MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXXI.	*March* 10, 1871.	No. 5.

William Lassell, Esq., President, in the Chair.

F. W. Levander, Esq., University College, London;
Wm. Mann, Esq., Royal Observatory, Cape of Good Hope; and
E. W. Snell, Esq., Kidbrook House Academy, Blackheath;

were balloted for and duly elected Fellows of the Society.

On the Total Eclipse of the Sun, on December the 11*th*, 1871, *as visible in the Madras Presidency.* By C. Ragoonathachary, First Assistant, Madras Observatory.

(*Communicated by N. R. Pogson, Esq., Government Astronomer.*)

Herewith I have the honour to submit to the Royal Astronomical Society the results of my calculations with reference to the Total Eclipse of the Sun, which will take place on the 11th December, 1871. Though the duration of this eclipse will be considerably shorter than that of 1868, yet I presume that so favourable an opportunity will not be suffered to pass away without adequate preparation for due record of all the important and interesting phenomena which present themselves for investigation on such occasions.

The central line of the eclipse will first meet the Earth's surface in the Arabian Sea, and entering on the western coast of India, will pass right across one of the most important parts of

Hindustan, in a S.E. by E. direction. In this part of the Peninsula the Sun will be about 20° above the horizon when totally obscured. The duration of totality will be two minutes and a quarter, and the breadth of the shadow about seventy miles. On leaving the eastern coast of the Madras Presidency, the central line will cross Palk's Straits, passing about ten miles S.W. of the island Jaffnapatam, and over the northern part of Ceylon, where the small towns of Moeletivoe and Kokelay will lie near the central line; and also the well-known naval station of Trincomalee, which will be about fifteen miles S.W. of the line. Continuing its course over the Bay of Bengal, the shadow will cross the S.E. point of Sumatra, and will touch the south-western coast of Java, where Batavia, the capital, will lie nearly sixty miles N.E. of the central line; and two other smaller towns, Chidamar and Nagara, will also be very near the middle of the shadow path. In the Admiralty Gulf, on the N.W. coast of Australia, the eclipsed Sun will be only ten degrees past the meridian, and not far from the zenith; in consequence of which the totality will last $4^{m}\ 18^{s}$, or only four seconds less than the time of greatest duration. Lastly, passing through the most barren and uninhabited portion of Australia, crossing the Gulf of Carpentaria and the York Peninsula, the shadow will ultimately leave the Earth's surface in the Pacific Ocean.

The following are the geographical positions of the central and limiting lines of the shadow, together with other details of calculation, applicable to Southern India, for intervals of fifteen seconds of Greenwich mean time. They are almost identical with the values obtained by interpolation, from the similar table furnished on page 441 of the *Nautical Almanac* for the year 1871.

	Northern Limit.		Central Line.		Southern Limit.	
Greenwich M.T.	North Latitude.	East Longitude.	North Latitude.	East Longitude.	North Latitude.	East Longitude.
h m s	° ′	° ′	° ′	° ′	° ′	° ′
14 25 45	13 1	74 58	12 36	74 42	12 12	74 24
14 26 0	12 48	75 22	12 23	75 6	11 59	74 48
14 26 15	12 35	75 46	12 10	75 30	11 46	75 12
14 26 30	12 23	76 9	11 58	75 53	11 33	75 35
14 26 45	12 11	76 31	11 46	76 15	11 21	75 57
14 27 0	11 59	76 53	11 34	76 37	11 9	76 19
14 27 15	11 47	77 14	11 22	76 58	10 58	76 40
14 27 30	11 36	77 35	11 11	77 18	10 46	77 0
14 27 45	11 25	77 55	11 0	77 38	10 35	77 20
14 28 0	11 14	78 14	10 49	77 57	10 24	77 39
14 28 15	11 4	78 33	10 38	78 16	10 13	77 58
14 28 30	10 53	78 51	10 28	78 34	10 3	78 16
14 28 45	10 43	79 9	10 18	78 52	9 52	78 34
14 29 0	10 33	79 27	10 8	79 10	9 42	78 51
14 29 15	10 23	79 44	9 58	79 27	9 32	79 8

On the Central Line.

