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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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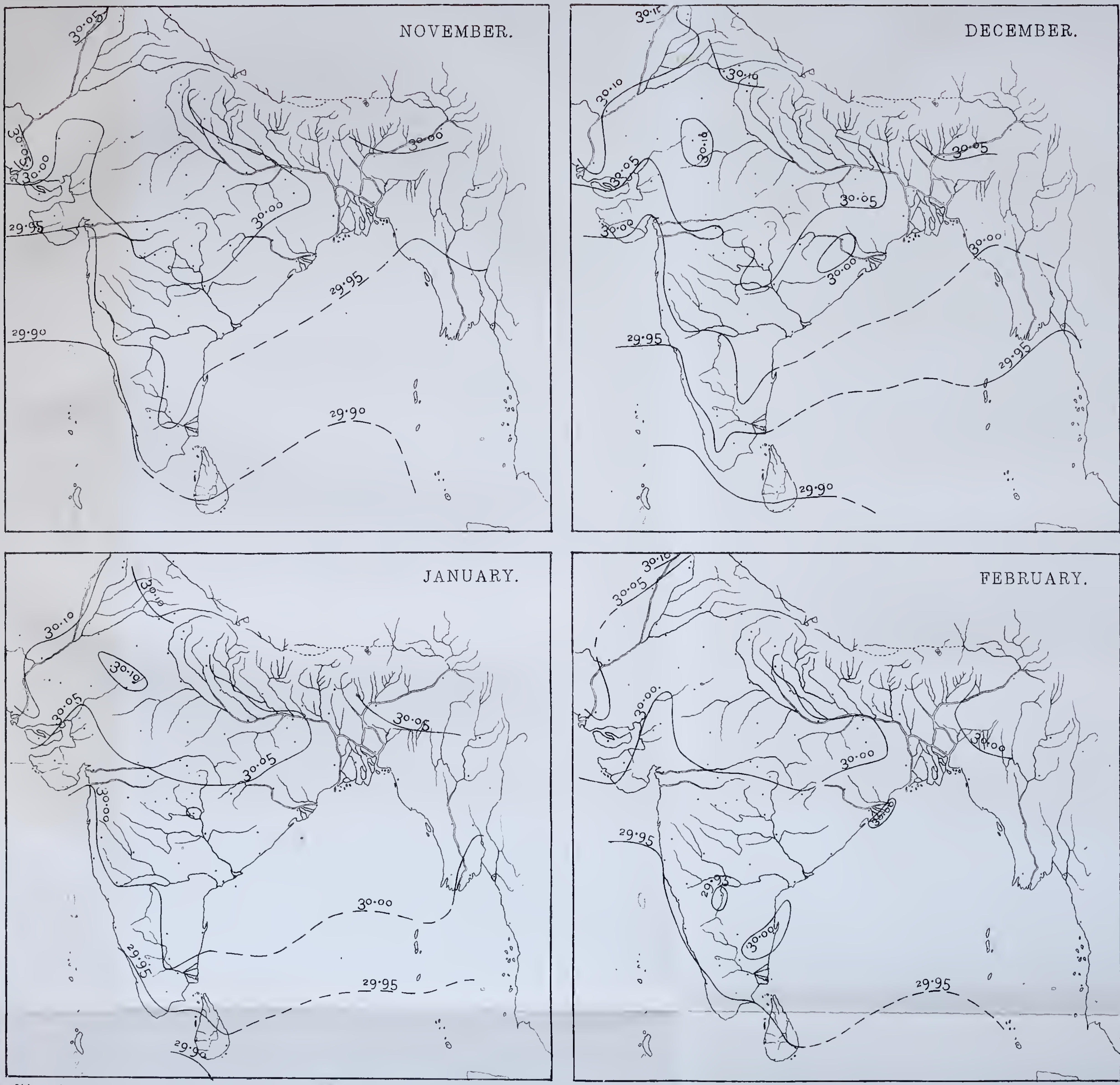

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ISOBARIC CHARTS OF AVERAGE PRESSURE.

JOURNAL

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ASIATIC SOCIETY OF BENGAL.

Part II.—NATURAL SCIENCE.

No. I.—1884.

I.—*The Theory of the Winter Rains of Northern India.—By* Henry F. Blanford, F. R. S., *President, Asiatic Society of Bengal, Meteorological Reporter to the Government of India.*

[Received and Read March 5th, 1884.]

(With Plate I.)

It has long been a commonplace of meteorological hand-books, that the winter, or, as it is more frequently (but less accurately) termed, the north-east monsoon, is due to a reversal of those conditions which, in the summer season, set in movement a flow of air from equatorial regions towards the plains of Southern and Eastern Asia. But, beyond this general statement of fact, very little has been done towards working out the physical characteristics of this familiar phenomenon of the Indian winter; and such vague conceptions as are implied in the popular theory, leave entirely unexplained the well-known occurrence of rain, about Christmas time, in Upper India; a region, which, according to that theory, should then be the seat of a barometric maximum, the fount and source of the winter monsoon.

Since the establishment of a Meteorological Department under the Government of India, has rendered it possible to study the weather of India as a whole, from day to day, some insight has been gained into the phenomena which precede and accompany the cold-weather rainfall of Northern India. In each of the annual reports on the Meteorology of India, in recent years, two or three instances of this cold weather rainfall have been described and illustrated at some length; and at the present time, although many important points still require further elucidation, it is at least possible to set forth some generalizations on the conditions which usher in the precipitation of the cold-weather rains, and on the probable source of the vapour which feeds them.

The four charts on Plate I exhibit the average distribution of atmospheric pressure in the months of November, December, January, and February. These charts, being based on the registers of duly verified barometers during the last seven years, corrected to a common standard and reduced to sea-level values from elevations, determined in all but a few exceptional instances, by actual spirit-levelling to the mean sea-surface, may be accepted as representing, with a near approximation to truth, the relative differences of pressure which characterize the winter months in India.* Certain characters common to all, may be regarded as distinctive of the season. The seat of highest pressure is in the neighbourhood of Peshawar. Whether this may be taken as indicating that the pressure on the highlands of Cabul is also greater than at similar elevations over the plains of India is, however, very doubtful. The situation of Peshawar on a plain of moderate extent, girt around with mountains, is such that the high pressure may be and very probably is a local effect of the cooled air, draining on all sides from the surrounding slopes and filling the basin from which its escape is much obstructed. A similar high pressure is shewn by some other stations near the foot of the N. W. Himalaya, of which Dehra is a notable example. The conditions of pressure at higher elevations over the Himalaya, will be noticed presently.

The next feature to be noticed is that, throughout the winter months, the axis of average high pressure on the plains and plateaux of India, occupies nearly the same situation as that of low pressure at

* Rigorously speaking any such representation must of course involve an element of unreality, which is the greater, the greater the difference of land levels in the area embraced in the chart; and, where, as in the case of India, large portions of the area differ by 2,000 feet and upwards, this element attains to some importance. Although it may not seriously impair the value of the chart as an illustration of the pressure-differences or potentials which maintain the system of wind-currents, the fact that the lower strata of air, resting on low alluvial plains, have no horizontal extension to the higher plateaux and cannot therefore be directly and immediately influenced by the atmospheric pressure there existing, is one that must be kept in view in discussing the relation of the winds to the pressure-distribution.

the opposite season. It extends from Upper Sind across Rajputana and the Central India plateau to Chutia Nagpur; the pressure along this axis declining, more or less irregularly, from N. W. to S. E. To the north of this ridge, a trough of relatively low pressure on the Gangetic plain separates it from the higher pressure along the foot of the Himalaya, and, in most years, the pressure in the Punjab is somewhat lower than that of Western Rajputana. On the other hand, to the south of this axis, the pressure falls gradually down to Cape Comorin and Travancore; being, however, considerably higher on the east than on the west coast of the peninsula. In fact, the isobars run down the peninsula almost parallel with the west coast. The low pressure area which runs down the west coast of the peninsula is prolonged to the north, up the Gulf of Cambay, producing a northward bend in the isobars of that region very similar to that shewn by them in the summer monsoon, but with reversed gradients.

Hence the cold weather distribution of pressure may be not inaptly described as a reversal of that which characterizes the summer monsoon; but, in the first place, the barometric differences between the extremes, and therefore the gradients effective in producing the monsoon current, are less than half as great, and, in the second place, the axis of high pressure across Northern India lies further south than its opposite in the summer monsoon. It lies well across the middle of the plateau to the south of the Ganges, instead of following the course of the river, or, as not unfrequently happens in the case of the summer trough of depression, somewhat to the north of it. Thus, both in summer and winter, low pressure tends to prevail in some part or other of the Gangetic valley and the Punjab; but in the summer the gradient declines towards the N. W., in the winter, to the S. E.

There is reason to believe that this normal distribution of pressure is restricted to the lower strata of the atmosphere, that is to say, to the stratum less than 7,000 feet in vertical thickness, measured from the sea-level. Thus, for instance, a row of stations on the plains of the Punjab and Ganges, ranging from Peshawar down to Purneah, shews a small, but decided, fall of pressure from N. W. to S. E., when all the mean readings are reduced to their equivalent values at the sea-level. But if the mean pressures of the hill-stations, Murree, Chakrata, and Darjeeling (all of which are between 6,000 and 7,000 feet, or a little over the latter elevation), be reduced to a common level of 7,000 feet, the gradient at that elevation is found to be slightly, but distinctly, reversed; Darjeeling, the easternmost station, shewing the highest pressure.

Sea-level Equivalents of Atmospheric Pressure on the Punjab and Gangetic Plains.

	November. ins.	December. ins.	January. ins.	February. ins.
Peshawar	30·098	30·174	30·161	30·115
Lahore	·023	·097	·084	·029
Delhi	·017	·089	·076	·020
Lucknow	·008	·078	·062	·006
Patna	29·995	·066	·060	·001
Purneah	·966	·028	·036	29·977

Equivalents at 7,000 *feet of Atmospheric Pressure at Stations on the outer Himalaya.*

	November. ins.	December. ins.	January. ins.	February. ins.
Darjeeling	23·404	23·380	23·339	23·320
Chakrata	·360	·340	·305	·281
Murree	·356	·332	·302	·268

It was shewn also in a paper on the winds of Northern India,* and in the *Indian Meteorologists' Vade Mecum*,† that, as between the Himalaya and Ceylon, the plane of neutral pressure, in January and February, is at a lower level than 7,000 feet; but not in the months of November and December; at least as an average condition. To this point, which is important, I shall presently return.

These facts of the pressure-distribution prepare us then to expect that which our wind-registers shew, *viz.*, that the winter monsoon is a much shallower, weaker, and more unsteady current than its correlative of the summer season. On the plains, the air is very calm in the Punjab; and, to the south and south-east, flows as a very gentle current, chiefly a day wind, drifting from the N. W. down the Gangetic plain; from north or N. E., and somewhat stronger, across the Central Indian plateau and the Satpuras; and from north or N. N. W. in Lower Bengal; then turning to N. E. or E. in the northern part of the peninsula, while, down the Bay of Bengal, it is pretty steady as the well-known N. E. monsoon. It turns, therefore, in an anticyclonic curve around the seat of maximum pressure in North Western India. Its rate of movement, its comparative steadiness, and its mean direction may be estimated from the following tables :—

* Phil. Trans. vol. 164, p. 563.
† Page 175.

Percentage of Wind-directions and Mean Daily Movement of the Wind at Stations in Northern India during the Winter Monsoon. (November to February.)

		Years.	Per cent.									Mean daily movement in miles.
			N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	
A North-Western India.	Rawalpindi	12	4	7	9	5	2	9	25	13	26	43
	Lahore	12	7	7	12	3	1	3	20	16	31	48
	Ludhiana	10	5	3	2	9	1	2	6	42	30	33
	Delhi	7	7	5	3	11	3	8	27	30	6	73
	Mooltan	12	8	21	1	10	4	14	2	15	25	47
	Jacobabad	4	17	14	9	5	1	3	6	13	32	48
	Bickaneer	4	10	18	8	7	9	20	5	7	16	68
B Gangetic Plain.	Roorkee	17	2	3	2	13	3	6	6	25	40	50
	Bareilly	12	3	5	4	8	1	7	17	39	16	68
	Lucknow	12	12	5	2	4	2	5	17	28	25	43
	Allahabad	12	9	6	9	2	3	6	24	11	30	38
	Gorakhpur............	12	1	2	4	6	2	7	29	15	34	?
	Benares	16	4	6	8	3	3	11	39	12	14	64
	Patna	13	4	5	7	3	3	8	35	16	19	44
	Purneah..............	7	4	9	9	3	2	8	52	13	...	46
C Western India.	Hyderabad	4	41	7	...	1	2	10	5	19	15	158
	Kurrachee............	21	9	18	16	4	4	14	18	9	8	229
	Rajkot	4	23	25	20	2	1	3	6	11	9	126
	Deesa	22	19	23	11	7	3	6	9	14	8	202
	Pachbudra............	3	4	24	15	5	4	9	4	6	29	?
	Surat	4	12	17	18	10	2	12	14	11	4	132
D Central India Plateau and Satpuras.	Mount Abu	5	9	19	14	8	10	18	9	7	6	105
	Neemuch	4	8	12	12	15	16	16	9	12	?	153
	Indore	4	10	15	28	8	8	4	12	5	10	59
	Jhansi..................	10	2	35	6	8	2	15	4	11	17	51
	Nowgong	4	18	9	9	3	1	5	11	16	28	38
	Saugor	11	16	29	10	6	5	7	11	14	2	54
	Sutna	5	17	13	8	3	4	5	11	32	7	89
	Jubbulpore............	11	24	18	7	6	16	6	8	9	6	55
	Pachmarhi............	11	15	17	8	15	7	9	5	21	3	68
	Seoni	11	2	40	5	16	1	18	...	16	2	68
	Chikalda	5	25	4	4	11	18	12	7	17	2	110
E Chutia Nagpur.	Hazaribagh	14	10	6	4	4	4	6	23	40	3	118
F Lower Bengal.	Berhampore	14	24	8	3	2	2	8	16	25	12	41
	Calcutta................	19	31	7	6	3	9	8	15	20	1	80
	Jessore	14	30	10	3	4	4	5	8	25	11	42
	Dacca	14	17	9	3	4	7	9	15	20	16	53

On comparing these tables with those for the summer monsoon, at the same stations, the relative greater frequency of calms, more especially in the Punjab and the Gangetic plains, the inferior steadiness of the wind in the prevailing quarter, and the very low absolute rate of its movement are strikingly apparent. The highest rates of movement are in Western India, as are also those of the summer winds, but the former vary from less than half to less than two-thirds of the latter, and the directions are much more variable.

It is further to be noticed that, while, at most stations, there is one direction of decided maximum, with some oscillation on either side (this being the local direction of the winter monsoon), at stations in the Punjab and the adjacent parts of the Gangetic plain, and also at Jhansi, Jubbulpore, Chikalda, Mount Abu, and Kurrachee, there is a distinct secondary maximum from an opposite quarter; and, at Mount Abu, Neemuch, and Bickaneer, a certain absolute preponderance of southerly winds. These are the winds which interrupt the winter monsoon and bring up the vapour that is condensed on the Himalaya as snow, and on the plains of Northern India as the winter rains of that region.

In fact, not only is the barometric gradient which characterizes the winter monsoon less highly inclined than that of the opposite season, and the vertical height to which it prevails (the elevation of the neutral plane) considerably less, but it is more frequently reversed, and especially so in January and February; and, as a temporary phenomenon, barometric minima, with the usual vortical systems of winds, occasionally appear in Northern India. On such occasions, rain almost invariably follows, beginning generally over the mountains that hem in the Punjab, and on the plains at their foot, and thence extending to the east and south-east; while the barometric depression moves eastward, and cold westerly winds, bringing fine weather and a wave of high barometric pressure, follow up in the rear.

In the majority of cases the history of which has hitherto been traced out, the barometric minimum first appeared, and was apparently formed in some part of the great north-western plain, most frequently in the Punjab or Upper Sind; but, in some cases, in Western Rajputana. Mr. F. Chambers has put forward the suggestion* that these minima travel hither from regions further west, from the plateau of Beloochistan or the still loftier mountain-tract of Afghanistan; but this seems to be a misapprehension. We have, indeed, no observatory in Afghanistan, and it may be long before any systematic observation is possible in that interesting, but turbulent, country. But an observatory has existed for some years past at Quetta, and, although its elevation is

* Nature, vol. xxiii, p. 400.

not known with sufficient precision to admit of its barometric register being reduced to terms comparable with those of the Sind and Punjab stations, I have compared the oscillations of the Quetta barometer with those in the valley of the Indus, when barometric minima have appeared in Upper Sind, and find that, with two very doubtful exceptions, in January and February 1880, any fall of pressure at Quetta was either simultaneous with the fall in Sind, or somewhat later. In one of these exceptional instances, there was a slight fall at Quetta two days, and in the other one day, before it took place at Jacobabad ; but on both occasions, the great fall, when the minimum was established in Upper Sind, was simultaneous at both stations. In such cases as that of the 25th January 1878 (when the minimum first appeared at Deesa) and those of January, February, and March 1881 (when a barometric depression which had existed in Western Rajputana throughout the cold season, was simply intensified immediately prior to the rainfall), there could be no question of a depression travelling from the westward.

But it is not only in North-Western India even, that barometric minima are occasionally formed in the winter months : in the case of the rain of the 10th to 13th January 1878, it first appeared on the western half of the Deccan plateau ; in that of the 10th February 1879, a long trough-shaped depression ran through the heart of India from Belgaum to Lucknow, and, in that of the 15th to 18th February 1880, it was first established in the Central Provinces, whence it was transferred to the Punjab ; and the distribution of pressure, in Northern India, became strikingly similar to that which characterizes the rainy season.

There is, then, no reason to doubt that, notwithstanding that Northern India is in general and on an average an area of high pressure in the winter season, relatively to lower latitudes, this condition is by no means constant or lasting. The atmospheric pressure, in extra-tropical India, more frequently than that of the peninsula, occasionally falls below that prevailing over the seas to the south, causing vapour-bearing currents to pour in from that direction; and these currents, in ascending around the seat of minimum pressure, chiefly on the east and north of the minimum, condense that vapour as rain (and on the hills as snow). This is a more or less regularly recurrent feature of the winter season.

Of the conditions which determine the formation of these barometric minima, but little can be positively asserted in the present state of our knowledge. That they do not originate in a local excess of temperature in the lower atmospheric strata, is abundantly apparent ; the rise of temperature that, in general, precedes the rainfall, and is accompanied with a rise in the relative and absolute humidity of the air, is simultaneous with the setting in of the southerly wind ; and this change of wind implies a pre-existing reversal of the barometric gradient, which is the phenomenon to be accounted for. The following considerations may, however, be worthy of attention as tending to throw some light into the prevailing obscurity.

It has been shewn above, that, at the very moderate elevation of 7,000 feet over the outer Himalaya, the barometric gradient is on an average slightly, but distinctly, reversed. At greater elevations, it is most probable that the reversal is more decided, for I have shewn elsewhere* that at Leh (11,500 feet) the pressure in February is at its annual minimum, and the wind-registers of all our hill-stations establish the fact that, throughout the winter months, the prevailing winds are southerly. This preponderance is no doubt, in some measure, perhaps mainly, due to the fact that the observations are those of 10 A. M. and 4 P. M. only ; at which hours the diurnal up-draught of the mountain winds, in an otherwise still atmosphere, is fully active. But I have myself witnessed at Darjeeling, in December, the effects of a strong steady current, sweeping overhead from the south-west, clothing the snowpeaks with cloud-banners. This strong southerly wind is, however, exceptional ; and is that which precedes rain ; and although it is not improbable that, at great elevations, there is a more or less steady flow of air towards Central Asia, to feed the outflow, at low levels, from the anticyclone which, as we know, normally exists in the winter over Northern and Central Asia, there is no reason to question that, up to a considerable elevation over Northern India, the more usual condition is one of comparative stillness or at most of light movement. And, in this state of the atmosphere, even a feeble local action, tending to reduce the density and therefore the pressure, may suffice to set up a centripetal influx of air which may in a short time produce a well-developed barometric minimum. How this may be brought about will be shewn presently.

The southerly surface winds that are invariably the precursors of precipitation, are not merely local ; they prevail also far to the south, indeed over a great part of India ; and they arrive charged with vapour gathered both from the sea and from the warmer land-surface of more southerly regions.

It seems not improbable, then, that the ulterior conditions which give rise to the winter rains, may have their seat in the more elevated or middle region of the atmosphere ; and we must look to the formation of cloud as the condition which, by disturbing the thermal equilibrium

* *Indian Met. Memoirs*, vol. i, p. 224.

of the atmosphere, determines a convective current with a cyclonic circulation, and a barometric minimum. The prevailing calmness of the Punjab atmosphere, combined with a high degree of relative humidity in the winter months, affords conditions not unfavourable to this action.

Before proceeding further with this discussion, it will be of advantage to consider the distribution of the winter rainfall, its distribution both in time and space.

For this purpose it will not be necessary to illustrate the subject in great detail, and, instead of giving the means of individual stations, I shall summarize the data in the form of the averages of large areas. The following table gives the average amount of the fall in each of the months from November to March.

Summary of the Winter Rainfall of Extra-tropical India.

	Stations.	Inches of rainfall.					
		November.	December.	January.	February.	March.	Total.
Peshawar and Derajat	5	0·46	0·51	0·65	1·06	1·29	3·97
Hazara and Patwar	4	1·06	1·50	1·57	2·64	2·66	9·43
The four doabs	11	0·18	0·60	0·77	1·15	1·14	3·84
Eastern Punjab	11	0·07	0·58	0·91	0·95	0·95	3·46
Kangra, Sirmoor and Kumaon	11	0·18	1·01	2·10	2·80	2·54	8·63
N. W. P. & Oudh, Western half*	24	0·06	0·33	0·81	0·66	0·57	2·43
Ditto ditto, Eastern half	15	0·10	0·15	0·66	0·55	0·34	1·80
North Behar and Bhagalpore	5	0·08	0·10	0·58	0·53	0·45	1·74
Northern Bengal	8	0·34	0·12	0·43	0·79	1·18	2·86
Assam and Cachar	13	0·95	0·36	0·64	1·35	3·45	7·00
Upper Sind	3	0·08	0·16	0·23	0·37	0·44	1·28
Lower Sind, Cutch and Gujarat	18	0·08	0·07	0·11	0·16	0·06	0·48
Rajputana	20	0·09	0·27	0·11	0·31	0·15	0·93
Central India, &c.	24	0·16	0·19	0·42	0·40	0·23	1·40
Mirzapore and Chutia Nagpur	14	0·22	0·13	0·58	0·78	0·57	2·28
Lower Bengal	15	0·50	0·17	0·48	1·07	1·60	3·82

The above table includes the whole of extra-tropical India, and it is only in a portion of this region that the cold weather rainfall can be regarded as a well-marked and regularly recurrent phenomenon; having a distinct maximum, that is to say, in the winter or spring months and equally defined minima before and after. The variations, shewn in the above table, are considerable, both as regards the total amount and the epoch of the maximum. It is on the N. W. Himalaya

* The meridian of Lucknow is taken as the boundary.

and on the hills of the Northern Punjab that these rains are most copious, and that the maximum falls latest; the precipitation frequently taking the form of snow at all but the less elevated stations. In the extreme north-west, they attain their maximum in March and April; for the April rainfall (not shewn in the table) is about equal to that of March at Peshawar and in the hills of Hazara, while that of May and June is insignificant. But south of the Salt Range, and on the plains of the Eastern Punjab, the rainfall of February and March exceeds that of April. Still further to the south-east, throughout the greater part of the Gangetic plain, the maximum occurs still earlier, *viz.*, in January; and this holds good as far as Behar and the confines of Northern Bengal. This anticipation of the maximum is not due to the January rainfall of the Gangetic plain being heavier than that of the Punjab. On the contrary, it is rather less: but the decrease in a south and S. E. direction is much less rapid in January than in the subsequent months. In Northern Bengal, even the January maximum has vanished; and while the average rainfall of that month is only slightly less than in Behar and the eastern part of the N. W. Provinces, that of February is higher, and that of March shews a further considerable increase. So far, the course of the variation seems to resemble that of the N. W. Punjab; but the further steady increase of the fall in April, May, and June shews that this resemblance is fallacious, and that we have here to do with a phenomenon of a different order, *viz.*, the storm precipitation of the spring months, the characteristics of which are still more pronounced in the more easterly province of Assam. As a well-marked feature of the local meteorology, the cold weather rainfall does not extend, in an easterly direction, beyond the province of Behar.

Turning now to the regions somewhat further south, but still, for the most part, without the tropic, we see that in Upper Sind the total fall of the five months is very small, notwithstanding that it represents nearly one-third of that of the year; and also that, as in the Derajat, it reaches its maximum in March. In Lower Sind, Cutch, and Gujarat, the whole precipitation of the season is insignificant; but a maximum is still faintly indicated in February, and the same is more strongly marked in Rajputana, where the fall is about double as great. In Rajputana, it would appear that the December rainfall is almost as great as that of March; but this is mainly due to an exceptionally heavy rainfall in December 1877,* combined with the fact that the Rajputana registers extend over a shorter period than those of most other parts

* On this occasion nearly five inches of rain were registered at Banswara, between 3 and 4 inches at Jhalrapatam and Ulwar, and over 2 inches at Kotah, Deoli, and Bhurtpore.

of the country. I do not think, therefore, that, on the average of a long period of years, the November rainfall of Rajputana would be found to follow a different law of distribution from that of other provinces around. In Central India, including those portions of the Central Provinces and the N. W. Provinces that extend between the Jamna and the Satpura range, the total fall is again higher, with a maximum in January and February; and, still further east, in Mirzapore, South Behar, and Chutia Nagpur, it is again greater, with the maximum in February; but this apparent retardation of the maximum is evidently due to the inclusion of the early spring storms which in Chutia Nagpur become of relatively greater importance; and this is rendered further evident in the table for Lower Bengal.

The conditions which determine the storm precipitation of the spring months will be noticed elsewhere. Meanwhile, it results from the above analysis that the cold weather rainfall, as here considered, is that which takes place chiefly on the north and east of the barometric depressions, which are occasionally formed, in the winter months, in North-Western India. It is most copious where normally the winter temperature is lowest, *viz.*, on the N. W. Himalaya. It decreases rapidly to the south, and less rapidly to the south-east, and, in this latter direction, it blends into and becomes with difficulty distinguishable from the rainfall of the spring storms, which are, however, a phenomenon of a different order.

Having thus defined the area and noticed the general characteristics of the winter rainfall of North-Western India, I will return to the question of the origin of those barometric depressions which have been shewn to be the immediate precursors of the precipitation, or perhaps rather of simultaneous formation. The area above defined as that of the winter rains, is identical with that in which, as has long been known, the relative humidity of the air, instead of diminishing towards the interior of the country, increases with the increasing distance from the sea-coast. On page 203 of the *Indian Meteorologist's Vade Mecum* (Part II, para. 109), I described this phenomenon as follows: "In the maritime provinces (of India) there are but one (annual) period of maximum and one of minimum humidity; in the Punjab and in Central India and the North-Western Provinces, there are two annual maxima and two minima; and in the drier part of the first named province, the winter is the dampest season of the year * * * *. Stations on the coast line have, at all times of the year, a higher degree of relative humidity than those on the plains of the interior. But the rate of increase is very different at different seasons; and in consequence of the greater cold of Upper and extra-tropical India, in the first three months of the year, the rule of increasing dryness with increasing distance from the coast holds good inland, only as far as Behar; and thence to the Punjab the relative humidity of the atmosphere increases steadily. It appears to be higher also through Central India, north of the Satpuras, but the meteorological statistics of this tract have not yet been sufficiently worked out to enable us to fix the limits of the area of higher winter humidity."

The above passage was written in 1876, only a year after the meteorological data for the whole of India had been, for the first time, concentrated in one central office, and when the system of observation had been but recently extended to many stations in Rajputana and Central India. It is, therefore, desirable to set forth, in a tabular form, some excerpts from the further evidence which has since been put on record; and, to this end, I give, in the following tables, first, the absolute humidity of the air as represented by the proportion of vapour in 1,000 parts (volumes) of air, second, the relative humidity, and, third, the cloud proportion (in thousandths of the sky-expanse*) in each of the six months November to April for four series of stations, three passing successively from east to west (or north-west) and representing respectively the Himalaya, the alluvial plain, and the plateau which extends between the latter and the Satpura range; and the fourth passing from south to north, beginning with stations south of the Satpura range, and terminating in the Punjab.

* The figures of the two latter tables are extracted from those of the average values of the several meteorological elements given in the Report on the Meteorology of India in 1881.

Mean Absolute and Relative Humidity of the Air and Proportion of Cloud in Northern India in the Winter and Spring Months.

Stations.	Elevation in feet.	Miles from Sea.	Volume of vapour in 1000 of air.						Percentage of saturation.						Cloud proportion $\frac{x}{1000}$.					
			November.	December.	January.	February.	March.	April.	November.	December.	January.	February.	March.	April.	November.	December.	January.	February.	March.	April.
Darjeeling,	6,712	375	12	9	9	10	12	15	75	73	78	78	71	77	439	425	569	592	531	614
Ranikhet,	6,069	730	10	8	8	8	10	11	58	56	59	60	55	47	122	270	344	461	378	335
Chakrata,	7,050	750	9	6	6	7	8	10	58	52	61	58	54	47	153	351	413	539	465	385
Murree,	6,344	750	7	6	5	6	8	10	43	49	48	57	51	50	315	455	516	541	595	520
Saugor Island,	6	0	22	17	18	22	27	32	74	73	75	77	78	80	248	180	180	188	356	474
Calcutta,	18	65	20	15	14	18	22	28	74	71	70	69	69	73	220	196	127	192	225	265
Jessore,	33	95	20	16	14	16	21	27	68	63	60	55	55	62	210	132	158	176	274	336
Berhampore,	66	176	18	14	12	14	18	22	72	71	69	65	58	62	257	194	215	192	291	320
Purneah,	125	295	17	14	12	13	16	21	70	69	66	59	55	56	93	107	122	113	140	150
Patna,	179	307	15	12	12	13	14	16	57	60	60	55	43	39	176	201	249	275	315	233
Benares,	267	368	13	10	10	11	12	13	62	64	63	57	43	36	120	162	222	240	217	184
Allahabad,	307	430	14	12	11	12	13	15	63	68	67	60	46	36	92	163	193	222	189	143
Lucknow,	369	550	12	10	10	11	14	15	53	58	59	55	46	37	91	192	282	333	291	222
Bareilly,	568	665	13	10	10	11	14	15	59	64	64	61	53	41	67	177	271	309	261	177
Roorkee,	887	690	12	10	10	10	12	12	57	64	65	62	52	36	87	222	285	358	264	227
Ludhiana,	812	690	10	9	9	11	12	15	51	62	63	63	57	50	155	249	333	389	386	264
Sialkot,	829	717	11	10	10	10	13	14	56	68	68	67	58	42	214	309	404	443	448	367
Rawalpindi,	1,652	730	10	9	8	9	12	16	62	67	67	68	63	59	199	305	388	442	439	382

Mean Absolute and Relative Humidity of the Air and Proportion of Cloud in Northern India in the Winter and Spring Months (Continued).

Stations.	Elevation in feet.	Miles from Sea.	Volume of vapour in 1000 of air.						Percentage of saturation.						Cloud proportion $\frac{x}{1000}$.					
			November.	December.	January.	February.	March.	April.	November.	December.	January.	February.	March.	April.	November.	December.	January.	February.	March.	April.
Hazaribagh,	2,010	205	12	10	9	10	10	12	53	52	51	44	36	32	203	192	236	211	258	262
Sutna,	1,040	450	10	8	8	9	8	10	42	48	47	41	29	25	137	162	216	292	262	252
Jhansi,	855	490	10	9	9	10	11	12	39	45	47	42	34	28	29*	38*	66*	75*	40*	46*
Neemuch,	1,639	280	9	7	7	8	9	11	35	38	35	35	30	26	63	149	151	310	234	230
Ajmere,	1,611	410	11	9	9	10	12	15	45	49	47	46	42	38	101	152	245	273	280	249
Raipur,	960	270	16	12	12	14	13	15	60	56	55	51	41	36	168	127	132	112	165	209
Nagpur,	1,025	350	14	12	11	12	11	13	52	50	49	42	32	28	257	238	233	194	255	305
Akola,	930	270	13	11	10	10	11	10	50	48	44	37	28	22	134	146	139	199	127	128
Jubbulpore,	1,351	420	13	10	11	12	13	13	57	56	58	53	40	32	171	197	218	238	246	217
Sutna,	1,040	450	10	8	8	9	8	10	42	48	47	41	29	25	137	162	216	292	262	252
Nowgong,	757	515	11	10	9	10	11	14	50	56	52	48	37	31	91	153	182	365	240	205
Jhansi,	855	490	10	9	9	10	11	12	39	45	47	42	34	28	29*	38*	66*	75*	40*	46*
Agra,	555	540	11	9	9	10	11	13	43	53	55	49	40	31	54	131	167	245	175	144
Delhi,	718	615	11	9	9	10	12	13	46	53	55	52	45	34	80	176	309	334	299	269
Ludhiana,	812	690	10	9	9	11	12	15	51	62	63	63	57	50	155	249	333	389	386	264

* The estimates of cloud proportion are probably affected by a large personal equation.

The above table confirms and justifies the description already quoted from the *Vade Mecum,* and also the generalization just given, that the area of the winter secondary rainfall maximum coincides with that in which there is also a winter secondary maximum of relative humidity. But it also brings into prominence some further facts, which assist in throwing much light on the causes of the rainfall. In the first place, it is to be noticed that the increase of the relative humidity of the later months, as we proceed from Behar towards the Punjab, is due, solely, to the fall of temperature ; the absolute humidity being almost constant ; but the latter is decidedly lower on the high ground of Central India and Rajputana, south of the Gangetic plain, than on the latter and in the Punjab. These two facts, *viz.*, the uniformity of the absolute humidity over the riverain tract, and its decrease on the higher ground to the south, indicate that it is mainly dependant on local evaporation ; being, in fact, furnished by the rivers, the undried swamps left by the autumnal floods, and, in no small degree, probably, by irrigation and the rich vegetation of the green winter crops. In the second place, it is to be observed that this riverain tract also coincides with the region of lower normal pressure, to the north of the axis of maximum pressure, shewn on the normal baric charts, on Plate II. And lastly, the tendency to cloud formation follows, on the whole, the same laws of distribution as the relative humidity of the lower atmosphere, with, however, this important exception ; that, except in April and to a slight extent in March, it is lower in the neighbourhood of the coast (in Lower Bengal), notwithstanding the higher relative humidity of the lower atmosphere, than in the Upper Provinces, where the rainfall generally originates.

Now putting together the several facts thus independently elicited from the study of our registers, we arrive, I think, at the outlines of a consistent theory of the production of the winter rainfall. We have, in the first instance, steady evaporation over an extensive moderately humid tract, at a comparatively low temperature, it is true, but in an atmosphere, the stillness of which allows of steady diffusion of the vapour to high levels, and the consequent formation of cloud. The slight disturbance of the baric equilibrium which follows (since the vertical decrease of temperature in a cloud-laden atmosphere is slower than in a clear atmosphere), is succeeded by a gentle indraught of warmer and more humid air from the south ; for the Himalaya bars access to northerly winds. A vortex is then rapidly formed, accompanied with an increased cloud-formation, and speedily followed by precipitation ; which takes the form of snow on the hills, and of rain over the river plains. The rainfall is invariably followed by a cool wind, and a wave of high barometric pressure from the west, which I can only attribute to a drainage of cool heavy air from the valleys of the hills surrounding the Punjab and the high lands of Beloochistan and Afghanistan; air cooled by the precipitation on the mountains.

If the above view be true, the stillness of the atmosphere, combined with the presence of a moderate evaporation, must be accepted as the condition which primarily determines the formation of barometric minima and the winter rains of Northern India. And this stillness is obviously due to the existence of the lofty mountain ranges which surround Northern India, leaving free access to the plains open only to the south.

Were the Himalayan chain absent and replaced by an unbroken plain, stretching up to the Gobi desert, it is probable that the winter rains of Northern India would cease; any local evaporation in the Punjab and Gangetic valley would be swept away by strong dry N. E. winds blowing from the seat of high pressure, which, in the winter months, lies in Central Asia; and instead of the mild weather and gentle breezes which now prevail at that season, on the Arabian Sea, it would be the theatre of a boisterous and even stormy monsoon, such as is its local equivalent of the China Seas. Other and even greater changes of climate, that would supervene on the suppression of the Himalayan range and the consequent alteration of the summer monsoon, its precipitation, and the course of the land drainage thereby fed, it would be beyond the province of my present subject to discuss.

II.—*Descriptions of some new Asiatic Diurnal* Lepidoptera; *chiefly from specimens contained in the Indian Museum, Calcutta.—By* Frederic Moore, F. Z. S., A. L. S. *Communicated by the* Natural History Secretary.

[Received May 14th,—Read June 4th, 1884.]

Family NYMPHALIDÆ.

Subfamily Satyrinæ.

Genus Ypthima, Hübner.

Ypthima mahratta, n. sp.

Male and female. Upperside brown; forewing with a subapical bipupilled ocellus; between which and the outer margin is a pale brown curved fascia as in *Y. newara:* hindwing with a very small subanal unipupilled ocellus.

Underside pale whitish-brown, very numerously covered with short delicate pale brown strigæ, which are uniformly disposed: forewing with a brownish marginal fascia, which curves below the ocellus and extends up the disc towards the costa: hindwing with a very small apical ocellus, and two anal ocelli of the same size.

Expanse $1\frac{1}{10}$ to $1\frac{4}{10}$ inch.

Hab. Deccan (*Dr. Day*). In coll. F. Moore.

Allied to *Y. ariaspa*, *Y. rura*, and to *Y. norma*. Nearest to *Y. norma*, the type specimens of which are from China. Differs from the last species, on the upperside, in having a smaller ocellus on the forewing, and a single subanal ocellus on the hindwing. Underside with shorter and more numerous strigæ; both the apical and the two anal ocelli of hindwing are half the size of those in *Y. norma*.

The hindwing also has a comparatively longer costal margin, which thus gives the apex and exterior margin less convexity.

Ypthima apicalis, n. sp.

Male. Upperside pale brown: forewing with a small rounded bipupilled apical ocellus, above which is a distinct broad whitish streak: hindwing with two very small subanal ocelli, the upper one minute, the anal and apical ocellus of the underside being slightly visible from above; across the middle of the lower discal area is a faint pale slight fascia. Underside pale brownish-ochreous, with indistinct darker brown uniformly disposed strigæ: forewing with the apical ocellus and white upper streak as above: hindwing with a small apical and three lower ocelli, the anal one bipupilled; an indistinct pale whitish fascia is traceable across the disc above the lower ocelli.

Expanse $1\frac{2}{8}$ inch.

Hab. Deyra Dhoon (*Godwin-Austen*). In coll. F. Moore.

Ypthima kasmira, n. sp.

Male and female. Upperside dark brown: forewing with a moderately small bipupilled apical ocellus: hindwing with two small subanal ocelli in male and, in female, a third minute anal ocellus.

Underside purpurascent brownish-white, densely covered with uniformly disposed purplish-brown strigæ: forewing with prominent apical ocellus: hindwing with prominent large apical and three lower ocelli, the anal one tripupilled.

Expanse ♂ $1\frac{2}{8}$, ♀ $1\frac{3}{8}$ inch.

Hab. Cashmere (*Capt. Hellard*). In coll. F. Moore.

Ypthima howra, n. sp.

Male and female. Upperside brown: forewing with a bipupilled apical ocellus: hindwing with two small subanal ocelli, some specimens of both sexes also having a smaller anal ocellus, all with a single pupil. Underside yellowish ochrey-white: forewing with the ocellus as above: hindwing with a very small apical ocellus and four lower ocelli, the two anal being geminated and the smallest. Both wings are crossed by ochreous-brown strigæ; with the three outer transverse fasciæ on forewing, and an angulated discal fascia, as well as a sinuous marginal fascia, on the hindwing.

Expanse ♂ $1\frac{2}{8}$, ♀ $1\frac{3}{8}$ inch.

Hab. Calcutta. In coll. Ind. Mus., Calcutta, and F. Moore.

Nearest to *Y. hübneri.* Distinguishable from typical specimens (figured as *Y. philomela*, Hubner, Zutr. fig. 83-84), on the underside, by the yellowish ochreous-white ground-colour, and the transverse fasciæ on the hindwing, as well as by the small size of the ocelli.

Ypthima horsfieldii, n. sp.

Male. Upperside dark olive-brown; discal area dusky; subapical ocellus oval, bipupilled: hindwing with two medial and a minute anal ocellus.

Female. Upperside: forewing with a large rounded ocellus: hindwing with two larger medial, a small anal, and a medium-sized apical ocellus. Underside of male and female ochreous-white: forewing almost covered with dark vinous-brown confluent strigæ: hindwing very sparsely covered with slender brown strigæ very similarly disposed to those in the typical Javan *Y. pandocus:* ocellus of forewing as above: hindwing with two small apical, two larger medial, and two smaller anal ocelli.

Expanse ♂ $1\frac{4}{10}$, ♀ $1\frac{6}{10}$ inch.

Hab. Java. In coll. F. Moore.

Subfamily Nymphalinæ.

Genus Euthalia, Hübner.

Euthalia andersonii, n. sp.

Male and female. Upperside dark umber-brown, palest in the female; both wings with a marginal bluish-grey band, which extends very narrowly from the apex of forewing and widens across the hindwing to broadly above anal angle. Within and beneath the cells the black streaks are most distinct in the female; across the discal area are two indistinct dusky sinuous fasciæ widening from the costa of forewing, at which end the interspace is slightly paler in the male and distinctly paler in the female. Cilia white.

Underside ochreous-brown in male and yellowish ochreous in female; the outer borders broadly suffused with purplish lilacine-white; cell-marks distinct; across the disc of both wings are too dusky lunular fasciæ with pale interspace, most distinct in the female, the fasciæ being disposed across the middle of the disc.

Expanse ♂ $2\frac{1}{4}$, ♀ $2\frac{3}{4}$ inches.

HAB. Mergui; Tavoy. In coll. Ind. Mus., Calcutta, and F. Moore.

Nearest allied to *E. cocytus*, Fab.; also to *E. lepidea*, Butler, and to *E. macnairii*, Distant.

Genus CIRRHOCHROA, Doubleday.

CIRRHOCHROA ABNORMIS, n. sp.

Male. Upperside ferruginous-yellow: forewing with a medial discal transverse black lunular waved band, which is broadest at the costal end, a narrower submarginal sinuous band, and a nearly straight marginal line, the interspace from the submarginal band and edge of the wing being suffused with black towards the apex; an indistinct dusky streak at end of the cell: hindwing with a medial discal transverse angulated black lunular band, which is broadest at the costal end; a submarginal lunular line, and a slender nearly straight marginal line; a row of minute black discal dots. Underside brownish-ochreous; a transverse medial slightly purpurascent band, with waved suffused dusky lunular inner border and slender almost straight outer border, the band being quite narrow where it crosses from fore to hindwing and broadly dilated at the costal end on forewing and at anal end on the hindwing; contiguous to the inner border of the band is a similar dusky suffused lunular fascia, the interspace being of a slightly pale yellowish colour; at end of each cell is a dusky double lunular mark, a similar double lunular waved line also extends from mid lle of the cell on forewing to below the cell on the hindwing; outer border of both wings traversed by faint traces of a yellowish submarginal lunular band; on the forewing is a conspicuous and whitish apical patch, and on the hindwing is a row of very small blackish transverse discal dots.

Expanse $2\frac{5}{8}$ inches.

HAB. Darjiling. In coll. F. Moore.

Genus ERGOLIS, Boisd.

ERGOLIS TAPESTRINA, n. sp.

Male and female. Comparatively smaller than *E. merione;* outline of forewing more irregular. Upperside paler; with similar transverse sinuous lines on both wings, the two medial lines being somewhat nearer together, the discal cordate marks having their outline of a uniform width, and being somewhat narrower transversely, thus leaving a slightly but perceptibly wider space between the contiguous lines; the interspaces between the basal lines, the subbasal and medial lines, the discal cordiform marks, and the marginal line and outer margin, are of a more dusky colour, and thus give the wings the appearance of being marked with alternately pale and dusky transverse bands. Underside also paler than in *E. merione*, with more regularly alternate pale and dark transverse bands.

Expanse $1\frac{6}{8}$ to $2\frac{1}{8}$ inches.

Hab. N. W. India (Manpuri; Deyra Doon). In coll. F. Moore.

Ergolis indica, n. sp.

Differs from typical Javanese specimens of *E. ariadne* in its smaller size. Upperside of a duller colour, the markings more obscure and comparatively less sinuous. Underside with paler interspaces between the bands, the apical border of forewing and the marginal border of hindwing greyer, and comparatively broader.

Expanse $1\frac{5}{8}$ to $1\frac{6}{8}$ inch.

Hab. Madras; Nilgiris; Bombay; Calcutta. In coll. F. Moore.

Family LYCÆNIDÆ.

Genus Parapithecops, Distant.

Parapithecops gaura, n. sp.

Male and female. Upperside brown: forewing with a large white medial longitudinally oval spot, occupying the centre of the wing from middle of the disc to near the base; a small brown dentate spot at upper end of the cell: hindwing with the apical and upper discal area broadly white and traversed by pale brown veins; a slender brown submarginal line enclosing a marginal row of brown spots. Cilia of forewing whitish posteriorly, of hindwing entirely white. Underside greyish white: forewing with a submarginal line composed of slender waved brown lunules, and a marginal line enclosing a row of small linear spots; a slender indistinct brown streak at end of the cell, and three or four dots along the costal edge: hindwing with an irregular submarginal row of brown lunules, a marginal line enclosing a row of darker spots; a black spot at upper end of submarginal line, and a subbasal row of three smaller more or less distinct black spots; a slender brown streak at end of the cell. Antennæ black, ringed with white; pale white beneath, third joint and tip of second black; legs white, banded with black.

Expanse ♂ $\frac{8}{10}$, ♀ $1\frac{1}{12}$ inch.

Hab. Calcutta. Assam. In coll. Ind. Mus., Calcutta, and F. Moore.

Genus MEGISBA, Moore.

MEGISBA SIKKIMA, n. sp.

Male. Differs from *M. thwaitesii*, on the upperside, in being of a darker violet-brown, and in the absence of the short oblique posterior white band on the forewing. Underside similarly marked to *M. thwaitesii*, except that on the forewing the black spot in middle of the cell is very minute, and there is a spot below the end of the cell between the middle and lower median veins in addition to the two dots, which are here placed beneath the lower median vein, whereas in *M. thwaitesii* the two latter dots, when present, are situated between the middle and lower medians. On the hindwing the three transverse subbasal black spots are comparatively larger, the upper one with two contiguous black dots in front; the cell-spot is prolonged upward to the costal vein and also has some black dots below it, the apical black spot is of an elongated form, and the discal macular band is composed of broader quadrate spots.

Expanse $\frac{7}{8}$ inch.

HAB. Sikkim. In coll. Indian Museum, Calcutta.

PATHALIA, n. g.

Closely allied to *Megisba:* forewing comparatively longer, and less regularly triangular in form : hindwing somewhat narrower, and with a slender tail at end of lower median vein. Venation similar. Second joint of palpi shorter, the third joint longer and more slender.

Type, *P. albidisca.*

PATHALIA ALBIDISCA, n. sp.

Male and female. Upperside dark violet-brown : forewing with a broad medial conical white patch, which extends obliquely from middle of the disc to posterior margin : hindwing with a broad white band crossing from the costal edge to near middle of the abdominal margin ; an indistinct marginal row of pale-bordered brown spots. Underside greyish-white : forewing with some black spots along the costal edge, a brown streak at end of the cell, a discal transverse row of short oblique slender interrupted lunules, a submarginal sinuous line enclosing a marginal row of indistinct spots : hindwing with a similar brown cell-streak, a discal zigzag series of broader lunules, a sinuous submarginal line enclosing the marginal row of spots, of which the penultimate is large and black ; three equidistant subbasal black spots, a black spot on the abdominal margin above the lower subbasal, and a larger black spot at the apex ; tail in both sexes black, tipped with white. Cilia edged with white. Body above black, antennæ black annulated with white; palpi white, tip black; legs white with black bands.

Expanse ♂ $\frac{11}{12}$, ♀ $1\frac{1}{12}$ inches.

Hab. Chittagong; Kurdah, Orissa; N. W. Himalaya (*Capt. Beckett*). In coll. Indian Museum, Calcutta, and F. Moore.

Pathalia malaya.

Lycæna malaya, Horsfield, Catal. Lep Mus. E. I. C. p. 70 (1828), ♀.

Hab. Java. (Horsfield collection.)

Genus Logania, Distant.

Logania substrigosa, n. sp.

Upperside dark violet-brown. Cilia white between the veins. Costal edge of forewing with a minute white dot at end of the veins. Underside purplish white, crossed by a few ochreous-brown short strigæ, and with a thicker streak across middle and end of the cell, and in a zigzag submarginal series; also a marginal series of black spots on the forewing, and a lunular streak on hindwing; a black costal spot also on the hindwing; and the outer marginal border of both wings is ochreous-brown. Body, antennæ, and legs above brown; palpi, legs, and abdomen beneath white.

Expanse $\frac{9}{10}$ inch.

Hab. Mergui. In coll. Indian Museum, Calcutta.

Logania marmorata, n. sp.

Upperside pale purplish violet-brown: forewing with the basal half, curving obliquely from middle of the costa to posterior margin near the angle, violaceous-white: hindwing with the lower basal and discal area also violaceous-white: the traversing veins on both wings being pale violet-brown. Cilia violet-brown. Underside densely mottled with purplish violet-brown and violet-white, interspersed with black speckles, which are most prominent in a lunular marginal fascia; a white spot at end of the cells. Body, antennæ, and legs violet-brown.

Expanse $\frac{8}{10}$ inch.

Hab. Mergui. In coll. Indian Museum, Calcutta.

Logania andersonii, n. sp.

Female. Upperside pale violet-brown: forewing with a broad longitudinal medial lilacine-grey band of a somewhat triangular form, disposed below the cell, the exterior border of the band being scalloped: hindwing with a narrow medial discal similar-coloured band. Cilia alternated with white. Underside purplish lilacine-white; both wings with a blackish zigzag cell streak, a transverse discal zigzag duplex line, and two narrow similar submarginal lines, a slender marginal line, and a waved interciliary line.

Expanse $1\frac{1}{10}$ inch.

HAB. Mergui. In coll. Indian Museum, Calcutta.

Genus LYCÆNESTHES, Moore.

LYCÆNESTHES ORISSICA, n. sp.

Male. Smaller than *L. lycænina* and *L. lycambes.* Upperside of a similar purpurascent blue. Underside pale purpurascent greyish-brown. Both wings with similar, but more regularly disposed, markings. On the hindwing the subbasal costal black spot is prominent, but the subbasal black spot—so conspicuous in the above species—is absent, the entire exterior margin being uniformly marked.

Expanse $\frac{9}{10}$ inch.

HAB. Orissa. In coll. Indian Museum, Calcutta, and F. Moore.

LYCÆNESTHES MERGUIANA, n. sp.

Male. Upperside violet-blue: hindwing with two indistinct small anal blackish spots and a larger subanal spot. Underside dull greyish-brown; forewing with a transverse antemedial pale-bordered band, a short band at end of the cell, and a broken discal band, two submarginal pale lunular lines: hindwing with a pale-bordered subbasal band, one at end of the cell, and a broken curved discal band; two submarginal pale sinuous lines enclosing a small anal and a large oval subanal black spot, both surmounted by a yellow lunule and speckled with a few metallic-blue scales.

Expanse $\frac{9}{10}$ inch.

HAB. Mergui. In coll. Indian Museum, Calcutta, and F. Moore.

A much smaller species than *L. bengalensis.* Distinguished from it, on the underside, in the forewing having the antemedial pale-bordered band, and in the hindwing in the more irregular and zigzag pale bands, and the large subanal spot. It is also distinct from *L. lycæna.*

Genus LYCÆNA, Fabr.

LYCÆNA CHAMANICA, n. sp.

Female. Upperside lavender-blue; extreme outer margin of forewing pale dusky-brown: hindwing with pale dusky-brown costal and marginal border, the latter traversed by an outer row of whitish lunules. Cilia dusky-brown, edged with white. Underside lilacine ochreous-grey: forewing with a large white-bordered black lunule at end of the cell, a discal transverse row of six spots, and a marginal row of white-bordered dark brown spots, the transverse interspace between the discal and marginal spots also dark brown: hindwing with three straightly disposed transverse subbasal white-bordered black spots, a lunule at end of the cell, and a curved discal interrupted row of eight spots; a marginal row of rounded dark brown spots bordered by an inner dark brown lunular line; the anal and penultimate spot is black, speckled with metallic-blue scales, and surmounted by orange-yellow.

Expanse 1 inch.

Hab. Chaman, S. Beluchistan (April). In coll. Ind. Mus., Calcutta.

This species is quite distinct from *L. bracteala*, Butler.

Lycæna nadira, n. sp.

Female. Upperside dark olivaceous violet-brown: hindwing with a very faint trace of paler marginal lunules. Cilia brown, edged with white. Underside pale olivaceous-ochreous: forewing with an olivaceous white-bordered large black linear spot at end of the cell, and a recurved transverse discal row of six spots, a submarginal row of small blackish dentate spots, and a marginal row of linear spots: hindwing with three subbasal olivaceous white-bordered black spots, a lunule at end of the cell, a curved discal row of eight spots, a submarginal row of small blackish dentate spots, and a marginal row of short linear spots.

Expanse 1 inch.

Hab. Kabul. In coll. Indian Museum, Calcutta.

Quite distinct from *L. fugitiva*, Butler.

Lycæna bilucha, n. sp.

Male. Upperside brilliant, glossy, opalised, lilacine cobalt-blue, the exterior margin with a very slender black border. Cilia brown, with a broad white edge. Underside pale lilacine ochreous-grey, the base of both wings slightly metallic-green: forewing with a small round white-bordered black spot in middle of the cell, a prominent streak at end of the cell, a transverse discal row of seven spots, and a marginal double row of pale brown white-bordered lunules: hindwing with a prominent white-bordered black spot in middle of the cell, one above it, a less distinct spot below it, and a narrow spot on abdominal margin, a streak at end of the cell, and a discal curved interrupted row of eight spots; a marginal row of white-bordered narrow black spots, each surmounted by a black-lined reddish lunule.

Expanse $1\frac{2}{10}$ inch.

HAB. Chaman, S. Beluchistan (April). In coll. Ind. Mus., Calcutta.

Genus CHRYSOPHANUS, Hübner.

CHRYSOPHANUS BARALACHA, n. sp.

Female. Differs from specimens of same sex of *C. phlœas* (var. *stygianus*) taken in the neighbouring country of Lahoul. Upperside: forewing golden-yellow, with a blackish quadrate spot in the middle of the cell, a larger spot at its end, three oblique subapical spots, and three lower discal spots, the lowest spot being the longest and curved; from the three subapical spots some black speckles proceed to the discocellular spot; the costal edge is very narrowly bordered with brown, and the exterior margin has a narrow macular brown border of half the width of that of the above-mentioned species: hindwing golden greyish-brown, with a broad pale red outer marginal band, which is very slightly indented with black at end of the veins on its outer border, and on the inner border by a row of indistinct blackish spots surmounted by blue-grey scales, above which is a discal row of five or six smaller black spots and also a black lunule at end of the cell. Underside of similar colour to that of above species: forewing with the spots as on upperside, but pale-bordered, and also a spot at base of the cell, two small spots on the costa above the discal series, and three linear spots on exterior margin above the angle, these latter spots being near the margin: hindwing with less defined red-streaked marginal band, the discal and other spots also comparatively larger.

Expanse $1\frac{3}{8}$ inch.

HAB. Baralacha Pass (16060 feet), Ladak. Taken in July 1879 by Mr. L. de Nicéville. In coll. Indian Museum, Calcutta.

Genus APHNÆUS, Hübner.

APHNÆUS TIGRINUS, n. sp.

Differs from typical *A. vulcanus* on the upperside of the forewing in the more prominent red bands, which, in the female, are conspicuously broader; there is also a slender marginal band, more or less indistinct in the male, but very distinct ih the female; on the hindwing is a red marginal band extending from above the anal lobe partly up the exterior margin, this band in the female being curved and reaching the subcostal vein. On the underside the bands are similar, but of a brighter red and with more clearly defined black borders.

Expanse 1 to $1\frac{2}{8}$ inch.

HAB. Lower Bengal, Calcutta, Maunbhoom, Orissa. In coll. F. Moore and Indian Museum, Calcutta.

APHNÆUS PEGUANUS, n. sp.

Male. Comparatively larger than *A. lohita.* Upperside similarly coloured, anal area dull red, the large black lobe-spot replaced by a few interciliary black and silver scales. Underside very pale reddish-ochreous; the bands dark red, somewhat narrower than in *A. lohita:* forewing with the streak at base longitudinal, narrow, and not extending above the costal vein; the short transverse broad end crossing the cell in *A. lohita* is here absent, the band crossing the middle of the cell is also shorter, the oblique discal and submarginal bands quite confluent at their posterior end, the inner costal band beyond the cell is short, and the next band is the longest, both being widely separated—whereas in *A. lohita* the inner band is the longest and the two are joined externally in the middle, the submarginal band is narrower, and the marginal band very slender: hindwing with the subbasal band composed of three well separated portions; anal lobe red, with a small interciliary black-speckled streak; the submarginal and marginal band narrower, the latter being interrupted in crossing the veins.

Expanse $1\frac{3}{10}$ to $1\frac{4}{10}$ inch.

HAB. Magaree, Pegu. In coll. F. Moore.

APHNÆUS HIMALAYANUS, n. sp.

Allied to *A. lohita.* Male and female much larger than typical Javanese specimens. Upperside similarly coloured; anal area duller red. Underside pale creamy-yellow; the bands similar, but of a darker purple-red, all comparatively broader, the marginal band conspicuously broader.

Expanse ♂ $1\frac{3}{10}$, ♀ $1\frac{4}{10}$ to $1\frac{7}{10}$ inch.

HAB. Nepal (*Ramsay*), Darjiling (*Elliot.*) In coll. F. Moore.

APHNÆUS KHURDANUS, n. sp.

Male. Upperside dark brown; base of forewing, and hindwing dark slaty-blue; anal lobe red, spots black. Underside dull pale purplish brownish-ochreous; markings very similar to those on underside of same sex of *A. trifurcatus*, but comparatively narrower and more regular in outline.

Expanse 1 to $1\frac{1}{10}$ inch.

HAB. Khurda, Orissa; Calcutta. In coll. Ind. Museum, Calcutta.

This species belongs to the *lohita*-group of *Aphnæus.* On the underside the markings are extremely like those in *A. trifurcatus*, but the upperside of the forewings has no red patch, as in *A. trifurcatus.* The colour of the upperside is also of a much darker tint; and the outline of the forewing is comparatively more triangular.

APHNÆUS ORISSANUS, n. sp.

Male. Forewing broader and less regularly triangular than in *A. khurdanus;* hindwing also less produced anally, and the exterior margin convex. Upperside dark brown; base of forewing, and hindwing, slaty-blue; anal lobe red, spots black. Underside pale ochreous-yellow; bands purple-red, similar to those in *A. peguanus*, with the marginal black black-streaked.

Expanse $1\frac{1}{19}$ inch.

HAB. Sonakhala and Bhatpara, Orissa. In coll. Ind. Mus., Calcutta.

APHNÆUS CONCANUS, n. sp.

Male and female. Nearest to the Ceylonese *A. lazularius.* Upperside similar. Underside pale reddish-ochreous; the bands dark purple-red, those on the forewing similar: hindwing with the subbasal band composed of three portions, the medial discal and submarginal bands disposed nearer together at their costal end, the submarginal straighter, and the three more or less confluent at their anal end.

Expanse $1\frac{2}{8}$ to $1\frac{4}{8}$ inch.

HAB. Bombay (*Dr. Leith*); Canara (*Ward*); Nilgiris (*Lindsay*). In coll. F. Moore.

APHNÆUS NIPALICUS, n. sp.

Male. Upperside dusky violet-brown, the lower basal and discal areas dark slaty-blue; anal lobe red, the black spots speckled with silvery-white scales. Underside dull sulphur-yellow, the bands of a slightly darker somewhat purpurascent yellow; forewing with an oblique oval black ring near base of the cell, a black-lined bar across middle of the cell from the costal edge, an oblique discal band from the costal edge, broken, but not disconnected, at lower end of the cell, a short upper discal bar, and two shorter subapical bars beyond, a submarginal band and a slender broken lunular marginal line; all but the last traversed by an extremely slight silvery line; beneath the cell is a dusky brown fascia, and a dusky streak also is at end of the submarginal band: hindwing with a small spot at base of the cell, three transverse subbasal oval black rings, a transverse medial band, broken at lower end, then bent upward to abdominal margin, and ending in a small ring-spot, and outer discal upper band, a narrower submarginal band broken above anal angle and bent upward, all traversed by an extremely slight silvery line; anal lobe-spots large, black, surmounted by bright scarlet.

Female. Upperside paler dusky olive-brown: forewing with sub-apical darker spot bordered on each side by red; basal area below the cell slaty-grey: hindwing with the lower basal area slaty-grey; anal lobe-as in male. Underside as in male.

Expanse ♂ $1\frac{1}{2}$, ♀ $1\frac{3}{8}$ inch.

Hab. Nepal (*Ramsay*). Sikkim. In coll. British Museum, and Indian Museum, Calcutta.

Nearest allied to *A. lunulifer*.

APHNÆUS ZEBRINUS, n. sp.

Male. Upperside dark brown, base of wings dark brownish violet-blue; anal black spot large, broadly bordered with red. Female. Upperside darker violet-brown, base of wings dark slaty violet-blue. Underside very pale ochreous, posterior border of forewing whitish. All the bands purplish-black, as in *A. zoilus;* forewing with the extreme costal edge black, the bands also extending from the costal edge; basal streak long and joined to the black costal border, with a cross bar from its upper end, and a band crossing the middle of the cell (both of which join the streak below the base of the cell), the oblique discal band and the transverse submarginal band are joined together at their lower end, and the two short upper discal bars are also joined together, the marginal band is broad with a very narrow interline between it and the submarginal band; hindwing with the upper basal streak slender, the subbasal band entire and continued to the angle of the discal band above the bright red anal area, black lobe-spots large, the discal and outer bands broad.

Expanse ♂ $1\frac{1}{8}$, ♀ $1\frac{2}{8}$ inch.

Hab. Ceylon. In coll. British Museum.

Nearest allied to the Andamanese species, *A. zoilus*. Distinguishable from it by its smaller size, by the bands on the forewing all starting from the extreme costal edge, by the oblique discal band and the submarginal band being broadly joined at their base, and by the marginal band being broader on both wings.

APHNÆUS LILACINUS, n. sp.

Male. Upperside brown: forewing with the basal and discal area, including the cell, pale lilacine-blue; a blackish spot at end of the cell: hindwing with the basal and medial area pale lilacine-blue; anal lobe ochreous, with a very small silver-speckled black spot. Underside pale brownish-ochreous : forewing with two black rings in the cell, a band at end of the cell dilated beneath and extending obliquely to the submedian, a ringlet spot beyond end of the cell, an upper discal inwardly oblique double ringlet spot and a submarginal broad chain-like band, the lower ends dusky, and each traversed by a black silvery streak : hindwing with very indistinct traces of darker-coloured transverse subbasal, discal, and submarginal bands, which are traversed by silvery black streaks ; anal spots minute, silver-speckled. The silvery streak traverses the middle of the markings, except on the submarginal band of both wings, where it extends along the outer border.

Expanse, $1\frac{3}{10}$ inch.

HAB. ? In coll. Indian Museum, Calcutta.

EUASPA, n. g.

Forewing short, broad, costa arched from the base, exterior margin erect, convex, posterior margin long, straight ; first subcostal emitted at two-sixths and second at one-sixth before end of the cell, second bifid at two-thirds from its base, fourth and fifth from end of the cell ; discocellular very slender, erect, waved ; radial from its middle ; cell broad, extending to half length of the wing ; middle median from near end of the cell, lower at one-third before the end, submedian straight : hindwing short, very broad, exterior margin convex and slightly sinuous, with a single slender tail from end of lower median ; costal and subcostal veins joined together at their base, costal much arched from the juncture ; cell broad, extending to half length of the wing ; first subcostal emitted at one-fifth before end of the cell ; discocellular very slender, erect ; radial from near its middle ; two upper medians from end of the cell, lower at one-third before the end ; submedian curved, internal short, recurved. Body short ; palpi porrect, second joint long, extending half beyond front of the head, pilose beneath, third joint slender, one-fifth as long as the second ; legs slender ; antennæ thickened at the end, tip blunt.

EUASPA MILIONIA.

Myrina milionia, Hewitson, Illust. D. Lep. p. 5, pl. 3, fig. 90, 80 (1869).

HAB. Nepal. Kangra.

Genus HYPOLYCÆNA.

Felder, Wien. Ent. Monats. vi, p. 293 (1862).

Male. Wings short, broad : forewing arched at the base, posterior margin nearly as long as the costal. Upperside with a large glandular patch of scales extending broadly across end of the cell; four subcostal branches, the first emitted at two-fifths, second at one-fourth, and third from close before end of the cell; discocellular slender, straight; radial from its middle; cell extending to more than half length of the wing; lower median emitted at nearly one-third and middle median from near end of the cell; submedian straight: hindwing short, somewhat produced hindward, anal lobe prominent; with a slender tail from end of lower median and another from the submedian; costal vein much arched at the base; first subcostal emitted at one-third before end of the cell; the cell broad and extending to half length of the wing; discocellular recurved; radial from its middle; lower median emitted at nearly one-half and middle median from near end of the cell; submedian straight; internal recurved. Palpi porrect, second joint stout, third joint very long, of nearly the same length as the second; legs slender; antennæ with a gradually thickened club.

Type, *H. tmolus.*

Hypolycæna tmolus.

Hypolycæna tmolus, Felder, Wien. Ent. Monats. vi, p. 293 (1862). Hewits., Ill. D. Lep. p. 49, pl. 21, figs. 3, 6.

Hab. Philippines.

Hypolycæna sipylus.

Hypolycæna sipylus, Feld., Reise Novara, Lep. ii, p. 242, pl. 30, figs. 15, 16. Hewits., Ill. D. Lep. pl. 22, figs. 13, 14.
Myrina sipylus, Feld., Sitzb. Ak. Wiss. Wien, 1860, p. 451.

Hab. Amboina.

Hypolycæna tharrytas.

Hypolycæna tharrytas, Feld., Wien. Ent. Monats. vi, p. 294 (1862).
Hyp. sisyphus, Hewits., l. c. pl. 22, fig. 11, 12.

Hab. Luzon.

Hypolycæna erylus.

Polyommatus erylus, Godt., Enc. Meth. ix, p. 633, (1823).
Amblypodia erylus, Horsf., Catal. Lep. Mus. E. I. C. p. 111 (1829).
Hypolycæna erylus, Hewits., Ill. D. Lep. p. 49, pl. 21, figs. 1, 2, 4.

Hab. N. E. Bengal, Sikkim, Khasia Hills, Cherra Punji, Burmah, Malacca, Singapore.

Hypolycæna andamana.

Hypolycæna andamana, Moore, P. Z. S. 1877, p. 589.

Hab. Andamans.

Hypolycæna thecloides.

Myrina thecloides, Feld., Wien. Ent. Monats. iv, p. 395 (1860).

Hab. Malacca, Singapore.

Hypolycæna astyla.

Hypolycæna astyla, Feld., Wien. Ent. Monats. vi, p. 294 (1862); Reise Novara Lep. ii, p. 243, pl. 30, figs. 17, 18,

Hab. Philippines.

Drupadia, n. g.

Differs from typical *Hypolycæna* in the more triangular form of forewing, the costa being longer and more regularly convex, the exterior margin more oblique, and the posterior margin shorter and convex towards the base: hindwing somewhat shorter, the costa being very convex in the middle, the exterior margin truncated from the middle median, the male on the upperside with a prominent glandular patch of scales between the costal and subcostal veins, and with three tails, the middle one being long the others short. Second joint of palpi much longer and the third shorter and stouter.

Type, *D. ravindra* (*Myrina ravindra*, Horsf.).

Drupadia boisduvalii, n. sp.

Myrina lisias, Boisd., Spec. Gen. Lep. Pap. pl. 22, fig. 2 ♂ (*nec* Fabr.).

Male. Upperside: forewing purplish violet-brown, with a broad oblique transverse discal almost quadrate red band: hindwing cobalt-blue, darkest and purplish-violaceous anteriorly; costal border and abdominal margin violet-brown; cilia and tails edged with white.

Female. Upperside: forewing somewhat paler brown, the red band of the same width and quadrangular form as in male: hindwing pale violet-brown, the discal area somewhat red-streaked; above the tails are four black spots surmounted by lilac scales.

Underside: forewing ochreous-red, with a brighter red pale-bordered streak at base of the cell, a band across middle of the cell, another at its end, and a similar discal band which has a slightly dusky lunulated border at the upper outer end, a submarginal slender black slightly sinuous line: hindwing white, the costal border and apex being slightly red, with the basal and subbasal spots entirely black, a duplex slender black streak at end of the cell, a similar one above it, a discal zigzag duplex line, and a single black submarginal line; a large anal and a subanal black spot surmounted by metallic-blue scales, which also traverse the intervening subanal space.

