locus of the middle point of the polar chord of P with regard to S is

$$F\left(\frac{x}{1+S},\ \frac{y}{1+S}\right)=0.$$

Similarly, if we consider the parabola

$$y^2=4ax,$$

any two points on the curve are

$$(a\tan^2\theta,\ 2a\tan\theta),\ \ (a\tan^2\phi,\ 2a\tan\phi),$$

so that the coordinates of the point of intersection of the tangents are given by

$$X=a\tan\theta\tan\phi$$
$$Y=a(\tan\theta+\tan\phi),$$

and the middle point of the polar chord is given by

$$\xi=\frac{a}{2}(\tan^2\theta+\tan^2\phi),$$

$$\eta=a(\tan\theta+\tan\phi).$$

These give

$$\frac{\eta^2}{a^2}=\frac{2\xi}{a}+2\tan\theta\tan\phi,$$

whence

$$X=\frac{\eta^2-2a\,\xi}{2a},\ Y=\eta.$$

Hence, substituting in $F(x, y)=0$, we have the

Theorem.—If from any point P tangents are drawn to the parabola

$$y^2=4ax,$$

and P is constrained to move on the curve

$$F(x, y)=0,$$

the locus of the middle point of the polar chord of P with regard to the parabola is

$$F\left(\frac{y^2-2ax}{2a},\ y\right)=0.$$

We will here simply add that the result obtained above in equation (200) is an immediate consequence of a new method which we propose to call the **Method of Elliptic Inversion.**

26*th October*, 1887.

Substituting from (197), (198), and (199) in (196), the equation of the locus sought is found to be

$$F\left(\frac{a^2b^2\xi}{b^2\xi^2+a^2\eta^2},\ \frac{a^2b^2\eta}{b^2\xi^2+a^2\eta^2}\right)=0. \quad \ldots\ldots\ldots\ldots (200)$$

We have, therefore, the

Theorem.—If from any point P, tangents are drawn to the conic

$$S\equiv\frac{x^2}{a^2}+\frac{y^2}{b^2}-1=0,$$

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the locus of the middle point of the polar chord of P with regard to S is

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Similarly, if we consider the parabola

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any two points on the curve are

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so that the coordinates of the point of intersection of the tangents are given by

$$X=a\tan\theta\tan\phi$$
$$Y=a(\tan\theta+\tan\phi),$$

and the middle point of the polar chord is given by

$$\xi=\frac{a}{2}(\tan^2\theta+\tan^2\phi),$$

$$\eta=a(\tan\theta+\tan\phi).$$

These give

$$\frac{\eta^2}{a^2}=\frac{2\xi}{a}+2\tan\theta\tan\phi,$$

whence

$$X=\frac{\eta^2-2a\xi}{2a},\quad Y=\eta.$$

Hence, substituting in $F(x, y)=0$, we have the

Theorem.—If from any point P tangents are drawn to the parabola

$$y^2=4ax,$$

and P is constrained to move on the curve

$$F(x, y)=0,$$

the locus of the middle point of the polar chord of P with regard to the parabola is

$$F\left(\frac{y^2-2ax}{2a},\ y\right)=0.$$

We will here simply add that the result obtained above in equation (200) is an immediate consequence of a new method which we propose to call the **Method of Elliptic Inversion.**

26th October, 1887.

XXI.—*A Descriptive List of the* Uredineæ *occurring in the Neighbourhood of Simla (Western Himalayas).—By* A. Barclay, M. B., *Bengal Medical Service.*

[Received 7th October ;—Read November 2nd, 1887.]

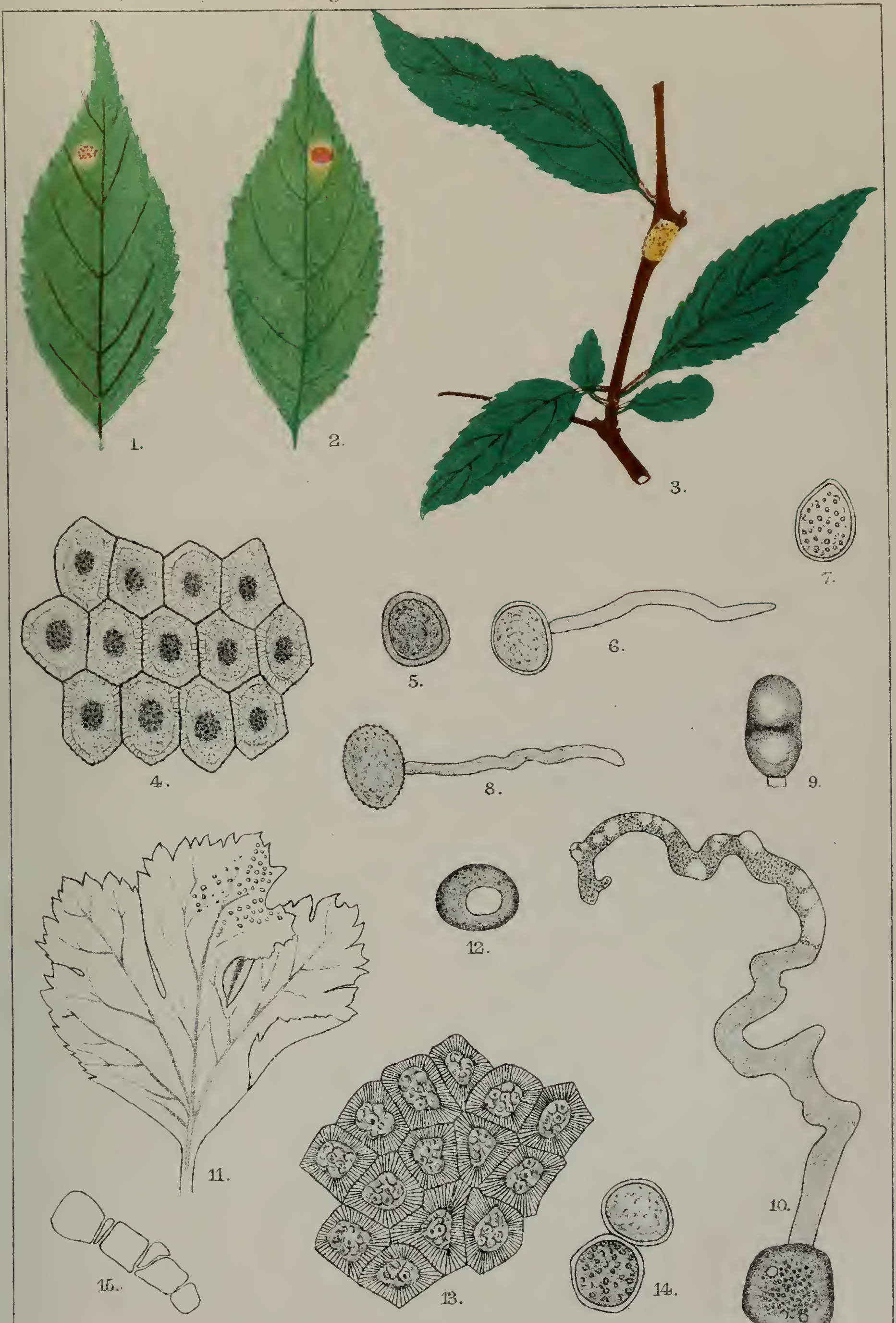
(With Plates XII.—XV.).

The neighbourhood of Simla is particularly rich in species of Uredines; and, as I have paid much attention to them during the last four years, it has been suggested to me that a descriptive list of them might usefully be recorded for the use of future workers in this very interesting field of cryptogamic botany. I have acted on the suggestion after much hesitation, for, with the very limited leisure at my disposal in the course of an active official life, I cannot hope to make the list a complete one, nor, indeed, can the descriptions of many of those I notice be as complete as might be desired. Nevertheless, so far as they go, my statements may, I hope, be accepted as correct in every respect, for every one of them has been made after careful and repeated observation. I may, therefore, be permitted to hope that the list may serve some useful purpose, more especially as no such attempt has ever before been made in India, so far as I am aware.

With regard to the order in which such a list should be given, I have determined, after some hesitation, to bind myself by no very strict rule, but, in general, to enumerate, first, all those species which bear aecidial fructification and, then, to go on to those which are at present known to me only in the teleutosporic stages. With reference to the æcidium-bearing species, I may note that I have described them generally as they occur in seasonal sequence, beginning with those which appear earliest in spring, and ending with those which disappear last towards autumn. The only exception I have made in following out this plan is to withdraw from the general list all those forms which occur on the Coniferæ, as I thought it better to enumerate the characters of these few well defined species together, rather than to disperse them among the others, which occur on hosts having no special relationship with one another.

In the present contribution, I will confine myself to the æcidial forms with which I am acquainted on hosts other than the Coniferæ; but, before proceeding to a description of them, I may draw the attention of the reader to one or two points of special interest concerning them.