Greenwich M.T.	Sun's Altitude above the Horizon.	Excess of the Sun's App. Diameter above that of the Earth.	Relative Motion of Sun in one minute of Time.	Duration of Totality.
h m s	°	″	′	m s
14 25 45	17	65·6	31·0	2 7
14 26 0	17	65·9	30 9	2 8
14 26 15	17	66·2	30·8	2 9
14 26 30	18	66·5	30·7	2 10
14 26 45	18	66·7	30·7	2 11
14 27 0	19	66·9	30·6	2 11
14 27 15	19	67·1	30·5	2 12
14 27 30	19	67·3	30·4	2 13
14 27 45	20	67·5	30·3	2 14
14 28 0	20	67·7	30·2	2 14
14 28 15	20	67·9	30·1	2 15
14 28 30	21	68·1	30·1	2 16
14 28 45	21	68·3	30·0	2 17
14 29 0	21	68·5	29·9	2 17
14 29 15	22	68·7	29·8	2 18

The principal places in the Madras Presidency, situated near the northern limit of the shadow, and their direct distances therefrom in miles, will be as follows:—

Districts.	Places.	Miles.
South Canara	Mangalore	11 within
,,	Oopin Ungadi	upon
Coorg	Mercara	9 within
Mysore	Honsoor	upon
Astragam Division	Mysore	13 beyond
Coimbatore	Sattimangulum	14 within
,,	Bowani	4 within
,,	Yirodu	8 within
Salem	Trichungode	upon
,,	Salem	24 beyond
,,	Namcul	upon
Trichinopoly	Moosery	7 within
,,	Trichinopoly	8 within
Tanjore	Tanjore	5 beyond
,,	Puttoocattay	10 within
,,	Point Calmere	upon

Places most favourably situated on or near the central line, with their geographical positions and direct distances therefrom:—

Districts.	Places.	North Latitude. ° ′	East Longitude. ° ′	Miles.
South Canara	Kassergode	12 30	75 1	5 N
,,	Baicull	12 24	75 4	upon
Coorg	Veerajunderpetta	12 13	75 52	16 N
Malabar	Gunote	12 0	75 45	2 S
,,	Manuntoddy	11 48	76 5	1 S
,,	Goodaloor	11 30	76 32	5 S
On the Neelgherries	Ootacamund	11 25	76 43	6 S
On the Neelgherries	Dodabetta	11 23	76 47	5 S
On the Neelgherries	Wellington	11 23	76 46	6 S
On the Neelgherries	Coonoor	11 21	76 52	5 S
On the Neelgherries	Kotagherry	11 24	76 56	2 N
Coimbatore	Sivamogay	11 20	77 5	2 N
,,	Avenasi	11 12	77 19	2 N
,,	Tirrupur	11 5	77 24	2 S
,,	Kangyam	11 1	77 37	upon
,,	Darapoorum	10 44	77 35	18 S
,,	Vellacoil	10 57	77 46	2 S
,,	Chinna Darapoorum	10 51	77 55	1 N
,,	Caroor	10 57	78 8	14 N
Madura	Veerallimalli	10 34	78 37	10 N
,,	Iluppur	10 31	78 41	5 N
,,	Poodoocottah	10 23	78 53	5 N
Tanjore	Ardangi	10 11	79 3	1 S
,,	Manamalgudi	10 3	79 16	2 S

And, lastly, for places near the southern limit of the shadow we shall have,—

Districts.	Places.	Miles.
Malabar	Cannanore	14 within
,,	Tellicherry	10 within
,,	Mahe	9 within
,,	Calicut	10 beyond
,,	Beyapur	15 beyond
,,	Palghaut	10 beyond
Coimbatore	Coimbatore	14 within
,,	Polachy	4 beyond
,,	Chuckragherry	8 beyond
Madura	Pulney	upon
,,	Dindigul	11 within
,,	Madura	9 beyond

Districts.	Places.	Miles.
Madura	Shevagunga	1 beyond
,,	Ramnaud	20 beyond
,,	Autencurray	16 beyond
,,	Ramaswarum	8 beyond

The calculation of the different phenomena of the eclipse was made accurately for Avenasi, a railway station situated midway between the two coasts, on the central line; and for the Madras and Trevandrum Observatories, which lie respectively at some distance north and south of the shadow. The usual equations of reduction applicable to places near the above three points are also given; in which l denotes geocentric north latitude, λ_Δ east longitude for Madras, and t the Madras mean time of each phenomenon. The results of the calculations are:—

For Madras.

