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A study of fifty years' rainfall of Madras City

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CONTENTS

1. Introduction

This study of the rainfall of Madras (Lat. 13° 04'N Long. 80° 15'E) was taken up as a part of a study of the climate of Madras—one of the major cities and headquarters of a State in the country. Even the one element, rainfall, can be studied from several aspects. For instance, one can concentrate attention on the monthly, seasonal and annual totals and follow their variations over a long period like 100 years or more. Or one can, as has been attempted in the present paper, rivet his attention to a medium unit like the daily total. Or again, one can see how the rain of even a single day is distributed over shorter periods, when one has autographic records of rainfall, as has been done by Krishnaswamy (1952).

2. Daily normal rainfall

2.1. Once the choice of the daily totals of rainfall for the city observatory at Nungambakam, Madras was made for the subject of the study, the next question was the period of data to be chosen. Fifty years seemed a reasonable period and conclusions of Carruthers (1945) and Satakopan (1951) lent support to this idea. The author would have preferred the period 1901-50, as being more recent; but the observations at this particular site was temporarily interrupted for about two years in the decade 1941-50, and so had to be satisfied with using data for the period 1891-1940.

2.2. The "Normal" rainfall of each calendar day was worked out by finding the simple arithmetic mean of the 50 January firsts, the 50 January seconds etc and are given in Table 1. They are also represented diagrammatically in Fig. 1.

2.3. One or two obvious limitations of the normals for each calendar date have to be specifically mentioned here—

(*i*) For 29 February, there will be obviously, only 12 instead of 50 years.

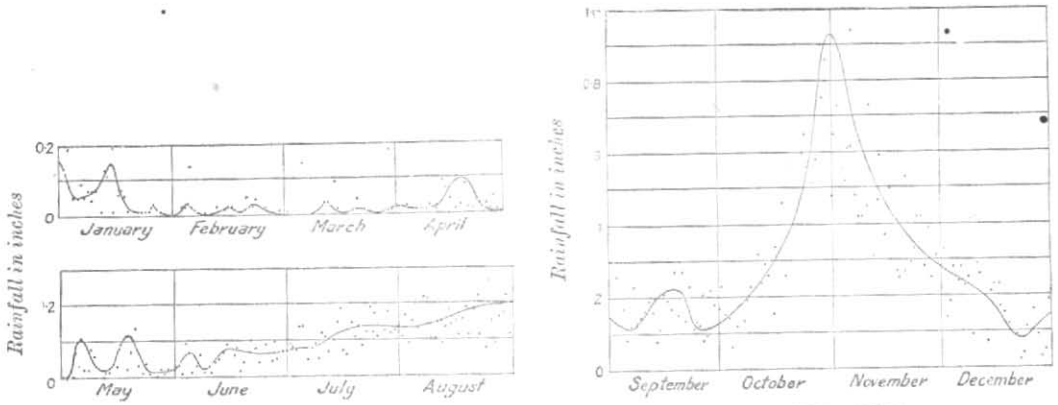


Fig. 1. Daily normal rainfall of Madras (Nungambakam) — (1891—1940)

TABLE 1

Daily normal rainfall * (*in*)

Madras (Nungambakam) (1891—1940)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	·13	·00	·01	·01	·00	·03	·09	·11	·10	·23	·65	·33
2	·19	·02	·00	·00	·00	·01	·08	·17	·26	·15	·73	·14
3	·05	·02	·00	·02	·00	·09	·07	·09	·10	·14	·55	·18
4	·05	·03	·00	—	·07	·07	·14	·15	·17	·20	·52	·28
5	·09	·14	·00	—	·11	·01	·14	·20	·08	·12	·61	·24
6	·05	·01	·00	·00	·02	·03	·05	·13	·12	·20	·94	·28
7	·07	·00	·00	·01	·02	·06	·08	·21	·23	·13	·48	·23
8	·04	·00	·00	·01	·08	·01	·09	·21	·13	·19	·42	·25
9	·07	·01	·00	·02	·06	·03	·05	·10	·14	·23	·42	·09
10	·07	·00	·00	·00	·02	·01	·12	·10	·16	·20	·45	·29
11	·01	·00	·03	·01	·00	·04	·11	·15	·19	·32	·73	·26
12	·13	·02	·03	—	·01	·05	·07	·09	·16	·24	·31	·10
13	·11	·01	·00	·09	·01	·07	·10	·13	·08	·29	·47	·07
14	·01	·01	·09	·07	·04	·09	·15	·18	·11	·26	·59	·21
15	·19	·02	·01	·04	·03	·08	·19	·14	·21	·15	·37	·23
16	·05	·02	·00	·01	·09	·06	·07	·15	·19	·34	·50	·23
17	·07	·01	·00	·10	·10	·08	·06	·11	·17	·23	·42	·17
18	·05	·00	·00	·02	·02	·02	·15	·16	·27	·46	·27	·15
19	·01	·01	·01	·08	·07	·04	·11	·19	·15	·26	·25	·12
20	·00	·05	·04	·01	·14	·07	·14	·11	·27	·57	·27	·10
21	·01	·02	·00	·01	·03	·10	·08	·18	·13	·40	·53	·09
22	·01	·02	·01	·03	·01	·08	·12	·22	·23	·40	·29	·02
23	·01	·04	·00	·00	·04	·04	·19	·11	·11	·60	·33	·04
24	·01	·00	·00	·01	·01	·06	·12	·07	·13	·65	·42	·11
25	·03	·02	·00	·02	·01	·09	·11	·26	·12	·56	·42	·10
26	·02	·00	·00	·01	·60	·04	·06	·15	·08	·52	·28	·16
27	·00	·00	·00	·04	·02	·10	·13	·09	·09	·58	·39	·09
28	·00	·01	·00	·01	·01	·05	·18	·16	·22	·90	·25	·03
29	·00	·00	·01	·00	·02	·07	·12	·17	·18	·75	·31	·05
30	·00	—	·01	·00	·00	·07	·13	·22	·17	·86	·45	·19
31	·01	—	·03	—	·02	—	·14	·11	—	·48	—	·21

* Arithmetic means of 30 values for first January, second January, etc. For 29 February, however, the mean is of 12 values

(*ii*) Stray exceptionally heavy falls have exerted undue influence over the normals of a few particular dates. For instance, on 15 January 1915, there was a fall of 8·4″. Even when distributed over 50 years, this single day's rain adds 17 cents to the normal for the date. The result is 15 January stands out with 19 cents in between 1 cent on 14th and 6 cents on 16th. Anomalies of this type will ordinarily be confined to the seasons of scanty rainfall and can be distinguished and treated as such.

2.4. Such minor limitations apart, Table 1 and Fig. 1 show the following features of interest—

(*i*) From middle of January to middle of April, rainfall is negligibly small

(*ii*) From middle of April to 10 October and again from about 10 December to middle of January, mean rainfall per day fluctuates near about 15 to 20 cents

(*iii*) The remaining period, *viz.*, the two months from about 10 October to 10 December is the real rainy season in Madras with daily averages of the order of half inch, rising to a peak value of about 1″ at the beginning of November

(*iv*) The scatter of the daily means is considerable, particularly in the more rainy periods, so that for having a significant daily normal value, it appears necessary to use a period much longer than 50 years. The daily normal values may not admit of a smooth curve to connect them until one uses about 80 or even 100 years' data. Whether they will fit into a smooth curve even then remains to be seen, but the attempt seems worth while and the author proposes to undertake it some time later.

3. Three-day normals

3.1. The time unit higher than 1 day and lower than the month for which normals of rainfall are in general use is the 5-day period. Since the "day" appears to be too small a unit to get reasonably smooth normals, it was thought worth while working out normals for a time unit between it and the 5-day period, the next higher unit in common use. Normals were, therefore, worked out for each successive 3-day period. These values are given in Table 2 and are represented diagrammatically in Fig. 2.

3.2. It is clear that the values for successive 3-day periods show very much less sporadic variations than the daily values and admit of a fairly smooth curve to be fitted connecting them. One can, therefore, reasonably assume, that for normals for 3-day and higher units, 50 years is a long enough period.

3.3. Other interesting features are—

(*i*) Three consecutive zeros, for the 3-day periods (Nos. 21-23 in Table 2) corresponding to 2 to 10 March, show the driest part of the year.

(*ii*) From the 97th to 110th 3-day periods (16 October—26 November), with one exception, the values exceed 1″. And values exceeding 1″ are confined to this spell—which is, therefore, the real core of the rainy season.

(*iii*) There is a well-marked single maximum with 2·51″ in the 101st 3-day period (28 to 30 October).