Expanse ♂ $1\frac{2}{8}$, ♀ $1\frac{3}{8}$ inch.

Hab. Moulmein; Mergui. In coll. F. Moore and Indian Museum, Calcutta.

Drupadia lisias (*Pap. lisias*, Fabr.) badly figured in Donovan's Ins. of India, pl. 40, fig. 1,—is distinct from the above. Both sexes of the type of *D. lisias* are in the British Museum Collection.

Drupadia fabricii, n. sp.

Female. Upperside: forewing violet-brown, with a slightly broader and more irregular-shaped oblique medial red band than in female of typical *D. lisias*, the band also having its outer border scalloped: hindwing paler brown, with grey-bordered anal marginal spots. Underside also differs from *D. lisias* in the apical area of forewing being suffused with a dusky tint; at the base of the cell is a small round pale-bordered spot, not an elongated triangular mark as in *D. lisias*, the short band crossing the middle of the cell is black, the streak at end of the cell is more distinct, the transverse discal band black-lined and blackish internally at upper end, the submarginal line also being broader and more prominent: hindwing with the markings less prominent than in *D. lisias*, the basal bar shorter, the outer costal narrow streak further from the second, the first bar between the subcostals being midway below the two outer costals, the three subbasal spots are small and widely separated, the bar at end of the cell and the spot beneath it are pale-centred, the zigzag discal interrupted band is composed of duplex streaks, which are wide apart with the interspace white.

Expanse ♀ $1\frac{2}{10}$ inch.

Hab. Mergui. In coll. Indian Museum, Calcutta.

Chliaria, n. g.

Male. Wings small: forewing triangular; costa gently arched; exterior margin oblique, posterior margin straight; four subcostal branches, first emitted at one-third before end of the cell and slightly touching the costal vein near its end; second and third branches at equal distances apart; cell extending to nearly half length of the wing; discocellular extremely slender; one radial from near its middle; the middle median from near end of the cell, lower at one-third before the end; submedian nearly straight: hindwing short; apex convex, exterior margin oblique and waved; cell short, broad; costa arched from near the base; first subcostal from near end of the cell; discocellular extremely slender, oblique; radial from its middle; two upper medians from end of the cell, lower at nearly one-half before the end; submedian straight; internal recurved; a slender tail from end of lower median and another from the submedian. Palpi porrect, second joint stout, third joint very slender; antennæ with a short spatular club.

Type, *C. othona.*

Chliaria othona.

Hypolycæna othona, Hewits., Illust. D. Lep. p. 50, pl. 22, fig. 17, 18 (1865).

Hab. Darjiling. Khasia Hills.

Chliaria eltola.

Hypolycæna eltola, Hewits., Illust. D. Lep. Suppl. p. 14, pl. 5, fig. 37, 38 (1869).

Hab. Andamans.

Chliaria kina.

Hypolycæna kina, Hewits., Illust. D. Lep. Suppl. p. 13, pl. 5, fig. 32, 34 (1869).

Hab. Sikkim. Nepal.

Chliaria chandrana.

Hypolycæna chandrana, Moore, P. Z. S. 1882, p. 249, pl. xi, fig. 2, 2a.

Hab. Lahul, N. W. Himalaya.

Chliaria cachara.

Hypolycæna cachara, Moore, P. Z. S. 1883, p. 527, pl. xlix. fig. 6.

Hab. Cachar.

Chliaria nilgirica.

Hypolycæna nilgirica, Moore, P. Z. S. 1883, p. 527, pl. xlix, fig. 8.

Hab. Nilgiris.

Sinthusa, n. g.

Male. Wings small: forewing somewhat broad, costa arched at the base, apex pointed, exterior margin slightly oblique and convex, posterior margin convex near the base; subcostal vein five-branched, first branch emitted at nearly one-half, second at one-fourth, and third from near the end of the cell, third bifid near its end; cell extending to half length of the wing; discocellular slender; radial from its middle; lower median at more than one-third and middle median from near end of the cell; submedian straight: hindwing short, broad, costa arched in the middle, exterior margin with a single slender tail from end of lower median; cell broad, triangular, extending half the wing; first subcostal at one-half before end of the cell; discocellular oblique, slender; radial from its middle; lower median at nearly one-half and middle median from near end of the cell; submedian and internal veins recurved. Palpi porrect, second joint long, third joint short, slender, pointed; antennæ with a large thick pointed club.

Type, *S. nasaka*.

Sinthusa nasaka.

Thecla nasaka, Horsfield, Catal. Lep. Mus. E. I. C. p. 91 (1829).
Deudorix nasaka, Hewits., Illust. D. Lep. pl. 5, fig. 45, 46.

Hab. Java.

Sinthusa malika.

Thecla malika, Horsfield, Catal. Lep. Mus. E. I. C. p. 90 (1829).
Dipsas malika, Moore, Catal. Lep. Mus. E. I. C. I. pl. 1 *a.*, fig. 5 (1857).
Myrina malika, Hewits., Illust. D. Lep. pl. 15, fig. 41—43.

Hab. Java. Sumatra.

Sinthusa grotei.

Hypolycœna grotei, Moore, P. Z. S. 1883, p. 527, pl. 49, fig. 5.

Hab. N. E. Bengal (*Grote*).

Genus Iolaus.

Hübner, Verz. bek. Schmett. p. 81 (1816-18).

Male. Forewing short, broad; costa very much arched from the base, apex acute, exterior margin very slightly oblique, posterior margin long, slightly convex in middle, the convex edge being fringed with long hairs; on the underside of the wing is a glandular patch of scales situated immediately above the submedian vein; cell broad, extending in length to half the wing; costal vein short; subcostal arched from the base, first branch emitted at one-half, second at one-fourth, and third immediately before end of the cell, third trifid at three-fourths from its base, fifth from end of the cell; discocellulars erect, upper shortest; radial from near their middle; the middle median emitted from near end of the cell, lower at one-fourth before the end; submedian straight:

hindwing short, lengthened hindward; costa very convex, apex almost angular, exterior margin very oblique and sinuous, lobate at anal angle, furnished with two short slender tails; on the upperside is a subcostal glandular patch of scales; costal and subcostal veins joined together for a short distance at their base, widely separated beyond, costal much arched from the basal juncture; cell broad, triangular; two subcostal branches, first emitted at one-third before end of the cell; discocellulars very oblique; radial from near their middle; two upper medians from end of the cell, lower at one-third before the end; median straight; internal short. Body moderate; palpi ascending, second joint long, ascending above level of the eyes, third joint half its length, slender; legs slender; antennæ slender, gradually thickened to end, tip pointed.

Type, *I. helius* (*helius*, Fabr.; Hewits., Ill. D. L. Suppl. pl. 4, f. 31.)

The typical species of *Iolaus* are African. The characters of the genus are here given for comparison with its Asiatic allies.

Cophanta, n. g.

Forewing broad, costa arched, exterior margin slightly convex, posterior margin nearly straight; cell broad, extending to half length of the wing, costal vein extending to half the margin; first subcostal emitted at two-fifths and second at one-fourth before end of the cell, third bifid at nearly two-thirds from the base; discocellular slender, slightly bent outward in the middle; the radial from its angle; lower median at one-third and middle median from close before end of the cell; submedian straight: hindwing broad, costa abruptly arched at the base, apex convex, exterior margin oblique and sinuous from middle median, anal angle lobed, with a slender tail from lower median and another from submedian; costal and subcostal joined together for a short distance at the base, the costal much arched from above the juncture, and extending to the apex; first subcostal emitted at one-fifth before end of the cell; discocellular outwardly oblique and bent outward at the middle; the radial from its angle; cell broad, extending to nearly half the wing; lower median at one-third and middle median from immediately before end of the cell; submedian straight; internal recurved. Body short, thick; palpi porrect, second joint long, extending half length beyond the eyes, third joint slender, slightly fusiform, nearly half length of the second; antennæ short, stout, with a gradually thickened club; legs short.

Type, *C. illurgis.*

Cophanta illurgis.

Iolaus illurgis, Hewitson, Illust. D. Lep. Suppl. p. 10, pl. 4, fig. 37, 38 (1869).

Hab. Darjiling.

Cophanta maculata.

Iolaus maculatus, Hewits., Illust. D. Lep. p. 47, pl. 21, fig. 29, 30 (1865).

Hab. Silhet. Darjeeling.

Dacalana, n. g.

Male. Forewing comparatively more triangular than in typical *Iolaus* (*I. helius*), the exterior margin being somewhat oblique, and the posterior margin shorter; venation similar; on the upperside of the typical species, between the median and submedian veins, is a tuft of fine hairs covering a small glandular-scaled spot, and on the underside there is also a tuft of hairs on the middle of the posterior margin: hindwing comparatively broader, being less produced hindward, the apex more convex, and the glandular subcostal spot less prominent.

Type, *D. vidura* (*Amblyp. vidura*).

Dacalana vidura.

Amblypodia vidura, Horsf., Catal. Lep. Mus. E. I. C. p. 113, pl. 1, fig. 6, 6a. ♂, (1829).

Hab. Java. Borneo.

Dacalana burmana, n. sp.

From typical Javan *D. vidura*, this differs in the darker blue of the upperside. The colour of the underside is also brighter and of an ochreous-brown tint, the transverse white band is somewhat broader, the submarginal black line composed of short curved portions between the veins, and the whole series forms a more curved line in crossing each wing; the black subanal and lobe-spot is slightly smaller, and the former is but very slightly surmounted with red.

Expanse ♂ $1\frac{1}{2}$ inch.

Hab. Moulmein. In coll. British Museum.

Dacalana cotys.

Iolaus cotys, Hewitson, Illust. D. Lep. p. 43, pl. 19, fig. 19, 20 (1865).

Hab. Nepal. Darjiling.

Genus Pratapa, Moore.

Pratapa bhotea, n. sp.

Female. Upperside purpurascent greyish-blue: forewing with the anterior margin from the costal vein, the apex broadly, and the exterior margin violet-brown; cilia grey: hindwing with a marginal row of narrow violet-black spots ending in a red anal lobe-spot; a slender black marginal line; cilia greyish-white; the two tails black with white cilia.

Underside glossy purpurascent greyish-white: forewing with an indistinct darker bluish-grey streak at end of the cell, and two slender lunular fasciæ along exterior margin; a transverse discal slender prominent black broken sinuous line: hindwing with a similar cell streak and outer marginal fasciæ, the latter darkest at anal end; a jet black anal lobe-spot, on which are a few scarlet scales and some turquoise-blue scales along its inner border; a transverse discal zigzag slender black broken line ending upward above the anal lobe.

Expanse $1\frac{1}{2}$ inch.

Hab. Sikkim. In coll. Indian Museum, Calcutta.

Remelana, n. g.

Male. Forewing less triangular than in *Tajuria* (*T. longinus*, Fabr.), the costal margin more abruptly arched at the base, exterior margin slightly convex, posterior angle rounded: hindwing broader and less produced hindward; costa less arched at the base, very convex externally, with a slender tail from end of lower median and another from the submedian, abdominal margin short. Palpi shorter, second joint stouter, and third joint longer; antennæ shorter, tip shorter and more regularly clavate. Venation similar.

Type, *R. jangala*.

Remelana jangala.

Amblypodia jangala, Horsfield, Catal. Lep. Mus. E. I. C. p. 113 (1829), ♀; Moore, ibid. p. 40, pl. 1 a, f. 11, ♂.

Hab. Java. N. E. Bengal.

Remelana travana.

Myrina travana, Hewitson, Illust. D. Lep. p. 38, pl. 17, f. 59-60 (1865) ♂.

Hab. Sumatra. Singapore. Borneo.

Apporasa, n. g.

From *Thaduka* this differs in the forewing having the exterior margin biangulated and produced outward below the apex. In the hindwing the costa is longer, arched at the base, and produced to an upward angle at the apex; the exterior margin is deeply scalloped; it also has three shorter tails. Palpi long, porrect, second joint extending two-thirds beyond the eyes, third joint also long and slender, being half the length of second; antennæ stouter and blunt at tip.

Apporasa atkinsoni.

Amblypodia atkinsoni, Hewits., Catal. Lyc, Brit. Mus. p. 3. pl. 8, fig. 92, 93 (1862).

Hab. Moulmein.

Satadra, n. g.

Forewing comparatively longer and narrower than in typical *Panchala*, the costa abruptly arched at the base, exterior margin oblique: hindwing slightly but regularly arched along the costa, apex very convex, exterior margin oblique, with a slender tail at end of lower median vein and a point at end of both the middle median and submedian. Venation similar to that of *Panchala*.

Type, *S. atrax*.

Satadra alea.

Amblypodia alea, Hewits., Catal. Lyc. B. M. p. 12, pl. 7, fig. 79, 81 (1862).

Hab. India.

Satadra selta.

Amblypodia selta, Hewits., Ill. D. Lep. p. 14. pl. 3a, f. 36, 37 (1869).

Hab. Moulmein.

Satadra agaba.

Amblypodia agaba, Hewits., Catal. Lyc. B. M. p. 8, pl. 4, f. 39, 40 (1862).

Hab. India.

In the Hewitson Cabinet this species is placed under *S. alea*.

Satadra bupola.

Amblypodia bupola, Hewits., Ill. D. Lep. ii. Suppl. p. 21, pl. 8, fig. 44, 45 (1878).

Hab. Nepal. Darjiling.

SATADRA BAZALUS.

Amblypodia bazalus, Hewits., Catal. Lyc. B. M. pl. 4, fig. 37, 38 (1862) ♂.

HAB. Nepal.

SATADRA ATRAX.

Amblypodia atrax, Hewits., Catal. Lyc. B. M. p. 13, pl. 7, fig. 80, 82 (1862).

HAB. Nepal.

SATADRA ANTHELUS.

Amblypodia anthelus, Doubleday and Hewits., Gen. D. L. pl. 74, f. 6 (1852). Hewits., Catal. Lyc. B. M. pl. 3, f. 23. 24.

HAB. Moulmein.

SATADRA CANARAICA, n. sp.

Allied to *S. alea* (*Amblypodia alea,* Hewits). Male and female. Upperside of a more purplish violet-blue than in *S. alea*, the marginal black border comparatively narrower in the male. Underside of a darker purplish violet-brown: forewing with the basal spots darker, the two cell-spots very small and round, the discocellular spot and the two below the cell narrower, the transverse discal band regular and not broken on the upper median vein, the submarginal and marginal lunules obsolescent: hindwing with the basal and subbasal spots darker and very small, the discal zigzag band narrower and less distinct, the submarginal and marginal lunules obsolescent; anal angle less speckled with metallic-green scales, the anal black spot only present.

Expanse ♂ $1\frac{3}{8}$, ♀ $1\frac{6}{8}$ inch.

HAB. Canara, S. India (*Ward*). In coll. F. Moore.

In *S. alea* the underside is uniformly purplish-brown, the markings all of a regular colour and distinctly lined with pale purplish-white.

SATADRA CHOLA, n. sp.

Closely allied to *S. areste* (*Amblypodia areste,* Hewits.). Male. Upperside of a comparatively darker purplish blue, the marginal black borders being one half less the width. Female. Upperside also with the blue area extending comparatively more over the disc. Underside: forewing more dusky olive-brown in colour, with much narrower whitish cell-streak, quadrate spot beneath it, and transverse discal band, the outer band being more defined: hindwing with similarly disposed markings except that the subbasal band is very broad and entire (not macular as in *S. areste*), and the markings are all of a dark somewhat aenescent-brown, with pale pinkish-white borders and the interspaces pale pinkish violet colour (not grey as in *S. areste) ;* at the anal angle is a marginal black spot and another between the middle and lower median veins, both spots and the intervening marginal space speckled with metallic-green scales.

Expanse ♂ ♀ $1\frac{6}{10}$ inch.

Hab. Sikkim. In coll. Indian Museum, Calcutta, and F. Moore.

Satadra lazula, n. sp.

Male. Upperside of both wings entirely ultramarine-blue ; the extreme costal edge of forewing, the costal and abdominal borders of hindwing, and the cilia being black.

Female. Dark violet-brown, the forewing with ultramarine-blue within the cell and obliquely below on the disc, and narrowly on middle of the hindwing from base of the cell. Underside dark purple-brown : forewing with similarly disposed but broader markings than those in *S. chola*, the two outer bands purplish-violet : hindwing dark purple-brown, with similar markings to those in *S. chola*, the discal bands continuous, the interspaces brighter pink, the anal marginal spots small and more numerously green-speckled.

Expanse $1\frac{8}{10}$ inch.

Hab. Sikkim. In coll. Indian Museum, Calcutta, and F. Moore.

Satadra patuna, n. sp.

Female. Smaller than *S. lazula*. Upperside dark violet-brown, the basal and discal areas purplish-blue, paler than in *S. lazula*, but disposed as in female of that species. Underside purplish-brown : forewing with similarly disposed cell, streak, discal band, and lower quadrate patches, but of a pale ochreous colour : hindwing with the basal area broadly and entirely dark bright purple-brown (more like that of typical *S. apidanus*), which merges into a transverse broad pale purplish-ochreous inner discal fascia, and again into a dark purplish-brown outer discal fascia, the outer border of the wing being broadly pale purplish-brown ; across the disc are traced two series of indistinct brown-lined marks, which are similarly disposed to, but are less continuous than, those in *S. lazula ;* an indistinct brown marginal lunular line, but no metallic speckles at anal angle.

Expanse $1\frac{1}{2}$ inch.

Hab. Nepal (*General Ramsay*). In coll. F. Moore.

Satadra cæca.

Amblypodia cæca, Hewits., Ill. D. Lep. p. 14, pl. 4, fig. 28 (1863).

Hab. Borneo (Sarawak).

Satadra areste.

Amblypodia areste, Hewits. Catal. Lyc. B. M. pl. 5. f. 43, 44 (1862).

Hab. Darjiling.

Satadra fulgida.

Amblypodia fulgida, Hewits., Ill. D. Lep. p. 11, pl. 5, fig. 31 (1863).

Hab. [? Philippines]. N. India.

Satadra chinensis.

Arhopala chinensis, Feld., Reise Novara Lep. ii, p. 231, pl. 29, f. 10 (1865).

Hab. China.

Satadra diardi.

Amblypodia diardi, Hewits., Catal. Lyc. B. M. p. 9, pl. 5, f. 41, 42, (1862).

Hab. Penang. Singapore.

Satadra apidanus.

Papilio apidanus, Cram., Pap. Exot. ii. pl. 137. f. F. G. (1779).
Amblypodia apidanus, Horsf., Catal. Lep. Mus. E. I. C. p. 100 (1829).

Hab. Java. Sumatra. Borneo.

Satadra absens.

Amblypodia absens, Hewits., Catal. Lyc. B. M. p. 9, pl. 5, f. 51, 52 (1862).

Hab. Darjiling.

Satadra zeta.

Amblypodia zeta, Moore, P. Z. S. 1877, p. 590, pl. 58, f. 6.

Hab. Andamans.

Acesina, n. g.

Forewing with the costa less arched than in *Panchala*, apex less pointed, exterior margin more oblique, and waved ; fourth subcostal vein emitted further from end of the third : hindwing not so broad or quadrate in shape, the costa but slightly arched from the base, exterior margin more oblique and regularly convex, with a slender tail one-fourth of an an inch long from end of lower median vein ; abdominal margin shorter. Antennal club somewhat shorter.

Type, *A. paraganesa.*

Acesina paraganesa.

Amblypodia paraganesa, De Nicéville, Journ. Asiat. Soc. Bengal, 1882, p. 63.
Panchala paraganesa, Moore, P. Z. S. 1883, p. 530.
Amblypodia ganesa, Hewits., Catal. Lyc. B. M. pl. 7, f. 72 (1862).

Hab. Nepal.

Darasana, n. g.

Forewing short, broad, triangular; apex acute, exterior margin very slightly oblique, posterior angle somewhat rounded: hindwing short, broad; costa arched towards the base, exterior margin very convex; no tail. Antennæ slender.

Type, *D. perimuta.*

Darasana perimuta.

Amblypodia perimuta, Moore, Catal. Lep. Mus. E. I. C. 1, p. 42 (1857). Hewits. Catal. Lyc. B. M. p. 12, pl. 6, fig. 65, 66.

Hab. Khasia Hills. Magaree, Pegu.

Darasana newara, n. sp.

Upperside violet-brown: forewing with the basal and discal area purplish violet-blue, which extends also above the cell to near the costal edge, the outer brown border being about one-tenth of an inch in width: hindwing with the basal area purplish violet-blue, the outer border being two-tenths of an inch in width. Underside pale-brown; with faint traces of pale-bordered marks within and beneath the cell, at its end, and a more distinct narrow macular discal and submarginal lunular band: hindwing with four indistinct pale-bordered darker brown basal spots, a similar subbasal series, a discal broken band, and marginal double lunular band.

Expanse $1\frac{2}{10}$ inch.

Hab. Nepal (*Genl. Ramsay*). In Coll. F. Moore.

Genus Narathura, Moore.

Narathura roona, n. sp.

Closely allied to, but smaller than *N. aroa* (*Amblypodia aroa*, Hewitson, Ill. D. Lep. p. 13, pl. 2, f. 12), from Sumatra. Female. Upperside dark violet-brown, costal edge and cilia paler: forewing with the basal and discal area, and the hindwing with the basal and medial discal area, violet-blue. Underside of a similar tint of brown to that in *N. aroa*, markings also similarly disposed, but with darker centres; on the forewing the cell-spots are smaller and oval in shape, and the discal band broader; on the hindwing the basal spots are more rounded, the discal band more conspicuous and less zigzag in shape, and the submarginal and marginal lunular line more distinctly formed; at the anal angle is a black spot and another between the median veins, the spots and intervening space being speckled with metallic-green scales.

Expanse $1\frac{3}{10}$ inch.

HAB. Andaman Isles. In coll. Indian Museum, Calcutta, and British Museum (Hewitson Cabinet).

Genus AMBLYPODIA, Horsfield.

AMBLYPODIA ANDERSONII, n. sp.

Male. Smaller than *A. taooana*. Upperside of a similar tint of ultramarine-blue; both wings with a much narrower black marginal border. Underside much darker-coloured, but similarly marked.

Expanse $1\frac{6}{8}$ inch.

HAB. Sampu, Mergui (*Dr. Anderson*). In coll. Ind. Mus., Calcutta.

Family PAPILIONIDÆ.

Subfamily PIERINÆ.

Genus CATOPHAGA, Hübner.

CATOPHAGA WARDII, n. sp.

Allied to the South Indian and Ceylonese *C. neombo*. Male and female of much larger size.

Male. Upperside olivaceous-white: forewing with a broad black apical band extending from middle of the costa to near the posterior angle, the band traversed by a curved subapical row of five small white spots, the inner border of the band excavated below the costa to below the second upper spot, then bulged inward to the disc in front of the two lower spots, concave below the middle median to lower median, below which the end of the band is imperfect and terminates on the submedian; base of wing broadly grey and sparsely speckled with minute black scales on base of the costa: hindwing with a marginal series of broad black confluent dentate spots, which decrease in width from the costa. Underside: forewing olivaceous-white, apex pale yellow, with a curved black subapical band similar to the inner portion on the upperside: hindwing pale yellow throughout.

Female. Upperside of a darker tint of olivaceous-white than in male: forewing with a broader black apical band, which is traversed by three subapical white spots, the inner border of the band being less excavated below the costa, the excavated space being shorter and angular on the middle median, more deeply concave beneath it, and the end entirely black to the submedian vein: hindwing with a broader continuous black band, the inner border of which is acutely dentated. Underside: forewing with the basal area tinged with yellow, the discal area olivaceous-white, and the apex glossy olivaceous-white; a broad curved subapical black band corresponding to the inner portion on the upperside: hindwing entirely pale glossy olivaceous-white.

Expanse ♂, ♀ $2\frac{5}{8}$ inches.

Hab. Coonoor, Nilgiris, S. India (*Ward and Lindsay*). In coll. Indian Museum, Calcutta, and F. Moore.

Catophaga roepstorffii, n. sp.

Male. Upperside white: forewing slightly grey and sparsely black-scaled along base of costal border; a black-speckled spot between upper and middle median veins. Hindwing immaculate. Underside: forewing white, apex very pale yellow; the black-speckled spot as above: hindwing very pale yellow.

Expanse $2\frac{3}{8}$ inches.

Hab. Nicobar Isles. In coll. Indian Museum, Calcutta.

Near to *C. paulina*. Male. Differs from the same sex of that species in the entire absence of the blackish apical margin on the forewing, and in the presence of the discal spot.

Genus Ixias, Hübner.

Ixias ganduca, n. sp.

Male and female. Upperside deep sulphur-yellow: male: forewing with the apex brownish black traversed by a moderately broad orange-red subapical band, the inner border of the band being very slightly edged with black: hindwing with a very slender black-speckled marginal band.

Female: forewing with a narrower and more irregular-bordered subapical band, which is slightly tinged with orange-yellow, the inner border of the band is broadly black across end of the cell, and from the upper median to the indentation of the lower portion of the band the border consists of a very slender black-speckled line, the lower portion of the band is indented with black, the next upper interspace has a medial black spot, and the third upper interspace is broken by a large black spot: hindwing with a broader dentate-bordered black marginal band. Underside of both sexes ochreous-yellow, palest on base of the forewing; both wings with sparsely disposed slender brown strigæ: forewing with a blackish spot at end of the cell, a transverse discal row of purple-brown-speckled spots with white centres: hindwing with a similar white-centred purple-brown-speckled costal spot and row of discal spots, the second and third upper spots being the largest: a brown dot also at end of the cell.

Expanse ♂ 2, ♀ $2\frac{1}{8}$ inches.

Hab. Calcutta (February). In coll. Indian Museum, Calcutta.

Nearest to, but distinct from, *I. moulmeinensis.* The male differs from it above in the comparatively narrower orange-red band and its less black inner border. The female also is quite different from the same sex of that species.

Genus Idmais, Boisd.

Idmais surya, n. sp.

Nearest to *I. oriens.* Male larger, upperside much brighter-coloured, the black apical band broader, and is traversed by three spots only, which are comparatively shorter; the marginal spots are more prominent, the black inner border terminating on the upper median as in *I. oriens;* below the three subapical spots are two black spots. Cell-spot on forewing three times the size of that in *I. oriens* on both the upper and underside: hindwing with six marginal black spots, larger than in *I. oriens.* Underside much brighter-coloured than in *I. oriens;* base of both wings deep yellow, the outer borders broadly suffused with orange-red, the discal macular band similar but much less prominent on the hindwing.

Expanse $1\frac{6}{8}$ inch.

Hab. Sonakhala, Orissa. In coll. Indian Museum, Calcutta.

Genus Mancipium, Hübner.

Mancipium naganum, n. sp.

Male. Upperside pale yellowish-white; forewing with the base of the costal border sparsely black-speckled; a black band at the apex, the inner border of the band being curved, slightly irregular, and terminating at the middle median vein; a small black discal spot between the upper and middle medians, and a slight black-speckled spot at lower end of the cell. Underside: forewing white, with the apex pale yellow, the discal and discocellular spot as on upperside: hindwing yellow.

Expanse 2 inches.

Hab. Naga Hills, Assam. In coll. Indian Museum, Calcutta.

Genus Appias, Hübner.

Appias amboïdes, n. sp.

Male. Upperside white: forewing with a narrow apical black band. Underside: forewing white, the costal border, and apex corresponding to the band on upperside, pale brownish-ochreous: hindwing entirely pale brownish-ochreous, with a slight indistinct dusky fascia extending from the base along the subcostal and median vein.

Expanse $1\frac{7}{8}$ inch.

Hab. Silhet. Dihung, Assam. In coll. Indian Museum, Calcutta, and F. Moore.

Genus Hiposcritia, Hübner.

Hiposcritia imbecilis, n. sp.

Male. Upperside white: forewing with a black-speckled apical band, which is traversed by four subapical white spots. Underside: forewing white, with the apex ochreous-white and slightly speckled with ochreous-brown scales: hindwing ochreous-white, sparsely speckled with ochreous-brown scales with slight traces of their clustering on the anterior margin near end of the costal and subcostal veins and across the disc in an indistinct zigzag fascia; a small blackish spot at end of the cell.

Expanse $1\frac{3}{4}$ to 2 inches.

Hab. Silhet; Assam. In coll. Indian Museum, Calcutta, and F. Moore.

Allied both to *H. indra* and to *H. mahana*. Distinguished from the latter by its smaller size. Forewing with paler and less defined blackish apical band. No subapical curved black fascia on the underside.

Subfamily Papilioninæ.

Genus Papilio, Linn.

Papilio ladakensis, n. sp.

Male. Distinguished from the N. W. Himalayan *P. asiaticus* by the absence of the elongated tail on the hindwing, which in this form is reduced to a short point but little more acute than the anal angle. The forewing is comparatively narrower, and the hindwing is less convex and with less acutely sinuous exterior margin. On the upperside the yellow is also of a paler tint: forewing numerously covered with yellow scales between all the markings, the cell bands are shorter transversely and broader, and the inner cell-band is regularly quadrate; the discal bands also comparatively narrower and with more slender intervening black veins; the marginal row of spots is broader, and the intervening transverse discal area is narrower: hindwing with the outer border of the yellow basal area excavated between the veins, the marginal spots shorter and somewhat broader, the anal lobe-spot also smaller and broader.

Expanse $3\frac{1}{4}$ inches.

HAB. Tarhsam, Ladak. In coll. Indian Museum, Calcutta.

PAPILIO SIKKIMENSIS, n. sp.

Differs from N. W. Himalayan and Nepalese specimens of *P. asiaticus* in the very much darker black colour of the upperside; and in the forewing having the yellow cell-bands quadrate in form, the discal band composed of smaller and shorter portions, and the area intervening between the band and the marginal spots broader. On the hindwing, the veins are broadly black-lined, the abdominal border also black and leaving but a small subanal lunule; the discal margin of the yellow area has a more regularly scalloped edge, and there is also a broader discal area intervening between it and the marginal spots; the crimson anal lobe-spot is smaller, narrower, and has a lower retort-like black spot.

Expanse $2\frac{6}{8}$ to $3\frac{3}{8}$ inches.

HAB. Sikkim (*Elwes*).

Family HESPERIIDÆ.

CUPITHA, n. g.

Male. Forewing elongated, triangular, costa arched at the base, exterior margin oblique, posterior margin convex towards the base; first subcostal emitted at nearly one-half before end of the cell, the branches at equal distance apart; cell extending to nearly two-thirds length of the wing; discocellular almost erect, slightly bent close to upper end and below the middle; upper radial from the angle near subcostal, lower radial from the angle below the middle; the middle median at one-sixth, and lower median at four-sixths before end of the cell, submedian undulated; on the underside of the forewing is a short, broad, nacreous patch on the middle of posterior margin, across which the submedian is lined with rough scales, and from near the base of the margin projects a broad pencil of long rigid hairs: hindwing short, costa very much arched from the base, apex rounded; costal vein extending to near apex, forked at its base; subcostal bent upward and slightly joined to costal close to the base, subcostal two-branched, first branch from close to end of the cell; discocellular very slender, slightly oblique and concave; cell extending to nearly half the wing, of equal width throughout; middle median from near end of the cell, lower at more than one-half before the end, *the portion from the middle median to lower median distorted and extending beneath a drum-like glandular sac, which extends upward in a circular form within the cell from base of lower median*, the sac, or drum, as seen from the upperside, is flat, with a well-defined circular rim, and on the underside, it stands out from the surface in a corrugated circular form; no radial present; submedian straight; internal vein curved.

Thorax stout; antennæ with a slender club.

Type, *C. tympanifera.*

CUPITHA PURREEA.

Pamphila Purreea, Moore, P. Z. S. 1877, p. 564, pl. 58, fig. 10, ♀. Wood-Mason, Journ. Asiat. Soc. Bengal, 1881, p. 261.

HAB. South Andaman.

CUPITHA TYMPANIFERA, n. sp.

Male. Upperside dark violet-brown; forewing with a broad gamboge-yellow basal costal band, and an oblique discal sinuous-bordered band extending upward from near base of the posterior margin to near the apex: hindwing with a broad transverse discal yellow band extending from near the abdominal margin to near the apex and thence upward along the costal border. Cilia yellow. Body brown; abdomen with yellow bands. Underside deep gamboge-yellow: forewing with a short ochreous-brown streak extending longitudinally from the base to end of the cell, and a broad patch at the posterior angle: hindwing with a similarly coloured speckled patch near anal angle ascending upward from end of submedian vein. Palpi and legs yellow, antennæ annulated with yellow.

Expanse ♂ $1\frac{2}{8}$.

HAB. Magaree, Pegu. In coll. F. Moore.

This is a comparatively larger insect than *C. purreea;* the bands on the forewing are broader and with more irregular borders, the bands on the hindwing are also broader.

Genus PLESIONEURA, Felder.

PLESIONEURA MUNDA, n. sp.

Male and female. Upperside olive-brown: forewing with an oblique transverse discal semidiaphanous white band, similar to, but more compact than that in *P. leucocera*, the apex-spot starting from above the costal vein, the two lower large spots, the small one beneath, as well as that outwardly between them, are not separated from each other, the second lower spot between the median and submedian only being apart from the rest; three subapical conjoined white spots and two minute lower dots; cilia very faintly alternated brownish-white: hindwing uniformly olive-brown: cilia deeply alternated with white. Underside paler than above: forewing marked the same: hindwing numerously speckled with olive-green scales towards abdominal margin; an olive-green-speckled lunule at end of the cell.

Expanse $1\frac{5}{8}$ inch.

HAB. Simla (*Lang*). In coll. F. Moore.

Genus SUASTUS, Moore.

SUASTUS ADITUS, n. sp.

Male. Upperside dark violet-brown: forewing with two small quadrate yellow spots at end of the cell, a larger spot immediately beneath end of the cell between the middle and lower medians, and a small spot between the base of upper and middle medians; between the lower median and submedian is a very slight trace of an opaque yellowish streak; cilia edged with grey. Underside paler brown: forewing with the spots as above, and a whitish discal patch below them: hindwing speckled with olive-grey scales, which are most thickly disposed along the abdominal border and form a distinct line along the submedian vein; two dark brown discal spots, one being situated between the middle and lower medians, the other between the latter and submedian. Body, palpi, and legs beneath olivaceous-grey.

Expanse $1\frac{2}{10}$ inch.

HAB. Andaman Isles. In coll. Indian Museum, Calcutta.

Allied to *S. sala* (*Hesperia sala*, Hewits.).

SUASTUS MÖLLERII, n. sp.

Male. Upperside very dark olive-brown: forewing with three small narrow white semidiaphanous subapical spots, a larger narrow spot at lower end of the cell, a still larger spot below end of the cell, and a small very slender spot between base of upper and middle medians; a small yellowish opaque spot also above middle of the submedian: hindwing with the abdominal border broadly paler olive-brown. Cilia cinereous-white. Underside: forewing dusky-black, the costal border and apical area pale olive-brown; spotted as above: hindwing very pale olive-brown, with the interspace between submedian and internal veins white. Palpi beneath, and legs, and abdomen beneath, white.

Expanse $1\frac{1}{2}$ inch.

HAB. Sikkim (*Otto Möller*). In coll. Indian Museum, Calcutta.

Genus Satarupa, Moore.

Satarupa phisara n. sp.

Male. Upperside dark vinous-brown: forewing with two, sometimes three or four, minute semidiaphanous yellowish white subapical spots, a small spot at lower end of the cell, a large quadrate spot below end of the cell, and a small spot also between the base of upper and middle medians; a very indistinct greyish-brown-speckled submarginal lunular fascia and a similar short fascia below the quadrate discal spot: hindwing with a transverse subbasal pale yellowish band, and a curved submarginal indistinct greyish-brown-speckled lunular fascia, which gives the discal area a macular appearance. Female: forewing marked as in male, the short fascia below the discal spot more distinct: hindwing with the transverse band somewhat broader, the discal area between it and the submarginal lunular fascia more distinctly macular, being traversed by pale veins. Underside as above, the markings more prominent. Abdomen with slender white narrow bands; front of head and base of palpi, and pectus, orange-yellow, tip of palpi black.

Expanse ♂ $1\frac{5}{10}$, ♀ $1\frac{6}{10}$ inch.

Hab. Khasia Hills. In coll. Indian Museum, Calcutta, and F. Moore.

Allied to *S. bhagava* and to *S. sambara*.

Satarupa narada, n. sp.

Upperside purpurascent violet-brown: forewing with three small upper and two lower subapical semidiaphanous white spots, a small erect oval spot at lower end of the cell, a slightly larger quadrate spot on the disc between upper and middle medians, and a broad band formed of three quadrate spots increasing in width from end of cell to posterior margin: hindwing with a broad white transverse medial band, the outer border with an ill-defined upper spot. Cilia edged with white. Underside marked as above; the hindwing with the band showing a more defined macular outer border and a well separated upper spot.

Expanse $1\frac{4}{10}$ inch.

Hab. Darjiling, Sikkim. In coll. Indian Museum, Calcutta, and F. Moore.

Nearest allied to *S. bhagava*, but quite distinct.

Genus Tagiades, Hübner.

Tagiades khasiana, n. sp.

Male. Nearest to *T. ravi.* Of larger size: forewing comparatively more pointed at the apex: hindwing also broader, and with a more angular apex. Upperside of a paler olivaceous-brown, the dusky markings less distinct on both wings, the apical and discal spots smaller. Female upperside also paler than in *T. ravi*, the apical spots on forewing somewhat smaller, the cell spots similar, the two discal spots somewhat larger.

Underside: forewing with the spots as above: hindwing more intensely whitish grey, the discal black spots much smaller and less defined.

Expanse ♂ 2, ♀ $2\frac{1}{10}$ inches.

Hab. Khasia Hills; Shillong; Assam. In coll. Indian Museum, Calcutta, and F. Moore.

Lobocla, n. g.

Male. Forewing triangular, the edge of the costal margin slightly folded over on to the upperside from near the base to end of the costal vein;* the costal vein extending to three-fifths the margin; subcostal five-branched, first branch emitted at one-third before end of cell, second and third at equal distances from the first, fourth and fifth from end of the cell: discocellular bent outward near upper end and inwardly oblique hindward; upper radial from the angle near subcostal, lower radial from the middle; cell long, extending beyond two-thirds the wing; three medians, lower at three-fourths and middle median at about one-fourth before end of the cell; submedian straight: hindwing short, broad, apex rounded, exterior margin slightly produced and angular at end of submedian vein; costal vein extending to the apex; subcostal touching the costal close to the base, two-branched, first branch at one-fourth before end of the cell; discocellular very slender, almost erect; the radial from its middle; cell broad, extending to half the wing; two upper medians from end of the cell, lower at about one-third before the end; submedian and internal vein nearly straight. Body short, stout, thorax hairy; palpi broad, thickly clothed, apical joint short, thick; antennæ with a long slender-pointed tip; femora and tibiæ short, stout, slightly pilose, middle tibiæ with two and hind with four spurs, tarsi long.

Type, *L. liliana.*

* The species of *Erynnis* (*(E. alceœ*, etc.) have a similar fold on the costal margin of the forewing.

LOBOCLA LILIANA.

Plesioneura liliana, Atkinson, P. Z. S. 1871, p. 216, pl. xxii, fig. 2.

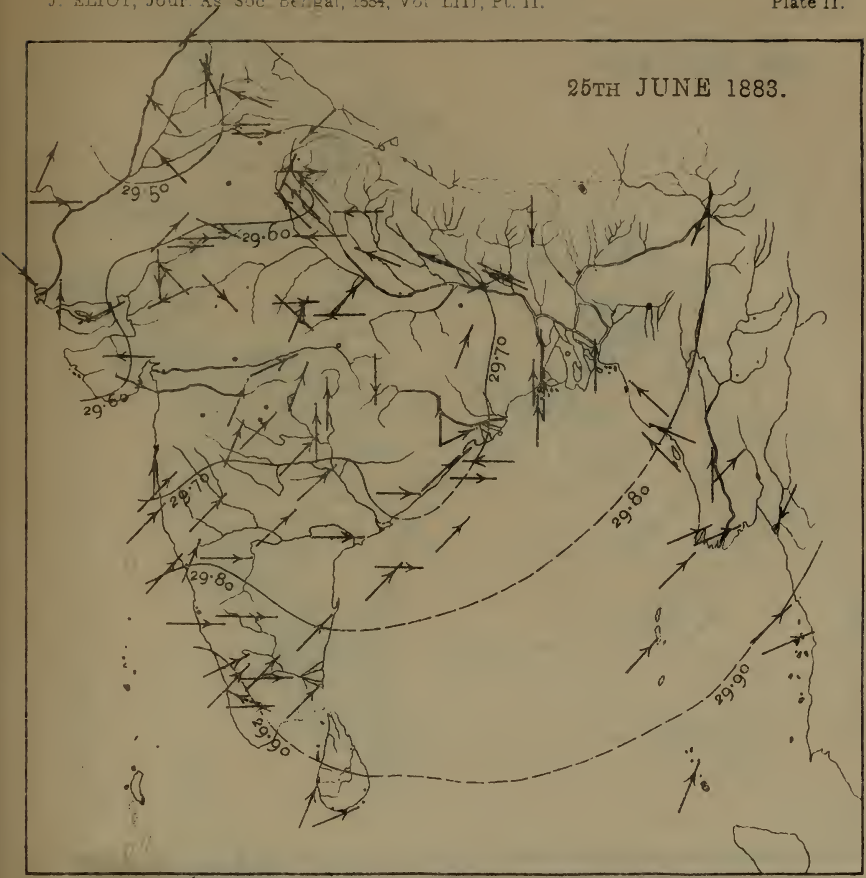
HAB. Yunan.

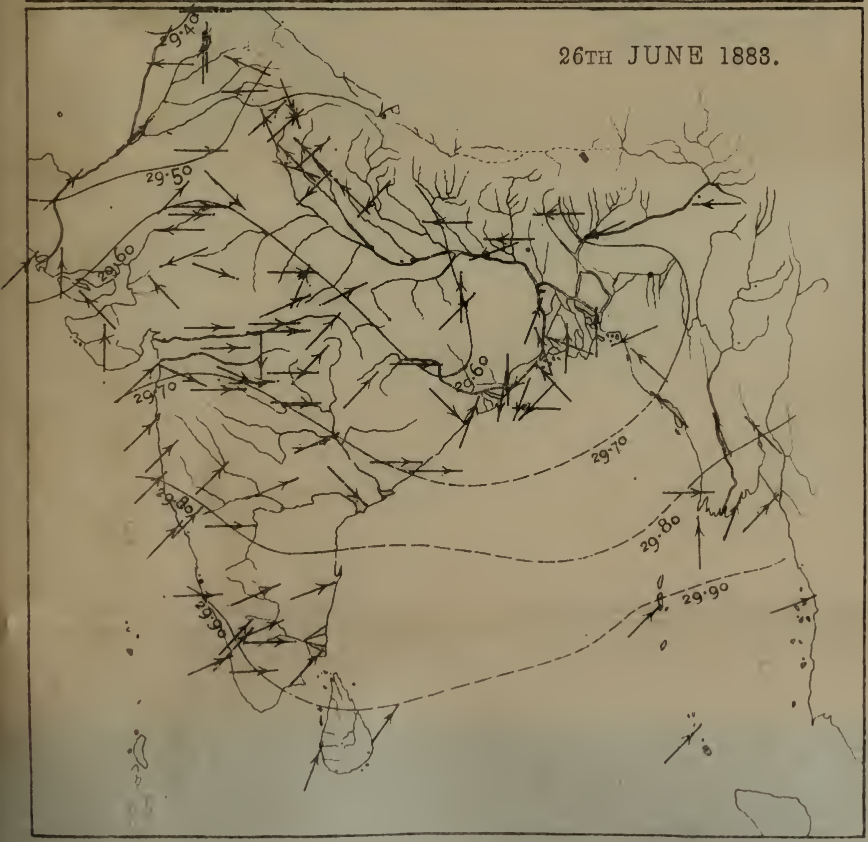
LOBOCLA CASYAPA, n. sp.

Differs from *L. liliana* in its smaller size. Upperside somewhat paler and of an olive-brown tint, sparsely speckled with olive-grey scales: forewing with the transverse semidiaphanous yellow band one-third less in width, the portions being distinctly defined by the traversing brown veins, the subapical spots also much smaller. Underside much paler: forewing numerously speckled with greyish-ochreous scales at the apex, the band and apical spots as above: hindwing with similarly disposed markings, but all composed of more numerous greyish-ochreous scales, these scales being whitish in *L. liliana*.

Expanse $1\frac{9}{10}$ inch.

HAB. Masuri (*Lang*). Cashmere (*Reed*). In coll. Indian Museum, Calcutta, and F. Moore.





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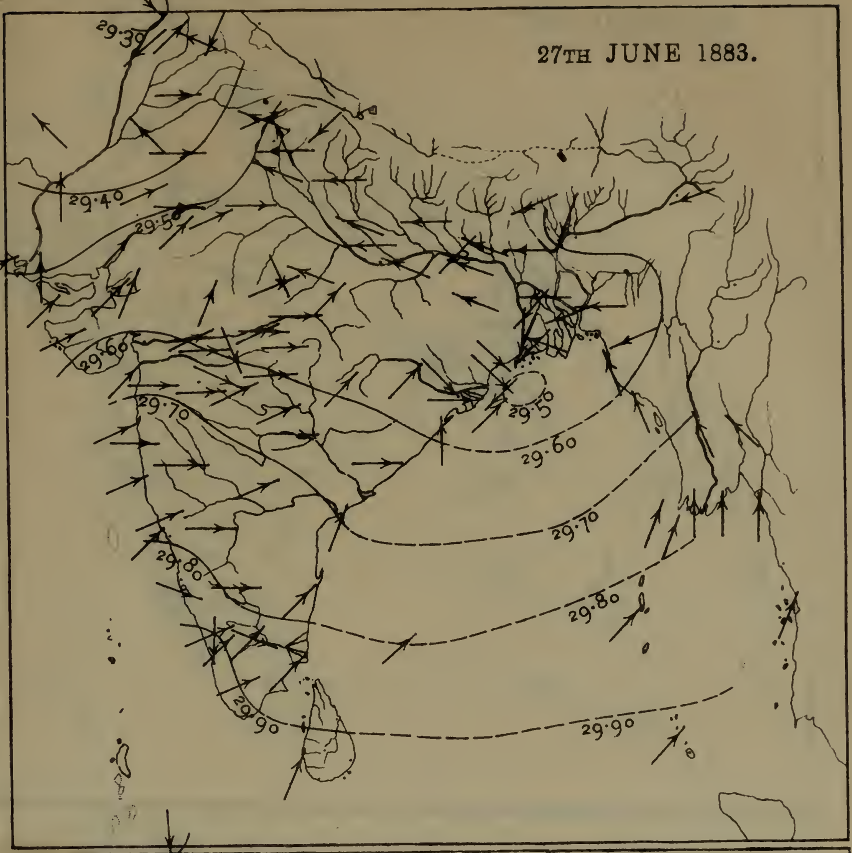

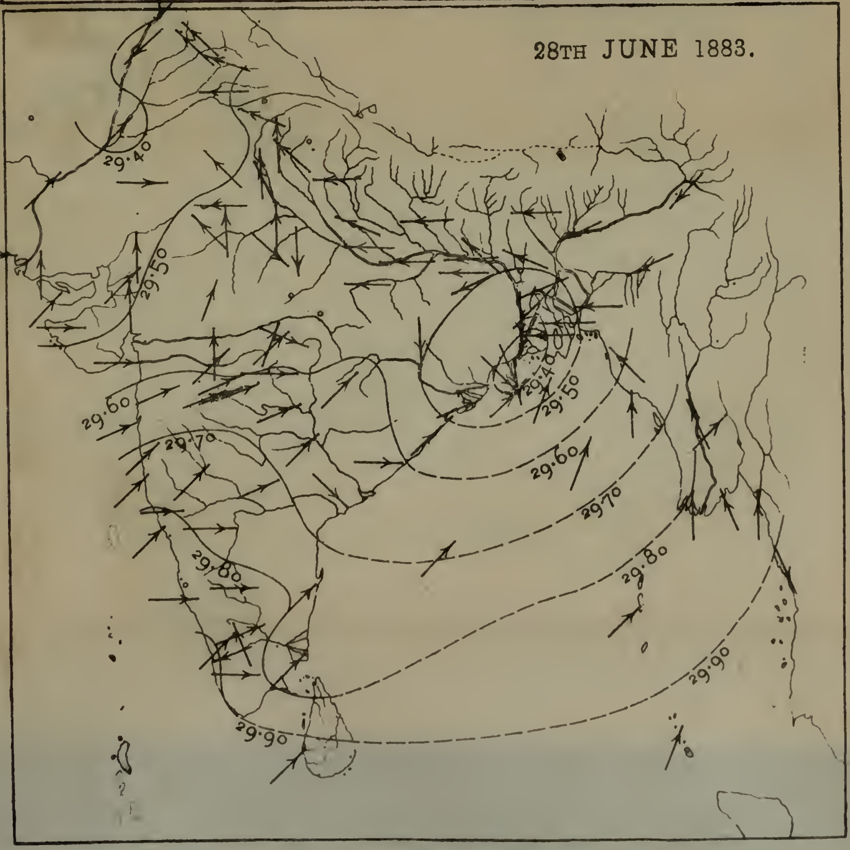

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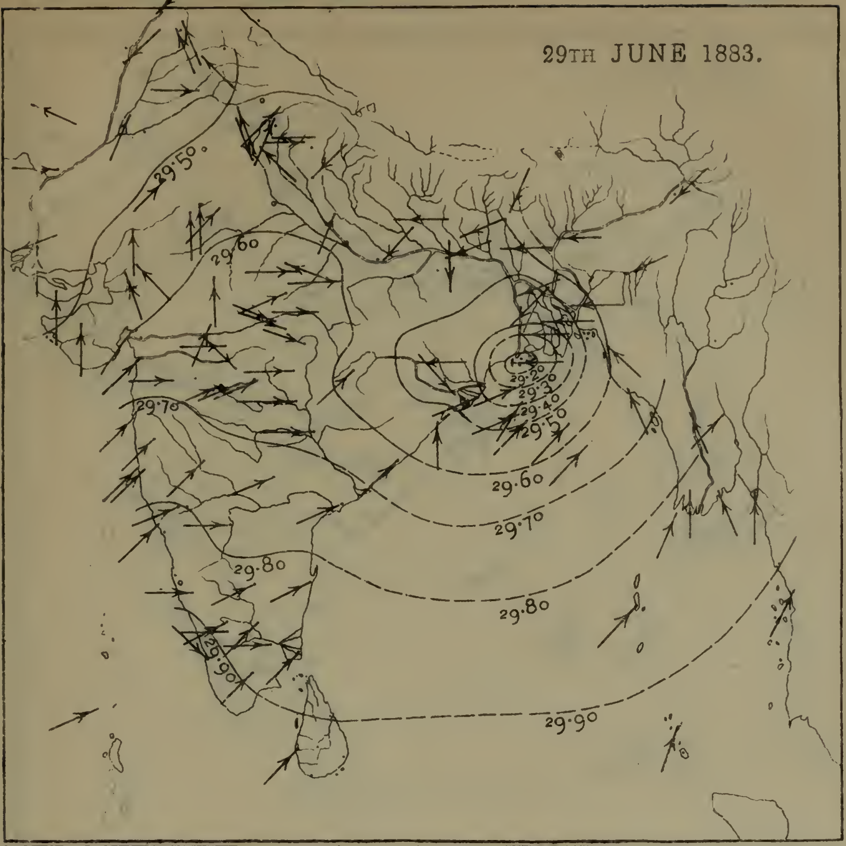

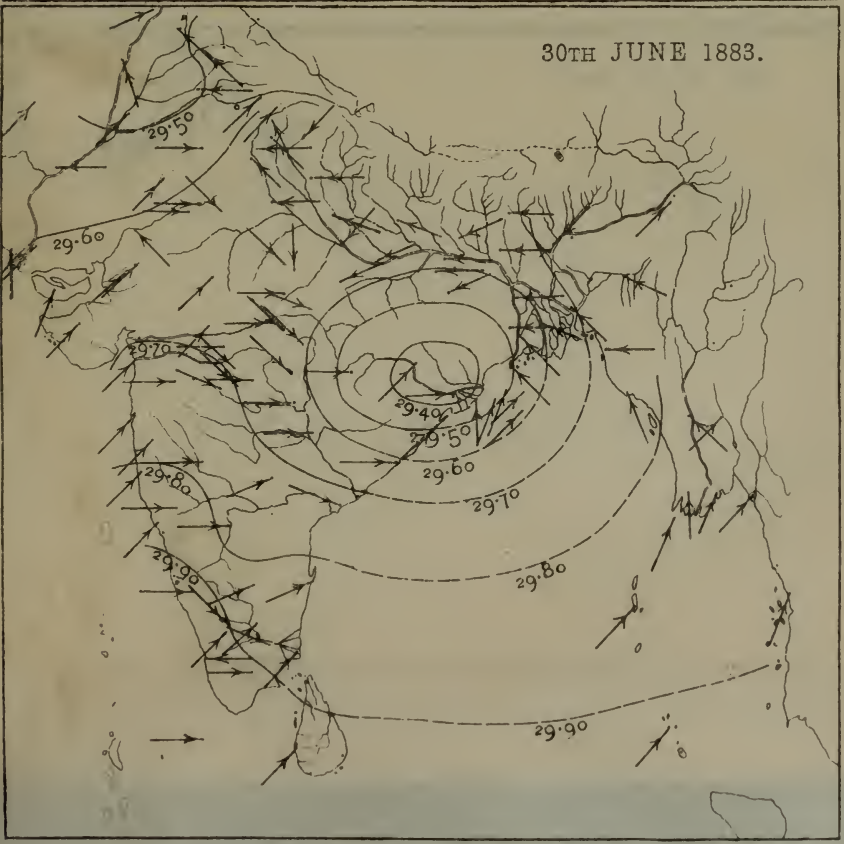

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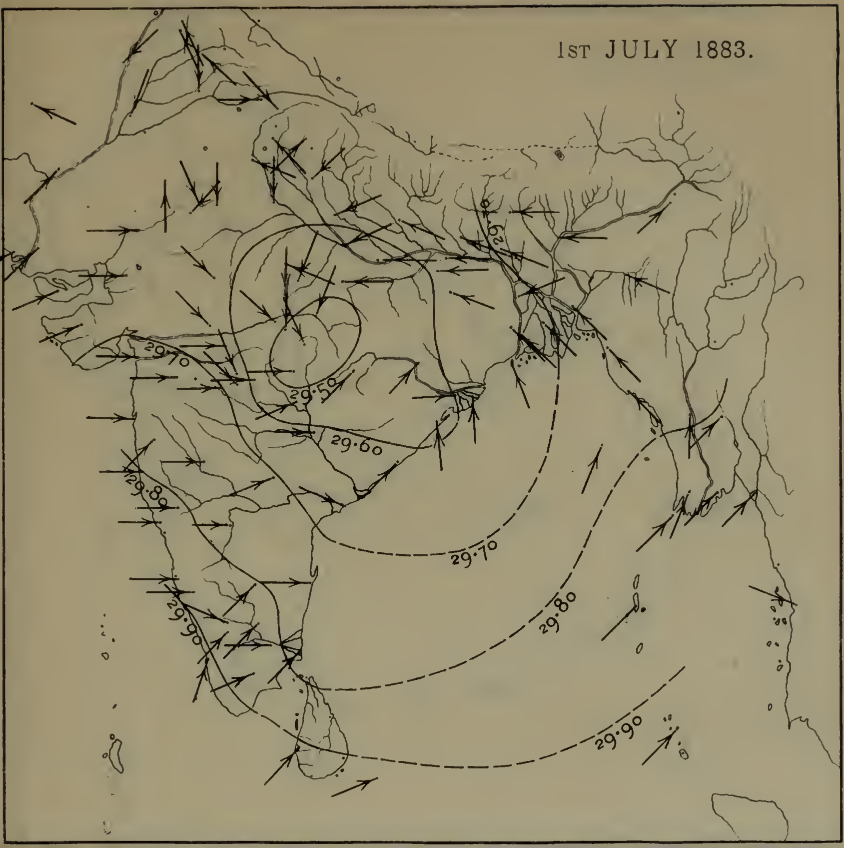

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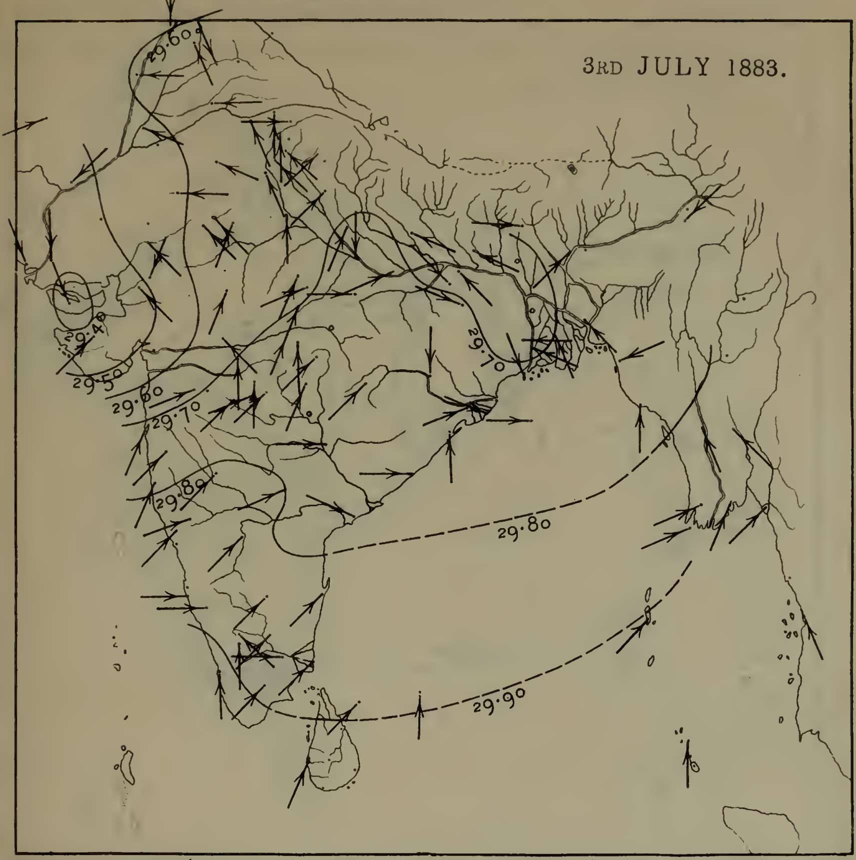

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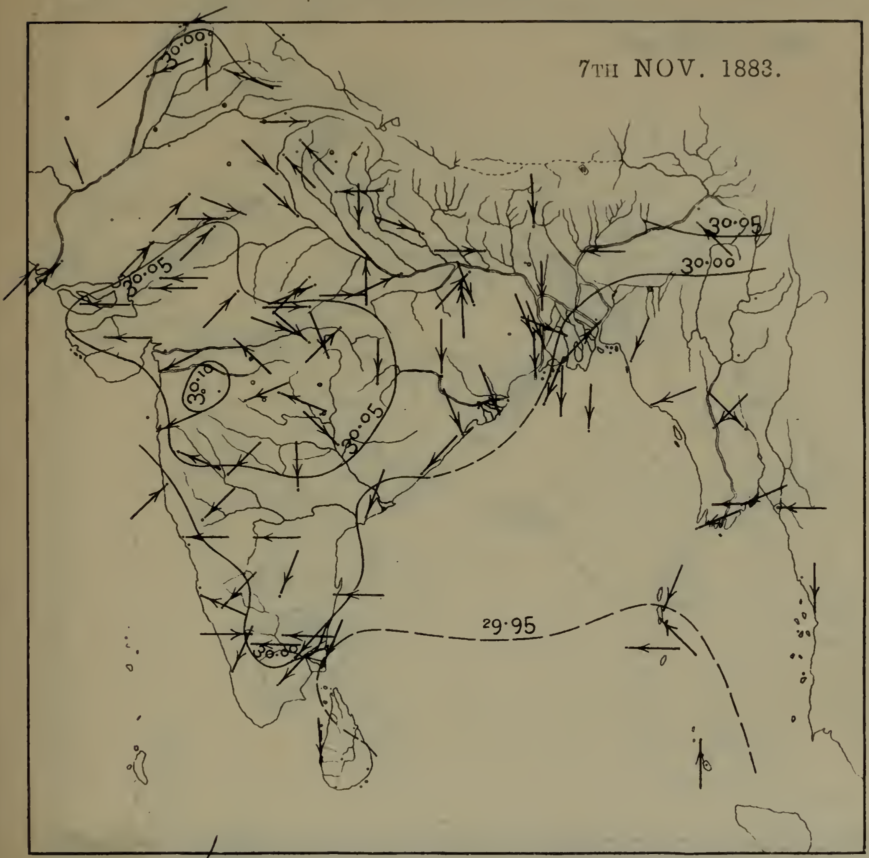

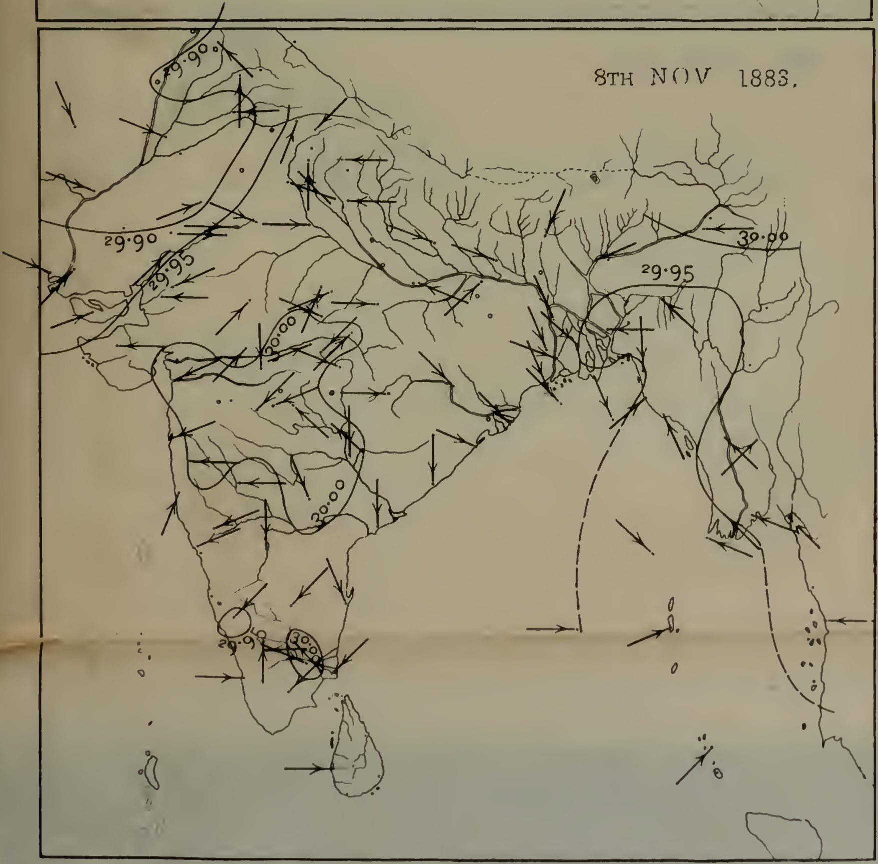

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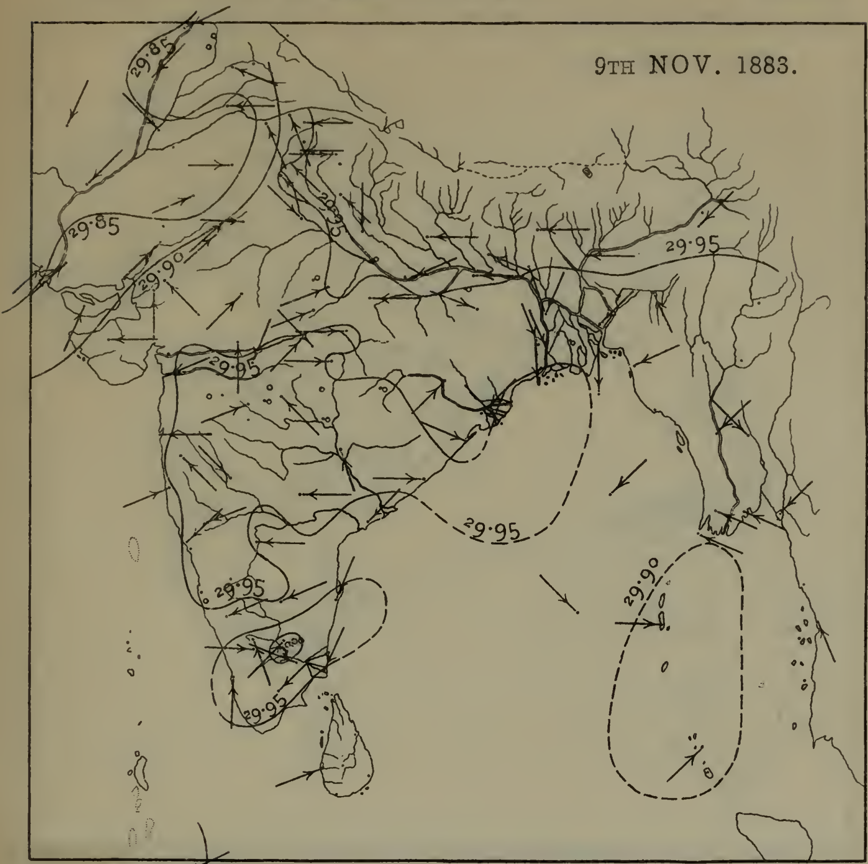

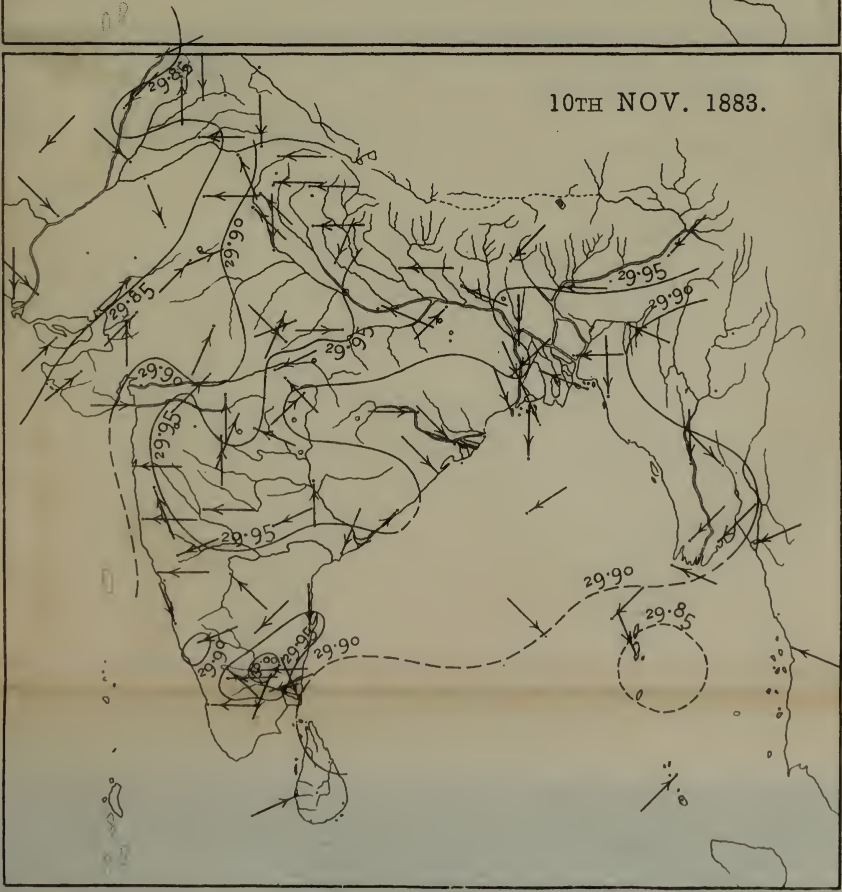

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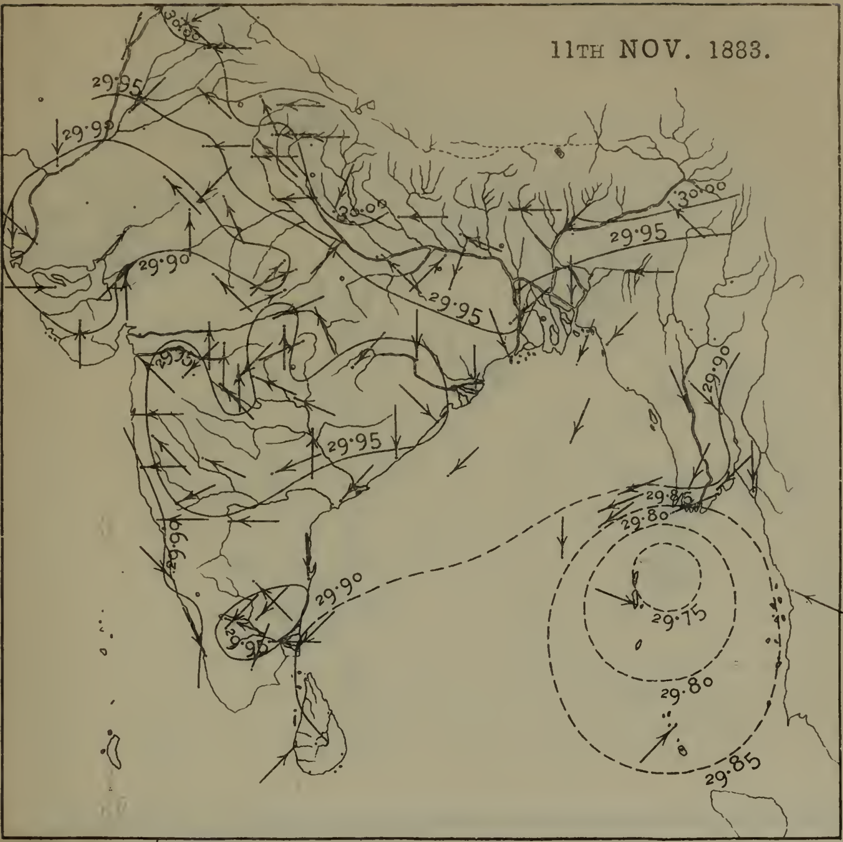

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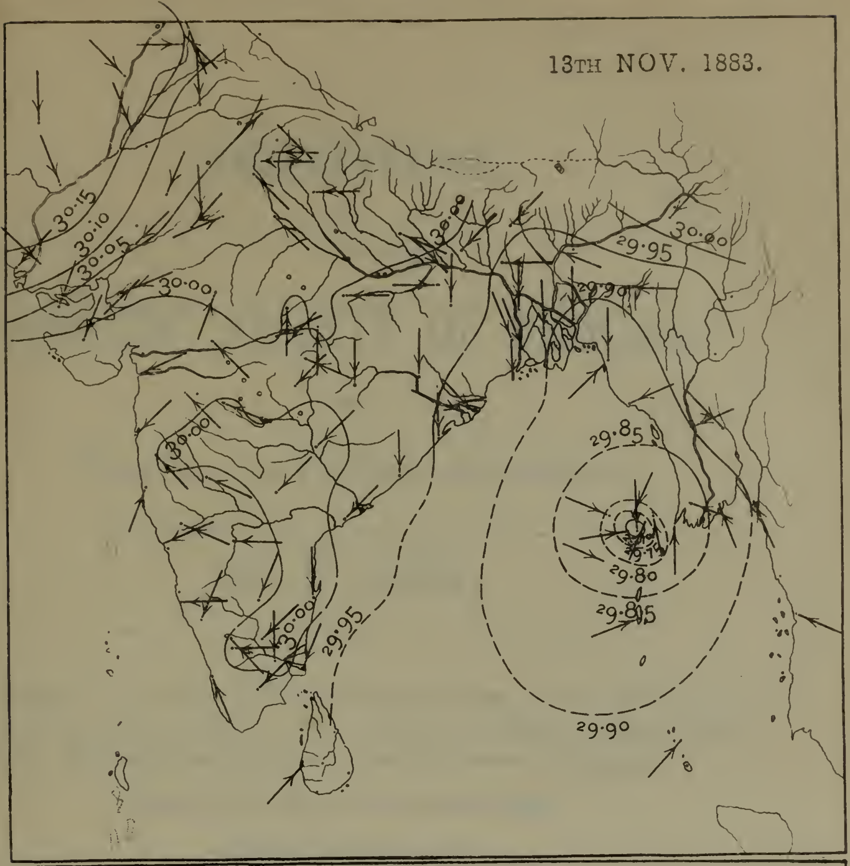

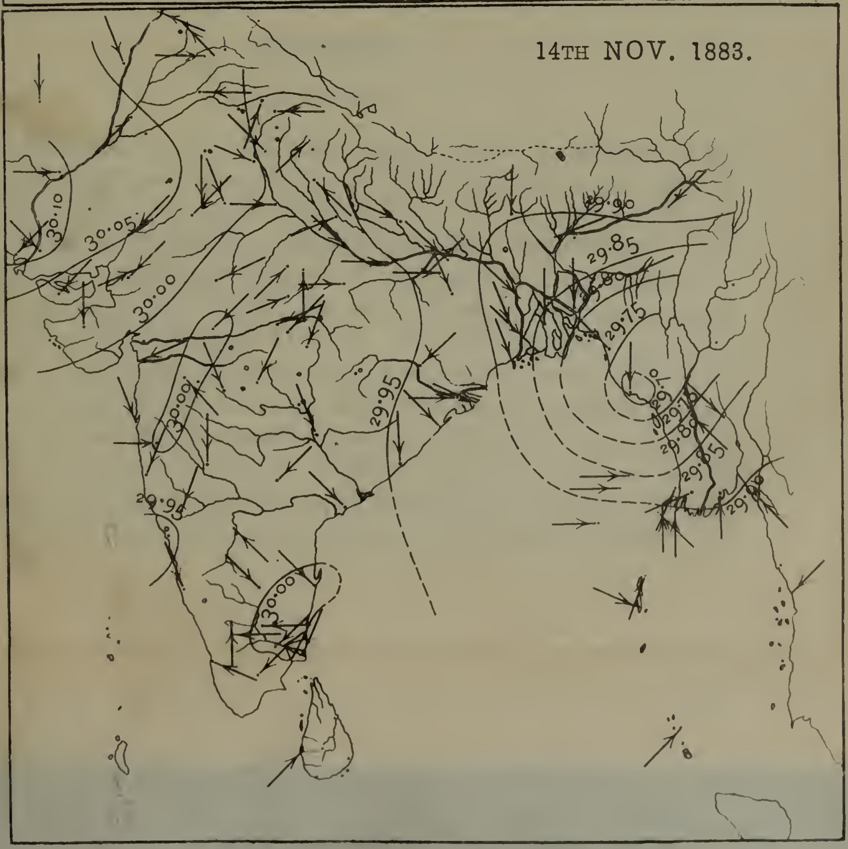

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JOURNAL

OF THE

ASIATIC SOCIETY OF BENGAL.