A. Barclay, del.
Parker & Coward, lith.
West, Newman & C° chr. imp.



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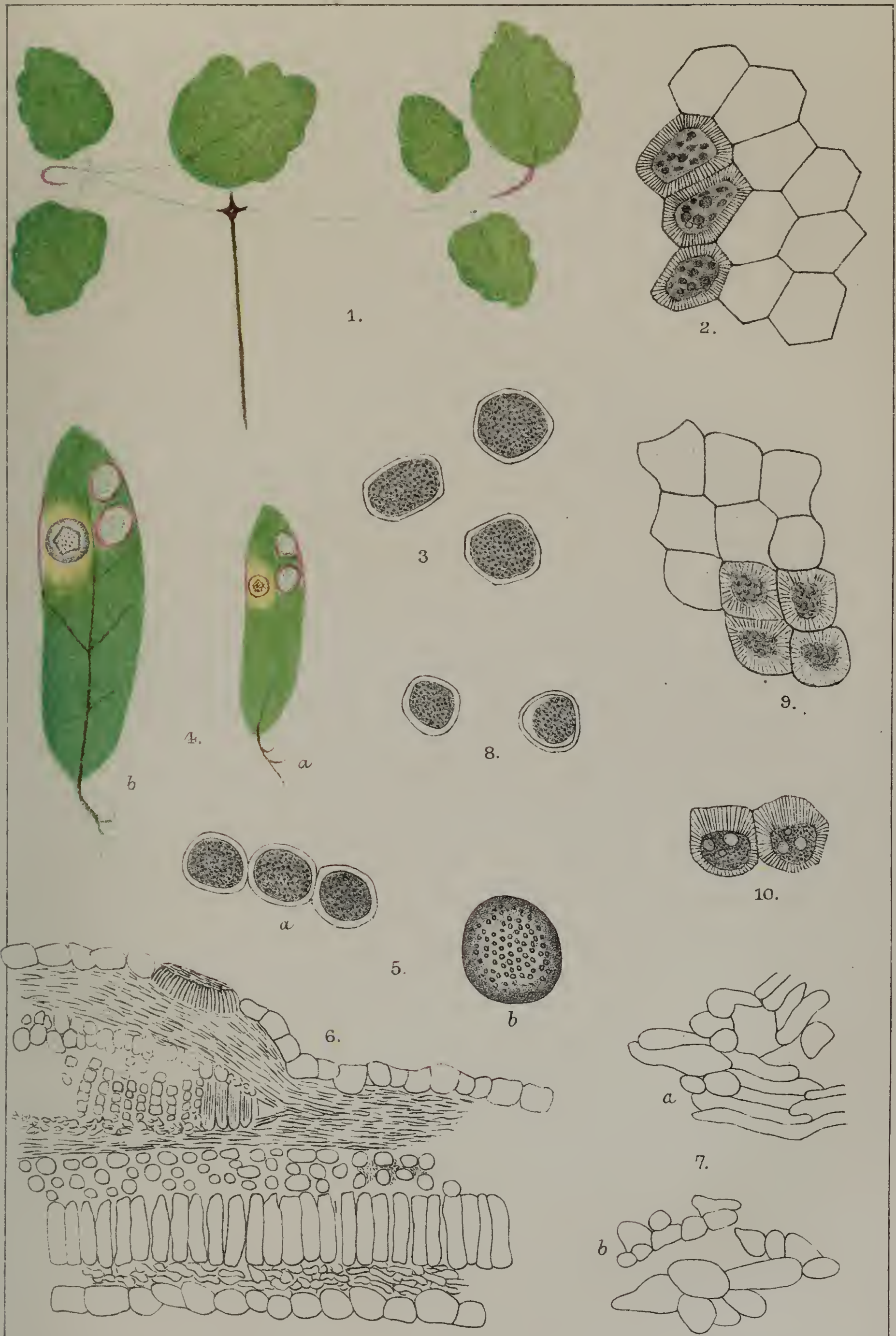
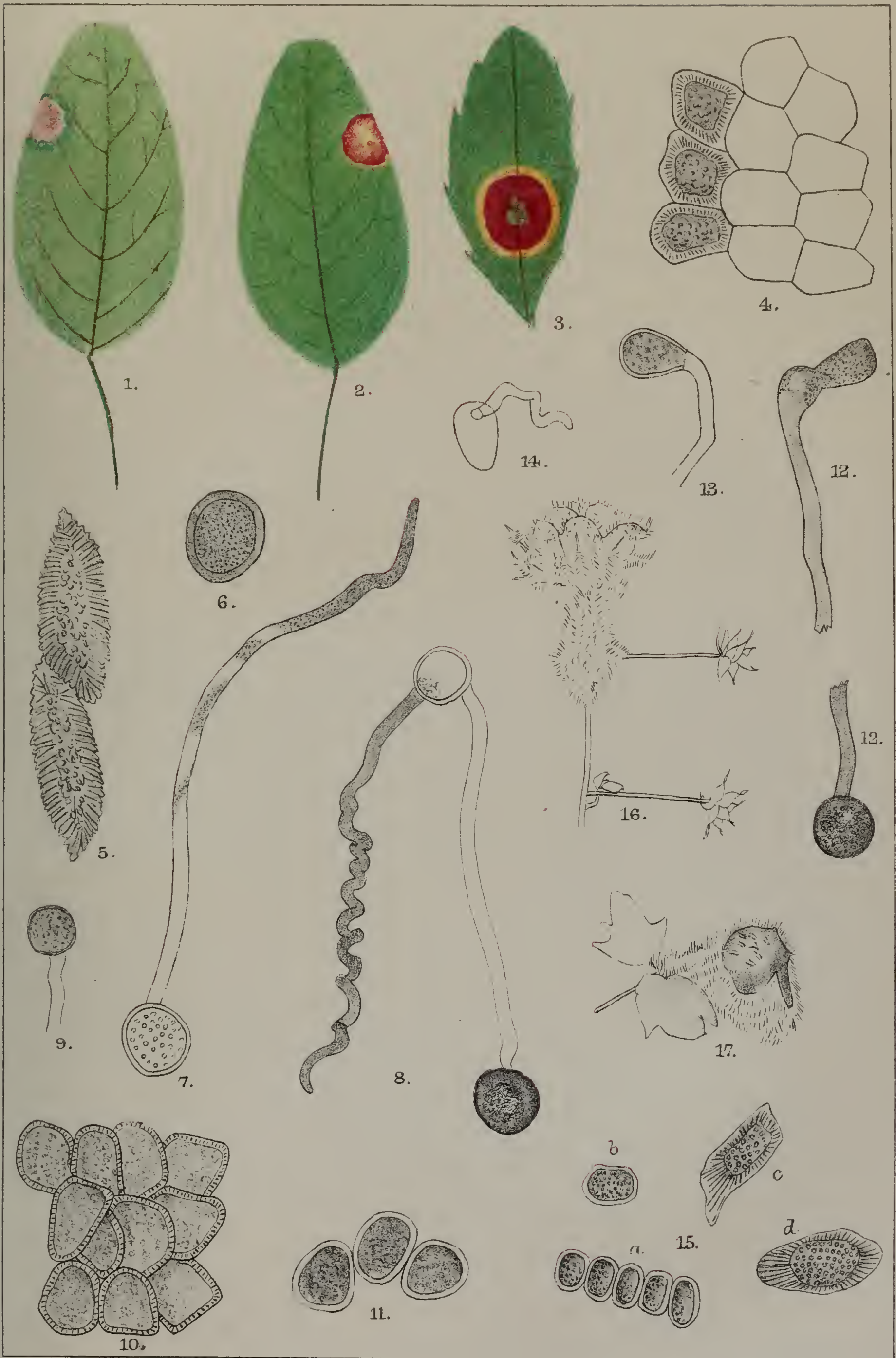
Parker & Coward, lith.

West, Newman & C° chr. imp.



A. Barclay, del.
Parker & Coward, lith.

West, Newman & Co. chr. imp.



A. Barclay, del.
Parker & Coward, lith.
West, Newman & Co. chr. imp.

In the first place, it will be observed that I have related several of them with a mark of interrogation to species already described as occurring in Europe. Until the complete life-histories of these are known, it is impossible to state definitely whether they are correctly so related or not. They are probably all varieties of, or identical with, the European forms with which I have associated them. In only one case (that of *Æcidium Urticæ*, Schum.) has the life-history of the Indian variety been fully traced.

Five of the species described are I believe quite new, in only one of which *(Æcidium Strobilanthis)* have I been able to trace the whole life-history. That on the wild strawberry (*Fragaria vesca*) appears to be a complete autoecious Uredine, but I have unfortunately not been able to prove this by actual experiment. And, in this connection, I would again draw attention to the inconvenience caused by the system of nomenclature now adopted of naming species of Uredines after their teleutosporic forms, an inconvenience which it appears to me will increase as our knowledge of this family is extended, for it sometimes happens that a host bearing an æcidium bears also a teleutospore, which, however, has no relationship whatever with the æcidium. For example, according to this principle, I have been obliged to name the Æcidium which occurs on *Valeriana Wallichii Uromyces Valerianæ*, although I have abundant evidence that the teleutospores have no genetic relationship whatever with the Æcidium. In all probability, future investigation will show that the Uromyces borne on this host is related to some other Æcidium on an entirely different host, whilst the teleutospores borne on some other host are related to the Æcidium on the Valeriana in question. In the cases of *Strolilanthes Dalhousianus* and *Urtica parviflora*, which bear Æcidia whose complete life-histories are known, teleutospores (puccinia) are also borne, which, however, have no relationship with the Æcidia.* The Æcidium on *Jasminum revolutum* presents no unusual features, but those on *Euphorbia cognata* and *Andrachne cordifolia* display aberrant features of great interest. Indeed, these two Æcidia differ so markedly from all others that I have regarded them, provisionally, and until I shall have had further opportunities of working out their complete life-histories, as belonging to a new genus, which I propose calling Monosporidium.

With these introductory remarks I shall pass on to a description of the several species.

* *See* " Scientific Memoirs by Medical Officers of the Army of India, " Part II, Calcutta, 1887.

I.—ÆCIDIAL FORMS.

1.—Æcidium Saniculæ, sp. nov.

Sanicula (Europæa, L. ?)

The earliest Æcidium which I have observed in Simla is that which occurs on *Sanicula Europæa.* Towards the latter end of March, some of the earliest leaves of this plant which are being unfolded in spring may be found attacked by this parasite. It is by no means an uncommon fungus. The invaded areas of the leaf are usually small, and generally convex below, where the aecidial cups are usually borne, though a few may open also on the upper surface of the leaf. The æcidia discharge their spores through a *porous* like opening at their summits, *i. e.*, the peridium does not open widely as in most cases with the fragments of the torn tissue forming a *stellate* opening. The petioles are also frequently attacked and at such places they are thickened and often bent. A single leaf blade may present from one to three patches of invasion, these patches being slightly paled in colour as seen from the upper surface.