4. Three-day "moving" normals

Normal totals for 3-day periods, shifting in daily stages, *e.g.*, 1-3 January, 2-4 January and so on, have also been worked out. These values are given in Table 3 and are represented diagrammatically in Fig. 3. Such so called "moving means" have come increasingly into meteorological and climatological use of late. Once again, the maximum of 2·51″ for the period 28-30 October and 3-day totals exceeding 1″ from 16 October to end of November stand out prominently.

Fig. 2. Three-day normal rainfall of Madras (1891—1940)

TABLE 2

Three-day normal rainfall in inches

Madras (**Nungumbakam**) (**1891—1940**)

	0+	10+	20+	30+	40+	50+	60+	70+	80+	90+	100+	110+	120+
1	0·37	0·03	0·00	0·03	0·00	0·06	0·24	0·38	0·50	0·57	**2·51**	0·95	0·17
2	0·19	0·19	0·00	0·00	0·20	0·17	0·35	0·41	0·46	0·52	1·86	0·92	0·63
3	0·18	0·01	0·00	0·04	0·16	0·10	0·22	0·54	0·27	0·52	1·68	0·70	
4	0·21	0·01	0·06	0·01	0·03	0·08	0·28	0·41	0·50	0·65	1·84	0·76	
5	0·31	0·04	0·10	0·20	0·08	0·21	0·32	0·37	0·51	0·76	1·60	0·64	
6	0·18	0·05	0·01	0·13	0·21	0·22	0·32	0·47	0·40	0·70	1·37	0·38	
7	0·02	0·06	0·05	0·10	0·24	0·13	0·30	0·46	0·63	1·03	1·29	0·63	
8	0·03	0·08	0·00	0·04	0·06	0·22	0·39	0·51	0·55	1·23	0·79	0·37	
9	0·05	0·02	0·00	0·07	0·03	0·19	0·29	0·44	0·47	1·65	1·15	0·15	
10	0·00	0·02	0·05	0·01	0·03	0·22	0·43	0·40	0·29	1·66	1·12	**0·37**	

Note—The year has been divided into 122 three-day periods and the normal of each 3-day successive period is given in the table, *e.g.*, the normal of 101st 3-day period (28 to 30 October) is 2·51″

TABLE 3

Three-day moving totals of daily rainfall in inches—Madras (1891-1940)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1—3	·37	·04	·01	·03	·00	·13	·24	·37	·46	·52	1·93	·65
2—4	·29	·07	·00	·02	·07	·17	·29	·41	·53	·49	1·80	·60
3—5	·19	·19	·00	·02	·18	·17	·35	·44	·35	·46	1·68	·70
4—6	·19	·18	·00	·00	·20	·11	·33	·48	·37	·52	2·07	·80
5—7	·21	·15	·00	·01	·15	·10	·27	·54	·43	·45	2·03	·75
6—8	·16	·01	·00	·02	·12	·10	·22	·55	·48	·52	1·84	·76
7—9	·18	·01	·00	·04	·16	·10	·22	·51	·50	·65	1·32	·57
8—10	·18	·01	·00	·03	·16	·05	·26	·41	·43	·72	1·29	·63
9—11	·15	·01	·03	·03	·08	·08	·28	·35	·49	·85	1·60	·64
10—12	·21	·02	·06	·01	·03	·10	·30	·34	·51	·76	1·49	·65
11—13	·25	·03	·06	·10	·02	·16	·28	·37	·43	·85	1·51	·43
12—14	·25	·04	·12	·16	·06	·21	·32	·40	·35	·79	1·37	·38
13—15	·31	·04	·10	·20	·08	·24	·44	·45	·40	·70	1·43	·51
14—16	·26	·05	·10	·12	·16	·23	·41	·47	·51	·75	1·46	·67
15—17	·32	·05	·01	·15	·22	22	·32	·40	·57	·72	1·29	·63
16—18	·18	·05	·00	·13	·21	·16	·28	·42	·63	1·03	1·19	·55
17—19	·13	·02	·01	·20	·19	·14	·32	·46	·59	·95	·94	·44
18—20	·06	·06	·05	·11	·23	·13	·40	·46	·69	1·29	·79	·37
19—21	·02	·08	·05	·10	·24	·21	·33	·48	·55	1·23	1·05	·31
20—22	·02	·09	·05	·05	·18	·25	·34	·51	·63	1·37	1·09	·21
21—23	·03	·08	·01	·04	·08	·22	·39	·51	·47	1·40	1·15	·15
22—24	·03	·06	·01	·04	·06	·18	·43	·40	·47	1·65	1·04	·17
23—25	·05	·06	·00	·03	·06	·19	·42	·44	·36	1·81	1·17	·25
24—26	·06	·02	·00	·04	·02	·19	·29	·48	·33	1·73	1·12	·37
25—27	·05	·02	·00	·07	·03	·23	·30	·50	·29	1·66	1·09	·35
26—28	·02	·01	·00	·06	·03	·19	·37	·40	·39	2·00	·92	·28
27—29	·00	·02	·01	·05	·05	·22	·43	·42	·49	2·23	·95	·17
28—30	·00	·02	·02	·01	·03	·19	·43	·55	·57	**2·51**	1·01	·27
29—31	·01		·05	·00	·04	·23	·39	·50	·58	2·09	1·09	·45
30—	·00		·05	·00	·05	·24	·38	·43	·55	1·99	·92	·53
31	·03		·04		·06		·42	·47		1·86		·53

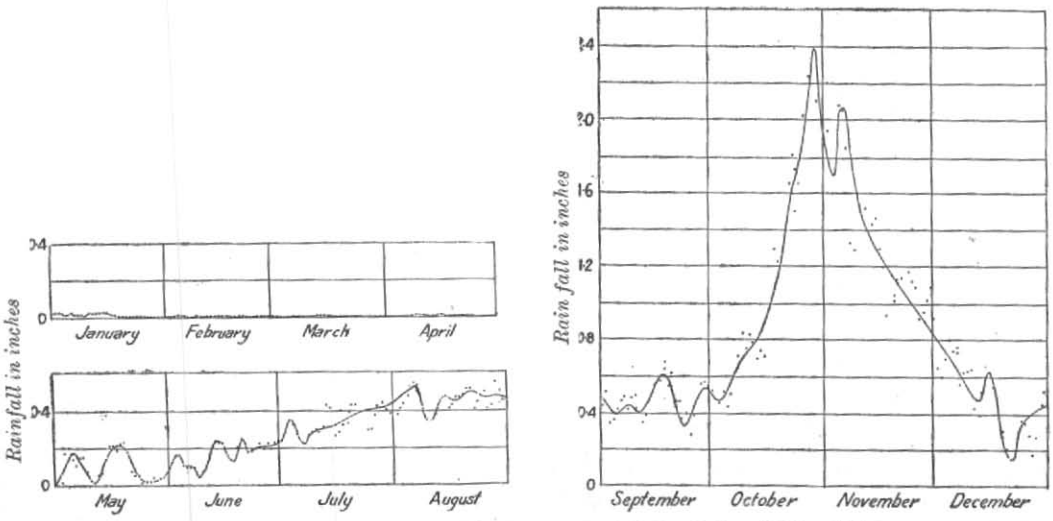


Fig. 3. Three-day "Moving" means of rainfall—Madras (1891—1940)

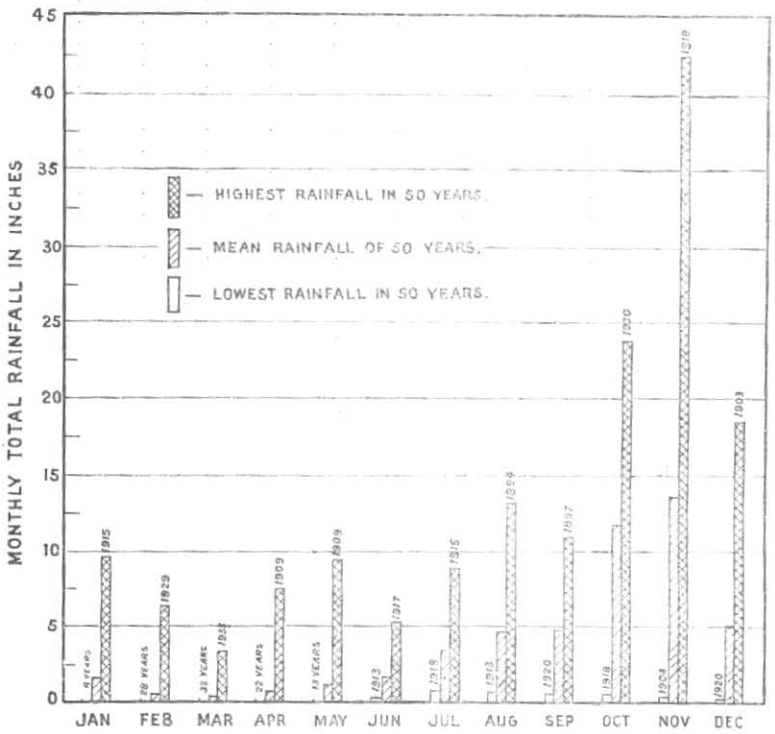
5. Mean and extreme monthly totals

Although, as mentioned in the introduction, greater attention is being paid in this study to the daily values, a brief reference to the monthly totals will help to make the paper self-contained. The mean, highest and lowest *monthly* total rainfall of Madras during the 50 years under study are accordingly given in Table 4. For the highest and lowest values, the years of occurrence have also been given. Because zero was the lowest total for certain months in many years, the number of years alone is given without cataloguing them. The information is also shown pictorially in Fig. 4. November 1918 with nearly 43 inches on the one hand and March having had no rain in 32 out of 50 years on the other are the two conspicuous features in the figure. We shall revert to the rainfall of November 1918 later on in the paper.