Part II.—NATURAL SCIENCE.

No. II.—1884.

III.—*Account of the South-West Monsoon Storms of the* 26*th June to* 4*th July and of* 10*th to* 15*th November* 1883.—*By* JOHN ELIOT, M. A., *Meteorological Reporter to the Government of Bengal.*

[Received June 4th;—Read July 2nd, 1884.]

(With Plates II—X.)

CHAPTER I.

INTRODUCTION.

It is proposed in the following paper to give an account of the two most important and remarkable storms that occurred in the Bay of Bengal during the year 1883. The first storm was generated during the last week of June near the Head of the Bay and gave very stormy weather off the Bengal and Orissa coasts, and was the only occasion on which it was necessary to hoist the storm signals at the Saugor Island station near the entrance to the Hooghly. The second storm was formed in the Gulf of Martaban during the second week of November, almost at the end of the south-west monsoon, and pursued a very unusual course. It crossed into the Bay of Bengal through the channel between Cape Negrais and the Andaman Islands. It then slightly recurved and moved in a general northward direction, approaching the Arracan coast near Akyab, where it was broken up by the action of the Arracan Hills.

The following is a list of all the cyclonic storms in the Bay of Bengal during the south-west monsoon period of the year 1883. They were all of comparatively small extent and intensity, or ordinary south-west monsoon storms accompanied with winds of force 8 to 10 at and near the centre.

1. Storm of June 13th to 20th at the commencement of the south-west monsoon, which gave the first heavy burst of rainfall to Behar. It formed near the Balasore coast on the 13th, and advanced into Behar, where it broke up on the 20th.

2. Storm of June 26th to 4th July. This was generated slowly near the Sandheads on the 26th and 27th, was of considerable intensity, and remained nearly stationary until the 29th. It crossed the Balasore coast early on the morning of the 30th.

3. Storm of July 6th to 8th. This was formed at or near the Sandheads under similar conditions to the preceding, but was of small intensity. It crossed the Balasore coast on the afternoon of the 7th.

4. Storm of the 12th to 14th July. This began to form on the morning of the 12th off the South Orissa coast, across which (between False Point and Gopalpore) the centre advanced on the evening of the 13th, or early on the morning of the 14th, into the Central Provinces. It was of slight intensity.

5. Storm of the 16th to 18th August. This was formed in the north-west angle of the Bay, and crossed the North Orissa coast near Balasore. This storm was very small, of very slight intensity, and of no importance.

6. Storm of the 23rd to the 26th of August. This was generated further to the south than the preceding storm, and crossed the Ganjam coast between Gopalpore and Vizagapatam on the evening of the 25th. It was of slight intensity.

7. Storm of the 30th August to the 3rd of September. This depression crossed the coast near Balasore on the afternoon of the 2nd of September, and was of moderate intensity.

8. Storm of the 6th and 7th of September. This was formed immediately after the preceding, and followed along nearly the same track, crossing the Orissa coast to the south of Balasore on the morning of the 7th. It was of small intensity.

9. Storm of the 11th to the 15th of November. This was generated in the Martaban Gulf, and advanced in a north-westerly direction as far as Lat. 16° N. Long. 93° E. to the west of Diamond Island, when it recurved and moved northwards parallel to the coast, breaking up in the neighbourhood of Akyab during the afternoon of the 14th. This was the most severe and intense storm of the year in the Bay, but was

of very limited extent, and hence did not affect the weather in the north-west angle of the Bay.

10. Storm of the 2nd to the 4th of December, which gave heavy rain at a very unusual time of the year to Bengal.

Two of these were remarkable for the length of time that elapsed before they broke up after they had crossed the Bengal or Orissa coast, and also for the very heavy rainfall and floods which accompanied their existence on land. The first of these was the storm of June 13th to 20th which was formed in the immediate neighbourhood of the Balasore coast. It drifted through Chutia Nagpur and South Behar into North Behar and gave excessively heavy rain to a narrow area in Behar stretching from Gya to Motihari and Durbhunga. This storm was of little importance at sea.

The second storm of the series was similar in its general character. It was generated near the Head of the Bay, crossed the North Orissa coast, and advanced over the Orissa Hills into the Central Provinces. Instead of breaking up as do three out of four storms or cyclonic circulations which pass from the Bay into the Central Provinces, it acquired fresh energy and drew large supplies of vapour from the Bombay monsoon current. It advanced across the head of the Peninsula almost parallel to the valleys of the Nerbudda and Tapti. The heavy rain accompanying it caused excessive floods in these two rivers which inflicted much damage on the town of Surat, and others in the lower portion of the valleys of these two rivers. This cyclonic circulation apparently broke up in the Arabian Sea in the immediate neighbourhood of the Guzerat and Sind coasts.

The meteorology of India for the year 1883 was remarkable in several respects. One or two of the more important features had a direct bearing on the number and character of the cyclones.

During the cold weather months several storms of unusual character and magnitude passed over Northern India and the Himalayas from west to east. They gave excessive snowfall over the higher Himalayas and affected the weather certainly for many weeks and probably more or less permanently for the year. The accumulation of snow reduced temperature for some time and gave a strong northerly element to the air motion or wind circulation over Northern India. The south-west monsoon set in about the normal period on the Burmah and Bengal coasts, but it never obtained its usual hold in Northern India. The rains were irregular in occurrence and distribution, and much below the average over the whole of Northern India. The deficiency was quite as marked in North Bengal as in North Behar or Rohilkhand or in the Western districts of the Punjab. The monsoon was in ordinary language very weak, and its weakness was more especially shown in Bengal by the early and complete termination of the rains in the last week of September.

The only theory which on the whole explains the phenomena of cyclonic generation and motion, *viz.*, the condensation theory, indicates that small cyclonic storms should be of frequent occurrence during the south-west monsoon, and that they should be most frequent when the monsoon is weak on land, or in other words, when the rainfall occurs to a smaller extent over the land and therefore usually to a greater extent over the sea area in the neighbourhood of the land. The rainfall in the Bay near the Burmah, Arracan, and Bengal coasts during the south-west monsoon of 1883 was, according to the various accounts received in the Meteorological Office, noticeably larger in amount than usual. The large number of cyclonic storms which formed during the period the south-west monsoon prevailed in Northern India in the year 1883 confirms this inference from theory.

After the south-west monsoon current finally retreated from Northern India in the last week of September, it recurved as usual over the Bay. The moisture brought up by it was, however, at once discharged on the Madras coast districts. The condensation theory indicates that there is a marked tendency during the transition period of October and November to the commencement and continuance of heavy rainfall over the centre of the Bay, and therefore to the generation of severe cyclonic storms at that period. If, however, the aqueous vapour or moisture is not discharged as rain over the Bay, but is carried westwards by the north-east monsoon winds and deposited on and near the Madras coast, the conditions for the formation of a cyclonic storm are not present in the Bay. In other words, if heavy general rain sets in and continues over the Madras coast at the change of this monsoon, the Bay will be free from severe and extensive storms. This rule was strikingly illustrated by the weather of the Bay and the Madras coast in October and November 1883.

The paper will deal with the subject under the following heads :—

1. History of the Storm of June 26th to July 4th.

2. Discussion of the more important features of the Storm of 26th June to 4th July.

3. History of the Storm of 10th to 15th November.

4. Discussion of the more important features and peculiarities of the Storm of 10th to 15th November.

5. General remarks on the generation of cyclones.

CHAPTER II.

History of the Storm of June 26th to July 4th.

The south-west monsoon set in slightly earlier than usual on the Bengal coast in 1883, but with no great strength. Moderate rain fell over the whole of the Province of Bengal during the first fortnight. On the 12th there began to form, in the north-west angle of the Bay, between False-point and Saugor Island, and over the adjacent portion of south-west Bengal, a small barometric depression ; and on the morning of the 13th, the winds in South-west Bengal and North Orissa indicated cyclonic convergence to it. The depression intensified on the 14th, and its centre was then to the north of and in the neighbourhood of Balasore. It advanced northwards through Chutia Nagpore and South Behar across the Ganges into the central districts of North Behar, and gave excessive rain over a narrow area stretching from Gya through Behar and Patna to Mozufferpore and Durbhunga. Amongst the remarkable rainfalls were the following :—

	15th	16th	17th	18th	19th
Gya	1·01	9·04	0·21	0·01	nil.
Behar	5·17	6·05	10·95	0·58	0·09
Patna	1·23	6·35	5·13	nil.	0·05
Mozufferpore	0·08	2·85	12·49	0·42	nil.
Hajipur	0·86	4·51	9·39	nil.	0·14
Durbhunga	0·53	1·02	5·02	8·52	0·24

The disturbance broke up in North Behar and finally disappeared on the 20th. During the next five days there was a partial break in the rains. The air was drier, sky less clouded, and rain showers local rather than general in character. The winds more especially diminished in strength, but continued to indicate the same general atmospheric motion over the Gangetic delta and valley as before. Southerly winds blew across the Bengal coast. In Northern Bengal and Behar the current was deflected up the Gangetic valley and hence gave winds blowing from directions varying generally between N. E. and S. E. In Chutia Nagpore and in Western Orissa the effects of the Bombay branch of the monsoon current were beginning to be shown by the prevalence of moist S. S. W. winds at Hazarabagh and of W. N. W.

winds at Cuttack. The Bombay branch of the monsoon current, it may be added, was late in being established on the Bombay coast, and was very feeble before the 20th of the month, when it rapidly increased in force, as measured by the strength of the winds.

The heavy rainfall attending the disturbance of the third week of the month had drained the southerly monsoon winds advancing into Bengal from the Bay of a very large portion of their moisture, and weakened them for some days. This is shown by the diminution in the amount of the rainfall and by the decreased velocity of the winds in Bengal.

The following table gives the average amount of the rainfall day by day between the 13th and the 26th in the various divisions in Bengal, and illustrates fully the general diminution in the rainfall of every part of the Province after the 20th :—

Table of Average Rainfall recorded in Bengal, June 13th to 26th 1883.

Province.	No. of Stations.	13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st.	22nd.	23rd.	24th.	25th.	26th.
Orissa.........	16	0·64	1·30	0·23	0·04	0·25	0·16	0·30	0·09	Nil.	0·37	0·10	0·43	0·10	0·41
S. W. Bengal	46	0·31	0·78	0·42	0·26	0·27	0·26	1·02	0·31	0·66	0·26	0·45	0·10	0·18	0·07
East Bengal	26	0·18	0·51	1·62	1·11	0·86	1·00	1·48	0·46	0·82	0·33	0·17	0·18	0·16	0·11
North Bengal	27	0·09	0·21	0·91	1·79	1·71	0·47	1·23	2·25	0·97	0·33	0·72	1·09	0·98	0·96
North Behar	16	0·04	0·12	0·52	1·86	3·69	1·36	1·13	1·21	0·42	0·42	0·30	0·07	1·98	0·89
South Behar	17	0·29	0·08	1·40	3·37	1·99	0·92	0·35	0·11	0·04	0·09	0·38	Nil.	0·38	0·77
Chutia Nagpore & Sonthal Perg.	16	0·39	0·50	2·04	0·48	0·21	0·56	0·63	0·97	0·15	0·37	0·13	Nil.	0·19	0·35

The following table gives the daily amounts of wind for the same period at the chief Meteorological Stations in Orissa, Bengal, and Behar.

Table of Daily Amount of Wind at eight Stations in Bengal. June 13*th to* 25*th*, 1883.

	13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st.	22nd.	23rd.	24th.	25th.	Average Daily Amount, June.
False Point ...	261	207	326	258	265	207	270	241	245	244	?	285	238	249
Calcutta	127	141	166	215	177	140	167	178	166	151	122	72	104	162
Dacca	102	174	164	174	177	160	193	229	217	211	181	142	155	186
Dinagepore ...	144	168	312	264	216	144	192	216	144	120	120	144	120	?
Purneah	76	100	170	111	126	114	255	158	24	26	21	47	29	98
Durbhunga ...	137	185	279	148	278	153	58	74	127	57	59	116	134	137
Patna	117	148	206	251	114	58	60	121	138	55	111	107	127	?
Hazaribagh ...	99	134	191	286	329	182	206	153	239	136	211	182	178	214

The rainfall table shews a very marked diminution in the amount of rain after the 20th. An examination of the complete rainfall returns of the Province of Bengal indicates that it occurred as isolated and local showers, which were occasionally heavy and gave large amounts at single stations. No general rain, however, fell over any considerable portion of the Province between the 20th and 25th. Similarly, an examination of the second table giving wind amounts indicates that, although strong winds generally prevailed between the 13th and 20th, winds were unusually light after the 20th and below their normal strength. This feature of weakness of its air motion was most markedly shown by the stations most distant from the sea, as, for example, Purneah.

The meteorological observations taken in Bengal thus show that what may be termed a strong monsoon prevailed at the Head of the Bay and in Bengal from the 1st to the 20th of the month, and that for some days afterwards, or between the 20th and the 25th, it was much feebler. Also, as will be seen from the following observations and from the history of the storm, the south-west monsoon winds increased in force to the west of the Andamans on the 23rd, advanced northwards as a strong atmospheric current along the coasts of Burmah and Arracan, and fed the cyclonic vortex which formed on the 26th and 27th with large supplies of aqueous vapour.

Table of Daily Amount of Wind at seven Stations to the east of the Bay. July 22nd to 28th, 1883.

	Average June.	22nd.	23rd.	24th.	25th.	26th.	27th.	28th.
Nancowry	263·5	115·0	98·8	97·3	124·2	252·7	354·5	289·8
Port Blair	257·6	128·7	212·9	386·0	283·8	305·4	315·6	323·0
Diamond Island............	203·0	122·9	118·5	118·7	240·7	310·4	346·6	336·5
Akyab	93·6	42·7	48·9	55·4	83·6	100·9	153·8	234·4
Chittagong	168·3	162·6	113·5	72·9	71·9	50·1	117·7	212·2
Saugor Island	332·4	362·7	312·4	284·7	235·2	144·5	137·1	357·4
Dacca	183·7	211·1	181·1	142·8	155·0	68·8	66·8	181·1

The preceding table shows that on the 22nd and 23rd the winds were barely half their normal strength over the east of the Bay. A rapid increase took place on the 24th at Port Blair, which extended to Diamond Island on the 25th and to Akyab and Chittagong on the 26th and 27th.

These figures suggest what is also indicated by the whole of the Bengal observations, *viz.*, that the weather in the Bay between the 20th and 23rd of June was that which usually accompanies the commencement of a partial break in the rains in Bengal or Northern India. Winds were light and unsteady over the whole of the north and centre of the Bay. The logs of vessels show that occasional rain-squalls local in character occurred, more especially in the south of the Bay. The observations at Port Blair, Nancowry, Diamond Island, and Akyab and of the ships traversing the Bay at the time, however, prove conclusively that south-westerly winds prevailed over the whole of the Bay ; and the Bengal observations establish that they were continued in Bengal and Behar as southerly and easterly winds. They also indicate that on the 24th a change occurred in the character of the winds to the west of the Andamans which lasted for some days. A very considerable increase occurred in the south-west winds of that part of the Bay which rapidly and steadily extended northwards.

Hence prior to the morning of the 25th the gradients were normal in direction, although smaller in amount than the average for the season, over the Bay ; the winds blew from the usual quarter and gave rise to the normal atmospheric current up the Gangetic valley. The only indication afforded at this time by the land observations of the subsequent stormy weather was the occurrence of a partial break in the rains, which, as has been ascertained by previous experience, establishes conditions which are favourable to the development of a cyclonic disturbance if an adequate motive power or disturbance act on the atmosphere.

The account of the storm of the last week of June hence begins with the 25th of June, the day before which there were any indications of the actual formation of an atmospheric whirl at the Head of the Bay.

25*th of June.*—The atmosphere was in a slightly disturbed state over nearly the whole of India. The barometer was rising in the North-Western Provinces, Bengal, and the south of the Peninsula, but elsewhere it was falling. A large depression accompanying the establishment of the south-west monsoon in Western India was advancing along the west coast of India and causing the barometer to fall quickly. Winds had backed to south-east on the 24th at Bombay. On the 25th, winds were southerly along the Bombay coast and easterly in Cutch. There were strong indications that gales of considerable force were blowing on and near the Bombay coast. The weather was cloudy everywhere, except in the Punjab; and rain in small or moderate amounts was falling in every part of India, except the Punjab, Behar, Sind, and parts of the Madras Presidency. The rainfall was very small in amount and local in its distribution over the North-Western Provinces, Bengal, Rajputana, and the North Bombay districts.

The following table gives the more important observations taken at the Coast Stations on the Bay of Bengal on the 25th June, 1883:—

STATIONS.	10 A. M. Barometer reduced to sea level.	Change since 10 A. M. 24th.	Wind direction.		Wind velocity of previous 24 hours miles per hour.	Percentage of wind amount to average.	Cloud 10 A. M.	Rainfall of previous 24 hours.
			10 h.	16 h.				
Nancowry	29·941	+ ·047	S. S. W.	S. S. W.	5	45	8	0·14
Port Blair	29·911	+ ·069	S. W.	S. W.	14	127	10	1·05
Diamond Island	29·847	+ ·024	S. W.	W. S. W.	8	100	9	0·24
Akyab	29·792	+ ·019	E. S. E.	S.	4	100	9	1·35
Chittagong ...	29·802	+ ·027	S. E.	S. W.	3	43	10	0·15
Dacca	29·752	+ ·024	S.	S. E.	7	88	10	...
Jessore	29·745	+ ·040	calm.	S. S. W.	7	140	8	...
Calcutta (Alipore)	29·719	+ ·025	S.	S. S. W.	5	83	9	0·05
Saugor Island	29·775	+ ·053	S.	S. S. E.	31	221	3	0·21
Balasore	29·715	+ ·010	S. W.	?	5	?	3	...

Stations.	10 A. M. Barometer reduced to sea level.	Change since 10 A. M. 24th.	Wind direction.		Wind velocity of previous 24 hours miles per hour.	Percentage of wind amount to average.	Cloud 10 A. M.	Rainfall of previous 24 hours.
			10 h.	16 h.				
Cuttack.........	29·695	+ ·015	W. S. W.	S.	3	75	9	1·01
False Point ...	29·722	+ ·005	Calm.	E.	11	110	8	0·03
Vizagapatam	29·672	— ·027	W.	W. by S.	6	150	8	...

Pressure had increased rather rapidly over the province of Bengal during the previous 24 hours. The general result of the changes of pressure since the dispersion of the disturbance of the third week of the month had been to give a high barometer, which culminated on the morning of the 25th in excessively high readings. The barometric readings at 10 A. M. of that day in Bengal were above the average by amounts which varied from ·19″ at Saugor Island to ·09″ at Durbhunga. Winds were, however, generally normal in direction, blowing from south in South-West Bengal, south-east in East Bengal, east in North and Central Behar, and south-west in Chutia Nagpore.

The unusual weakness of the wind is shown by the following comparison table:—

	Wind amount of 24 hours preceding 10 A. M.	Average daily wind amount June.	Percentage of actual to average wind amount.
Saugor Island	256·9	332·4	77·3
Calcutta..................................	104·0	152·3	68·3
Berhampore	132·6	132·3	100·2
Dacca.......................................	162·1	183·7	88·3
Jessore	118·3	118·3	100·0
Chittagong	71·5	168·3	42·5
Burdwan	110·7	124·2	89·1
Cuttack.....................................	40·0	96·3	41·5
False Point	263·3	247·2	106·5

The average rainfall in each of the seven meteorological divisions of Bengal for the 24 hours preceding 6 P. M. of the 25th June is given in page 58.

The following table gives the meteorological information for the 25th extracted from the logs of vessels:—

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	Remarks.
Bancoora	4 A. M.			29·899	S. S. W.	3	8 A. M. Light breeze and hazy.
	8 A. M.			30·988	N. E.	2	11 A. M. Heavy rain squall.
	Noon	N. 5° 58′ by D. R.	E. 80° 58′	·963	W. S. W.	3	Noon. Moderate breeze and fine.
	4 P. M.			29·889	S. W.	3	
	8 P. M.			·901	S. W.	3	
	Midnt.			·889	S. W.	3	Midnight. Moderate breeze and clear.
India	4 A. M.				S.	4	Moderate breeze with passing squalls.
	8 A. M.			29·750	N. W.	3	Breeze moderating and fine.
	Noon	N. 15° 10′	E. 83° 14′	·730	W.	3	Moderate breeze and fine.
	4 P. M.				W.		Moderate fresh wind; cloudy with showers.
	8 P. M.			·730	W.	4	Fresh breeze and overcast.
	Midnt.			·730	W.	3	Threatening to N. W. with lightning.
Himalaya	4 A. M.			29·712	S. S. W.		
	8 A. M.			·747	W. S. W.		
	Noon.	N. 15° 13′	E. 82° 29′	·737	S. W.	3	Moderate breeze and overcast.
	4 P. M.			·731	W. S. W.		
	8 P. M.			·734	S. W.		
	Midnt.			·757	S. W.		
Roma	4 A. M.				S. W.	5	Fresh breeze and moderate sea.
	8 A. M.				...	...	
	Noon	N. 17° 15′	E. 85° 17′		...	0 to 3	Moderate variable wind with very heavy rain squalls and dark overcast sky.
	4 P. M.				...	4	Rain squalls.
	8 P. M.				...	...	Lightning, similar weather and high S. S. W. sea.
	Midnt.				...	...	Overcast sky.

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	Remarks.
Saint Magnus	4 A. M.			29·690	W. S. W.	4	
	8 A. M.			·700	S. W.	4	
	Noon	N. 18° 31′	E. 86° 29′	·710	W.	1	
	4 P. M.			·680	S.	1	Calms and rain.
	8 P. M.			·710	S. W.	5	Cloudy, lightning to S. W. & S. E.
Star of Albion	4 A. M.			29·730			
	8 A. M.			·740			Easterly current. Squally.
	Noon	N. 18° 46′	E. 86° 40′	·740	W.	4 to 5	Cloudy weather.
	4 P. M.			·710			
	8 P. M.			·720			
Scottish Chieftain	8 A. M.			29·680		0	Very light airs and dark cloudy weather.
	Noon	N. 18° 58′	E. 86° 34′	·690	S. by W.	1	
	4 P. M.				S. W.	2	Strong westerly current.
	8 P. M.			·660	N. N. W.	3	
British Princess	4 A. M.				S. by W.	5	Cloudy sky and S. W. swell.
	8 A. M.				S. W.	4	Variable winds.
	Noon	N. 19° 9	E. 85° 15′	29·700	E.	2	Fine clear weather.
	4 P. M.				E. S. E.	4	Squally with rain.
	8 P. M.				S.	3	Cloudy sky.
	Midnt.				W. S. W.	4	S. W. swell moderating.
					S. S. E.		Midnight.
Prince Amadeo	4 A. M.				S. W.	4	A. M. Weather clearing, wind moderate. 4 A. M. Gentle wind, fine weather. Noon. Close sultry weather. Sea smooth.
	Noon	N. 19° 23′	E. 85° 56′	29·700	S.	4	
	4 P. M.				E. S. E.	3	4 P. M. Weather fine. Sea very smooth.
Commilla	8 A. M.				Variable	2	Showery.
	Noon	N. 20° 13′	E. 92° 28		S. E.	3	Clear weather and smooth sea.
	4 P. M.			29·611	S. S. E.	3	Fine weather.
	8 P. M.			·683	S. E.	4	Fine weather and lightning to eastward.
	Midnt.			·671	E. S. E.	4	Clear weather and smooth sea.

The logs of the vessels received in the Meteorological office give an imperfect view of the weather in the Bay, as they were chiefly those of steamers passing up to Calcutta along the west coast of the Bay.

The Bancoora rounding Ceylon had light to moderate south-west breezes (force 1 to 3) during the day. The India and Himalaya were a few miles apart off the coast to the south-east of Coconada. The former was in Lat. 15° 10′ N. and Long. 83° 14′ E. at noon and the latter in Lat. 15° 13′ N. and Long. 82° 29′ E. Both had moderate breezes and overcast skies. The winds were of force 3 and from directions between W. and S. W. The Roma, in Lat. 17° 15′ N. and Long. 85° 17′ E. at noon, had moderate variable winds with calms and very heavy rain squalls. The Star of Albion, Scottish Chieftain, and Saint Magnus were all near each other off the Gopalpore coast. The winds were very light and unsteady, but were generally from directions between west and south-west. The Scottish Chieftain had calms at 8 A. M., and the Saint Magnus calms and rain at 4 P. M. The British Princess and Prince Amadeo were a little further to the north. The former, in Lat. 19° 9′ N. and Long. 85° 15′ E. at noon, had variable winds during the day varying in force between 2 and 5. The latter, in Lat. 19° 23′ N. and Long. 86° 56′ E., had gentle south-west winds, sultry weather, and a smooth sea. There were hence no indications on this day of the existence of an atmospheric whirl in the Bay.

26*th June.*—During the previous 24 hours the barometer had risen rapidly at the Bombay stations, and the depression off that coast was much less marked than on the 25th at Bombay and the adjacent coast stations. South-westerly gales were blowing, but the rainfall brought up by them was as yet moderate in amount. In parts of Southern and Central India the barometer had also risen, but over the whole of Northern India a considerable fall had taken place. Along the foot of the hills, from Assam to the Punjab, the wind was generally easterly or north-easterly, and in the Central Provinces and Central India it was westerly. The weather was dull and sky overcast over the whole country except the Punjab, and rain was falling except in North-Western and Central India, but the amounts registered were in the great majority of cases small. The rainfall returns, as compared with the average rainfall between June 1st and 26th, shew that there was a deficiency of from 1 to 3 inches over the plains of the Punjab, the western half of the North-Western Provinces, Central India, and Rajputana, and of 7 inches in Bombay.

The following are the more important observations taken at 10 A. M. of the 26th at the selected stations near the Head of the Bay :—

Stations.	10 A. M. Barometer reduced to sea level.	Change since 10 A. M. 25th.	Wind. 10 h.	Wind. 16 h.	Average wind velocity of previous 24 hours.	Wind percentage	Cloud 10 A. M.	Rainfall of previous 24 hours.
Nancowry	29·915	—·026	S. W.	S. W.	11	100	7	...
Port Blair	29·886	—·025	S. W.	S. W.	11	100	10	0·32
Diamond Island...	29·801	—·046	S.	S. W.	10	125	8	1·26
Akyab...............	29·711	—·081	S. E.	S. S. E.	4	100	9	1·98
Chittagong.........	29·660	—·142	S. E.	E.	2	29	5	0·01
Dacca	29·682	—·070	S.	S. E.	6	75	9	1·67
Jessore	29·673	—·072	S.	S.	6	120	10	0·04
Calcutta (Alipore)	29·646	—·073	E. S. E.	E. by S.	3	50	8	0·71
Saugor Island ...	29·647	—·128	S. E.	E. S. E.	7	50	2	0·08
Balasore	29·636	—·079	N. N. E.	?	2	?	6	...
Cuttack	29·626	—·069	S. S. W.	Calm.	1	25	9	0·12
False Point.	29·621	—·101	N. E.	E.	8	80	4	...
Vizagapatam	29·668	—·004	W.	W·	5	125	6	0·10

Pressure, it will be seen from the above, had given way, and the fall was greatest at Saugor Island and Chittagong. This was due, as shewn by the wind directions, to the formation of an area of cyclonic disturbance and barometric depression near the Head of the Bay. The winds at Saugor Island had shifted to south-east, at False Point to north-east, and at Gopalpore to north-west. From the information extracted from the logs, it will be seen that light north-east winds were established over a considerable portion of the north-west of the Bay. Hence, the cyclonic circulation was just beginning to affect the direction of air motion at Saugor Island and was causing it to back. It was, however, not yet participating directly in the cyclonic indraught. The sky was more or less clouded in all parts of the province of Bengal, the air very damp (especially in Behar, after the floods of the previous week), and winds unusually light and somewhat unsteady.

The following table gives the average rainfall in the seven divisions of the province of Bengal for the 24 hours preceding 6 P. M. :—

Table of Average Rainfall in Bengal on the 26th June 1883.

Name of Province.	Average Rain.
Orissa	0·41
South West Bengal..................	0.07
East Bengal	0·11
North Bengal	0·96
North Behar...........................	0·89
South Behar...........................	0·77
Sonthal Pergannahs and ...... Chutia Nagpore	0·35

The following extracts from the logs of vessels give information respecting the Bay on the 26th :—

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced baro-meter.	Wind. Dir.	Wind. Force.	REMARKS.
Bancoora	4 A. M.			29·876	SW. by S.	2	4 A. M. Light breeze and fine.
	8 A. M.			·883	SW. by S.	2	8 A. M. Light following wind and clear.
	Noon	N. 8° 35′	E. 82° 35′	·863	S.W.byS.	2	
	4 P. M.			·780	W S. W.	2	
	8 P. M.			·856	S. S. W.	2	
	Midnt.			·816	S. S. W.	3	Evening. Moderate breeze and fine.
Pemba ...	Noon	N. 16° 46′	E. 96° 12′				10 A. M. At Rangoon. Unmoored and proceeded towards Calcutta.
	4 P. M.				S. W.	5	
	Midnt.			29·750	...	5	Midnight. Fresh to moderate breezes and frequent rain squalls.
Himalaya	4 A. M.			29·657	W.		
	8 A. M.			·635	W.		
	Noon	N. 17° 32′	E. 84° 38′	·615	W.		Moderate breeze and overcast.
	4 P. M.			·506	S. W.		
	8 P. M.			·586	W. S. W.		Moderate breeze and fine.
	Midnt.			·539	W. S W.		
Star of Albion	8 A. M.	N.	E.	29·700			Principally light unsteady winds, finer at night than in the day time.
	Noon	19° 21′	86° 20′	·630	W. to SW & N. W	1to2	
	4 P. M.			·620			

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
British Princess	4 A. M.				W. S. W.	4	Dark cloudy sky.
	8 A. M.				W. N. W.	3	Light green sky.
	Noon	N. 19° 30′	E. 87° 3′	29·600	N. N. E.	4	Weather fine and clear with S. W. swell.
	4 P. M.				E. N. E.	3	
	8 P. M.				E.	0 to 3	High southerly swell and cloudy, the stars showing through with great brilliancy.
	Midnt.				W. N. W.	5	
India ……	4 A. M.				W.	4	Strong winds & squally with clouds.
	8 A. M.			29·610	N. by E.	3	Moderating breezes and cloudy weather.
	Noon	N. 19° 36′	E. 86° 33′	·630	…	3	Moderate breeze and cloudy.
	4 P. M.			·630	N. E.		Moderate breeze, fine.
	8 P. M.			·590	Calm.		Calm and clear.
	Midnt.			·580	N. E.	3	Moderate breeze with passing clouds.
Saint Magnus	4 A. M.			29·610	W.	4	Cloudy weather.
	8 A. M.			·610	N.	2	
	Noon	N. 19° 47′	E. 87° 18′	·600	N. E.	1	Faint airs and calms.
	4 P. M.			·530	E.	1	Faint airs, calms, heavy southerly sea.
	8 P. M.			·590	N. W.	1	Cloudy with lightning.
	Midnt.			·550	N. W.	5	Cloudy.
Prince Amadeo	4 A. M.				N.	Light.	4 A. M. Heavy cloudy and unsettled looking weather. Much lightning and southerly swell. Noon, similar looking weather, light variable airs; unsettled looking all round, high southerly swell.
	Noon	N. 19° 52′	E. 87° 9′	29·600	N. to NE.	Light.	
	8 P. M.				W. to W. N. W.	Gentle.	8 P. M. same weather, much lightning.
Scottish Chieftain.	4 A. M.			29·640	S. S. W.	0	A strong current setting about W. Winds very unsteady in force and direction.
	8 A. M.				S. E.	1	
	Noon	N. 20° 04′	E. 86° 58′	·600	E.	2	
	4 P. M.				E. S. E.	3	
	8 P. M.				E. N. E.	4	
	Midnt.			·580	S. E.	4	

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	Remarks.
Roma	4 A. M.				W.		4 A. M. swell from S. S. W. overcast sky and rain.
	8 A. M.				North	3	8 A. M. Gentle breeze, sky clearing at intervals.
	Noon	N. 20° 19′	E. 86° 50′		N.	3	Noon, similar weather with southerly swell, light breeze, sky clearing at intervals.
	4 P. M.				N. E.	1	
	midnt.				N. E.	1	10 P. M. light showers.
Commilla ...	4 A. M.			29·635	E. N. E.	3	Light cloudy weather.
	8 A. M.			·642	E. N. E.	3	
	Noon	N. 22° 21′	E. 91° 50′	·607	E. N. E.	4	
	4 P. M.				East	4	Threatening appearance to S. E. Squally with very heavy rain.
	8 P. M.			·543	S. S. E.	4	Continuous heavy rain.

The Nancowry and Port Blair observations prove that strong steady south-westerly winds continued to blow in that part of the Bay. These winds were also extending to Diamond Island. The average wind velocity during the past 24 hours at that station was 10 miles, and for the previous day had been 8 miles per hour. The sea was also reported to be rising. Hence it is certain that the vigorous current indicated by the strong winds at Port Blair on the 25th was steadily advancing up the east of the Bay, and that its front was off the West Burmese coast on the morning of the 26th. The Pemba, which left Rangoon at 10 A. M., had south-westerly winds of force 5 with frequent rain squalls, as she advanced westwards in the Martaban Gulf to the south of the Burmese coast.

It is almost certain that this strong current was giving heavy rain over a portion of the north-east of the Bay in the neighbourhood of the Burmese and Arracan coasts. The direct evidence of this does not appear in the extracts from the logs of the vessels given above, but it will appear in those for the 27th. It is, however, indicated by the large rainfall at Diamond Island and other stations in South Burmah and in Arracan.

For the present we shall accept it as almost certain that in the front of this advancing strong moisture current, where the resistance to its advance was greatest, and where therefore ascensional motion was necessarily occurring to a large extent, rainfall of a more or less concentrated character was going on. The current was being deflected to the west by the coast and the Burmese and Arracan hills, and was moving more rapidly in its eastern than in its western portion. Hence probably also arose a strong tendency to an eddying motion in front and towards the west. The various actions going on were thus such as might set up vorticose motion. That such a result was taking place was indicated by the wind observations of all the vessels near the Head of the Bay. The Himalaya, in Lat. 17° 32′ N. and Long. 84° 75′ E., had moderate westerly winds. The India, British Princess, Star of Albion, Scottish Chieftain, Saint Magnus, Roma, and Prince Amadeo, which were all between Lat. 19° 20′ N. and 20° 19′ N. and between Long. 86° 20′ E. and 87° 18′ East, experienced light unsteady north-easterly winds. The weather was fine and sky clear during the greater part of the day, but became more clouded during the evening. There was a heavy swell from the south during the day. This was evidently due to the strong winds and high sea prevalent in the centre and south-east of the Bay. The only log which gives any indication of the subsequent weather is that of the Prince Amadeo, in which the Captain notes that, although light variable airs were blowing, the appearance of the sky was unsettled in all directions. Probably the light green sky to the east noted by the Captain of the British Princess was another sign of the large amount of moisture brought up by the southerly winds in the East of the Bay.

The various observations of the 26th hence indicate that cyclonic motion on a considerable scale commenced on the afternoon of the 25th over a portion of the Head of the Bay. The atmospheric whirl was fed and maintained by a very strong south-westerly air current moving northwards up the Bay near the Burmah and Arracan coast. It was apparently formed in the front of this air-current, and was causing winds to draw round over the north-west of the Bay. The indraught from that quarter was, however, feeble and unimportant, except as an indicator of bad weather to the south-east.

27*th June.*—The decrease of pressure which commenced on the 26th had now extended over the whole country. The change was still greatest in the north. On the northern frontier of the Punjab, in Eastern and Lower Bengal, and at Akyab the decrease exceeded one-tenth of an inch. It was smallest in parts of Bombay and Madras, where it only amounted to two or three-hundredths of an inch. A considerable depression lay over the Punjab. This, however, is a frequent feature of the hot weather months of June and July in that province. A smaller depression was, however, forming at the Head of the Bay to the south of Saugor Island. Pressure ranged from 29·9 inches in Ceylon to 29·28 inches at Peshawar.

The wind was from directions between south-west and west over the Peninsula. In the neighbourhood of the two depressions, cyclonic circulations were established. Up the Gangetic valley the wind had a general easterly direction. The weather was cloudy and gloomy in all parts of the country except in the upper districts of the Punjab. Rain in small amounts had fallen during the preceding 24 hours, except in the Punjab, Sind, and West Madras. The rainfall was heavier on the Bombay coast than it had been hitherto, and strong monsoon winds were blowing there.

The following table gives the observations at the selected stations on and over the coast of the Bay on the 27th :—

STATIONS.	10 A. M. Barometer reduced to sea level.	Change since yesterday.	Wind.		Average wind velocity	Wind percentage	10 A. M. Cloud.	Rainfall of previous 24 hours.
			10 h.	16 h.				
Nancowry	29·912	—·003	S. W.	S. S. W.	15	136	8	...
Port Blair	29·853	—·033	S. W.	S. W.	13	118	10	...
Diamond Island ...	29·763	—·038	S. S. W.	S. S. W.	14	175	8	1·79
Akyab	29·606	—·105	S. S. E.	S. S. E.	6	150	10	0·57
Chittagong	29·578	—·082	E. N. E.	S. E.	3	43	4	1·02
Dacca..................	29·566	—·116	E.	E.	3	38	8	1·16
Jessore	29·604	—·069	E. N. E.	E.	6	120	10	0·04
Calcutta (Alipore)	29·529	—·117	E. S. E.	E.	5	83	9	0·20
Saugor Island	29·532	—·115	N. N. E.	N. E.	35	250	7	0·09
Balasore	29·537	—·099	N.	?	1	?	8	0·40
Cuttack...............	29·565	—·061	N. W.	N. N. W.	3	75	10	1·01
False Point	29·544	—·077	W.	W. S. W.	7	70	10	0·26
Vizagapatam	29·634	—·034	W.	W. S. W.	7	175	10	1·70

The preceding observations show that pressure had decreased rapidly over the north of the Bay and the adjacent coasts during the preceding 24 hours. The fall was greatest in South-West Bengal and more especially at Saugor Island. The distribution of pressure, taken in connection with the wind directions at the Bengal and Orissa stations, indicates that there was now a well-defined atmospheric whirl at the Head of the Bay, the centre of which was at a little distance to the S. S. E. of Saugor Island. Pressure was below the normal for the day over the province of Bengal by amounts varying from ·1″ at Chittagong to zero at Patna. Winds were very light over the whole province. Northerly winds had fully set in over South-West Bengal and Orissa, whilst winds more or less easterly prevailed over East and North Bengal, Behar, and Chutia Nagpore.

Ths weakness of the winds is shown by the following observations :—

	Amount of wind during 24 hours preceding 10 A. M.	Average wind amount. June.	Percentage of actual to average.
Calcutta	139·0	152·3	91·3
Berhampore	94·7	132·3	71·6
Dacca	63·1	183·7	34·3
Purneah	24·0	94·4	25·3
Hazaribagh	130·5	214·9	60·9

The slight indraught to the cyclonic disturbance from the north and east had already diminished the humidity of the air and the amount of cloud in North Bengal and Behar. The sky was overcast in Orissa and South-West Bengal and the southern districts of East Bengal. The rainfall in the province was small in amount and localized in its distribution, except in Orissa and the southern districts of South-West Bengal, where moderate rain had already began to fall in connection with the cyclonic disturbance.

The weather in Orissa at this time is described as unsettled. Winds were light and variable and gave occasional showers of rain.

The following table gives the average rainfall in each of the divisions of Bengal for the 24 hours preceding 6 P. M. :—

Rainfall Table of the 27*th June* 1883.

Province.	Number of stations in each division.	Average Rainfall of preceding 24 hours.	Heaviest fall reported in 24 hours.
Orissa	16	0·17	2·25
South-West Bengal	46	0·28	2·20
East Bengal	26	0·49	2·50
North Bengal	27	0·09	0·57
North Behar	16	0·13	0·67
South Behar	17	0·16	0·69
Sonthal Pergunnahs and Chutia Nagpore	16	0·24	0·84

The meteorological extracts from logs of the vessels relating to the 27th of June are tabulated below for reference.

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
Bancoora	4 A. M.			29·751	S. W.	4	Brisk breeze, fine.
	8 A. M.			·796	SW. by S.	4	Fresh following wind and fine.
	Noon	N. 11° 42′	E. 84° 8′ 30″	·796	S. W.	4	Current S. 23 W. 17 miles.
	4 P. M.			·706	S. W,	4	Fresh following wind and fine.
	8 P. M.			·816	S. W.	5	Strong breeze and overcast.
	Midnt.						Less wind with occasional rain.
Pemba	4 A. M.			29·690	S. W.	5	A. M. Fresh breeze with moderate sea and occasional rain squalls.
	8 A. M.			·720	S. S. W.	6	6-15 A. M. Passed Alguada.
	Noon	N. 16° 13′	E. 93° 30′	·720	S. S. W.	7	Noon. Strong breeze with rising sea.
	4 P. M.	(by D.R)	(by D.R)	·690	S. S. W.	9	Afternoon. Wind rapidly increased to a strong gale with furious squalls blowing away sails and awnings.
	8 P. M.			·660	S. S. W.	9	
	Midnt.			·640	S. S. W.	9	
Himalaya	4 A. M.			29·514	N. W.		
	8 A. M.			·549	N. N. W.		
	Noon	N. 19° 58′	E. 86° 32′	·484	N. E.		Moderate breeze and fine.
	4 P. M.			·404	N.		
	8 P. M.			·447	N.		
	Midnt.			·359	N. N. W.		Overcast with rain.
Star of Albion	8 A. M.						Squally, with rain distant thunder to Northward and heavy looking clouds.
	Noon	N. 20° 10′	E. 87° 28′	29·500	W.	4	
	4 P. M.				N. W.	4	Clearer to S. E.

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind. Dir.	Wind. Force	Remarks.
British Princess	4 A. M.				N. W.	5	Cloudy sky, southerly swell.
	8 A. M.				N. W.	5	Heavy squall with rain, overcast, passing showers.
	Noon	N. 20° 38′	E. 88° 2′	29·500	N. W.	5	Heavy rain at intervals, sky overcast and weather finer.
	4 P. M.				N. W.	5	Sky looking very unsettled patches of green colour.
	8 P. M.				N. W.	6	11 P. M. Heavy bank of clouds in the N. W. with vivid lightning, distant thunder, and rain.
	Midnt.				N. W.	7	
Scottish Chieftain.	4 A. M.				W. S. W.	1	The whole of this day, the weather has been very unsteady. — Strong westerly current.
	8 A. M.			29·520	S. W.	2	
	Noon	N. 20° 40′	E. 87° 50′	·480	S. W.	3	
	4 P. M.			·460	N. W.	4	
	Midnt.			·450	N. W.	5	
Saint Magnus	4 A. M.			29·500	W. N. W.		Cloudy, rainy, squally weather.
	8 A. M.			·540	North	5	Thick rainy weather.
	Noon	N. 20° 44′	E. 87° 54′	·450	N. W.	5	Cloudy and passing showers.
	4 P. M.	(by D. R)		·400	N. W.	2	Squally, rainy weather.
	8 P. M.			·460	N. N. W.	4	

Vessel.	Hour.	Latitude.	Longitude.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
							Midnight—Moderate W. to W. N. W. winds unsettled looking weather.
Prince Amadeo	4 A. M.				N. W.		4 A. M. Squally with heavy rain.
	Noon	N. 20° 46′ (by D. R)	E. 87° 35′ (by D. R)	29·500		Vble	Noon, squally winds from N. W. to N. E., much rain high S. to S. S. E. swell. 8 P. M. Moderate N. W. winds, weather same.
India	4 A. M.			29·530	E.	3	Moderate and overcast.
	8 A. M.			·520	E.	2	
	Noon	N. 20° 39′	E. 88° 5′	·520			
Roma	4 A. M.				...	3	A. M. Light showers
	8 A. M.				...	5	3 A. M. Anchored at Saugor. 9 A. M. proceeded up the river, weather showery.
	Noon				N. E.	...	
Commilla	8 A. M.			29·523	S. S. E.	3	Cloudy and threatening to S. E.
	Noon	N. 22° 21′	E. 91° 50′	·499	S. S. E.	4	Heavy unsettled appearance to S. E.
	4 P. M.			·396	South	4	Squally unsettled appearance to S. E.
	8 P. M.			·411	S. S. E.	4	Hard squalls and threatening appearance with light rain at times. High sea getting up from S.
	Midnt.			·379	S. S. W.	5	Wild squally weather. High sea from S. S. W. Rain at times.

The strong south-west monsoon winds which the meteorology of the 26th shewed to be advancing northwards up the eastern part of the Bay, were on the morning of the 27th not far from the Head of the Bay and were certainly in the parallel of Akyab. The wind velocity was very considerable at Port Blair and Nancowry. Strong winds were also blowing at Diamond Island, where the sea was now rough. The wind velocity at Akyab had increased from a rate of 4 miles per hour to 6 miles per hour, the average force of the wind in June at that station being 4 miles. The remarks in the log of the Pemba are very valuable. She passed round Cape Negrais into the Bay to the west of Burma in the morning. The wind increased very rapidly to a strong gale and blew in furious squalls. The wind was steady at S. S. W. and of average force 9. On the other hand, the winds at the stations in South Bengal and Orissa, and also those observed at the Light Vessels and the vessels near the Head of the Bay, were very feeble. The only conclusion warranted by the evidence is that these strong winds on the Burmah and Arracan ccast were feeders to an ascending current to the northward; and that the ascensional movement was hence near the Head of the Bay, and was partly maintained by the rainfall accompanying the ascensional motion, and by the various resistances to the motion of the strong current advancing northwards. The south-west winds, it has already been remarked, were much stronger than those from any other direction. It is, so far as can be judged, probable, if not certain, that the whirl was not at this time a fully developed cyclonic disturbance with a well-defined centre. The centre of the barometric depression at the Head of the Bay can only be roughly approximated from the observations. Its most probable position at noon was in Lat. $20\frac{1}{2}°$ N. and Long. $89\frac{3}{4}°$ E. and almost identical with its position at 10 A. M. Assuming this position of the centre of depression, the relative positions of the Light Vessels at 10 A. M. and of the ships at Noon are given in the following table :—

	Time.	Position.		Barometer.	Wind.		Direction of Centre.	Distance from probable position of Centre.	Weather.
		Latitude.	Longitude.		Direction.	Strength.			
								Miles.	
Saugor Island Light House...	10 A. M.	N. 21° 39′	E. 88° 5′	29·505	N.N.E.		S.E.	120	Cloudy.
Upper Gasper Light Vessel ...		N. 21° 31′	E. 88° 3′	29·484	N. E.	4	ESE	120	Squally.

	Time.	Position. Latitude. N.	Position. Longitude. E.	Barometer.	Wind. Direction.	Wind. Strength.	Direction of centre.	Distance from probable position of centre.	Weather, &c.
Intermediate Light Vessel...	Noon.	21° 15′	88° 11′	29·472	E.N.E.	3	ESE	miles 115	Showery.
Eastern Channel Light Vessel...	...	21° 1′	88° 12′	29·478	N.N.E.	5	ESE	105	High Sea.
Balasore	...	21° 30′	86° 50′	29·479	N.		ESE	205	Gloomy.
False Point	...	20° 20′	86° 47′	29·522	S. W.		E.	195	Gloomy.
Saint Magnus.....	...	20° 44′	87° 54′	29·450	N. W.	5	E.	120	Squally.
Scottish Chieftain	...	20° 40′	87° 50′	29·480	S. W.	3	E.	120	Unsettled.
Star of Albion ...	...	20° 10′	87° 28′	29·570	W.toS. W. &N.W.	4	ENE	150	Squally.
British Princess	...	20° 38′	88° 2′	29·500	N. W.	5	E.	110	Unsettled.
Prince Amadeo ...	...	20° 46′	87° 35′	29·500	NW. to N. E.		E.	145	Squally.
Himalaya	...	19° 58′	86° 32′	29·484	N. E.		ENE	210	Fine.
Pemba	...	16° 13′	93° 30′	29·720	S.S.W.	7	N. W.	380	Strong increasing breeze.

The position of the centre at 4 P. M. was probably almost identical with its position at noon. The following observations taken at 4 P. M. indicate that it was at that hour in Lat. 20° 35′ N. and Long. 89° 35′ E.

	Position. Latitude. N.	Position. Longitude. E.	Barometer.	Wind. Direction.	Wind. Strength.	Direction of centre.	Distance from probable position of centre.	Weather, &c.
Saugor Island Light House...	21° 39′	88° 5′	29·407	N. E.	Light.	S.E.	miles 125	Cloudy.
Upper Gasper Light Vessel...	21° 31′	88° 3′	29·375	Calm.	0	E.S.E.	120	
Intermediate Light Vessel...	21° 15′	88° 11′	29·355	N.N.E.	1	E.S.E.	102	Sea rough.
Eastern Channel Light Vessel...	21° 1′	88° 12′	29·377	N. E.	2½	S.E.	95	Stormy.
False Point	20° 20′	86° 47′	29·406	WS.W.	moderate	E.	175	Gloomy.

The Bancoora was in Lat. 11° 42′ N. and Long. 84° 8′ E. at noon. She had strong steady south-west winds of force 4 during the day, with overcast skies and occasional rain.

The Pemba was in the north of the Gulf of Martaban early in the morning, when she experienced fresh breezes with moderate sea and occasional rain-squalls. She doubled Cape Negrais and passed into the Bay of Bengal about midday. The wind began to increase rapidly, and during the afternoon and evening it blew a gale with furious squalls, which carried away her sails and awnings. The wind blew steadily from the S. S. W. during the afternoon with average force 9.

The remaining vessels were all in the north-west angle of the Bay. They were the India, Himalaya, Star of Albion, Scottish Chieftain, Saint Magnus, British Princess, and Prince Amadeo, and were at noon between Lat. 19° 58′ and Lat. 20° 46′ N. and between Long. 86° 32′ and 88° 5′ E. Their observations enable the storm-centre to be approximately identified, as in the majority of these vessels the usual midday observations were taken; so that the positions of the vessels are known in nearly all cases with approximate exactness at noon of this day.

The Saint Magnus and British Princess were very near each other. The former was in Lat. 20° 40′ N. and Long. 87° 50′ E. and the latter in Lat. 20° 38′ N. and Long. 88° E. Both experienced strong currents during the day. These two vessels were probably nearest the centre, but in the westerly quadrant. They had squally weather with thick rain and north-westerly winds of average force 5.

The Scottish Chieftain, which was about 10 miles to the west of the previous vessels, had very variable winds during the day, which increased in force from 1 to 5. They shifted from W. S. W. to S. W., and then hauled to N. W. She experienced a strong westerly current.

The Prince Amadeo, about 15 miles further to the west, in Lat. 20° 46′ N. and Long. 87° 35′ E., had unsettled weather with light variable winds and heavy rain. She experienced a strong southerly current.

The Himalaya, which was considerably further to the west and near the Orissa coast, had moderate north-easterly breezes and fine weather.

28*th June.*—The barometer rose quickly in the Punjab, during the previous 24 hours, and was standing at its normal height at 10 A. M. Pressure continued to give way over the rest of India. The fall was not large in amount, except in and near the depression at the Head of the Bay. The barometer had fallen at Saugor Island from 29·53″ at 10 A. M. on the 27th to 29·37″ at the same hour of the 28th.

The wind had backed to south-west and south over the Central Provinces, Central India, and Rajputana. This was evidently due to the continuance of strong westerly winds on the Bombay coast and their extension eastwards over the centre and north of the Peninsula. Light easterly winds were blowing, as on the 27th, up the Gangetic plain, indicating that the circulation was as yet unaffected in direction by the atmospheric whirl in the north of the Bay. To the north of the centre of depression, or in South Bengal, the circulation was increasing, but was still very weak. The weather was generally cloudy, and rain had fallen in moderate amounts over the same areas as on the 27th.

The observations at the selected stations in Bengal are given below :

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since yesterday.	Wind.		Average wind velocity of previous 24 hours.	Percentage wind.	10 A. M. Cloud.	Rainfall of previous 24 hours.
			10 h.	16 h.				
Nancowry	29·913	+ ·001	S. W.	S. W.	13	118	6	nil.
Port Blair	29·856	+ ·003	S. W.	S. W.	12	109	6	0·13
Diamond Island	29·807	+ ·044	S.	S. S. W.	29	363	9	0·25
Akyab	29·639	+ ·033	S.	S. S. W.	12	300	10	6·84
Chittagong	29·571	— ·007	S. E.	E. S. E.	9	129	9	3·81
Dacca	29·526	— ·040	E.	E.	6	75	10	0·85
Jessore	29·445	— ·159	E.	E. S. E.	6	120	10	0·10
Calcutta (Alipore)	29·392	— ·137	E.	E. by N.	9	150	10	0·22
Saugor Island ...	29·374	— ·158	N. N. E.	N. N. E.	8	57	10	0·91
Balasore	29·423	— ·114	N.	?	2	?	10	0·32
Cuttack	29·507	— ·058	calm.	N. W.	4	100	10	0·62
False Point	29·452	— ·092	W. S. W.	W. S. W.	10	100	10	4·84
Vizagapatam ...	29·614	— ·020	W.	W.	7	175	10	0·20

Pressure had given way over the whole of the Province of Bengal, and was below the normal of the day by amounts varying between ·05″ at Patna and ·25″ at Saugor Island. The air-motion over the whole of Bengal was now largely dependent on the cyclonic vortex. In East and South-West Bengal winds ranged between east and north-east. Northerly winds prevailed at Balasore, and south-west winds at Gopalpore and False Point. The air was calm at 10 A. M. at Cuttack. Over North Bengal, Behar, and Chutia Nagpore light easterly winds were blowing. The indraught to the vortex had diminished the humidity and cloud-amount considerably in North Bengal and Behar during the previous 24 hours, as shown by the following results :—

	10 A. M. Average Humidity.		Average Cloud Amount.	
	27th.	28th.	27th.	28th.
North Bengal	81	73	6·0	4·0
North Behar	79	72	4·8	3·2
South Behar	80·5	70·4	6·8	4·4

The rainfall returns for the 24 hours previous to 6 P. M. indicate that moderate general rain had fallen over the whole of East and South-West Bengal, and that very heavy rain had been received in Orissa.

The following table gives the whole of the Orissa rainfall returns for the day :—

District.	Station.	Rainfall.
Pooree	Pooree	0·59
	Khurdah	0·60
	Banpur	nil.
	False Point	8·04
	Hookitola	3·68
Cuttack	Jagatsingpore	7·50
	Banki	0·35
	Cuttack	1·79
	Kendrapara	2·70
	Jaipur	2·80
Balasore	Chandbali	3·25
	Bhuddruck	1·78
	Sora	1·50
	Balasore	0·94
	Jellasore	3·40
	Baripoda	1·12

The weather on the Orissa coast is thus described by an observer : "Thick heavy weather with heavy rain and overcast skies prevailed during the day. At 4 P. M. it was blowing hard. Heavy rain fell all night with variable winds."

A few light showers fell in North Bengal and Chutia Nagpore, but rain had almost entirely ceased in Behar.

The following table gives the average rainfall throughout the Province of Bengal, and indicates clearly its distribution :—

District.	Average rainfall of previous 24 hours.	Heaviest rainfall in 24 hours.
Orissa	2·50	8·04
South West Bengal	0·15	0·76
East Bengal	0·65	6·46
North Bengal	0·17	1·25
North Behar	0·03	0·30
South Behar	0·01	0·10
Chutia Nagpur and Sonthal Pergunnahs	0·13	0·70

The information respecting the weather in the Bay on the 28th June, extracted from the logs of the vessels, is given in the following statement :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	REMARKS.
Bancoora	4 A. M.			29·653	S. W.	3	Moderate breeze and puffy.
	8 A. M.			·716	S. W.	3	Overcast at times.
	Noon	15° 08′	85° 33′	·683	S. W.	3	Moderate following wind and overcast.
	4 P. M.			·801	S. W.	3	Moderate breeze and overcast.
	8 P. M.			·716	S. W.	3	Moderate following wind and fair.
	Midnt.			·671	S. W.	4	Fresh breeze and cloudy.
Pemba ...	4 A. M.				S. S. W.	9	A. M. Strong gale with high sea and heavy squalls. Noon. A heavy sea smashed in the port bulwark rail forward of bridge. Midnight. Very high sea running.
	8 A. M.			29·540	...	9	
	Noon	18° 34′	90° 59′	·540	...	9	
	4 P. M.	Rang	oon to-	·460	...	9	
	8 P. M.	wards	Sand	·500	...	9	
	Midnt.	Heads.		·520	...	9	

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	Remarks.
Star of Albion ...	8 A. M.			29·500			Wind freshening, weather cloudy and threatening.
	Noon	20° 14′	88° 23′	·450	N. by W.	5 to 8	Continued lightning. Slight sea.
	4 P. M.			·440	W. N. W.		Latter part, strong gale with thick driving rain, and westerly sea.
	8 P. M.			·490			
	Midnt.			·470	West.		
British Princess	4 A. M.				N. W.	7	4 A. M. Heavy rain, vivid lightning with thunder. High confused sea. 8 A. M. Heavy squall with torrents of rain. Moderate gale, high confused sea. Noon. Fresh gale, high confused sea. 4 P. M. Fresh gale, high sea, and heavy rain. 8 P. M. Heavy squalls, torrents of rain, high sea. Midnight. Furious squalls, torrents of rain, and high sea.
	8 A. M.				...	7	
					...	8	
	Noon	20° 46′	88° 7′	29·420	W. N. W.	9	
	4 P. M.				West	10	
	8 P. M.				S. W.	10	
					...	11	
	Midnt.				...	11	
Scottish Chieftain	4 A. M.			29·400		1	Noon. Weather very unsteady, much rain, thunder and lightning. Very strong westerly current.
	8 A. M.			·300	N. N. W.	2	
	Noon	20° 50′	88° 10′	·250	...	3	
	4 P. M.			·220	N. W.	4	Sky presenting a very wild appearance.
	Midnt.			·200	W.	8	
Saint Magnus......	4 A. M.			29·330	N. W.	6	Heavy gusts and heavy continued rain.
	8 A. M.			·330			Strong winds and high sea.
	Noon	20° 52′	88° 3′	·290	N. W.	4	Winds and sea more moderate.
	4 P. M.			·260	W. S. W.	6	Terrific squalls. Tremendous sea at times.
	8 P. M.			·320	W. S. W.	2	Heavy sea, dense darkness.
	Midnt.			·300	S. W.	10	Furious gale, high squalls, heavy sea.
Prince Amadeo	4 A. M.				N. W.	Strong	Midnight. Boisterous squally weather with much heavy rain. 4 A. M. Squally weather, high southerly sea. Noon. Squally unsettled weather. 4 P. M. Weather more moderate. 6 P. M. Weather having a wild unsettled appearance. 8 P. M. Heavy squalls from W. S. W. to S. S. W. much rain.
	Noon	Pilot bearing about	Brig N.E. 5 miles	29·330	N. W. and W. N. W.		
	6 P. M.				Variable between W. & S.		

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
Commilla	4 A. M.			29·379	South	7	4 A. M. Very high sea from South and S. W. Breeze very variable in force with very hard squalls from S. S. W. and rain. 8 A. M. A very high sea running from S. S. W. Noon. Hard squalls from S. S. W. and very high sea from S. W. 4 P. M. Hard squalls from S. S. W. and very high sea from S. S. W. 6 P. M. Breeze very unsettled and hauling to N. W. at times. 6-30 P. M. Very heavy rain, tremendous sea from S. S. W. and S. W. 7 P. M. Eased down and stood S. by E. 7-30 P. M. Terrific sea carried away starboard cutter. 8 P. M. Terrific squalls from S. W. and very high sea. New jib and stay sail split.
	8 A. M.			·317	S. S. W.	7 to 4	
	Noon	21° 04′	89° 31′	·277	S. S. W.	6	
	4 P. M.			·121	S. W.	8	
	6 P. M.				Var.	6	
	8 P. M.			·159	S. W.	9 to 10	
	Midnt.			·182	S. W.	11	
Himalaya	4 A. M.			29·354	Variable		Fresh breeze and cloudy, with frequent rain squalls.
	8 A. M.				N.		
	Noon	22° 32′	88° 20′	·264	N.		
	4 P. M.			·354	N.		
	8 P. M.			.449	N.		
	Midnt.			·427	N.		

The position of the centre of the barometric depression can be determined with approximate accuracy on the 28th. The observations at the Light Vessels show that it was in the immediate neighbourhood of the Sandheads at 10 A. M. It was hence very approximately in Lat. 21° 0′ N. and in Long. 88° 45′ E. The following table gives the barometric and wind observations taken at the Light Vessels and nearest land stations, as well as the distance and direction of the centre (assuming this to be in the position assigned to it above) from each :—

	Position.		Barometer 10 A. M.	Wind 10 A. M.		Direction of centre.	Distance from probable position of centre.	Weather, &c.
	Latitude. N.	Longitude. E.		Direction.	Strength.			
Saugor Island Light House...	21° 39′	88° 5′	29·349	N.N.E.	Strong.	S. E.	miles 63	Gloomy.
Upper Gasper Light Vessel...	21° 31′	88° 3′	29·327	N. E.	5	S. E.	57	Threatening heavy sea.
Intermediate Light Vessel...	21° 14′	88° 11′	29·241	N.N.E.	4	E.S.E.	40	Threatening.
Eastern Channel LightVessel ...	21° 0′	88° 12′	29·209	N.N.E.	6	E.	35	High sea.
Balasore	21 30	86° 58′	29·364	N.	Light.	E.S.E.	130	Threatening.
False Point	20° 20′	86° 47′	29·431	W.S.W	Moderate	E.N.E.	135	Gloomy.

The centre at this time was only at a distance of about 35 miles from two of the Light Vessels ; yet these were experiencing comparatively feeble winds, as compared with the strong gales blowing, as the log of the Pemba proves, at distances of 200 and 300 miles from the centre in the south-easterly quadrant.

The ships' logs do not give 10 A. M. observations. Their positions are given for noon, together with barometric readings and wind directions and force. When these are charted, they indicate the existence of a centre of depression in about Lat. 21° 3′ N. and Long. 88° 40′ E. The following table gives the positions of the ships at noon, and the distance and direction of the centre (assuming the position of this to be in Lat. 21° 3′ N. and Long. 88° 40′ E.) in each case.

	Position at noon.		Barometer at Noon.	Wind (Noon).		Direction of centre.	Distance from probable position of centre at Noon.	Weather.
	Lat. N.	Long. E.		Direction.	Strength.			
Saugor Island Light House	21° 39′	88° 5′	29·311	N. N. E.	Light.	S. E.	56	Overcast.
Commillah ...	21° 04′	89° 31′	29·277	S. S. W.	6	W.	54	Hard squalls. Very high sea.
Scottish Chieftain	20° 50′	88° 10′	29·250	N. N. W.	3	E. N. E.	35	Unsettled.
Saint Magnus	20° 52′	88° 3′	29·290	N. W.	4	E. N. E.	42	Strong wind. High sea.
Prince Amadeo	20° 52′	88° 5′ ?	29·330	N. W.	...	E. N. E.	40	Squally. High sea.
British Princess	20° 46′	88° 7′ ?	29·420	N. W.	8	E. N. E.	43	Heavy squalls High sea.
Star of Albion	20°14′?	88°23′?	29·450	N. by W.	5	N. N. E.	?	Threatening weather. Slight sea.
Pemba	18° 34′	90° 59	...	S. S. W.	9	N. W.	225	Strong gale. Heavy sea.
False Point ...	20° 20′	86° 47′	29·309	W. S. W.	Moderate.	E. N. E.	125	Overcast.