Æcidiospores.—The moistened æcidiospores measure on an average $25{\cdot}4 \times 19{\cdot}4\ \mu$, the measurements exhibiting extremes of $26\ \mu$ in length and $20\ \mu$ in breadth. The epispore is finely punctated and contains from two to three germ pores. The endospore is very fine and not readily distinguishable from the epispore (Fig. 1, Pl. XII.). The spores, when placed in water under suitable circumstances, readily germinate, throwing out long curved tubes measuring 6 to $7\ \mu$ in diameter. Only one germinal tube is produced by each spore. The peridial cells measure about $30 \times 22\ \mu$ (Fig. 2, Pl. XII.).

Remarks.—This æcidium is, I believe, a new species; but may be compared with that which I have described below on *Pimpinella diversifolia.*

2.—Uromyces Valerianæ, Schum ?

Valeriana Wallichii, D. C.

Next to the foregoing Æcidium one on this plant is among the earliest of these parasites to be found in spring. Towards the end of March, some plants may be found in initial stages of attack; but it is towards the latter part of April that it is seen in its fullest development. This Æcidium is one of the most common and abundant in Simla, and individual plants are often so extensively affected in blade and petiole as to be completely destroyed. The affection is usually confined to the blades and petioles of the radical leaves, but may also be found on the upper leaves of the flowering stalks and even, though rarely, on the bracts of the flower heads. When a leaf is extensively affected, it is considerably distorted, and the parts actually invaded by the mycelium are considerably thickened. At an early stage of the affection, patches of pale yellow discoloration may be observed on the leaf blades, which are usually convex above. On this upper convex surface, a few spermogonia may be seen, whilst the æcidial fructification usually emerges from the lower or concave side. The æcidia consist of short tubular peridia filled with reddish yellow spores bursting at their summits in a stellate way.

The spermoginia are remarkably few and their mouths are surmounted by a tuft of paraphyses.

The æcidial affection above described is met with abundantly throughout the time the plants are in flower, but, as soon as the seeds are being matured, towards the middle or end of May, this affection disappears entirely. After an interval of some weeks from the time the æcidial parasite has entirely disappeared, these plants are seen to be attacked by a teleutospore-bearing mycelium also mainly on the radical leaves, though occasionally also on others. This affection always appears on leaves which bear no trace of formerly having borne the æcidial parasite. The spores are extruded from dark brown pustules of minute size, which usually occur in great numbers on each affected leaf. Each pustule is surrounded by a zone of yellow discoloration. At first, these spores are extruded only from the upper surface of the leaf, but later also from the lower surface, exactly opposite the site of the upper spore bed and therefore from the same mycelium. The lower pustule is usually smaller than the upper. At first, when a spore pustule exists only in the upper surface of the leaf, the affected area bulges upwards (convex upwards) with a corresponding concavity below; but this disappears when the lower surface is also involved in spore extrusion.

Æcidiospores.—These are abstricted serially from basidia arranged on a flat hymenium. They are pale orange-yellow round or oval bodies measuring, when dry, $17 \times 15\ \mu$ and, after lying some time in water, $22 \times 20\ \mu$ (Fig. 12, Pl. XII.). The epispore is smooth and unmarked. They do not germinate readily in water (Fig. 10, Pl. XIII.). The peridium consists of a layer of single cells.

Teleutospores.—These are brown single-celled bodies—Uromyces—borne singly on stalks (Fig. 13, Pl. XII.). They are somewhat pear-shaped, measuring when moist $25 \times 22\ \mu$, and the stalks bearing them are about twice the length of the long diameter of the spore. The spores are readily detached from their beds without any portion of the stalk adhering to them. The epispore is firm and resistant and a little thickened towards the base, where it joins the stalk. It is sparsely beset externally with tubercles. A few fine paraphyses usually occur among the spores. Most spores exhibit a nuclear space or body in the centre. Although I placed them in several nutritive solutions and in water, I never observed them germinating.

Remarks.—I have made very numerous experiments with the view of tracing the life-history of this very common Æcidium, but without success. I am quite convinced that the teleutospore-bearing fungus has no connection whatever with that bearing the æcidium, not only because many carefully conducted experiments failed to establish any such connection, but also because a considerable interval elapses, as I have already noted, between the complete disappearance of the Æcidium and the appearance of the teleutospores. I have also attempted to reproduce the Æcidium by inoculating leaves with almost every teleutospore with which I am acquainted, and most of which I hope to describe later in this series.

This fungus may be identical with *Uromyces Valerianæ*, Schum, in which the æcidiospores are stated to measure 17 × 24 μ and the Uromyces spores, 20 to 26 by 15 to 19. The latter fungus, however, also possesses uredospores, which are entirely absent in the Himalayan species.

3.—Puccinia Violæ, Schum ?

Viola serpens, Wall.

An Æcidium of a very destructive kind is extremely common on *Viola serpens* in spring (April) and occurs simultaneously with that described on Valeriana. As a rule, large areas of the leaves become affected and very frequently the petiole also is extensively involved. Sometimes there is scarcely a portion of the whole leaf, blade and stalk, which is not involved, and, in such cases, the whole leaf speedily succumbs to the parasite. In such extreme cases, the blade of the leaf is crumpled up almost beyond recognition, while the affected stalk is bent in various directions and considerably hypertrophied. Limited patches on the leaf blade are generally round and very deeply bulged downwards, *i. e.*, with a concavity upwards. The æcidia are borne most usually on the under surface of the leaf, but a few burst forth also from above. But little discoloration is caused by the mycelium on the upper surface of the leaf, which is only slightly paled.

Later in the season, about the beginning of June, when the æcidial fungus has disappeared, the new leaves of the violet are often attacked by another puccinia-bearing parasite. Many leaves may now be found, in the same localities where formerly the æcidial parasite was common, studded with numerous dark brown or black pustules of the size of a small pin's head, mostly on the under surface. These pustules are irregularly scattered over the leaf blade, bursting through the epidermis (after having raised it considerably) by a clean rent. Opposite the pustules, on the upper surface of the leaf, small greenish yellow spots may be seen. Although the greater number of pustules emerge from the lower surface, yet many also burst forth from the upper surface, especially when the leaf is very largely attacked (Figs. 4 & 5, Pl. XII.).

It has been stated above that these puccinia-pustules are usually borne on newly unfolded leaves, but, in one or two instances, I found the dried up remains of *æcidial* patches on the petioles of leaves which bore these teleutospores. This observation naturally led me to think that the two forms were genetically related, and I accordingly made numerous attempts to establish the relationship upon experimental grounds, but always without success. I am therefore inclined now to regard the two parasites as entirely distinct, and I am supported in this view here, as in the case of Valeriana above, by the fact that, as a rule, a distinct interval of about a month or more elapses between the complete disappearance of the æcidium and the appearance of the teleutospores; and it is quite exceptional to find any trace of old æcidia on plants bearing the puccinia-producing mycelium. I may here note that I have made numerous attempts during the last two years to connect the Æcidium on the violet with several teleutospores occurring on various plants in Simla, but, as in the case of the even more common Valeriana Æcidium, always without success.

Æcidiospores.—When well moistened in water, the spores measure $21 \times 18\ \mu$, but, when dry or immediately after immersion in water, they measure on an average $19 \times 14{\cdot}8\ \mu$. They readily germinate in water, throwing out a single more or less sinuate tube measuring about $6\ \mu$ in diameter (Fig. 6, Pl. XII.). This germ-tube has a tendency to throw out short lateral branches. The orange-red contents of the spore wander into the furthest end of the tube. The spores appear to have 3 to 4 germinal pores, but only one germ-tube is formed by each.

Teleutospores.—These are dark brown puccinia easily detached from their beds without any portion of the stalk remaining adherent (Fig. 7, Pl. XII.). When dry, these spores measure as follows:—whole length, $30\ \mu$; length of upper cell, $14\ \mu$; length of lower cell, $16\ \mu$; breadth at septum, $18\ \mu$. The spores are somewhat thickened at their free ends, sometimes to the extent of $4\ \mu$. Among these puccinia-spores, a few single-celled spores were often found which may have been either uredospores or a second form of teleutospore. They are brown bodies with thick resistant walls covered externally with prominent tubercles. They measure, when dry, $20 \times 18\ \mu$ on an average: I never observed their germination. Some freshly collected spores were placed in water in a growing cell on the 20th March, and they germinated freely, although some spores preserved in botanical drying paper since the previous autumn had lost vitality (Figs. 7 & 8, Pl. XII.). The promycelium from the upper cell emerges from the apex, whilst that from the lower cell emerges from a point close to the septum. The promycelium produces four sporidia from four cells into which the end of the promycelium is divided, the most distant one being produced upon a sterigma arising from the very apex of the germ-tube (Figs. 7, 8, 9, Pl. XII.). The sporidia are oval, measuring from 6 × 4 μ to 7 × 5 μ (Fig. 10, Pl. XII).

Remarks.—It is possible that this fungus is identical with, or, more probably, a variety of, *Puccinia Violæ*, Schum., although the measurements of the latter given by Winter* do not agree with mine very nearly. Winter's measurements are as follows:—æcidiospores 16 to 24 μ by 10 to 18 μ (average 20 × 14 μ) against my measurement of 21 × 18; uredospores 19 to 26 μ in diameter against my measurement of 20 × 18 μ; teleutospores 20 to 35 μ by 15 to 20 μ (average 27·5 × 17·5) against my measurements of 30 × 18 μ. The characters of the teleutospores as given by Winter agree with those of mine.

4.—Puccinia Pimpinellæ, Strauss.

Pimpinella diversifolia, D. C.