TABLE 4

Mean and extreme monthly totals of rainfall in inches Madras (Nungumbakam) (1891—1940)

Month	Normal	Highest amount	Year	Lowest amount	Years
Jan	1·57	9·61	1915	0·00	8 years
Feb	0·49	6·41	1929	0·00	28 years
Mar	0·30	3·42	1933	0·00	32 years
Apr	0·65	7·52	1909	0·00	22 years
May	1·03	9·49	1909	0·00	13 years
Jun	1·65	5·34	1917	0·13	1913
Jul	3·47	8·87	1915	0·65	1918
Aug	4·64	13·24	1894	0·72	1913
Sep	4·79	11·01	1897	0·47	1920
Oct	11·71	28·84	1930	0·44	1918
Nov	13·61	42·85	1918	0·20	1904
Dec	5·06	18·55	1903	0·01	1920



MEAN AND EXTREME MONTHLY TOTALS OF RAINFALL
MADRAS - NUNGUMBAKAM.
(1891 - 1940)

Fig. 4

6. Frequency of raininess of each calendar date

6.1. For each calendar date, the number of years out of the 50 in which there was some rain (however small) is shown in Table 5 (See also Fig. 5). Obviously, doubling the figure will give the percentage and hence no separate table for percentage is given. The dates which had rain 20 or more occasions have been marked out by a vertical line by their side and those with 30 or more occasions are printed in thick types. Once again, the figures do show some amount of sporadic changes, as for example from 8 to 9 January, or again from 22 to 23 September, thus suggesting the desirability of using data for a longer period for such minute analysis. Yet the broader facts must be dependable.

6.2. March is easily the driest month and October—November the wettest. 31 October is the rainiest day with 68 per cent of days raining.

6.3. Consider periods with 10 or more days, *i.e.*, having 20 per cent chance of rain :

From 10 June to 20 December, there is only one date which has had less than 10 rainy days in 50 years, *viz.*, 3 October. This may be ruled off as a freak ; so also the two or three days in December, and we may treat the period 10 June to 30 December as a period when any day has random chance of at least 20 per cent to get some rain.

6.4. When we go to the next stage of 20 days or 40 per cent random chance (marked out by vertical lines on the left side of the figures in the table), the period no longer shows itself as equally continuous but is mostly interspersed with days with less chance of rain. Ignoring a few stray instances, one can yet distinguish two long spells when almost any day has a 40 per cent or higher chance of rain. These are : (*i*) from 30 June to 29 August—about 60 days and (*ii*) from 9 October to 1 December—about 40 days. It is interesting that spells of 2 to 3 days stay distributed in September.

6.5. Dates with 30 or more rainy days (*i.e.*, 60 per cent random chance) number only 10 in the year and 8 of them lie between *22 October and 1 November*. This period is thus the one having the greatest chance of rain in Madras. Conversely a year in which there was no rain in this period, *viz.*, 21 October to 1 November, must, in all probability, be a very bad northeast monsoon year.

7. Mean intensity per rainy day

By dividing the total rainfall in the 50 years for each calendar date by the number of years in which any rain fell on that particular date, the mean intensity per rainy day was worked out for each calendar date. The values are given in Table 6 and shown pictorially in Fig. 6. These figures are a truer measure than the daily normals of the order of quantity of the rain which falls on any particular calendar date when rain does at all occur. There are a few sporadic and non-significant values, like 2·40″ for 15 January—which is due to the exceptionally high fall of 8·4″ on 15 January 1915—and 2·26″ for 20 May. These apart, two features are fairly well brought out by the table—

(*i*) In the southwest monsoon period, say from 10 June to middle of October, the mean intensity oscillates between 20 and 60 cents. The quantity of rain to forecast on a day when rain is expected in this season is, therefore, very reasonably from $\frac{1}{4}$ to $\frac{1}{2}$ inch.

(*ii*) In the peak of the northeast monsoon season, from middle of October to about 25 November, 1 to $1\frac{1}{2}$ inches is the quantity to be expected when it does rain.

8. Frequencies of different 24-hour intensities

8.1. The numbers of occasions when rainfall with different ranges of intensity per day occurred in each of the 12 months are given in Table 7 and represented diagrammatically in Fig. 7. In Table 7, the values are also grouped in three seasons of 4 months each. It is realised that there can be some difference of opinion in the matter

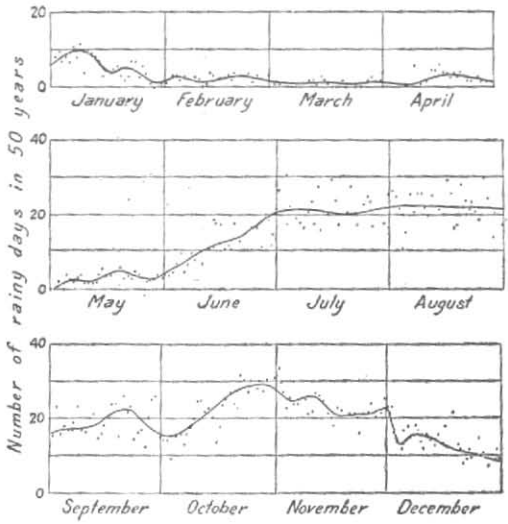


Fig. 5. Madras (Nungumbakam) (1891-1940)

TABLE 5

Number of days in 50 years (1891—1940) when each calendar date was rainy

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8	2	2	1	0	4	27	25	15	14	**30**	23
2	10	3	1	1	2	5	22	22	23	14	27	16
3	7	3	1	1	0	7	18	20	16	9	23	13
4	8	2	1	1	4	10	23	16	18	15	25	12
5	7	3	0	1	3	5	19	26	17	16	24	17
6	11	2	0	0	2	7	18	21	17	13	24	18
7	8	2	0	1	3	10	17	26	19	16	25	15
8	12	3	0	1	4	8	21	26	23	18	25	18
9	4	2	1	6	2	13	24	22	17	20	21	14
10	10	0	1	1	2	7	18	19	16	25	22	12
11	9	1	2	2	2	11	28	26	20	25	27	15
12	8	4	2	2	2	11	16	23	21	22	26	14
13	7	3	1	5	4	19	20	22	15	23	24	13
14	3	2	3	5	6	18	21	23	16	20	21	16
15	4	2	2	6	4	18	**30**	**30**	18	14	20	13
16	4	2	1	4	4	11	24	26	20	18	18	18
17	5	3	0	4	5	12	17	17	24	24	23	12
18	6	2	0	3	5	11	20	18	24	25	22	21
19	3	4	1	4	6	18	21	29	15	27	20	13
20	2	3	2	3	3	13	28	24	26	24	21	12
21	3	3	0	4	4	15	20	22	21	23	21	8
22	7	3	1	3	3	15	17	24	23	**32**	20	9
23	7	4	1	2	5	15	23	21	14	**30**	16	12
24	3	1	0	2	4	17	25	19	16	27	21	10
25	6	3	0	3	3	17	24	**31**	17	**30**	21	15
26	4	2	1	3	2	12	17	25	12	28	24	10
27	1	2	2	2	3	20	22	14	20	**30**	20	11
28	0	3	3	2	3	19	22	21	25	27	21	7
29	1		2	2	4	15	18	22	26	**30**	25	10
30	1		2	0	3	22	26	18	15	**31**	23	12
31	1		4		4		27	19		**34**		9