In examining the above, it should be remembered that the positions assigned to the Commillah, Scottish Chieftain, Saint Magnus, and Star of Albion were determined by observation at noon, and hence are assumed to be approximately correct. The position of the Prince Amadeo is stated to have been a few miles to the S. W. of the Pilot Brig. The position given has been determined from that statement on the assumption that the station for the Pilot Vessels during the S. W. monsoon, is at a distance of from 7 to 10 miles to the south or south-west of the Eastern Channel Light Vessel (*vide* Elson's Sandheads Sailing Directory, page 156) ; and is probably correct within five or six miles. The position of the British Princess at noon was ascertained by dead reckoning, and is certainly not correct, as all the vessels had drifted considerably with the currents now set up at the Head of the Bay. The noon observations of the barometer and wind direction indicate that she was probably in about Lat. 20° 55′ and Long. 87° 45′.

The preceding table confirms much of the information given by the Light Vessels. The winds in the western quadrant, at distances of 30 to 50 miles from the centre, were very light and unsteady in force, as compared with those in the eastern quadrant. The barometric observations, when charted, shew that the depression, as defined by the isobar of 29·3″, was an elliptical shaped area at the centre of which the pressure probably did not exceed 29·2″. The larger axis of this stretched E. N. E. and W. S. W., and was probably at least twice as long as the axis at right angles to it.

The observations taken on board the Light Vessels at 4 P. M. also enable the centre to be approximately determined at that hour. When charted, they indicate that the centre was in about Lat. 21° 10′ N. and Long. 88° 30′ E.

The following table shows that this gives consistent results for the direction and distance of the centre from each position :—

	Position.		Barometer.	Wind.		Direction of centre.	Distance from probable position of centre.	Weather, &c.
	Lat. N.	Long. E.		Direction.	Strength.			
Saugor Island Light House	21° 39′	88° 5′	29.270	N. N. E.	Moderate.	S. E.	43	Overcast.
Upper Gasper Light Vessel	21° 31′	88° 3′	29·215	N. E.	5	S. E.	38	Heavy sea.
Intermediate Light Vessel	21° 15′	88° 11	29·155	N.	4	E. S. E.	21	Threatening weather.
Eastern Channel Light Vessel	21° 1′	88° 12′	29·142	N. W.	5 to 8	E. N. E.	23	High sea from S. W.
False Point Light House	20° 20′	86° 47′	29·301	W. S. W.	strong.	E. N. E.	125	Overcast.

These observations also show the weakness of the winds in the western quadrant. The Intermediate Light Vessel, although only 21 miles distant from the centre, experienced winds of force 4 at this time, whilst the Pemba, about 200 miles to the south-east, had winds of force 9 to 10.

Hence, the path of the centre during the day is determined by the positions given in the following table :—

Hour.	Latitude.	Longitude.
10 A. M.	21° 0′ N.	88° 45′ E.
Noon	21° 3′ N.	88° 40′ E.
4 P. M.	21° 10′ N.	88° 30′ E.

The character of the weather is fully shown by the reports given in the logs. Two vessels, the Commillah and Pemba, were in the east and south-east quadrants, in which alone the winds were violent. The Pemba was in Lat. 18° 14′ N. and Long. 90° 59′ E. by account at noon. She experienced strong S. S. W. gales during the whole day, with a high sea, and heavy rain squalls. A heavy sea smashed in her port bulwark rails early in the morning, after which the Captain eased the engines, and laid to, with the ship's head to S. S. E., during the greater part of the afternoon. The Commilla, which was proceeding from Chittagong to Calcutta, did not feel the full weight of the south-westerly winds until the afternoon, when she was between the Mutlah station and the Sandheads. She experienced, early in the morning, winds varying very considerably in force, with occasional hard squalls from S. S. W., and much rain. During the whole of the afternoon, she had very hard squalls with heavy rain, and a tremendous sea. At 7-20 P. M. a terrific sea carried away the starboard cutter. This was followed by very violent squalls of force 11 from the south-west.

The position of the British Princess was not ascertained by observation during the day, and it is almost certain that she must have drifted considerably with the strong currents set up at this time in the Head of the Bay. She was in the south-western quadrant in the morning, and had heavy rain with a high confused sea. The rainfall increased early in the morning, and during the greater part of the day she had "torrents of rain." The squalls also became heavier as the day advanced, and at midnight furious squalls (force 11) from the south-west passed over the vessel.

The Saint Magnus was in the western quadrant in the morning, when she had north-westerly winds of force 4 to 6. Heavy gusts of wind passed over the vessel, and continuous rain fell during the whole morning. In the evening, she was in the southerly quadrant, where she began to experience terrific squalls with a tremendous sea. At midnight, it was blowing a furious gale (force 10) from the south-west.

Hence, over a large area to the east and south-east of the central depression, violent south-westerly winds of force 9 to 11 were blowing at this time, producing a very high and dangerous sea near the Head of the Bay.

Further south, as shewn by the log of the Bancoora, the winds in the centre of the Bay (Lat. 15° N., Long. 83° E.) were of moderate force and gave very faint indications of the action and disturbance to the northward.

The Star of Albion, Roma, Prince Amadeo, and Scottish Chieftain were to the west of the centre of the whirl during the greater part of the day. The Scottish Chieftain was probably nearest to it at noon.

The position of the Star of Albion is doubtful. The weather was threatening in the morning, and the winds shifted from north through north-west to west in the evening, increasing in force during the day. In the afternoon and evening, as the wind backed to west, a strong gale set in with thick driving rain.

The Scottish Chieftain was in Lat. 20° 50′ N. and Long. 88° 10′ E. at noon. The winds were light during the morning; much rain fell, but it was not until midnight, when the wind hauled to west, that she began to have strong winds and rain squalls.

The Prince Amadeo was near the Pilot Station and to the west of the centre. Boisterous squalls with heavy rain and a high sea were experienced during the morning. In the evening, the weather had a very wild appearance. The wind shifted round to the south-west, and heavy squalls passed over the vessel, bringing up much rain.

The Light Vessels were all in the western quadrant during the day.

The Captain of the Meteor (Intermediate station) states that the winds were changeable between north and west, and that frequent heavy showers occurred during the day.

The Captain of the Comet (Upper Gasper Station) notes that the weather appeared very wild. Squalls with rain passed over the vessel, and a very heavy sea came up from the south-east.

29*th June.*—The changes of the barometer over India during the preceding 24 hours were partly due to the further development of the depression and cyclonic disturbance off the coast of the Sunderbands, and partly to the appearance of a depression off the west coast.

The barometer at Saugor Island had fallen two tenths of an inch since 10 A. M. of the 28th, and by considerable amounts at all the Lower Bengal stations. It had risen in the surrounding districts, so that the differences of pressure had become considerably greater and the depression very marked. The disturbance was now giving strong easterly winds, with overcast skies and moderate rain, to East and South Bengal, and strong northerly and westerly winds and incessant rain to Orissa.

The barometer had also fallen considerably at Kurrachee, where very strong N. E. winds were blowing. The wind had backed from west to south-west along the Bombay coast, thus almost certainly indicating the appearance or formation of a depression off the west coast.

Over the Gangetic plain and the western Himalayas, variable winds obtained, with cloudy weather and light rain.

The following table gives the observations at the selected stations in the neighbourhood of the Bengal depression :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since yesterday.	Wind.		Average wind velocity of previous 24 hours.	Percentage wind.	10 A. M. Cloud.	Rainfall of previous 24 hours.
			10 h.	16 h.				
Nancowry	29·914	+ ·001	S. W.	S. W.	8	73	7	2·21
Port Blair......	29·875	+ ·019	S. W.	S. W.	13	118	5	0·20
Diamond Island	29·835	+ ·028	S. S. W.	S. S. W.	13	163	8	0·40
Akyab	29·695	+ ·056	S. S. E.	S. S. E.	11	275	7	1·43
Chittagong ...	29·608	+ ·037	S. E.	E.	11	157	10	2·31
Dacca............	29·530	+ ·004	E.	E.	13	163	10	0·26
Jessore	29·445	0	E.	E.	18	360	10	0·78
Calcutta (Alipore)	29·322	—·070	E.	E.	19	317	10	0·64
Saugor Island	29·173	—·201	E.	S. W.	26	186	10	...
Balasore	29·355	—·068	N. N. W.	?	8	?	10	1·22
Cuttack.........	29·463	—·044	N. W.	W. N. W.	6	150	10	3·83
False Point ...	29·440	—·012	W. S. W.	W. S. W.	23	230	10	8·22
Vizagapatam...	29·613	—·001	S. W.	W. by N.	6	150	10	...

The meteorological returns of the Bengal stations show that a large fall of the barometer had occurred in South-West Bengal and Orissa, whilst, over the remainder of the province, a considerable recovery of pressure was taking place. The depression off Saugor Island was now unusually large in amount, and such as is rarely observed in the rainy season. Pressure was below the normal of the day at all stations, by amounts varying between ·01″ at Durbhunga and ·45″ at Saugor Island. The atmospheric circulation in Bengal was now directly dependent on the cyclonic vortex off the coast of the Sunderbands, and winds were very strong in the neighbourhood of the vortex in South-West Bengal, Orissa, and Chutia Nagpore. The winds in Chutia Nagpore and South Behar at 10 A. M. were from directions between E. N. E. and N. N. E. In North Bengal and Behar the winds were from the east, the normal direction during the south-west monsoon.

The air was now almost saturated in East and South-West Bengal and Orissa. Humidity had also increased very considerably over the remainder of the Province, more especially in South Behar and Chutia Nagpore. The skies were overcast, or densely clouded, in all parts of the Province, except North Bengal and Behar.

Orissa again received very heavy rain. The following table gives the amounts recorded at all the reporting stations during the 24 hours preceding 6 P. M. of this day :—

District.	Stations.	Rainfall.
Pooree	Pooree	9·44
	Khurdah	7·96
	Banpur	3·46
	False Point	5·39
	Hookitola	4·48
Cuttack	Jagatsingpore	4·90
	Banki	6·40
	Cuttack	5·61
	Kendrapara	3·60
	Jajpore	1·98
Balasore	Chandbali	4·15
	Bhuddruck	0·93
	Sora	1·60
	Balasore	2·65
	Jellasore	5·00
	Baripoda	1·60

General rain, moderate to heavy in amount, fell in East Bengal, South-West Bengal, and Chutia Nagpore, and local showers in North Bengal. No rain of any importance fell in Behar.

The following table gives the average rainfall for the preceding 24 hours in the various divisions of the Province of Bengal, and indicates the distribution at this time :—

Rainfall Table of the 29*th June*, 1883.

Division.	Number of stations in each province.	Average rainfall of 24 hours.	Heaviest fall in 24 hours.
Orissa	16	4·32	9·44
South-West Bengal	46	0·65	3·76
East Bengal	26	1·59	5·50
North Bengal	27	0·24	2·97
North Behar	16	0·03	0·25
South Behar	17	...	0·02
Sonthal Pergannahs and Chutia Nagpore	16	0·25	1·54

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Direction.	Wind. Force.	Remarks.
Bancoora	4 A. M.			29·597	S. W.	5	Strong increasing breeze and puffy.
	8 A. M.			·666	S. W.	5	Lightning in N. W.
	Noon	18° 40′	86° 58′	·666	S. W.	5	Strong unsteady wind and squally.
	4 P. M.			·517	S. W.	6	Strong breeze and squally.
	8 P. M.			·517	S. W.	4	Fresh following wind and overcast.
	Midnt.			·495	S. W.	5	Strong breeze with hard squalls throughout.
Pemba ...	4 A. M.			29·420	S. W.	10	A. M. Fierce gale with high irregular sea and hard squalls blowing with hurricane violence. 1 A. M. Kept away course again (N. 51 W.) 5 A. M. Lay to again. 9 A. M. Kept away course again, sea breaking over the ship fore and aft. 9-15 A. M. Laid to. 0·30 P. M. Course again. 3 P. M. Hauled to the wind again. 5 P. M. Kept away course again. 10-20 P. M. Sea becoming confused; weather inclined to moderate, sky clearing.
	8 A. M.			·470	W. S. W.	10	
	Noon	19° 16′	89° 56′	·500	S. W.	9	
	4 P. M.	Rangoon Calcutta.	towards	·450	...	9	
	8 P. M.			·500	...	9	
	Midnt.			·530	...	7	
Star of Albion.	8 A. M.			29·520	W. S. W.		Hard gale and heavy sea, thick continued rain.
	Noon	19° 43′	88° 37′	·530	S. W.	9 to 10	
	4 P. M.			·520			
	8 P. M.			·570		9 to 10	
	Midnt.			·550	S. W.		Weather, more moderate and less rain.
Saint Magnus.	4 A. M.			29·230	W. S. W.	10	Heavy gale with terrific gusts, heavy sea, and continued heavy rain.
	8 A. M.			·300	W. S. W.	10	
	Noon	19° 58′	88° 28′	·370	W. S. W.	10	Heavy squalls, rain, and high sea.
	4 P. M.			·380	S. S. W.	9	
	8 P. M.			·430	S. S. W.	8	Dirty appearance and heavy gusts.
	Midnt.			·340	S. S. W.	8	

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Direction.	Wind. Force.	Remarks.
Prince Amadeo.	4 A. M.				W. to S. S. W.	8	Morning. Strong gale, furious squalls. Sharp vivid lightning, wild unsettled appearance. Noon. Strong gale, heavy squalls, sea high and very confused. Evening. Similar wind and weather.
	Noon	20° 00′	88° 55′	29·320	S. W.	to	
	Midnt.				S. W.	10	
Commilla	4 A. M.			29·190	S. W.	11	4 A. M. Terrific storm, continual rain, and furious squalls. 8 A. M. Squalls of hurricane force. Mountainous sea. Noon. Very high and dangerous sea running; both anchors lifted out of catchhooks, breaking one stock. 4 P. M. Wind and sea slightly moderating. Violent squalls from S. W. 8 P. M. Sky overhead clearing at times; very dark wild squally weather. Very heavy rain in the squalls.
	8 A. M.			·247	S. W.	11	
	Noon	20° 18′	88° 40′	·252	S. W.	11	
	4 P. M.			·232	S. W.	10	
	8 P. M.			·237	S. W.	10	
	Midnt.			·234	S. W.	10	
British Princess	4 A. M.				S.W.byS.	11	Torrents of rain.
	8 A. M.					10	High confused sea.
	Noon	20° 24′	88° 42′	29·340		10	Westerly gale.
	4 P. M.					10	
	8 P. M.				S. W.	9	Sea very high.
	Midnt.				...	9	
Scottish Chieftain	4 A. M.				W. S. W.	10	Lost fore topsail, laid ship to under close reefed main topsail.
	8 A. M.			29·250	...	11	
	Noon	20° 40′	88° 10′	·300	...	10	
	4 P. M.			·350	...	8	
	8 P. M.				...	6	Heavy rain and confused sea. Very strong westerly current.
	Midnt.			·400	S. W.	6	

The various observations enable the centre of the barometric depression to be determined very approximately at 10 A. M. and at noon of the 29th. The wind directions at 10 A. M. observed on board the Light Vessels at the Upper Gasper and Intermediate stations were south-east and west, and hence the centre was between these vessels. Its position as determined by charting the wind directions and barometric heights was Lat. 21° 30′ N. and Long. 87° 55′ E.

The following table gives the chief observations taken at the light vessels and neighbouring land stations at 10 A. M., and the distance and bearing of the centre from each of them.

	Position.		Barometer.	Winds.		Direction of centre.	Distance from probable position of centre.
	Latitude. N.	Longitude. E.		Direction.	Strength.		
Saugor Island Light House.	21° 39′	88° 5′	29·146	E.	Moderate.	S. W.	14
Upper Gasper Light Vessel.	21° 31′	88° 3′	29·140	S. E.	5	W.	8
Intermediate Light Vessel.	21° 15′	88° 11′	29·164	W.	6	N. W.	24
Eastern Channel Light Vessel.	21° 1′	88° 12′	29·199	W. S. W.	8 to 9	N. W.	38
Balasore	21° 30′	86° 58′	29·296	N. N. W.	8	E.	60
False Point	20° 20′	86° 47′	29·419	W. S. W.	Strong	N. E.	110

The nearest light-vessels were between 5 and 25 miles from the centre in the eastern quadrant, and yet experienced very moderate winds of force 5 to 6, whilst the Pemba and Commillah, at much greater distances in the same quadrant, had winds of force 9 to 11.

The unusual weakness of the winds in all quadrants near the centre, as compared with those in the south-eastern quadrant at considerable distances from the centre, is a remarkable fact, and one that is opposed to the general experience of cyclonic motion.

The noon barometric readings and wind directions of the ships, when charted, indicate that the centre was at that hour probably in Lat. 21° 30′ N. and Long. 87° 50′ E. It had moved about five miles to the west during the previous two hours.

The following table gives the distance and bearing of the centre from each of the vessels at that hour :—

	Position.		Barometer.	Wind.		Direction of centre.	Distance from probable position of centre.
	Latitude. N.	Longitude. E.		Direction.	Strength.		
Saugor Island Light House.	21° 39′	88° 5′	29·146	E.	Moderate.	S. W.	19
Commillah	20° 18′	88° 40′	29·252	S. W.	11	N. W.	100
Scottish Chieftain	20° 40′	88° 10′	29·300	W. S. W.	10	N.N.W	60
Saint Magnus	19° 58′	88° 28′	29·370	W. S. W.	10	N.N.W	115
British Princess...	20° 24′	88° 42′	29·340	S. W. by S.	10	N. W.	95
Prince Amadeo......	20° 00′	88° 55′	29·320	W. to S.S.W	8 to 10	N. W.	125
Star of Albion	19° 43′	88° 37′	29·53	S. W.	9 to 10	N.N.W	145
Pemba	19° 16′	89° 56′	29·50	S. W.	9	N. W.	200

The preceding table shows that the vessels were all in the south eastern quadrant. They were experiencing violent west to south-west winds with frequent squalls of hurricane force. The majority of them were for the first time feeling the full strength of the storm.

The storm continued to pass to the westward during the day. The centre was probably in Lat. 21° 35′ N. and Long. 87° 30′ E. at 4 P. M.

The observations taken at the light-vessels and the neighbouring land stations, with the probable distance and bearing of the centre from each, are given below :—

	Position.		Barometer.	Wind.		Direction of centre.	Distance from probable position of centre.
	Latitude. N.	Longitude. E.		Direction.	Strength.		
Calcutta (Alipore)	22° 32′	88° 20′	29·214	E.	Strong	S.S.W.	85
Burdwan	23° 14′	87° 54′	29·245	N. E.	Light	S.W.	115
False Point	20° 20′	86° 47′	29·361	W. S. W.	Strong	N.N.E.	98
Cuttack...............	20° 29′	85° 54′	29·285	W. N. W.	Light	N.E.	130
Saugor Island Light House.	21° 39′	88° 5′	29·112	S. W.	Very strong	W.	38
Upper Gasper Light Vessel.	21° 31′	88° 3′	29·108	S. W.	9	W.	36
Intermediate Light Vessel.	21° 15′	88° 11′	29·199	S. W.	9	W.N.W.	50
Eastern Channel Light Vessel.	21° 1′	88° 12′	29·237	S. W. by W.	8 to 9	W. N. W.	60

The preceding observations show that the light-vessels were now experiencing very strong south-westerly winds, and that frequent severe squalls passed over them.

The remarkable difference between the force of the south-westerly winds at distances of more than 30 miles from the centre and the winds from other directions and also the winds near the centre, is shown very conclusively by the Saugor Island observations. The greatest amount of wind, as registered by the anemometer at that station in any interval of two hours between 1 P. M. of the 28th and 3 P. M. of the 29th, was 23 miles. The amount recorded between 1 P. M. and 3 P. M. of the 29th, when very variable unsteady winds were blowing, was only 5 miles. Between 3 P. M. and 5 P. M., during which hours south-west winds prevailed, 78 miles of wind were recorded, and between 5 P. M. and 7 P. M., 46 miles. During this period, a severe gale of wind blew from the south, and gave rise to a tremendous sea.

The position of the centre has been deduced from the various observations. It moved during the day almost due westwards, parallel to the coast of the Sunderbunds. The vessels bound for Calcutta, which were approaching the entrance to the Hooghly, were almost without exception in the eastern quadrant during the day. Their logs describe the force of the south-westerly winds in this part of the whirl in very similar language.

The Commillah, in Lat. 20° 18′ N. Long. 88° 40′ E. at noon, had terrific gales, with continual rain and furious squalls, in the morning. Squalls of hurricane force passed over the steamer. A tremendous and dangerous sea was running. South-westerly winds of average force 11 obtained during the morning. The wind and weather slightly moderated during the afternoon, but violent squalls continued to come up from the south-west, bringing very heavy rain.

The Pemba, 100 miles to the S. E. of the Commillah, experienced a fierce gale with hard squalls blowing with hurricane violence. No improvement occurred in the weather until late in the evening, when the sky began to clear and the sea to moderate a little.

The Star of Albion and the Scottish Chieftain experienced similar weather. The log of the Saint Magnus (in Lat. 19° 58′ N. Long. 88° 28′ E. at noon) describes the weather in the morning as a heavy gale with terrific gusts and continued heavy rain. The Captain of the British Princess (in Lat. 20° 24′ N. and Long. 88° 42′ E. at noon) notes that the wind decreased from force 11 in the morning to force 9 in the evening, and that torrents of rain fell during the morning. The wind blew steadily from the south-west quarter, and brought up a very high sea.

The Captain of the Comet speaks as follows of the weather on the 29th: "Weather was very threatening. A heavy sea came up from the south-east; the wind was very variable, shifting all round the compass. Rain squalls frequently came up. At midnight it was blowing a furious gale."

The Captain of the Meteor remarks of the weather he experienced during the day: "The sea was very rough and a high squall from south-west came up at 8 A. M. Frequent heavy rain-squalls passed over the vessel. The wind shifted to south-west at 10·30 A. M. The barometer began to rise at 2 P. M. During the evening a strong south-west gale blew, and frequent terrific rain-squalls passed over the vessel. At 11 P. M. the wind began to decrease in force and the squalls were less frequent."

30*th June.*—The depression off the mouth of the Hooghly on the 29th had travelled in a westerly direction, crossed the coast near Balasore, and passed westward to the north of Cuttack.

The depression was apparently smaller than on the previous day, the lowest recorded reading of the barometer at 10 A. M. being 29·35″. It was, however, a well-marked depression of about a quarter of an inch at the centre. The westward motion of the disturbance caused the barometer to fall briskly at Cuttack and in the adjacent districts of Chutia Nagpore and the Central Provinces, whilst, over the whole of Bengal, a very rapid recovery of pressure occurred. The wind directions in North-Eastern India indicated the continuance of cyclonic circulation in Bengal, Orissa, the Central Provinces, and Chutia Nagpore. Winds were from west in Orissa, south to east in Bengal, north in Chutia Nagpore, and north-west in the Central Provinces.

In other parts of India, the barometer rose generally during the preceding 24 hours. The changes over the greater part of the North Western Provinces and Bombay slightly exceeded a tenth of an inch, but the relative distribution of pressure was unaltered, except in Bengal and Orissa. The wind on the Bombay Coast had veered again to south-west, and was moderating. Very cloudy skies prevailed over the whole of Northern India. Heavy rain showers had fallen in the North-Western Provinces, and diminished the temperature over a large portion of Upper India from 10° to 15°.

Heavy rain continued to fall in connection with the cyclonic vortex in Orissa and the western districts of the Central Provinces.

The preceding remarks are illustrated by the following observations :—

STATIONS.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Wind velocity in miles per hour since 10 A. M. previous day.	Percentage wind.	Cloud 10 A. M.	Rainfall at 10 A. M. of preceding 24 hours.
			10 h.	16 h.				
Nancowry	29·912	— ·002	S. W.	S. S. W.	10	91	8	...
Port Blair	29·846	— ·029	S. W.	S. W.	12	109	4	...
Diamond Island ...	29·832	— ·003	S. S. W.	S. W.	9	113	5	...
Akyab	29·776	+ ·081	S. S. E.	S.	7	175	7	2·75
Chittagong	29·758	+ ·150	E.	E.	9	129	10	2·25
Dácca..................	29 684	+ ·154	S. E.	S.	12	150	10	0·24
Jessore	29·645	+ ·200	E. S. E.	S. E.	21	420	10	0·29
Calcutta (Alipore)	29·555	+ ·233	S. E.	S. S. E.	16	267	10	1·17
Saugor Island	29·517	+ ·344	S. E.	S. E.	19	136	10	0·36
Balasore	29·433	+ ·078	S.	?	14	?	10	7·37
Cuttack	29·382	— ·086	W.	W. N. W.	10	250	10	4·08
False Point	29·444	+ ·004	S.	S.	24	240	9	1·47
Vizagapatam.........	29·618	+ ·005	W.	W. by S.	6	150	10	...

The following observations taken at stations in and near the area of cyclonic disturbance on the morning (10 A. M.) of 30th June give data for the determination of the storm centre at that hour :—

STATION.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rainfall at 10 A. M. of preceding 24 hours.
			Direction 10 A. M.	Amount in miles per hour since 10 A. M. previous day.		
Saugor Island	29.517	+ ·344	S. E.	19·0	10	0·36
Calcutta..........................	29·556	+ ·233	S. E.	16·0	10	1·17
Burdwan	29·546	+ ·121	E.	12·0	10	0·88
Hazaribagh	29·518	— ·027	E. N. E.	18·0	10	0·38
Jubbulpore	29·686	+ ·042	W. N. W.	6·0	10	0·45
Seoni..............................	29·665	+ ·002	N. W.	5·0	6	0·45
Nagpur	29·674	+ ·017	N. W.	9·0	10	...
Raipore	29·512	— ·087	W.	20·8	10	1·28
Sambalpore	29·353	— ·111	S. W.	3·3	10	4·74
Cuttack............................	29·382	— ·086	W.	10·0	10	4·08
False Point	29·444	+ ·004	S.	24·0	9	1·47

The observations indicate that the cyclonic area extended over Orissa and the north-eastern districts of the Central Provinces, and that the centre was in the neighbourhood of Sambalpore and to the north-west. The probable position of the centre at 10 A. M. was Lat. 21° 45′ N. and Long. 83° 50′ E.; and the barometric height there was almost certainly not lower than 29·3″. It had consequently crossed over the Northern Orissa Hills (in the Hill States of Morbhanj, Keunjhar, and Pal Lahara), the average height of which appear to be about 2000 ft., and the highest points of which slightly exceed 3,500 ft. This area is described in the following language by Dr. Hunter in his Statistical Account of the Orissa States:—"From the north bank of the Mahanadi, the ranges tower into a fine watershed, from 2000 to 2500 feet high, running north-west and south-east, and forming the boundary of the States of Nursingpore and Baramba. On the other side, they slope down upon the States of Hindol and Dhenkanal supplying countless little feeders to the Brahmani, which occupies the second of the three valleys. From the north bank of this river, the hills again roll back into magnificent ranges, running in the same general direction as before, but more confused and wilder, till they rise into the Keunjhar watershed, with peaks from 2500 to 3500 feet high, culminating in Malayagiri, 3,895 feet high, in the State of Pal Lahara. This watershed, in turn, slopes down into the third valley, that of the Baitarani, from whose eastern or left bank rise the hitherto almost unexplored mountains of Morbhanj, heaped upon each other in noble masses of rock, from 3,000 to nearly 4,000 feet high, sending countless tributaries to the Baitarani on the south, and pouring down the Burabalang, with the feeders of the Subarnarekha, on the north. The peaks are densely wooded to the summit, and, except at the regular passes, are inaccessible to beasts of burden. The intermediate valleys yield rich crops in return for negligent cultivation; and a vast quantity of land might be reclaimed on their outskirts and lower slopes."

Hence, during the interval between 4 P. M. of the 29th and 10 A. M. of the 30th, the centre of the storm had crossed the Balasore coast, been transferred across the very broken and elevated ground of the North Orissa Hills, and was at 10 A. M. of the 30th in the direct line of its advance previous to crossing the hills. What actions occurred during its passage across this hilly country are unknown, but it is certain that they produced no appreciable resultant effect on the line of motion of the vortex, and only a very moderate one on the depression at the centre. This was 29·3″ at 10 A. M. of the 30th, as compared with 29·14″ at 10 A. M. of the 29th. There can be little doubt that the effect of the irregular character of the country would be to break up and disintegrate the cyclonic or rotatory motion in the lower atmospheric strata, or to diminish as a whole the intensity and amount of the cyclonic motion, and, therefore, also of the depression at the centre, which roughly measures the intensity of the disturbance.

The observations taken at 4 P. M. in the neighbourhood of the centre are given in the following table :—

Station.	Barometer at 4 P. M. reduced to sea level.	Change since 4 P. M. previous day.	Wind.		Cloud amount at 4 P. M.
			Direction at 4 P. M.	Amount in miles per hour since 10 A. M.	
Saugor Island	29·508	+ ·371	S. E.	20·0	10
Burdwan	·516	+ ·172	S. E.	12·0	9
Hazaribagh	·446	— ·001	E.	22·9	10
Sutna....................................	·533	+ ·013	E. N. E.	24·5	6
Jubbulpore	·538	— ·033	N. W.	24·8	10
Seoni....................................	·543	— ·038	W. N. W.	24·4	5
Nagpur	·546	+ ·007	N. W.	12·2	10
Raipore	·415	— ·084	W.	60·0	10
Sambalpore	·215	— ·122	S. W.	1·5	10
Cuttack..................................	·395	+ ·029	W. N. W.	65·0	10

In comparing these observations with the preceding 10 A. M. observations, it should be remembered that the fall of the barometer between 10 A. M. and 4 P. M., due to the diurnal oscillation, is ·11″ during the months of June and July in the Central Provinces. Hence, making allowance for this, it will be seen that the barometric changes due to the storm were of the following character. Pressure had increased about ·08″ at Cuttack and ·11″ at Hazaribagh, and had fallen ·03″ at Sambalpore. It had, consequently, risen during the previous six hours at all stations in the immediate neighbourhood of its centre, except Sambalpore, the nearest station. These facts appear to establish in this case that which I believe, from an examination of other similar cyclonic disturbances, to be a general result of the advance of a storm over a hilly country, *viz.*, that the storm tends to break up, the cyclonic motion becoming more irregular, and the barometric depression smaller in amount over the greater part, if not the whole, of the area of cyclonic circulation, but frequently extending over a larger area. In other words, the cyclonic action becomes less intense and more diffuse, which is probably the first step in the disintegration of cyclonic disturbances. On the other hand, if, after its passage across hills, it receives increased energy and again intensifies, this is usually indicated by a contraction of the storm area, and by an increase of the depression near the centre.

The position of the centre at 4 P. M. was apparently almost identical with that in which it had been at 10 A. M., and was, so far as can be inferred from the observations, in Lat. 21° 50′ N. and Long. 83° 30′ E., or about 20 miles to the west of its position at 10 A. M.

The rainfall during the previous 24 hours in Orissa and Chutia Nagpur is given in the following table:—

Division.	Districts.	Average rainfall of district.	Highest rainfall in district.
Orissa	Pooree	1·83	3·88
	Cuttack	2·07	3·21
	Balasore	3·02	5·64
Chhattisgarh	Bilaspore	0·51	2·54
	Sambalpore	1·17	4·08
	Raipore	1·30	2·03
Nagpur	Wardha	1·82	2·71
	Bhundara	2·71	4·54
	Balaghat	0·03	0·10
	Nagpur	nil.	nil.
Jubbulpore	Jubbulpore	0·54	0·65
	Seoni	0·73	2·09
	Mandla	0·26	1·81
	Damoh	0·26	0·90
	Saugor	0·03	0·11
Nerbudda	Narsinghpore	0·88	3·00
	Chhindwara	1·03	4·09
	Betul	0·43	2·83
	Hoshangabad	0·01	0·05
	Nimar	nil.	nil.

The meteorological information extracted from the logs of vessels at the Head of the Bay on the 30th is given to show the improvement in the weather, and the establishment of southerly winds over the Head of the Bay.

30*th June* 1883.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	REMARKS.
Bancoora ..	4 A. M.			29·552	S. W.	5	Strong wind and overcast.
	8 A. M.			·539	S. W.	3	Moderate breeze and fine throughout.
	Noon	20° 01′	88° 25′	·542	S. W.	3	Do. do. do.
	4 P. M.			·638	S.	3	Current 80 miles adverse.
	8 P. M.			·539	S.	3	Moderate breeze and fine.
	Midnt.			·552	S.	3	Moderate and fine at Saugor.
Star of Albion ...	4 A. M.			29·540			Gale moderating, weather finer and less sea.
	8 A. M.			·570			
	Noon	20° 15′	87° 28′	·610	S. S. W.	6 to 4	
	4 P. M.			·620	S.		
	8 P. M.			·670			Latter part much finer.
	Midnt.			·670			
Saint Magnus......	4 A. M.			29·440	S. S. W.	8	Squally rainy weather, heavy sea.
	8 A. M.			·490	S. S. W.	7	Do. do. do.
	Noon	20° 32′	87° 56′	·470	S. S. W.	6	Strong breeze, cloudy hazy weather.
	4 P. M.			·490	S.	5	Cloudy rainy weather, nasty sea.
	8 P. M.			·570	S.	4	Moderate and fine.
Scottish Chieftain	4 A. M.			29·450	S. W.	5	Weather having a much finer look, and barometer rising, are proofs that the strong winds are now over. A very strong westerly current.
	8 A. M.	20° 50′		·500		4	
	Noon	20° 32′	87° 34′	·430		3	
	4 P. M.			·580		1	
	8 P. M.			·620		1	
	Midnt.			·680			
Pemba ...	4 A. M.			29·490	S. W.	6	A. M. Strong breeze, sea going down.
	8 A. M.			·540	...	6	
	Noon	20° 33′	88° 31′	·540	...	5	Noon. Moderate breeze and clear.
	4 P. M.			·520	...	5	3-45 P. M. Passed E. Channel Light Vessel,
	8 P. M.			·580	...	5	8 P. M. Anchored in Saugor Roads.
	Midnt.			·600	...	5	

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind. Dir.	Wind. Force.	Remarks.
British Princess	4 . M.					9	Squally with rain.
	8 A. M.					9	Sea very high.
	Noon	20° 33′	88° 19′			8	Sea very high.
	4 P. M.					8	
	8 P. M.					6	Sea very high.
	Midnt.					5	High confused sea.
Prince Amadeo	4 A. M.				S. S. W.	10	Midnight. Gale breaking. 4 A. M. Strong S. S. W., occasional heavy squalls. Noon. Strong wind S., weather finer.
	Noon	20° 39′	88° 20′	29·530	S.	8	
	8 P. M.					5	
	Midnt.					5	
Commillah	4 A. M.			29·349	S. W.	9	A. M. Hard squalls and heavy rain and high sea, stood to southward. A very high sea running from S. W. 5 A. M. Stood up to Northward. Weather clearing at times for observations. 8 A. M. Hard squalls from S. W. and high sea. Noon. Overcast, weather hazy. 4 P. M. Fine weather.
	8 A. M.			·423	S. S. W.	8	
	Noon			·434	S. S. W.	7	
	4 P. M.			·401	S. W.	5	
	8 P. M.			·464	Var.	4	
	Midnt.			·569	E. S. E.	3	

The preceding observations call for little remark. They show that south-westerly winds were fully established over the whole of the north of the Bay, but that they were diminishing rapidly in force. Before sunset, moderate breezes and finer weather had set in. Heavy squalls came up during the early part of the day, but the only vessel which reports rain during the afternoon was the Saint Magnus. In her case, however, it is stated that the weather improved rapidly and was fine, with moderate winds, at 8 P. M. Hence, the stormy weather in the Bay ceased about noon of the 30th. A heavy swell continued to run for some little time afterwards, and strong westerly winds prevailed for the next 24 hours.

July 1*st*.—The following table gives the observations taken at a few of the most important stations, and indicates the general character of the weather over India on the morning of the 1st :—

Station.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rainfall at 10 A.M. preceding 24 hours.	Weather.
			Direction. 10 A. M.	Amount in miles per hour since 10 A.M. previous day.			
Calcutta.........	29·676	+ ·121	S. E.	7	8	0·29	Fine.
Allahabad	·566	— ·070	E. N. E.	8	10	...	Strong wind.
Lahore	·701	+ ·212	N.	3	8	0·77	Dark, gloomy.
Kurrachee......	·642	+ ·057	W. S. W.	17	9	0·17	Sultry.
Bombay	·765	— ·010	W.	17	10	0·21	Showery.
Jeypore.........	·678	+ ·032	N.	5	7	0·74	Showery.
Nagpur	·471	— ·203	W.	11	10	4·08	Continuous rain.
Madras	·775	— ·038	W.	8	6	...	Fine.
Bangalore......	·803	— ·042	S. W.	11	5	...	Fine.

The observations of the 1st indicate that the barometric depression moved during that day in the same direction as hitherto and at a rate of about 15 miles per hour. The westward motion of the depression had caused a fall of nearly two-tenths of an inch in the barometer over the greater part of the Central Provinces, and a general, although a slight, decrease over the whole of the Peninsula and Bombay. In Bengal, the rapid recovery in progress on the 30th continued. A rapid rise had also occurred over the Punjab and the western districts of the North Western Provinces, due to some other and independent action. A very distinct circulation of the air was shown round the centre of depression. In the mid-Gangetic valley, the winds had drawn round to north-east, and, over the western portions of the Central Provinces, they were blowing from north-west. Moderately strong winds continued at the Head of the Bay and in South Bengal. No change of importance had occurred in the wind directions over Bombay and the south of the Peninsula. Strong west winds prevailed along the Bombay coast, where, however, little or no rain was falling. Local winds obtained in the Punjab. The sky was less clouded, the weather finer, and rainfall less in amount over the Gangetic delta and valley. The depression was, however, giving very heavy rain to the Central Provinces, where the sky was overcast. Over the remainder of the country, the weather was of the usual monsoon character.

The storm had advanced through the Chhatisgarh division of the Central Provinces (which includes the Sambalpore, Bilaspore, and Raipore districts), and was now passing through the Jubbulpore and Nagpur divisions.

The following table gives the 10 A. M. observations at the stations in the neighbourhood of the centre at that hour :—

Station.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rainfall at 10 A. M. of preceding 24 hours.	Weather.
			Direction at 10 A. M.	Amount in miles per hour since 10 A. M. previous day.			
Sambalpore ...	29·526	+ ·173	S. W.	1·4	6	1·84	
Raipore	·535	+ ·024	S. W.	20·0	10	...	Overcast.
Hazaribagh ...	·627	+ ·109	E. S. E.	20·0	8	0·34	Gale of wind.
Sutna............	·534	— ·090	E.	21·0	10	0·08	Ditto.
Seoni	·463	— ·202	N. N. W.	15·0	10	4·60	Continuous rain.
Jubbulpore ...	·483	— ·204	N. N. E.	8·0	10	1·82	Moist & muggy.
Nagpur	·471	— ·203	W.	11·0	10	4·08	

The number of observatories in Chutia Nagpore and the north-eastern districts of the Central Provinces is very small for their extent. Hence, it is not possible to state with approximate exactness the position of the centre of the depression at this time.

The observations, however, indicate that the centre was to the east of Seoni, and that it was at nearly equal distances from Jubbulpore, Seoni, and Nagpore, and hence almost certainly in Lat. 22° N. and Long. 81° E.

The following table gives the observations at 4 P. M. for the determination of the position of the centre at that hour :—

Station.	Barometer at 4 P. M. reduced to sea level.	Change since 4 P. M. previous day.	Wind.		Cloud amount at 4 P. M.	Weather.
			Direction at 4 P. M.	Amount in miles per hour since 10 A. M.		
Nagpur	29·355	— ·191	W.	11·7	10	Overcast.
Raipore	·415	— 0	S. W.	64·1	10	Overcast.
Seoni	·323	— ·220	E.	9·2	10	Overcast, raining.
Sutna...............	·435	— ·098	E.	30·0	7	
Jubbulpore	·375	— ·163	E. N. E.	14·2	10	Gloomy.
Saugor	·412	— ·178	N. W.	2·3	8	
Hoshangabad ...	·420	— ·153	W. S. W.	2·8	10	Overcast.
Khandwa	·478	— ·132	W. N. W.	20·1	10	Raining.
Akola...............	·509	— ·091	W. N. W.	21·0	10	Overcast.
Indore	·533	— ·073	W. N. W.	15·0	10	Overcast.

Allowing for the amount of the fall of the barometer between 10 A. M. and 4 P. M. due to the diurnal oscillation, the barometer had risen at Sambalpore ·11″, and had also risen at Akola ·02″. The only portion of the area in which it had fallen was that represented by the station of Seoni, where it had fallen ·03″.

The wind directions at Seoni and Nagpore were east and west respectively, and indicate that the centre was between these two stations, and probably some little distance to the east of the line joining them. Its probable position was hence in Lat. 22° N. and Long. 79° 45′ E.

The following table gives the average rainfall during the previous 24 hours in every district of Orissa and the Central Provinces :—

Division.	District.	Average rainfall of district.	Highest in district.
Orissa	Pooree	0.01	0.05
	Cuttack	nil.	nil.
	Balasore	0·09	0·20
Chattisgarh	Sambalpore	1·05	5·25
	Raipore	1·60	4·25
	Bilaspore	0·56	2·92
Nagpore	Bandhara	2·97	4·36
	Balaghat	2·47	5·00
	Nagpore	3·88	4·80
	Wardha	1·91	4·18
Jubbulpore	Jubbulpore	0·66	1·62
	Seoni	2·76	5·65
	Mandla	0·02	0·15
	Damoh	0·27	0·80
	Saugor	0·28	0·48
Nerbudda	Nursinghpore	0·53	1·25
	Chhindwara	4·16	4·90
	Betul	3·91	6·13
	Hoshangabad	2·90	5·99
	Nimar	0·64	1·01

This table indicates that rain had practically ceased to fall in Orissa, and that moderate rain had fallen in Chattisgarh. Heavy rain had been received in all districts of the Central Provinces through which the cyclone passed during the day, namely, the Seoni, Chhindwara, and Hoshangabad districts, and also in the districts to the south of the line of motion; whilst in the districts to the north the rainfall was light.

The following table shews that the amount of rain in Bengal was very small:—

Districts.	Average rain-fall of district.	Highest in district.
Orissa	0.04	0·20
South West Bengal	0·12	0·96
East Bengal	0·09	0·50
North Bengal	0·08	1·37
North Behar	nil.	0·07
South Behar	0.05	0·80
Chutia Nagpore	0·11	0·46

2nd July.—The following table gives the 10 A. M. observations of this day at the nine most important observatories in India.

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind. Direction. 10 h.	Wind. Amount in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. of preceding 24 hours.	Weather.
Calcutta	29·673	— 003	S. W.	4	8	0·03	Fine.
Allahabad	·613	+ ·047	E.	8	2	0·04	Strong wind.
Lahore	·590	— ·111	W.	2	5	...	Fine.
Kurrachee	·556	— ·086	N. W.	18	2	...	Fine.
Bombay	·708	— ·057	W. S. W.	20	10	0·15	Showery.
Jeypore	·541	— ·137	E. S. E.	7	6	...	Fine.
Nagpore	·621	+ ·150	S. W.	18	10	3·22	Strong wind.
Madras	·795	+ ·020	W.	6	7	1·83	Thunder storm.
Bangalore	·794	— ·009	W. S. W.	10	6	...	Fine.

The observations taken throughout India shew that the barometric depression had continued to travel westward in the same general direction as during the previous two days, and with the same velocity approximately as during the afternoon of the 1st. A rapid recovery of pressure had occurred over the greater part of the Central Provinces, amounting at several stations to ·15′. The barometer had on the other hand fallen over the districts towards which the centre was advancing. The fall was greatest at Indore, where it slightly exceeded ·25″ since 10 A. M. of the 1st. Pressure had decreased over the whole of the Punjab, the North-Western Provinces, Bombay, and the greater part of Bengal and Burmah. This fall was due to general actions unconnected with the continuance of the depression in Western India.

The general character of the air motion remained the same, except in the neighbourhood of the moving area of depression. Southerly winds now prevailed in the Central Provinces. The westerly winds on the Bombay coast were slightly stronger than they had been on the previous day. The easterly winds prevalent over the area to the north and north-east of the storm centre were comparatively dry, and little or no rain fell in that part of the depression where they were blowing. The rainfall was heavy in the southern quadrant of the disturbance.

Little or no rain was falling at the time in Assam, North Bengal, Behar, the North-Western Provinces, the Punjab, and over the greater part of Bombay.

During the interval between 4 P. M. of the 1st and 10 A. M. of the 2nd, the centre continued to advance in a general westerly direction through the Narbadda Division of the Central Provinces.

The following are the observations taken at the meteorological stations in the area of depression at 10 A. M. of the 2nd.

STATIONS.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather
			Direction at 10 A. M.	Amount in miles per hour since 10 A.M. previous day.			
Saugor	29·488	—·056	N. E.	11·0	8	0·38	Showery.
Akola............	·577	—·061	W.	22·0	10	7·43	Continuous rain.
Amraoti.........	·553	—·050	W. S. W.	42·0	9	6·35	Ditto.
Neemuch	·509	—·154	E. N. E.	20·0	10	0.86	Showery.
Indore	·410	—·259	N. E.	13·0	10	1·58	Showery.
Jeypore	·541	—·137	E. S. E.	7·0	6	...	Fine.
Ajmere	·546	—·140	N. E.	5·0	4	0·43	Thunder.
Khandwa	·494	—·141	W. S. W.	13·0	10	2·64	Continuous rain.
Mount Abu ...	25·692	—·169	N.	9·0	9	3·34	Ditto.
Surat	29·588	—·138	S. W.	17·0	10	0·33	Showery.
Malagaon	·670	—·073	W.	18·0	10	2·83	Continuous rain.
Nagpore	·621	+ ·150	S. W.	18·0	10	3·22	Strong wind.
Seoni	·603	+ ·140	S.	12·0	8	1·20	Continuous rain.
Jubbulpore ...	·599	+ ·116	S.	12·0	9	0·05	Strong wind.

The barometer was lowest at Indore. The barometric heights and wind directions, when charted, indicate that the centre of the depression was at noon very near Indore and to the east of it, and hence in Lat. 22$\frac{1}{2}$° N. and Long. 76° E. Strong winds and very heavy rain characterized the western and southern quadrants. In the northern quadrant, winds were much more moderate, and rain fell only near the centre of the depression.

The following are the 4 P. M. observations, which enable the position of the depression and its centre to be determined at that hour:—

Station.	Barometer at 4 P. M. reduced to sea level.	Change since 4 P. M. previous day.	Wind.		Cloud amount at 4 P. M.	Weather.
			Direction at 4 P. M.	Amount in miles per hour since 10 A. M.		
Saugor	29·473	+ ·061	S.	14·0	8	Cloudy.
Akola...............	·529	+ ·020	W. S. W.	21·7	10	Strong wind.
Amraoti............	·565	+ ·136	S. W.	23·3	10	Strong wind.
Neemuch	·368	— ·148	E.	11·7	9	
Indore	·414	— ·119	S. W.	8·7	10	Overcast.
Jeypore	·398	— ·125	E.	10·9	7	Strong wind.
Ajmere	·399	— ·183	E.	12·4	5	
Khandwa	·444	— ·034	W.	17·6	10	
Surat	·495	— ·135	W. S. W.	33·0	10	Overcast.
Malegaon	·557	— ·050	W.	19·8	10	Strong wind.
Deesa...............	·370	— ·166	W.	18·0	10	Overcast.
Rajkot	·458	— ·131	W.	20·3	10	Strong wind.
Bhuj	·422	— ·151	W.	15·8	8	Strong wind.
Hyderabad	·422	— ·175	S. W.	5·0	9	Overcast.

Allowing for the amount of the diurnal oscillation between 10 A. M. and 4 P. M., it will be seen that the barometer had fallen during the preceding six hours at Neemuch, Ajmere, and Deesa, whilst it had risen rapidly in the Central Provinces. The centre was between Neemuch and Deesa, where the barometric heights were practically the same, and winds were in opposite directions. It was approximately in Lat. 23° 30′ N. and Long. 74° 30′ E.

The following table gives the rainfall in each district of the Central Provinces during the 24 hours preceding 6 P. M. of the 2nd.

Division.	District.	Average Rainfall of district.	Highest in district.
Chattisgarh	Sambalpore	0·09	0·45
	Raipore	nil.	nil.
	Bilaspore	0·05	0·20
Nagpur	Bhandara	0·25	0·70
	Balaghat	0·71	1·90
	Nagpur	2·25	3·86
	Wardha	nil.	nil.
Jubbulpore	Jubbulpore	0·02	0·05
	Seoni	0·06	0·17
	Mandla	nil.	nil.
	Damoh	0·07	0·20
	Saugor	0·10	0·41
Narbudda	Narsinghpore	0·19	0·75
	Chhindwara	0·06	0·19
	Betul	0·91	2·45
	Hoshangabad	0·96	3·35
	Nimar	5·62	8·20

The rainfall of the previous 24 hours was small in amount. The Nagpur district received local heavy rainfall. The only district where the rainfall due to the cyclonic disturbance was large in amount was the Nimar district. It was in the southern quadrant of the storm area during the greater part of the day, and received an average of 5·62 inches.

3rd July.—The following table gives the observations for the 3rd July at the chief meteorological stations in India :—

STATION.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind. Direction. 10 h.	Wind. Amount in miles per hour since 10 A.M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A.M. of preceding 24 hours.	Weather.
Calcutta	29·685	+ ·012	E. S. E.	3	9	nil.	Fine.
Allahabad	·712	+ ·099	N.	4	4	nil.	Fine.
Lahore	·613	+ ·023	E.	1	5	nil.	Fine.
Kurrachee	·446	— ·110	N. N. W.	18	9	0·05	Gloomy.
Bombay	·732	+ ·024	S. S. W.	25	10	0·21	Gale of wind.
Jeypore	·664	+ ·123	S. S. W.	12	8	nil.	Strong wind.
Nagpur	·760	+ ·139	S. S. W.	6	5	0·04	Showery.
Madras	·845	+ ·050	S. W.	6	5	0·11	Showery.
Bangalore	·854	+ ·060	S. W.	8	5	nil.	Fine.

The depression was now in the immediate neighbourhood of the Arabian Sea, between Kurrachee and Rajkot. The barometer during the previous 24 hours had fallen between ·1″ and ·15″ in Sind, Cutch, Guzerat, and the adjacent districts of Rajputana. In the rear of the disturbance, over the Central Provinces, the Berars, and Central India, a recovery of pressure, varying in amount between ·15″ and ·25″, had occurred. Over the remainder of India, pressure had increased briskly. The depression in Cutch and Guzerat had consequently been emphasized by these changes, and the baric gradients over the area of depression were large. South-westerly gales were now blowing on the west coast, from Bombay northwards, and were giving very heavy rain over the southern and eastern portions of the depression. Over Northern India, the winds varied considerably in direction and were light and unsteady. The weather was cloudy, and light and partial rain was falling, over the greater part of Northern India, except the Punjab and parts of the North-Western Provinces.

The centre of the depression at 4 P. M. on the 2nd was to the west of Neemuch in the Indore State, and was advancing westwards into Guzerat. The following table gives the 10 A. M. observations of the 3rd at the stations in the area of cyclonic disturbance:—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rain at 10 A. M. preceding 24 hours.	Weather.
			Direction at 10 A. M.	Amount in miles per hour since 10 A. M. previous day.			
Kurrachee......	29·446	—·110	N. N. W.	18·0	9	0·05	Gloomy.
Rajkote	29·435	—·171	S. W.	33·0	10	9·85	Dust storm with rain.
Deesa............	29·467	—·076	S. E.	17·0	10	0·43	Threatening weather.
Ajmere	29·636	+ ·090	S. E.	11·0	9	0·10	Strong wind.
Indore	29·676	+ ·266	S. E.	7·0	6	0·10	Gloomy.
Neemuch	29·639	+ ·130	S. S. W.	22·0	10	0·21	Thunder and lightning at distance.
Bhuj	29·326	—·207	N. N. W.	3·0	10	0·76	Fine.
Hyderabad ...	29·420	—·137	N.	5·0	8	0·26	Strong wind.

The barometer had risen rapidly at Indore and Neemuch, whilst it had fallen somewhat less rapidly at Bhuj, Rajkote, Deesa, Hyderabad, and Kurrachee. The preceding observations indicate that the centre was between the three stations of Bhuj, Rajkote, and Deesa, and probably not far from the first-named station, in Lat. $23\frac{1}{2}°$ N. and Long. $69\frac{3}{4}°$ E., and hence nearly in the centre of the district of Cutch. The observations show that winds were unusually light in the north-western quadrant. The average wind velocity at Bhuj during the previous 24 hours was only 3 miles, and at Hyderabad 5 miles. The westerly and south-westerly winds at Rajkote and other stations in the easterly and southerly quadrants contrast strikingly with the feeble winds to the north of the centre of the depression.

The following are the 4 P. M. observations taken at the stations within the storm area:—

Stations.	Barometer at 4 P. M. reduced to sea level.	Change since 4 P. M. previous day.	Wind.		Cloud amount at 4. P. M.	Weather.
			Direction at 4 P. M.	Amount in miles per hour since 10 A. M.		
Kurrachee......	29·304	—·182	N. N. W.	16·8.	10	Strong wind.
Rajkote.........	29·454	—·004	S. S. W.	32·3	10	Strong wind.
Mount Abu ...	25·598	+ ·042	S.	13·8	10	Gloomy.
Ajmere	29·565	+ ·166	W.	12·2	5	Gloomy.
Indore	29·627	+ ·213	S.	6·7	10	Gloomy.
Neemuch	29·587	+ ·219	S. S. W.	11·2	10	Gloomy.
Bhuj	29·215	—·207	S.	25·7	10	Thunderstorm.
Hyderabad ...	29·317	—·105	E. N. E.	58·8	6	Strong wind.
Jacobabad......	29·382	—·066	E.	17·2	6	Strong wind.
Multan	29·481	+ ·021	N. E.	3·0	4	Fine.

When the observations are charted, they indicate that the centre was between Bhuj and Kurrachee, where the barometric readings were lowest, and winds were from S. and N. N. W.; and at a short distance to the W. N. W. of the former station. Its probable position was in Lat. $23\frac{3}{4}°$ N. and Long. $68\frac{3}{4}°$ E. If allowance be made for the diurnal oscillation, it will be seen that the barometer had altered little at Bhuj, and was rising quickly at Rajkote, but continued to fall rather rapidly at Kurrachee.

The following table gives the average rainfall in the divisions of Bengal:—

	Average rainfall in previous 24 hours.	Highest rainfall in 24 hours.
Orissa..	0·03	0·30
South West Bengal	0·04	0·52
East Bengal	0·12	1·40
North Bengal	0·04	0·56
North Behar	nil.	nil.
South Behar	0·03	0·40
Chutia Nagpur	0·06	0·50

The above return shews that, with the exception of a few local showers, rain had ceased in the Province of Bengal.

As daily returns of rainfall in Central India and the Bombay Presidency are not at my disposal, it is not possible to give full details of this element of observation for the previous 24 hours. The returns of Bhuj, Rajkote, Kurrachee, &c., however, indicate clearly that the rainfall was heavy over the southern half of the cyclonic area and light over the northern.

4th July.—The following are observations taken at 10 A. M. of the 4th, and illustrate the more important changes that had occurred during the previous 24 hours in the meteorology of India.

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind. Direction at 10 h.	Wind. Amount in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
Calcutta ...	29·643	— ·042	N. W.	5	10	2·12	Gloomy.
Allahabad ...	29·669	— ·043	N. W.	2	5	...	Fine.
Lahore	29·652	+ ·039	Calm.	5	6	0·89	Fine.
Kurrachee...	29·380	— ·066	E.	33	10	0·83	Duststorm with rain.
Bombay......	29·867	+ ·135	S.	28	10	0·23	Gale of wind.
Jeypore	29·751	+ ·087	W. N. W.	7	8	...	Fine.
Nagpore......	29·811	+ ·051	W.	4	7	...	Fine.
Madras	29·864	+ ·019	W. S. W.	7	4	...	Fine.
Bangalore ...	29·901	+ ·047	W.	7	4	...	Fine.

The observations taken at the observing stations in Sind and Guzerat at 10 A. M. are given below. They shew that the whirl was still quite distinctly marked, that it continued to advance to the westward, and that it was now near the Head of the Arabian Sea, to the S. W. of Kurrachee. A rapid rise of the barometer had occurred over upper Sind and Guzerat. Kurrachee was the only station where pressure was lower than on the morning of the 3rd. South-westerly winds prevailed in Cutch and Guzerat. The wind had shifted round to east at Kurrachee, and was blowing with considerable force. It brought up a dust-storm from the Rajputana desert followed by rain.

The centre of the depression had crossed the Sind coast during the previous evening. It is not possible to follow its motion further, as no observations are available for this portion of its path. It is, however, probable that it speedily broke up.

The following 10 A. M. observations taken at stations in Western India nearest the area of cyclonic disturbance illustrate the previous remarks.

Station.	Barometer 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind.		Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			Direction at 10 A. M.	Amount in miles per hour since 10 A. M. previous day.			
Kurrachee...	29·380	—·066	E.	33·0	10	0·83	Duststorm with rain.
Mount Abu	25·890	+ ·221	S. S. W.	17·0	10	2·36	Passing showers.
Deesa.........	29·725	+ ·258	S.	?	10	0·39	Strong wind.
Rajkote	29·695	+ ·260	S. S. W.	24·0	10	0·58	Clouds low, moving rapidly with scuds.
Bhuj	29·583	+ ·257	S. S. W.	11·0	10	4·24	Continuous rain.
Hyderabad .	29·626	+ ·206	S. W.	240	10	0·05	Gale of wind.
Jacobabad...	29·614	+ ·132	E.	90	3	...	Fine weather with passing clouds.
Mooltan......	29·648	+ ·073	S. W.	30	0	...	Fine weather with passing clouds.

The following 4 P. M. observations shew that the barometer was rising rapidly at Kurrachee, as well as at the neighbouring stations, and that the wind at that station was slowly shifting round to its normal direction (S. W.) in July. They indicate clearly the continued existence of the whirl at the head of the Arabian Sea.

Stations.	Barometer at 4 P. M. reduced to sea level.	Change since 4 P. M. previous day.	Wind.		Cloud amount at 4 P. M.	Weather.
			Direction at 4 P. M.	Amount in miles per hour since 10 A. M.		
Kurrachee......	29·490	+ ·186	E. S. E.	38·7	10	Strong wind.
Mount Abu ...	25·856	+ ·258	S. S. W.	18·5	10	Gloomy.
Deesa............	29·667	+ ·163	E. N. E.	?	10	Strong wind.
Rajkote.........	29·653	+ ·199	S. W.	28·7	8	Strong wind.
Bhuj	29·581	+ ·366	S. S. W.	23·0	10	Strong wind.

The history of the cyclone ends with the evening of the 4th, as the observations of the 5th and subsequent days shew that normal winds were established in Sind, and no further evidence of the existence of the cyclonic whirl is furnished by the land observations.

CHAPTER III.

Discussion of the more important features of the Storm of the 26th June to the 4th July, 1883.

The cyclonic storm of the last week of June and the first week of July is interesting in several respects. It occurred after the rains had fully set in over Bengal, and was of unusual intensity in the Bay for a storm of the rains. After it passed into the Central Provinces, it acquired fresh energy, and advanced slowly across the Head of the Peninsula into Guzerat. During this part of its motion, it gave excessive rain, and presented in a marked degree the phenomena of a south-west monsoon storm on land. It was thus one of the most complete storms of the rains that has occurred in recent years, and as such is deserving of careful study. Before discussing its more important features in detail, it appears desirable to give a brief connected history of the antecedents, the formation, the progress, and the dissolution of the storm.

The south-west monsoon proper of 1883 commenced a few days earlier than usual at the Head of the Bay and in Bengal. The Bombay branch of the monsoon current was first felt in force on the Bombay coast on the 24th and 25th of June, when strong winds, almost approaching to a gale, were blowing, and general rain began and extended to the Central Provinces. Very shortly after the commencement of the south-west monsoon proper in Bengal, an atmospheric eddy, or cyclonic vortex, formed in the north-west angle of the Bay. It passed through North Orissa, Chutia Nagpore, and South Behar into North Behar, where it broke up on the 20th of June. This disturbance drew large supplies of vapour from the southerly current advancing into Bengal from the Bay, which it discharged as rain in unusually large amounts over a considerable portion of Central and North Behar, and thus occasioned very heavy floods in the Gya, Behar, Patna, Durbhanga, and Mozufferpore districts.

The disappearance of this eddy or whirl was followed by a partial break in the rains. The winds, although they continued to blow from the normal directions over Bengal and in the south and centre of the Bay, fell off in strength. The sky was less densely clouded, more especially in Central Bengal and Behar. The air also was drier, and the rainfall much smaller in amount and confined to local showers, which fell chiefly in the neighbourhood of the hills in North and East Bengal. Whilst this partial break in the rains (which commenced on the 20th) held in Bengal, the winds diminished in strength *pari passu* over the north of the Bay. They were light to moderate, and rarely exceeded force 3. The weather was comparatively fine, and the sea almost smooth.

The wind observations taken at Nancowry and Port Blair show that the south-westerly winds of the centre and south of the Bay, which had been very feeble from the 15th, began to increase in force on the 23rd, and blew strongly during the remainder of the month. This apparently indicated the commencement of another burst of the monsoon.

It appears to be a general rule that each strong advance of south-west monsoon winds and consequent influx of aqueous vapour into Bengal commences in the south of the Bay. The winds first strengthen for some days in that part of the Bay, as is proved by the wind observations at the Ceylon stations and at Nancowry in the Nicobars. The area of strong winds then extends northwards. When the advancing strong winds approach the Burmah and Bengal coasts, there is a strong tendency to eddying motion at and near the front. This incipient vorticose motion may, under favourable conditions, develop into a large cyclonic circulation and storm.

The strong current, in the present instance, advanced northwards along the Burmese and Arrakan coasts, and increased the strength of the winds at Diamond Island from the 25th, and at Akyab from the 26th. These may, therefore, be assumed as the dates of the arrival of the front of the advancing mass of air in the latitudes of these two stations. The log of the Pemba proves that, on the 27th, the force of the winds off the west Burmese coast was very considerable and averaged 9. At the same time that these strong winds were blowing off the Burmese coast, the winds at the Head of the Bay were very light and variable, and of average force not exceeding 2. The strong advancing south-westerly current was opposed by the line of the Arrakan hills, by the resistances due to friction between itself and the earth's surface, and by the slower moving air currents to the west. The actual effect of the various resistances was to produce a deflection of the current to the west in the neighbourhood of the Burmese and Arrakan coasts, and a large amount of eddying or rotatory motion in the front of the current, and, therefore, also of ascensional motion and its concomitant action (in the case of a very humid current), rainfall. The energy or latent heat given out in the process of condensation, or rain formation, in its turn increased the ascensional motion, and the various actions and reactions gave rise to an extensive whirl near the Head of the Bay. The existence of this was plainly indicated on the morning of the 27th, when winds shifted round to north-east over the north-west of the Bay. Very heavy rain ("torrents of rain") were then falling over a comparatively small area near the Head of the Bay, which became an area of increasing barometric depression and of cyclonic air motion. The disturbance increased in intensity on the 28th and moved slowly westwards near the parallel of 21° N. At 10 A. M. of the 29th, the centre of the depression was between the Light Vessels at the Intermediate and Upper Gasper stations. It was then travelling with an average velocity of about 3 miles an hour. Its rate of motion apparently increased as it approached the Balasore coast.

The storm advanced in a general W. N. W. direction during the afternoon of the 29th, and crossed the Balasore coast a few miles to the north of the station of Balasore a little before midnight. It then apparently marched without change of direction across the North Orissa hills, as, next morning at 10 A. M., the centre of the barometric depression was near to Sambalpore and in the continuation of its line of its advance on the 29th. The disturbance apparently diminished for some time, but began to draw supplies of vapour from the Bombay branch of the monsoon current, which had been blowing strongly for some days previous. In consequence of the increased energy thus given to it, it again intensified slightly and moved almost due westward across the Head of the Peninsula at an average rate of about fifteen miles per hour. On the morning of the 1st, the centre was near Seoni, on the morning of the 2nd near Indore, and on the morning of the 3rd near Bhuj, whence it passed westwards across the coast into the Arabian Sea, and was a little to the south of Kurrachee on the evening of the 3rd. The wind directions at Kurrachee and the neighbouring stations indicated cyclonic indraught to a centre, to the south-west of Kurrachee on the morning of the 4th, after which they give no further indications of its existence. In the absence of observations, it is impossible to state whether it broke up immediately, or passed over the whole breadth of the Arabian Sea.

The following table gives the positions of the centre at the hours stated, from the 27th of June to the date of its disappearance beyond the limits of India in the Arabian Sea :—

Date.	Hour.	Position of centre. Latitude. N.	Position of centre. Longitude. E.	Distance travelled during preceding interval.	Rate of motion.
June 27th ...	Noon.	20° 30′	89° 45′		
	4 P. M.	20° 35′	89° 35′	12	3
June 28th ...	10 A. M.	21° 0′	88° 45′	62	$3\frac{1}{2}$
	Noon.	21° 3′	88° 40′	$6\frac{1}{2}$	$3\frac{1}{4}$
	4 P. M.	21° 10′	88° 30′	13	$3\frac{1}{4}$
June 29th ...	10 A. M.	21° 30′	87° 55′	45	$2\frac{1}{2}$
	Noon.	21° 30′	87° 50′	$5\frac{1}{2}$	$2\frac{3}{4}$
	4 P. M.	21° 35′	87° 30′	22	$5\frac{1}{2}$
June 30th ...	10 A. M.	22° 0′	84° 0′	230	13
	4 P. M.	22° 0′	83° 30′	32	$5\frac{1}{3}$
July 1st	10 A. M.	22° 0′	81° 0′	162	9
	4 P. M.	22° 0′	79° 45′	80	$13\frac{1}{3}$
July 2nd......	10 A. M.	22° 30′	76° 0′	245	$13\frac{1}{2}$
	4 P. M.	23° 30′	74° 30′	120	20
July 3rd	10 A. M.	23° 30′	69° 45′	308	17
	4 P. M.	23° 45′	68° 45′	66	11

The atmospheric whirl was fully developed on the 27th and continued intact for at least seven days. During the latter part of its existence, it drifted across from the coast of Orissa to the coast of Cutch or Sind, and disappeared and probably broke up in the Arabian Sea.

The following table gives the lowest reading of the barometer at 10 A. M., the average barometric height at the same station, and the amount of the greatest known barometric depression at 10 A. M. on each day :—

		Lowest 10 A. M. barometric reading.	Average 10 A. M. barometric height. July 1st.	Depression.
June 29th..	Bay (Sandheads)	29·140	29·602	·462
June 30th..	Sambalpore	29·353	29·589	·236
July 1st ...	Seoni........................	29·463	29·624	·161
July 2nd...	Indore	29·410	29·662	·252
July 3rd ...	Bhuj	29·326	29·616	·290
July 4th ...	Kurrachee	29·380	29·589	·209

Hence the barometric depression at the Head of the Bay was very nearly half an inch. During its progress overland, the depression observed nowhere exceeded ·29″, and, as two of the stations named in the preceding table (Indore and Bhuj) were at a very short distance from the centre, it is almost certain that the barometric depression on land, after crossing the Orissa hills, never exceeded three-tenths of an inch. The decrease in the amount of the depression was evidently due to the greater frictional resistance encountered by the cyclonic disturbance on land than at sea.

An interesting feature of the storm was that its centre moved in a path which was approximately straight. The general direction of its path was N. 83° W. or almost due west.

The steady march in an almost constant direction across the Continent is very striking, when the varying character of the surface over which it passed is taken into consideration. During the first part of its existence, it passed slowly over the water surface at the Head of the Bay, where the resistance to its motion was a minimum. After crossing the Balasore coast, it advanced intact over the North Orissa hills, a very broken and irregular country, the highest points of which are from 3000 to 4000 ft. high. It then crossed the highlands of Sambalpore (where the hills which rise out from the plateau attain an elevation varying from 1,500 to 2,500 feet) and passed over the comparatively low plain of Chattisgarh, the average height of which is less than 1000 feet. Thence it advanced through the Balaghat, Seoni, Chhindwara, and Betul districts of the Central Provinces, which cover the extensive highlands known as the Satpura plateau, and have an average height of 2000 feet. It thence passed across the valleys of the Taptee and Nerbudda and the Vindhya Hills into Indore and Malwa. The average elevation of the Vindhyas in that portion over which the cyclonic storm advanced is 2,500 feet. From Malwa, it passed westwards over the low plains of Guzerat and Cutch, the highest points of which do not exceed 800 or 900 feet in height, and crossed the coast of Sind between Bhuj and Kurrachee into the Arabian Sea, where its existence for at least twelve to eighteen hours afterwards is proved by the direction of the winds at Kurrachee and the neighbouring stations.

The above briefly indicates the varied character of the surface over which it advanced. During a considerable portion of its course on land, the average elevation of the country over which it travelled exceeded 2000 feet. Much of the ground was very broken and irregular country, the higher points of which exceeded 3000 feet in elevation. The only inference that can reasonably be drawn is that the cyclonic circulation extended to a height very considerably greater than 2000 or 3000 feet. Hence it was a cyclone of high elevation, and the cyclonic circulation near the earth's surface was of comparatively little importance, and not necessarily an index or measure of the intensity of the cyclone.