The next æcidium which attracts attention is not so common as those above described, and occurs on *Pimpinella diversifolia.* This parasite may be found in certain localities towards the end of April or the beginning of May, and is very soon after that missed again. Indeed, towards the end of May, it has already become very scarce. The fungus usually attacks the first leaves that are unfolded of this plant, these being simple leaves of the shape of the common violet leaf. The compound leaves later unfolded were very rarely found attacked. The invaded areas of leaves are discoloured, becoming pale yellowish green, and the æcidia are borne almost wholly on the under surface, though a few occasionally break through the upper surface. The æcidial fruit consists of tubular peridia measuring about 2 to 2·25 m.m. in length which burst at their summits in a stellate manner. In addition to the leaf blade, the petiole is not unfrequently attacked, and here the peridial tubes are somewhat longer than they are on the leaf blade. Several distinct patches of æcidia sometimes occur on a single petiole, but in such cases the blade is also largely affected. At these places on the petiole the tissues are somewhat hypertrophied. The leaf blade also where invaded is thickened, the depth of the laminal tissues at

* Die Pilze Deutschlands, &c. Von Dr. George Winter.

such places being about 0·441 m.m., whilst the normal thickness is about 0·239 m.m.

A little later, towards the end of May, when the æcidial parasite is becoming rare, some of the compound leaves (never the simple ones) may be found attacked by a separate mycelium bearing uredospores. This uredospore-bearing mycelium is never found on the same leaf bearing æcidiospores, and it is therefore quite probable that the two mycelia are in no wise genetically related to one another. The uredo-pustules are minute, circular, and saffron-coloured, mostly on the upper surface of the leaf, though by no means infrequently also on the lower. Sometimes the upper surface of a leaf may be seen to be densely covered with these uredo-pustules.

Again in autumn, about the end of September and October, the same plant may be seen largely affected by a puccinia-bearing fungus, a distinct interval having elapsed since the disappearance of all trace of the uredo-bearing fungus. These puccinia-pustules are minute and round, like the uredo-pustules, but black, and occur both on the upper and lower surfaces of the leaves, sometimes in great profusion. The stem is also often affected; the pustules here are linear, their long axes corresponding with the long axis of the stem.

The *æcidiospores* are reddish yellow with very thin walls, the epispore and endospore not being distinguishable from one another: they are round, oval, or somewhat fusiform (Fig. 14, Pl. XII.). The round spores measure 20 to 21 μ in diam., the oval about 32 $\times$ 20 μ, and the fusiform about 38 $\times$ 14 μ, shortly after being wetted with water.

The *spermogonia* are likewise situated on the under surface of the leaf: they measure about 0·163 m.m. in depth and 0.189 m.m. in breadth. Their mouths are beset with paraphyses projecting about 0.063 m.m. The spermatia are round or oval and measure 4 $\times$ 3 μ.

The *peridium* consists of elongated cells, very unlike those of the æcidium on Sanicula described above, measuring about 60 $\times$ 20 μ, and easily detached from one another by teasing (Fig. 15, Pl. XII.).

Uredospores.—These are reddish yellow round or oval bodies with coarse tubercles on the surface of the epispore. On an average, the moistened spores measure 22 $\times$ 18·3 μ. They germinate readily in water. (Fig. 3, Pl. XII.).

Teleutospores.—These are brown two-celled bodies (puccinia) readily detached from their beds with a very small portion of the stalk remaining adherent to them. In each cell, a clear nuclear body or space may be seen. The epispore is marked externally by fine ridges. They are not thickened at their free ends. As with the uredospores, I never succeeded in getting them to germinate in water. Their measurements are as follows :—whole length of spore 30 μ; length of lower cell 13 μ and of upper cell 17 μ; breadth at septum 23 μ; extreme breadth of upper cell 24 μ and of lower cell 22 μ.

Remarks.—At first it seemed extremely probable that all the three forms above described were phases of one fungus, and I attempted frequently to establish a relationship between them by experiment, but always without success. This alone, however, does not justify me in definitely denying a relationship between them, since it is quite possible that some condition of my experiments militated against the manifestation of a relationship. However, the experiments were carefully conducted and often repeated. I also attempted to reproduce the æcidium by laying the teleutospores found on several grasses in the neighbourhood on the young leaves ; but in these attempts also I failed.

This parasite is probably identical with *Puccinia Pimpinellæ*, Strauss, in which the æcidiospores are said to measure 18 to 35 μ long and 16 to 21 μ broad (average 26·5 × 18·5 μ), the uredospores, 23—32 μ long and 19 to 24 μ broad (average 27·5 × 21·5), and the teleutospores, 26 to 35 μ long and 17 to 26 μ broad (average, 30·5 × 21·5). The only feature in which this fungus differs from that which I have described is in the characters and size of the uredospores. In Strauss's plant the uredospores are said to be pale brown, while in mine they are reddish yellow and smaller.

5.—Puccinia coronata, Corda ?

Rhamnus dahuricus, Pall.

The Æcidium which occurs on this plant is not very common, although occasionally an attacked tree or bush is very extensively affected. The fully ripe æcidium may be found as early as the latter part of May, but it is more usually met with about the middle of July. The fungus attacks leaves, young stem (Figs. 1, 2, 3, Pl. XIII.), and drupes, the last sometimes very extensively indeed. When the leaf is attacked, the invaded areas are usually small, and generally only one patch occurs on each leaf. These patches are dark reddish brown above, surrounded by a halo of pale yellow (Fig. 2, Pl. XIII.), and the orange-yellow æcidia are borne on the lower or concave surface of the leaf, opposite the dark central part seen above (Fig. 1, Pl. XIII). The red colour of the patch is due especially to discoloration in the palisade cells, and the abnormal thickness to hypertrophy of the spongy tissue, the palisade cells retaining their normal dimensions and characters. The tissues in the areas invaded are very extensively permeated by hyphæ, and many cells are destroyed. While the thickness of the leaf blade is normally 0·126 m.m., it is about 0·440 m.m. in patches bearing ripe æcidia. A patch of ordinary size measured 1 c.m. in total diameter, the central reddish brown part measuring 6 m.m. in diameter. The patches are sometimes considerably larger, however, and more irregular in shape. The æcidia are tubular structures, very deeply sunk into the laminal tissue, measuring about 1·75 m.m. in length, and therefore resembling in some degree the Æcidium on *Pyrus variolosa* described below. With very few exceptions, the æcidia burst from the lower surface of the leaf. These patches on the leaves are often placed near the margin of the leaf, and are usually between and not over the principal veins; but when a vein is involved it is considerably thickened. When the stem is attacked, which occurs but rarely, it is considerably swollen. The drupes when attacked are often densely covered with æcidial tubes, set at right angles, all over them.

The *spermogonia* are formed on both the upper and lower surfaces of the patches, and may often be found ripe when the æcidia on the same patches are also fully developed. They are inserted between the cells of the single layer of palisade cells when situated on the upper surface. They have a tuft of paraphyses protruding through their mouths, and measure about 0·107 m.m. in depth and breadth.

The *æcidiospores* are round orange-yellow bodies of very uniform size measuring 23 μ in diameter when recently wetted with water (Fig. 5, Pl. XIII.). The *peridial* cells are roughly hexagonal, adhere very firmly to one another, and measure about 26×16 μ. The centre of each cell contains orange-yellow matter like the contents of the æcidiospores (Fig. 4, Pl. XIII.).

Remarks.—There can be little doubt that this Æcidium is caused by a Puccinia, with all the characters of *Puccinia coronata*, which occurs on *Brachypodium sylvaticum* in Simla, but unfortunately I have not had sufficient opportunities of verifying this. So far as my insufficient experiments go, I have always obtained negative results. I am also not quite sure whether this Æcidium does not also occur on *Sageretia oppositifolia.*

6.—Puccinia Fragariæ, nov. sp.

Fragaria vesca, Linn.

During May, and just before it flowers, the Wild Strawberry, *Fragaria vesca*, may in some years be seen attacked by an æcidial fungus. This parasite is, however, a rare one, and I found it on two occasions only in 1885 at localities distant a few miles from one another, and on each occasion only a single affected plant was found. Æcidial fructification was found both on the petiole and on the leaf blade. It is somewhat curious that the same leaf bore *simultaneously* uredo and teleutospore pustules, but all the three forms of spore-pustules were quite distinct from one another, with green normal tissue between them—at least, I could not trace any mycelial connection between them. The æcidial fructification consists of groups of æcidia on the margins of the leaves. The portions of the leaf blade bearing these quickly wither and dry up after the æcidia ripen. The æcidia break through both the upper and lower surfaces of the leaf, but more frequently from the lower. Spermogonia of the usual form are frequently present, especially on the petiole when this is affected, and they are placed usually close by the side of the æcidia.

The *æcidiospores* are pale yellow and very irregular in size and shape, varying from round to oval, often faceted and irregularly angular. Their average measurements when moistened are $22 \times 15{\cdot}8\ \mu$. The epispore is finely punctated (Fig. 6, Pl. XIII.). Placed in a decoction of cow-dung (Brefeld) several in 24 hours threw out short germinal tubes of an average diameter of $5{\cdot}3\ \mu$, but the greater number of spores would not germinate.

The *uredospores* are oval or pear-shaped and pale yellow in colour (Fig. 7, Pl. XIII.). They are produced in little circular yellow pustules, which are situated on both surfaces of the leaf. The external surface of the epispore is beset with prominent tubercles. The moistened spores measured on an average $21 \times 17\ \mu$. Placed in a decoction of cow-dung, only two were found to have germinated on the 5th day, whilst those placed in water did not germinate at all (Fig. 8, Pl. XIII.). The *teleutospores* are contained in little black pustules situated close to the æcidial fructifications. They were produced on both the upper and lower surfaces of the leaf blade, but more frequently on the lower surface, as in the case of the æcidia. The spores are dark brown, two-celled bodies, puccinia, easily detached from their beds, breaking off with only a small fragment of stalk adhering (Fig. 9, Pl. XIII.). The average measurements of these spores when moistened were as follows:—whole length $31{\cdot}7\ \mu$; length of upper cell $15{\cdot}8\ \mu$, and breadth of same $22{\cdot}4\ \mu$; length of lower cell 15·8, and width of same $21\ \mu$. The stalks bearing these spores are from 2 to $2\frac{1}{2}$ times the whole length of the spore. Amongst these teleutospores a few uredospores occurred of the characters above given. The teleutospores were sown in a decoction of cow-dung, as well as in water, but they did not germinate. On one occasion, in autumn (November), I found a single leaf of this plant plentifully covered with teleutospore-pustules. I did not succeed in getting them to germinate.