TABLE 6

Mean intensity per rainy day in cents (1891—1940)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	082	008	032	046	—	043	017	023	033	083	108	072
2	097	029	003	006	010	011	019	039	057	054	135	043
3	035	037	001	095	—	065	020	023	032	077	120	068
4	033	075	022	013	088	034	031	048	047	068	104	118
5	065	229	—	001	175	015	038	039	025	037	122	070
6	025	024	—	—	056	018	013	030	035	076	197	072
7	043	008	—	068	027	029	025	040	060	040	097	079
8	019	007	—	029	098	009	023	040	029	052	084	070
9	093	016	002	019	153	013	010	022	041	082	100	033
10	035	—	010	001	043	004	032	026	050	040	103	115
11	004	004	085	030	009	020	020	029	049	064	136	086
12	081	027	087	003	025	023	023	019	038	055	159	036
13	079	008	001	087	013	018	025	029	025	062	099	027
14	012	030	158	070	034	024	036	039	035	065	140	066
15	240	040	014	037	035	023	031	024	060	052	093	090
16	078	041	003	018	116	028	015	029	048	094	138	064
17	068	019	—	121	104	034	019	034	036	047	091	072
18	046	002	—	036	024	008	036	045	057	093	061	035
19	014	011	026	100	060	010	027	032	052	048	062	047
20	012	085	098	010	226	027	025	024	052	118	064	040
21	014	039	—	007	044	034	021	041	030	087	126	056
22	006	033	016	051	003	263	036	045	051	062	073	013
23	008	049	003	006	004	001	041	028	041	100	102	019
24	008	011	—	035	013	019	024	017	040	120	100	057
25	030	030	—	041	019	026	022	042	037	094	100	033
26	022	005	024	014	008	016	019	031	035	093	059	078
27	002	004	001	097	029	026	030	033	023	097	098	040
28	—	016	004	037	013	012	042	037	043	167	059	023
29	002	—	021	005	027	024	033	040	035	125	062	027
30	013		034	—	002	016	024	062	058	139	097	078
31	038		034		026		025	028		071		115

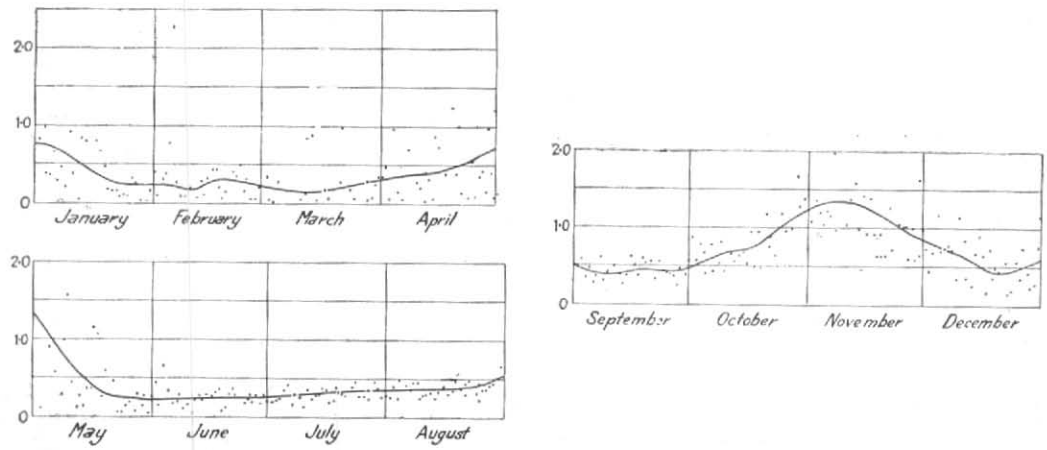


Fig. 6. Mean intensity of rain per rainy day in inches—Madras (Nungumbakam) (1891-1940)

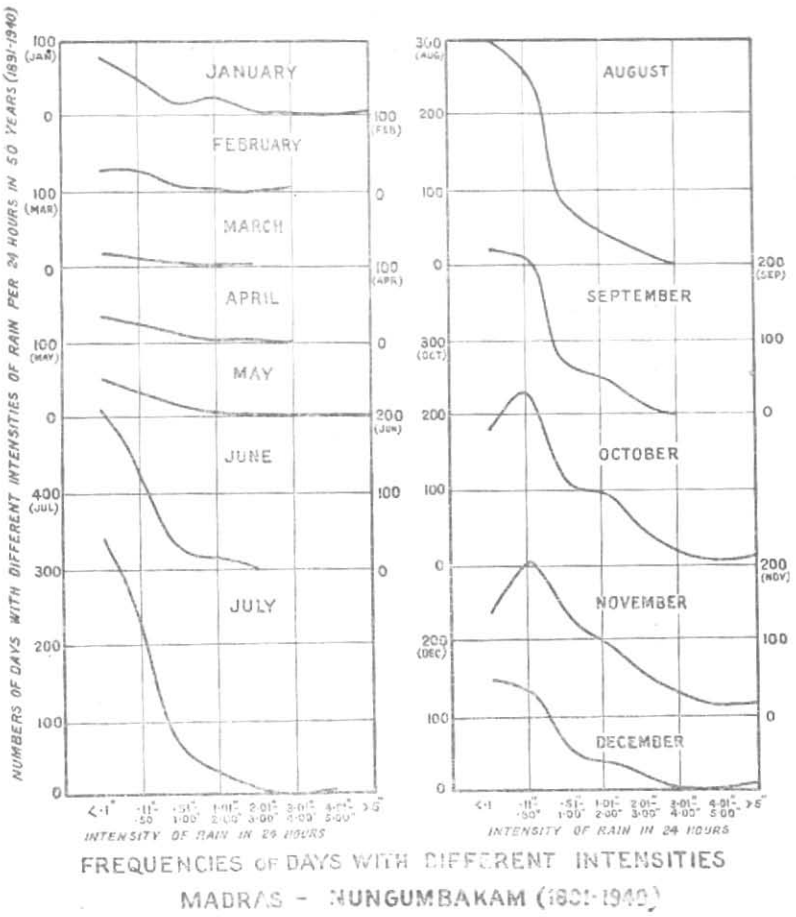


Fig 7

TABLE 7

Distribution of rain according to intensity in 24 hours—Madras (1891—1940)

Month	Number of occasions with rainfall of day								
	0·00	Less than 0·10″	0·10″ to 0·50″	0·51″ to 1·00″	1·01″ to 2·00″	2·01″ to 3·00″	3·01″ to 4·00″	4·01″ to 5·00″	Greater than 5·00″
Jan	1380	76	50	16	21	4	2		1
Feb	1345	26	28	9	4		1	1	
Mar	1513	17	11	3	4	2			
Apr	1425	33	24	8	6	3	1		
May	1448	50	28	10	6	3	3	1	1
Jun	1115	210	130	26	17	2			
Jul	877	343	233	61	31	5		1	
Aug	851	299	258	78	45	18	1		
Sep	923	220	213	72	52	12	8		
Oct	846	180	232	108	98	46	18	7	15
Nov	821	133	208	129	99	53	29	11	17
Dec	1133	151	137	56	40	17	5	4	7
Feb-May	5731	126	91	30	20	8	5	2	1
Jun-Sep	3766	1072	834	217	145	37	9	1	—
Oct-Jan	4180	540	627	309	258	120	54	22	40

of grouping of the months. The grouping adopted here is considered suitable because the data presented in this paper mostly have certain homogeneous characteristics within each season. The most difficult month to classify is September, which in some years gets mainly southwest monsoon rainfall and in others mainly northeast monsoon rainfall. This difficulty can be solved only if we sort out individual days according to the weather situation. So long as we confine ourselves to calendar dates for the analysis, more homogeneous results are not likely to be obtained by any alternative grouping of months.

8.2. A very interesting feature that is brought out by Table 7 and Fig. 7 is that whereas in most of the months, the frequency drops off continuously as we go up along the scale of intensities, in October and November it actually increases as we go from the range less than 0·1″ to the range 0·1 to 0·5″ and then only decreases. A high proportion also occurs in the ranges 0·5 to 1″ and 1 to 2″ in these 2 months. In August, September and December, the frequency of rainfalls in the 0·1 to 0·5″ range is quite comparable to that in the less than 0·1″ range.

8·3. The frequencies in each rainfall range expressed as a percentage of the total number of days on which any rain fell are given in Table 8.