The chief features of the motion of the storm centre have already been indicated in the history of the cyclone. Its very slow motion during and for some time after its formation, or from noon of the 27th to noon of the 29th, is remarkable. During this interval of 48 hours, its rate of motion apparently never exceeded 5 miles per hour, and during the greater part of the period it varied between 2 and 4 miles. After noon of the 29th, it rapidly increased its speed, and, during the greater part of the next 24 hours, moved with a velocity varying between 10 and 15 miles. When the centre approached the high hills and broken ground of North Orissa, it experienced a very considerable retardation. As already stated (*vide* page 99), it lost energy and shewed signs of disintegration. The rainfall decreased in amount, the barometric depression was much smaller, and the disturbance was diffused over a larger area, although it was less regular and weaker in character. This was, however, followed by an increase of its energy due to its drawing supplies of vapour from the Bombay coast. The preceding changes were reversed. During this interval, the average rate of its motion was about 8 miles per hour. Its velocity increased on the 1st of July, and, during the remaining three days of its existence on land, it moved with a fairly uniform velocity of about 15 miles per hour.

Another important feature was the amount and distribution of the rainfall during the cyclonic storm. At the Head of the Bay, the rainfall was torrential in character, more especially in the eastern and southern quadrants. The British Princess had "torrents of rain," the Saint Magnus "heavy continuous rain," the Star of Albion "thick continued rain," the Commillah "very heavy rain," and the Scottish Chieftain "heavy rain."

The following table gives the daily rainfalls during the period—June 28th to July 4th—at the meteorological stations situated in the area covered by the cyclonic storm during its existence on land :—

Stations.	June 1883.			July 1883.			
	28th.	29th.	30th.	1st.	2nd.	3rd.	4th.
Pooree	0·59	9·44	2·25	...	...	...	0·23
Saugor Island	...	0·17	0·36	...	...	1·08	3·82
Balasore	0·94	2·65	5·64	0·17	0·21	0·12	0·76
False Point	8·04	5·39	1·10	0·05	...	...	0·09
Cuttack	1·79	5·61	3·21	...	...	...	...
Sambalpore	0·05	2·47	7·00	1·84	...	...	0·80
Raipore	...	0·11	2·03	2·16	...	0·03	...
Nagpur	0·17	...	...	6·22	1·12	...	...
Seoni	1·22	0·45	...	5·65	0·17	...	...
Jubbulpore	0·12	0·12	0·65	1·62	0·05	0·06	...
Pachmarhi	1·29	...	0·02	5·99	1·36	...	0·05
Amraoti	0·85	...	...	4·60	3·65	...	...
Akola	0·42	...	...	2·17	6·85	0·03	...
Indore	0·07	...	...	1·01	0·89	0·02	...
Neemuch	0·04	...	1·47	0·86	0·21	0·09	...
Surat	3·64	3·51	0·52	0·11	1·78	3·76	0·35
Ahmedabad	0·18	0·05	...	...	0·76	3·88	0·79
Rajkote	...	0·46	...	0·13	...	10·05	0·40
Bhuj	0·90	0·54	0·02	...	0·48	3·78	1·56
Hyderabad	0·42	...	...	...	...	0·26	0·12
Kurrachee	...	0·37	...	0·17	0·06	0·12	1·65
Deesa	1·23	0·08	0·03	...	1·84	0·03	0·74
Mount Abu	0·45	0·18	0·14	2·16	2·64	1·31	2·22
Ajmere	0·07	...	...	...	0·43	0·10	...

As the rainfall was especially heavy in Orissa and the Central Provinces, I give the following table shewing the average district rainfall for each day of the period (June 27th to July 3rd) in these two divisions of the Empire, and illustrating more fully than the previous statement the distribution of the rainfall in a portion of the area covered by the disturbance. As daily returns of rainfall in Central India and the Bombay Presidency are not at my disposal, I am not able to give the corresponding data for the western portion of the course of the cyclone.

Division.	District.	No. of Stations.	27th.	28th.	29th.	30th.	1st.	2nd.	3rd.	Total.
Orissa	Pooree	5	0·23	2·58	6·15	1·83	0·01	nil.	0·06	10·86
	Cuttack	5	0·06	3·03	4·50	2·07	nil.	nil.	nil.	9·66
	Balasore	6	0·71	2·00	2·66	3·02	0·09	0·09	0·13	8·70
Chittasgarh	Sambalpore	5	0·32	0·31	0·74	1·17	1·05	0·09	0·01	3·69
	Raipore	4	1·74	nil	0·73	1·30	1·60	nil.	0·01	5·38
	Bilaspore	7	0·11	0·51	0·35	0·51	0·56	0·05	0·01	2·05
Nagpore	Nagpur	5	1·06	1·48	0·19	nil.	3·88	2·25	0·01	8·87
	Bhandara	3	2·81	0·57	0·04	2·71	2·99	0·25	0·05	9·42
	Wardha	4	1·29	0·01	nil.	1·82	1·91	nil.	0·01	5·04
	Balaghat	4	1·21	0·08	0·23	0·03	2·47	0·71	0·06	4·79
Jubbulpore	Jubbulpore	3	0·59	0·13	1·44	0·54	0·66	0·02	0·02	3·40
	Saugor	4	0·46	0·26	nil.	0·03	0·28	0·10	nil.	1·13
	Damoh	5	0·41	0·04	nil.	0·26	0·27	0·07	nil.	1·05
	Seoni	3	0·83	0·68	0·38	0·73	2·76	0·06	0·03	5·47
	Mandla	7	0·02	0·20	0·04	0·26	0·02	nil.	nil.	0·54
Nerbudda	Betul	7	0·55	0·19	0·12	0·43	3·91	0·91	0·04	6·15
	Chhindwara	3	1·15	0·37	nil.	1·03	4·16	0·06	nil.	6·77
	Hoshangabad	5	1·01	0·72	0·01	0·01	2·90	0·96	0·07	5·68
	Nursinghpore	4	0·05	0·68	0·15	0·88	0·53	0·19	nil.	2·48
	Nimar	3	0·06	0·44	0·14	nil.	0·64	5·62	0·38	7·28

The chief peculiarity in the distribution of the rainfall was the contrast between the large amounts registered at stations to the south of the line of advance, and those received at stations situated to the north of the path of the centre.

The following tables give the average district rainfall in the districts immediately to the south of the centre and those to the north of it for the same periods in the Central Provinces, Orissa, and the adjacent districts of South-west Bengal :—

Districts to north of centre.	Total average rainfall June 27th to July 1st.	Districts in Orissa to south of centre.	Total average rainfall of the same period.
24-Pergunnahs	2·50	Balasore	8·47
Midnapore	3·58	Cuttack	9·66
		Pooree	10·80

Districts in the Central Provinces to north of the path of the centre.	Total district rainfall June 30th to July 2nd.	Districts of the Central Provinces through which the centre passed, or which lay to the south of the path of the centre.	Total district rainfall June 30th to July 2nd.
Bilaspore...............	1·12	Sambalpore	2·31
Mandla..................	0·28	Raipore	2·90
Jubbulpore	1·22	Balaghat...............	3·21
Narsinghpore	1·80	Seoni	3·53
Damoh..................	0·60	Chindwara............	5·25
Saugor..................	0·41	Hoshangabad.........	3·87
		Nagpur	6·13
		Bhandara	5·75
		Wardha	3·73
		Betul	5·24
		Nimar..................	6·26

The centre, it should be remembered, passed westwards near the northern boundaries of Sambalpore and Raipore and thence across the centre of the Balaghat, Seoni, Chindwara, and Hoshangabad districts. It will thus be seen that the rainfall was distinctly heaviest at some distance to the south of the path of the centre, and that the rainfall in the northern half of the cyclonic area was barely twenty-five per cent. of the amount received in the southern half.

It is not possible to give similar details for Central India and the northern districts of the Bombay Presidency. The following table gives the rainfall at the nearest meteorological observatories to the north and south of the path of the centre, and a glance will show that there was the same marked contrast between the rainfall in the northern and southern portions of the storm area during the latter part of its course, when it was approaching the Arabian Sea.

Meteorological stations north of path of centre.	Total rainfall July 1st to 4th.	Meteorological stations south of path of centre.	Total rainfall July 1st to 4th.
Indore	1·92	Surat	5·80
Neemuch	1·16	Ahmedabad	5·43
Deesa	2·61	Malegaon	4·17
Ajmere..................	0·53	Bombay..............	1·09
Hyderabad	0·38	Rajkot	10·58
Kurrachee	2·00	Bhuj	5·82

The previous peculiarities to a certain extent explain the striking contrast between the force of the wind in different quadrants, more especially when the storm was advancing over the sea or low ground. This has already been briefly referred to in the account of the meteorology of the present storm on the 28th and 29th (*vide* pages 86 and 93). It was there shown that the Pemba, at a distance of at least 200 miles to the south-east of the centre, had strong south-westerly winds of average force 9, which were frequently interrupted by excessively violent squalls; and that the ships and light-vessels, so long as they were in the western and northern quadrants, had winds from directions between N. W. and N. E. varying in force from 1 to 5, but that, when they passed in to the opposite quadrants, they experienced very violent westerly or south-westerly winds of force varying from 9 to 11.

This feature is shewn most strikingly by the anemometric observations taken at Saugor Island during the storm, which have been referred to in page 95, but are now given in full in illustration of this feature :—

Date.	Hour.	Barometer.	Wind.		Weather and Sea.
			Direction.	Amount during preceding 2 hours.	
June 28th..	13	29·332	N. N. E.	37	Sea rough. Threatening.
	15	·389	N. E.	38	Dark gloomy weather.
	17	·287	N. N. E.	45	Thunder and lightning at distance.
	19	·289	N. N. E.	48	
	21	·327	N.	43	Raining.
	23	·286	N. W.	54	Strong wind.
June 29th..	1	·204	W.	53	Raining.
	3	·126	N. N. E.	27	
	5	·176	N.	37	
	7	·183	N.	44	Sea very rough.
	9	·171	E.	18	Dark gloomy weather.
	11	·166	E.	34	
	13	·126	N. N. E.	54	
	15	·129	W.	5	
	17	·162	S.	78	Sea tremendous.
	19	·242	S.	46	Severe gale of wind.

Hence a prominent feature of this, as of many of the storms of the rains in the Bay, was excessively violent westerly and south-westerly winds in the southern and eastern quadrants and comparatively feeble winds in the northern and western quadrants. The great inequality of the winds in different quadrants in the majority of storms of the rains has caused them to be considered as mere westerly gales by seamen. It is, however, now proved beyond doubt that they are cyclonic disturbances in which the winds are rarely violent and dangerous except in the south and east quadrants, where westerly and south-westerly winds of force 8 to 10 may be experienced, interrupted by squalls as violent in character, so far as can be judged from the accounts of sailors, as are felt in the largest and most intense cyclones of the Bay.

The following additional illustrations are given of the difference of the force of the wind in the different quadrants of the cyclonic disturbance. It should, however, be remembered that it is difficult to explain many of the differences in the amount of wind recorded at different stations apparently similarly situated with regard to the storm. They can only be ascribed either to erroneous reading of the anemometers by the observers at the stations under consideration, or to slight but influential differences in the geographical or topographical features of the districts or stations in which the meteorological observatories are situated. The latter appears to be the more probable explanation.

	Stations.	Direction.	Average wind velocity during previous 24 hours.	Stations.	Direction.	Average wind velocity during previous 24 hours.
28th...	Saugor Island ...	N. N. E.	8·0	False Point	W. S. W.	10·0
29th...	Saugor Island ...	E.	16·0	False Point	W. S. W.	23·0
30th	Seoni	N. W.	5·0	Raipur	W.	20·8
	Jubbulpore	W. N. W.	6·0	Cuttack	W.	10·0
	Nagpur	N. W.	9·0	Saugor Island	S. E.	19·0
				Balasore...............		
1st	Seoni	N. N. W.	15·0	Raipur	S. W.	20·0
	Jubbulpore	N. N. E.	8·0	Nagpur	W.	11·0
	Sutna	E.	21·0	Sambalpore	S. W.	1·4
				Cuttack	W.	7·0
2nd	Indore	N. E.	13·0	Surat	S. W.	17·0
	Jeypore	N. E.	7·0	Akola	W.	22·0
	Ajmere	E. N. E.	5·0	Amraoti...............	W. S. W.	43·0
	Saugor	N. E.	11·0	Khandwa	W. S. W.	13·0
				Nagpur	S. W.	18·0
3rd	Kurrachee.........	N. N. W.	18·0	Raipur	S. W.	33·0
	Bhuj	N. N. W.	3·0	Neemuch	S. S. W.	22·0
	Hyderabad	N.	8·0	Deesa..................	S. E.	17·0

The contrast between the winds in different quarters is also evidenced by the amounts of wind received at the same station from different directions. Thus, at Saugor Island, the amount of wind registered for the 24 hours preceding 4 P. M. of the 28th was 192 miles, and for the same period prior to 4 P. M. of the 29th it was 524 miles. The wind during these intervals was from N. E. During the next 24 hours, when southerly winds chiefly prevailed, 776 miles were recorded. Similarly, at Balasore, 240 miles were registered for the 48 hours preceding 10 A. M. of the 29th, and 576 miles during the succeeding 48 hours (with southerly winds). At Rajkot, the amount of north-westerly winds during the 24 hours preceding 4 P. M. of the 2nd was 272 miles, and at Bhuj 390 miles. During the next 24 hours, when south-westerly winds blew at these stations, 391 and 760 miles respectively were registered. The amount of wind (mainly from N. W.) recorded at Kurrachee for the 24 hours preceding 4 P. M. on the 3rd was 406 miles. For the succeeding 24 hours, when easterly winds prevailed, 933 miles were registered.

There are other and less important features, to which it will be sufficient to refer briefly. One of these was the comparative smallness of the storm area proper. If we estimate it by the area in which strong winds prevailed and heavy rain fell, it almost certainly did not exceed 250 miles in length by 100 to 150 miles in breadth, at any time during its passage across the continent. The smallness of the storm area and the slight barometric depression in all storms of the rains are cognate features due probably to the peculiar conditions of their formation, as cyclones of high elevation. Another feature was the very great irregularity of the winds. This was shown (at Saugor Island, for instance) by intervals of comparatively feeble winds during the middle of the storm, and also by the apparent occurrence of much feebler winds at stations nearer to the centre than at those at a greater distance. As, however, anemometric observations are confessedly not intercomparable, it is not possible to establish the fact of this irregularity on such evidence.

APPENDIX I.

Extract from the Log of the F. L. V. Comet, giving observations during Storm of June 27th to 30th.

Date.	Hour.	Wind.		Barometer reduced.	Weather.	Remarks.
		Direction.	Force.			
28th of June 1882.						Commences with dirty threatening weather. Lightning all round the horizon. A long heavy swell from E. S. E. 3 A. M. Squally with passing showers, ugly appearance of weather.
	8	N.	4	29·321	Thunder.	8 A. M. Weather the same. A large circle round the sun.

Date.	Hour.	Wind. Direction.	Wind. Force.	Barometer reduced.	Weather.	Remarks.
28th of June 1883.	9	N. N. E.	4	29·327		
	10	N. E.	4	29·327	Raining.	
	11	...	3to5	29·308		
	12	...	4to6	29·277	Thunder.	Noon. Every appearance of a cyclone. Heavy confused sea, with squally weather, and passing showers and thunder.
	13			29·266		
	14	...	6to5	29·252	Thunder.	
	15			29·241		
	16	...	5	29·215	Squally.	4 P. M. Wind and weather the same. Observed the sky of dark red appearance to the southward and eastward.
	17			29·220		
	18	N.	5	29·226	Squally.	
	19			29·230		
	20	...	5	29·253	Thunder.	8 P. M. Wind and weather the same.
	21	...		29·260		
	22	N. N. W.	5	29·236	Thunder.	
	23			29·197		
	24	N. W.	6	29·195	Thunder.	Midnight. Wind and weather the same. Barometer still falling, every appearance of heavy weather. Thunder and lightning all round the horizon.
29th of June 1883.	1	W. N. W.	6	29·148		Commences with dirty and very threatening weather. Lightning all round the horizon. A very heavy sea running from S. E. Winds variable.
	2	N. N. E.	6	29·070	Raining.	
	3	...	6	29·094		
	4	...	5	29·074	Thunder.	
	5	N. N. W.	5to6	29·112		
	6	...	6	29·126	Squally.	
	7	...	6	29·138		

Date.	Hour.	Wind. Direction.	Wind. Force.	Barometer reduced.	Weather.	Remarks.
29th June 1883.	8	W.	6	29·120	Squally.	8 A. M. Wind and weather the same, but sea increasing. Wind shifting all round the compass, from west through south and east, accompanied with terrific rain squalls.
	9			29·122		
	10	S. S. E.	3	29·140	Squally.	
	11			29·086		
	12	E. N. E.	7	28·998	Raining.	Noon. Blowing a furious gale with terrific heavy squalls. Sea still increasing and barometer falling.
	13	N. N. W.	8	28·989	Raining.	
	14	W.	8	29·068	Raining.	
	15	...	8	29·088	Raining.	
	16	S. W.	9	29·108	Raining.	4 P. M. Wind and weather the same.
	17	S. S. W.	9	29·184	Raining.	
	18	S. W.	9	29·184	Raining.	
	19	S. S. W.	9	29·164	Raining.	
	20	...	9	29·247	Raining.	8 P. M. Wind and weather the same.
	21	S. S. W.	9	29·288	Raining.	
	22	...	9	29·306	Raining.	
	23	...	9	29·320	Raining.	
	24	...	9	29·326	Raining.	Midnight. Weather more moderate, less wind and sea.
30th of June 1883.	1	S.S.W.	7	29·324	Raining.	Commences with moderate gale and high sea but better appearance in the weather.
	2	,,	7	29·336	Raining.	
	3	,,	7	29·346	Raining.	
	4	,,	7	29·353	Raining.	
	5	,,	7	29·356	Raining.	
	6	,,	7	29·361	Overcast.	
	7	S.	8	29·365	Overcast.	
	8	,,	8	29·415	Raining.	8 A. M. Observed a large circle round the sun.
	9	,,	8	29·440	Raining.	
	10	,,	8	29·474	Overcast.	
	11	,,	6	29·486	Overcast.	
	12	,,	6	29·464	Raining.	Noon. Strong breezes with blinding rain squalls.
						P. M. Weather fine. Heavy swell from southward.

CHAPTER IV.

The History of the Storm of the 10th to 15th November, 1883.

The present storm was generated in the Gulf of Martaban, after the north-east monsoon had been established for more than a month over the north and centre of the Bay. The rains of the south-west monsoon terminated prematurely in Bengal in the last week of September. It is a well-known fact that the commencement of the north-east monsoon on the Coromandel coast is due to the recurvature of the south-west monsoon winds over the south and centre of the Bay. The lower atmospheric current, which is from south-west in the extreme south, at that period changes, through south-east and east in the centre of the Bay, to north-east on the Madras coast. The south-west monsoon current of the year 1883 was unusually weak, and, when it retreated from Bengal, it recurved immediately, and north-east winds were established on the Madras coast in the first week of October. Hence the north-east monsoon rains set in over the Madras Presidency a week or ten days earlier than usual. They gave general, and unusually heavy, rainfall, as is shown by the following table of rainfall at eight of the more important stations in that Presidency.

Rainfall at eight stations of the Madras Presidency, October 1883.

Stations.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Coconada ...	...	...	...	...	...	...	...	...	...	...	...	...	1·62	2·35	0·10	0·23	1·50
Masulipatam	0·30	...	...	0·18	0·13	...	...	0·02	...	...	...	...	0·75	2·44	...	1·47	0·31
Madras	...	4·88	0·20	0·34	...	0·01	0·08	...	...	...	0·48	0·36	1·81	1·51	1·06	3·40	0·57
Salem...	...	...	2·75	...	0·20	0·15	...	...	...	0·01	1·05	0·75	0·14	0·66	1·04	1·83	0·80
Nellore	...	0·50	0·35	...	...	...	0·05	0·15	...	...	...	0·50	0·60	4·45	0·95	0·45	2·20
Madura	...	...	0·05	0·04	0·35	...	...	...	0·45	...	...	2·10	0-26	0·20	2·16	0·34	0·13
Trichinopoly	...	...	0·43	1·55	...	...	...	...	...	0·70	...	...	0·10	0·26	0·46	0·63	...
Tanjore	...	1·04	...	0·47	...	...	...	...	...	...	...	0·06	...	1·47	0·83	0·10	...

Stations.	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total.	Average.
Coconada ...	0·66	...	...	...	...	...	...	...	...	...	...	0·90	0·25	5·70	13·31	8·60
Masulipatam	0·28	...	0·21	0·05	0·01	...	0·24	0·03	...	...	0·03	1·25	0·70	4·95	13·35	8·58
Madras	0·16	0·10	0·12	0·37	...	...	...	0·02	0·16	2·89	2·12	1·54	...	...	22·18	10·80
Salem...	...	1·27	...	0·08	...	...	...	...	0·40	0·35	...	...	...	0·96	12·44	7·22
Nellore	0·30	...	...	...	...	...	...	...	0·15	...	...	2·55	8·20	3·00	24·40	9·84
Madura	...	0·41	...	0·07	...	0·50	...	1·35	...	0·25	0·12	...	...	0·20	8·98	8·88
Trichinopoly	...	2·47	...	0·46	...	...	...	...	...	0·10	0·09	...	...	0·69	7·94	7·86
Tanjore	0·08	0·06	1·70	...	...	...	...	...	0·20	0·60	...	0·05	...	0·20	6·86	5·60

Rainfall at eight stations of the Madras Presidency, November 1883.

Stations.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Coconada....	6·45	3.25	0·22	...	0·05	...	...	...	...	...	...	...	...	...	...
Masulipatam	12·56	2.29	...	...	...	...	...	...	...	...	...	...	...	...	...
Madras	1·87	2·46	2·12	1·15	0·27	0·12	0·14	0·41	0·02	...	...	...	...	...	...
Salem...	0·73	0·94	0·27	1·16	0·16	...	0·02	0·01	0·75	0·06	...	...	...	...	...
Nellore	1·00	1·60	0·45	0·60	0·05	0·95	...	...	...	...	...	...	...	...	...
Madura	1·95	1·80	1·08	3·00	...	0·20	0·04	0.03	...	0·33	2·00	...	...	...	...
Trichinopoly	...	0·06	0·25	1·96	...	...	1·44	...	0·10	...	...	...	...	...	...
Tanjore	...	0·27	0·08	1·78	1·02	0·06	...	0·85	...	...	...	...	...	...	...

Stations.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total.	Average.
Cocanada ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9·97	3·59
Masulipatam	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14·85	4·11
Madras	...	...	0·30	4·75	1·31	...	...	...	...	...	...	...	...	...	...	14·92	13·40
Salem...	...	...	0·25	0·01	...	...	...	...	...	...	...	...	...	...	...	4·36	2·65
Nellore	...	...	0·55	0·70	...	...	...	...	...	...	...	...	...	...	...	5·90	10·17
Madura	...	...	0·20	...	...	0·35	...	...	...	...	...	...	...	...	...	10·98	5·37
Trichinopoly	...	1·26	...	0·08	0·07	...	...	...	...	...	...	...	...	...	...	5·22	5·23
Tanjore	...	...	2·90	0·02	0·17	0·48	...	...	...	...	...	...	...	...	...	7·63	5·54

The preceding table shews that rain fell more or less continuously during the whole of October and until the 4th of November, after which a few showers fell until the 9th and 10th, when rain entirely ceased for several days. After the 4th, the north-east monsoon current decreased in strength, as is shewn by the following return of the wind observations on the Madras coast :—

	November average.		1st.		2nd.		3rd.		4th.		5th.		6th.		7th.	
	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.	Dir.	Amount.
Vizagapatam.	N83°E	2·5	N	2	N	1	N	3	N	3	NE	3	N	4	NE	2
Masulipatam.	N56°E	6·0	NNE	9	SE	9	ENE	6	ENE	9	ENE	7	NE	8	NNE	7
Madras. .	N24°E	6·8	WSW	5	SE	6	SE	7	NNE	5	N	5	N	6	E	4
Negapatam.	N37°E	5·6	SW	?	SW	0	WNW	?	NE	?	NNE	2	NE	4	NNE	6

The preceding observations shew that the north-east winds on the Madras coast were diminishing in force. It is, therefore, probable that the south-west monsoon current over the south of the Bay was much weaker, and that, instead of recurving and blowing strongly on the Madras coast, it was continued over the centre of the Bay as light and variable winds. This supposition is, it will be seen, confirmed by the accounts of the weather contained in the logs of the vessels navigating the Bay to the west of the Andamans at that time. The cyclone did not commence to form until the 9th of November, but the meteorology of the Bay on the 7th and 8th is given to shew the character of the weather prior to the storm.

7th November.—The barometer was oscillating at the time slowly over the whole of India, and the distribution of pressure was almost identical with that which had obtained for the previous three or four days, and differed very slightly from the normal. A slight rise of the barometer occurred during the previous 24 hours at the great majority of stations. The barometric changes were, however, of no importance. The barometer was highest in Scind and Rajputana, where the readings averaged 30·05″, and was lowest over the south of the Bay, where, as shown by the returns of Negapatam, Trincomalee, Port Blair, and Nancowry, it was slightly below 29·95″. The differences of pressure were hence comparatively small over the whole area.

The following table gives the 10 A. M. readings of the barometer, reduced to sea level and for temperature, at the more important meteorological stations around the Bay :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Stations.	Barometer at 10 A. M. reduced to sea level.
Saugor Island	30·028	Chittagong	29·994
False Point	30·028	Akyab	29·975
Gopaulpore	30·016	Diamond Island	29·970
Vizagapatam	30·014	Port Blair..............	29·945
Madras	30·013	Nancowry...............	29·943
Negapatam	29·948	Moulmein	29·958
Trincomalee	29·951	Rangoon	30·004(?)
		Mergui	29·956

The gradients over the Bay were normal in character, pressure decreasing from north to south. The total barometric difference was slightly less than nine-hundreths of an inch. The average barometric difference between the north and south of the Bay in the middle of November is ·075″. The distribution of pressure over the Bay on the 7th was very approximately normal.

Over the greater part of India, including the whole of Northern and Central India and the North Deccan, the weather was fine and skies clear. These were clouded in Southern India, more especially on the Coromandel coast, where they were generally overcast. Over the whole of the Indian land area, winds were normal in direction. North-westerly to westerly winds prevailed over the greater part of the Gangetic plain, and northerly winds in the Gangetic Delta. Along and near the Coromandel coast, north-easterly humid winds were giving moderate showers of rain. In Burmah, winds varying between east and north-east prevailed. The weather in every part of the Indian area, so far as can be judged from the land observations, was of the usual November, or cold weather, type. There were no signs of the existence of any atmospheric disturbance either in the land or adjacent sea area.

The only indications of the probable early occurrence of stormy weather in the Bay were the lightness and variability of the winds over the centre and south of the Bay, and the rapid and steady decrease in the rainfall of the Madras Presidency.

The following table gives the chief observations taken during the day at the stations subsequently affected by the cyclone:—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction.		Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			10 A. M.	4 P. M.				
Nancowry	29·943	+ ·041	S.	S.S.W.	4	6	0·62	
Port Blair	29·945	+ ·003	S. E.	S. E.	4	7	...	
Diamond Island	29·970	+ ·033	E. N. E.	E.	5	5	0·11	Thunder.
Akyab	29·975	+ ·027	E. N. E.	W.	2	1	...	Fine.
Chittagong ...	29·994	+ ·027	N.N. E.	E.	2	1	...	Fine.
Tounghoo	29·969	+ ·081	N. W.	N. W.	?	10	...	Threatening weather
Bassein	20·977	+ ·037	E.	S. E.	4	10	0·02	Gloomy.
Rangoon	30·004?	+ ·068	E. N. E.	E.N.E.	3	10	0·28	Cloudy.
Moulmein	29·958	+ ·073	E.	N.NW	2	9	...	Cloudy.
Mergui	29·956	+ ·015	N.	Calm	1	6	...	Cloudy.

The information relating to the state of the weather in the Bay on the 7th of November, contained in the logs of vessels navigating the Bay at this period, is given in the following statement:—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
Mount Stuart	Noon	11° 50′	91° 50′	29·925	E.	...	Passing clouds towards noon, heavy rain clouds all round, but cleared away towards sunset. Weather unsettled-looking.
	4 P. M.				E.	2	
	8 P. M.				variable.	3	
	Midnt.				S.	...	
KwangTung	4 A. M.			29·851	S. E.	2	
	8 A. M.			·909	N. E.	2	Fine weather throughout.
	Noon	12° 33′	93° 6′	·943	N. E.	2	
	4 P. M.			·921	N. E.	2	Sea smooth.
	8 P. M.			·909	N. E.	2	
	Midnt.			·906	S. W.	2	

Vessel.	Hour.	Latitude. N.	Longitude.	Probable reduced barometer.	Wind.		Remarks.
					Dir.	Force.	
Frank Stafford	4 A. M.				N.	4	Fine weather and smooth sea.
	Noon	19° 43′	88° 15′	29·980	N.	4	
	Midnt.				N.	4	
Parthenope	Noon	20° 10′	89° 51′	29·975	N.	Moderate	A. M. Light unsteady breeze, fine, and clear. Noon. Wind very unsteady. Current perceptible, setting to the S. W. 4 P. M. Moderate breeze. 8 P. M. Light breeze and clear, with frequent lightning.
	Midnt.				N. W.	Light.	
Breadalbane	Noon	20° 55′	88° 8′	29·975	N. N. E.	0 to 1	Calm and variable airs throughout, current to S. W.
	4 P. M.				NE by N	2 to 3	Sea moderate. No rain.

The information respecting the weather in the Bay is very limited, and confined to extracts from the logs of five vessels, and to the observations at Port Blair, Nancowry, the coast stations, and on board the light vessels near the entrance to the Hooghly.

Three vessels, the Frank Stafford, Parthenope, and Breadalbane, were near the Head of the Bay. The weather was fine, the sea smooth, and winds light and unsteady. These varied between N. E. and N. W. in direction, and did not exceed force 4 at any time during the day. At Port Blair, the sky, which had been almost clear on the 4th, 5th, and 6th, was clouding over. The air was unusually clear in the morning, but the weather became cloudy and gloomy in the afternoon. No rain fell on this day, nor had any fallen since the 4th. The winds also were extremely light. Only 100·6 miles were registered for the 24 hours preceding 4 P. M., the smallest amount in 24 hours recorded during the month.

The sky had been densely clouded at Nancowry for some days past, and rain in moderate amounts had been recorded on every day. On the 6th ·62 inch fell with S. S. W. winds. During the first three days of the month, the winds were from south-east, the normal direction in November, when the south-west monsoon is recurving over the centre of the Bay, and giving north-easterly monsoon winds and rain to the Coromandel coast. The amount of wind registered at Nancowry on each day of the first week of the month, is given in the following table :—

	Total wind amount of the 24 hours previous to 4 P. M.	Rainfall at 6 P. M. of the preceding 24 hours.	Wind direction 10 A. M.
1st	46·7	0·47	S. E.
2nd........................	38·2	0·21	S. E.
3rd	44·0	2·86	E. S. E.
4th	19·5	0·41	S. W.
5th	18·8	0·96	S. W.
6th	17·1	0·62	S. W.
7th	125·4	1·14	S. S. W.
Average October	149·7	...	S. 50° W.
„ November ...	117·2	...	S. 29° E.

This shows that, in consequences of atmospheric actions, the nature of which can only be conjectured, the air motion over the south of the Bay was unusually and remarkably feeble during the first week of the month. The moist current advancing northward, instead of curving through south-east and east and arriving as north-east winds charged with vapour on the Coromandel coast, was exceedingly weak for some days in the neighbourhood of the Nicobars. It had also shifted in direction on the 4th, and was proceeding from the south-west directly into the Martaban Gulf. Rain also began to fall in increasing amounts over this and the adjacent parts of the Bay.

The ship Mount Stuart was advancing northwards, a little distance to the west of the Andamans. She was in Lat. 11° 50′ N. and Long. 91° 50′ at noon, and during the day had very variable winds commencing from N. E. by N. and ending at S. The weather was fine, but the air was charged with moisture. This is shown by the fact, noted by the Captain, that, during the hotter part of the day, when there is undoubtedly much upward movement of the air, heavy rain clouds formed all around, but cleared away again towards sunset.

The Kwang Tung, on the other hand, was to the east of the Andamans in Lat. 12° 33′ N. and Long. 93° 6′ E. She had fine weather throughout, with light and variable winds during the day of force 2. The wind shifted from S. E. to N. E. and thence to S. W. during the day.

Hence, so far as can be judged from the various meteorological returns, light winds and fine weather prevailed over the greater part of the Bay. The usual change in the direction or recurvature of the south-west monsoon current (which gives a feeble cyclonic circulation to the air over the centre and south of the Bay) was not only much weaker than usual, but was suspended over a part of the area in the neighbourhood of the Nicobars and Andamans, where very light unsteady winds had prevailed for the previous two or three days. There is, however, no evidence in the meteorology of this day of the existence of any local cyclonic circulation, such as might form the initial stage in the development of a cyclonic disturbance or storm.

The observations at Moulmein and Mergui confirm the previous statements, and prove the existence of light variable winds, chiefly from the east and north, on the east coast of the Martaban Sea.

8th November.—During the preceding 24 hours, a rapid fall of the barometer had taken place in the Punjab. The amount of the fall was ·26″ at Mooltan, ·13″ at Quetta, and ·12″ at Dera Ismail Khan and Lahore.

It will be seen from the meteorology of the 9th and 10th that this fall was the first indication of the occurrence of a cold weather or north-east monsoon storm in Upper India. It is during these storms that a large portion of the snowfall of the higher Himalayas takes place. In consequence of this rapid fall, pressure was lowest over the Punjab. Sudden and large changes of pressure are a frequent feature of the cold weather in the Punjab. It is not yet quite certain whether the formation of these Punjab areas of low pressure commences simultaneously over the Western Punjab and the adjacent districts of Afghanistan or Belochistan. This appears to be the most probable explanation, but it is not unlikely that some may occasionally form much further to the west, and pass through Afghanistan or Belochistan into the Punjab or Sind. It will, however, presently be seen that this considerable disturbance in the Punjab exercised no appreciable action on the atmospheric circulation in the Bay of Bengal.

The distribution of pressure was somewhat complicated over India itself. Pressure was lowest in the Indus Valley. A broad band of high pressure stretched down the middle of India from Ajmere to Secunderabad, whilst pressure was approximately uniform over the Bay.

The changes of pressure were not accompanied by any immediate marked change in the wind or weather. Skies were clear, and weather fine and dry over all parts of India, except South Burmah and Southern India (more especially the Coromandel Coast), where skies were overcast and occasional showers continued to be received. The amounts which fell at the various rainfall registering stations were very small.

The only alteration in the wind directions that deserves notice occurred at Diamond Island and Akyab, where the wind had shifted round to south-east. This of course indicated the further northward extension of the south-west monsoon current which had commenced on the 4th at Nancowry.

The following table gives the 10 A. M. reduced barometric readings of the recording stations on the coast of the Bay :—

Stations on west coast of the Bay.		Stations on east coast of the Bay.	
Stations.	Barometer 10 A. M. reduced to sea level.	Stations.	Barometer 10 A. M. reduced to sea level.
Saugor Island	29·977	Chittagong	29·953
False Point	29·983	Akyab	29·930
Vizagapatam	29·976	Diamond Island	29·930
Madras	29·983	Moulmein	29·928
Negapatam	29·978	Port Blair	29·936
		Nancowry	29·922

The differences of pressure along the west coast were much smaller than on the 7th, and pressure was very approximately uniform. It was slightly lower at the east coast stations, but, even there, the differences were extremely small.

The following table gives the 10 A. M. observations at stations in the neighbourhood of the area in which the storm was generated :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction. 10 A. M.	Wind direction. 4 P. M.	Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
Nancowry	29·922	— ·021	S. W.	S. W.	7	10	1·14	
Port Blair	29·936	— ·009	W. S. W.	W. S. W.	5	9	0·18	
Diamond Island	29·930	— ·040	E. S. E.	S.	13	10	2·35	Thunder.
Akyab	29·930	— ·045	S. S. E.	?	2	6	0·16	
Chittagong ...	29·953	— ·041	N.	E. S. E.	1	0	...	
Toungoo	29·980	+ ·011	S. W.	S. E.	?	10	...	
Bassein	29·941	— ·036	S. E.	S. S. E.	4	10	0·10	
Rangoon	29·965	— ·039	E.	S. S. E.	2	10	0·41	Showery.
Moulmein	29·928	— ·030	S. E.	N. W.	2	7	...	Thunder.
Mergui	29·965	+ ·009	E.	S.	2	10	0·25	

The information relating to the meteorology of the Bay on the 8th is given in the following table :—

Vessels.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Mount Stuart	4 A. M.				S. to W.	2 to 3	Sea smooth. Passing showers during day. Heavy black clouds all round, with momentary puffs from N. W., and smart showers towards midnight. There was lightning in the N. W. during the morning. Midnight. Weather was a little squally.
	Noon	12° 17′	92° 00′	29·925	...	1 to 2	
	4 P. M.				W to SE.	1	
	Midnt.				W to NW	2 to 4	
Scottish Hill	Noon	12° 31′	89° 25′	29·920	E. to W.	1	Light airs and calms.
	4 P. M.					0	Wind very variable.
	8 P. M.					0	Sky dull lead colour.
	Midnt.			29·900		1	
Kwang Tung	4 A. M.			29·901	N. W.	2	
	8 A. M.			·926	N. W.	2	
	Noon	15° 11′	92° 6′	·893	N. W.	2	Smooth sea.
	4 P. M.			·901	N. W.	4 to 5	
	8 P. M.			·871	N. W.	do.	
	Midnt.			·903	N. W.	do.	
Frank Stafford.	4 A. M.				NW by N	2	Fine weather, smooth sea.
	8 A. M.				North.	2	Very sharp lightning in the S. E. during the night.
	Noon	20° 16′	90° 28′	29·975	N. N. W.	2	
	8 P. M.				N. N. W.	1	
	Midnt.				N. N. W.	0	
Breadalbane	Noon	21° 00′	88° 18′	29·975	N.		Sunrise. Moderate breeze from N., dying away in the afternoon to a calm.
Parthenope	Noon	21° 2′	88° 52′	29·975	N. W.	gentle.	A. M. Light breeze, fine and clear. 8 A. M. Moderate breeze and hazy. Noon. Less wind, current setting west. 4 P. M. Light airs. 8 P. M. Calm. Midnight. Gentle breeze and clear.
	Midnt.				N. by E.		

The Nancowry returns prove that the south-west winds in the neighbouring part of the Bay began to increase in strength. The sky was overcast during the day, and 1·14 inches of rain were registered for the 24 hours preceding 1 P. M. The wind during the previous night had shifted round to W. S. W. at Port Blair, and blew steadily during the day, and somewhat more strongly than on either of the previous two days. The sky had clouded over, and rain in small amounts began to fall. ·18 inch was recorded at 4 P. M.

The weather was slightly disturbed in South Burmah. Passing showers fell during the day, and thunderstorms occurred in one or two cases. East-south-east winds set in at Diamond Island and at Rangoon. In the interior of Burmah, winds were not so steady as they had been previously. The sky was overcast at Mergui, winds were light and variable, and veered from east to south during the day.

The prevalence of S. W. winds at Port Blair and Nancowry, and of E. and S. E. winds at the Burmah stations, shews that there was on this day no well-defined cyclonic circulation, or centre of large disturbance, in the Martaban Gulf.

The logs of the vessels in the Bay for the day indicate that similar conditions obtained to those of the preceding day.

The Frank Stafford, Parthenope, and Breadalbane were at the Head of the Bay near the entrance to the Hooghly. They experienced fine weather, light winds and calms, and a smooth sea. The Kwang Tung had steamed to the north-west during the previous 24 hours, and was in Lat. 15° 11′ N. and Long. 92° 6′ E. at noon. Her log shows that there was no perceptible current in this part of the Bay at this time, an almost conclusive proof of the absence of any strong atmospheric cyclonic circulation in the neighbourhood. The ships Mount Stuart and Scottish Hill were a little to the west of the Andamans. The former was in Lat. 12° 17′ N. and Long. 92° E. Her log states that the sea was smooth, but that the weather was becoming unsettled. She began to experience puffs or slight squalls from the north-west. The sky during the day was covered with dense black clouds, and occasional showers fell, which became heavier and "smarter" as the day advanced. The winds were very variable, veering from S. through W. thence to S. E. and back to W. and N. W. The log of the Scottish Hill, which was about 180 miles to the west of the Mount Stuart, gives similar information. The winds were very light and variable, veering round the compass, the sky was heavily clouded, and the weather dull and gloomy.

Hence the various observations indicate the continuance and slight development of the conditions which, according to our experience of the meteorology of the Bay, precede the formation of cyclonic storms. On the other hand, they give no evidence of the existence at this time of a cyclonic circulation in the Martaban Gulf. South-westerly winds were increasing in force over the south-east of the Bay, and were being continued much further north than is usual in the month of November. To the west of the Andamans, winds were exceedingly light and variable, and such as to show that the south-west winds advancing northwards were not being continued in that direction near the earth's surface. The clouding over of the sky, the commencement of showers increasing in intensity and accompanied with slight squalls, indicate clearly that ascensional movement on a large scale was commencing over that area, and giving rise to its usual result when it is partly fed and maintained by a moist current, namely, rainfall increasing in intensity, which, by a known law of rainfall, tends to become concentrated over a limited area.

9th November.—There are no new features of interest in the meteorology of the Indian land area. Pressure continued to give way in all parts of India. The decrease was greatest in Sind, Rajputana, and the Punjab. The area of barometric depression over the Indus valley was now very distinctly marked. It had as yet exercised no marked influence in the weather of Upper India. The winds were, however, drawing round in the Punjab and neighbouring districts, and indicated a feeble cyclonic air circulation over Upper India. The ascensional movement which necessarily accompanied it, had not given rise to the formation of cloud, except over the North-Western Himalayas.

Over the whole of Bengal and the North-Western and Central Provinces, the air motion was very slight, averaging only 1 to 2 miles per hour.

In Southern India the weather conditions were unchanged. Cloudy skies continued in the Madras Presidency, and a few occasional showers of no importance were received.

The observations at the coast stations of the Bay of Bengal present the same features as hitherto. The baric gradients were apparently normal in direction, but somewhat smaller than usual, and the differences of pressure comparatively small. The most important feature was the weakness of the north-easterly winds on the Coromandel coast. This is shown by the following statement:—

Stations.	Amount of wind in miles per hour since 10 A. M. previous day.	Average daily amount of wind (miles per hour) in November.
Vizagapatam	2	2·5
Masulipatam	2	6·0
Madras	5	6·8
Negapatam	3	5·6
Trichinopoly	1	4·6
Madura	3	4·1

The information respecting the weather in the Bay is as hitherto meagre.

The following are the observations taken at the land observatories in the neighbourhood of the cyclonic disturbance :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction.		Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			10 A. M.	4 P. M.				
Nancowry	29·897	—·025	S. W.	S. W.	8	9	2·02	
Port Blair......	29·894	—·042	W.	W. S. W.	7	9	0·17	Gloomy.
Diamond Island	29·900	—·030	E. S. E.	E. S. E.	10	5	1·41	Fine.
Chittagong ...	29·921	—·032	E. N. E.	N. N. W.	1	2	...	Fine.
Tounghoo	29·873?	—·107?	N. W.	N. W.	?	10	1·10	Thunder storm.
Bassein	29·924	—·017	E. S. E.	S. E.	5	10	0·17	Gloomy.
Rangoon	29·942	—·023	E. S. E.	S. S. E.	4	10	0·69	Showery
Moulmein	29·898	—·030	N. E.	E. S. E.	2	1	0·71	Showery
Mergui	29·995?	+·030?	S. S. E.	S. S. E.	2	10	...	Gloomy.

The Nancowry returns shew that a fall of ·03″ had occurred in the barometer. The winds were slightly stronger, but were only blowing with an average velocity of 8 miles per hour, the normal rate at that station in November. The sky was overcast, and rain continued to fall in moderate amounts. 2·02 inches were registered for the 24 hours preceding 10 A. M.

Heavy rain was apparently falling at this time to the north-east of the Nicobars and to the east of the Andamans. There is no direct evidence of this statement. The first indications, however, of cyclonic motion are presented by the Port Blair observations of this day. The barometer was falling at that station, the sky was, as on the 8th, densely clouded, and heavy rain began to fall in the afternoon and evening. The wind shifted round to west at 10 A. M. and to W. S. W. at 4 P. M. On the opposite coast of the Martaban Gulf, the sky was overcast, but little rain fell. In South Burmah, the weather was fine with passing clouds, which gave occasional showers. The sea was slight at Diamond Island. Hence the evidence is fairly complete that there was, as on the 8th, no definite cyclonic circulation, although there were slight indications of its commencement.

The shift of wind at Port Blair, and the occurrence of rainfall with squalls to the west of it, render it almost certain that the usual actions, which initiate the formation of an atmospheric whirl on a large scale, were now commencing. The meteorology of the 10th will show that the formation probably proceeded slowly during the afternoon and night of the 9th, but afterwards with increasing rapidity.

The meteorological information relating to the weather in the Bay of Bengal on the 9th, extracted from the logs of vessels, is tabulated below :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds.		Remarks.
					Dir.	Force.	
Scottish Hill	Noon	13° 1′	89° 42′	29·920	N. W.	1	Light airs and calms.
	4 P. M.				W.	0	Very sultry, clouds in light masses.
	8 P. M.				N. N. W.	0	Sky dull lead colour.
	Midnt.			·890	W.	2	
Mount Stuart	Noon	13° 8′	92° 2′	29·875		0	Sky overcast with heavy clouds all round. Weather unsettled. There was a good deal of lightning in the sky this morning and towards midnight, mostly in the N. W. Midnight. Weather showery.
	8 P. M.				N. E.	1 to 3	
	Midnt.				E. S. E.	1 to 2	
Kwang Tung	4 A. M.			29·924	N. E.	5	
	8 A. M.			·911	N. E.	5	Current during the 24 hours, S. 12° E. 15 miles.
	Noon	17° 37′	90° 20′	·936	N. E.	5	
	4 P. M.			·883	N. E.	5	Sea smooth.
	8 P. M.			·856	N.	5	
	Midnt.			·891	N. E.	5	
Satara	Noon	Anchored at Gopaul-	pore Roads.	29·950	E. by N.	2	Light breeze and fine clear weather.
	4 P. M.			·840	...	1	Light airs and fine.
	8 P. M.			·880	...	1	
	Midnt.			·870	N E by E	3	Gentle breeze and fine.
Frank Stafford.	4 A. M.				N.	2	
	8 A. M.				...	2	Fine and smooth sea.
	Noon	21° 03′	90° 10′	29·935	...	0	
	4 P. M.				N. W.	2	
Parthenope	Noon	Near the	Sand heads.	29·930	N.	Moderate	A. M. Light breeze and clear. Noon. Moderate breeze and hazy.
Breadalbane	Noon	Near the	Sand heads.	29·935	N.		Calms and light airs from north throughout.
	4 P. M.				N.	1	Sea smooth and smart showers in the latter part of the day.
	8 P. M.				Calm.	0	

The Parthenope and Breadalbane, near the Sand Heads, had light airs and calms during the day. The ship Frank Stafford (in Lat. 21° 3′ N. Long. 90° 10′ E.) experienced gentle northerly winds with fine weather and a smooth sea.

The S. S. Kwang Tung had advanced 200 miles to the N. W., and was at noon in Lat. 17° 37′ N. and Long. 90° 20′ E. She experienced steady north-east winds of moderate force (5) during the day. The ships Mount Stuart and Scottish Hill were proceeding very slowly up the Bay, and had only made about 50 miles during the 24 hours preceding noon. The former was in Lat. 13° 8′ N. and Long. 92° 2′ E., and experienced similar weather to that of the preceding day. The sea was smooth as hitherto. The sky was covered with dense clouds, and heavy showers fell, more especially in the afternoon. The Scottish Hill was in the same latitude, but 160 miles further to the west. She had calms during the greater part of the day. The weather was very sultry. The air was apparently almost saturated with moisture. The sky was covered with clouds, and had an ominous appearance suggestive of bad weather.

The observations of the 9th shew that no atmospheric whirl had been initiated as yet in the Gulf of Martaban. Several of the conditions necessary for the formation of a cyclonic disturbance were present. Winds were light and variable over a considerable portion of the Bay. A strong humid current was advancing over the south of the Bay into the Gulf of Martaban, and was giving moderately heavy rain in the neighbourhood of the Andamans and Nicobars. The rainfall had hitherto been too diffused to initiate a large cyclonic disturbance. It was, however, increasing in amount, and becoming more concentrated in character, the one additional condition now apparently required for the establishment of a large atmospheric whirl.

10*th November*.—During the previous 24 hours, a further barometric fall occurred throughout the greater part of India. The fall was not so general as on the 8th and 9th, and was much smaller in amount. Pressure was very considerably below the normal over the whole country. The distribution of pressure was generally similar to that which obtained on the morning of the 9th. The area of lowest pressure included the south-western districts of the Punjab and Rajputana, over which there was a distinctly marked cyclonic circulation of the air. In the south of the Punjab, cloud had formed to a considerable extent, whilst, in the north-western Himalayas, thunder-storms with rain had occurred over the lower ranges, and snow had fallen on the higher ranges.

In the North West Provinces, Bengal, the Central Provinces, Central India, Bombay, and the northern districts of Madras, the sky was, as it had been for some time, clear, and the weather fine and settled, but unusually dry for the season. The sky was clouded on the Madras coast, but rain had now ceased to fall, as is shewn by the data given in the table on p. 130. The winds on the Madras coast were approximately normal in direction, varying between N. and N. N. W., but were unusually weak.

Hence the effect of the deflexion of the south-west monsoon current from its usual course at this time, which had been previously indicated by the light winds experienced by the Mount Stuart and Scottish Hill to the west of the Andamans, had now extended across the centre of the Bay to the Coromandel coast, over the whole of which area light unsteady winds were blowing. Pressure was very uniform round the north and west coasts of the Bay, as is shown by the following :—

Saugor Island	29·929	Vizagapatam	29·957
False Point	29·951	Madras	29·960

The following table gives the observations at the land stations for the day ·—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction.		Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			10 A. M.	4 P. M.				
Nancowry	29·856	—·041	S. W.	S. W.	8	9	1·16	Showery.
Port Blair......	29·850	—·044	N. N. W.	W. N. W.	7	8	0·30	Gloomy.
Diamond Island	29·917	+ ·017	E. S. E.	E. S. E.	12	10	0·65	Gloomy.
Chittagong ...	29·915	—·006	N.	N. W.	1	6	...	Fine.
Tounghoo	29·905?	+ ·032?	N. W.	N. W.	?	10	0·22	Gloomy.
Bassein	29·917	—·007	N. E.	S. S. .	4	10	0·18	Overcast.
Rangoon	29·920	—·022	N. E.	E. S. E.	4	8	0·85	Showery.
Moulmein	29·871	—·027	E. N. E.	S. E.	2	8	...	Showery
Mergui	29·868?	—·127?	E. S. E.	E.	1	10	0·65	Gloomy.

The preceding observations establish that a considerable fall of the barometer had taken place during the previous 24 hours. The fall amounted to ·04″ at Nancowry and Port Blair, ·03″ at Moulmein, and ·02″ at Rangoon, and was greatest at Port Blair. Westerly winds of the same average strength as on the 9th had prevailed during the previous 24 hours at Nancowry. The sky was densely clouded and moderate rain was falling. 1·16 inches of rain were registered at 10 A. M. At Port Blair, the wind had shifted round to north-west, but was not as yet blowing strongly. Rain was falling, but the amount registered up to 10 A. M. of the 10th was small. In South Burmah, the sky had become overcast, and the weather gloomy and threatening, more especially at Diamond Island and Toungoo. Less rain, however, fell on the Burmah coast than had been received on the previous day. It thus again appears probable, if not certain, that the rainfall was becoming more concentrated over a smaller area than hitherto, a favourable, if not a necessary, condition, according to the condensation theory, for the development of an atmospheric whirl.

These observations also show that cyclonic circulation had been initiated, and was now established over the centre and north of the Gulf of Martaban, and the adjacent part of the Bay; and that the central depression or centre of disturbance, as determined by the fall of the barometer, the amount of rain, and the velocity of the wind, was nearest to Port Blair, and to the east of it.

Hence it is evident that, although the conditions for the formation of a whirl had been present for some days, it was only on the 10th that the meteorological observations at the nearest land stations gave clear indications of its existence.

The information contained in the meteorological abstracts from the logs of vessels is tabulated below :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds.		Remarks.
					Dir.	Force.	
Scottish Hill	4 A. M.				N.	1	Light airs and calms.
	8 A. M.				N. E.	1	Winds very variable.
	Noon	13° 31′	89° 40′	29·910	N. W.	1	Light airs and calms.
	4 P. M.				N. N. W.	2	Squally and dirty.
	8 P. M.				N. N. E.	3	Arched rain squalls.
	Midnt.			·890	N. W.	3	
Mount Stuart	4 A. M.				N. E.	1 to 0	Sea moderate with light westerly swell.
	8 A. M.				...	3 to 4	Light fleecy clouds. Lightning in the N.W.
	Noon	13° 55′	91° 31′	29·865	...	...	Towards the afternoon, weather began
	4 P. M.				...	4	to be squally. At sunset, sharp squalls
	8 P. M.			·805	...	...	and squally -looking all round. Midnight.
	Midnt.				E. by N.	...	Showery.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Satara	4 A. M.			29·870	N. N. E.	5	Fresh breeze and fine.
	8 A. M.			·940	E. N. E.	4	Moderate breeze & fine.
	Noon	17° 56′	88° 45′	·890	NE by E.	5	Fresh breeze and fine throughout. Current during previous 24 hours, north 4 miles.
	4 P. M.			·810	N. E.	4	Moderate breeze and fine.
	8 P. M.			·860	E. by S.	2	Light breeze and fine clear weather.
	Midnt.			·860	E. N. E.	2	Same wind and weather.
Kwang Tung	4 A. M.			29·942	N. E.	5	
	8 A. M.			·899	N.	4	
	Noon	20° 00′	88° 49′	·920	N.	3	Current S. 32° E. 24 miles.
	4 P. M.			·859	N.	3	Sea smooth.
	8 P. M.			·904	Calm.		
	Midnt.			·934	Calm.		
Frank Stafford.	4 A. M.				N. N. W.	2	
	Noon	21° 16′	89° 20′	29·915	...	2	Fine, and smooth sea.
	Midnt.				...	2	Lightning during the night.
Chanda	Noon	Hughl	y River	29·910	E. N. E.	2	
	4 P. M.			·830	E. N. E.	4	
	8 P. M.			·870	Calm.	...	
	Midnt.			·910	E.	2	
Mahratta ...	4 P. M.	Passing Saugor	Island	29·820	E.	2	Fine weather.
	8 P. M.			·900		0	Clear sky but slightly hazy.
	Midnt.			·920	N. N. E.	2	
Parthenope	Noon			29·915	N.		A. M. Light breeze and hazy weather.
	4 P. M.	Passing Saugor	Island.		Calm.		P. M. Wind unsteady with gusts and calms. Midnight. Wind north and light.

The observations given in the ships' logs, although not numerous, confirm the information of the land observations given above.

The Frank Stafford and Kwang Tung, north of Lat. 20° N. and near the Head of the Bay, met with light northerly winds or calms and a smooth sea. The Mount Stuart and Scottish Hill were passing very slowly up the Bay at this time. The former was in Lat. 13° 56′ N. and Long 91° 31′ E., and observed several of the evidences of cyclonic formation in its neighbourhood. The area of heavy rainfall, as already noticed, had contracted. This explains the fact mentioned in her log that in the morning there were only a few light clouds in the sky. The weather, however, rapidly changed during the day, and became squally in the afternoon. Sharp squalls were experienced at sunset. The barometer was also falling rather rapidly. Winds were from north, and increased in strength from 1 to 4 during the day, indicating the rapid increase of indraught. The Scottish Hill was 120 miles further to the west, and had winds ranging between N. E. and N. W. during the day. They were very light and variable during the earlier part of the day, but the weather became squally towards the evening, and arched rain squalls passed over the ship at 8 P. M. The Satara, which was passing from Gopalpore to Rangoon, was in Lat. 17° 56′ N. and Long. 88° 45′ E. at noon. The winds varied during the day between N. N. E. and E. N. E., but decreased in strength during the afternoon. She experienced light breezes and fine clear weather throughout the day. The Chanda and Marhatta left Saugor in the evening, and had fine weather and a clear sky.

Hence, except in the neighbourhood of the Andamans, weather was fine. A definite cyclonic circulation had been established to the east of the Andamans between 10 A. M. of the 9th and 10 A. M. of the 10th. The area of rainfall had for some time contracted, and the rainfall had intensified over the diminished area. Winds of indraught had hence been established, and were increasing in force. This proceeded slowly at first, but, during the evening of the 10th and morning of the 11th, it went on more rapidly, and there was a perfectly well-defined cyclonic circulation, or large atmospheric whirl, established in that part of the Bay on the morning of the 11th November.

11*th November*.—During the previous 24 hours the barometer had risen rapidly over Northern and Central India. The increase of pressure was due to the filling up of the depression in the Punjab and neighbouring districts. The rise of the barometer at Peshawar and Rawal Pindi was ·2″. The depression had given a large amount of rain over the Punjab, and stormy weather over the north-west Himalayas, on the higher parts of which much snow had fallen. Amongst the heaviest rainfalls during the previous 24 hours were the following:—Simla 2·15 inches, Peshawar 1·22 inches, and Rawal Pindi 1·20 inches.

The sky was overcast, and the weather unusually cold, in Upper India. The winds over a large part of Northern India continued to indicate feeble cyclonic circulation about a centre in the north-eastern districts of Sind. Over the whole of Bombay (excluding Sind), Bengal, the Central Provinces, and Central India, the weather was fine, skies cloudless, and the winds blowing from the usual quarter.

Round the coast of the Bay, from Saugor Island to Madras, the differences of pressure were unusually small. The following statement gives the 10 A. M. reduced readings at the more important stations :—

Saugor Island	29·940
False Point	29·955
Vizagapatam	29·945
Madras	29·948

The winds at the Bengal stations near the Head of the Bay blew from directions between north and north-east, the easterly component being probably due to the cyclonic circulation in the middle of the Bay. They were very light. On the Madras coast, the winds were not only more northerly than usual, but were unusually feeble. The data are given in the following table :—

Stations.	Amount of wind in miles per hour since 10 A. M. previous day.	Daily average amount of wind (miles per hour) of November.
Vizagapatam	1	2·5
Masulipatam	3	6·0
Madras	5	6·8
Negapatam	2	5·6
Salem	2	3·6
Madura	2	4·1

Over the Coromandel coast, the weather was fine with passing clouds, and rain had entirely ceased.

The following table gives the observations taken at the recording stations in the neighbourhood of the disturbance :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction.		Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			10 A. M.	4 P. M.				
Nancowry	29·836	—·020	S. W.	S. W.	12	7	2·90	Fine.
Port Blair	29·760	—·090	W. N. W.	W. S. W.	8	9	3·90	Overcast and rain.
Diamond Island	29·848	—·069	E. N. E.	E. N. E.	12	10	1·12	
Chittagong ...	29·918	+ ·003	N. E.	W. N. W.	1	3		Fine.
Toungoo	29·860	—·045	N. W.	N. W.	?	10		Gloomy.
Bassein	29·861	—·056	N. N. E.	N. N. E.	5	10	1·24	Overcast.
Rangoon	29·913	—·007	N. E.	N. E.	5	9	0·04	Showery.
Moulmein	29·855	—·016	N.	E. S. E.	2	8	0·03	Fine.
Mergui	29·884	+ ·016	E. S. E.	E.	3	10	1·30	Overcast.

These observations show that the barometer had fallen considerably at Port Blair, and to a less extent at Nancowry and Diamond Island. The cause of this is also evident from the observations. Heavy rain had fallen at Port Blair and the neighbourhood. Port Blair registered 3·9 inches at 10 A. M., Nancowry 2·90 inches, and Diamond Island 1·12 inches. The rainfall on the Burmese coast was smaller than on the previous day. Hence the evidence indicates that the rainfall was more concentrated than hitherto, and was falling mainly over an area near to and including Port Blair. This is confirmed by the fact that cyclonic circulation of the air was now fully established. Winds were S. W. at Nancowry, E. S. E. at Mergui, E. N. E. at Diamond Island, and W. N. W. at Port Blair. They were increasing in force rapidly, but were as yet of moderate strength. The wind directions indicate that the centre of the cyclonic circulation was to the east-north-east of Port Blair. It is not possible to infer its position with any approach to exactness from the observations, but we are probably not far from the truth in placing it in Lat. 13° 30′ N. and Long. 94° 15′ E.

As the vessels which have contributed meteorological data were all to the west and north of the Andamans, they only furnish information of the weather in the outer portion of the north-west quadrant of the cyclonic circulation.

The following table gives the whole of the information contained in their logs respecting the weather in the Bay on the 11th :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds.		Remarks.
					Dir.	Force.	
Scottish Hill	4 A. M.						Dirty rain squalls.
	8 A. M.				N. E. to N. W.	4	No sea.
	Noon	14° 08′	90° 33′	29·850		4	Heavy rain squalls and hail.
	4 P. M.					5	Cloudy, gloomy sky. 6 P. M. Heavy swell from N. E.
	8 P. M.				N. N. W.	2	Scud from N. E. and N. N. E.
	Midnt.			·870	N.	5	Wind shifting in squalls.
Mount Stuart	4 A. M.				E.N.E.	2 to 3	A. M. Moderate in the first part of the day Towards night, a heavy swell from E. by N. Thick heavy rain most of the day. Overcast heavy sky all round, and dark gloomy weather. Bent storm sails at 2 P. M. and kept away south, as weather was looking very bad. Heavy swell from E. N. E. at midnight.
	8 A. M.				E. by N.	...	
	Noon	15° 30′	91° 06′	29·820	NNE to E	3 to 5	
	4 P. M.			·750	N. E.	...	
	8 P. M.			·810			
	Midnt.				N. by E to N. by W.	Squally.	
Byculla	4 A. M.			29·880	N. E.		7 A. M. Moderate breeze and squally.
	8 A. M.			·890	E. N. E.		8 A. M. Overcast and squally with heavy rain.
	Noon	16° 00′	91° 10′	·840	...		Noon. Moderate breeze and overcast, with threatening appearance and rising sea. 4 P. M. Strong breeze and overcast, with frequent hard squalls. 8 P. M. Strong freshening breeze, with hard squalls and rising sea. Midnight. Moderate gale and heavy squalls.
	4 P. M.			·770	...		
	8 P. M.			·770	...		
	Midnt.			·740	...		

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Satara	4 A. M.			29·800	N. E.	4	4 A. M. Moderate breeze and overcast sky, with passing squalls of wind. 8 A. M. Fresh breeze, sky cloudy and overcast. Squally appearance. Black bank of clouds rising to the East. 10 A. M. A gale of wind from N. E. 11 A. M. Wind moderating. Noon. Strong head wind and mountainous sea. Shipping large quantities of water, vessel pitching and rolling. 4 P. M. Strong breeze and heavy sea, with severe squalls of wind, and incessant rain. 8 P. M. to midnight. Same weather continued.
	8 A. M.			·850	N. E.	5	
	Noon	16° 35′	92° 09′	·800	E. N. E.	6	
	4 P. M.			·740	E. N. E.	6	
	8 P. M.			·800	E.	6	
	Midnt.			·780	E. by N.	6	
Loanda	Noon	16°30′?	92° 0′?		N. E.	4 to 5	Weather overcast.
Bancoora ...	4 A. M.			29·902	E.	2	
	8 A. M.			·929	N. E.	3	
	Noon	17° 19′	85° 44′	·887	N. E.	4	Moderate wind and fine.
	4 P. M.			·838	N. N. E.	4	
	8 P. M.			·867	NE. by N.	4	
	Midnt.			·840	N. N. E.	4	
Chanda	4 A. M.			29·830	N. E.	2	Hazy.
	8 A. M.			·920	N. N. E.	4	
	Noon	18° 56′	90° 30′	·920	N. N. E.	4	Current N. 23° E. 0·5 mile per hour.
	4 P. M.			·750	N. E. to S. E.	2	
	8 P. M.			·770	Variable.	4	At short intervals, heavy squalls from S. E.
	Midnt.			·770	S. E. to E. by S.	5	Heavy squalls from the eastward.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Asia	Noon	18° 53′	84° 39′		N. E.		Moderate wind, clear weather.
Mahratta ...	4 A. M.			29·860	N. N. E.	4	
	8 A. M.			·920	...	4	
	Noon	21° 16′	90° 35′	·940	...	4	Fine weather, smooth sea, and clear sky throughout.
	4 P. M.			·800	N.	3	
	8 P. M.			·870	...	3	
	Midnt.			·900	...	2	

The Satara, Byculla, Mount Stuart, and Scottish Hill were now in directions varying between N. N. W. and W. N. W. from the centre and at approximately the same distance, 250 miles. The Satara was in Lat. 16° 35′ N. Long. 92° 9′ E. by account at noon, and proceeding eastwards to Rangoon. Early in the morning, the weather was fine with moderate breezes. Occasional squalls of wind passed over the vessel. The weather became rapidly worse after 8 A. M. A heavy and dark bank of clouds appeared in the east, and at 10 A. M. a gale of wind blew from north-east. The sea rose very rapidly. During the afternoon and evening, the vessel experienced strong easterly winds with frequent heavy squalls, incessant rain, and a heavy sea. The Satara was not only approaching the centre, but was crossing its line of motion in front. Hence the very rapid change of weather which she experienced during the afternoon.

The Byculla was about 70 miles to the W. S. W. of the Satara at noon in Lat. 16′ N. and Long. 91° 10′ E. Her positions, as obtained by observation and dead reckoning, agree so closely as to show that there was no strong current in the northern and western quadrants of the cyclone, and hence that the position assigned to the Satara by account is probably approximately correct. The Byculla was advancing in almost the same track as the Satara, and gives a similar account of the weather. The morning began with moderate breezes and occasional squalls. The sky clouded over about 8 A. M., and heavy rain fell. The winds increased in force, and frequent hard squalls passed over the ship.

The Log of the ship Mount Stuart, which was in Lat. 15° 30′ N. and Long. 91° 6′ E. at noon, states that the sky was overcast, weather dark and gloomy, and so threatening at 2 P. M. that the Captain changed her course and kept away south. The Scottish Hill was 100 miles to the south-south-west in Lat. 14° 8′ N. and Long. 90° 33′ E. at noon. The sky was overcast, and frequent heavy rain squalls passed over the ship. A heavy swell from the north-east came up during the day. The weather over the north-east of the Bay is described in the logs of the Chanda, Bancoora, and Mahratta. The Bancoora, in Lat. 17° 19′ N. and Long. 85° 44′ E. at noon, had fine weather and moderate north-easterly winds of force varying from 2 to 4 during the day. The Chanda, in Lat. 18° 56′ N. and Long. 90° 30′ E. at noon, had fine weather with a hazy atmosphere, and light to moderate north-east winds. She was proceeding to Rangoon, and steaming directly towards the northern quadrant of the cyclone. Late in the evening, she began to experience squally weather and variable winds. Frequent heavy rain squalls came up from south-east and east after 8 P. M. The Mahratta proceeding from Chittagong to Calcutta, and the light vessels at the entrance to the Hooghly, had fine weather, clear skies, and a smooth sea throughout the whole day.

The meteorological data hence shew conclusively that, during the 24 hours preceding 10 A. M. of the 11th, a definite cyclonic circulation of considerable intensity had been established to the west of the Andamans, the centre of which at noon of the 11th was probably in Lat. 13° 30′ N. and Long. 94° 15′ E. Heavy rain was falling over and near the centre, winds increased considerably in force during the day, the sea rose rapidly, and gave rise to a heavy swell extending to a distance of three or four hundred miles from the centre. The very rapid changes which had been initiated by the cyclonic motion are indicated very clearly by the weather experienced by the Satara.

12th November.—The barometric changes of the preceding 24 hours were irregular. This was in part due to the continuance of unsettled weather in Upper India. The depression which had formed on the 9th and 10th was filling up, and its existence was chiefly shewn on the morning of the 12th by cyclonic circulation of the air in Sind, and the adjacent districts of Rajputana. A smaller depression had, however, formed in the south-eastern districts of the Punjab, the centre of which was at or near Lahore. This was shown by a slight fall of the barometer at Lahore and the neighbouring stations. The barometer had continued to rise rapidly over the greater part of the Punjab, Rajputana, and the Central Provinces, and over the whole of Central and Southern India. A rapid fall had occurred in Burmah, and a slight one in Bengal, due to the development and extension of the atmospheric whirl in the neighbourhood of the Andamans.

In Upper India, skies were more or less clouded in the area of the small depression, and rain fell during the day over nearly the whole of the Punjab, and the western districts of the North Western Provinces. In Bengal, the Central Provinces, Bombay, and Madras, skies were generally clear, weather fine, and winds light. Skies were overcast in Southern Burmah, and rain was generally falling.