From want of sufficient material, I could not experimentally determine a genetic relationship between these different spores, but the close proximity of the teleutosporic sori to the æcidial fructification and the occurrence of uredospores in the teleutospore-pustules lend some support to the view that we have here to do with a complete autoecious Uredine. However, in the absence of experimental evidence, this remains a mere presumption.

Remarks.—I believe that this is an entirely new species, and I have therefore named it *Puccinia Fragariæ*, in accordance with recognised precedent in nomenclature, although I should have preferred naming it *Æcidium Fragariæ.*

7.—ÆCIDIUM LEUCOSPERMUM, D. C. ?

Anemone rivularis, Ham.

This fungus is remarkably localised. During the last three years, although I have looked for it everywhere about Simla, and the host may be found everywhere, I have found it in only two localities, one in Simla (Annandale), the other in a forest (Cheog) about 14 miles distant. In these localities I have found it in June, July, and the beginning of August, before the plant flowers. The most striking peculiarity of this æcidium is that it is white. The whole leaf is often involved, though generally only well-defined portions are, and frequently the margin of the leaf (Fig. 11, Pl. XIII.). The æcidia break out almost entirely from the under surface, though a few may occasionally be seen on the upper surface. When a young immature leaf is attacked, as is often the case, there is a striking arrest of growth, the leaf never attaining the usual size shown by sister leaves of the same plant which are not affected—indeed, a fully affected young leaf is often only one quarter the normal size. The petioles were never seen to be attacked. Sometimes every leaf of a plant was found attacked. The attacked areas after the ripening of the æcidia quickly turn brown and wither.

The *æcidiospores*, when just wetted, are round or oval and measure on an average $17{\cdot}7 \times 15{\cdot}6\ \mu$. The epispore is beset with very minute tubercles (Fig. 12, Pl. XIII). I never succeeded in getting them to germinate in a growing cell. The peridial cells measure about $18 \times 16\ \mu$.

The *spermogonia*, formed only on the upper surface of the leaf, measure about 80 μ in depth and 120 μ in breadth. They are very superficially situated, having their bases sunk only through the epidermis and resting on the palisade cells. A tuft of paraphyses projects through their mouths about 40 to 50 μ in length.

Remarks.—*Puccinia Anemones*, Pers., occurs on *A. nemorosa* and *A. ranunculoides*, forming powdery masses of teleutospores (without uredospores) on the under surfaces of the leaves. Each of these hosts also bears an Æcidium, that on *A. ranunculoides* (*Æc. punctatum*, Pers.) having violet-brown æcidiospores and that on *A. nemorosa*

(*Æc. leucospermum*, D. C.) having white spores. Although I have carefully searched for teleutospores on *A. rivularis* in Simla, I have never found them, and I am therefore constrained to call this Æcidium *Æc. leucospermum* in the meantime. Schröter, I understand, thinks the teleutospores on *A. nemorosa* are related to the Æcidium borne on the same host, whilst Fuckel relates the Æcidium on *A. ranunculoides* with the teleutospores borne on it. The Himalayan Æcidium would appear to throw some doubt on the connection between their teleutospores (*Puccinia fusca*, Relhan) and the two æcidia, or, at any rate, if that be indisputable, the Himalayan Æcidium must be entirely different, being most probably a heteroecious Uredine.

8.—Æcidium Thalictri flavi, D. C. ?

Thalictrum Javanicum, Blume.

The Æcidium on this plant, as in the case of that just described on Anemone, is remarkably localised, although the host is widely diffused. It is therefore a rare parasite, although, in the localities in which it is found, it occurs abundantly enough. It is met with during the rains, in July, while the plant is flowering. Only the leaf blades are as a rule affected, but occasionally the petiole is also attacked, when it is considerably hypertrophied and distorted. Fig. 1, Pl. XIV. represents the petiole attacked in two places : in both cases it will be seen that the petiole has become considerably elongated and in one case also bent completely round through 360°. When the parasite attacks the leaf blades, little reddish yellow spots are formed as seen from above, measuring ordinarily from a minute point to 4 or 5 m.m. in diameter. Sometimes, however, the patches are much larger—in one case 1 c. m. in diameter—and then the leaf is considerably distorted, especially when a main vein is involved. These larger patches are reddish brown above. The attacked areas are generally convex above at first, but often, as the area becomes larger, the converse obtains. The patches are frequently placed over a prominent vein, which is then, within the affected area, considerably swollen. The number of patches on a single leaflet varies from one to twelve or perhaps more. These attacked areas on the leaf blade are considerably thickened : the normal thickness of these delicate leaves is 0·095, m.m., whilst near a young still immature æcidium it was found to be 0·410 m.m.

Spermogonia are formed abundantly both on the upper and lower surfaces, and to the naked eye appear as minute pellucid reddish yellow spots. They are of the usual structure, measuring about 63 to 80 μ in depth and 75 to 94 μ in width. These structures are well sunk into the leaf tissue. Their mouths are surmounted by a tuft of paraphyses about 60 to 65 μ in length. The tissues of the leaf are not so greatly hypertrophied in the spermogonial stage as they afterwards become, the depth of the laminal tissues near a ripe spermogonium being 0·189 m.m. in one case.

The *peridium* (Fig. 13, Pl. XIII) consists of a single layer of angular flattened cells measuring from 31·5 or 37·8 μ in length by 16 to 31 μ in breadth, or on an average 33·6 $\times$ 23·21 μ, shortly after immersion in water. It opens stellately. The *œcidiospores* are oval or round (Fig. 14, Pl. XIII.) reddish yellow bodies with a smooth epispore. The contents are either homogeneous or granular, more usually the latter. When just wetted, they measure about 25 μ in diameter, and the epispore is about 1·5 μ to 2 μ in thickness. They are given off serially as usual from basidia, but there are intermediate cells between succeeding spores (Fig. 15, Pl. XIII.).

Remarks.—It may not be out of place here to refer to a very fine Æcidium on *Thalictrum minus*, Linn., which I found on the 7th May 1884 at Urni, a village on the Hindustan-Thibet road about 126 miles from Simla towards the "Interior." It is quite possible that this is the same species as that which I have just described as found in Simla, but it gives rise to very considerably greater distortions and hypertrophies in its host. The attacked plants were indeed extremely distorted: sometimes a whole flower head exhibited a mass of small æcidial tubes (Fig. 16, Pl. XV.), and individual leaflets when largely invaded exhibited the most curious forms (Fig. 17, Pl. XV.). In this form, sometimes, though not very frequently, the stalk also was affected. The æcidiospores are orange-yellow, and measured, when dry, 19 $\times$ 16 μ on an average, but, when well moistened, 22 $\times$ 18 μ.

It is possible that both these forms are identical with, or varieties of, *Æcidium Thalictri flavi*, D. C., the æcidiospores of which are said to measure 17 to 28 μ long and 14 to 20 μ broad.

9.—Æcidium Jasmini, nov. sp.

Jasminum humile, Linn.

An Æcidium may be found on this plant during July and August, but is decidedly uncommon. The parasite attacks both leaf and petiole, but more commonly the leaf blade, giving rise to an irregularly circular patch, slightly paled above, greenish yellow and brownish red below. These patches vary in size, but are usually about 8 m.m. to 1 c. m. in diameter. The involved areas of the leaf are slightly thickened. The æcidia burst out exclusively from the under surface of the leaf, so far as my observations extend. They contain brilliant orange-yellow spores, the peridium, a short tubular structure, bursting at the summit in a stellate manner. Spermogonia exist only on the upper surface, preceding the appearance of the æcidia by a very short time—indeed, while ripe spermogonia exist on the upper surface of a patch, young unopened æcidia may also be found on the lower surface of the same patch.

The *mycelium*, which ramifies between the parenchyma cells, is colourless. The bases of the spermogonia extend to the inner level of the palisade cells, and the bases of the æcidia from the other side reach down to the same point. The spermogonia measure about 126 μ in depth and 157 μ in breadth, and have a tuft of paraphyses projecting from the mouth to about 63 μ.

The *peridium* consists of a single layer of flat cells, more or less hexagonal and measuring about 26 $\times$ 22 μ (Fig. 2, Pl. XIV.). These cells are thick-walled and contain some yellow oil globules in their cavities.

The *æcidiospores*, after lying a few minutes in water, measured 26·2 $\times$ 20·2 μ on an average. Their contents are of a brilliant orange-yellow colour, and they have a thin epispore without any markings (Fig. 3, Pl. XIV.). I did not succeed in observing their germination, as they steadily refused to grow in water. The only other species of Jasmine common in Simla is *J. officinale*, L., but this host nevers bears an Æcidium, although the closely related *J. grandiflorum*, L., which grows at considerably lower elevations, harbours a very distinct and peculiar one, which I hope to describe later.

10.—Monosporidium Euphorbiæ, gen. et sp. nov.

Euphorbia cognata, Klotzsch.