9. Proportion of rain falling in different ranges of 24-hour intensities

In the last section, we examined on what proportion of the rainy days rain of different 24-hour intensities occurred. We shall now examine what proportion of the total rain actually occurred in each intensity range. To a first approximation, this information is derivable from Table 7, by taking all the days in any intensity range to have had the mean value of that range. For instance, taking January, one could say: $76 \times \cdot 05$ or 3·8″ fell with 24-hour intensities of less than 10 cents, $50 \times \cdot 30$ or 15″ fell with those between 10 and 50 cents and so on. These values are only approximate and when dealing with particular questions, it may be found useful to have the correct values readily worked out. As a matter of fact, the author did get a request for information on this point while engaged in writing this paper. Tables 9 and 10 accordingly show the distribution of the rain over different 24-hour intensity ranges. In Table 9, the quantity of rain in each intensity range is given as such. In Table 10, the quantity in each intensity range is expressed as a percentage of the total rain.

10. Frequencies of rainy spells of different lengths

10.1. Once rain occurs on a day, on how many successive days does it generally occur? This, of course, depends very much on the weather situation at the time. Yet, when the information is collected over a long period and presented together as in Table 11, certain broad features come out, which are both significant and helpful. A rainy spell starting in a month may sometimes extend into the next. In such cases, the spell has been entered in the month in which it started. The longest rainy spell that occurred in Madras city in the 50 years here studied was one of 21 days, starting from 17 October and lasting till 6 November 1930.

10.2. It will be seen that the season June—September gets longer spells than February—May and the season October—January gets still longer spells. Two and three-day spells together, for instance, are less than half one-day spells in February—May, are just over half one-day spells in June-September and actually more than one-day spells in October-January.

10.3. Further, while a much larger number of spells (of all lengths) of rainy days occur in June-September than in October-January, longer spells are relatively more common in the latter season. In short, one could broadly generalise that in Madras city (and such regions that it may be taken to represent) the southwest monsoon season is one when a comparatively

smaller quantity of rain falls over a larger number of spells of fewer days at a time and in smaller units per day; whereas in the northeast monsoon season, a larger quantity falls in fewer spells of more days at a stretch and in larger units per day. Though northeast monsoon rain can and does occur at Madras in any of the four months October, November, December or January, in any particular year, it is confined to a shorter period. In different years, it may take up different parts of the 4-month period, but the interval from its commencement to its termination, in any particular year, is considerably shorter than the corresponding interval for the southwest monsoon season.

10.4. It may be noted that no rainy spell exceeding 5 days occurred in the months February to May.

11. The intervals between rainy spells

11.1. Frequencies of dry (rainless) intervals of different durations in each month and season are given in Table 12. They are given for 4-day ranges upto 20 days and for 10-day ranges from 20 to 100 days. All cases of longer than 100 days are given in a single group. At first sight, it may appear strange that there should be fewer intervals in some months and seasons than in others; but this will easily get itself explained when one realises that each long interval can cover a period equivalent to several short intervals. In this table again, as in Table 11, each spell is given against the month in which it starts. It may of course extend into the next month or even several succeeding months.

TABLE 8

Frequency of occurrence of rain of different ranges in 24 hours expressed as percentage of total number of days with any rain

	Less than 0·10″	0·10″ to 0·50″	0·51″ to 1·00″	1·01″ to 2·00″	2·01″ to 3·00″	3·01″ to 4·00″	4·01″ to 5·00″	Greater than 5·00″	Total number of rainy days
January	45	29	9	12	2	1	..	1	170
February	38	41	13	6	..	1	1	..	68
March	46	30	8	11	5	..	..	..	37
April	44	32	11	8	4	1	..	..	75
May	49	28	10	6	3	3	1	1	102
June	55	34	7	4	1	..	..	..	385
July	51	35	9	5	1	..	1	..	674
August	43	37	11	6	2	..	..	..	699
September	38	37	12	9	2	1	..	..	577
October	26	33	15	14	7	3	1	2	704
November	20	31	19	15	8	4	2	2	679
December	36	33	13	10	4	1	1	2	417

TABLE 9

Statement showing the break up of the total rainfall into the amounts (*in*) contributed by falls within specified ranges

Month	0·50″ and less	0·51″ to 1·00″	1·01″ to 1·50″	1·51″ to 2·00″	2·01″ to 2·50″	2·51″ to 3·00″	More than 3·00″	Total rain (*in*)
January	14·1	14·8	13·0	12·0	6·8	2·6	15·6	78·8
February	8·0	6·6	3·4	1·9	..	..	4·9	24·7
March	3·5	1·9	..	6·9	..	2·5	..	14·8
April	7·1	5·9	4·0	5·3	4·3	2·6	3·3	32·5
May	7·7	8·0	2·1	6·7	4·4	2·7	19·8	51·5
June	36·1	18·8	15·5	6·7	4·5	..	..	81·5
July	66·7	45·2	20·1	25·2	11·4	5·7	..	174·3
August	70·9	57·9	40·9	18·6	23·9	16·6	3·1	231·8
September	58·6	52·0	46·3	24·2	11·5	19·4	27·6	239·6
October	66·8	78·3	72·3	100·1	69·8	35·0	171·1	593·4
November	58·0	98·7	76·7	61·5	70·0	67·5	248·3	680·7
December	38·3	41·0	36·9	17·5	24·2	16·1	79·2	253·0

TABLE 10

Distribution of total rainfall over different ranges of 24-hour falls (percentages)

Month	0·50″ and less	0·51″ to 1·00″	1·01″ to 1·50″	1·51″ to 2·00″	2·01″ to 2·50″	2·51″ to 3·00″	More than 3·00″
January	18	19	16	15	9	3	20
February	32	27	14	8	..	..	20
March	24	12	..	46	..	17	..
April	22	18	12	16	13	8	10
May	15	16	4	13	9	5	38
June	44	23	19	8	5	..	..
July	38	26	11	14	7	3	..
August	30	25	18	8	10	7	1
September	24	22	19	10	5	8	11
October	11	13	12	17	12	6	29
November	9	15	11	9	10	10	36
December	15	16	15	7	10	6	31
February-May	23	18	8	21	5	8	17
June-September	34	24	17	10	7	5	3
October-January	13	16	13	12	10	6	29

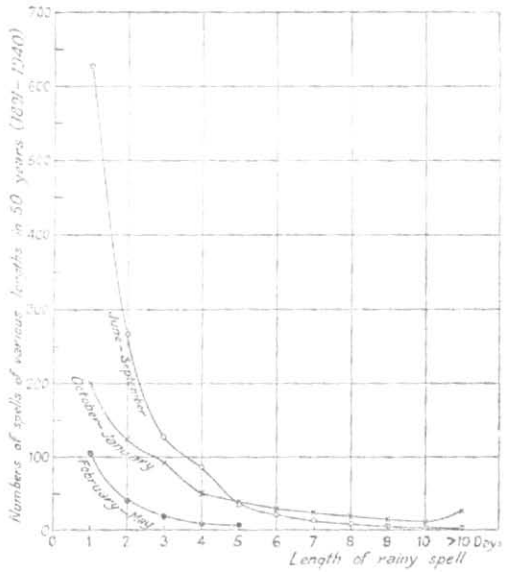


Fig. 8. Frequencies of rainy day spells of different lengths
Madras (Nungambakam) (1891—1940)

TABLE 11

Frequency of rainy spells of different durations
Madras (1891—1940)

Month	Duration of spell (days) 1	2	3	4	5	6	7	8	9	10	More than 10	Total No. of spells
January	30	24	10	6	1	1	..	..	1	..	..	73
February	18	11	5	2	1	..	..	..	..	..	..	37
March	15	4	1	1	1	..	..	..	..	..	..	22
April	32	7	5	2	1	..	..	..	..	..	..	47
May	43	13	4	3	2	..	..	..	..	..	..	65
June	141	54	20	11	1	3	1	1	1	..	..	233
July	175	71	47	23	10	4	4	2	1	..	..	337
August	163	84	28	23	18	7	1	3	..	1	1	329
September	150	58	28	24	13	5	4	..	..	1	..	283
October	77	40	33	11	12	3	8	5	5	4	18	216
November	46	29	26	17	10	16	6	6	3	3	3	165
December	47	33	25	14	11	5	3	5	1	..	..	144
February-May	108	35	15	8	5	—	—	—	—	—	—	171
	(63)	(20)	(9)	(5)	(3)							
June-September	629	267	123	81	31	19	10	6	2	2	1	1182
	(53)	(23)	(10)	(7)	(4)	(2)	(1)	(1)				
October-January	260	126	94	48	34	25	17	16	9	7	21	598
	(33)	(21)	(16)	(8)	(6)	(4)	(3)	(3)	(1)	(1)	(3)	