Lat. $13^\circ\ 4'.1$ N.; Long. $80^\circ\ 14'.3$ E. of Greenwich.

		Madras Mean Time.
		d h m s
Time of first contact ..	.. ..	Dec. 11 18 47 37
Time of greatest obscuration	.. ..	. 19 49 32
Time of last contact ..	.. ..	20 59 59
Duration of the eclipse ..	.. ..	2 12 22
		° ′
Angle from north point, of	First contact	73 33 West.
	Last contact	119 9 East.
Angle from the Sun's vertex, of	First contact	1 19 Right.
	Last contact	173 33 Left.
Magnitude of the eclipse (Sun's diameter = 1)		0.9165
Limb of the Sun eclipsed	.. ..	South.

Formulæ for Reduction to different places near Madras.

First Contact.

$$\text{Cos } w = -0.2214 - [0.20128] \sin l - [9.98190] \cos l \cos (\lambda_\Delta - 121^\circ\ 15'.5)$$

$$t = 21^h\ 35^m\ 36^s - [3.55274] \sin w - [3.35619] \sin l - [3.79315] \cos l \cos (\lambda_\Delta + 6^\circ\ 24'.3)$$

Greatest Phase.

$$\text{Cos } w = -0.0382 - [0.19815] \sin l - [9.99342] \cos l \cos (\lambda_\Delta - 107^\circ\ 48'.3)$$

$$t = 21^h\ 45^m\ 3^s - [3.42904] \sin l - [3.84182] \cos l \cos (\lambda_\Delta + 20^\circ\ 47'.6)$$

Magnitude of the eclipse = $1.0175 - (1.0175 \cos w)$

Last Contact.

$$\text{Cos } w = 0.2244 - [0.19578] \sin l - [0.00173] \cos l \cos (\lambda_\Delta - 92^\circ\ 3'.4)$$

$$t = 21^h\ 38^m\ 9^s + [3.65898] \sin w - [3.49952] \sin l - [3.89599] \cos l \cos (\lambda_\Delta + 37^\circ\ 3'.3)$$

For Avenasi.

Lat. $11^\circ\ 12'$ N.; Long. $\begin{cases} 77^\circ\ 19'{\cdot}0 \text{ E. of Greenwich.} \\ \ \ 2\ \ 55{\cdot}3 \text{ W. of Madras.} \end{cases}$

	Madras Mean Time. d h m s		Local Mean Time. h m s
Time of first contact	Dec. 11 18 47 33	=	18 35 52
Beginning of the total phase ..	19 47 19	=	19 35 38
Middle of totality	19 48 26	=	19 36 44
Ending of the total phase ..	19 49 32	=	19 37 51
Time of last contact	20 57 31	=	20 45 50
Duration of the Eclipse	h m s 2 9 58		
Duration of totality	0 2 13		
Angle from north point, of First contact	$68^\circ\ 8'$ West.		
Last contact	113 26 East.		
Angle from the Sun's vertex, First contact	7 3 Left.		
Last contact	171 44 Left.		

Formulæ for Reduction to different places near Avenasi.