Towards the end of July and during the first half of August, a very peculiar Æcidium on this plant presenting some very unusual characters is not uncommon; and some individual plants are very extensively attacked. Only the leaf blades are attacked, so far as I have observed, and a single leaf may exhibit from one to six patches of invasion. These patches are circular and rosy red above with a broad and irregular halo of paled yellowish tissue around them, the paling increasing in area as the patch grows older (Fig. 4, Pl. XIV.). On the under surface the patch is quite white and cushion like (convex). When very young, this cushion on the lower surface of the leaf is uniformly convex, and with a field lens a few pellucid spots may be seen in its centre, which are spermogonia. Later, as the spermogonia wither, a very distinct pit or depression is formed in the centre of the cushion, and, while this central pit enlarges in area, so the circular cushion surrounding it becomes more and more prominent and whiter. At last the central pit is very distinct with now *black* points, the dried up spermogonia, over it (Fig. 4, Pl. XIV), and then the epidermis covering the surrounding cushion tears circularly near the external margin of the cushion and curls up inwards towards the centre disclosing a bed of white æcidiospores (*see* left-hand patch in Fig. 4, *a.* and *b.*). The *spermogonia*, which are extremely superficially placed (*see* Fig. 6, Pl. XIV.), are thus situated on the under surface of the leaf only. They are of the usual form and structure with a tuft of paraphyses protruding through the mouth. The whole organ, excluding the paraphyses, measures about 50 μ in depth and 100 μ in breadth. The *æcidiospores*, when just wetted with water, measure from 22 $\times$ 20 μ to 19 $\times$ 18 μ, the average of several measurements being 21 $\times$ 19·2 μ. The spores are colourless and almost round (Fig. 5, *a.* Pl. XIV.) with an epispore densely studded with minute tubercles. The distribution of the *mycelium* is peculiar and deserves description. In a section of a leaf passing through the æcidium, it will be seen that the mycelium lies mainly in two strands, one under the upper epidermis, between it and the palisade-cells, the other and larger under the lower epidermis, between it and the spongy cells (Fig. 6, Pl. XIV.). Moreover, the character of the layer of hyphæ under the upper epidermis is of a somewhat looser, more pseudo-parenchymatous character, than that under the lower epidermis (Fig. 7, Pl. XIV.). It should be noted that these layers of mycelial filaments are composed solely of hyphæ without any part of the host tissue being involved within them, and thus resemble strikingly the non-algal parts of lichens. The palisade-cells and spongy tissue between the two layers of mycelium are indeed extremely little affected or altered in any way. While in unaffected normal places the length of the palisade-cells is about 60 μ, and the depth of the spongy tissue layer about 50 μ, these measurements within attacked areas are about 56 μ and 36 μ, thus showing some diminution in size, especially in the spongy layer. The lower mycelial layer is about 50 μ in depth and the upper layer only 24 μ. The æcidial fructification is, as it were, inserted within the lower mycelial layer (*see* Fig. 6, Pl. XIV.), some strands passing above it and some below it. The *peridium* consists of a layer of cells about 32 $\times$ 30 μ in size, forming only a *roof* to the extremely large circular æcidium (*see* Fig. 6, Pl. XIV.). These cells are very loosely attached to one another, readily becoming isolated. Such an isolated cell is shown in Fig. 5, *b.* Pl. XIV; and this figure also shows that it is beset externally with tubercles. The æcidiospores are given off in rows from a pseudo-parenchymatous hymenium without any well defined basidia, and have no intermediate cells between successive spores (Fig. 6, Pl. XIV.). The æcidiospores, as seen in rows in sections of leaves that have been hardened in absolute alcohol, are cubical (Fig. 6, Pl. XIV.).

The germination of these æcidiospores is very peculiar and unlike that of any other species with which I am acquainted, with the single exception of the æcidiospores of the Æcidium on another Euphorbiaceous plant *(Andrachne cordifolia)* described further on. I have not here, unfortunately, access to special memoirs on the development of individual Uredines, so that I am unable to state definitely that the mode of germination of these spores is altogether unknown, but, so far as I have been able to consult the works of others on this subject, I have not seen this mode described. The spores germinate fairly readily in water, throwing out the usual single germ-tube, measuring 5 μ in diameter (Fig. 7, Pl. XV.). After a time, from 24 to 48 hours, a secondary spore (sporidium ?) is formed at the end of the germ-tube, not upon any sterigma, but simply separated from the tube by a septum (Fig. 9, Pl. XV.). This secondary spore is round or oval, is double-contoured, and contains well defined granules in a mass of protoplasm (Fig. 9, Pl. XV.). They measure as a rule 14 μ in diameter. The day after the formation of this secondary spore, it germinates while still attached to the primary germ-tube, throwing out a secondary germ-tube which soon takes on a spiral form (Fig. 8, Pl. XV.). After this, the whole structure perishes, and I have not been able to determine its future history.

Remarks.—This Æcidium is evidently not *Æc. Euphorbiæ*, Gmelin, (or *Uromyces Pisi*, Pers.), as in this species the mycelium is described as pervading the whole plant or shoot, deforming all the leaves and preventing the formation of flowers on the shoots attacked. In the Æcidium above described, only local and well-defined areas of the leaves are attacked by the mycelium; the leaves are not altered in general shape, and the shoots bear flowers as usual. For much the same reasons this Æcidium is not *Uromyces scutellatus*, Lév., which also markedly deforms the leaves. It remains to consider its affinities with the genus Endophyllum and especially with *E. Euphorbiæ silvaticæ*, D. C., on *Euphorbia amygdaloides*, which is said to cause a well defined alteration in the leaves of the host, rendering them shorter and wider and somewhat fleshy, and discolouring them to a pale yellowish green colour. Moreover, this parasite has orange-yellow spores 16 to 26 μ long and 12 to 18 μ wide, whilst in the Simla Æcidium the spores are colourless or pale brownish and measure, as stated above, 22 $\times$ 20 μ to 19 $\times$ 18 μ. Moreover, the germination of the æcidiospores of the last mentioned Æcidium is different from that described in the case of Endophyllum, which is essentially of the nature of the germination of teleutospores. There is, however, some resemblance between the two Æcidia in this respect, for we may consider the secondary spore of the

Simla Æcidium to be of the nature of a sporidium, and then the only difference that exists between them is that, whilst in Endophyllum four deciduous sporidia are formed on sterigmata, in the Simla parasite only one non-deciduous one is produced directly at the end of the promycelium instead of at the end of a sterigma. But these differences are still great enough, I think, to entitle the species to be regarded as the type of a very distinct group of the Æcidiomycetes having its closest affinities with the genus Endophyllum. The only other Æcidium with which I am acquainted that would find a place in this new group or genus would be that which I have described further on on *Andrachne cordifolia.* I would define the characters of this new (provisional) genus as follows :—

MONOSPORIDIUM, gen. nov.

Spore layer very like, or identically the same as, that of the Æcidia of Puccinia and Uromyces. The spores are abstricted in rows, but behave in germination somewhat like teleutospores in that the germ tube (promycelium ?) produces a secondary non-deciduous spore (sporidium ?) directly at its extremity without the intervention of a sterigma.

11.—PUCCINIA GRAMINIS, Pers.

Berberis aristata, D.C.

During August, the Barberry may frequently be found attacked by an æcidium-bearing parasite. Only the leaves are attacked, and, on them, circular patches are formed, almost crimson-red on the upper surface with a narrow halo of pale yellow-green (Fig. 3, Pl. XV) and pale rosy red below with pale yellow æcidia thickly strewn over it. A single leaf may contain from one to six or eight such patches. A medium-sized patch measures from 4 to 5 m.m. in diameter (including the halo of yellow), but sometimes the patches exceed 1 c. m. in diameter. With a field lens, numerous spermogonia may be seen on the upper red surface, but also a few in the centre of the lower surface, around which the æcidia are arranged.

The *æcidiospores*, when just moistened, measure from $22 \times 17\ \mu$ to $20 \times 18\ \mu$, or, on an average, $20{\cdot}8 \times 17{\cdot}8\ \mu$. The contents are bright orange-yellow, and usually on one side of the spore a colourless space is left filled apparently with colourless protoplasm (Fig. 8, Pl. XIV) giving a characteristic appearance to the spores. The peridial cells are generally square in outline and measure about $20 \times 18\ \mu$ (*see* Fig. 9, Pl. XIV.). They are thick-walled, thicker on one side (Fig. 10, Pl. XIV.), and contain orange-yellow matter in their centres.

When invaded by mycelium, the leaf is generally considerably thickened, and the cells of the host are filled densely with starch grains. The *spermogonia* are situated mostly on the upper surface of the leaf, though some are borne also on the under surface. They are of the usual structure, well sunk into the tissue of the host, and with a tuft of paraphyses protruding from their mouths. These organs generally measure about 0·198 to 0·151 m.m. in depth and 0·138 to 0.126 m.m. in width, the tuft of paraphyses measuring about 75 μ in length.

Remarks.—There can be no doubt, I think, that this is identical with *Puccinia Graminis* as described by De Bary, although I have not confirmed its genetic relationship with the Puccinia on cereals which occurs very abundantly in all the fields around Simla. I am also not quite certain that all the three forms of Berberis which occur in Simla (namely, *B. vulgaris*, L., and *B. Lycium*, Royle, in addition to that already mentioned) bear the same species of Æcidium. The subject is one which requires further investigation and I will therefore leave it at present an open question.

12.—Æcidium Urticæ, Schum., var. Himalayense.

Urtica parviflora, Roxb.

I have described the life-history of this remarkable and very common Æcidium elsewhere,* so it is only necessary here to state briefly its characters. The parasite gives rise to remarkable hypertrophies of the tissues of the host invaded, usually the leaves and petioles, though frequently also the stems. When attacking the leaves, it has a special proneness to invade the main veins; and, by causing very great hypertrophy in them, gives rise to remarkable contortions. When it attacks the stem, it usually produces well defined comparatively large tumours or excrescences. The parasite is usually found in its fullest development during July. The hypertrophy of the parts invaded is due mainly to the increased size of the parenchyma cells, which are stored with nutritive material, and, to a very subordinate extent, to mycelial invasion. The mycelium penetrates some of the parenchyma cells forming haustoria of the branched type.