(*i*) Longest spell : 21 days, from 17 October 1930 to 6 November 1930

(*ii*) Spells extending beyond the month in which they began are classified only under the month of beginning

(*iii*) The figures in brackets are percentages

TABLE 12

Dry (rainless) spells of different durations

Madras (1891—1940)

Month	Duration of spells (days)													
	1–4	5–8	9–12	13–16	17–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	More than 100
January	22	6	6	4	3	6	8	2	2	1	5	4	5	6
February	13	3	1	2	—	2	4	3	1	2	1	2	3	1
March	6	—	2	1	2	2	2	4	1	3	—	—	—	1
April	11	8	2	2	4	9	3	2	5	—	—	—	—	—
May	15	12	8	13	6	7	4	—	—	—	—	—	—	—
June	170	33	11	6	1	1	—	—	—	—	—	—	—	—
July	278	41	11	1	1	—	—	—	—	—	—	—	—	—
August	283	42	7	1	2	—	—	—	—	—	—	—	—	—
September	210	49	12	4	2	3	—	—	—	—	—	—	—	—
October	138	38	13	5	1	1	1	—	—	—	—	—	—	—
November	115	27	13	3	3	3	1	—	—	—	—	—	—	—
December	67	32	22	15	5	4	4	2	1	—	—	—	—	—
February-May	45	23	13	18	12	20	13	9	7	5	1	2	3	2
June-September	941	165	41	12	6	4	—	—	—	—	—	—	—	—
October-January	342	103	54	37	12	14	14	4	3	1	5	4	5	6

11.2. The most striking point brought out by Table 12 is that there are fewer long dry intervals in the southwest monsoon season than in the northeast monsoon season. Dry intervals exceeding 30 days never occurred in the months June to September, and intervals of 17-20 days and 21-30 days were much less frequent than in the other seasons. Thus, although the northeast monsoon season is the one in which more rain falls, failures, as typified by long rainless spells, are also more common in that season than in the southwest monsoon season. A 20-day stretch without rain is a rarity in the southwest monsoon season, but not at all uncommon in the northeast monsoon season.

11.3. In these 50 years, there have been 10 spells of 100 or more rainless days at a stretch. Six of these commenced in January, one in February, one in March and two in December. Three of them were of 102 days, the rest being of 107, 110, 131, 144 (two spells), 149 and 155. The last of these, which was the longest, was from 16 January to 19 June 1912. It is worth while studying the circumstances, considering synoptic weather situations and other matters, under which these droughts occurred and the author proposes to undertake such a study when state of work permits.

12. Spells of heavy rain

12.1. We shall now examine instances when heavy rain occurred on one or more days. There is no unique way of saying what constitutes heavy rain, and a certain amount of arbitrariness in choosing the limits cannot be escaped. One thing is clear; when rain falls on several days at a stretch, even a smaller fall on a preceding or suceeding day heightens the importance of the heavy rain on any one day. Keeping this principle in mind, as a basis of selection of heavy falls, the limits 4″ in 1 day, 6″ in 2 days, 8″ in 3 days and 10″ in 4 days were chosen. Details of the dates and falls of all cases when the above limits were reached or exceeded are given in Table 13. The material in Table 13 is arranged month by month.

12.2. The first fact brought out by Table 13 is that by far the bulk of heavy rain occurs in the three months October, November and December. The very fact that the nine months from January to September have taken only one fourth of the space

TABLE 13

Spells of heavy rain in Madras (1891—1940)

4″ or more in a day			6″ or more in 2 days			8″ or more in 3 days			10″ or more in 4 days			*Weather Remarks
Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	
						JANUARY						
1915	15	**8·38**†	1915	15-16	8·59	1915	15-17	8·69				B
						FEBRUARY						
1929	5	4·85										C
						MARCH						
Nil												
						APRIL						
Nil												
						MAY						
1909	5	5·22	1909	4-5	7·95	1909	4-6	9·06				A
			1909	5-6	6·33							
			1930	8-9	6·77							A
1940	20	4·66										A
						JUNE						
Nil												
						JULY						
1910	28	4·58	1910	28-29	6·15							B
						AUGUST						
Nil												
						SEPTEMBER						
Nil												
						OCTOBER						
1898	31	4·05	1898	30-31	6·37							C
1899	26	4·29				1899	24-26	9·32	1899	23-26	11·07	B
1902	28	**9·16**	1902	27-28	9·30	1902	26-28	9·64	1902	25-28	**12·27**	A
			1902	28-29	**10·17**	1902	27-29	**10·31**	1902	26-29	10·65	
						1902	28-30	**11·30**	1902	27-30	11·44	
									1902	28-31	11·68	
1905	16	5·05				1905	14-16	8·15	1905	13-16	11·01	A
1907	3	4·59	1907	3-4	**8·07**	1907	2-4	8·63				A
						1907	3-5	8·50				
1908	23	5·29	1908	22-23	7·67	1908	22-24	**14·25**	1908	23-25	**15·36**	B
1908	24	**6·58**	1908	23-24	**11·87**	1908	23-25	**12·98**	1908	23-26	**13·48**	
			1908	24-25	7·69	1908	24-26	8·19				
1912	20	4·44										A
1913	27	5·08	1913	26-27	6·15	1913	25-27	8·84	1913	28-31	10·57	C
1913	31	**6·86**	1913	30-31	**9·60**	1913	29-31	9·98				
1917	20	**8·38**	1917	20-21	**10·31**	1917	20-22	**10·96**	1917	20-23	11·43	B
1920	26	5·30	1920	25-26	6·14	1920	25-27	**10·97**	1920	24-27	11·20	B
			1920	26-27	**10·13**	1920	26-28	**13·52**	1920	25-28	**14·36**	
			1920	27-28	**8·22**	1920	27-29	**12·01**	1920	26-29	**17·31**	
			1920	28-29	7·18				1920	27-30	**12·09**	
			1922	28-29	6·88	1922	28-30	8·06	1922	26-29	10·42	C

*(A) Associated with well-marked depressions or cyclonic storms which were near enough to Madras to influence rainfall there

(B) Associated with low pressure waves or depressions so far away that their influence on Madras rainfall is dubious

(C) Not associated with depressions or cyclones

† Rainfall amounts exceeding by 2″ than the limits shown at the top of the respective columns have been indicated in thick types

TABLE 13 (*contd*)

4″ or more in a day			6″ or more in 2 days			8″ or more in 3 days			10″ or more in 4 days			*Weather Remarks
Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	
						OCTOBER—*contd*						
1923	28	4·08	1923	27-28	6·70							A
1928	21	5·73	1928	20-21	**8·90**	1928	19-21	9·62				
1930	24	**6·66**	1930	23-24	**8·50**	1930	22-24	**11·00**	1930	21-24	**12·19**	A
			1930	24-25	**8·32**	1930	23-25	**10·16**	1930	22-25	**12·66**	
						1930	24-26	8·81	1930	23-26	11·65	
									1930	24-27	10·93	
1932	11	5·97	1932	10-11	6·02	1932	10-12	8·27	1932	9-12	10·06	C
			1932	11-12	**8·22**	1932	11-13	8·24				
1932	30	**7·34**	1932	29-30	**9·40**							C
1933	29	5·40										C
			1934	29-30	6·29							B
1935	18	**7·34**	1935	17-18	7·49	1935	16-18	8·94				A
			1935	18-19	7·70	1935	18-20	9·24				
1937	28	4·08										C
						NOVEMBER						
1893	5	**6·30**	1893	4-5	**8·56**	1893	3-5	8·79	1893	3-6	**12·56**	A
			1893	5-6	**10·07**	1893	4-6	**12·33**	1893	4-7	**13·05**	
						1893	5-7	**10·79**	1893	5-8	11·49	
1895	25	4·66	1895	25-26	7·72	1895	24-26	8·23				C
1896	22	5·26										C
			1901	6-7	6·56							C
1903	6	4·95	1903	5-6	**8·51**	1903	4-6	8·94	1903	5-8	11·57	A
						1903	5-7	8·77				
						1903	6-8	8·01				
1908	2	5·06	1908	2-3	7·22							A
			1910	5-6	7·89	1910	5-7	8·20				A
			1910	6-7	7·33							
1910	21	4·31										C
1911	21	4·81	1911	20-21	7·38	1911	20-22	8·62				B
			1911	21-22	6·05							
1912	13	5·78										B
			1912	20-21	6·05							B
1913	10	5·78	1913	9-10	7·88	1913	8-10	8·88	1913	8-11	**12·80**	A
			1913	10-11	**9·70**	1913	9-11	**11·80**	1913	9-12	11·81	
						1913	10-12	9·71				
1914	2	5·86	1914	1-2	7·56	1914	31-2	9·18				A
1918	1	4·10	1918	1-2	7·49	1918	1-3	**13·43**	1918	31-3	**13·76**	C
1918	3	5·94										
1918	7	**6·09**	1918	2-3	**9·33**	1918	2-4	9·92	1918	1-4	**14·02**	
			1918	3-4	6·54	1918	5-7	**10·20**	1918	2-5	11·05	
			1918	6-7	**9·07**	1918	6-8	9·62	1918	3-6	10·64	
			1918	7-8	6·64				1918	4-7	10·79	
1918	11	**6·23**							1918	5-8	10·75	