First Contact.

$$\text{Cos } w = -0{\cdot}2075 - [0{\cdot}20204] \sin l - [9{\cdot}97944] \cos l \cos (\lambda_\Delta - 120^\circ\ 51'{\cdot}1)$$

$$t = 21^h\ 32^m\ 10^s - [3{\cdot}54328] \sin w - [3{\cdot}34120] \sin l - [3{\cdot}78431] \cos l \cos (\lambda_\Delta + 6^\circ\ 32'{\cdot}3)$$

Middle of Totality.

$$\text{Cos } w = -1{\cdot}9887 - [1{\cdot}96825] \sin l - [1{\cdot}76185] \cos l \cos (\lambda_\Delta - 107^\circ\ 36'{\cdot}0)$$

$$t = 21^h\ 42^m\ 37^s - [3{\cdot}41653] \sin l - [3{\cdot}83247] \cos l \cos (\lambda_\Delta + 20^\circ\ 51'{\cdot}7)$$

Semi-duration of totality $= [1{\cdot}82258] \sin w$.

Last Contact.

$$\text{Cos } w = 0{\cdot}2277 - [0{\cdot}19709] \sin l - [9{\cdot}99844] \cos l \cos (\lambda_\Delta - 91^\circ\ 31'{\cdot}4)$$

$$t = 21^h\ 37^m\ 24^s + [3{\cdot}65178] \sin w - [3{\cdot}48527] \sin l - [3{\cdot}88985] \cos l \cos (\lambda_\Delta + 37^\circ\ 14'{\cdot}3)$$

For Trevandrum.

Lat. $8^\circ\ 30'{\cdot}5$ N.; Long. $\begin{cases} 76^\circ\ 59'{\cdot}8 \text{ E. of Greenwich.} \\ \ \ 3\ \ 14{\cdot}5 \text{ W. of Madras.} \end{cases}$

	Madras Mean Time. d h m s		Local Mean Time. h m s
Time of first contact ..	Dec. 11 18 48 37	=	18 35 39
Time of greatest obscuration ..	19 49 30	=	19 36 32
Time of last contact ..	20 58 21	=	20 45 23
Duration of the eclipse	h m s 2 9 44		

Angle from north point, of	First contact	63° 29′ West.
	Last contact	108 56 East.
Angle from the Sun's vertex, of	First contact	14 15 Left.
	Last contact	170 4 Left.
Magnitude of the eclipse (Sun's diameter = 1)		0·9371
Limb of the Sun eclipsed		North.

Formulæ for Reduction to different places near Trevandrum.

First Contact.

$$\text{Cos } w = -0{\cdot}2099 - [0{\cdot}20201] \sin l - [9{\cdot}97990] \cos l \cos (\lambda_\Delta - 120^\circ\ 55'{\cdot}0)$$

$$t = 21^h\ 31^m\ 48^s - [3{\cdot}54223] \sin w - [3{\cdot}34107] \sin l - [3{\cdot}78326] \cos l \cos (\lambda_\Delta + 6^\circ\ 31'{\cdot}2)$$

Greatest Phase.

$$\text{Cos } w = -0{\cdot}0358 - [0{\cdot}19843] \sin l - [9{\cdot}99265] \cos l \cos (\lambda_\Delta - 107^\circ\ 40'{\cdot}8)$$

$$t = 21^h\ 42^m\ 22^s - [3{\cdot}41661] \sin l - [3{\cdot}83136] \cos l \cos (\lambda_\Delta + 20^\circ\ 50'{\cdot}1)$$

$$\text{Magnitude of the eclipse} = 1{\cdot}0173 - (1{\cdot}0173 \cos w)$$

Last Contact.

$$\text{Cos } w = 0{\cdot}2263 - [0{\cdot}19676] \sin l - [9{\cdot}99962] \cos l \cos (\lambda_\Delta - 91^\circ\ 42'{\cdot}0)$$

$$t = 21^h\ 37^m\ 26^s + [3{\cdot}65169] \sin w - [3{\cdot}48752] \sin l - [3{\cdot}88948] \cos l \cos (\lambda_\Delta + 37^\circ\ 10'{\cdot}8)$$

The approximate details of the eclipse for Baicull on the western coast, Ardangi near the east coast, and Trincomalee in Ceylon, all of which will be near the central line, will be as follows:—

For Baicull.

Lat. 12° 24′ N.; Long. { 75° 4′·0 E. of Greenwich. / 5 10·3 W. of Madras.