The *spermogonia* measure about 0·178 m.m. in depth and breadth with a tuft of paraphyses 68 μ long.

The æcidiospores are contained in a *peridium* of a single layer of flattened polygonal cells measuring on an average 20 μ in diameter. The *æcidiospores* are given off in long rows from basidia arranged very regularly on a level base. They are yellow round bodies with finely granular contents and beset externally with minute deciduous

* "Scientific Memoirs by Medical Officers of the Army of India," Part II. Calcutta, 1887.

tubercles. The moistened spore measures on an average 15·6 × 13·1 μ. The life-history of this æcidium is completed on *Carex setigera*, Don. The uredospores on this second host measure from 19·8 × 13·5 μ to 19·2 × 12·8 μ. The teleutospores (puccinia) are 56 μ long by 15 μ broad on an average. The upper cell measures 24 to 20 μ in length by 12 to 17 μ in breadth, whilst the lower cell varies from 20 to 14 μ in length and 12 to 14 μ in breadth. In germinating, each cell forms a promycelium which divides at its end into four compartments each forming a sporidium at the end of a slender sterigma. The sporidia measure 12 × 8 μ. For further particulars I must refer to the paper already alluded to.

13.—Æcidium Strobilanthis, Barclay.

Strobilanthes Dalhousianus, Clarke.

The Æcidium which occurs on this plant is probably the most common and widely diffused in Simla. I have described its life-history fully in a paper in " Scientific Memoirs by the Medical Officers of the Army of India "*, to which I would refer those who desire further information, while here I will only note its main characters. The parasite may be found abundantly during July and August attacking only the leaf-blades and very rarely indeed the petiole. The leaves are often found very extensively bespattered with circular discoloured patches, yellow or yellowish green above and rosy or purplish or yellow below. The patches usually measure about 4—5 m.m. in diameter, but sometimes more, and are usually slightly concave above. The spermogonia are borne on the upper surface and maybe recognised as minute points. The æcidia are borne on the lower surface. The invaded areas are considerably thickened, the thickening being due mostly to hypertrophy of the spongy cells and to a lesser extent to that of the palisade-cells. The mycelial filaments are of the usual characters and form here and there simple tubular haustoria.

The *peridium* consists of a single layer of flattened angular cells measuring on an average 16·3 × 11·6 μ. The *æcidiospores* are given off in rows, as usual, without intermediate cells. They are irregularly round pale orange-yellow and measure, when just moistened, 18 × 16 μ.

The *spermogonia* measure about 100 μ in depth by 94 μ in width. They are formed both on the upper and on the lower surface of the leaf, but more frequently on the upper. They have a tuft of paraphyses protruding through their mouths about 80—90 μ.

This fungus completes its cycle of development on *Pollinia nuda*,

* " Scientific Memoirs by the Medical Officers of ihe Army of India," Part II. Calcutta, 1887.

Trin. The uredospores on this last mentioned host measure, when just wetted, 21·6 × 20·2 μ. The teleutospores (puccinia) on the same measure 36 μ in length by 16 μ at the septum. The septum divides the spore into two equal halves. The promycelia from each cell divide at their ends into four cells, each of which produces a sporidium at the end of a slender sterigma. The sporidia measure from 10 × 6 μ to 12 × 7 μ.

14.—Gymnosporangium clavariæforme, Jacq. ?

Pyrus variolosa, Wall.

An Æcidium (Roestelia) on this single species of the several members of the Pomaceæ in and about Simla is fairly common from May to August: but I have observed in this case, as in several others, that in some years it is more common than in others. For example, in 1885, I found no difficulty in obtaining as many specimens as I desired: in 1886, I experienced the greatest difficulty in finding a very few, while now, in 1887, it is again fairly common, though not so common as in 1885. It attacks only the leaf-blades and no other parts, so far as my observations have extended, forming well defined patches, orange-red above and yellowish below, the upper surface being densely studded with spermogonia. Generally the fully developed older dark green leaves bear these æcidial patches, the younger paler leaves being only exceptionally attacked and these late in the season, namely, in July, The area of the leaf blade invaded varies in extent from a few millimeters in diameter to 1 c. m. or even a little more, and is considerably thickened. While the thickness of the normal leaf blade is about 0·170 to 0·190 m.m., the attacked parts when æcidia are developed measure about 0·880 m.m. The thickening of the leaf blade is due mostly to an apparent proliferation of the spongy tissue cells, which are also altered in form, becoming long palisade-like cells instead of irregularly round as under normal conditions. The true normal palisade-cells are about 44 μ in length, whilst the transformed spongy cells are 63 to 107 μ in length. The mycelium ramifies throughout the cells of the attacked areas.

The æcidia are very deeply sunk, long tubular structures, the portion sunken beneath the level of the epidermis being about 0·756 m.m. in length and about 0·190 m.m. in diameter. Each æcidium is situated on a minute papilla and is extruded only from the under surface of the leaf, never from the upper. That portion of the æcidial fruit which projects freely beyond the level of the epidermis is about 1 to 2 m.m. in length.

The *peridium* consists of a single layer of cells, the lower ones being more elongated than the upper. Those situated about the middle measure about 70 × 22 μ, and all are beset with prominent rod-like excrescences (Fig. 5, Pl. XV.). When the æcidium is ripe, the peridium bursts longitudinally in strips from summit to base.

The *œcidiospores* are round or oftener oval, measuring, when just wetted, 28·6 × 24·6 μ on an average. They are pale brown in colour and their surfaces are beset with minute tubercles (Fig. 6, Pl. XV.).

The *spermogonia* are formed only on the upper surface of the leaf, and when ripe have a sticky clear fluid over them probably secreted by the tuft of paraphyses, which, arising from the very base of the organ, project considerably (about 50 to 60 μ,) from the mouths. They are well sunken into the tissue of the leaf, their bases pushing down and disintegrating the palisade-cells. They remain covered over by the cuticle until ripe, when the cuticle is raised and opened by a porous opening. The formation of the spermogonia precedes that of the æcidia by a very considerable length of time. In the spermogonial stage, the hypertrophy of the leaf tissue is not so great as it becomes later, the thickness of the lamina being about 0·41 m.m. If sections of the leaf through a spermogonium be stained with Spiller's purple, it will be found that, while the sterigmata are coloured blue, the spermatia are coloured brick-red. The spermatia are oval and measure 8 × 4 μ.

Remarks.—From the nature of the dehiscence of the peridium, there can be no doubt that this Æcidium is identical with or allied to *Gymnosporangium clavariæforme*, Jacq., though in some respects it is not unlike *G. juniperinum*, L., especially in the colour of the spores. I made very frequent and numerous attempts to reproduce this Æcidium with teleutospores from a Gymnosporangium on *Cupressus torulosa* which is by no means uncommon on the few trees which occur in Simla, but always without result. Notwithstanding these negative results, I am still, however, inclined to believe that this Gymnosporangium (the only one I am acquainted with in these parts) is genetically related to the Æcidium just described, and I attribute my negative results to the influence of some unknown condition attending my experiments, although I have varied the conditions in every conceivable manner.

15.—Monosporidium Andrachnis, gen. et. sp. nov.

Andrachne cordifolia, Müll. Arg.

During August, especially towards its latter end, an Æcidium is not unfrequently met with on this host, which is common at elevations a little below that of Simla. It is not, however, a common Æcidium. Only the leaves are attacked and on them circular patches are formed by the fungus, red above with an irregular halo of yellow around it (Fig. 2, Pl. XV) and pale rosy red beneath (Fig. 1, Pl. XV.). The patch is concave on the upper or red surface, the under surface being correspondingly convex, and on this latter surface only are the Æcidia produced. Generally only one patch is to be found on a single leaf, though I have seen as many as six. The patches are usually very uniform in size, generally measuring about 6 m.m. in a diameter. The centre of the under surface of the patch is occupied by a number of spermogonia, while around it the æcidia are grouped more or less irregularly. A few spermogonia, however, emerge from the upper surface also. This Æcidium, therefore, in its general characters already resembles that described above on *Euphorbia cognata*, but differs notably in the æcidia being isolated cups, whilst in Euphubia we may imagine that the several cups have all fused together into one large circular æcidial fruit. The peculiar arrangement of the mycelium, however, in layers so characteristic of *M. Euphorbiae* is not found here. The mycelium ramifies generally among the cells as in other æcidia. The palisade-cells are not disarranged or deformed in any way, but the spongy tissue cells are hypertrophied and proliferated. The thickness of the leaf where invaded and where ripe aecidia were borne was in one instance 0·334 m.m., whilst the normal thickness was 0·138 m.m. The spermogonia are very small and superficial, as in *M. Euphorbiae.* They are insinuated between the epidermis cells and measure about 44 μ in width and 25 to 30 μ in depth. The æcidia when fully ripe measure about 0·265 to 0·248 m.m. in width and 0·233 to 0·217 m.m. in depth.

The *æcidiospores* are round, oval (Fig. 11, Pl. XV.), colourless, or very pale brown, and measure, when just wetted, on an average 21·6 $\times$ 18·4 μ, varying from 20 $\times$ 16 to 24 $\times$ 20 μ. They are given off in rows without any intermediate cells. The peridial cells are flat and irregular in shape, imbricate in arrangement, and measure from 18 to 24 μ in diameter (Fig. 10, Pl. XV.). They are beset with small ridges or tubercles. The mode of germination of these æcidiospores is exactly like the peculiar germination of the spores of *Monosporidium Euphorbiae.* The spores germinate very readily in water, throwing out a long non-septate tube, when the empty spore wall is seen to be beset very densely with minute tubercles. After lying in water 24 to 36 hours, a secondary spore is formed at the extremity of the germ tube (Fig. 13, Pl. XV.) just as I have described it in the case of Euphorbia. This secondary spore or sporidium is separated off from the germ tube by a septum, but never falls off altogether from the tube. In a cultivation of 48 hours' duration, I saw numerous secondary spores, and several of them, while still attached, had commenced to germinate, throwing out narrow tubes, which, though twisted a little (Fig. 14, Pl. XV.), never became spiral as in the case of *M. Euphorbiae*, nor so long. These secondary spores measure from 18 × 15 μ to 22 × 16 μ and on an average 20·3 × 15 μ. They are double-contoured and contain large granules in their protoplasm.