*(A) Associated with well-marked depressions or cyclonic storms which were near enough to Madras to influence rainfall there

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(C) Not associated with depressions or cyclones

† Rainfall amounts exceeding by 2″ than the limits shown at the top of the respective columns have been indicated in thick types

TABLE 13 *(contd)*

4″ or more in a day			6″ or more in 2 days			8″ or more in 3 days			10″ or more in 4 days			*Weather Remarks
Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	Year	Date	Rainfall (*in*)	
						NOVEMBER—*contd*						
1919	6	4·29										C
1920	13	4·32	1920	12-13	7·79	1920	13-15	8·35	1920	12-15	11·82	C
1920	15	4·02										
1920	23	4·36	1920	23-24	**10·28**	1920	22-24	**10·94**	1920	22-25	**12·62**	B
1920	24	5·92				1920	23-25	**11·96**	1920	23-26	11·98	
1922	3	**6·71**	1922	2-3	**8·70**	1922	1-3	9·68	1922	31-3	11·28	A
			1922	3-4	7·71	1922	2-4	9·70	1922	1-4	10·68	
1922	16	**9·30**	1922	16-17	**9·33**							C
1926	4	4·42				1926	4-6	9·79	1926	3-6	10·00	C
1926	6	4·09							1926	4-7	11·66	
1930	29	**6·99**	1930	28-29	7·01	1930	28-30	9·27	1930	28-1	11·39	A
			1930	29-30	**9·25**	1930	29-1	**11·42**	1930	29-2	11·54	
1931	1	**6·48**	1931	31-1	7·49							A
			1931	1-2	6·77							
			1932	24-25	6·10							A
						1937	3-5	8·22				C
1937	16	5·65	1937	15-16	7·10	1937	14-16	**10·33**	1937	14-17	**12·20**	A
			1937	16-17	7·52	1937	15-17	8·97				
						1937	16-18	8·34				
1940	11	5·06										
						DECEMBER						
1896	5	4·37										
1896	7	4·40	1896	7-8	7·64	1896	5-7	**10·06**	1896	5-8	13·28	C
						1896	6-8	8·91				
						1896	7-9	8·23				
1898	26	4·10										C
1901	10	**10·30**	1901	9-10	**11·65**	1901	8-10	**13·48**	1901	8-11	**14·11**	A
			1901	10-11	**10·95**	1901	9-11	**12·30**				
1902	4	5·25	1902	3-4	6·38							C
1903	30	5·72	1903	29-30	6·03	1903	29-31	**12·21**	1903	28-31	**12·22**	A
1903	31	**6·18**	1903	30-31	**11·90**	1903	30-1	**13·14**	1903	29-1	**13·45**	
			1903	31-1	7·42				1903	30-2	**13·69**	
1906	14	4·18										B
1933	16	**6·42**	1933	15-16	**8·47**							
1933	17	5·53	1933	16-17	**11·95**	1933	14-16	8·68	1933	14-17	**14·21**	A
						1933	15-17	**14·00**	1933	15-18	**14·02**	
						1933	16-18	**11·97**				
1937	11	5·55	1937	10-11	6·16							C

*(A) Associated with well-marked depressions or cyclonic storms which were near enough to Madras to influence rainfall there

(B) Associated with low pressure waves or depressions so far away that their influence on Madras rainfall is dubious

(C) Not associated with depressions or cyclones

† Rainfall amounts exceeding by 2″ than the limits shown at the top of the respective columns hav been indicated in thick types

taken by the remaining three months brings this out prominently. In March, April, June, August and September, no instance of heavy rain (on the basis above adopted) occurred. Stray instances— one each—did occur in January, February and July; but these should be considered as not very significant. Thus the only month from January to September in which heavy rain has some chance is May.

12.3. The number of spells of each category in the remaining three months, *viz.*, October, November and December are given in Table 14.

It may be mentioned that some of these spells will have one or more days in common. For instance the rainfall amounts on 27, 28 and 29 October 1902 were 0·14″, 9·16″ and 1·01″. The six inch limit is reached by both combinations 27-28th and 28-29th. Thus the date 28 October enters in two spells of 6″ or more in 2 days.

12.4. The highest total in each category is given below in Table 15 along with dates of occurrence.

12.5. The distribution of the spells of heavy rain according to intensities, irrespective of month of occurrence, is shown in Table 16.

12.6. All rainfall amounts exceeding by 2″ or more than the limits shown at the top of the respective columns of Table 13

TABLE 14

Number of spells of heavy rain in October, November and December

Month	4″ or more in 1 day	6″ or more in 2 days	8″ or more in 3 days	10″ or more in 4 days
Oct	21	26	26	21
Nov	27	31	29	22
Dec	11	10	10	7

TABLE 16

Frequency of spells of heavy rain according to intensities irrespective of month of occurrence

Rainfall range (*inches*)	One-day spells	Two-day spells	Three-day spells	Four-day spells
	Frequency			
4·01— 5·00	25	..	..	..
5·01— 6·00	21	..	..	..
6·01— 7·00	10	21	..	..
7·01— 8·00	2	22	..	..
8·01— 9·00	2	10	26	..
9·01—10·00	2	8	15	..
10·01—11·00	1	5	8	11
11·01—12·00	..	4	6	13
12·01—13·00	..	..	3	9
13·01—14·00	..	..	5	7
14·01—15·00	..	..	1	3
15·01—16·00	..	..	..	1
16·01—17·00	..	..	..	..

TABLE 15

1-day spell				2-day spell				3-day spell				4-day spell			
Date	Month	Year	Total rainfall (*in*)	Date	Month	Year	Total rainfall (*in*)	Date	Month	Year	Total rainfall (*in*)	Date	Month	Year	Total rainfall (*in*)
10	Dec	1901	10·3	23-24	Oct	1908	11·9	22-24	Oct	1908	14·3	26-29	Oct	1920	17·3
				30-31	Dec	1903	11·9								
				16-17	Dec	1933	11·9								

for the different periods have been indicated by thick type. For instance, for two-day spells, 6″ is taken as the minimum to be considered heavy. Falls of 8″ or more in 2 days are printed in thick type. These may be considered as exceptionally heavy.

13. Association of heavy falls with depressions and storms

In order to see how far the heavy falls were directly connected with depressions or cyclonic storms, the accounts of such depressions etc in the India Weather Reviews and in some years the Monthly Weather Reviews of the periods when there was heavy rain were looked into. The weather situations were divided into three groups, *viz.*,

A. Well-marked depression or cyclonic storm near enough to Madras to influence rainfall there

B. Low pressure wave, or depression so far away that their influence on Madras rainfall must be doubtful

C. No depression, storm, or even low pressure wave effecting weather over Madras.

The general weather in each spell is indicated in Table 13 by the letters A, B or C in the last column. Summarising the examination, the 60 spells of heavy falls were distributed over the three categories A, B and C as follows—

A	B	C
26	12	22

In distinguishing A and B, no hard and fast rule was adhered to. An element of subjectivity would thus have crept into this division, but on actual examination of a few cases, it will be seen that most meteorologists will agree with the classification in most cases.

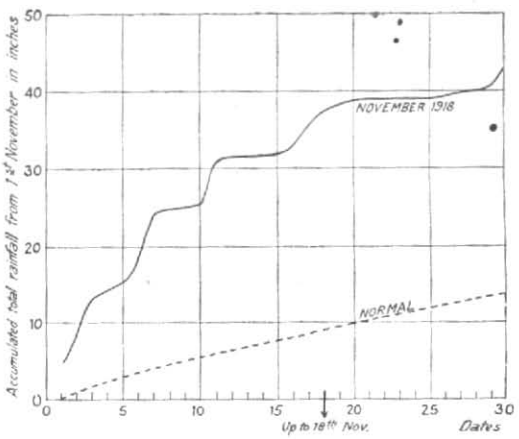

Fig. 9. Exceptionally heavy rainfall at Madras in November 1918

Quite a large number of spells of heavy rain thus occurred unconnected with depressions or storms—that is, as far as can be judged from available data. Nor could it be said that the heavier falls are so associated—for instance, see spells in October 1920, November 1918 or December 1896.