		Madras Mean Time. d h m s		Local Mean Time. h m s
Time of first contact	..	Dec. 11 18 47 5	=	18 26 23
Beginning of the total phase	..	19 45 51	=	19 25 9
Middle of totality ..	..	19 46 55	=	19 26 13
Ending of the total phase	..	19 47 59	=	19 27 17
Time of last contact	..	20 54 13	=	20 33 31
Duration of the Eclipse	..	h m s 2 7 8		
Duration of totality	..	0 2 8		

Angle from north point, of	First contact	69° West.
	Last contact	113 East.
Angle from the Sun's vertex, of	First contact	6 Left.
	Last contact	171 Left.

For Ardangi.

Lat. 10° 11′ N.; Long. {79° 3′·0 E. of Greenwich. / 1 11·3 W. of Madras.}

		Madras Mean time. d h m s		Local Mean Time. h m s
Time of first contact	..	Dec. 11 18 48 7	=	18 43 22
Beginning of the total phase	..	19 48 49	=	19 44 4
Middle of totality	..	19 49 57	=	19 45 12
Ending of the total phase	..	19 51 5	=	19 46 20
Time of last contact	..	21 0 15	=	20 55 30
Duration of the eclipse	..	h m s 2 12 8		
Duration of totality	..	0 2 16		
Angle from north point, of	First contact	68° West.		
	Last contact	114 East.		
Angle from the Sun's vertex, of	First contact	8 Left.		
	Last contact	171 Left.		

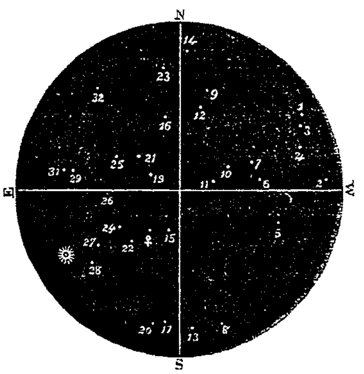
For Trincomalee.

Lat. 8° 33′ N.; Long. {81° 24′·0 E. of Greenwich. / 1 9·7 E. of Madras.}

		Madras Mean Time. d h m s		Local Mean Time. h m s
Time of first contact	..	Dec. 11 18 49 9	=	18 53 48
Beginning of the total phase	..	19 51 19	=	19 55 58
Middle of Totality	..	19 52 16	=	19 56 55
Ending of the total phase	..	19 53 13	=	19 57 52
Time of last contact	..	21 4 23	=	21 9 2
Duration of the eclipse	..	h m s 2 15 14		
Duration of totality	..	0 1 54		
Angle from north point, of,	First contact	67° West.		
	Last contact	114 East.		
Angle from the Sun's vertex, of	First contact	9 Left.		
	Last contact	170 Left.		

I have adhered throughout to the method of Mr. Woolhouse, adopting the positions of the Sun and Moon as given in the *Nautical Almanac*. Subjoined are the approximate positions of bright stars and planets most conspicuous to the naked eye during the time of totality, referred to the zenith of Avenasi.

		Zenith Distance.	Azimuth			Zenith Distance.	Azimuth
		°	°			°	°
1	Castor	78	N 59 W	17	β Centauri	72	S 8 E
2	Procyon	80	N 86 W	♀	Venus	28	S 39 E
3	Pollux	76	N 63 W	19	Arcturus	20	N 60 E
4	Jupiter	71	N 71 W	20	α^2 Centauri	74	S 12 E
5	α Hydræ	58	S 72 W	21	ϵ Bootis	29	N 52 E
6	Regulus	44	N 84 W	22	α Libræ	38	S 45 E
7	γ^1 Leonis	41	N 71 W	23	β Urs. Min.	66	N 8 E
8	η Argus	76	S 18 W	24	β Libræ	39	S 59 E
9	α Urs. Maj.	56	N 16 W	25	α Cor. Bor.	38	N 62 E
10	δ Leonis	29	N 66 W	26	α Serpentis	40	S 87 E
11	β Leonis	19	N 76 W	27	β Scorpii	54	S 56 E
12	γ Urs. Maj.	45	N 14 W	28	Antares	62	S 52 E
13	α^1 Crucis	74	S 5 W	29	α Herculis	61	N 81 E
14	Polaris	80	0	⊙	Sun	71	S 61 E
15	Spica	23	S 13 E	31	α Ophiuchi	66	N 80 E
16	η Urs. Maj.	40	N 11 E	32	γ Draconis	71	N 39 E