16.—ÆCIDIUM COMPOSITARUM, Martins.

Myriactis nepalensis, Less.

I have never found this Æcidium actually in Simla, where the host is common, but at Mashobra, a few miles beyond the Station, at about the same elevation. It may be found there towards the end of August and beginning of September. Only the lower leaves are affected, and generally before the plant sends up its flowering stalk, though I found one plant with three of its lower leaves affected while it was in full flower. The patches are circular and usually single, but sometimes more, on each leaf, and they are very large, measuring about 1·5 c. m. in diameter. The upper surface is pale yellow with a dark discoloured centre as the patch becomes older, while the lower surface is very pale yellow and here the æcidia are borne in great numbers thickly set together. With a field-lens it may be seen that the spermogonia are borne on the upper surface quite on the *margin* of the patch and not within it.

The *æcidiospores* are irregularly round or oval, pale yellow, and, when just wetted, measure from 14 × 14 to 17 × 12 μ and on an average 16 × 15·2 μ. (Fig. 15, *a.*, *b.*, Pl. XV.). The spores are given off in rows as usual. The epispore is thin.

The peridial cells measure about 34 × 16 μ to 42 × 20 μ and are arranged in an imbricate manner (Fig. 15, *c.*, *d.*, Pl. XV.).

Remarks.—The Æcidium not occurring actually in Simla, so far as I am aware, I have not been able to pay special attention to it. I presume it may be included under *Æcidium Compositarum*, Martins, although the measurements I give of the æcidiospores are smaller than those given by Winter in the case of *Puccinia flosculosorum*, Alb. & Schw., and *Uromyces Junci*, Desmaz. However, as I do not know of any teleutospore belonging to this Æcidium, I cannot do better than refer it provisionally to *A. Compositarum*, as recommended by Winter.

Concluding Remarks.—This completes the list of æcidium-bearing Uredines I have hitherto been able to examine in Simla, with the exception of the five which occur in Coniferæ, and which I hope to describe in a future paper. Three of these (on *Abies Smithiana* and *Cedrus Deodara*) I have already described in this Journal.* The other two occur on *Pinus longifolia* and *P. excelsa*.

* J. A. S. B. 1886, vol lv, pt. ii, pp 1—11, pls. i—iii; pp. 140 143, pls. iii, iv; et pp. 223—226, pls. vi, vii.

In addition to these, I have seen Æcidia on a species of *Geranium* (probably *nepalense*) and on *Ranunculus diffusus*, but in each case I only once found specimens, and unfortunately in each case I was unable to examine them. They are extremely rare about Simla. I may here also note that a very interesting Æcidium occurs on *Jasminum grandiflorum*, L., whose life history I am now engaged in investigating, but it is confined to the low-lying valleys near Simla and never appears in the station, which is too high for the host. A nearly allied species (*Jasminum officinale*, L.) which occurs abundantly in the woods about Simla never harbours this parasite or that which I have described above on *Jasminum humile*.

DESCRIPTION OF THE PLATES.

Plate XII.

1.	Sanicula	:	æcidiospore, × 350.
2.	Ditto	:	peridial cells, × 350.
3.	Pimpinella	:	uredospore, × 350.
4.	Violet	:	leaf, lower surface, natural size.
5.	Ditto	:	leaf, upper surface, natural size.
6.	Ditto	:	æcidiospore, 24 hours in water, × 250.
7.	Ditto	:	promycelium, × 350.
8.	Ditto	:	ditto.
9.	Ditto	:	ditto : showing terminal sporidial formation, × 350.
10.	Ditto	:	germinating sporidium, × 350.
11.	Ditto	:	peridial cells, × 400.
12.	Valeriana	:	æcidiospore, × 580.
13.	Ditto	:	uromyces spore, × 580.
14.	Pimpinella	:	æcidiospore, × 350.
15.	Ditto	:	peridial cells, × 350.

Plate XIII.

1.	Rhamnus	:	leaf, lower surface, natural size.
2.	Ditto	:	ditto, upper surface, natural size.
3.	Ditto	:	stem attacked, natural size.
4.	Ditto	:	peridial cells, × 350.
5.	Ditto	:	æcidiospore, × 350.
6.	Fragaria	:	æcidiospore, × 350.
7.	Ditto	:	uredospore, × 350.
8.	Ditto	:	germinating uredospore, × 350.
9.	Ditto	:	teleutospore, × 350,
10.	Valeriana	:	æcidiospore, × 400.
11.	Anemone	:	outline of leaf showing attack : natural size.
12.	Ditto	:	æcidiospore. × 480.
13.	Thalictrum	:	peridial cells, × 350.
14.	Ditto	:	æcidiospore, × 350.
15.	Ditto	:	basal cells of a row of æcidiospores showing intermediate cells, × 480.

Plate XIV.

1.	Thalictrum	:	portion of shoot showing petioles attacked, natural size.
2.	Jasminum	:	peridial cells, × 350.
3.	Ditto	:	æcidiospores, × 350.
4.	Euphorbia	:	*a.* leaf, natural size. *b.* same somewhat enlarged.
5.	Ditto	:	*a.* æcidiospore, × 350. *b.* peridial cell, × 350.
6.	Ditto	:	transverse section of leaf showing peculiar disposition of mycelium and superficial nature of spermogonium.
7.	Ditto	:	*a.* layer of mycelial filaments on lower side of leaf ; *b.* same on upper side, × 480.
8.	Berberis	:	æcidiospore, × 350.
9.	Ditto	:	peridial cells, × 350.
10.	Ditto	:	two isolated peridial cells, × 350.

Plate XV.

1.	Andrachne	:	under surface of affected leaf, natural size.
2.	Ditto	:	upper surface.
3.	Berberis	:	upper surface of attached leaf, natural size.
4.	Berberis	:	peridial cells, × 350.
5.	Pyrus	:	peridial cells, × 350.
6.	Ditto	:	æcidiospores, × 350.
7.	Euphorbia	:	æcidiospore germinating, × 350.
8.	Ditto	:	germinating æcidiospore, showing formation of secondary spore (sporidium) and its germination while *in situ*, × 350.
9.	Ditto	:	secondary spore (sporidium), × 350.
10.	Andrachne	:	peridial cells, × 350.
11.	Ditto	:	æcidiospores, × 350.
12.	Ditto	:	showing end of germinal tube (promycelium ?) of æcidiospore with commencing formation of secondary spore or sporidium, × 350.
13.	Ditto	:	completely developed secondary spore, × 350.
14.	Ditto	:	showing germination of secondary spore (sporidium) 350.
15.	Myriactis	:	*a.* row of æcidiospores ; *b.* isolated spore ; *c.* and *d.* peridial cells, × 350.

16. Flower head of *Thalictrum minus* completely involved and distorted by the Æcidium, natural size, approximately.

17. Leaf of same. Leaf deeply hollowed, much enlarged and thickened, and covered profusely with æcidia outside with a few tubes also inside, natural size, approximately.

XXII.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator,' *Commander* Alfred Carpenter, R. N., *Commanding, No.* 8. *Description of a new species of the Brachyurous Genus* Lyreidus *from the Depths of the Andaman Sea.—By* J. Wood-Mason, Esq., *Superintendent of the Indian Museum, and Professor of Comparative Anatomy and Zoology in the Medical College of Bengal, Calcutta.*

Lyreidus gracilis, n. sp.

♂. Very closely allied to *L. channeri.** Body and legs slenderer. Rostrum acutely triangular with straight sides. Extraorbital and antero-lateral spines absolutely as well as relatively longer. The head being narrower and more produced, its sides (between the extraorbital and anterior antero-lateral spines) are less deeply hollowed out, and its supraorbital borders, more deeply and narrowly emarginate. Eye-peduncles and corneæ equal and similar, apparently of the same form and proportions as in the left eye of *L. channeri*, the former reaching to about the junction of the second with the apical third of the length of the rostrum, the latter opaque yellow with the subjacent pigment showing through the cuticle as a dark ring round their bases. Propodite of the chelipeds armed below with three triangular spines. The meropodite bears two sharp erect spinules about the middle of the length of its upper border. In all other respects much as in *L. channeri.*

The unique example obtained measures :—

	Millims.
Length of carapace, from tip of rostrum to posterior margin, ...	23·3
,, ,, ,, ,, to middle of a straight line joining bases of posterior anterolateral spines, ...	8·5
,, ,, from same straight line to posterior margin,	15·0
Breadth of carapace, across the parallel-sided part, ...	12·7
Breadth of head, between tips of extraorbital spines,... ...	4·7
Distance between tips of posterior antero-lateral spines, ...	17·9
Length of posterior antero-lateral spines, ...	5·4
,, ,, anterior ,, ,, ,, ...	3·7
,, ,, rostrum, from a straight line tangent to the bottoms of the supraorbital emarginations, ...	3·0
,, ,, extraorbital spines from the same tangent, ...	4·0

Locality.—Off Port Blair; 271 fathoms; green ooze; January 2nd, 1888.

* Supra, p. 206 *et seqq*, pl. i.

INDEX.‡

Names of New Genera and Species have an asterisk (*) prefixed.

‡ A complete Index to the articles on *Rhynchota* published in this volume will be issued with the last of the series in a subsequent volume.

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Correction.

In volume LIV, Part II, 1885, p. 125, in the Essay on "The Swatch-of-no-Ground" 4 lines from the top of the page *for* "1400 fathoms" *read* "1000 fathoms"; and *for* "60 miles" *read* "100 miles."

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