14. The exceptionally high rainfall of November 1918

14.1. One feature which will impress any one who looks through the rainfall data of Madras in these 50 years as very remarkable is the exceptionally high total rainfall that occurred in November 1918. As against the monthly normal of 13·6″, this particular November had 42·85″ which is about 315 per cent. The next lower November, which was in 1922, had 32·83″ or just 240 per cent of the normal. The progressive total rain from 1 November 1918 till the end of the month, with the normal for comparison, has been shown in Fig. 9.

14.2. The deviation from normal was in fact more pronounced in the first 18 days. The total upto 18th was 37·74″, against a normal of 9·43″—the actual was thus 400 per cent of the normal for this 18-day period.

14.3. There were, in this November, one storm which crossed coast very near Madras in the early hours of the 11th and

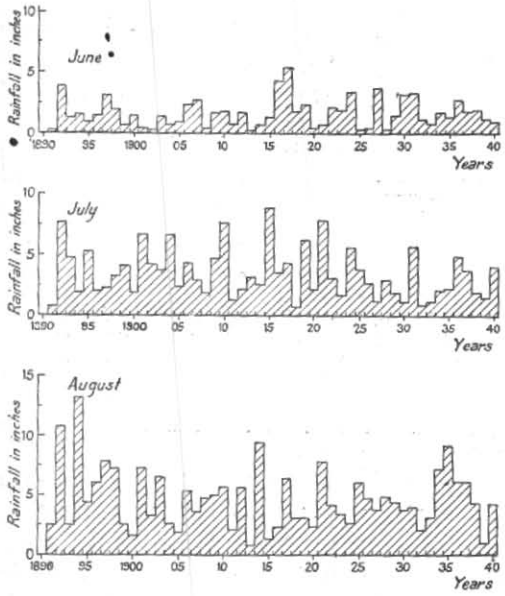

Fig. 10. Monthly total rainfall of Madras (Nungambakam) year by year (1891-1940)

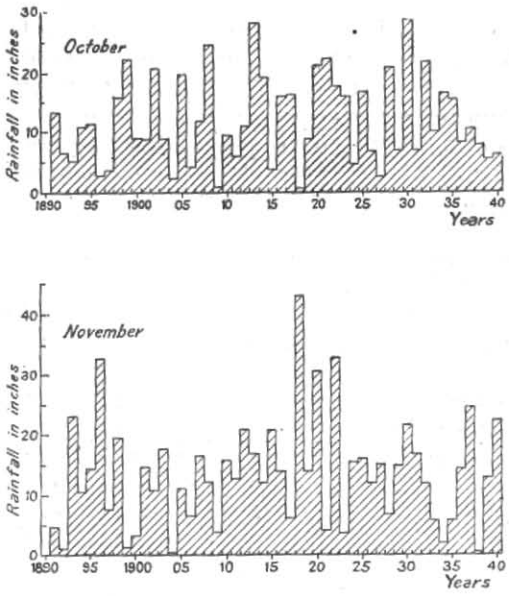

Fig. 11. Monthly total rainfall of Madras (Nungambakam) year by year (1891-1940)

a depression which moved over the Bay from the 17th to the 21st almost parallel to the coast and at a distance of 150 to 200 miles from it. However one depression and one storm are not exceptional for November and so do not explain away the heavy rainfall of the month.

15. Variability of rainfall from year to year

In order to give an idea of the variability of the rainfall from year to year, the monthly totals of each of the 50 years studied are represented diagrammatically in Figs. 10 and 11. Diagrams are shown only for selected months, June, July and August to represent the southwest monsoon season and October and November to represent the northeast monsoon season. The diagrams bring out the comparatively smaller variability in the southwest monsoon season. The disparity between the two seasons, however, gets narrowed down—almost disappears—when the individual year's (or month's) rain is expressed as a percentage of the normal. This has been done in Figs. 12 (June and July) and 13 (October and November).

16. Some miscellaneous points of interest incidental to the study

The following are some miscellaneous points of interest brought out during the study.

16.1. The calendar dates on which rain *never* occurred in all the 50 years investigated are—

28 January, 10 February, 5, 6, 7, 8, 17, 18, 21, 24 and 25 March, 6 and 30 April and 1 and 3 May*.

It is not suggested that this result is significant in respect of each date. However, the fact that there have been 9 such days in March cannot be brushed aside as accidental. Two spells of about 4 days each in March, one towards the end of the first week and the other spread between the third and fourth weeks,

* The normal rainfall, expressed to the nearest cent, will be " zero " on a few more dates. On the remaining dates, however, the zero only means that the total rain on the date in all the 50 years was less than 0·25". Rain might have occurred in several years but may have been so light that the total would have failed to accumulate to 25 cents

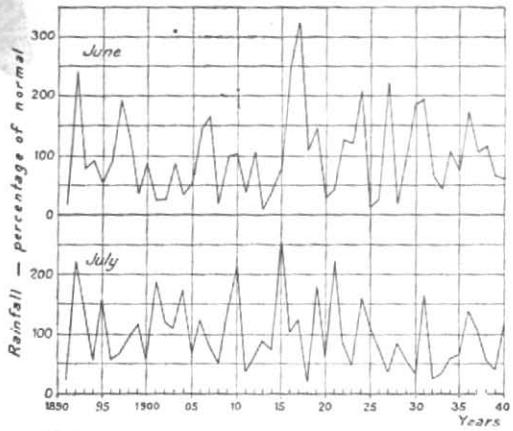

Fig. 12. Monthly total rainfall of Madras—Nungambakam year by year (1891-1940) (Expressed as percentage of normal)

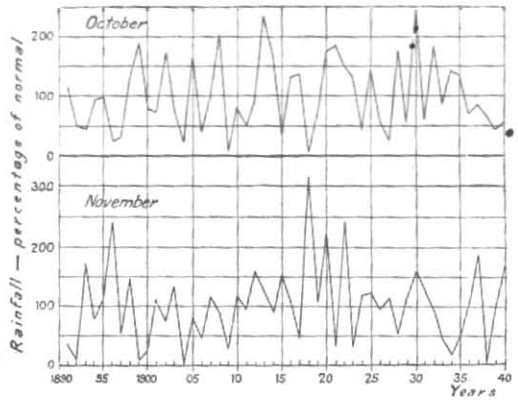

Fig. 13. Monthly total rainfall of Madras (Nungambakam) year by year (1891-1940) (Expressed as percentage of normal)

have the greatest probability of being rain-free in Madras. Putting the same in another way, if one is faced with the question of when one can have a stretch of 4-5 dry days in Madras, the anwser is : " Look for it in the first week or the second half of March ".

16.2. In the 50 years, there was no rain in February in 28 years, in March in 32 years and in April in 22 years. In 21 of these, there was no rain either in February or in March. Eight years—1895, 1896, 1904, 1911, 1912, 1922, 1927 and 1935 had droughts in February, March and April, while four years, *viz.*, 1895, 1911, 1937 and 1938, had their entire first quarters dry. 1895 and 1911 had the distinction of having droughts for their first four months.

16.3. One may like to have an idea of the pattern in which these dry — rather comparatively drier—years occur. A good idea can be formed by seeing the years in which March, the driest month, was so. The years were 1891, 92, 94, 95, 96, 98, 99, 1900, 02, 03, 04, 07, 08, 09, 10, 11, 12, 13, 14 (8 consecutive years), 16, 17, 20, 21, 22, 26, 27, 31, 32, 34, 35, 37 and 38.

16.4. In 1930, 28·84″ fell on 25 days in October and 21·45″ fell on 20 days in November. These two months thus had 50·29″, which is just above the normal for a whole year.

16.5. 1918, the year in which November had the record heavy fall of 42·85″, also happened to be the year in which October had the lowest total rain in 50 years, *viz.*, 0·44″. One may be tempted to conclude *A poor October will be compensated by a good November*. The hope will get shattered by seeing the rainfall in 1909, when October had 0·61″, and November had only 3·7″.

16.6. Falls of 10″ or more in 24 hours which occurred at Madras in the period prior to 1891 are—

9-5-1827	12·1″	24-10-1857	18·0″
21-10-1846	20·6″	18-5-1877	12·1″

No fall of 10″ or more occurred in the period 1941-1951.

17. Acknowledgements

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