Over the west coast of the Bay, pressure was remarkably uniform, the isobar of 29·95 being, in fact, almost identical with the coast line. The winds on the Coromandel coast were stronger than they were on the previous day, but were below their normal force. This is shown by the following statement:—

Stations.	Amount of wind in miles per hour since 10 A. M. previous day.	Daily average amount of wind per hour.
Vizagapatam	2	2·5
Coconada	6	9·0
Masulipatam	2	6·0
Madras	5	6·8
Negapatam	5	5·6
Salem	2	3·6
Madura	4	4·1

The following are the observations taken at the stations affected by the cyclonic depression:—

Stations.	Barometer at 10 A. M. reduced to sea level.	Changes since 10 A. M. previous day.	Wind direction. 10 A. M.	Wind direction. 4 P. M.	Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
Nancowry	29·884	+ ·048	S. W.	S. W.	7	7	1·91	Fine.
Port Blair	29·834	+ ·074	W. S. W	W. S. W.	18	8	0·41	Overcast
Diamond Island	29·659	— ·189	E. S. E.	S. S. E.	25	10	4·58	Severe gale.
Akyab	29·887	?	N. N. E.	E. N. E.	?	10	...	Fine.
Chittagong	29·899	— ·019	Calm.	N. N. W.	1	6	...	Fine.
Toungoo	29·885	+ ·025	N. W.	N. W.	?	10	...	Gloomy weather.
Bassein	29·762	— ·099	E. N. E.	E. S. E.	12	10	5·97	Overcast
Rangoon	29·870	— ·043	E. N. E.	S. E.	6	10	0·84	Showery
Moulmein	29·869	+ ·014	S. E.	S. E.	3	6	0·04	Clouds low with scud.
Mergui	29·936	+ ·052	E. S. E.	S. S. E.	4	10	0·50	Overcast

The following information relating to the meteorology of the Bay for the 12th is taken from the logs of the vessels named :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Mount Stuart	4 A. M.			29·700	N. N. W.	5	
	Noon	14° 19′	91° 41′	·750	W. N. W.	5 to 6	A number of small land birds at about sunset. The moon has had a large ring round it the last few nights.
	4 P. M.				N. W.	5	
	Midnt.				N. W.	5	
Scottish Hill	4 A. M.			29·770	N. N. W.	5	4 A. M. Cloudy and rain squalls. Heavy sea from N.E. 8 A. M. Heavy rain squalls, sky thick and gloomy, heavy sea from N. N. E. Noon. Shift of wind to N. W. with heavy, fierce squalls. Sky one mass of heavy black clouds, and rain like a black wall to W.N.W. 2 P. M. Fierce squalls. Heavy bank of clouds to the N. W. and N. 5 P. M. Weather clearer, and squalls lighter. Heavy confused sea. Scud in dark masses from N. W. Midnight. Fresh squalls and heavy rain.
	8 A. M.			·790	N. N. W.	4	
	Noon	14° 36′	92° 17′	·720	N. W. to W. N. W.	10	
	4 P. M.			·630	W. S. W.	10	
	5 P. M.			·660	W. S. W.		
	Midnt.			·720	SW by W	8	
Byculla	2 A. M.			29.730	E. N. E.		A. M. Freshening gale with very heavy squalls, blinding rain, and high head sea. Ship labouring heavily. 8 A. M. Strong gale with heavy squalls, and high N.E. sea. Shipping water fore and aft. Noon. Wind and sea increasing. Heavy gale, with overcast sky, and continual heavy squalls. Ship labouring heavily, and shipping heavy seas fore and aft.
	4 A. M.			·660	...		
	6 A. M.			·570	...		
	8 A. M.			·480	N. E.		
	10 A.M.			·480	...		
	Noon	16° 03′	92° 36′	·410	NE. by N.		
	2 P. M.			·380	N. N. E.		
	4 P. M.			·380	N. by E.		
	6 P. M.			·370	N. by W.		

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Byculla ...... (*Contd.*)	8 P. M.			29·370	N. N. W.		8 P. M. Heavy gale with terrific squalls from the North.
	10 P.M.			·390	N. W. to W. N. W.		
	Midnt.			·400	West.		Midnight. Weather moderating.
Satara	4 A. M.			29·710	NE. by E.		A. M. Strong gale from N. E. with heavy sea, accompanied with heavy squalls of wind, and incessant rain.
				·660	N. E.	9	
	8 A. M.			·650	...	9	8 A. M. Hard gale, violent squalls, heavy rain, very thick weather.
	Noon	16° 30′	93° 30′	·610	E. by N.	9	Noon. Wind and sea continued the same; heavy rain squalls.
	4 P. M.			·530	...	9	4 P. M. to midnight. Strong gale from E. by N.,
	8 P. M.			·540	...	9	
	Midnt.			·520	E. S. E. S. E.	9	Same wind and weather.
Chanda	4 A. M.			29·710	E. to NE.		Morning. Heavy squalls from E. N. E. Sea rising fast; S. E. swell increasing rapidly.
	8 A. M.			·730	E.N.E. to N. E.		
	Noon	16° 31′	93 °09′	·640	N. E.		Noon. Strong gale with high cross sea. Weather having all the appearance of a cyclone.
	4 P. M.			·560	N. E.		Afternoon. Fierce gale and high sea, with hard squalls and heavy rain. Barometer falling slowly.
	8 P. M.			·610	N.N. E.		Evening. Terrific squalls and high sea.
	10 P.M.			·490			
	Midnt.			·560	N. N. W.		Cleared up a little, less rain and sea.
Bancoora ...	4 A. M.			29·798	N.	4	6 A. M. Squally appearance to northward.
	8 A. M.			·849	N.	5	
	Noon	16° 40′	89° 11′	·805	N.	5	2 P. M. Fresh breeze and squally with light rain. Heavy sea from E. and E. N. E.
	4 P. M.			?	N. N. W.	4	
	8 P. M.			·818	N. W.	4	
	Midnt.			·849	N. N. W.	4	

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds.		Remarks.
					Dir.	Force.	
Loanda	Noon	16°45′?	91°46′?	29·700	E. N. E.	6	Heavy rain and sky overcast.
Asia	4 A. M.				N. E.	Moderate	Clear weather.
	8 A. M.				N. E.	Fresh.	
	Noon	17° 42′	87° 42′		N. E.	„	Cloudy and confused swell.
	4 P. M.				N. E.	„	Cloudy and heavy S.E. swell.
	8 P. M.				N. E.		Cloudy and heavy S.E. swell.
	Midnt.				N. E.	Strong.	Overcast and heavy easterly swell.

The observations at the land observatories indicate that the depression was to the north of the Andamans on the morning of the 12th. The centre had thus moved in a north-north-west direction since noon of the 11th. The barometer had risen considerably at Port Blair and Nancowry, and on the east coast of the Martaban Gulf. Strong winds continued at Nancowry and Port Blair, more especially at the latter station. The sky was cloudy at Nancowry, and was still very dark and gloomy at Port Blair. Moderate rain had fallen during the preceding 24 hours at these stations.

A very considerable fall of the barometer had occurred in South West Burmah, more especially at Diamond Island and at Bassein. The winds were unusually strong at Diamond Island. The observer at that station reported a severe gale at 10 A. M. Very heavy rain was also falling in South Burmah. Diamond Island registered 4·58 inches at 10 A. M., and Bassein, 5·97 inches. On the Arakan coast, the weather at 10 A. M. was fine with passing clouds, and light N. N. E. winds.

The position of the centre can only be roughly approximated from the land observations. It was evidently to the W. S. W. of Diamond Island and at no great distance. The information extracted from the ships' logs enables us to determine it with approximate accuracy. An examination of the positions of the vessels, as determined by observation and dead reckoning on the 12th and 13th, indicates, that the positions assigned to all the vessels, except the Satara, at noon of the 12th, may be accepted as approximately true. There appears to have been very little current in the western and northern quadrants of the cyclonic area. The only marked current at this time in the Bay was in the eastern quadrant of the storm area, where the winds were strongest. This current was continued northwards along the west coast of Burmah. The Satara, which was nearest the coast, experienced a very strong northerly current, which carried her 171 miles to the northward and westward (N. 13° W.) between noon of the 11th and noon of the 14th. Her probable position at noon of the 12th, so far as can be determined from the wind direction and height of her barometer, was in Lat. 16° 30′ N. and Long. 93° 30′ E.

The Byculla, Satara, Loanda, and Chanda were all in the northern quadrant. The Byculla was nearest the centre, which apparently passed a short distance to the east of that steamer, late in the evening (about 8 P. M.) Early in the morning, she had a gale with very heavy squalls, blinding rain, and a high sea. The weather grew worse as she advanced southwards. At noon, she experienced a heavy gale with continual heavy squalls. The weather was at its worst about 8 P. M., when a heavy gale was blowing with terrific squalls. Her barometer (corrected) stood at that hour at 29·37, the lowest reading taken during the storm. The weather began to moderate at midnight, when she had westerly winds, and the storm was passing to the northward.

The Chanda also passed to the westward of the storm. She was at least 150 miles from the centre early in the morning of the 12th. At that time, heavy squalls from the E. N. E. passed over the vessel, and a swell came up from the south-east which increased rapidly. At noon, she had a fierce gale with hard squalls, and heavy rain. The barometer fell slowly, and the Captain at 4 P. M. judiciously changed the course of the vessel to the south-west, and thus kept clear of the storm centre. At 8 P. M., the squalls were terrific in force, and the sea very high. The barometer was at its lowest at 10 P. M., when the corrected reading was 29·49. The wind at that hour was hauling from N. N. E. to N. N. W. Shortly afterwards, the weather began to moderate.

The Satara was to the north of the centre during the day, and crossed from the western to the eastern quadrant. She, consequently, not only experienced the full force of the hurricane, but was carried a considerable distance to the northward by the current, and thus involved in it for a much longer time than either of the preceding vessels. Early in the morning, she had a strong gale from the N. E. with heavy squalls, incessant rain, and a high sea. She continued to experience similar weather during the day. The wind, which was from N. E. at 4 A. M., shifted to E. by N. at noon, and to S. E. at midnight. She was, judging from the unusually small rise of her barometer between 4 P. M. and 8 P. M., probably nearest to the centre between 8 P. M. and midnight. Her lowest reading is not given, but when corrected, it probably slightly exceeded 29·5. She was about the same distance as the Chanda from the centre The Mount Stuart and Scottish Hill were in the south-west quadrant, but at considerable distances from the centre. The former, which was in Lat. 14° 19′ N. and Long. 91° 41′ E. at noon, had winds of force 5 to 6 during the day. The Scottish Hill was nearer to the centre. During the morning, she had cloudy weather with rain squalls, and a heavy sea. Occasional shifts of wind occurred in heavy squalls, which passed over the vessel from the N. W. She was just on the margin of the storm area. The force of the wind varied from 4 to 5. The Captain describes the appearance of the cyclone area crossing to the N. W. in front of his ship as a mass of heavy black cloud and rain. During the remainder of the afternoon, fierce squalls passed over the vessel. The wind was of force 10, and hauled to W. S. W. at 4 P. M. The weather moderated a little afterwards, but she continued to have fresh squalls, heavy rain, and a high confused sea, during the remainder of the night.

The Asia was about 400 miles to the W. N. W. in Lat. 17° 42′ and Long. 87° 42′ E. at noon. She had fresh to strong N. E. winds during the day, and a heavy swell from the S. E. The Bancoora was 260 miles to the W. N. W. in Lat. 16° 40′ N. and Long. 89° 11′ E. She had northerly winds of force 5 until noon, and N. N. W. winds of force 4 during the remainder of the day. The weather had a squally appearance in the morning. As she advanced eastward, a heavy swell set in from the E. and E. N. E., which increased during the day. The logs of the Bhandara and of the light vessels near the mouth of the Hooghly show that light northerly winds were blowing at the Head of the Bay, and that the weather was fine, sky clear, and sea smooth.

A comparison of the position of the vessels at noon with respect to the storm indicates that the centre was approximately in Lat. 15° 30′ N. and Long. 93° E. at noon.

On this supposition, the following were the distances and bearings of the vessels from the storm centre at noon :—

	Bearing of centre of storm.	Distance of centre of storm.	Barometer at noon.
Diamond Island	E. N. E.	90	29·64
Byculla	N. N. W.	45	29·41
Chanda	N.	75	29·64
Satara	N. E.	75	29·61
Scottish Hill	S. W.	85	29·72
Mount Stuart	S. W.	120	29·75
Bancoora	W. N. W.	260	29·81
Asia	W. N. W.	400	?

13th November.—The chief feature in the meteorology of India on the 13th was the cyclonic disturbance off the Burmese coast. A rapid rise of the barometer during the preceding 24 hours over the Punjab and Sind, completely obliterated the barometric depression in that area. Pressure was highest over the Indus valley, where it slightly exceeded 30·15″. The barometer had also risen in the Central Provinces, Bombay, and Madras, but had decreased in Bengal and Arakan. Hence pressure diminished from west to east, and was lowest at Diamond Island, where it was 29·826″.

The large depression off the Burmese coast was very distinctly marked. Winds were blowing a southerly gale in the Gulf of Martaban. They were easterly at Akyab, northerly in Bengal and on the Ganjam and Madras coasts, thus establishing general cyclonic circulation over the Bay. Elsewhere the winds were generally from the eastward, except in the Indus valley, where they were northerly.

The sky was dull and cloudy in the Punjab, and moderate rain had fallen during the previous 24 hours. The sky, however, rapidly cleared during the day, and was almost free of cloud by 4 P. M. Over the remainder of the Indian land area, excepting Burmah, the sky was clear and the weather fine. The following table gives the more important meteorological observations taken at the land stations :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction.		Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
			10 A. M.	4 P. M.				
Nancowry	29·940	+ ·056	S. W.	S. W.	3	7	0·83	Fine.
Port Blair	29·896	+ ·062	W. S. W.	W. S. W.	10	5	0·15	Fine.
Diamond Island	29·826	+ ·167	S.	S.	29	10	1·47	Severe gale.
Akyab	29·863	— ·024	E. N. E.	N. N. E.	5	10	0·59	Showery.
Chittagong ...	29·855	— ·044	N.	Calm.	1	9	...	Sultry.
Tounghoo	29·881	— ·004	N. W.	N. W.	?	10	0·42	Threatening weather.
Bassein	29·830	+ ·068	E. S. E.	S. S. E.	18	10	5·90	Overcast.
Rangoon	29·887	+ ·017	E. S. E.	S. S. E.	9	8	2·42	Constant rain.
Moulmein	29·902	+ ·033	S. S. E.	S. S. E.	3	3	1·11	Constant rain.
Mergui	29·943	+ ·007	S. E.	Calm.	2	5	0·30	

The information extracted from the logs of vessels affectedt ı › cyclonic disturbance off the Burmese coast is given in the ensuing statement :—

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	REMARKS.
Shazada......	8 A. M.	13° 14′	94° 00′	29·836	S. by E.	Strong.	
	Noon	13° 51′	93° 57′				Cloudy and overcast.
	4 P. M.			·714	S.		
Mount Stuart	4 A. M.				N. W.	5	Sea heavy from N. E. by N. It was more northerly towards noon. 2 P. M. Showery. 4 P.M. Heavy detached clouds. 5 P. M. Dull heavy sky, with bright pink colour at sunset.
	8 A. M.			29·870	...	5	
	Noon	14° 47′	91° 20′		W. N. W.	5	
	4 P. M.			·740	...	5 to 6	
	8 P. M.				...	5	
	Midnt.			·800	vble. to W	5	
Asia	4 A. M.				N. E.	Moderate.	Cloudy, heavy easterly swell, and squally.
	8 A. M.				N.	Fresh.	Overcast and heavy N. E. swell.
	Noon	15° 54′	90° 58′		...	...	Squally, overcast, heavy N. E. swell.
	4 P. M.				N. W.	Moderate.	Overcast, N. E. swell going down.
	8 P. M.				W.	...	Moderate breeze and overcast. Swell gone down.
	Midnt.				SW by W	Steady.	Moderate breeze and cloudy.
Loanda	Noon	16° 16′	92° 54′	29·500	N. E.	10	Gale increasing.
	Midnt.						A hurricane.
Scottish Hill	8 A. M.			29·750			Noon. Heavy rain squalls.
	Noon	15° 56′	92° 10′	·720	W. by S.	9	6 P. M. Scud flying fast from N. W. Severe squalls and heavy sea. 10 P. M. Weather clearer, sea lighter, squalls less violent.
	4 P. M.			·700			
	6 P. M.			·680			
	8 P. M.				W. by S.	10	
	Midnt.			·790			

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Chanda	4 A. M.			29·610	NNW. to W. N. W.		Wind and sea going down. At short intervals, terrific squalls attended by heavy rain.
	8 A. M.			·650	WNW. to S. W.		
	Noon	16° 02′	93° 11′	·670	S. S. W.		Strong wind and heavy rain squalls.
	4 P. M.			·690	S. S. W.		Strong breeze and cloudy. Occasional heavy squalls.
	8 P. M.			·790	S. E.		
	Midnt.			·770	SE. by S.		Strong increasing breeze, and cloudy weather.
Byculla	2 A. M.			29·440	W.		Heavy gale with dark overcast sky. Wind veered to S. W., increased and blew with great violence in terrific squalls with rain. High confused sea.
	4 A. M.			·450	S. W.		
	6 A. M.			·460	...		
	8 A. M.			·510	S. S. W.		8 A. M. Heavy gale with terrific squalls from S. W. to S. S. W. High confused sea. Shipping heavy water fore and aft. 11 A. M. Weather moderating, but sea very confused. Noon. Wind and sea moderating. Squalls less frequent and not so hard.
	10 A.M.			·520	...		
	Noon	16° 10′	93° 11′	·560	...		
	2 P. M.			·580	S. W.		
	4 P. M.			·660	...		
	6 P. M.			·720	...		
	8 P. M.			·780	...		8 P. M. Strong breeze and overcast, with sharp squalls and heavy rain, high sea still running. Midnight. Fresh breeze with passing squalls. Sea going down.
	10 P. M.			·810	...		
	Midnt.			·830	...		
Satara	4 A. M.			29·520	S. E.	8	4 A. M. Fresh gale, violent squalls of wind and rain, heavy head sea. 8 A. M. Strong gale, violent squalls, heavy rain. 10-45 A.M. Wind shifted to S. by E. Noon. Strong gale
	8 A. M.			·630	...	9	
	Noon	16° 20′	93° 30′	·680	S. E.	9	
	4 P. M.			·670	S. E.	8	

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Satara ...... *(Contd.)*	8 P. M.			·730	...	8	from S. E. Violent squalls of wind and rain. 4 P. M. Fresh gale, violent squalls of wind and rain. Sea moderating. Water had a greenish tint. 6-30 P. M. Fresh gale, thick weather, with violent squalls.
	Midnt.			·750	S by W to S. E.	8	
Bancoora ...	4 A. M.			29·828	N. W.	7	6-15 A. M. Tremendous heavy sea from N. E. 10 A. M. Lulls and very heavy squalls and rain. 7 P. M. Clearing somewhat, wind and sea moderating, vessel at times rolling fearfully.
	8 A. M.				W. N. W.	7	
	Noon	16° 31′	91° 55′	·770	W. N. W.	6	
	4 P. M.				West	7	
	8 P. M.				W. S. W.	4	
	Midnt.			30·049	W.	3	
Mahratta ...	Noon	22° 00′	91° 44′	29·910	S. W. to S. E.	1	4 P. M. Slight swell from S. E. To eastwards, dense heavy clouds; to westwards, sky clear near the horizon; to northwards, light fleecy looking clouds, apparently motionless. Midnight. Sky completely overcast, with occasional rain and heavy swell.
	4 P. M.			·760	E.	2	
	8 P. M.			·780	N. E.	3	
	Midnt.			·780	E.N.E. to N. E.	5	

The observations taken at the land stations show that the barometer had risen rapidly at Diamond Island, moderately at Bassein, Port Blair, and Nancowry, and very slightly at Mergui and Rangoon. It was falling slowly at Akyab and Chittagong, in front of the storm area.

Winds were much lighter at Nancowry and Port Blair, but were unaltered in direction, and continued to give moderate rain. They had veered to S. S. E. in Burmah, except at Diamond Island, where they were from the south. A severe gale of wind had prevailed at that station during the previous 24 hours, but was beginning to moderate. Heavy rain had been brought up by the southerly winds into South Burmah. Bassein received 5·9 inches, Rangoon 2·4, and Diamond Island 1·47 during the previous 24 hours.

The land observations are not sufficient to enable the position of the centre of the storm at this time to be inferred. The slight shift of wind at Diamond Island, the considerable rise of the barometer at that station, and the very small fall at Akyab, indicate that the storm was being largely influenced and retarded by the action of the Burmese and Arakan hills. The southerly winds in the easterly quadrant, instead of passing mainly over a water surface, were now blowing partly over South Burmah. The friction between the winds and the earth's surface, and the action of the hills in breaking up and disintegrating the rotatory or vorticose motion of the air, evidently account for the change which was taking place, and which is more clearly shown by the ships' observations.

The Satara was in the north-east quadrant. Her position at noon was probably about Lat. 16° 20′ N. and Long. 94° E. She was between the storm centre and the Burmese coast, and received the full weight of the southerly winds during the day. She had strong gales with violent squalls and heavy rain during the whole day, and the weather only began to moderate about 8 P. M., after which she had a fresh gale with thick weather and heavy squalls.

The position of the Loanda is slightly doubtful. She was almost in front of the cyclonic centre, probably a few miles only to the west. She had north-easterly winds of force 10 at midday. The storm increased, and at midnight was blowing a hurricane. Her barometer at midday (corrected) was 29·5.

The Byculla was in the south-east quadrant. She had crossed the path of the centre on the previous evening at about 11 P. M., and steamed away to the east during the day. Early in the morning, she was near the centre, and received the full weight of the south-westerly winds. The wind veered to south-west shortly after midnight, and blew with great violence; terrific squalls of wind and rain passing over the ship at intervals. At 8 A. M., the wind blew a heavy gale with terrific squalls from S. S. W. and S. W., bringing up a high confused sea. Weather began to moderate after 11 A. M., and in the afternoon, when the vessel was probably 200 miles away from the storm centre, she experienced fresh breezes with passing squalls. The barometer rose rapidly and continuously during the day from 29·44 at 2 A. M. to 29·83 at midnight.

The Chanda and Bancoora were passing early in the morning through the south-west and south quadrants of the depression. The Chanda experienced terrific squalls with heavy rain. The winds commenced at W. N. W., and hauled round to S. W. at 8 A. M. As she advanced south-eastwards during the afternoon, the weather improved, and wind shifted round to S. E., when strong breezes with occasional squalls and cloudy weather prevailed.

The Bancoora was further to the westward, and hence did not encounter such strong winds as the Chanda. During the day, the winds gradually shifted from north-west to west, and were of average strength 7. Very heavy squalls of wind and rain passed over the vessel, and a tremendous heavy sea came up from north-east early in the morning. As the storm centre passed to the northwards, and the vessel proceeded eastwards, the wind and sea moderated.

The remaining vessels were at greater distances away. The Scottish Hill to the W. S. W. of the centre (in Lat. 15° 56′ N. and Long. 92° 10′ E.) had very heavy rain squalls (force 9 to 10) during the day. The weather began to clear at about 10 P. M.

The Asia, in Lat. 15° 54′ N. and Long. 90° 58′ E. at noon, was proceeding south-eastward to Port Blair, and passed through the outer part of the south-westerly quadrant. She had squally overcast weather with a heavy N. E. swell during the day. At midnight, she had steady, moderate S. W. breezes with cloudy weather. The Mount Stuart was in the west and south-west quadrants, and experienced moderate winds of force 5, with occasional squalls.

The Mahratta, between Chittagong and Akyab, had light variable winds, and fine weather, during the early part of the day. The sky clouded over and was overcast at night, when rain began to fall, and a heavy swell to come up. The Bhundara, off Gopaulpore, had light airs or calms, and a clear sky.

Assuming the position for the storm centre at noon to have been in Lat. 16° 10′ N. and Long. 93° E., the following table gives its position with respect to the vessels near it:—

Names of Vessels.	Position. Longitude. N.	Position. Latitude. E.	Direction of storm centre from vessel.	Distance of storm centre from vessel.	Barometer at Noon.
Loanda	16° 16′	92° 54′	N. N. W.	9	29·50 ?
Chanda	16° 02′	93° 11′	E.	15	29·69 ?
Byculla	16° 10′	93° 11′	E.	12	29·56
Satara	16° 20′	93° 30′	E. N. E.	35	29·68
Scottish Hill	15° 56′	92° 10′	W.	56	29·72
Bancoora	16° 31′	91° 55′	W.	74	29·77
Mount Stuart	14° 47′	91° 20′	S. S. W.	140	29·85
Asia	15° 54′	90° 58′	W.	130	29·85
Mahratta	21° 59′	91° 44′	N. N. W.	400	29·91
Bhundara	Off Gopa	ulpore.	W.	...	29·89

14th November.—The only feature of importance in the meteorology of India was the depression off the Arakan and Burmese coasts. Pressure was again giving way quickly over the Punjab, and to a less extent in all other parts of the country, except at a few stations in Bombay, South Madras, and in Arakan. The highest pressure (30·1) was over Sind, and the lowest (29·69) in Arakan at Akyab. Gradients were not steep, except in and near the cyclonic disturbance. The storm centre in the Bay was approaching Akyab at 10 A. M. The weather was overcast with heavy rain in Burmah and Arakan. A considerable increase of cloud had taken place in Lower Bengal. The sky had cleared in the Punjab and North-west Himalaya, and weather was fine over the whole of India, except in the immediate neighbourhood of the cyclonic disturbance. The winds were more northerly than usual in Northern India. In Bengal and on the Madras coast, winds were blowing chiefly from the north west. They were, however, as during the previous week, light in the neighbourhood of the Madras coast.

The following tables give the observations relating to the weather of the 14th taken at the land stations in the neighbourhood of the cyclonic disturbance, and the meteorological information extracted from the logs of vessels :—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Wind direction. 10 A. M.	Wind direction. 4 P. M.	Velocity in miles per hour since 10 A. M. previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A. M. preceding 24 hours.	Weather.
Nancowry	29·921	— ·019	S. W.	S. W.	2	8	0·63	Cloudy.
Port Blair	29·924	+ ·028	W. N. W.	S. S. E.	6	6	0·61	Cloudy.
Diamond Island	29·898	+ ·072	S.	S.	17	7	0·64	
Akyab	29·692	—·171	N.	W.	8	10	2·44	Raining.
Chittagong ...	29·772	—·083	N. W.	W.	1	8	...	Gloomy.
Toungoo	29·866	—·015	N. W.	S. W.	?	10	0·15	Showery.
Bassein	29·922	+·092	W. S. W.	S.	14	10	1·42	Overcast.
Rangoon	29·921	+·034	S.	S. S. W.	8	10	0·83	Drizzling.
Moulmein	29·913	+·011	S. E.	W.	4	1	0·33	Fine.
Mergui	29·948	+·005	N. E.	N.	1	8	1·55	Cloudy.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Asia	4 A. M.				S W by S.	Moderate.	Moderate breeze and fine weather during the day.
	8 A. M.				S. S. W.		
	Noon	13° 26′	93° 27′		...	...	
	4 P. M.				S.	Light	Light breeze.
Shazada......	8 A. M.			29·841	W. N. W.	Moderate.	
	Noom.	14° 05′	90° 50′				
	4 P. M.			·758	N. N. W.	Light	
Chanda	4 A. M.	15° 27′	95° 15′	29·860	S. S. W.	5	Clear weather.
	8 A. M.			·860	S. S. W.	3	
Bancoora ...	4 A. M.			29·927	W. S. W.	3	4 A. M. Heavy northerly sea. Ship rolling heavily. 6 A. M. Moderate breeze, heavy confused sea, ship rolling violently. Noon. Pleasant breeze and cloudy.
	8 A. M.			...	W. S. W.	3	
	Noon	15° 51′	93° 50′	·899	S. E.	3	
	4 P. M.			·812	S.	3	
	8 P. M.			·907	E. S. E.	2	
	Midnt.			·897	S. E.	2	
Mount Stuart	4 A. M.				Varies to W.	5	Heavy cross N. N. W. to N.N.E. sea which gradually abated. A flash of lightning ahead at 3 A. M. Passing clouds, weather gradually getting finer looking. Passed through lots of bamboo roots to-day. Fine moonlight night.
	Noon	15° 51′	91° 30′	29·890	...	5	
	4 P. M.				N. W.	3	
	8 P. M.				...	2	
	Midnt.				N. N. W.	1 to 2	
Byculla	2 A. M.			29·780	S. W.		2 A. M. Fresh breeze and cloudy.
	4 A. M.			·760	...		
	6 A. M.			·820	...		4 A. M. Moderate breeze and cloudy, with passing squalls. 7 A. M. Water very much discoloured, muddy appearance, bottom 28 fathoms. Moderate breeze and cloudy, light passing squalls. 0-40 P. M. Sighted Alguada Light House to S. E. 1-30 P. M. Light breeze and fine with smooth water.
	8 A. M.			·860	S.		
	10 A.M.			·890	...		
	Noon	15° 58′	93° 58′	·890	...		
	4 P. M.			·880	S. W.		
	8 P. M.			·920	S. S. W.		
	Midnt.			·950	S. S. E.		

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Satara	4 A. M.			29·730	S. S. E.	7	Moderate gale accompanied with heavy squalls of wind and rain. 4 A. M. Strong breeze with heavy squalls. 5 A. M. Very dirty weather, wind moderating, very heavy squalls, and sharp rain. 6-30 A. M. Sighted land. 8 A. M. Strong breeze and thick dirty weather. 10 A. M. Fresh breeze, weather clearing up generally, occasional heavy squalls. Noon. Light breeze and fine. Sea smooth. 4 P. M. Light breeze and fine, 8 P. M. Sighted Alquada Reef Light. Moderate breeze and fine. Sea smooth. Midnight. Light breeze and fine.
						6	
	8 A. M.			·850	S. S. W.	6	
	Noon	16° 45′ *	94° 3′	·880	...	2	
	4 P. M.			·730	...	2	
	8 P. M.			·900	...	4	
	Midnt.			·900	S. W.	2	
Scottish Hill	4 A. M.			29·820	W.		Sky clearing. Sea lighter, though much confused. Heavy sea from N. N. W. and N. Weather fine, but heavy bank of clouds to N. N. W. and N. N. E. Sea going down fast. Clouds clearing off.
	8 A. M.			·870	...		
	Noon	17° 00′	92° 25′	·880	...		
	8 P. M.				W. N. W.		
	Midnt.			·890	N. W.		
Loanda	4 A. M.						Wind hauled round through N.
	Noon	17° 34′	92° 46′		W.	7 to 8	Weather overcast with light rain.
	Midnt.						Weather improving.
Mahratta ...	4 A. M.			29·590	N. N. E.	9	Thick continual rain, with heavy sea
	8 A. M.	Entered Akyab.		·740	N. N. W.	8	

* A current set the ship from noon of 11th instant to noon of 14th instant N. 13° W. 171 miles.

The barometer had risen at Diamond Island and all the stations to the south and east, except Nancowry, where a slight fall was observed.

The rise was nowhere large, and was less than a tenth of an inch at all stations in that part of the Bay. A considerable (·17″) fall had occurred at Akyab, and smaller changes of the same character at Chittagong and Toungoo. Judging from the barometric movements, the centre at 10 A. M. was in the immediate neighbourhood of Akyab.

The wind observations, however, are anomalous and almost unintelligible on the supposition of a well defined cyclonic circulation. The winds at Nancowry were steady from south-west, but were very feeble. At Port Blair, the wind was very unsteady, shifting from W. N. W. at 10 A. M. to S. S. E. at 4 P. M. Moderately strong S. W. winds continued at Diamond Island. The winds at 10 A. M. at Akyab were from N. and at Chittagong and Toungoo from N. W. They shifted at 4 P. M. to west at Akyab and Chittagong, and to S. W. at Toungoo. They were, however, very feeble at all these stations. The wind velocity averaged 8 miles per hour at Akyab, and only 1 mile per hour at Chittagong, where the air motion was actually less than the average in November, which is 2 miles per hour. The only inference from these observations is, that the cyclonic or vorticose motion had been broken up to a large extent by the action of the hills and the friction of the land, and that it was no longer a well-defined cyclonic circulation. This is also indicated by the character of the rainfall at the land stations. It was more widely distributed than before, and was smaller in amount, the largest quantity registered being 2·44 inches at Akyab.

The vessels which have contributed logs were all on the southern and western quadrants at some distance from the centre. They give information which is less valuable and conclusive than that of the preceding days. The whole of the meteorological observations, when charted, indicate that the centre of the barometric depression at 10 A. M. was to the east of Akyab in Lat. 20° N. and Long. 93½° E., and that the cyclonic circulation was very irregular and fast breaking up. The Mahratta, from Chittagong, entered Akyab harbour at 8 A. M. She had thick continued rain during the night with northerly winds of force 9. The Scottish Hill, in Lat. 17° N. Long. 92° 25′ E., was to the south of the centre at noon. She had winds from west to north-west. During the day, the sky cleared, and the sea went down. At noon, weather was fine, although a heavy bank of clouds was still to be seen to the N. N. W. and N. N. E., but it cleared off during the night.

The Loanda, in Lat. 17° 34′ N. and Long. 92° 46′ E. by account, had westerly winds, and overcast skies with slight rain.

The Satara found herself at noon in Lat. 16° 45′ N. and Long. 94° 3′ E. She experienced moderate winds of force 7 from S. S. E. early in the morning, and continued to have sharp squalls and heavy rain until

6 A. M., after which the weather rapidly improved. A fresh breeze was blowing at 10 A. M. with occasional heavy squalls. At noon, the storm was completely over, and she had light breezes of force 2 from the S. S. W., fine weather, and a smooth sea.

The Mount Stuart, in Lat. 15° 51′ N. Long. 91° 30′ E. at noon, had westerly winds of force 5 early in the morning, with a heavy cross sea. The weather improved rapidly, and was quite settled in appearance at night, with fine clear skies and light winds of force 1 to 2. The Byculla, Bancoora, and Chanda were steaming along the south coast of Burmah towards Rangoon. They had fine weather with south-westerly winds of average force 3.

It thus appears that the first action of the Burmese hills, which are comparatively low, had been to retard the advance of the centre very considerably between noon of the 12th and of the 13th. During the next 24 hours, it advanced rapidly almost due northwards with a very slight easterly tendency. It then approached the coast to the east of Akyab on the morning of the 14th. The depression was, however, very much smaller than hitherto, and the cyclonic motion very considerably broken up. The winds were irregular in direction near the centre. The rainfall was evidently much less in amount, and more widely distributed. The observations taken at Akyab and Chittagong at 4 P. M. shew that the disturbance was then almost completely disintegrated. There was at that hour an irregular, but very feeble, cyclonic circulation, which passed away before the following morning.

15*th November*.—The meteorology of the 15th is given to show how completely the cyclonic disturbance had broken up.

The barometric changes of the previous 24 hours were exceedingly irregular. The only important change was in Arakan, where the barometer had risen very rapidly with the disappearance of the cyclonic disturbance. The winds show very little alteration generally. In the North-West Provinces and Punjab, they were very variable. In Bengal and Orissa, they had a much stronger northerly component than is usual in November. The weather was fine, and skies were clear over nearly the whole country, except Burmah and Arakan, where they were still more or less clouded, and moderate rain was falling. In the Punjab, though the sky was generally clear and humidity decreasing, the weather still appeared unsettled. The exceptional character of the weather in the Punjab during the previous week, is illustrated by the fact that the average rainfall of the hill stations at Simla and Chakrata for the month of November is *nil*, whilst, during the previous fifteen days, four inches had fallen at the former station, and $3\frac{1}{2}$ inches at the latter.

The following tables give the observations of the same stations as hitherto, and the meteorological information from the logs of several vessels in the Bay for the 15th November:—

Stations.	Barometer at 10 A. M. reduced to sea level.	Change since 10 A. M. previous day.	Winds. 10 A. M.	Winds. 4 P. M.	Velocity in miles per hour since 10 A. M previous day.	Cloud amount at 10 A. M.	Rainfall at 10 A.M. preceding 24 hours.	Weather.
Nancowry	29·889	— ·032	E.	S.	2	8	1·47	Cloudy.
Port Blair	29·932	+ ·008	N. N. E.	E. S. E.	5	3	0·13	Fine.
Diamond Island	29·937	+ ·039	E. S. E.	E. S. E.	7	6	0·16	Fine.
Akyab	29·937	+ ·245	E.	S. S. E.	5	9	0·33	Gloomy.
Chittagong ...	29·925	+ ·153	S. S. E.	S. S. W.	2	6		Gloomy.
Tounghoo	29·913	+ ·047	N. W.	N. W.	?	6	0·04	Drizzling.
Bassein	29·952	+ ·030	S. S. E.	W.	3	10	0·04	Cloudy.
Rangoon	29·952	+ ·031	S. E.	S. S. E.	5	9	0·74	Cloudy.
Moulmein	29·899	— ·014	N.	N. E.	2	0		Fine.
Mergui	29·920	— ·028	Calm.	N.	1	10	1·50	Overcast.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	Remarks.
Shazada......	4 A. M.			29·911	N. N. E.	Light.	Weather fine with light winds.
	8 A. M.						
	Noon	12° 47′	87° 14′				
	4 P. M.			·781	N. N. E.	Light.	
	8 P. M.						
Satara	4 A. M.			29·870	S. E.	2	Light breeze and fine clear weather.
	8 A. M.			·940	...	4	Moderate breeze and fine weather.
	Noon	15° 50′	95° 50′	·980	...	4	Current during the previous 24 hours, W. 65 miles.
	4 P. M.			·810	N. E.	2	Light breeze and fine weather.

Vessel.	Hour.	Latitude. N.	Longitude. E.	Probable reduced barometer.	Winds. Dir.	Winds. Force.	REMARKS.
Asia	4 A. M.				Variable	Light	Light and variable airs, fine weather.
	Noon	Port	Blair.		...	...	
	4 P. M.				E. N. E.	Light	Light breeze and fine clear weather.
	8 P. M.				...	Fresh.	
Mount Stuart	4 A. M.				N. N. W.	1	1 P. M. Smooth with light N. swell. 4 P. M. Heavy clouds all round the horizon. 5 P. M. Weather settled looking.
	8 A. M.				N. by E.	1 to 2	
	Noon	16° 24′	92° 00′	29·890	N. N. E.	...	
	4 P. M.				NE by N	2	
	Midnt.				NNE to NE by N	2	Midnight. Clear fine weather.
Scottish Hill	8 A. M.				N. W.		Light winds and swell from N. N. W.
	Noon	18° 03′	92° 48′	29·900	...		
	8 P. M.				NNW to N.		Light winds and clear sky.
Loanda	Noon	18° 38′	92° 30′	29·800	W by N.	5	

The observations call for little remark. The rapid recovery of pressure at Akyab, and the lightness and irregularity of the winds in Arakan and Burmah, indicate the complete disappearance of the cyclonic vortex. The land observations show that the winds were very unsteady during the day. For instance, at Nancowry, they were from east at 10 A. M. and south at 4 P. M. Similarly, at Port Blair, they shifted from N. N. E. at 10 A. M. to S. S. E. at 4 P. M. It is probable that these were light local winds, for the logs of the vessels prove that, over the greater part of the Bay, north-easterly winds were again established. The Clan Macpherson, at the entrance to the Bay, in Lat. 6° N., had moderate north-easterly winds.

Hence the cyclonic circulation had not only broken up, but the south-westerly winds which had, as shown by the Nancowry registers, prevailed steadily up to the afternoon of the 14th, although they had decreased in strength considerably during the 12th, 13th, and 14th, had given way so rapidly and entirely on the afternoon of the 14th, that light north-easterly winds were again established over nearly the whole of the Bay on the morning of the 15th. This speedy restoration of the normal circulation of the air after the disappearance of the disturbance, is perhaps less remarkable than it might seem to be, but is nevertheless noteworthy.

CHAPTER IV.

Discussion of the chief features of the Storm of November 10th to 15th.

The following gives a brief connected narrative of the more important features of the storm.

After the termination of the south-west monsoon in Bengal in the last week of September 1883, the winds shifted round to north over the Head of the Bay, and the lower air current of the south-west monsoon recurved over the middle of the Bay. The north-east monsoon hence commenced on the Madras coast during the first week of October. Unusually heavy rain fell over Southern India, more especially over the eastern districts of the Madras Presidency, during the month of October and the first week of November. During the whole of this interval, the period of the year when the most severe and extensive cyclones are known to occur, the Bay was entirely free from storms. In the beginning of the second week of November, the rainfall rapidly decreased in amount in Madras, and ceased entirely on the 9th and 10th. The logs of vessels shew that winds were, at that time, as they had been for some days previously, very light and variable in the neighbourhood of the Andamans and Nicobars. South-westerly winds were re-established at Nancowry on the 4th, and south-easterly winds at Port Blair on the 7th, but they were at first very weak.

The wind observations taken on board the ships Mount Stuart and Scottish Hill prove that, at the same time, winds were unusually light over the centre of the Bay, in the neighbourhood and to the west of the Nicobars and the Andamans. This condition of excessively feeble air motion was very marked on the 7th and 8th. On the 9th, there were indications for the first time of the occurrence of moderately heavy and localized rainfall to the north-east of the Nicobars, and to the east of Port Blair, and also of a shift of wind, significant of the commencement and establishment of cyclonic circulation. On the morning of the 10th, there was a well-defined atmospheric whirl to the east of Port Blair. Weather was at that time cloudy, with very light breezes, and occasional passing showers; and the sea was smooth, and free from any considerable current over the greater part of the Martaban Gulf, and the north and centre of the Bay.

The ship Kwang Tung, it may be remarked, passed, on the 7th and 8th, over the area in which the disturbance was generated; and there is not the slightest indication in her log, or in the observations of the neighbouring land stations, of the existence of any atmospheric whirl, large or small, at that time, or previous to the 10th. The central depression at noon on the 10th was very small, probably less than a tenth of an inch, and the atmospheric whirl, although clearly established, was as yet in an initial state. It, however, rapidly acquired increased energy during the afternoon of the 10th, and the morning of the 11th. At noon of the 11th, there was a well-defined cyclonic disturbance with its centre in Lat. $13\frac{1}{2}°$ N. and Long. $94\frac{1}{4}°$ E., the barometric depression at which certainly exceeded ·3″. Strong winds were now blowing into it from the south, and bringing up much vapour. During the succeeding 24 hours, the centre moved to the north-westward through the channel separating Diamond Island and Cape Negrais from the Andaman Islands, and probably over the Coco Islands. Its centre, at noon on the 12th, was in Lat. $15\frac{1}{2}°$ N. Long. 93° E. The disturbance was of small extent, as vessels at distances of only 150 miles had light to moderate winds of force 3 to 5. The Satara, Byculla, and Loanda, all of which were near the centre, on the other hand, experienced squalls of terrific and hurricane force.

Hence it was at that time a small but well-defined atmospheric whirl or cyclonic disturbance. The winds and squalls near the centre were of the most violent character, the sea excessively high and dangerous, and the currents in the eastern quadrant considerable. During the next 24 hours, it retained the same characteristics, but moved very slowly to the north, so that, at noon, its centre was in Lat. 16° 10′ N. and Long. 93° E. The retardation of its motion was evidently due to the resistance of the land and hills in the eastern quadrant. The centre passed a few miles to the east of the Loanda and the Byculla on the evening of the 12th and morning of the 13th. The decrease in the indraught from the eastern quadrant due to the action of the Burmese and Arakan coasts continued. The whirl began to diminish in intensity, and also recurved slightly after noon of the 13th, and passed to the north-north-eastward, thus approaching the Burmese and Arakan coasts. On the morning of the 14th, it was much enfeebled. The barometric depression was smaller in amount, the winds weaker, the rainfall more diffuse and less localised, and the sea less violent. Moreover, the directions of the winds were so irregular over the area of barometric depression as to suggest the existence of several imperfect and feeble vortices, rather than of one large and well-defined whirl. The centre of the depression was in the neighbourhood of Akyab on the morning of the 14th. The land observations at 4 P. M. of that day indicate that the cyclonic circulation was completely broken up, and that fine weather, with moderate winds, and a slight sea, obtained at that hour in the north-east of the Bay, over which the cyclone had previously advanced. The disturbance passed so completely away on the 14th that normal north-easterly winds were re-established over the greater part, if not the whole, of the Bay, on the morning of the 15th. The storm hence was generated and dispersed between the morning of the 10th and the evening of the 14th.

The following are a few of the more important points in connection with this cyclone.

One of the more remarkable features, which has already been discussed, but which deserves special mention, was the change which occurred when the cyclone approached the Burmese coast. Whatever the explanation may be, there can be no doubt of the facts.

The following table gives approximately the position of the centre at noon on the various days, and the distance passed over by it in the preceding 24 hours :—

	Position of Centre.		Distance passed over in preceding 24 hours.
	Latitude.	Longitude.	
11th	13° 30′	94° 15′	
12th	15° 30′	93° 0′	160 miles.
13th	16° 10′	93° 0′	47 ,,
14th	20° 0′	93° 30′	275 ,,

It will thus be seen that, between noon of the 12th and 13th, the storm centre began to recurve, and only advanced a distance of about 50 miles, as compared with 160 miles during the previous 24 hours, and 275 during the succeeding 24 hours. The only apparent explanation depends on what I have already suggested as probable, namely, that the cyclonic action extends through very different heights in different storms. In the storms of the rains proper, it is almost certain that the condensation, and therefore the seat of the disturbance, is at a much greater elevation than it is in storms formed during the October Transition period. In the latter case, the storms appear to be generated near the northern limit of the retreating south-west monsoon current, which is at that period diminishing in strength. It is probably much shallower at its northern limits than elsewhere. Many of the phenomena of the cyclones of the Bay appear to be intelligible and explicable only on this supposition.

If it be granted that the October and November storms of the Bay of Bengal are formed near the northern edge of a diminishing and retreating current, it is hence almost certain that the vapour condensation, in the case of the November cyclone under discussion, occurred at a comparatively small height in the atmosphere, and that the resulting motion was mainly confined to the lower strata. Hence the effects due to friction with land, and to the destructive or disintegrating action of the hill barriers of Burmah and Arakan cutting almost radially across the cyclonic area, would be large and marked. This was undoubtedly the case. So long as the cyclone was to the south of the Burmah coast, the cyclone increased in intensity. When the centre was in a line with the coast, and at a short distance from it, retardation was at once shown, and the cyclonic or vorticose motion began to diminish. And as the centre advanced northwards, so that the Arakan hills (of greater height than the west Burmese hills) were included within the area of disturbance, the disintegrating action became rapidly more marked, and caused a speedy disruption of the vortex.

A feature which deserves special notice in the smaller cyclonic storms of the Bay is the behaviour of the barometer. The barometer affords practically no indication of the approach of a small cyclonic storm in the Bay, and should not be trusted by the mariner to give due warning. The reason of this is simple. A favourable condition antecedent to the formation of a storm is approximate uniformity of pressure over the whole or a large portion of the Bay. If a small atmospheric whirl be set up in an almost quiescent mass of air, which is therefore under nearly identical and uniform conditions, it produces a small depression at and near the centre, which extends slowly outwards. The fall of the barometer at distances of 80 or 100 miles from the centre is generally small in amount, and is frequently less than the changes due to general actions common to the whole of India. The depression at the centre rarely exceeds half an inch, and steep baric gradients are confined to its immediate neighbourhood. Over the rest of the Bay, the pressure is slightly affected by the indraught, but frequently not to such an extent as to obscure the changes going on over the whole of India. In other words, during the formation and existence of a small storm, the barometer immediately outside of the storm area proper oscillates in obedience to the larger atmospheric movements common to the whole of India, as well as to the distant storm, and hence, if used as a guide to the weather, it should be remembered that its indication may refer mainly to these general movements, and not to the whirl in the neighbourhood. Hence it cannot be used as a reliable guide to the existence of small storms in the Bay of Bengal.

A few examples from the present cyclone will not only indicate that the barometer gives no certain and marked warning of the approach of a smaller cyclone in the Bay, but suggest that the mariner in the Bay of Bengal should rely mainly on the appearance of the sky, the strength and changes of the wind, the amount of the swell, and the direction from which it travels, as indications of an approaching storm.

The Mount Stuart passed through the western quadrant. The following table gives her barometric readings, her position with respect to the storm centre, strength of wind, and amount of swell:—

	Barometer.	Wind.	Swell.	Distance of storm centre.	Weather.
7th	29·90	2 to 3	None	...	Unsettled.
8th	·92	1 to 4	None	...	Unsettled.
9th	·87	0 to 3	None	...	Unsettled.
10th ...	·86	0 to 4	None	...	Unsettled.
11th ...	·82	2 to 5	None	250	Weather looking very bad.
12th ...	·75	5 to 6	...	100	Squally.
13th ...	·87	5 to 6	Heavy sea.	125	Squally.
14th ...	·89	5 to 1	Heavy.	280	Fine.

The preceding table shows that, although she was within 100 miles of the centre of a storm between the 10th and 14th, the range of the barometer at noon during the whole interval was only ·14″, or very little more than the diurnal range of the barometer in the Bay.

The Bancoora may be taken for another example:—

	Barometer.	Distance.	Wind.	Swell.	Weather.
11th ...	29·887	550	2 to 4	None.	Fine.
12th ...	·805	250	4 to 5	Heavy N. E. sea.	Squally.
13th ...	·770	70	3 to 7	Tremendous sea in the morning. Heavy sea during the afternoon.	Very squally
14th ...	·839	280	2 to 3	Heavy sea.	Improving.

The above shows that the Bancoora, which left the River Hooghly on the 11th, approached within 70 miles of the centre of the cyclone at noon of the 13th. She had heavy squalls and a tremendous sea, and yet the total range of her barometer, as determined by the noon observations, was only ·117″, or actually less than the diurnal range of the barometer in the Bay.

The Satara furnishes equally strong evidence. She was for a considerable time in the eastern quadrant of the cyclone at no great distance from the centre, and hence felt the full force of the storm.

	Barometer.	Distance.	Wind.	Swell.	Weather.
10th ...	29·89		2 to 5	None.	Fine.
11th ...	·80	250	4 to 6	Heavy sea.	Gale. Heavy squalls.
12th ...	·61	90	9	Heavy sea.	Hard gale.
13th ...	·68	35	8 to 9	Heavy sea.	Strong gale.

The preceding observations show that on the 11th, when the state of the sea and the strength of the wind indicated the existence of a cyclonic storm, her barometer had not fallen a tenth of an inch. It was only on the 12th, when she was in the midst of the storm, and the wind had increased to force 9, and was blowing a hard gale, that the barometer began to fall to any considerable extent.

These examples appear to establish that the barometric movements are very small in the outer portion of the smaller cyclonic disturbances of the Bay, and are generally smaller than those due to the regular changes common to the whole of India. Hence the barometer gives little or no practical warning of the approach of a small cyclone in the Bay, and mariners should therefore rely mainly on other indications.

The path of the cyclone was contrary to all recorded experience of storms in the Martaban Gulf. The following is the list of storms that have been known to occur in that portion of the Bay, taken from Mr. Blanford's Catalogue of the recorded Cyclones in the Bay of Bengal, up to the end of 1876, in Journ. As. Soc., Bengal, 1876, Vol. XLVI, Pt. II:—

1840—November 21st. To the N. E. of the Andamans.

1844—November 9th—14th. East of the Andamans. Encountered by the Briton and Runnymede troop ships. Both vessels were dismasted and thrown on the Andamans.

1850—November 17th—19th. In the Andaman Sea. Passed east of Port Blair and travelled N. N. W.

1854—April 21st—23rd. A violent hurricane in the Gulf of Martaban and Rangoon.

1858—April 9th—10th. A storm from the Andamans to Cape Negrais. Much destruction of property occurred at Henzada and Rangoon, betw een which the centre passed.

There is no direct evidence in this list that any of these storms passed from the Martaban Gulf into the Bay of Bengal. It is, however, probable that the third storm in the list did so. It appears to be parallel in time of occurrence, and line of advance, with the storm under discussion. There is no apparent theoretical reason in support of the opinion that a storm generated in the Gulf of Martaban should not pass into the Bay. Experience certainly appears to indicate that such a line of motion is very rare. The great majority of the cyclonic storms in the Gulf of Martaban are generated to the east of the Andamans and north-east of the Nicobars, and advance in a general northerly direction across the south coast of Burmah, when they rapidly break up.

Hence, although experience is doubtless valuable in indicating the probabilities of the occurrence of cyclones, and their line of motion, it should be most carefully borne in mind, that they are mere probabilities based, at the present time, on very limited experience, and that it would almost certainly be misleading and dangerous to dogmatize our limited experience into rules or laws, which might fail on their first application.

Another feature deserving notice was the short period of its existence. Favourable conditions, according to the condensation theory, were present for some days previous to the 10th. The log of the Kwang Tung for the 7th proves that there was no cyclonic vortex in existence in the Andaman Sea on that day. The various observations of the 8th and 9th indicate that cyclonic motion on a considerable scale had not commenced on either of these days. The observations of the 10th, on the other hand, establish the existence of a small depression on that day which rapidly developed into a large atmospheric whirl. Hence the existence of the cyclonic vortex dates from the evening of the 9th, or morning of the 10th. The circulation intensified and developed rapidly on the evening of the 10th and morning of the 11th, so that there was a large barometric depression and cyclonic circulation on that day, to the north-east of the Andamans. The cyclone was then moving north-westwards.

It continued to accumulate energy until the morning of the 12th, when the action of the land on the atmospheric motion in the eastern and north-eastern portions of the cyclone retarded the advance of the vortex, and began to influence the cyclonic motion considerably. This proceeded at first slowly, but, as the storm moved northwards, the destructive effect of the Burmese and Arakan hills increased, so that the rotatory motion was gradually and completely broken up and disintegrated before the afternoon of the 14th, in the neighbourhood of Akyab. There was thus a period of about 48 hours, from the morning of the 10th to that of the 12th, during which the storm accumulated energy. During the next 24 hours, the rotatory motion continued almost undiminished, whilst the motion of translation was largely decreased. During the remaining 36 hours of its existence, the vorticose or rotatory motion was gradually diminished.

The force of the winds at and near the centre (which might perhaps be used to measure the intensity of the storm) depends mainly upon the strength of the atmospheric disturbance producing the cyclonic motion, that is, upon the rate at which aqueous vapour is condensed into rain and upon the character and distribution of the rainfall (*i. e.*, whether it is localized and concentrated over a comparatively small area or diffused). On the other hand, the extent of area over which the cyclonic disturbance extends appears to depend mainly, if not entirely, upon the length of time that has elapsed from its formation, and during which it has advanced over the sea area uninfluenced by the land. Hence it is that the most extensive cyclones have been generated in the centre of the Bay, near the Andamans, and have advanced northwards to the Bengal coast. This is not due to any meteorological peculiarity of the Bay in the neighbourhood of the Andamans, but to the fact that a cyclone generated there, and advancing northwards, takes a longer time to reach the land than if it were formed in any other part of the Bay, and has therefore a longer period during which its energy can increase.

CHAPTER V.

Concluding Remarks on the Condensation Theory.

In the preceding pages, all the observations throwing light on the two largest and most severe storms in the Bay of Bengal during the year 1883 have been given, together with a discussion of their more important features. It remains to explain the chief features of the two storms as physical phenomena, and hence also to suggest the theory of cyclonic generation and motion which appears to be applicable to them, and is consistent with our knowledge of the physics of the atmosphere.

In both examples, the greater portion of the mass of air that was thrown into a state of violent motion during the storm was for some days antecedent to the disturbances almost at rest, and in a state of approximate equilibrium. There was a break in the rains immediately preceding the formation of the first storm, which is well-known to be a period of light and unsteady winds in Bengal, and over the Head of the Bay. The second storm occurred very shortly after the first break in the north-east monsoon rains on the Coromandel coast, and when, as the various observations prove, winds were very light and variable over the greater portion of the Bay. Hence the first and most striking feature of these cyclones was, that a vast amount of kinetic energy, or motion, was rapidly given to a large mass of air which, previously to that action, was in an almost quiescent state. The gradual increase of the motion was in those two examples proved from observations taken by vessels passing through the areas of disturbance. The transformation from the state of approximate quiescence to that of violent cyclonic motion in the Bay is consequently a continuous process, the successive stages of which can be fully traced. And the entire development of these, and of all storms in the Bay of Bengal, appears to be due to actions occurring over the Bay itself, and not to atmospheric conditions at a considerable distance from the area of cyclonic disturbance.

The question of cyclone generation is therefore essentially one of transfer of energy. Viewed in this light there are two subjects for enquiry :—

1st. The source and character of the energy which is transferred to the atmosphere, and transformed into the kinetic energy of a mass of air.

2nd. The conditions necessary for the transfer of energy under consideration.

If these two questions are fully answered, a satisfactory explanation will be given of cyclonic generation as a meteorological problem. The complete mathematical treatment of this subject as a dynamical question is beyond the scope of the present article.

The energy which is transformed during the generation and existence of a cyclone, and which maintains the cyclonic circulation against the various resistances opposing it, and therefore tending to disintegrate it, is undoubtedly the latent heat energy given out during the condensation of aqueous vapour contained in the atmosphere. In all cyclones of the Bay of Bengal that have hitherto been investigated, heavy and, in the majority of cases, torrential rain is the most prominent feature. It increases in amount during the generation of the cyclone, is excessive during the existence of the cyclone in its complete form, and rapidly decreases during the disintegration of the cyclone, ceasing with the disappearance of the cyclonic vortex. It is thus a phenomenon parallel in character and duration with the cyclonic motion or disturbance.

It is also equally certain that when aqueous vapour is condensed into rain, practically the whole of the solar thermal energy utilized to perform the work of evaporation is given out by the mass of vapour during condensation, and is transferred to the adjacent mass of air. Major Cunningham's Hydraulic Experiments at Roorkee appear to establish that the sun's heat under the most favourable conditions, that is, dry weather and high air temperature, does not evaporate more than one-tenth of an inch *per diem* from the surface of slowly moving water. The inverse process of condensation, in consequence of certain features of air motion dependent on rainfall, usually proceeds much more rapidly, and frequently restores the aqueous vapour in the form of rain to the earth's surface at the rate of one to two inches per hour. Prolonged rainfall at the rate of 10 to 30 inches *per diem* for periods varying from 24 to 72 hours are by no means uncommon during the passage of the larger cyclones of the Bay of Bengal across the Bengal or Madras coasts. It is probable, judging from the expressions used by sailors to describe the rainfall during cyclones in the Bay, that it is more intense and prolonged than on land.

If we therefore compare the rates at which evaporation and condensation can occur, it is certain that the energy released during the act of condensation is transferred to the atmosphere with very great rapidity during heavy rainfall and probably at a rate occasionally amounting to 100, 200, or even 400 times that at which it was absorbed during the process of evaporation. The effect of a continuous fall of 20 or 30 inches of rain over any portion of the earth's surface would, on the assumption of Major Cunningham's results, be equivalent to that of a sun 250 times as powerful as our present luminary acting directly on the mass of the atmosphere above the area of rainfall, instead of indirectly by means of convection currents due to the heating of the earth's land surface. The action is also usually continuous, and is not interrupted, as in the case of the direct solar action, by the succession of night and day. There is therefore the strongest probability that so powerful a disturbing action can produce very large and rapidly accumulating effects on the mass of the earth's atmosphere affected and influenced by it in a comparatively short space of time.

There hence appears to be no doubt that the energy transferred to the atmosphere during heavy rainfall is very large, and that the source of the energy thus indicated is adequate from every point of view to account for the production of the largest and most intense cyclonic circulations. Other causes of the origin of cyclones have been assigned, as, for instance, differences of pressure, friction between parallel winds blowing from opposite directions, &c., but the slightest consideration seems to show that none of these is sufficient to account for the enormous and continuous transfer of energy that occurs during the prolonged existence of a large cyclone. The strongest argument against these theories, in the case of cyclones of the Bay of Bengal, is, that experience has established that the larger the cyclone, the smaller are the antecedent differences of pressure, and the feebler are the winds blowing from opposite directions, immediately before the formation of the cyclonic vortex.

The following statements based on the preceding remarks hence give the answer to the first part of the required explanation. When water is converted into aqueous vapour on the large scale at the earth's surface, thermal energy, derived from the sun, performs the work of evaporation, and is hence transformed. The aqueous vapour thus produced possesses an equivalent amount of energy, the greater part, if not the whole, of which it retains, so long as it continues in the vaporous condition. When it is reconverted into water, or condensed as rain, this portion of its total energy is given out, and transferred to the air. The *modus operandi* of this transfer is a matter of no importance in the present enquiry. Also, in all cases when the rainfall is heavy, and prolonged for a considerable time, the energy is given out at a much more rapid rate than that at which it was absorbed during the process of evaporation. Hence heavy and prolonged rainfall may give rise to a powerful, persistent, and continuously accumulating disturbance on the adjacent atmosphere, and, therefore, produce violent and extensive air motion. In virtue of the constitution of the atmosphere, the motion will be rotatory. Prolonged heavy local rainfall is hence an adequate and sufficient cause. It is, moreover, the only known cause which is equal or similar in amount to the effect, and hence there are strong reasons for assuming that it is the motive power which produces the peculiar motion of the atmosphere called cyclonic circulation on the large scale. It is, in fact, the most powerful disturbing action to which the air is subject, and the consequent motion of the air is, when the rainfall and consequent disturbance are excessive, the most violent in its character with which we are acquainted.

The history of the two cyclones has shewn most fully that heavy rainfall over the area of cyclonic motion or disturbance was a characteristic feature, and that in this respect they confirm previous experience. Hence the source of the energy of these two cyclones was almost certainly that which we have indicated in the previous statement, that is, the latent heat energy of the aqueous vapour derived previously from the sun, and transferred to the atmosphere during the process of condensation.

As rainfall does not always appear to produce cyclonic motion, it is clear that, although rainfall may be the source of energy, it is only when the rainfall occurs under special conditions that the accompanying air motion increases and accumulates in the peculiar manner necessary to give rise to a large and intense cyclonic circulation. Experience has shown that the following conditions, which can be proved to have a direct bearing on the formation of cyclones, are always present before and during the generation of cyclones in the Bay of Bengal :—

1st. The establishment and prevalence of a humid current over the extreme south of the Bay, which brings up large quantities of aqueous vapour into the centre or north of the Bay.

2nd. The occurrence of approximate uniformity of meteorological conditions, more especially of pressure, over the coasts of the Bay, and frequently over a considerable portion of the Bay.

3rd. The prevalence of light and variable winds over Bengal and the coasts of the Bay, and over a considerable portion of the Bay extending from the Bengal coast southwards. This condition is practically identical with the previous, as both are due to, and accompany, the same general atmospheric conditions.

4th. The absence of rainfall, and the prevalence of clear skies with fine weather, over the north and centre of the Bay, and in Bengal.

The relative importance of these conditions will be evident on very brief consideration. The first is evidently necessary to supply the aqueous vapour in sufficiently large amounts to give rise to continuous heavy rainfall over such a large area as is covered by a considerable cyclonic disturbance. The Bay of Bengal is not a large enough evaporating area to afford such a supply. Hence cyclonic storms are only formed in the Bay of Bengal when there is a humid current blowing into it from the Indian Ocean. This occurs only during the south-west monsoon period, when the south-west winds blowing at the entrance of the Bay are the northward continuation beyond the Equator of the south-east Trade Winds of the Southern Tropics. That such is the case is sufficiently proved by the fact that cyclonic storms on the large scale are entirely restricted to that portion of the year when south-west monsoon winds are blowing over a part or the whole of the Bay, that is, from the beginning of May to the end of December. It is also shown by the fact that, at the commencement and termination of the south-west monsoon period, any cyclones that are generated, form in the south of the Bay, whilst in the months of July and August, or during the height of the south-west monsoon, they form near the Head of the Bay. In short, the area of cyclonic generation in the Bay of Bengal depends mainly upon the season, and travels northwards or southwards, according as the south-west monsoon is advancing or retreating over the Bay.

The remaining conditions appear to be necessary in order that the rainfall may occur in such a manner as to give rise to and produce an atmospheric whirl. It is evident that if rainfall tends to set up rotatory motion in the air, it is absolutely necessary for rotatory motion on the large scale that there should not be several separate centres of rainfall and disturbance, each producing its own rotatory or cyclonic action, and therefore interfering with the others. It is essential that the rainfall should be localized and concentrated, that it should continue for some time over a comparatively small area, and be confined to that area. The more perfectly this is realized, and the longer this continues, the greater will be the accumulated disturbance. In order that the rainfall may occur over the same area for such a considerable period as to permit of the continuous accumulation of action, it is evident that ascensional motion should mainly occur there, and hence that, previously, there should be little horizontal motion of the air, and therefore very slight differences of pressure at the sea level. The necessity for the further conditions is hence also evident.

It will be seen that these conditions were fulfilled in the case of both storms, more completely (as might have been anticipated) in the case of the second storm, when the south-west monsoon current was weaker than it was at the time of the first storm. The history and discussion thus fully bear out the existence of the conditions immediately antecedent to the two storms which the condensation theory asserts to be necessary for the initiation and generation of a cyclonic storm in the Bay.

The preceding remarks hence indicate that the energy given out during the process of aqueous vapour condensation on the large scale is the motive power of cyclones, and that the rainfall must be localized and concentrated over a considerable area, for a period of one or more days, in order to produce the continuous and rapid accumulation of energy which characterizes a large cyclonic disturbance. Experience has also shown that the conditions which the condensation theory suggests as being essential for the occurrence of continuous and prolonged local rainfall over a portion of the Bay are exactly those which are present before and during all cyclonic storms in the Bay of Bengal, and that they are more fully marked before the occurrence of the larger than of the smaller cyclones of the Bay. It is, moreover, these antecedent conditions which form the only test or indication of the possible or probable early formation of cyclones in the Bay, and which are utilized in the preparation of the daily weather Reports issued by the India and Bengal Meteorological Departments.

EXPLANATION OF PLATES II—X.

The plates give the weather charts for each day during the whole period covered by the two storms of 1883 described in the preceding pages. The curved lines or isobars indicate the distribution of pressure. Along any one of these lines, the estimated air pressure at the sea-level (as determined from the reading of the barometer) is the same. Hence no change of pressure occurs along these lines, and the change of pressure is greatest perpendicularly across these lines. The rate of change is most rapid where the lines are nearest together. As the difference of air pressure between consecutive lines is the same, the rate of increase or decrease of pressure is inversely proportional to the distance between consecutive lines. The isobars form closed curves about the centre of a cyclonic disturbance. Hence the position of the cyclonic vortex on any day is at once determined by an inspection of the charts. The probable path is determined by joining these positions by lines. The direction of the air motion near the earth's surface is determined by the winds, which are shown by arrows flying with the wind, or pointing to the direction towards which the moving air is advancing. Small circles (o) indicate a calm at the hour of observation.

The charts give the distribution of pressure and wind directions at 10 A. M. of each day. They are based on the 10 A. M. observations taken at the land meteorological stations, and on the 8 A. M. or noon observations taken on board the ships which have furnished logs of the weather experienced by them in the Bay during either storm, allowance being made, wherever at is possible, for the difference of time between the two sets of observations.

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IV.—*Some Rough Notes for the Construction of a Chapter in the History of the Earth.*—*By* R. D. Oldham, A. R. S. M., *Assistant-Superintendent, Geological Survey of India.*

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To the coal-miner, or to the mere geological surveyor, the exact correlation of the rocks in different parts of the world is of little importance. Little does the mine-owner reck of whether his coal does or does not belong to the carboniferous era so long as it is saleable at a profit, nor need the geologist, asked to survey and report on a coalfield, trouble his head about this ; but, to one who would unravel the physics or the history of the earth, the solution of this problem may well be of paramount importance, though unfortunately often impossible of attainment; generally, one might almost say always, he has to depend on fossils, but the answers these give are often contradictory or Delphic in their obscurity; at no time should they be too literally interpreted, but, like the cutcherry gong in an Indian station, must be made the most of as the only available substitute for a more accurate timepiece. But just as in this city where there are many thousand timepieces of various descriptions, of which probably no two keep identical time, every day the time-ball falls and the signal gun is fired to let all who may be concerned know that it is one o'clock; so in the past time-signals have been given throughout the earth, by which we can determine the contemporaneity of the strata in which their records have been preserved. Of this nature would be a wide spread glacial epoch comparable to that which in the recent past has affected both hemispheres of the globe, but, as there is reason to believe that such have occurred at various periods in the history of the earth, we are dependent on the otherwise less accurate palæontological evidence for determining whether the strata shewing signs of glacial action can have been deposited at the same period or must belong to widely separated geological epochs.

There can be no doubt that of all forms of palæontological evidence the most trustworthy is that afforded by the marine mollusca. Inhabiting as they do an element of more uniform temperature, and of which every part is in continuous if circuitous connection with the rest, it is but natural that they should be more uniform in character than the fauna of the land, while the simplicity of their structure, greater than that found among vertebrates or higher invertebrates, renders them less liable to change through alteration of the conditions under which they live. On the other hand, this very stability of organism renders them useless for the exact correlation of strata far separated from each other; for mere determination of homotaxy, even did this exist in the sense in which the term was originally intended to bear, would be but of little value to the physical geologist, to whom the terms 'Jurassic' or 'Carboniferous,' if determined merely on palæontological grounds, are as meaningless, for determination of dates in the history of the earth, as the analogous terms 'Stone Age' and 'Bronze Age' are for determining periods in the history of the human race.