To facilitate the independent determination of the longitude of any place of observation, I have calculated such occultations of stars by the Moon as will occur about a week before or after the day of the eclipse. It unfortunately happens, however, that during this time only one bright star lies within the limits of the Moon's path, and so I have been obliged to rest contented with much smaller stars than are usually selected for such a purpose. The computations have been made for Madras and Avenasi, by an approximate method, which usually gives the times within a minute, and the angular points of contact within a degree, of those found by a more refined process. The times at Avenasi will differ but slightly from those for any other spot along the shadow line, in its course across India.

Occultations as seen at Madras.

Date.	Stars.		Mag.	Disappearance. Madras Mean T.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Madras Mean T.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.
				h m	°	°	h m	°	°
Dec. 3	η Leonis		$3\frac{1}{2}$	14 35	128 E	143 Right	16 8	84 W	9 Right
6	XII. 394 Weisse		9	14 13	147 E	136 Right	15 9	92 W	15 Right
14	20114	Oeltezon Argelander's zone.	9	6 41	16 E	50 Right	7 5	44 W	115 Right
14	20133		9	7 1	53 E	16 Right	7 43	80 W	154 Right
14	20138		$8\frac{1}{2}$	7 7	109 E	39 Left	7 45	136 W	150 Left
15	21093		8	8 22	83 E	11 Left	9 16	128 W	156 Left
16	21791		8	6 9	36 E	8 Right	7 26	100 W	160 Right
16	21810		$7\frac{1}{2}$	6 31	88 E	37 Left	7 36	150 W	148 Left

Occultations as seen at Avenasi.

Dec. 3	η Leonis		$3\frac{1}{2}$	14 32	136 E	137 Right	15 58	89 W	15 Right
6	XII. 394 Weisse		9	14 16	155 E	125 Right	15 5	103 W	24 Right
14	20114	Oeltez n Argelander's zone.	9	6 38	18 E	48 Right	7 7	46 W	117 Right
14	20133		9	6 59	55 E	15 Right	7 43	82 W	157 Right
14	20138		$8\frac{1}{2}$	7 6	110 E	40 Left	7 45	138 W	147 Left
15	21093		8	8 21	84 E	12 Left	9 15	132 W	151 Left
16	21791		8	6 2	36 E	8 Right	7 15	100 W	160 Right
16	21810		$7\frac{1}{2}$	6 26	87 E	37 Left	7 32	151 W	148 Left

The general circumstances under which the Total Eclipse of Dec. 11th, 1871, will occur, are singularly and unusually favourable, the greater portion of the shadow-path being easily accessible by means of the railway and good public roads; while a well-managed line of telegraph will afford facilities for that most incomparable means of fixing the longitude of the place of observation with regard to Madras. The favourite Sanitarium of the Presidency, Ootacamund, will doubtless be selected by many persons as a convenient and familiar station from which to observe the eclipse; as also the hilly region of Wynaad, in the Malabar district, where numerous European gentlemen reside for the purpose of superintending their coffee-plantations. The lofty peak of Dodabetta, the highest point of the Neilgherries, 8640 feet above sea-level, would agreeably to the often-repeated and enlightened view of Prof. C. Piazzi Smyth, the Astronomer Royal for Scotland, offer a grand opportunity for spectroscopic observations, in an atmosphere of small density and free from all the impurities which abound at lower levels, but unfortunately haze and mist are very prevalent on the hill-ranges in the month of December. The weather is in general fine elsewhere about that time along the shadow-path, but more especially so eastward of the Neilgherry hills than towards the Malabar coast.

Madras,
5th December, 1870.