But, if the evidence afforded by marine mollusca is not sufficiently accurate and trustworthy, how much more is this true of that afforded by the terrestrial fauna and flora. True, the duration of the existence of a species of cycad, conifer, and, possibly, even a fern may be shorter on the average than that of a species of mollusc, and to this extent it may be a more accurate index of contemporaneity; but it is comparatively seldom that identical species are found in far separated deposits, and palæontologists have consequently to depend mainly on what are called 'allied species.' Now the hard parts of animals, which in almost every case are all that are preserved to us, give, for the most part, a very true and real indication of the affinity of the animal to which they belonged, while, from the leaf of a tree or the frond—generally barren or with the fructification obliterated in fossilization—of a fern, little or nothing can be gleaned of the relationship of the plant to which it originally belonged; thus no one would doubt that two specimens of *Terebratula* or Ammonite, declared by a competent palæontologist to belong to the same species, would, if we could recover their soft parts, still prove to belong to the same or very closely allied species, while, on the other hand, we have lately been informed, by a palæobotanist whose competence none can doubt, that the Indian and Australian forms of the celebrated *Glossopteris browniana*, long believed to belong to the same species, differ so widely in their fructification that it is doubtful whether they can be included in the same family, and that they must certainly belong to different genera.*

As an instance of uncertainty of palæontological evidence, I need only quote the well-known case of the Umia and Katrol beds of Kutch, where beds containing a flora with a well-marked Lower Oolite facies overlie other beds in which the fauna is equally distinctly Upper Oolite in type; another case that might be quoted is that of the Rajmahal and Damuda floras; in the Rajmahal flora, there are, out of 47 species† in all, 26 which are identical with or allied to‡ European species: of these, *fifteen* are represented in the Rhætic beds of Europe, one species being hardly distinguishable from the European form: seven are represented by Palæozoic species, two belonging to an exclusively Palæozoic genus *(Eremopteris)*, while another *(Macrotæniopteris lata)* is, on Dr. Feistmantel's own admission, so like the Permian *Tæniopteris abnormis* as to be almost undistinguishable: two species only are allied to Liassic forms, and of these one is also represented in the Rhætic: five species are represented in the Lower Oolite of Europe, two by identical forms, while, of the other three, one is also related to a Carboniferous, and the other two to Rhætic, species. From this, an impartial observer would be inclined to place the flora as certainly not later than Rhætic, but, as on this point the talented palæontologist of the Geological Survey has expressed a very positive opinion that the flora is Liassic in facies, I must perforce

* Palæontologia Indica, Fossil Flora of the Lower Gondwanas, Vol. III, p. 103 In this connection, I may quote Dr. Feistmantel as follows:—after noting the difference in the fructification of the two forms, he adds 'so that I would be quite justified in placing these in a separate genus altogether and thus disposing of the difficulty in determining the age of our Damuda series owing to the correlation of the Indian Australian species." An easy way of 'disposing of the difficulty' forsooth, but my colleague can hardly have perceived the full force of these words when he penned them, for, carried to their legitimate conclusion, they cut away the ground on which alone palæobotanists can base their claim for the acceptance of fossil plants as a means of correlating distant deposits. The lesson to be learnt is rather that the conclusions of even the ablest palæobotanists must, owing to the nature of the material they have to work with, be received with caution, and that generic and specific names of fossil plants do not necessarily represent any real affinity, and that in some cases the latter and in most cases the former are names merely and nothing more.

† Here and elsewhere, except where the reverse is distinctly stated, I owe my palæontological facts to Dr. O. Feistmantel's writings in the publications of the Geological Survey of India.

‡ I use this term in the same sense as it is used by palæobotanists; it may well be that some of these 'allied species' have no real connection with each other.

bow to his opinion, a feat I can the more easily perform that the exact determination of the age of the Rajmahal series is irrelevant to my present purpose, this being merely to point out that the flora, judged by European standards, is of an extremely heterogeneous character.

Turning now to the Damudas, we find that, out of a total 63 species, only twenty shew any affinity to European forms : of these, six are represented by Rhætic species, two of which are identical in Europe and in India : eight are represented in Jurassic beds, one being identical with a species from the Yorkshire Oolite, and two have their nearest allies among living forms : while, of those which are related to species older than the Rhætic, two are represented in the Permian, and two only are represented by allied species in the Trias. The flora of the Damudas is thus seen to be as heterogeneous in its character as that of the Rajmahals and, like that of the latter, would naturally be attributed to a Rhætic age, yet the two series are not merely separated by a break in the stratification, but the two floras are so contrasted in their characters that, whereas the Damuda flora is almost exclusively composed of ferns, that of the Rajmahals is markedly the preponderance of cycads, and, of all the Rajmahal species, three only are represented in the Damudas and those by "allied species." These beds have been classed by Dr. Feistmantel as Triassic, and the probabilities in favour of their being contemporaneous in the Trias of Europe are about the same as those in favour of a Liassic age for the Rajmahals or a Rhætic age for either of the two, but this is all that can safely be said.

Turning now to the Kach flora, which, whether we judge from the associated marine fauna or from the flora itself, is of Oolitic age, we find, out of a total of 27 (excluding Algæ) species, 18 are represented by identical or allied species in Europe, *four* are identical with European Oolitic species, of which, however, one ranges down to the Rhætic, nine more forms are related to European Oolitic species, while four only are related to species older than the Oolite and in two cases at least the relationship is not very close; we have here, then, a much closer relation with a definite European flora than is the case with the Damuda and Rajmahal beds, and this, as I shall presently shew, is of considerable importance in unravelling the history of the Gondwana age.

In Australia, there is a series of plant-bearing beds whose flora shews many affinities with that of the Indian Gondwanas, but which range over a more extensive period of time, and are marked, both at their upper and at their lower limits, by the association of the plants with marine fossils.*

* *Conf.* principally Rev. W. B. Clarke, Remarks on the Sedimentary formations of New South Wales, 4th edition, and Dr. O. Feistmantel in *Palæontographica*, 1878 (Appendix).

At the base of the series, are beds whose marine fauna indicates a Devonian age ; above these, come beds which contain a flora consisting principally of such genera as *Lepidodendron*, *Rhacopteris*, and *Calamites*, among which occurs a single species of *Glossopteris*.* Above these, but still below beds in which a marine fauna of Carboniferous type is found, there is a flora which, judged by European standards, is Mezozoic in facies. At the top of the Newcastle series, to which the beds just mentioned belong, a more abundant flora is found, which presents many relationships to that of our Indian Damudas : in both, *Glossopteris* is a dominant type, both contain the *Glossopteris browniana* and two other species allied to Damuda forms : *Sphenopteris*, which in the Newcastle beds is represented by six species, is only represented in the Damudas by one (*S. polymorpha*, Fstm.), which, however, is said to be more closely allied to the Australian *S. alata* than to any European form : the only species of *Phyllotheca* is allied to the Damuda *P. indica*, and the common occurrence of *Vertebraria* in both is another link. That this relationship is not so close as was at one time believed, I readily admit, but nevertheless the relationship is real, and, though it may be presumptuous to express an opinion at variance with that of the talented palæontologist of the Geological Survey of India, I must say that to me the relationship seems far closer than that which unites the Damudas to the Trias of Europe.

Above the Newcastle beds, come the Hawskbury beds, which have yielded but two species of ferns, one of which (*Sphenopteris alata*, Bgt.), however, is allied to a Damuda species. Above the Hawksbury, come the Wianamatta beds, which have yielded six species of plants, no less than three of which are allied to Damuda forms.

It is thus evidently impossible to correlate, on palæontological grounds alone, these beds directly with any of our Indian horizons, but, like the Indian Talchirs, the Hawksbury beds contain certain beds of fine clay through which boulders of all sizes are scattered promiscuously in a manner that can only be attributed to the agency of floating ice. In Victoria, there are beds which similarly indicate the existence of a severe climate at the time of their deposition, and these—the Bacchus Marsh beds—have yielded three species of *Gangamopteris*, of which one is identical with, and the other two are closely allied to, Talchir species. The Bacchus Marsh beds have not yielded a single species common to themselves and to the Hawksbury beds, but this is of little importance, as it is impossible to suppose that the entire flora of the Bacchus Marsh period consisted

* There is some doubt attaching to the correctness of this statement. The *Glossopteris* was obtained from a different locality and possibly from a newer series of beds than the others.

of three species of *Gangamopteris*, or that of the Hawksbury period to have been limited to two species of ferns. But, if not directly referable to the same epoch by their contained fossils, there can be no doubt that they are on the same horizon, for, in the uppermost beds of the Newcastle series, two species of *Gangamopteris* are found, one identical with, and the other allied to, species from the Bacchus Marsh sandstones of Victoria, while the beds above the Hawksbury series in New South Wales can be correlated with those which overlie the Bacchus Marsh beds in Victoria by the occurrence of *Pecopteris australis*, Morr. and *Tœnopteris daintreei*, McCoy in both. The presence of beds indicating glacial action in both and the absence of similar beds in the associated strata further prove their absolute contemporaneity; and by an extension of the same reasoning we may assign the Talchirs of India to the same glacial epoch.

The palæontological relations of the Gondwanas with the Karoo and Uitenhage series of South Africa are much simpler than with the Australian formations. From the upper part of the Karoo beds, which unconformably overlie strata containing an Upper Palæozoic fauna, a limited flora of but five species has been obtained. Of these five, one is *Glossopteris browniana*, another, *Dictyopteris? simplex*, Tate, is, according to Dr. Feistmantel, allied to *Glossopteris damudica*, Fstm., and *Rubidgea mackayi* is, on the same authority, probably a *Gangamopteris;* in addition to these, Tate gives a species of *Phyllotheca*, but the identification is doubted by Dr. Feistmantel.* Associated with these, there is an abundant and peculiar Reptilian fauna with *Dicynodon* as a dominant type, a genus not known elsewhere, except from the Panchet subdivision of the Damuda in India. In the overlying Uitenhage series, there is a flora consisting of eleven determinable species; of these one species of ferns is also found in the Rajmahals, while two, and possibly three, species of ferns and one conifer are closely allied to Rajmahal forms.† These Uitenhage plants are associated with beds containing an Oolitic marine fauna. The palæontology of these beds sufficiently indicates a parallelism with the Gondwanas, and, in confirmation of this, we find, at the base of the Karoo series, an undisputably glacial boulder bed,‡ which we shall be justified in assigning to the same epoch as those of the Talchirs in India and of the Hawksbury and Bacchus Marsh beds in Australia.

Viewing these circumstances, there can, I think, be no doubt that these glacial boulder clays of Africa, India, and Australia represent one and the same epoch in the history of the earth and are, as strictly as the word can be applied, of contemporaneous, if not absolutely coeval, origin.

* Q. J. G. S., XXIII, 140, *Palæontographica*, 1878, p. 114.

† Q. J. G. S., XXIII, p. 140.

‡ Q. J. G. S., XXVII, 58 and 535.

And further, as in every case the palæontological evidence indicates that these glacial beds are of late Palæozoic or early Secondary age, I think it is probable that, as has been suggested by Mr. H. F. Blanford, they are of the same age as the Permian boulder clays of Europe.*

Having thus obtained a common era in the geological history of these three countries (India, Africa, and Australia), we are able to examine their history in an intelligent manner. The first thing noticeable is that, in Australia, at a period corresponding fairly to the Devonian, both the fauna and the flora were, judged by European standards, of a Palæozoic type. Later on, probably in Lower Carboniferous times, there appears, among species of *Lepidodendron*, *Rhacopteris*, and *Calamites*, which, in Europe, are found in rocks of Carboniferous age, a single species of *Glossopteris*, the forerunner of a newer flora destined to supplant the older forms. In the Newcastle (Upper Carboniferous) beds, this flora has completely ousted the older forms, and, as I have already noticed, shews considerable relationship to that of the Damudas in India. Yet, if the Talchirs and the Bacchus Marsh beds are really of contemporaneous origin as was first suggested by Dr. Feistmantel, and if the Bacchus Marsh and Hawskbury beds are also contemporaneous (and the presence of traces of glacial action in all three is at least presumptive evidence in favour of this conclusion), the Damudas must be of very much later date than the Newcastle beds, and we have to explain why it is that the Newcastle flora left Australia when it did, and why it or its descendants lingered on in India, and, as I propose to shew, spread over what is now the Old World producing important modifications in its flora.

It is possible to suppose that the Newcastle flora required a warm —though from internal evidence one would rather look upon it as indicating a cool temperate—climate; that, on the advent of more severe conditions, it migrated towards the Equator and remained there, not merely through a period of extreme severity, but through a further period, when the climate was cooler than it had been during the deposition of the Newcastle beds, and during which a flora more suited to the latitude flourished in Australia. But there are so many objections to this hypothesis that it can hardly be tenable, and, however wild my alternative hypothesis may be thought, I hope to prove that it is really the more probable of the two.

In the first place, we have to account for the prevalence of glacial conditions at a low level in India even within the tropics. This was not paralleled during the last glacial period, for even the erratics of the Petwar are 10 degrees beyond the tropics and 2,000 feet above the level

* This correlation of the Indian, African, and European boulder beds has been suggested by Mr. H. F. Blanford, Q. J. G. S., XXI, p. 519.

of the sea, while the Petwar was certainly not less elevated during the glacial period than it is now. Further, the glacial deposits in India are far better developed, and, to judge from the descriptions, must be far thicker and represent a much longer period of time during which the climate was severe than those in Australia. Yet the glacial deposits of New South Wales are 10° further from the Equator than the Indian, so that, if we might shift the Equator some 10° further south between India and Australia, observed facts would be more in accordance with what one would expect than can be the case if we are compelled to assume the Equator fixed throughout all time.

But, if we try to compare the facts observed in Australia and Africa, we are landed in a still greater difficulty, for, lying as they do on about the same parallel of South Latitude, the glacial beds are more strongly developed in Africa even than in India; and, as we can hardly suppose the greater severity of climate to be due to altitude, it must have been due to latitude, to obtain which we must suppose that that portion of the Earth's crust which now forms South Africa then lay in a higher latitude than that which is now Australia; in other words, the comparison of the Permian (?) glacial beds of Africa and Australia, as in the case of Australia and India, points to the conclusion, either that there has been a change in the position of the axis of revolution of the earth, or, what is more probable, that the crust of the earth then occupied a position relative to the central nucleus different from that which it now does. An experiment with a globe will shew that the relations of India, Australia, and Africa indicated above, *viz.*, that Central India was in a higher latitude than New South Wales and South Africa in a higher latitude than either, are best satisfied by taking the Equator between India and Australia, but nearer the latter than is now the case, and thence through a point lying between the Cape of Good Hope and the South Pole in not less than 70° of South Latitude; a disposition which would bring some point in Central Africa over one of the poles.

Turning now from these physical and climatic arguments to those derivable from palæontology, I hope to shew that they lead to the same conclusions.

I have already referred to the fact that the Damuda and Rajmahal floras of India shew affinities with those of almost every division of the Mezozoic era in Europe, and I would now draw attention to the fact that those species which are related to upper Secondary forms in Europe belong very largely to types which first appear in the Palæozoic beds of Australia. Foremost among these, of course, are *Glossopteris*, *Phyllotheca*, and *Vertebraria;* not known in Europe before Jurassic times, these were certainly living in Australia at the commencement of the Carboniferous epoch. *Pecopteris*, *Thinnfeldia*, *Gangamopteris*, *Nœggerathiopsis* likewise are found in the Newcastle series of New South Wales, but in Europe only in Secondary beds. Allowing that some of these genera are purely artificial, and that the species grouped under them may not really be allied in every case, it is on the other hand probable that some forms placed under distinct genera should properly be united with some of those grouped under the genera above mentioned, and, making the most liberal deduction for the value or want of value of negative evidence, I think that there is still a very considerable weight of probability, on this count alone, in favour of a newer type of vegetation having originated in Australia in Palæozoic times and in the Permian period commenced to spread over the rest of the world.

The explanation seems to be that, on the advent of the Glacial period, the flora, which had supplanted the older types in Australia, was driven towards the Equator. As the climate ameliorated, it did not again retreat towards Australia, either because its place was taken by newer species, or, more probably, because, owing to changes in the distribution of land and water, it could no longer do so, but to the north—or what for convenience we may provisionally call the north,—of the Equator it lived on in what is now India and, gradually spreading over the hemisphere, produced a profound modification in the pre-existing floras of what we now know as the Old World.

The flora of the Wianamatta beds, as I have explained, shews a certain relationship with that of the Damudas, but none with that of the Newcastle beds as far as species go ; of the genera, however, three out of the six, or, if we include the Hawksbury beds, four out of seven are also found in the Newcastle beds. The beds newer than the Wianamattas have yielded a flora consisting of nine species belonging to seven genera, of which, if we except the *Phyllotheca australis*, only one species is allied to an Indian form, *viz.*, *Pecopteris australis*, Morr. allied to *P. indica*, Oldh. and Morr. from the Rajmahals. We have here a distinct decline in the closeness of relationship between the Indian and Australian floras, and, though, of course, this might be due to the imperfection of the record, the probabilities are against its being entirely due to that cause, and we may safely conclude that some barrier separated the two areas, by which the floras of India and Australia were kept apart and followed separate and consequently diverging lines of descent.

Turning now for a while to South Africa, I must commence by declaring it as my opinion that the relationships between the Indian and African floras of the periods I am discussing are with difficulty explicable, unless it is granted that there was in those days a continent, or at any rate a continuous chain of islands, stretching from South Africa towards India. I am aware that Mr. A. R. Wallace has declared such to be uncalled for and impossible to grant,* and I am ready to admit that the facts of distribution of animals as detailed by him are conclusive against the possibility of such a distribution of land and water, at any rate since the Miocene period. But there is no reason to suppose that the present distribution of plants or animals can throw any light on the distribution of land and water in late Palæozoic and early Secondary times. On the other hand, in favour of the land connection, I claim, *firstly*, that the relationship between the fauna and flora of the Damudas on the one hand and the Karoo beds on the other is far more real and close than the mere 'similarity of animal and vegetable productions' to which Mr. Wallace seems to have considered it to be confined; *secondly*, that this relationship of the two floras continued into the Uitenhage and Rajmahal series, which could hardly have been the case had the two areas been as separated then as now; and, *thirdly*, that the very peculiar relationships and differences between the cretaceous faunas of Central and Southern India on the one hand and Arabia and South Africa on the other are such as imperatively to demand the existence of a continuous barrier of dry land stretching between India and Africa. It is needless to expatiate further on this point, for, if such a barrier existed during the Cretaceous period, any argument against its possibility derived from the doctrine of the permanence of continents must fall to the ground, and there remains no reason why, if on independant grounds its existence is shewn to be probable, such a modification as I require may not have existed at the commencement of the Secondary period. That, during the deposition of the Damudas, there was continuous land communication with South Africa I do not suppose, for the very remarkable reptilian fauna, which, like the recent marsupial fauna of Australia, mimicked many of the higher mammalia, points rather to some isolated continental island which was connected with India, as Australia now is with Asia, by a chain of large islands separated by narrow straits, across which the spores of ferns and the seeds of plants could be wafted, but which were impassable to terrestrial reptiles.

But even a land connection of this sort would probably be inadequate by itself to account for the close relationship which the small fragment preserved to us of the flora of the Uitenhage period shews to that of the Rajmahals. For it is at least highly probable that the heat of the Equator would be as effectual a barrier as a broad sea, and, if the floras of India and Africa had pursued independent courses of development for a period sufficient for the dying out of every species and almost every genus, and for a change in the facies of the flora from one composed mainly of ferns to one composed mainly of cycads, it is inconceivable that the floras of the Uitenhage and Rajmahal series should exhibit the close

* Island Life, p. 398.

relationships they do. But this difficulty would not exist could we suppose that what are now South Africa and India then lay on the same side of the Equator; and thus the palæontology of these beds, as well as their petrology, points towards the conclusion that in early Secondary times the crust of the earth did not occupy the same position with respect to the axis of rotation as it now does.

That none of these arguments are conclusive by themselves I admit; I willingly admit that the floras preserved to us represent but a fraction of the species that lived when the beds that have yielded our fossils were being deposited, but the probability is vastly against only those species which were related to each other in the two countries being preserved, and we may, I think, safely argue from the small sample preserved to the larger bulk which is lost. In the same manner, I freely admit that the differences in the severity of climate may have been due to other causes besides difference of latitude, but on the average a colder climate indicates a higher latitude, and, when we find that, from whatever point we approach this matter, we are led towards the same conclusion, it seems to me that there is a very strong presumption in favour of its truth.

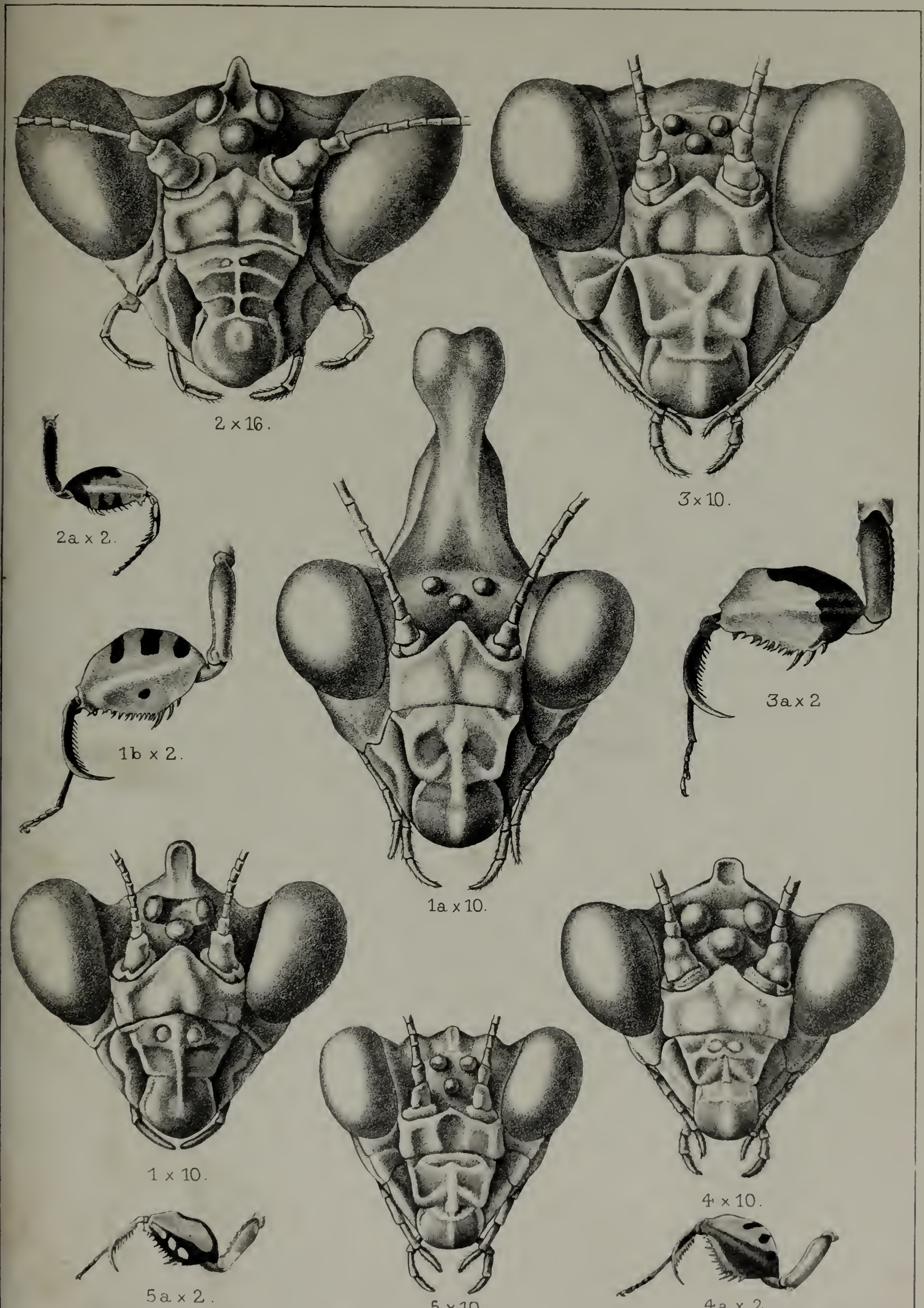
I fear this paper has already extended to too great a length for me to examine the arguments that have been put forward to prove that any change of latitude is physically impossible, but I cannot conclude without pointing out that what has been proved is that no conceivable elevation or depression of the earth's surface could produce an appreciable alteration in the axis of rotation of the earth as a whole. But, though the mathematical reasoning on which this conclusion is based may be unassailable, it has no bearing on the question of whether changes of latitude may not have taken place in the past, except on the assumption that the earth is rigid throughout, and that the crust has no power of sliding over the heated if solid core, an hypothesis which has been ably combated by the Rev. O. Fisher,* and which I hold to be inconsistent with the known facts of stratigraphical geology. While, if the views put forward in this paper are true,—and there seems to me a very strong presumption in their favour,—the crust of the earth must in Mezozoic times have occupied a very different position with reference to the axis of rotation from that which it does at the present day.

As yet the only fact which has in any material degree attracted the attention of English geologists is the prevalence during the past of mild climates within what are now the Arctic regions; and hypotheses have been broached to account for this independent of an alteration of the position

* Physics of the Earth's Crust *passim;* see particularly p. 184.

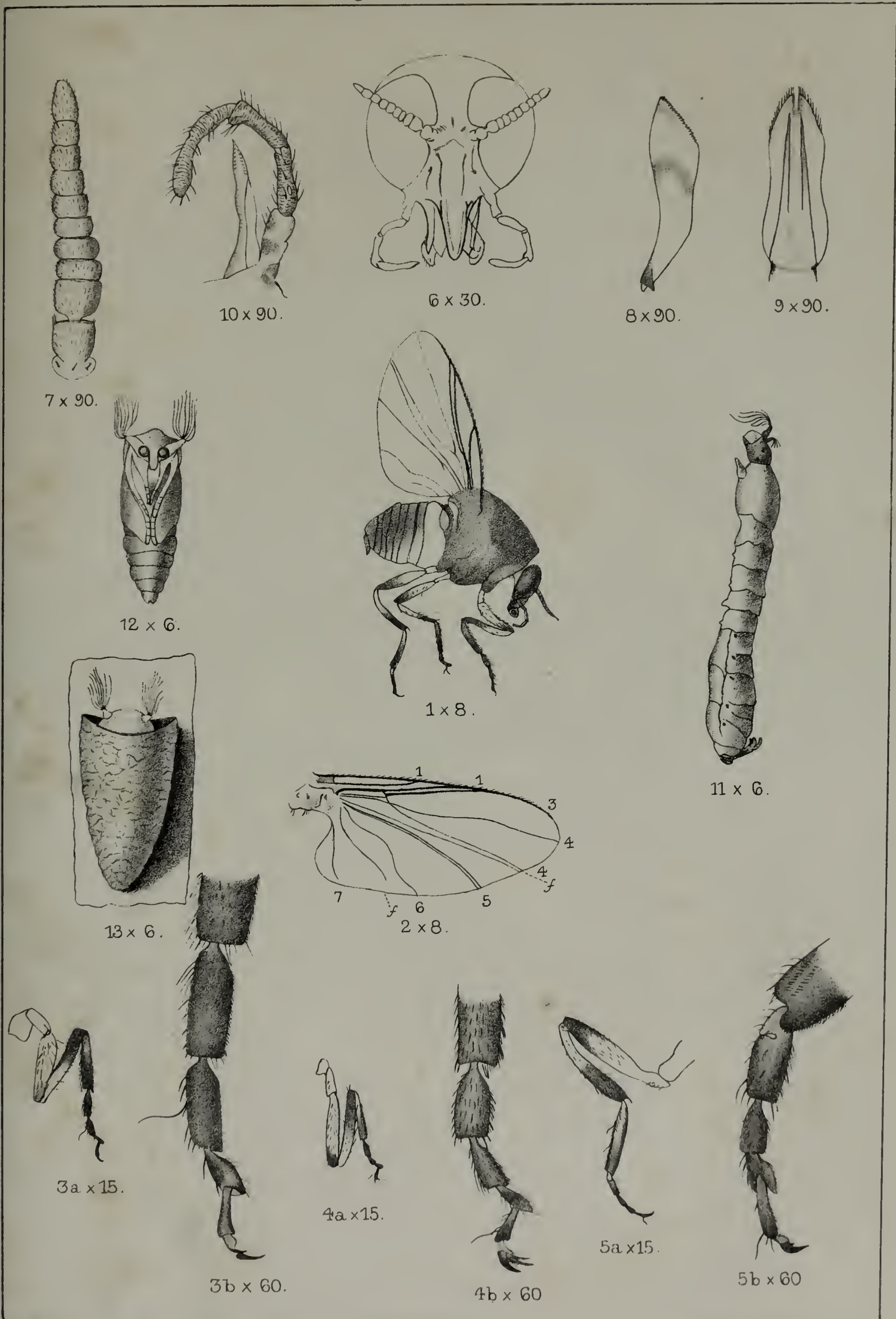
of the crust relative to the central core of the earth; but the more completely such an hypothesis may explain the absence of any trace of glaciation in the Palæozoic, Secondary, or Tertiray rocks of the Arctic regions, to which Baron Nordenskjöld has drawn our attention, the more irreconcileable is it with the repeated traces of glacial action that are met with almost within the tropics. Yet the latter as urgently requires explanation as the former, and I have put these suggestions forward not from any conviction of their intrinsic truth, but because I feel that the rigid bonds within which mathematicians have sought to confine geologists must be largely and materially relaxed, because I feel that every addition to the growing pressure against these bonds is of some—even if but small—importance, but chiefly because I trust that I may be instrumental in drawing the attention of others with greater opportunities and greater abilities to the solution of this problem.

P. S.—Just a week before this paper was read Mr. W. T. Blanford, addressing the geological section of the British Association at Montreal, devoted the greater part of his address to the consideration of a subject to which he has before now referred, more particularly in the Records of the Geological Survey of India, and on which I have cursorily touched in the introductory part of this paper; I mean the uncertainty of palæontological evidence in determining the exact correlation of widely separated beds. He also refers to a report on the Stormberg coal-fields by Mr. E. J. Dunne, which I have strangely overlooked: Mr. Dunne mentions the existence of three species of plants in the Stormberg beds identical with Australian species, an identification which, if correct, greatly diminishes, if it does not altogether annihilate, the value of my argument from the relationships between the African and Indian early Secondary floras, but this is of the less importance, as, owing to the known value or want of value of negative evidence in palæontology, little value would in any case attach to an argument of this kind.



B. L. D. del. J. W-M. dir. Mintern Bros. imp. Parker & Coward lith.

Genus HESTIAS.



Autor del. Mintern Bros. imp. Parker & Coward lith.

SIMULIUM INDICUM.

V.—*A new Species of* Simulium *from Assam.*—*By* Dr. Edward Becher, *Vienna. Communicated and translated by the* Natural History Secretary.

[Received October 13th;—Read November 5th, 1884.]

(With Pl. XIV.)

Simulium indicum, nov. spec.

♀. *Caput et thorax brunneo-nigra; thorax convexus, scutellum nigrum; palpi 4-articulati, fusci; antennae 10-articulatae, fuscae; alae magnae, latae, nervi costales crassiores quam reliqui; pedes varii: femora et tibiae in basi flavae, in apice fuscae, tarsi fusci; abdomen breve, segmentum primum latissimum; hoc et trium sequentium pars ventralis flavicans, cœtera subfusca. Longitudo* 3 *mm.*

Head free, standing pretty low; brown-black; forehead broad, clypeus short, nearly vertical; eyes kidney-shaped, with a moderate notch for the reception of the first antennal joint. Ocelli wanting. Antennæ dark brown-black, 10-jointed; the second joint distinctly constricted off from, and equal in length to, the first, and longer than the rest; the three succeeding joints broader than long, telescoped into one another; the four next equally long and broad, each tapering to the apex, the last joint pointed at the apex, somewhat longer than the preceding.

Proboscis salient, dark; mouth-parts differing in matters of detail only from those of the typical form; palpi dark, 4-jointed, the basal joints lighter; the first joint short, the palp-scale resembling it and thus apparently representing a fifth joint, the second and the third joints almost of the same length, the fourth $1\frac{1}{2}$ times as long as the third, all the joints pretty equally broad and moderately bristly.

Thorax brown-black, high-arched, without transverse suture, tergum and scutellum velvet-black, somewhat shining, sides of the thorax lighter, especially near the coxæ of the first pair of legs.

Wings* large and broad, the marginal vein thick, terminating before the apex of the wing, the anterior branch of the first longitudinal vein

* In order to facilitate comparison with other descriptions, the usual nomenclature of the veins of the wings is retained in the following description. According to Adolf's theory, the veins should, in consideration of Brauer's work on this subject, be named as follows:—the anterior branch of the first longitudinal vein = the auxiliary vein *(Hilfsader)*; the principal branch of the first longitudinal vein = the first longitudinal vein; the small transverse vein = the trunk of the third longitudinal vein; the third and the fourth longitudinal veins = the third longitudinal vein; the succeeding fold = the fourth longitudinal vein; the fifth and the sixth longitudinal veins = the fifth longitudinal vein; the fold = the anal vein (*Conf.* Brauer, Denkschr. d. Kais. Akad. d. Wissen. Wien, Math. Nat. Cl. Bd. xliv, 1882, p. 90, and Wiener Ent. Zeitschr. ii, 1883, Heft 2, p. 27).

short, scarcely reaching the middle of the wing, the principal branch longer, running out near the third longitudinal vein; the second longitudinal vein wanting; the third branching off from the first before the middle, running into the marginal vein far before the apex of the wing; the three first veins thick and distinct; the succeeding ones very weak; the fourth longitudinal vein forked at the so-called small transverse vein, the prongs of the fork hence much longer than the handle, the upper prong slightly bisinuous, the lower almost straight; the fifth vein straight, a little bent outwards; the sixth strongly bisinuous; the axillary vein not reaching the hinder margin, slightly sinuous; between the fourth and the fifth veins a straight, very distinct fold; a similar though weaker fold behind the sixth vein. Halteres uncovered, dazzling white.

Legs: coxæ dark, trochanter long, yellowish; femora and tibiæ throughout black-brown, metatarsus lighter at the base, a little shorter than the tibia; all the tibiæ with spurs, metatarsus of the third pair of legs notched at the apex (figs. 5, 6), those of the two first pairs truncate, spurred; the fourth tarsal joint expanded into a heart-shaped figure; the fifth longish clavate, with long divergent curved bristles, which in the first pair of legs are seated on the *third* tarsal joint; legs thickly covered with hairs, particularly on the tarsus, ungues small, pulvilli rudimentary.

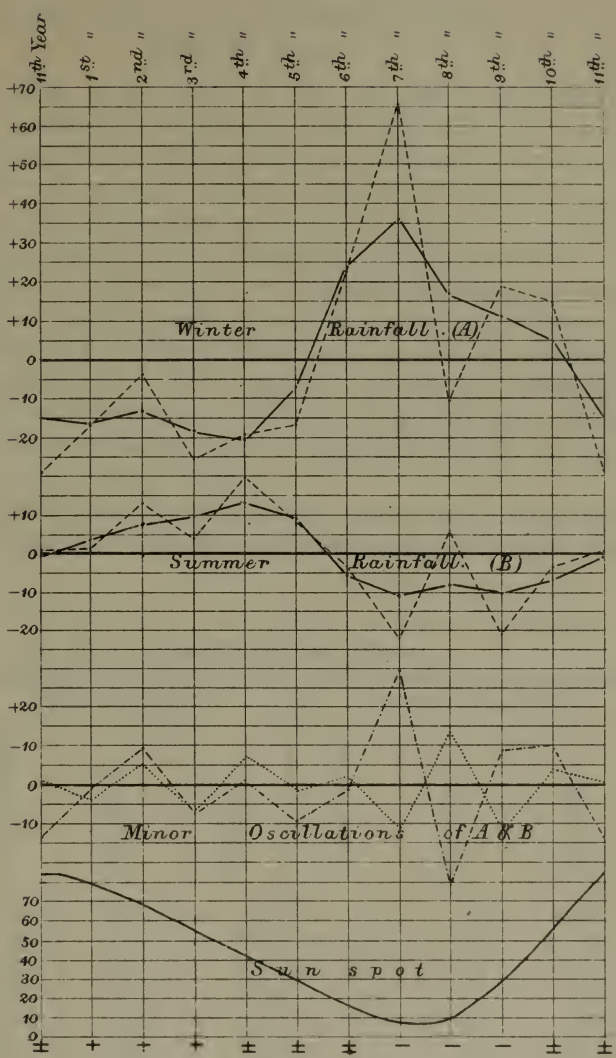
Abdomen short, of eight segments; the first segment is the broadest and, like the sternal parts of the three succeeding segments, yellowish; the genital parts a little projecting.

The above-described species of *Simulium* is the first that has yet been made known from Asia, as only a few non-European forms have hitherto been described, whereas the number of European species is not inconsiderable.

The larvæ and the pupæ (figs. 11, 12, 13) of the European species live in water; the latter in conical (*tütenartigen*) cocoons attached to stones, stalks of grass, confervæ, and the like.

Explanation of Plate XIV.

Fig. 1. *Simulium indicum*, ♀, × 8. Fig. 2. Wing × 8. 3*a*. A leg of the first pair × 15. Fig. 3*b*. Tarsus of the same leg × 60. Fig. 4*a*. A leg of the second pair × 15. Fig. 4*b*. Tarsus of the same × 60. Fig. 5*a*. A leg of the third pair × 15. Fig. 5*b*. Tarsus of the same × 60. Fig. 6. Head from in front × 30. Fig. 7. Antenna × 90. 8. Mandible × 90. Fig. 9. Hypopharynx × 90. Fig. 10. Maxilla and palp × 90. Fig. 11. Larva of *Simulium ornatum*, Mg. × 6. Fig. 12. Pupa of *Simulium* sp. in its conical cocoon.



Lithographed at the Survey of India Offices, Calcutta, December 1884.

VI.—*Variations of Rainfall in Northern India during the Sunspot Period.*—*By* A. N. PEARSON, ESQ., *Officiating Meteorological Reporter for Western India. Communicated by the* PRESIDENT.

[Received October 6th ;—Read November 5th, 1884.]

(With Pl. XI.)

Mr. S. A. Hill, in his paper on the "Variations of Rainfall in Northern India," published in the *Indian Meteorological Memoirs*, Vol. I, showed very clearly the opposition that exists between the variations of the winter and of the summer rainfall in Northern India during the sunspot period. For the purpose of bringing forward with greater clearness the main points of his investigation, he put the actual rainfall totals—which, as they stood, showed considerable apparent irregularities—through a simple process of smoothing such as is frequently adopted in dealing with statistical tables; and, by so doing, eliminated the apparent irregularities. But it appears to me that the unsmoothed results present points of interest over and above those that are presented by the smoothed results; that, in fact, the apparently irregular variations are regulated in a very definite manner.

In the table here given, I reproduce the general means of Mr. Hill's Tables II and IV, together with the smoothed results as he gave them in the text.

Variations of the Rainfall for each Year of the Eleven Year Cycle in Percentages of the Local Means.

Year of the Cycle.	Winter Rainfall.			Summer Rainfall.		
	Unsmoothed.	Smoothed.	Difference.	Unsmoothed.	Smoothed.	Difference.
1st	— 17·6	— 17·1	— 0·5	+ 0·8	+ 3·6	— 2·8
2nd	— 4·6	— 13·6	+ 9·0	+ 12·7	+ 7·4	+ 5·3
3rd	— 25·6	— 18·8	— 6·8	+ 3·3	+ 9·8	— 6·5
4th	— 19·5	— 20·4	+ 0·9	+ 19·8	+ 12·6	+ 7·2
5th	— 17·0	— 7·8	— 9·2	+ 7·4	+ 7·8	— 0·4
6th	+ 22·1	+ 23·1	— 1·0	— 3·5	— 5·6	+ 2·1
7th	+ 65·4	+ 35·6	+ 29·8	— 22·7	— 10·8	— 11·9
8th	— 10·4	+ 15·7	— 26·1	+ 5·6	— 8·1	+ 13·7
9th	+ 18·3	+ 10·2	+ 8·1	— 21·0	— 10·0	— 11·0
10th	+ 14·9	+ 4·9	+ 10·0	— 3·6	— 7·0	+ 3·4
11th	— 28·6	— 14·9	— 13·7	+ 0·2	— 0·6	+ 0·8

The smoothed numbers of the above table are curved in the accompanying diagram (Pl. XI) in thick continuous lines, under the names "Winter Rainfall, A" and "Summer Rainfall, B." The figures so produced are identical with the curves given by Mr. Hill in his paper. The unsmoothed numbers of the above table are in the diagram superposed in dotted lines upon the smoothed curves. At the bottom of the diagram, I have reproduced the sunspot curve as given by Mr. Hill.

On inspecting the smoothed rainfall curves, it will be seen that the winter and the summer curve both agree in showing a single oscillation during the eleven years of the sunspot period; but they differ in the character of that oscillation, for, while the winter rainfall is at its maximum during the year of sunspot minimum, the summer rainfall on the contrary is then at a minimum. This is the main fact pointed out in the paper above quoted.

On inspecting the actual figures, however,—the unsmoothed numbers in the above table and the dotted curves A and B of the diagram—it will be seen that, besides this eleven yearly oscillation, both the winter and the summer rainfall show several variations of minor period such as one might naturally suppose to be accidental; thus the winter rainfall shows three distinct maxima, one in the 2nd year of the sunspot cycle, one in the 7th year, and one in the 9th and 10th, and shows marked minima in the 3rd, 8th, and 11th years; while the summer rainfall has maxima in the 2nd, 4th, and 8th years and minima in the 3rd, 7th, and 9th.

It is to these minor period oscillations that I wish in this short paper to call attention. And, in order that they may present themselves in a more convenient form for study, I have separated them from the eleven yearly oscillation by the simple method of subtracting the smoothed numbers in the above table from the unsmoothed. The differences are curved in the diagram under the name "Minor Oscillations of A and B," the winter oscillations being given in dot-and-dash lines, and the summer in simple dotted lines.

Confining attention to these "minor oscillations" curves, it will be noticed that, in those years which at the foot of the diagram are marked +, and which are years of maximum sunspot, the short period oscillations in the winter and the summer rainfall are of the same character, that is to say, that when there is more winter rain there is more summer rain, and when there is less of the one there is less of the other also. But it will be seen that, in those years which at the foot of the diagram are marked —, and which are years of minimum sunspot, the short period oscillations in the winter rainfall are of opposite character to those in the summer rainfall, that when there is more rain in the winter there is less during the summer, and *vice versâ.* Again, in those years which in the diagram are marked $\pm$, and which immediately precede the years of sunspot maximum and minimum, the order above pointed out obtains only in a slight degree ; in other words, these are years of transition.

That these facts are purely the result of accident seems very unlikely, for they are supported by three other series of concurrent facts ; which are as follow :—

1st. The *plus* years begin immediately *after* the sunspot maxima, and the *minus* years begin immediately *at* the sunspot minimum.

2nd. There are more transition years during the slow descent of the sunspot curve than during its rapid ascent.

3rd. The oscillations of both the winter and the summer rainfall are of greater amplitude during the *negative* years than during the *positive.*

With reference to the first of the above series of facts, it might be supposed that, as the *minus* years begin immediately *at* the sunspot minimum, so for perfect analogy the *plus* years should begin immediately *at* the sunspot maximum. But this is by no means necessary, for the slight delay in the coming in of the positive years agrees very well with the slow descent of the sunspot curve as compared with its rapid ascent.

The main fact which I have pointed out in this paper,—namely, that the smaller variations of the winter rainfall are the same in character as those of the summer rainfall during years of maximum sunspot ; and opposite in character during years of minimum sunspot,—if it can be established as a general rule, will be an important one ; for it will indicate that, whatever be the cause which produces the general opposition in character between the eleven yearly variations of the winter and of the summer rainfalls, that cause operates chiefly during the years of minimum sunspot, and during three years of maximum sunspot it operates only in a very minor degree, and in two of those years (namely, the 1st and 2nd) it probably does not operate at all. By thus limiting the period during which the cause operates, a valuable point is gained, and a clue to a knowledge of the cause possibly afforded.

It is also interesting to notice that not only do the rules above indicated obtain *qualitatively*, but that there is also a near approach to a *quantitative* relation between the short period oscillations of the summer and the winter rainfall respectively. The nature of this relation in the years which I have denoted as *positive*, namely, in the 1st, 2nd, and 3rd years of the sunspot cycle, will be seen at once on inspecting the " minor oscillations " curve of the diagram. It will be observed that the oscillation which takes place in the two curves during those three years is not only the same in phase, but is nearly the same in amplitude. The fact can be expressed numerically by taking the percentage rainfall as given in the " Difference " columns of the above table ; when it will be seen that the winter rainfall of the 2nd year was 16·3 heavier than during the 1st and 3rd years taken together ; while the summer rainfall was 14·6 heavier. The numbers 16·3 and 14·6, which according to this method are a measure of the excess of the winter and the summer rainfall respectively during the 2nd year, approach each other sufficiently to be noticeable.

The nature of the quantitative relation during the negative years, namely, the 7th, 8th, and 9th, will be best seen by an examination of the actual rainfall of those years. This, obtained from Mr. Hill's Tables I (A and B) and III (A and B), is as follows :—

Year of the Cycle.	Winter Rainfall.			Summer Rainfall.		
	Hills.	Plains.	Mean.	Hills.	Plains.	Mean.
	inches.	inches.	inches.	inches.	inches.	inches.
1st	17·95	6·30	12·12	41·81	26·36	34·08
2nd	9·58	3·23	6·40	54·01	34·63	44·32
3rd	16·55	4·59	10·57	47·13	27·03	37·08
Average of the three years.			9·70			38·49

Dealing only with the mean results, the variations in each year from the three years' average are in the case of the summer and the winter rainfalls respectively as follows :—

	7th year.	*8th year.*	*9th year.*
Winter	+ 2·42	— 3·30	+ 0·87
Summer	— 4·41	+ 5·83	— 1·41

Now the poiut to be noticed is that

$$2{\cdot}42 : 4{\cdot}41 :: 3{\cdot}30 : 5{\cdot}83 :: 0{\cdot}87 : 1{\cdot}41,$$

or very nearly so ; the winter figures to be in exact proportion should be 2·53, 3·34, and 0·81 ; but the approach to exactness is sufficiently near to be striking, and to make one suspect that there has been something more than chance at work in its production. If this proportion can be established as a general rule, it will signify that, during the three years at, and immediately succeeding, the sunspot minimum, an excess of 1 inch in the winter rainfall is accompanied by a defect of about 1·74 inches in the summer rainfall, and a defect of 1 inch during winter is accompanied by an excess of 1·74 inch during summer.

It is not my intention, for the present at least, to seek out the full meaning of these facts ; indeed, it is scarcely within my province to do so, as the investigation is already in more experienced hands than mine. But the facts forced themselves on my notice, and they seemed of sufficient importance to justify their publication.

VII.—*Description of a new Lepidopterous Insect belonging to the Heterocerous Genus* Trabala.—*By* F. Moore, F. Z. S., A. L. S. *Communicated by the* Natural History Secretary.

(Received August 26th ;—Read December 3rd, 1884.)

Trabala irrorata, n. sp.

♀. Upperside dark olivaceous ochreous-yellow, sparsely speckled with dark purple-brown scales, which are most numerously disposed on the exterior border, and sinuously across the inner disc of both wings and also subbasally across the forewing, as well as on the posterior border of the forewing. Both wings with a discal transverse zigzag series of large lilacine-grey spots, which are also thickly speckled with the dark brown scales ; forewing also with the posterior border blotched with lilacine-gray, and with a prominent lilacine-gray spot, with dark brown speckled border, in the middle of the cell. Cilia entirely yellow.

Underside slightly paler than the upperside ; both wings with the discal zigzag spots as above, the exterior borders less sparsely speckled with brown scales ; a slight brown-speckled sinuous discal band also on the hindwing ; cell-spot indistinct.

Body brighter yellow, and tuft lilacine-white.

Expanse $3\frac{1}{4}$ inches.

Hab. Mergui. Collected by Dr. J. Anderson, F. R. S.

VIII.—Phyllothelys, *a remarkable Genus of* Mantodea *from the Oriental Region.—By* J. Wood-Mason, *Deputy Superintendent, Indian Museum, Calcutta.*

(With Plate XII.)

Genus Phyllothelys, W.-M.

P. A. S. B. 1876, p. 176.—A. & M. N. H. 1876, 4th ser. vol. xviii, p. 507.—P. E. Soc. 1877, p. xviii.

♂. ♀. Vertex directed forwards and slightly upwards, strongly protuberant between the juxtocular lobes; the protuberance flat and triangular in front, behind convex and trefoil-shaped, being divided into three lobes, one large and median and two small, equal, and lateral; the former produced at the apex into a long, narrow, and very gradually tapering horn, which is expanded, together with the lobes themselves, in the middle line posteriorly and at the sides, into sharp foliaceous crests, and which may be rudimentary in the male; facial shield pentagonal, about as long as broad, marked with two blunt longitudinal ridges, and with its basal angle slightly projecting. Eyes oval, tolerably prominent, not narrowed as in *Phyllocrania.* Pronotum long and slender, nearly five times as long as its parallel-sided anterior lobe, very gradually widening from its narrowest part just behind the dilatation, and equally gradually increasing in height, to its base, close to which it bears a prominent smooth tubercle, and where it is nearly as wide as at the distinct dilatation; prosternum slightly and decreasingly roof-shaped from the insertion of the forelegs backwards. Anterior coxæ, long and slender, when laid back not reaching to the base of prothorax, their apical lobes not divergent, but close together; tibiæ half the length of the femora, with only the basal 5 or 6 of the spines of the outer edge curved towards the margin; femora with 3 spines on the outer edge and 4 on the disc; four posterior legs short; femora with genicular spines and with foliaceous lobes on the lower crest; tibiæ with their apical half inflated latero-superiorly. Axillary and anal veins of tegmina running one immediately after the other into the internal ulnar vein, first ulnar vein branched; ulnar vein of wings 2-branched. Abdomen depressed, widening more (♀) or less (♂) from base to end of 5th somite, the remaining somites forming a triangular figure with more or less serrated sides; the dorsal arc of its 10th somite roof-shaped, broader than long, subtriangular.

This interesting and curious form may be provisionally placed between the African genus *Phyllocrania* and the Oriental genus *Anaxarcha.*

B.L.D et J.W-M. del. Mintern Bros imp Parker & Coward lith

1-2. Phyllothelys westwoodi, ♂ ♀.

3. Phyllothelys paradoxum, ♂ nymph.

1. Phyllothelys westwoodi, W.-M., Pl. XII, Figs. 1—2.

loc. supra cit.

♂. ♀. Rich dark or light umber-brown of the colour of bark and dead and rotten leaves.

♀. Vertex greatly protuberant; the protuberance divided into three lobes, two small and hemispherical, lateral and basal, and one large, the median lobe of the vertex, flat, smooth, and triangular in front, but convex in every direction behind, and rounded at the apex, from which it suddenly gives off a long, slender, and very gradually tapering almost linear horn; the protuberance is marked off in front from the rest of the head by a transverse groove which corresponds to an imaginary straight line drawn tangentially to the upper surface of the eyes, and the sides of its median lobe and of the horn into which this is prolonged are expanded into foliaceous crests, which are turned up or rather back at their outer edges and, being longitudinally wrinkled on their anterior surface, are hence sharply marked off from the perfectly smooth primitive horn; this is raised, in the middle line of its posterior face, into a thin, sharp, and prominent crest, which is continued a short distance on to the protuberance itself, and, owing to the forward curvature of the horn, as well as to its own decrease in height from the base upwards, hence has its free edge distinctly arched. In the male, the horn and its parts are reduced to a quite rudimentary condition and are folded up into a soft, flexible, and slightly asymmetrical conical process only about 1 millim. in length. Facial shield pentagonal, fully as long as broad, with two distant and incomplete longitudinal ridges on its disc and a blunt spiniform tubercle projecting from its basal angle. Eyes rather prominent; not nearly so narrow as in *Phyllocrania*.

Prothorax greatly elongated and slender, devoid of all traces of foliaceous expansions; prosternum roof-shaped decreasingly from the setting-on of the forelegs backwards and thickly speckled with darker; pronotum narrowing behind the dilatation and then widening again, concomitantly increasing in height, to the base, where it is as broad as at the dilatation, and where it bears in the middle line an elongate and slightly bilobed smooth tubercle; with its lateral margins finely denticulate and with a well-developed supracoxal dilatation; its anterior lobe parallel-sided, with a median dorsal ridge lodged in a shallow depression; its posterior lobe provided with a raised median longitudinal ridge decreasing from the base forwards and becoming stronger again at the dilatation, where, like the ridge on the anterior lobe with which it is in unbroken continuity, it is lodged in a shallow depression.

The forelegs are long and slender. The coxæ are triquetrous and when laid back do not reach to the base of the prothorax; their inner face is coloured red-violet surmounted on the upper crest by yellowish marked with 10—13 minute elongate black spots lying at the bases of as many minute black spinules, between which are some very much more minute yellowish ones. The femora are very slightly sinuous above, but arched below; their outer face bears one distinct oblique bar and a minute mottling of a darker shade of brown than the ground-colour; their inner face is black, with the apex, a complete transverse bar nearer to the ungual groove than to the apex, and an oblong mark nearly midway between the ungual groove and the base on the upper half, all yellow; tibiæ jet-black internally and below, armed on the inner edge with 14—15 and on the outer edge with 16 teeth, the basal five only of which are more recumbent than the rest and even they do not nearly touch the margin, or even one another; the intermediate and posterior legs are short; they are ridged as in *Phyllocrania;* the posterior of their lower crests bears a foliaceous lobe divided by an emargination into a very small proximal and a much larger distal portion with a rounded and nearly entire margin; the tibiæ have no foliaceous crests, but, in lieu thereof, the proximal half swollen and thickened club-like laterodorsally, as in one or both of the same pairs of legs in the species of the tropical American genus *Acanthops* and its allies.

Organs of flight extending very little beyond the extremity of the abdomen, coloured. Tegmina coriaceous, opaque umber-brown anteriorly, posteriorly membranous and hyaline covered irregularly with brown-smoky spots, which tend in places to coalesce so as to form a coarse mottling; anal gusset reticulate, with the membranous meshes smoky and the net-work obsoletely lined with hyaline; the stigma elongate, polished. Wings with the anterior margin semiopaque umber-brown, the apex of the anterior area distinctly brown-spotted like the corresponding part of the tegmina; all the rest of the organs brown smoky-quartz-coloured, gradually increasing in intensity from the base to the outer margin, and tolerably distinctly lined with hyaline on both sides of the transverse veinlets.

Abdomen broad and depressed, gradually widening from its base to the end of the 4th somite, whence it widens with greater rapidity to the end of the 5th, the posterior angles of which are produced outwards; the rest of the abdomen forming a triangular mass the sides of which are slightly jagged owing to the production of the posterior angles of the dorsal arcs of the 6th and 7th somites; the terminal dorsal arc is crescent-shaped, longitudinally roof-shaped, and more than twice as broad as long.

The cerci are of the ordinary slender conical form and do not reach so far as the end of the ovipositor.

♂. Smaller and slenderer with the cephalic horn and its crests, as has been already stated, reduced to a rudimentary condition and all folded or shrivelled up together so as to form a soft and flexible projection no more than about a millimetre in length.

Organs of flight almost wholly membranous and hyaline. Tegmina with the marginal field semiopaque brown resolved into spots at the apex, with a few scattered groups of areolets in the discoidal area and the meshes of the anal gusset faintly smoky, and with some dark brown linear dashes on the longitudinal veins. Wings with their anterior margin pale brown spotted at the apex, the rest of these organs being very faintly iridescent-smoky, with obsolete double hyaline edgings to the transverse violets, from the base nearly to the outer margin, along which the smokiness and the longitudinal veins are alike darker, especially in the anterior area.

In the Tenasserim specimen of this sex the cephalic protuberance is more broadly rounded at the top and less produced, and the horn is more rudimentary (? in consequence of the specimen being a dried one), but there is no other apparent difference between it and the spirit-specimen from Assam described above, except perhaps in the tint (exaggerated in fig. 1) of the wings, which is slightly deeper in the latter.

Total length, ♀ 51, ♂ 40; height of head, from free margin of labrum to apex of horn, ♀ 14, ♂ 4·5, breadth of head between the eyes, ♀ 4·5, ♂ 3·75, length of horn, from a straight line drawn tangentially to the upper surface of the eyes, ♀ 10, ♂ 1·5; length of antennæ, ♀ 22, ♂ 22; length of pronotum, ♀ 22, ♂ 14·5, of its anterior lobe, ♀ 5, ♂ 3·3, of its posterior lobe, ♀ 17, ♂ 11·2, breadth of pronotum at supra-coxal dilatation, ♀ 3·5, ♂ 2·75; length of fore-coxa ♀ 13, ♂ 9, femur, ♀ 14·5, ♂ 10, tibia, ♀ 8, ♂ 5·5, intermediate femur, ♀ 5·5, ♂ 4·5, tibia, ♀ 5, ♂ 4, posterior femur ♀ 7·5, ♂ 6, tibia ♀ 7, ♂ 5·5; length of tegmina ♀ 27, ♂ 27, breadth across middle ♀ 6·5, ♂ 6 millims.

Hab.—2 ♀ and 1 ♀ nymph, Sibságar, Assam (*S. E. Peal*), 1 ♂, Buxa, Bhutan (*Dr. Lewis Cameron*), and 1 ♂ Moolai, Upper Tenasserim (*Moti Ram*) in Indian Museum, Calcutta. A fine female is preserved in the British (Natural History) Museum, South Kengsington, London.

2. Phyllothelys paradoxum, n. sp., Pl. XII, Fig. 3.

♂ nymph. Nearly allied to the preceding, which it closely resembles in the relative proportions of its parts and in every detail of colour and ornamentation, but from the same sex of which it differs in the possession of a fully developed cephalic horn and from the opposite sex in the form of this horn, which is slenderer, much more thinly foliaceous, and jagged, instead of entire, on the edges, so as to resemble a very narrow pinnately-cleft leaf, the mid and lateral ribs of which are represented by the thick and hence opaque axes of the horn and its lateral processes. The fore tibiæ have 16 teeth on the outer edge and 14 on the inner.

The only measurements of this immature insect that can usefully be given are :—length of pronotum 11, of fore femur 7, height of head, from free edge of labrum to top of horn, 7 millims.

Hab. Burmah.

This interesting animal was presented to me many years ago by my friend Mr. William Theobald of the Geological Survey of India.

Explanation of Plate XII.

Fig. 1. *Phyllothelys westwoodi*, W.-M., ♂, with wings extended, nat. size; 1 *a*. the head, viewed from in front, × 2; 1 *b*. the left fore-leg, from the inside, × 2.

Fig. 2. *Phyllothelys westwoodi*, ♀, with wings extended, nat. size; 2 *a*. the head, from behind, × 2; 2 *b*. the same, from in front, × 2; 2 *c*. the end of the abdomen, from above, × 2; 2 *d*. the posterior leg of right side, from in front, × 2.

Fig. 3. *Phyllothelys paradoxum*, n. sp., ♂ nymph, the head, from in front, × 3.

IX.—*Notes on Indian* Rhynchota, No. 1.—*By* E. T. Atkinson, B. A.

Unless where expressly stated to be descriptions, the notes attached to each species are merely intended as aids to identification; and the measurements of specimens not in the Indian Museum have been converted into millimetres from the measurements of the several authors.

HOMOPTERA.

Family Cicadidæ, Westwood, Introd. Mod. Class. Ins. ii, 420 (1840).

Stridulantia, Stål, Hem. Afric. iv, p. 1 (1866).

Ocelli three, placed on the disc of the vertex. Pronotum and mesonotum very large. Anterior coxæ prismatic, oblong, inserted in the anterior angles of the prostethium: intermediate and posterior coxæ briefly subconical, somewhat contiguous, remote from the sides of the body. Anterior femora incrassated, very often spinose, tibiæ smooth. Tarsi 2—3 jointed. Abdomen in the males with an organ of sound on each side at the base.

Genus Polyneura, Westwood.

Westwood, Arc. Ent. i, p. 92 (1842): Am. et Serv., Hist. Nat. Hém. p. 460 (1843): Stål, Hem Afric. iv, p. 3 (1866).

1. Polyneura ducalis.

Polyneura ducalis, Westwood, Arc. Ent. i, p. 92, t. 24, f. 2 (1842); Jardine, Nat. Lib. t. 18, f. 1 (1843); Am. et Serv., Hist. Nat. Ins. Hém. p. 460 (1843); Walker, List. Hom. B. M., i, p. 2 (1850).

Easily recognised by its rich golden brown colour and the apical half of the tegmina being finely reticulated with hexagonal cells. Body long 35; exp. teg. 102 millims.

Reported from Assam, Sikkim, Nepál. The Indian Museum possesses specimens from Sikkim and Assam.

Genus Pœcilopsaltria, Stål.

Hem. Afric, iv, p. 2, (1866); Berl. Ent. Zeitschr. p. 168 (1866).

Allied to *Tettigades*, Am. et Serv. Thorax angulated on each side, anterior femora not spinose, metasternum elevated, the elevated part sulcate, produced and subsinuato-truncated in front.

2. Pœcilopsaltria affinis.

Tettigonia affinis, Fabr., Syst. Rhyn. p. 37 (1803).

Cicada affinis, Germar in Thon's Archiv. Ent. ii, fasc. 2, p. 1, 6, (1830); in Silbermann's Rev. Ent. ii, p. 79 (1834); Walker, List Hom. B. M. i, p. 3 (1850).

Pœcilopsaltria affinis, Stål, Hem. Fabric. ii, p. 4 (1869).

Body long 23; exp. teg. 77 millims.

Reported from India, but no specimens appear in the British Museum list, and it would be well again to identify the locality of the specimen noted in Mus. Lund.

Genus Platypleura, Amyot & Serville.

Amyot et Serville, Hist. Nat. Ins. Hém. p. 465 (1843): Stål, Hem. Afric. iv, p. 2 (1866): Butler, Cist. Ent. i, p. 184 (1874).

(*a.*) *Species with yellow or tawny wings.*

3. Platypleura phalænoides.

Platypleura phalænoides, Walker, List Hom. B. M. i, p. 4 (1850): Butler, Cist. Ent. p. 185 (1874).

Platypleura interna, Walker, l. c. iv, p. 1119 (1852), which differs in having the anal angle only (instead of the whole flap) of the wings black.

Platypleura congrex, Stål, MS., is also possibly only a variety of this species.

Reported from Bengal, Assam, Silhat, N. India. A somewhat common species in Sikkim. The Indian Museum possesses specimens from Sibságar, Sikkim, and Darjiling.

An examination of some fifty males shows some variations in individuals, even amongst those collected in the same locality. In the hyaline apical portion of the tegmina, the brown band is sometimes connected with the marginal row of spots, sometimes with the brown band across the middle part of the tegmina, and sometimes with neither. The hyaline spots in the radial and 3—4 ulnar areas vary much in size, and the metathoracic markings vary in size and distinctness. The venation, too, is not altogether uniform, and the colour of the thorax varies from green to brown.

♀. Body sordidly luteous above and below. Face moderately convex, transversely sulcated, with a longitudinal groove, luteous, vertex and pronotum furrowed, luteous. The mesonotal marks are represented by two almost obsolete short black lines on fore border and two faint black dots on hinder border. Abdomen black above, first three segments marginally luteous-pubescent; below, central portion tawny, thickly pubescent. Opercula small, somewhat rounded, wide apart. Legs concolorous with body: posterior tibiæ spinose, tarsi and claws piceous. Tegmina, markings as in ♂, but basal half suffused with deep fulvous. Wings as in ♂, but apical third alone brown, limbus hyaline, flaps fulvous. Length body, 22½; exp. tegm. 75; of one tegmen 34; breadth of pronotum 13 millims.

Hab. Sikkim, one specimen only in the Indian Museum.

4. Platypleura assamensis, n. sp.

Sordid green, face very slightly convex, transversely sulcated, with a longitudinal groove: a fascia extending from eye to eye through the base of the antennæ, black. Rostrum extends to third abdominal segment, tip piceous. Markings above as in *P. phalænoides*, Walker. Abdomen piceous, each abdominal segment with a slight marginal fulvous pubescence. Opercula very small, wide apart piceous in the ♀; close together, piceous and margined with slight tawny in the ♂. Basal half of tegmina, brown, with irregular pale markings: a hyaline spot in the third quarter of the radial area, a pale spot at the base of the radial area and the 4—5 ulnar areas. Apical half of the tegmina pale hyaline; a brown patch extending through the apical anastomoses of the 1—3 ulnar areas: an inner apical row of six brown spots, first two and last broadest, first two confluent, middle sagittate, last confluent with the dot on the limbus: apical veins ending in six small oblong brown spots, beyond which in the limbus are six minute dots. Wings marked as in *P. phalænoides* with which it is closely allied, but the body is much less robust, and smaller; and there is a difference in the markings and colour of the tegmina. Length body, 23½; exp. tegm., 69; of single tegmen, 30; breadth of the pronotum 12, millims.

♂ is slightly smaller, tegmen, 27 millims.

Hab. Sibságar and Nága Hills : ♂ and ♀ in Indian Museum.

5. Platypleura nicobarica, n. sp.

Light ochraceous, shining. Face moderately convex, transversely sulcated, with a median longitudinal groove, an interrupted fascia extending from eye to eye, and a patch on each side of the base of the rostrum and along the first joint thereof, black. The rostrum extends well beyond the posterior coxæ, tip black. Eyes dull castaneous, pilose behind. Vertex deeply grooved, the hollows, a small triangular patch below the ocelli, a narrow fascia from eye to eye through the ocelli, and a narrow short longitudinal line between the ocelli and eyes, black. Pronotum furrowed, with a single, longitudinal, narrow, short, black line in the middle of the anterior margin, lateral processes subtriangular and their external margins brown. The mesonotum with two triangular black spots, their bases resting on the anterior margin, and on each side a large distinct V- shaped mark, slightly interrupted on the inner side, and two small round spots near the posterior margin. Segments of abdomen black, margined with yellow, above and below, slightly pubescent. Legs ochraceous, extremities of tibiæ and claws brown-black, posterior tibiæ spinose. Opercula ochraceous, small, rounded, contiguous, having a black patch near the base of posterior coxæ. Tegmina, basal half tawny with irregular brown markings in the radial and 1—4 ulnar areas and one in the costal membrane. The upper third of the third ulnar area and the apical areas hyaline, with an almost obsolete series of minute dots at the end of each vein : wings ochraceous, apical third brown, with veins ochraceous, a discal streak to anal angle and two lines confluent at the inner angle, brown. Length body, 24 : exp. tegmina, $75\frac{1}{2}$ of single tegmen 33 : breadth of the pronotum, $14\frac{1}{2}$ millims.

Hab. Nicobar Islands : in Indian Museum.

6. Platypleura sphinx.

Platypleura sphinx, Walker, List. Hom. B. M. i, p. 13 (1850) : Butler, Cist. Ent. p. 188 (1874).

Tegmina whitish, brownish-tawny towards the base and having elsewhere some irregular pale-brown marks which here and there include white spots. Body long 18 ; exp. teg. 43 millims.

Reported from N. Bengal, N. India.

7. Platypleura cælebs.

Platypleura cælebs, Stål, Trans. Ent. Soc. 3rd Ser. i, p. 573 (1863) : Butler, Cist. Ent. p. 188 (1874).

Allied to *Pœcilopsaltria capitata*, Olivier, (Enc. Méth. v, p. 754) in regard to size, broadness of apical limbus, tegmina and wings. Body long 23: exp. teg. 68 millims. Reported from N. India.

8. Platypleura andamana.

Platypleura andamana, Distant, Trans. Ent. Soc. p. 174 (1878).

This species was described from a specimen procured from the Andaman islands. Body long 22: exp. teg. 84 millims.

9. Platypleura roepstorffii, n. sp.

♂. ♀. Brownish tawny. Face gamboge colour, moderately convex, transversely sulcated, with a brown longitudinal groove. Rostrum extending almost to the posterior margin of the first abdominal segment, tip brown. Legs brown above, tawny below; tibiæ setose, posterior pair spinose. Eyes bright castaneous, moderately prominent, pilose behind. Second joint of antennæ pale tawny. A fascia from eye to eye, through the base of the antennæ and frons, and another through the ocelli, black. Pronotum grooved, with an obtuse-angled black mark on middle of posterior border; lateral processes subtriangular, anterior margin slightly brown. Mesonotum with two obconical spots extending backwards from anterior border and having between them a variable sagittate mark, two dots wide apart, near posterior border, and a very obscure mark situate on the outer side of each of the obconical spots, black. Abdominal sutures black, margined with luteous, pubescent; anal segment below, luteous. Opercula very small, subelliptical, wide apart in the ♂; contiguous, semi-rounded, in the ♀. Tegmina brown, opaque: basal third tinged with tawny, very apparent when stretched out; two spots in the radial area (the basal extending into the costal membrane) and one in the fourth ulnar area, black. A patch in the middle of the first ulnar area, extending into the third, and one near the base of the third ulnar area, extending into the fourth, pale brown. Apical area pale brown; veins adorned with oval marks, brown, with a centre of pale brown. External margin with a row of six subquadrangular brown spots, divided by oval pale brown spots. Wings fulvous tawny, disc and a band along the fore and external borders brown. Length of body, $24\frac{1}{2}$; exp. tegm. $76\frac{1}{2}$; of one tegmen, 34; breadth of pronotum, 12 millims.

Closely allied to *P. andamana*, Distant.

Hab. Andaman Islands. Several specimens are in the Indian Museum.

(*b.*) *With black and white wings.*

10. Platypleura basialba.

Oxypleura basialba, Walker, List Hom. B. M. i, p. 26, (1850).
Platypleura basialba, Butler. Cist. Ent. i, p. 191 (1874).

Body long 19, exp. teg. 61 millims. Reported from N. Bengal.

11. Platypleura nobilis.

Cicada nobilis, Germar in Thon's Archiv. ii, fasc. 2, p. 9 (1830); in Silbermann's Rev. Ent. ii, pt. 2, p. 82, (1834).

Cicada hemiptera, Guérin, Voyage Bélanger Ind. Orient. p. 500 (1834).

Platypleura semilucida, Walker, List Hom. B. M. i. p. 20 (1850).

Platypleura nobilis, Butler, Cist. Ent. i, p. 191 (1874); Distant, J. A. S. B. xlviii, (2), p. 38 (1879).

Reported from Java, Singapore, and Tenasserim: there is a specimen in the Indian Museum from Tenasserim. As this is a typical species of the smaller members of this genus, I re-describe it, the original description being practically unobtainable.

Tawny. Face tawny, moderately convex, transversely sulcated with the furrows brown and a longitudinal groove broadly black. Rostrum extending to the fourth abdominal segment, tip piceous. Eyes dull castaneous, with a narrow black fascia, extending from anterior margin around the base of the antennæ. Vertex with a bright tawny fascia on anterior margin and two minute obconical black marks, extending from posterior margin on each side of the ocelli, obsolete in some. Pronotum tawny, furrowed, furrows black; a line from the middle of the anterior border to the posterior border, black and quadrangularly expanded on the disc. Mesonotum fulvous brown, with two moderate obconical black spots, extending backward from the fore border, midway between which there is a discal line connected with a fascia on the hinder border also black. On the outer side of both the moderate obconical spots is a large obconical patch, black, and extending from the fore border almost to the hind border. The metanotum is bright tawny. The abdominal sutures are black, edged with fulvous, slightly pubescent. Below, the fulvous margins of the abdominal segments alone appear. Opercula tawny, brown at the base, rounded, small, wide apart. Legs tawny, anterior and middle femora spotted brown, posterior tibiæ spinose. Tegmina, basal third tawny, with some irregular lighter markings: a hyaline spot, at the apex of the radial area, just above a dark brown spot which extends into the costal membrane: a black spot in the ulnar space. Apical two-thirds of tegmina hyaline, with three minute brown spots on the apical anastomoses of the first and second ulnar areas, also a very minute brown spot on each side of the middle of the vein separating the second from the third apical area and the third from the fourth; six minute brown spots on the limbus. Basal two-thirds of the wings brown, with a discal streak extending to the anal angle, tawny; apical third, hyaline; flaps tawny with a brown line on the suture. Length body 16; exp. teg. 46; length of one tegmen 24; breadth of pronotum 8 millims.

Variety, *a.*—Markings on face and pronotum more distinctly black. The markings on the basal third of the tegmina are more distinctly pale forming a band of five spots extending from the costal membrane through the ulnar areas. The brown spots in the hyaline apical portion broader, the internal apical row produced through the apical areas and the external apical row of dots duplicated. The tawny discal streak of the wings wanting, flaps grey hyaline. From Munipur, in Indian Museum. Allied to *Platypleura insignis*, Distant.

12. Platypleura insignis.

Platypleura insignis, Distant, J. A. S. B. xlviii (2), p. 39, t. 2, f., 2 (1879).

Allied to the preceding, but tegmina and wings very distinct, the opaque portion being much less than in that species. Body long 15; exp. teg. 45 millims. Reported from Tenasserim and Hindustan: a specimen from the former locality is in the Indian Museum.

(*c.*) *With black, white, and red wings.*

13. Platypleura octoguttata.

Tettigonia octoguttata, Fabricius, Ent. Syst. Suppl. p. 515 (1798); Syst. Rhyng. p. 39 (1803); Coquebert, Ill. Ins. i, p. 34, t. 9, f., 1 (1790).

Oxypleura sanguiflua, Walker, List Hom. B. M. i., p. 24 (1850); Ins. Saund. Hom. p. 2 (1858).

Pœcilopsaltria octoguttata, Stål, Berl. Ent. Zeitschr. x, p. 168 (1866) (re-described).

Platypleura octoguttata, Butler, Cist. Ent. i, p. 192 (1874).

Body long 27: exp. teg. 80 millims. Reported from the Panjab, N. India, N. Bengal, S. India. The Indian Museum possesses specimens from Bengal, Calcutta, and Sambhalpur in the Central Provinces.

14. Platypleura subrufa.

Oxypleura subrufa, Walker, List. Hom. B. M. i, p. 25 (1850).

Pœcilopsaltria capitata, Stål, Berl. Ent. Zeitschr. x, p. 169 (1866), who joins together '*subrufa*' and '*capitata*' Olivier (Enc. Méth. v, p. 754, t. 112, f. 10), the former an Indian and the latter a Ceylon species. They have been separated again by Butler (Cist. Ent. i, p. 192) and should remain separate.

Platypleura subrufa, Butler, Cist. Ent. i, p. 192 (1874).

Body long 27: exp. teg. 75 millims. Reported from Coromandel and India.

(*d.*) *With black, white, and brown wings.*

15. Platypleura bufo.

Oxypleura bufo, Walker, List Hom. B. M. i. p. 27 (1850).

Platypleura bufo, Butler, Cist. Ent. i, p. 195 (1874).

Body long 25: exp. teg. 81 millims. Reported from India.

16. Platypleura cervina.

Platypleura cervina, Walker, List Hom. B. M. i, p. 16 (1850) ♀ ; Butler, Cist. Ent. i, p. 198 (1874).

Platypleura straminea, Walker, l. c. p. 17, ♂.

Body long 17 : exp. teg. 50 millims. Reported from N. Bengal.

Genus Tacua, Amyot & Serville.

Am. & Serv., Hist. Nat. Ins. Hém., p. 461 (1843) : Stål, Hem. Afric. iv, p. 3. (1866).

17. Tacua speciosa.

Tettigonia speciosa, Illiger in Wied. Zool. Arch. ii, 145, t. 2 ; Fabricius, Syst. Rhyn. p. 33 (1803).

Cicada indica, Donovan, Ins. Ind. Hem., t. 2, f. 3, (1800).

Cicada speciosa, Blanchard, Hist. Nat. Ins. iii, 165 ; Hém. t. 9 (1840-41).

Tacua speciosa, Am. et Serv., Hist. Nat. Ins. Hém. p. 462 (1843) ; Walker, List. Hom. B. M. i, p. 46 (1850). J. A. S. Zool. i. p. 141 (1857).

Body long 55 millims. Reported from Java, Bengal (Donovan).

Genus Tosena, Amyot & Serville.

Am. & Serv., Hist. Nat. Ins. Hém. p. 462 (1843) : Stål, Hem. Afric. iv. p. 3. (1866).

18. Tosena melanoptera.

Tosena melanoptera, White, A. & M. N. H. xvii, p. 331 (1846) ; Walker, List Hom. B. M. i, p. 46 (1850).

Body long 60 : exp. teg. 142 millims. Reported from Silhat, N. India. The Indian Museum possesses specimens from Sibságar and Sikkim.

19. Tosena mearesiana.

Cicada mearesiana, Westwood, Arc. Ent. i, p. 98, t. 25, f. 1 (1842).

Tosena mearesiana, Am. & Serv., Hist. Nat. Ins. Hém. p. 463 (1843) ; Walker, List Hom. B. M. i, p. 46 (1850).

Body long 44 : exp. teg. 130 millims. Reported from N. India. The Indian Museum possesses specimens from Sikkim.

20. Tosena albata.

Tosena albata, Distant, Trans. Ent. Soc. Lond. 1878, p. 175.

Body long 59 : exp. teg. 132 millims. Reported from N. India.

21. Tosena splendida.

Tosena splendida, Distant, Ent. Month. Mag. xv, p. 76 (1878).

♂. Body long 47 : exp. teg. 124 millims. ♀. Body long 49 ; exp. teg. 127. Reported from Assam, Nága Hills, Khasiya Hills. The Indian Museum possesses ♂ and ♀ from the Lushai country.

Genus Huechys, Amyot & Serville.

Am. & Serv., Hist. Nat. Ins. Hém. p. 464 (1843) : Stål, Hem. Afric. iv, p. 4 (1866).

22. Huechys philæmata.

Tettigonia philœmata, Fabricius, Syst. Rhyn. p. 42 (1803) ; Stoll, Cig. p. 53, t. 13, f. 62 (1788).

Cicada philœmata, Germar in Thon's Archiv. ii, fasc. 2, p. 26 (1830) ; in Silbermann's Rev. Ent. ii, p. 75, n. 52 (1834) ; Burmeister, Handb. Ent. ii, (i) p. 180 (1835).

Cicada sanguinea, Guérin, Voyage La Favorite, v, p. 155 (1839) ; Mag. Zool. p. 75 (1839).

Huechys philœmata, Am. & Serv., Hist. Nat. Ins. Hém. p. 465 (1843) ; Walker, List Hom. B. M. i. p. 251 (1850).

Guérin (l. c.) unites this species with the following and keeps *H. sanguinolenta*, Fabr., which he had not seen, distinct, but he is not followed in this arrangement by later writers.

Body above black with the frons, two quadrate patches on mesothorax, and abdomen sanguineous: tegmina brown, wings cindery-grey and subhyaline. Body long 22 millims.

Reported from Philippine Islands, N. Bengal, and Silhat. The Indian Museum possesses specimens from the Nága Hills, N. India, and Tenasserim.

23. Huechys sanguinea.

Cicada sanguinea, De Géer, Ins. iii, 221, t. 33, f. 17 (1773) ; Gmelin Ed. Syst. Nat. i, 3, 2098 (1782) ; Westwood in Donovan's Ins. China, t. 16, f. 1 (1842).

Tettigonia sanguinolenta, Fabricius, Syst. Ent. p. 681 (1775) ; Spec. Ins. ii, p. 321 (1781) ; Mant. Ins. ii, p. 267 (1787) ; Ent. Syst. iv, p. 25 (1794) ; Syst. Rhyn. p. 42 (1803).

Cicada sanguinolenta, Olivier, Enc. Méth. v, p. 756 (1790) ; Germar in Thon's Archiv, ii, fasc. 2, p. 3 (1830), in Silbermann's Rev. Ent. ii, p. 75 (1834) ; Blanchard, Hist. Nat. Ins. iii, p. 165 (1840-41) ; Guérin, Voyage La Favorite, v, p, 155, t. 45, f. 1 (1839) ; Mag. Zool. p. 76, t. 237, f. 1 (1839).

Huechys sanguinea, Am. & Serv., Hist. Nat. Ins. Hém. p. 465 (1843) ; Walker, List Hom. B. M. i, p. 251 (1850) ; J. L. S. Zool. i, p. 84 (1856) ; ibid., x, p. 95 (1867) : Distant, J. A. S. B. xlviii, (2) p. 38 (1879).

Guérin separates '*sanguinolenta*, Fabricius' and unites '*philœmata*' with '*sanguinea*'. *H. incarnata*, Germar, Silb. Rev. Ent. ii, p. 75, (1834), and Brullé Hist. Nat. Ins. Hém. ii, t. 3. f. 2, is probably only a variety of *H. sanguinea.*

Head, thorax, and feet black: frons, two great spots on the mesothorax, and abdomen sanguineous : tegmina black : wings fuscous. Body long 18 ; exp. teg. $41\frac{1}{2}$ millims.

Reported from India, Singapore, China, and the Eastern Archipelago. Specimens exist in the Indian Museum from Sikkim, Sibságar, Calcutta, and Tenasserim.

24. Huechys testacea.

Tettigonia testacea, Fabricius, Mant. Ins. ii p. 267 (1787) ; Ent. Syst. iv, p. 24 (1794) ; Syst. Rhyn. p. 42 (1803) : Stoll, Cig. p. 41, t. 8, f. 41 (1788).

Cicada testacea, Gmelin Ed. Syst. Nat. i, pt. 4, p. 2098 (1782) ; Olivier, Enc. Méth. v, p. 756, t. 113, f. 5 (1790) ; Germar in Thon's Archiv. ii, fasc. 2, p. 3, (1830) ; Guérin, Voyage La Favorite, v, p. 155 (1839) ; Mag. Zool. p. 78 (1839).

Huechys testacea, Walker, List Hom. B. M. i, p. 252 (1850).

The upper surface of the body without red marks : tegmina brown, only partly transparent : wings concolorous, veins black : abdomen sanguineous.

Reported from Coromandel.

25. Huechys phænicura.

Cicada phœnicura, Germar in Silbermann's Rev. Ent. ii, p. 76 (1834) ; Guérin, Icon. du Règne Animal, p. 78 (1830-34).

Huechys phœnicura, Walker, List Hom. B. M. i, p. 252 (1850).

Black, entire frons, mesothorax, and abdomen sanguineous ; tegmina and wings black ; sometimes frons black in the middle and thorax with a black basal spot or band running through it, sides and small median spot red.

Reported from India, Sikkim.

26. Huechys transversa.

Huechys transversa, Walker, List Hom. B. M. Suppt. p. 40 (1858).

Black : tegmina with costa and transverse veins red and a testaceous band. Body long 23 : exp. teg. 62 millims.

Reported from Hindustan.

27. Huechys thoracica.

Huechys thoracia, Distant, J. A. S. B. xlviii, (2), p. 39, t. II, f. 3 (1879).

Known by the red hour-glass-shaped fascia on pronotum. Body long 19 : exp. teg. 43 millims.

Reported from Tenasserim and Hindustan.

28. Huechys trabeata.

Cicada trabeata, Germar in Thon's Archiv, ii, fasc. 2, p. 3 (1830) : Guérin, Mag. Zool. p. 78 (1839).

Huechys trabeata, Walker, List Hom. B. M. i, p. 252 (1850).

Body ferruginous, tegmina and wings fuscous with ferruginous veins. Body long, 20½ millims ; tegmina broken at the ends.

Reported from Java.

There is a specimen in the Indian Museum, locality unknown.

Genus Scieroptera, Stål.

Hem. Afric. iv, p. 4 (1866).

Allied to *Gæana :* ulnar veins contiguous at the base or united for a short distance; head scarcely narrower than the base of the thorax ; anterior femora incrassated, spinose beneath.

29. Scieroptera crocea.

Cicada crocea, Guérin in Voyage La Favorite, v, p. 159, t. 45, f. 3 (1829) ; Mag. Zool. p. 79, cl. ix, t. 237, f. 3 (1839) ; in Voyage La Coquille, Zool. ii (2), p. 182 (1830).

Huechys crocea, Walker, List Hom. B. M. i, p. 252 (1850).

Scieroptera crocea, Stål, Berl. Ent. Zeitschr. x, p. 169 (1866).

Yellow: thorax above with four reddish brown spots: abdomen saffron-red, more obsolete below. Feet yellow, tibiæ and tarsi black. Tegmina and wings hyaline with yellow veins.

Reported from Bengal.

30. Scieroptera splendidula.

Tettigonia splendidula, Fabricius, Syst. Ent. p. 681 (1774) ; Spec. Ins. ii, p. 321 (1781) ; Mant. Ins. ii, p. 267 (1787) ; Ent. Syst. iv, p. 25 (1794) ; Syst. Rhyn. p. 42 (1803).

Cicada splendidula, Gmelin Ed. Syst. Nat. i, pt. 4, p. 2098 (1782) : Olivier, Enc. Méth., v, p. 756 (1790) : Germar in Thon's Archiv, ii, fasc. 2, p. 45 (1830) : Guérin, in Voyage La Favorite, v, p. 159 (1839) ; Mag. Zool. p. 79 (1839) : Westwood in Donovan's Insects China, t. 16, f. 4 (1842).

Huechys splendidula, Walker, List Hom. B. M. i, p. 252 (1850).

Scieroptera splendidula, Stål, Berl. Ent. Zeitschr. x, p. 169 (1866) : Distant, J. A. S. B. xlviii (2), p. 38 (1879).

Yellow; thorax above with four large blackish rounded spots. Tegmina golden brown : anterior tibiæ red, femora black : posterior femora red : abdomen sanguineous. Body long 17 : length of one teg. $19\frac{1}{2}$ millims.

Reported from N. India, Silhat, Tenasserim. The Indian Museum possesses specimens from Tenasserim, Arakan, and the Khasiya Hills.

31. Scieroptera fumigata.

Huechys fumigata, Stål, Ofvers. Kong. Vet. Akad. Förh. p. 244 (1854) ; Walker, List Hom. B. M. Suppt. p. 314 (1858).

Scieroptera fumigata, Stål, Berl. Ent. Zeitschr. x, p. 169 (1866).

Head, thorax, and scutellum black; their lateral margins, a median patch on the thorax, and spot on the scutellum yellow: tegmina fusco-vinaceous, costa and veins weakly yellow testaceous; wings weakly vinaceous hyaline, abdomen and femora testaceous, the former above blackish. Body long 12 : exp. teg. 28 millims.

Reported from India.

Genus Graptotettix, Stål.

Hem. Afric. iv, p. 4 (1866).

Allied to *Gœana:* tegmina with ten apical cells: vertex twice as wide as the eyes: anterior femora spinose beneath; tibiæ longer than femora.

32. Graptotettix guttatus.

Graptotettix guttatus, Stål, Berl. Ent. Zeitschr. x, p. 170 (1866).

Blackish with the frons, four oval spots on the thorax, two large spots on the scutellum, and the abdomen sordidly yellow: tegmina and wings fuscous. Body long 25: exp. teg. 67 millims.

Reported from the Himálaya. The Indian Museum has a specimen from Sikkim.

Genus Gæana, Amyot & Serville.

Hist. Nat. Ins. Hém. p. 463 (1843).

33. Gæana octonotata.

Cicada octonotata, Westwood, Arc. Ent. ii, p. 34, t. 57, f. 2, ♀ (1843).
Huechys octonotata, Walker, List Hom. B. M. i, p. 253 (1850).

Easily recognised by the tegmina brown with four yellowish spots and the wings roseate. Body long 37: exp. teg. 61 millims.

Reported from Assam. The Indian Museum possesses specimens from Sikkim.

34. Gæana dives.

Tosena dives, Westwood, Arc. Ent. i, p. 98, t. 25, f. 2 (1842): Am. et Serv. Hist. Nat. Ins. Hém. p. 464 (1843): Walker, List Hom. B. M. i, p. 46 (1850).

Black: tegmina with reddish veins and a median transverse, narrow whitish band: wings testaceous, apical part black. Body long 25: exp. teg. 75 millims.

Reported from Silhat. The Indian Museum possesses specimens from Sikkim.

35. Gæana consors.

Gœana consors, White, Proc. Zool. Soc. 1850; Walker, List Hom. B. M. i, p. 253 (1850).

Close to *G. festiva,* but differing in the markings on the tegmina. Body long 29: exp. teg. 84 millims.

The Indian Museum possesses specimens from the Nága Hills and Samaguting in Assam. One specimen has the body above and below black without a single spot or mark except a testaceous tinge on the lower part of the face; and the markings on the tegmina are dark green.

36. Gæana festiva.

Tettigonia festiva, Fabricius, Syst. Rhyn. p. 41 (1803).

Cicada thalassina, Percheron, Gen. Ins. (Hém.), t. 2 (1834): Guérin, Voyage La Coquille, Ins. p. 183 (1838).

Cicada percheronii, Guérin, Icon. Règne Animal, p. 355 (1838).

Gœana consobrina, White, Proc. Zool. Soc. 1850; Walker, List Hom. B. M. i, p. 254 (1850).

Gœana festiva, Stål, Berl. Ent. Zeitschr. x, p. 170 (1866); Hem. Fabr. ii, p. 5 (1869).

Black: a testaceous band across the face from eye to eye and around each eye: four narrow longitudinal yellow lines on the thorax. Tegmina bluish green or greenish yellow, the radial area with a small and larger spot below, a median band, three confluent apical patches, and a broad apical limbus, black: wings white or bluish, apical part black with a white or bluish spot on the disc. Body long 33: exp. teg. 80 millims.

Reported from Assam, Bengal.

The Indian Museum possesses specimens from Darjiling and Sikkim. Some of these have the tegmina green, others greenish yellow, and, in some, the wings have the basal portion and a discal spot bright testaceous not white or pale, the size and arrangement of the markings on the body and tegmina remaining exactly the same.

37. Gæana maculata.

Tettigonia maculata, Fabricius, Syst. Ent. App. p. 831 (1775); Spec. Ins. ii, p. 319 (1781); Mant. Ins. ii, p. 266 (1787); Ent. Syst. iv, p. 20 (1794); Syst. Rhyn. p. 37 (1803).

Cicada maculata, Drury, Ill. Nat. Hist. ii, p. 69, t. 37, f. 1 (1773); Gmelin, ed. Syst. Nat. i, pt. 4, p. 2100 (1782): Olivier, Enc. Méth. v, p. 750, t. 112, f. 4 (1790): Germar in Thon's Archiv. ii, fasc. 2, p. 12 (1830); in Silbermann's Rev. Ent. ii, p. 74 (1834).

Gœana maculata, Am. et Serv., Hist. Nat. Ins. Hém. p. 464 (1843); Walker, List Hom. B. M. i, p. 253 (1850).

♀. Black shining: two yellow spots on vertex between the eyes, one below each eye: six on mesonotum, four in front, two behind. Tegmina black, with five spots, two basal (of which one within radial area is minute) and three larger subequal median spots, whitish yellow: a white dot in 1—3 ulnar and in all the apical areas except the last. Wings black, basal part sordidly white and a sub-apical row of five white dots. A form of the ♂ has, instead of the dots or spots in the ulnar and apical areas, broad smears of dirty white, and is also larger than the ordinary ♀. Body long 32: exp. teg. 92 millims, ♀: body long 40 exp. teg. 97 millims. , form last mentioned.

The Indian Museum possesses specimens from Sikkim, Khasiya Hills, Samaguting, and the Dhansiri Valley.

38. GÆANA SULPHUREA.

Cicada sulphurea, Hope, in Royle's Ill. Bot. Him., Introd., p. liv, t. 10, f. 2 (1839).

Cicada pulchella, Westwood, Arc. Ent. ii, p. 34, t. 57, f. 1. (1843).

Gæana sulphurea, Walker, List Hom. B. M. i, p. 254 (1850).

Black; head, pronotum, and mesonotum spotted sulphureous: tegmina and wings sulphureous for the basal two-thirds; apical third blackish-fuscous: tegmina with a blackish-fuscous median band: abdomen beneath and on each side at the tip, spotted yellow. Body long 38: exp. teg. 90 millims.

Reported from Nepal and N. India.

The Indian Museum possesses specimens from Sikkim and N. India.

Genus DUNDUBIA, Am. & Serv.

Am. et Serv., Hist. Nat. Ins. Hém. p. 470 (1843): Stål, Hem. Afric. iv. p. 5 (1866).

Head triangular: frons large, very convex, transversely sulcated, with a longitudinal groove in the middle: pronotum not ampliated on the lateral margins: cheeks without a tubercle: rostrum not or barely reaching the base of the posterior coxæ: opercula long, extending beyond the middle of the venter, very often to the last segment.

This and the remaining genera of this group have been so imperfectly worked out, and the synonymy is so defective, that it is impossible for any one in this country to do more than indicate the recorded species. Walker's work here is particularly untrustworthy, and his descriptions quite unintelligible.

39. DUNDUBIA MANNIFERA.

Cicada mannifera, Linnæus, Mus. Ad. Fried. p. 84 (1754), excluding synonymy.

Tettigonia vaginata, Fabricius, Mant. Ins. ii, p. 266 (1787); Ent. Syst. iv, p. 18 (1794); Syst. Rhyn., p. 35 (1803).

Cicada vaginata, Gmélin Ed. Syst. Nat. i, pt. 4, p. 2099 (1782); Olivier, Enc. Méth. v, p. 748 (1790); Stoll, Cig. p. 38, t. 7, f. 35 (1788).

Cicada virescens, Olivier, Enc. Méth. v, p. 747 (1790) t. 110, f. 2; Walker, List Hom. B. M. i, p. 64 (1850).

Dundubia vaginata, Am. et Serv., Hist. Nat. Ins. Hém. p. 471 (1843); Walker, List Hom. B. M. i., p. 47, 1120, (1850); J. L. S. Zool. x, p. 84 (1867).

Dundubia mannifera, Stål, Berl. Ent. Zeitschr. x, p. 170 (1866): Distant, J. A. S. B. xlviii, (2), p. 38 (1879); Trans. Ent. Soc. p. 634 (1881).

Body pale yellow-olive or virescent, spotless; tegmina and wings hyaline, spotless, costa of the former black or brown; opercula almost as long as the abdomen, narrowed near the base, thence oval, rounded at the tip, testaceous or pale green. ♂. Body long 43: exp. teg. 110 millims.

Reported from Morty, Sumatra, Tenasserim, Assam.

The Indian Museum possesses specimens from Java, Tenasserim, and Sikkim.

40. Dundubia microdon.

Dundubia microdon, Walker, List Hom. B. M. i, p. 55 (1850).

Body long, 34: exp. teg. 88 millims. Reported from N. India.

41. Dundubia lateralis.

Dundubia lateralis, Walker, List Hom. B. M. i, p. 61 (1850).

Body long, 29: exp. teg. 87 millims. Reported from Silhat.

42. Dundubia intemerata.

Dundubia intemerata, Walker, J. L. S. Zool. i, p. 84 (1856).

Pale testaceous: tegmina and wings hyaline, spotless, the costa of the former tawny, veins green. Opercula acute, triangular, narrow, extending to fifth ventral segment. Body long 21: exp. teg. 72 millims.

Reported from Singapore.

The Indian Museum possesses specimens from Tenasserim, Dhansiri-valley, Sibságar, Nága Hills, Samaguting.

43. Dundubia vibrans.

Dundubia vibrans, Walker, List Hom. B. M. i, p. 54 (1850): J. L. S. Zool. x, p. 84 (1867).

Body pale tawny, wings colourless, pale tawny at the base; apex of tegmen slightly clouded with brown. Body long 36: exp. teg. 92 millims.

Reported from Silhat.

44. Dundubia nicomache.

Dundubia nicomache, Walker, List Hom. B. M. i, p. 67 (1850).

Body long 22: exp. teg. 85 millims. Reported from N. India.

45. Dundubia tigrina.

Dundubia tigrina, Walker, List Hom. B. M. i, 69 (1850).

Body long 23: exp. teg. 69 millims. Reported from Malabar. The Indian Museum possesses specimens from Assam ?

46. Dundubia maculipes.

Dnndubia maculipes, Walker, List Hom. B. M. i, p. 70 (1850).

Body long 25: exp. teg. 71 millims. Reported from N. Bengal.

47. Dundubia samia.

Dundubia samia, Walker, List Hom. B. M. i, p. 77 (1850).

Body long 28: exp. teg. 71 millims. Reported from N. India.

48. Dundubia singularis.

Dundubia singularis, Walker, List Hom. B. M. Suppt. p. 7 (1858).

Body long 19: exp. teg. 62 millims. Reported from India.

49. Dundubia radha.

Dundubia radha, Distant, Trans. Ent. Soc. p. 634 (1881).

Allied to *D. mannifera*, Linn., from which it differs by the much broader head, attenuated apices of the opercula, and its much larger size. In superficial appearance, it bears a strong resemblance to the genus *Cosmopsaltria*. (*Distant*). Body long 53: exp. teg. 124 millims.

Reported from Madras Presidency and Mussooree.

50. Dundubia tripurasura.

Dundubia tripurasura, Distant, Trans. Ent. Soc. p. 635 (1881).

This species is allied to *D. vibrans*, Walker, from which it structurally differs by the long and subtriangular opercula. The abdomen is also broader, the tegmina unspotted, and the sanguineous colour of the abdomen and opercula are also somewhat peculiar and distinct. (*Distant*). Body long 33: exp. teg. 85 millims.

Reported from Assam.

51. Dundubia nagarasingna.

Dundubia nagarasingna, Distant, Trans. Ent. Soc. p. 635 (1881).

Distant writes:—'I am somewhat at a loss for a closely allied species with which to compare it, but its distinct colour and markings and shape and the length of the opercula should sufficiently distinguish it.' Body long 39: exp. teg. 95 millims.

Reported from N. W. Burma.

52. Dundubia immacula.

Dundubia immacula, Walker, List Hom. B. M. i, p. 50 (1850).

Body fawn colour, wings whitish. Body long 40: exp. teg. 102 millims. Reported from Tenasserim.

Genus Melampsalta, Kol.

Melet. Ent. vii. p. 27 (1857).

53. Melampsalta varians.

Cicada varians, Germar in Silbermann's Rev. Ent. ii, p. 59 (1834).

Dundubia varians, Walker, List Hom. B. M. i, p. 48 (1850); iv, p. 1120 (1852): Suppt. p. 6 (1858).

Dundubia chlorogaster, Walker (*nec* Boisduval), l. c. p. 47, ♀.

Melampsalta varians, Stal, A. S. E. F. (4 Sér.) i. p. 619 (1862).

Reported from Silhat.

Genus Cosmopsaltria, Stål.

Hem. Afric. iv, p. 5 (1866).

In Ofvers. Kong. Vet. Aka. Förh. p. 708 (1870), Stål distributes this genus amongst three subgenera:—*Platylomia* to which *C. flavida*, Guérin, belongs; *Cosmopsaltria* to which *C. spinosa*, Fabr., belongs; and *Diceropygia* to which *C. obtecta*, Fabr., belongs. *Cosmopsaltria* is closely allied to *Dundubia;* cheeks without a tubercle; rostrum reaching the base or most often the apex of the posterior coxæ; opercula long, extending beyond the middle of the venter.

54. Cosmopsaltria obtecta.

Tettigonia obtecta, Fabricius, Syst. Rhyn. p. 35 (1803).

Cicada obtecta, Germar, in Thon's Archiv, ii, fasc. 2, p. 5 (1830).

Dundubia obtecta, Walker, List Hom. B. M. i, p. 47 (1850).

Cosmopsaltria obtecta, Stål, Hem. Fabr. 2, p. 4 (1869).

Reported from N. India, N. Bengal, Nepál and Assam. Body long 25: exp. teg. 85 millims.

Specimens in the Indian Museum are from Sikkim and Assam.

55. Cosmopsaltria sita.

Cosmopsaltria sita, Distant, Trans. Ent. Soc. p. 636 (1881).

It is difficult to separate this and the two following species from the genus *Dundubia* except by the length of the rostrum. They also resemble the '*vibrans*' group of that genus. Body long 24: exp. teg. 73 millims.

Reported from S. India or Bombay. (*Distant*).

56. Cosmopsaltria durga.

Cosmopsaltria durga, Distant, Trans. Ent. Soc. p. 637 (1881).

This species in size and markings (excluding the spotted tegmina) much resembles *Dundubia tripurasura*, Distant; the less produced frontal portion of the head and the length of the rostrum, however, place it in this genus (*Distant*). Body long 33: exp. teg. 98 millims.

Reported from Assam.

57. Cosmopsaltria abdulla.

Cosmopsaltria abdulla, Distant, Trans. Ent. Soc. p. 639 (1881).

This is a large and distinct species, near *C. doryca*, Boisd., from which it differs by its large size, more spotted tegmina, and different size and structure of the opercula. Body long 46 : exp. teg. 116—122 millims.

Reported from Penang and Singapore.

58. Cosmopsaltria oopaga.

Cosmopsaltria oopaga, Distant, Trans. Ent. Soc. p. 641 (1881).

This species is also allied to *C. doryca*, Boisd., but the body is much broader, the tegmina are unspotted, and the shape of the opercula more like those of *C. abdulla*, Distant. Body long 39 : exp. teg. 96 millims.

Reported from Burma.

59. Cosmopsaltria spinosa.

Tettigonia spinosa, Fabricius, Mant. Ins. ii, p. 266 (1787) ; Ent. Syst. iv, p. 17 (1794) ; Syst. Rhyn. p. 34 (1803).

Cicada spinosa, Olivier, Enc. Méth. v, p. 748 (1790).

Dundubia spinosa, Walker, List Hom. B. M. i, p. 47 (1850).

Cosmopsaltria spinosa, Stål, Berl. Ent. Zeitsch. x, p. 171 (1866) ; Ofvers. Kong. Vet. Aka. Förh. p. 708 (1870).

Varies much in size and coloration. Tegmina towards the apex of the veins sometimes immaculate and sometimes with fuscous spots.

Reported from India.

60. Cosmopsaltria flavida.

Cicada flavida, Guérin, Voyage Belanger in Ind. Orient. p. 498, t. 3, f. 1, (1834) ; Walker, List Hom. B. M. i, p. 118 (1850).

Dundubia saturata, Walker, List Hom. B. M. Suppt. p. 6 (1858).

Cosmopsaltria flavida, Stål, Berl. Ent. Zeitschr. x, p. 171 (1866).

Body long 45 : exp. teg. 140 millims. Reported from Java and Sikkim.

Genus Leptopsaltria, Stål.

Hem. Afric. iv, p. 5 (1866).

Allied to *Dundubia*, Am. et Serv. ; cheeks with a tubercle near the apex ; rostrum extending a little beyond the posterior coxæ ; opercula short : second and third segments of the abdomen in the ♂ with a lateral tubercle.

61. Leptopsaltria guttularis.

Cicada guttularis, Walker, List Hom. B. M. Suppt. p. 29 (1858), ♀.

Leptopsaltria guttularis, Stål, Hem. Ins. Philip. in Ofvers. Kong. Vet. Akak. Förh. p. 710 (1870), ♂.

Very like *L. tuberosa*, Sign., but differs in the opercula being more obtuse, apex much less obliquely truncated, exterior apical part more obtuse, less produced, ventral tubercles of the ♂ larger, black. Body long 13 : exp. teg. 46 millims.

Reported from Burma.

There are several unnamed species of this genus in the Indian Museum.

Genus Pomponia, Stål.

Hem. Afric. iv, p. 6 (1866).

Allied to *Cosmopsaltria:* opercula short, somewhat transverse: rostrum reaching at least to the base but most often to the apex of the posterior coxæ. Stål (Ofvers. K. V.-A. Förh. p. 710, 1870) separates the subgenera *Pomponia* and *Oncotympana.*

62. Pomponia urania.

Dundubia urania, Walker, List Hom. B. M. i, p. 64 (1850).
Pomponia urania, Stål, Berl. Ent. Zeitschr. x, p. 171 (1866).

Hind-scutcheon bright green; abdomen green. Body long 34: exp. teg. 83 millims.

Reported from Hindustan.

63. Pomponia bindusara.

Pomponia bindusara, Distant, Trans. Ent. Soc. p. 642 (1881).

This species, above, resembles *Dundubia vibrans,* Walker, and *Cosmopsaltria sita,* Distant. Many of these Indian species belonging to the genera *Dundubia, Cosmopsaltria,* and *Pomponia* have a common facies in colour and markings which Distant thinks is probably due to mimetic resemblance, and which, in practice, renders their identification exceedingly difficult. Body long, 30: exp. teg. 87 millims.

Reported from Tenasserim.

64. Pomponia linearis.

Dundubia linearis, Walker, List Hom. B. M. i, p. 48 (1850). Var., l. c. iv, p. 1120 (1852).
Dundubia ramifera, Walker, var., l. c. p. 53 (1850): J. L. S. Zool. x, p. 84 (1867).
Dundubia cinctimanus, Walker, List l. c., p. 49 and Suppt. p. 6 (1858): J. L. S. Zool. x, p. 84 (1867).
Pomponia linearis, Stål, Berl. Ent. Zeitschr. x, p. 171 (1866).

Body tawny. Body long 46: exp. teg. 118 millims.

Reported from Silhat.

The Indian Museum possesses a specimen from Assam.

65. Pomponia kama.

Pomponia kama, Distant, Trans. Ent. Soc. p. 643 (1881).

Allied to *P. transversa,* Walker, but much smaller, abdomen narrowed and more linear, head broader in comparison with pronotum and colour different. Body long 18: exp. teg. 66 millims.

Reported from N. India, Darjiling.

66. Pomponia madhava.

Pomponia madhava, Distant, Trans. Ent. Soc. p. 644 (1881).

Allied to *P. tigroides,* Walker, from which it differs by its being pale greenish and unicolorous, the tegmina broader, with the costal margin irregularly curved and not deflexed at the termination of the radial veins, and also in having both the second and third abdominal segments beneath rounded, produced and pointed anteriorly. Body long 22: exp. teg. 55 millims.

Reported from Assam.

67. Pomponia imperatoria.

Cicada imperatoria, Westwood, Arc. Ent. ii, p. 14, t. 51, (1843): Walker, List Hom. B. M. i, p. 47: J. L. S. Zool. i, p. 83 (1856): ibid. x, p. 84 (1867).

Pomponia imperatoria, Stål, Berl. Ent. Zeitschr. x, p. 171 (1866).

A very large species, yellow luteous, body long 88, exp. teg. 209 millims.

Reported from Nepál.

68. Pomponia tigroides.

Pomponia tigroides, Distant, J. A. S. B. xlviii (2), p. 38 (1879).

The Indian Museum possesses a specimen from Tenasserim.

Genus Emathia, Stål.

Hem. Afric. iv, p. 8 (1866).

Inner ulnar area of tegmina not widened towards the apex; apical cells one and two extending equally far forward; thorax widened at the base: tympana chiefly exposed; opercula short: anterior femora spinose.

69. Emathia ægrota.

Emathia œgrota, Stål, Berl. Ent. Zeitschr. x, p. 172 (1866).

Body long 20: exp. teg. 50 millims. Reported from Bombay.

Genus Cicada, Linn.

Linnaeus, Syst. Nat. i, p. 704 (1766): Stål, Rio. Jan. Hem. ii, p. 19 (1862) Ofvers K. V. A. Förh. p. 714 (1870).

70. Cicada subtincta.

Cicada subtincta, Walker, List B. M. i, p. 147 (1850).

Body long 32: exp. teg. 105 millims. Reported from Silhat.

71. Cicada anæa.

Cicada anœa, Walker, l. c., p. 207 (1850).

Body long 13: exp. teg. 40 millims. Reported from N. Bengal.

72. Cicada aurata.

Cicada aurata, Walker, l. c., p. 215 (1850).

Body long 17: exp. teg. 42 millims. Reported from Assam.

73. Cicada subvitta.

Cicada subvitta, Walker, l. c., p. 222 (1850).

Body long 16: exp. teg. 38 millims. Reported from N. India.

74. Cicada ferruginea.

Cicada ferruginea, Olivier, Enc. Méth. v, p. 750, t. 112, f. 1 (1790); Stoll, Cig. p. 65, t. 16, f. 86 (1788); Walker, List Hom. B. M. i, p. 117 (1850).

Reported from India.

75. Cicada xantes.

Cicada xantes, Walker, List Hom. B. M. i, p. 198 (1850).

Body, drums, and legs tawny: wings colourless, veins yellow. Body long 17: exp. teg. 48 millims.

Reported from N. India.

76. Cicada maculicollis.

Cicada maculicollis, Guérin, Voyage La Coquille, Zool., p. 183 (1830); Walker List Hom. B. M. Suppt., p. 28 (1858).

Body long 24: exp. teg. 65 millims. Reported from Bengal.

Genus Cryptotympana, Stål.

A. S. E. F. (4 Sér.), i, p. 613 (1862).—Hem. Afric. iv, p. 6 (1866).

77. Cryptotympana recta.

Fidicina recta, Walker, List Hom. B. M. i, p. 79 (1850) ♀.
Cryptotympana recta, Distant, J. A. S. B. xlviii (2), p. 40, t. ii, f. 4 (1879), ♂.

Body long 32: exp. teg. 95 millims. Reported from Silhat and Tenasserim.

The Indian Museum possesses a specimen from Tenasserim.

78. Cryptotympana vicina.

Cicada vicina, Signoret, Rev. Mag. Zool., p. 410, t. 10, f. 4 (1849).
Fidicina vicina, Walker, List Hom. B. M. i, p. 90 (1850).
Cryptotympana vicina, Stal, A. S. E. F. (4 Sér.) i. p. 613 (1862).

Reported from Silhat.

The Indian Museum possesses specimens from the Bhutan Duárs.

79. Cryptotympana immaculata.

Cicada immaculata, Olivier, Enc. Méth. v, p. 749, t. 112, f. 7 (1790) : Stoll, Cig. p. 40, t. viii, f. 39 (1788) : Signoret, Rev. Mag. Zool. p. 410 (1849).

Fidicina immaculata, Walker, List Hom. B. M. i, p. 90 (1850) ; iv, p. 1121 (1852).

Cryptotympana immaculata, Stål, A. S. E. F. 4 Sér. i. p. 613 (1862).

Reported from N. Bengal.

80. Cryptotympana intermedia.

Cicada intermedia, Signoret, Mag. Rev. Zool. p. 406, t. 10, f. 2 (1849).

Fidicina intermedia, Walker, List Hom. B. M. i, p. 90 (1850).

Cryptotympana intermedia, Stål, A. S. E. F. 4 Sér. i. p. 613 (1862).

Abdomen reddish yellow with a blackish band on each segment: allied to *C. atrata*, Fabr.

Reported from Tenasserim.

Genus Fidicina, Amyot & Serville.

Amyot et Serville, Hist. Nat. Ins. Hém. p. 472 (1843) : Stål, Rio. Jan. Hem. ii, p. 18 (1862) ; Ann. Soc. Ent. Fr. (4 sér) i, p. 614 (1861) ; Hem. Afric. iv, p. 7 (1866) ; Distant, Biol. Cen. Amer. p. 16 (1881).

81. Fidicina operculata.

Cicada operculata, Carreno.

Fidicina operculata, Walker, List Hom. B. M. i, p. 90 (1850).

Reported from N. India.

The Indian Museum possesses a specimen.

82. Fidicina corvus.

Fidicina corvus, Walker, List Hom. B. M. i, p. 86 (1850).

Reported from Silhat. Body long 29 : exp. teg. 113 millims.

The Indian Museum possesses a specimen of the ♀ from Silhat.

Genus Tibicen, Latreille.

Latreille, Fam. Nat. p. 426 (1825) : Stål, Hem. Afric. iv, p. 25 (1866).

83. Tibicen aurengzebe.

Tibicen aurengzebe, Distant, Trans. Ent. Soc., p. 646 (1881).

Body long 18: exp. teg. 48 millims. Reported from Bombay Presidency.

84. Tibicen apicalis.

Cicada apicalis, Germar in Thon's Archiv, ii, fasc. 2, p. 8 (1830) ; in Silbermann's Rev. Ent. ii, p. 63 (1834) ; Walker, List Hom. B. M. i, p. 161 (1850).

Tibicen apicalis, Stål, A. S. E. F. 4 Sér., i, p. 618 (1862).

Body long 18: exp. teg. 48 millims., ♀. Reported from N. India.

The Indian Museum possesses a specimen from Calcutta.

Genus Mogannia, Amyot & Serville.

Amyot et Serville, Hist. Nat. Ins. Hém, p. 467 (1843): Stål, Hem. Afric. iv. p. 5 (1866).

85. Mogannia illustrata.

Mogannia illustrata, Am. et Serv., Hist. Nat. Ins. Hém. p. 467, t. 9. f. 4 (1843); Walker, List Hom. B. M. i, p. 248 (1850).

Body uniform ferruginous brown: basal half of tegmina and a small semicircular patch on the tips, transparent yellow, a brown transverse band across the middle. Body long, 12 millims.

Reported from N. India.

86. Mogannia recta.

Mogannia recta, Walker, List Hom. B. M. Suppt. p. 39 (1858).

Abdomen with a red band on the posterior border of each segment. Body long, 12 millims.

Reported from Hindustan.

87. Mogannia obliqua.

Mogannia obliqua, Walker, List Hom. B. M. Suppt. p. 39 (1858).

♀. green mostly reddish beneath: abdomen reddish with a spot on each side near the base. Pronotum and mesonotum with some testaceous marks. Body long, 14: exp. teg. 41 millims.

Reported from Hindustan.

88. Mogannia venustissima.

Mogannia venustissima, Stål, Ofvers. Kong. Vet. Aka. Förh. p. 154 (1865).

Cærulean or metallic black. Tegmina with the veins at the base pale sanguineous, before the middle black, thence sordid straw-colour: wings with the veins at the base sanguineous and thence piceous. Body long, 16: exp. teg. 37—41 millims.

Reported from E. India.

89. Mogannia funebris.

Mogannia funebris, Stål, Ofvers. Kong, Vet. Aka. Förh. p. 155 (1865).

Aeneous black. Tegmina, before the middle, black with the basal areola and a band towards the apex of the black part sordid lutescent. ♀ Body long, 19: exp. teg. 46 millims.

Reported from Silhat.

90. Mogannia indicans.

Mogannia indicans, Walker, List Hom. B. M. i p. 249 (1850).

♂ bright or dark red, ♀ black. Tegmina with a broad basal brown band, veins yellow. Body long 12—16: exp. teg. 35—40 millims.

Reported from China.

The Indian Museum possesses specimens from Sikkim.

91. Mogannia locusta.

Cephaloxys locusta, Walker, List Hom. B. M. i, p. 236 (1850).

Body ferruginous beneath and abdomen pale tawny. Body long 50: exp. teg. 85 millims.

Reported from E. India.

92. Mogannia lacteipennis.

Cephaloxys lacteipennis, Walker, List Hom. B. M. i, p. 237 (1850).

Body luteous: abdomen black with the hind borders of the segments tawny: tegmina and flaps white, opaque, luteous at the base. Body long 36: exp. teg. 97 millims (?).

Reported from N. India.

93. Mogannia quadrimacula.

Cephaloxys quadrimacula, Walker, List Hom. B. M. p. 238 (1850).

Body bright tawny: hind margins of abdomen having the borders of the segments with slender interrupted reddish bands, a broad pale tawny band near the tip and beneath, piceous. Body long 30: exp. teg. 53 millims.

Reported from N. India.

94. M. terpsichore.

Cephaloxys terpsichore, Walker, List Hom. B. M. p. 239 (1850).

Body apple-green: abdomen with two last segments pitchy above: tegmina colourless, tinged with brown towards the tips, costa green. Body long 25: exp. teg. 74 millims.

Reported from E. India.

Correction and Addition.

Page 213, 4 lines from top of page, *for* "nicobarica," *read* "distincta," the former of these names being praeoccupied; and, between the 10th and 11th lines from bottom of page, *insert*

"5* Platypleura nicobarica.

Platypleura nicobarica, Butler, Ann. & Mag. Nat. Hist. April, 1877.

Reported from the Nicobars."

X.—*List of the Lepidopterous Insects collected in Cachar, by* Mr. J. Wood-Mason, Part I,—Heterocera.—*By* F. Moore, F. Z. S., A. L. S. *Communicated by the* Natural History Secretary.

[Received August 26th ;—Read December 3rd, 1884.]

Sphinges.

1. Macroglossa belis, Cram., Pap. Exot. i. pl. 94, fig. C.
2. Macroglossa luteata, Butler, P. Z. S. 1875, p. 241, pl. 37, fig. 5.
3. Macroglossa gilia, H. Schæff., Samml. Exot. Schmett. pl. 23, fig. 107.
4. Macroglossa gyrans, Walk., Catal. Lep. Het. Brit. Mus. viii, p. 91.
5. Lophura pusilla, Butler, P. Z. S. 1875, p. 244.
6. Hæmaris hylas, Linn. (Cram., Pap. Exot. pl. 148, fig. B.).
7. Calymnia panopus, Cram., Pap. Exot. pl. 224, fig. A, B.

Bombyces.

8. Melittia eurytion, Westw., Cab. Orient. Ent. pl. 30, fig. 5.
9. Eusemia communis, Butler, Ann & Mag. Nat. Hist. 1875, p. 140, pl. 13, fig. 1.
10. Eusemia bellatrix, Westw., Cab. Orient. Ent. pl. 33, fig. 2.
11. Nyctalemon zampa, Butler, Ent. Monthly Mag. v. p. 273.
12. Syntomis atkinsoni, Moore, P. Z. S. 1871, p. 245, pl. 18, fig. 2.
13. Euchromia polymena, Linn. (Cram., Pap. Exot. pl. 31, fig. D.
14. Milionia zonea, Moore, P. Z. S. 1872, p. 569.
15. Nyctemera lacticinia, Cram., Pap. Exot. pl. 128, fig. E.
16. Pitasila varians, Walker (Butler, Types Lep. Het. B. M. v. pl. 88, fig. 4).

*17. Tryphæromera plagifera, Walk. (Butler, l. c., pl. 88, fig. 3).

18. Euschema militaris, Linn. (Cram., Pap. Exot. pl. 29, fig. B).
19. Histia papilionaria, Guérin, Mag. de Zool. 1831, p. 12.
20. Cyclosia papilionaris, Drury, Exot. Ins. pl. 11, fig. 4.
21. Cyclosia panthona, Cram., Pap. Exot. pl. 322, fig. C.
22. Chalcosia argentata, Moore, Desc. Lep. Coll. Atkinson, p. 17.
23. Pidorus glaucopis, Drury, Exot. Ins. pl. 6, fig. 4.
24. Heterusia magnifica, Butler, Trans. Ent. Soc. 1879, p. 5.
25. Heterusia edocla, Dbleday, Zoologist, ii, p. 469.

26. Devanica bicolor, Moore, n. sp.

Female: forewing black, crossed by a yellow outwardly oblique medial band; veins indistinctly lined with blue: hindwing yellow, with a black marginal band, which is broad and truncated at the apical end and very narrow at anal end; base of wing also slightly black. Body, legs, and antennæ bluish-black. Expanse $1\frac{1}{2}$ inch.

This species is nearest allied to *D. risa* (*Eterusia risa*, Dbleday).

27. Pintia ferrea, Walk. (Butler, Types Lep. Het. B. M. pl. 83, fig. 7.

28. Trypanophora humeralis, Walk., Catal. Lep. Het. B. M. vii, p. 1593.

29. Hypsa alciphron, Cram., Pap. Exot. pl. 133, fig. E.

*30. Hypsa plaginota, Butler, Types Lep. Het. B. M. pl. 87, fig. 7.

31. Hypsa heliconia, Linn. (Walk., Catal. Lep. Het. B. M. ii, p. 452.

32. Hypsa clavata, Butler, Trans. Ent. Soc. 1875, p. 317.

33. Hypsa marmorea, Walk., Catal. Lep. Het. B. M. p. 1674.

34. Philona inops, Walk. (Butler, Types Lep. Het. B. M. pl. 87, fig. 6).

35. Bizone bianca, Walk., Catal. Lep. Het. B. M. vii, p. 1684.

36. Barsine gratiosa, Guerin, Delessert's Voy. pl. 26, fig. 1.

37. Barsine conjunctana, Walk. (*tessellata*, Butler, Types Lep. Het. B. M. pl. 86, f. 12).

38. Alope ocellifera, Walk., Catal. Lep. Het. B. M. iii, p. 620.

39. Aloa sanguinolenta, Fabr., Ent. Syst. iii, 1, p. 473.

40. Creatonotus diminuta, Walk. (Butler, Types Lep. Het. B. M. pl. 85, fig. 5).

41. Rhodogastria astrea, Drury, Ins. ii, pl. 28, fig. 4.

42. Orgyia albifascia, Walk., Catal. Lep. Het. B. M. Suppl. p. 325.

43. Artaxa subfasciata, Walk., l. c. Suppl. p. 332.

44. Redoa submarginata, Walk. (Butler, Types Lep. Het. B. M. pl. 89, fig. 3).

45. Perina basalis, Walk., Catal. Lep. Het. B. M. iv, p. 966.

46. Numenes insignis, Moore, Catal, Lep. E. I. C. ii, pl. 10, fig. 6.

47. Lymantria obsoleta, Walk., Catal. Lep. Het. B. M. iv, p. 880.

48. Trabala vishnu, Lefebvre, Zool. Journ. iii, p. 207.

49. Dreata testacea, Walk., Catal. Lep. Het. B. M. iv, p. 905.

50. Cricula trifenestrata, Helfer, Journ. As. Soc. Beng. 1873, p. 45.

51. Aphendala divaricata, Moore, n. sp.

Female. Upperside pale purplish brownish ochreous: forewing with a slender dark ochreous-brown band curving upward from posterior margin at one-third from the base to one-third before the apex, and from which a straight erect similar band extends from its costal end to the posterior angle. Body dark ochreous-brown. Expanse $1\frac{3}{8}$ inch. Taken at Silcuri.

52. Natada rugosa, Walk. Catal. Lep. Het. B. M. v. p. 1109.

[53. Zeuzera, sp. The larvæ, pupæ, and perfect insects observed by J. Wood-Mason. The 'borer' of tea-planters.].

Noctues.

54. Prodenia ciligera, Guén., Noct. i, p. 164.
55. Amyna selenampha, Guén., Noct. i, p. 406.
56. Alamis umbrina, Guén., Noct. iii, p. 4.
57. Xanthodes transversa, Guén., Noct. ii, p. 211.
58. Varnia ignita, Walk., Catal. Lep. Het. B. M. xxxiii, p. 825.
59. Anophia olivescens, Guén., Noct. iii, p. 48.
60. Athyrma, sp. ?
61. Calesia hæmorrhoda, Guén., Noct. iii, p. 258.
62. Remigia frugalis, Fabr. (Walker, Catal. Lep. Het. B. M. xiv, p. 1507).
63. Remigia archesia, Cram., Pap. Exot. pl. 273, fig. F. G.
64. Callyna jaguaria, Walk., Catal. Lep. Het. B. M. xiii, p. 1809.
65. Sericea substruens, Walk., l. c. xiv, p. 1276.
66. Lygniodes hypoleuca, Guén., Noct. iii, p. 125.
67. Argiva hieroglyphica, Drury, Exot. Ins. ii, pl. 2, fig. 1.
68. Nyctipao crepuscularis, Cram. (Walk., Catal. Lep. Het. B, M. xiv, p. 1304).
69. Nyctipao obliterans, Walk., l. c. xiv, p. 1307.
70. Hulodes caranea, Cram., Pap. Exot. pl. 269, fig. E. F.
71. Lagoptera honesta, Hubn. (Walk. Catal. Lep. Het. B. M. xiv, p. 1352).

*72. Ophideres salaminia, Cram., Pap. Exot. pl. 174, fig. A.

73. Ophideres fullonica,
74. Spirama cohærens, Walk., Catal. Lep. Het. B. M. xiv, p. 1321.

[75. Eumeta crameri. The larvæ observed by J. Wood-Mason. The 'leaf-insect' of planters.]

[76. Eumeta, sp. The larvæ observed by J. Wood-Mason. The 'stick-insect' of planters.]

Geometres.

77. Lagyra talaca, Walk., Catal. Lep. Het. B. M. xx, p. 59.
78. Urapteryx crocopterata, Kollar, Hügel's Kasch. ix, p. 483.

79. Buzura multipunctaria, Walk., Catal. Lep. Het. B. M. xxvi, p. 1531.

80. Elphos scolopaica, Drury, Exot. Ins. ii, pl. 22, fig. 1.

81. Macaria nora, Walk., Catal. Lep. Het. B. M. xxiii, p. 934.

82. Naxa textilis, Walk., l. c. vii, p. 1743.

83. Micronia caseata, Guén., Phal. ii, p. 27.

84. Micronia aculeata, Guén., l. c. ii, pl. 13, fig. 8.

85. Argyris ocellata, H. Sch. (Walk., Catal. Lep. Het. B. M. xxii, p. 807.

86. Acidalia, sp. ?

87. Abraxas martaria, Guén, Phal. ii, p. 205.

Pyrales.

88. Astura punctiferalis, Guen., Delt. et Pyral. p. 320.

89. Euglyphis procopialis, Cram., Pap. Exot. pl. 368, fig. E.

Crambices.

90. Apurima xanthogastrella, Walk., Catal. Lep. Het. B. M. xxvii, p. 194.

Tineines.

*91. Nosymna repletella, Walk., Catal. Lep. Het. B. M. xxix, p. 831.

92. Sagora rutilella, Walk., Characters of Und. Lep. Het. p. 101 (1869).

[The insects before whose names an asterisk (*) is prefixed were captured on Nemotha, a peak of the North Cachar Hills about 3300 feet high. All the rest were taken at Silcuri, Borakhai, Silduby, Dharmkhal, Durgakuna, Doarbun, Irangmara, Doloo, Subong, and other tea-gardens in the plains. The only species of any interest to tea-planters are the *Zeuzera* and the two case-bearers belonging to the genus *Eumeta*, descriptions of which will be published hereafter elsewhere. J. W-M.]

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

(With 15 Woodcuts.)

Since the former version of this Synopsis was published, some additional material has fallen into my hands, by the aid of which I have been enabled to establish the existence of two distinct Indian species, and to identify with certainty a larva which I had previously assigned with hesitation to *Ch. rhombicollis.*

Two Indian species have been described, one by Fabricius under the name of *Mantis cancellata*, and the other by De Saussure as *Ch. squilla* from a perfect male insect and a larva. The recent discovery of the true female of the latter proves that the insects I had previously considered to be females and abnormal males of it represent a different species, to which I have the less hesitation in applying the Fabrician name that Prof. Westwood has named a female from Saugor in the Oxford Museum *Ch. cancellata.*

De Saussure has described and figured one of the remarkable larvæ of the genus—that of his *Ch. squilla*—, and pointed out the close resemblance it bears to that of an American species; De Borre has recently figured a larva of *Ch. rhombicollis* which is nearly intermediate in age between my figures 3 and 4; a larva of *Ch. rhomboidea* is preserved in the British Museum; and I give figures of the larvæ of three additional species and also of an earlier stage of *Ch. squilla;* so that, counting the larva of *Ch. strumaria* figured by Mérian, larvæ of no less than 7 out of the 9 species recognized by me are now known.

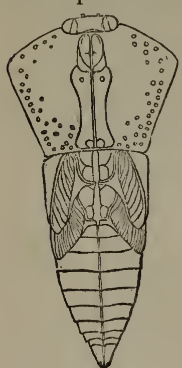


Fig. 1.
Chœradodis cancellata.
♀ nymph.

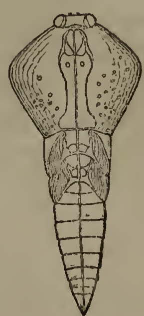


Fig. 2.
Ch. brunneri.
♂ nymph.

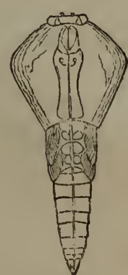


Fig. 3.
Ch. servillei.
♂ nymph.

Fig. 4.
Ch. squilla.
♀ nymph.

The close similarity of these larvæ to one another furnishes a remarkable confirmation of the view that the adults are congeneric.

Genus Chœradodis, Serville.

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

1. Chœradodis strumaria.

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

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

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

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

——— *cancellata*, Stoll, Spectres et Mantes, pl. xi, fig. 42, ♀ (*non* Fabr.).

Chœradodis cancellata, Serville, Hist. nat. des Orthopt. 1839, p. 206, ♀ (*non* Fabr.).

——— *cancellata*, Saussure, Mant. Americ. p. 19, ♂, ♀.

——— *strumaria*, Wood-Mason, J. A. S. B. xlix, pt. ii, p. 82, 1880, ♀.

Madame Mérian was the first to figure a species of this genus. Her figures were named and described by Linnæus, whose description applies to the perfect female insect, his name having obviously been suggested by a fanciful resemblance of the swellings on the sides of the pronotum in the supposed nymph to series of scrofulous tumours (*strumæ*).

Fig. 5, ♀.

The accompanying outline drawing of the pronotum of a specimen when superposed upon the same part of Mérian's figure, accurately coincides therewith.

Stoll's figure 42 without doubt represents a specimen of the same species.

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

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

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

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

2. Chœradodis rhombicollis.

Mantis rhombicollis, Latr. in Voy. de Humb., Zool., Ins. p. 103, pl. 39, figs. 2, 3, ♂.
Chœradodis peruviana, Serville, Hist. nat. des Orthopt. 1839, p. 207, ♂.
——— *strumaria*, Stål, Syst. Mant., 1877, p. 15, ♂ ♀.
——— *rhombicollis*, Wood-Mason, l. c. p. 82 ♂ ♀.—De Borre, Liste des Mant. Mus. Roy. de Belg. 1883, p. 5; et Comptes-rendus Soc. Ent. Belg. Nov. 1883, ♀ et nymph fig.

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

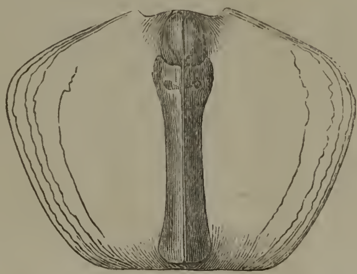


Fig. 7, ♀.

Fig. 6, ♂.

Hab. ♂ ♀, Guayaquil, in the collection of the British Museum; New Granada (♂ ♀, Stål); ♀ et nymph, Ecuador, in Mus. Roy. Belg.

3. Chœradodis servillei.

Wood-Mason, l. c. p. 83, ♀ et nymph.

♀. Closely allied to the preceding, from which it differs in having the marginal field of the tegmina proportionately narrower, and in the smaller size, as well as in the different shape, of the femoral blotch, which

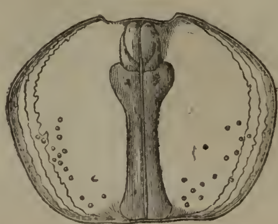


Fig. 8, ♀.

is small and oval, commences just beyond the ungual groove, and is followed by a marginal row of small black points.

Hab. 2 ♀, Cache, Costa Rica, in the collection of Messrs. Godman and Salvin and of the Indian Museum; nymph (Fig. 3), Chiriqui, in the collection of the Indian Museum, Calcutta.

4. Chœradodis brunneri.

Wood-Mason, J. A. S. B., 1882, xli, p. 21, ♀ et nymph.

♀. Closely allied to *Ch. rhombicollis*, Latr., and *Ch. Servillei*, W.-M., differing from both in the size, shape, and position of the femoral blotch, which is nearly thrice as long as broad, extends rather further in front of the ungual groove than it does behind it, and is followed by four black puncta arranged along the lower margin of the joint at the bases of alternate spines), and in having the posterior margin of the pronotum slight-

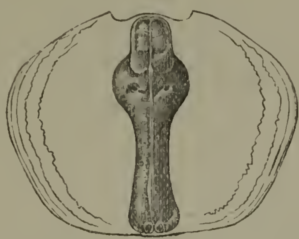


Fig. 9, ♀.

ly convex instead of concave ; from the former in its much narrower and from the latter in its rather broader tegmina ; and from the latter in the upper margin of its fore femora being coarsely granulated, and sinuous instead of straight, in which latter respect it approaches the former.

Hab. ♀ and nymph (Fig. 2), Santa Fé de Bogotá, New Granada, in coll. Ind. Mus. Calcutta.

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

5. Chœradodis laticollis.

Chœradodis laticollis, Serville, Revue, p. 24 ; Hist. nat. des Orthopt. 1839, p. 208, pl. iv, fig. 2, ♀.
—— —— Saussure, Mantes Americ. p. 20, ♀.
—— *strumaria*, Id , ibid. p. 18, ♂.
—— *laticollis*, Stal, Syst. Mant. 1877, 17, ♀.
—— —— Wood-Mason, J. A. S. B. 1880, vol. xlix, pt. ii, p. 83. ♂ ♀.

The blotch is situated, in both sexes, just beyond the ungual groove, is oblong-rhomboidal in shape, and is followed by two black points on the bases of alternate spines ; there is a fuscous speck at the end of the stig-

Fig. 11, ♀.

Fig. 10, ♂.

matal spot of the tegmina; and the antero-lateral margins of the pronotal lamellæ are arcuate or convex, especially in the female.

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

6. Chœradodis stalii.

Wood-Mason, l. c. p. 83, ♂ ♀.

Differs from the preceding in the shape of the blotch (which is pointed at both ends and commences in the ungual groove, and on either side of which the femur is pale luteous-yellow instead of being clouded with fuscous); in being without a fuscous speck at the distal end of the

Fig. 13, ♂.

Fig. 12, ♀.

stigma; in its shorter and differently shaped facial shield; and in having the antero-lateral margins sinuous-concave and the lateral angles of the pronotal expansions more broadly rounded off.

Hab. 1 ♂, 4 ♀, Ecuador, in the Museums of Calcutta and Oxford.

7. Chœradodis rhomboidea.

Mantis rhomboidea, Stoll, Spectres et Mantes, pl. xi, fig. 45, ♂.
Chœradodis rhomboidea, Wood-Mason, l. c. p. 84, ♂.

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

The blotch commences in the ungual groove, thence extending as far along the femur as in the preceding four species, but it is not followed by a marginal row of black points. The pronotal lamellæ have no posterior angles, their postero-lateral margins dwindling away to nothing posteriorly.

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

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

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

8. CHŒRADODIS CANCELLATA.

Mantis cancellata, Fabr., Ent. Syst. ii, 1793, p. 18.
Chœradodis squilla, Lucas, Ann. Ent. Soc. Fr. 5 sér. ii, 1872, p. 32, ♀.
——— ——— Wood-Mason, l. c. p. 48 *(ex parte)*.

Pronotum dissimilar in the sexes, being much less dilated in the male than in the female; its antero-lateral and postero-lateral margins not forming an angle at their junction in the female.

Femoral blotch narrower, confined to the foliaceous crest of the joint, and bordered below by a band of enamel-like bright emerald-green.

In the shape and extent of the pronotal expansions, the male of this species much resembles the same sex of *Chœradodis rhomboidea*, differing, however, strikingly therefrom in its much shorter pronotum. The female approaches and differs from those of *Chœradodis rhombicollis* and its allies in the same respects.

HAB. India *(Fabricius)* generally, from Ceylon, through Madras and Central India (♀ in coll. Hop. Oxon.), to the banks of the Killing River on the N. E. Frontier (nymph [Fig. 1] in coll. Ind. Mus. Calc.)

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

9. CHŒRADODIS SQUILLA.

Chœradodis squilla, Saussure, Mél. Orthopt. t. i, 3me fasc. p. 161, pl. iv, fig. 3, 3a, ♂ et nymph.
? —— —— Lucas, Ann. Entom. Soc. Fr. 5 sér. t. ii, 1872, p. 32, ♀.
—— —— Wood-Mason, l. c. p. 84 *(ex parte)*.

Pronotum similar in the sexes, its postero-lateral forming with its antero-lateral margin a distinct angle in both; that of the male differing from that of the female only in being rather less expanded, and consequently less convex, postero-laterally.

Femoral blotch broader, extending on to the primitive femur up to the inner end of the unequal groove and not bordered with green.

Fig. 14, ♂.

Fig. 15 ♀.

It is much more probable that the insect obtained by M. Jansen in the neighbourhood of Madras and described by Lucas as the opposite sex of De Saussure's species is a female of the preceding than of this species.

Hab. Ceylon, ♂ et nymph in Geneva Museum, ♂ ♀ and larvæ in Museums of Calcutta and Colombo.

I am indebted to the courtesy and liberality of the Trustees of the Colombo Museum for perfect insects and nymphs, and to Mr. F. M. Mackwood for a nymph of this species.

In Fig. 14, the left lateral angle has been much too rounded off by the engraver; it should be like the right.

INDEX.

☞ Names of New Genera and Species have an asterisk (*) prefixed.

ERRATA.

Page 17, sixth line from top, for "*rura*" read "*rara*."
" " sixth line from bottom, for "tripupilled" read "bipupilled."
" 19, ten lines from bottom, omit the word "and" after "conspicuous."
" 23, thirteen lines from top, for "subbasal" read "subanal."
" " five lines from bottom, for "*lycœna*" read "*lycœnina*."
" 24, fourteen lines from top, for "*bracteala*" read "*bracteata*."
" 25, fourteen lines from bottom, for "near" read "nearer."
" 27, eleven lines from top, for "black" read "band."
" 28, eleven lines from top, for "*lunulifer*" read *lunulifera*."
" 38, ten lines from top, for "Catal. Lyc, Brit. Mus. p. 3. pl. 8, fig. 92, 93 (1862)," read "Illus. Diurn. Lep., *Lycœnidœ*, p. 14*g*, pl. 3*b*, figs. 48, 49 (1869)."
" 40, twelve lines from bottom, substitute a hyphen for the comma between the words "cell" and "streak."
" 41, fifteen and fourteen lines from bottom, for "ABSENS" and "*absens*" read "ABSEUS" and "*abseus*."
" 48, twelve lines from top, for "564" read "594."
" 52, two lines from top, for "xxii" read "xii."

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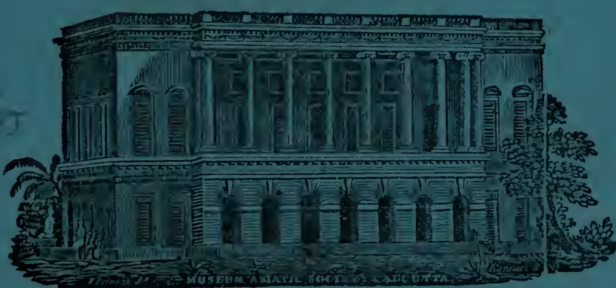

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Plate I, illustrative of Mr. H. F. Blanford's article on '*The Theory of the Winter Rains of Northern India*,' is issued herewith.

The Title-page, Index, &c. and the Plates wanting to complete Vol. LII, Pt. II for 1883, will be issued in a separate wrapper as soon as they are ready.

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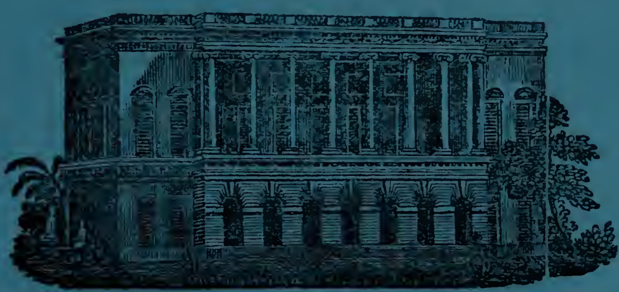

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