SUPERPOSED EPOCH STUDY OF THE RAINFALL OF KERALA DURING THE ONSET PHASE OF THE SOUTHWEST MONSOON

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ABSTRACT

Using daily areal rainfall from a dense raingauge network, the dates of onset of the southwest monsoon over south and north Kerala have been derived on the basis of objective criteria for the years 1901 to 1980 and the statistics of the dates of onset presented. The sharp increase in the rainfall that heralds the onset of the monsoon is spectacularly brought out by the superposed epoch method. The prevailing concept that the rainfall due to premonsoon thunderstorms progressively increases and merges with the monsoon rainfall is shown to be not correct.

INTRODUCTION

The southwest monsoon (or summer monsoon) season is traditionally known as 'Edavappadi' in Kerala. Literally this term means the middle of the Malayalam month of 'Edavam'. This date coincides almost exactly with the 1st of June which is the normal date of onset of the southwest monsoon rains over Kerala according to the records of the India Meteorological Department (IMD). The local nomenclature for the southwest monsoon which associates a fixed date for the entire season implies that the near regularity in the onset of the monsoon rains around the normal date was known to the residents of Kerala from the remote past. The onset of the southwest monsoon over Kerala marks the beginning of the rainy season for the Indian subcontinent and hence is an annual event of national and meteorological importance and significance.

TRANSITION FROM THE PRE-MONSOON TO THE MONSOON SEASON

January and February are months of least rainfall over Kerala. With growing insolation accompanying the apparent annual northward march of the sun, thunderstorm activity sets in and progressively increases in frequency and associated rainfall through the months of March–April–May, culminating in the onset of the southwest monsoon. Although the mean date of onset of the southwest monsoon is around 1 June, there are year to year fluctuations in the onset date. This can be seen from figure 1, in which the frequencies of monsoon onset dates over south Kerala in 3-day chronological intervals are depicted for the 80-year period 1901 to 1980. During this period the earliest date of monsoon onset over south Kerala was 7 May in 1918 and the latest date was 22 June in 1972. Incidentally it may be noted that these two extreme years were characterized by poor monsoon rainfall leading to severe drought conditions over large parts of the country.

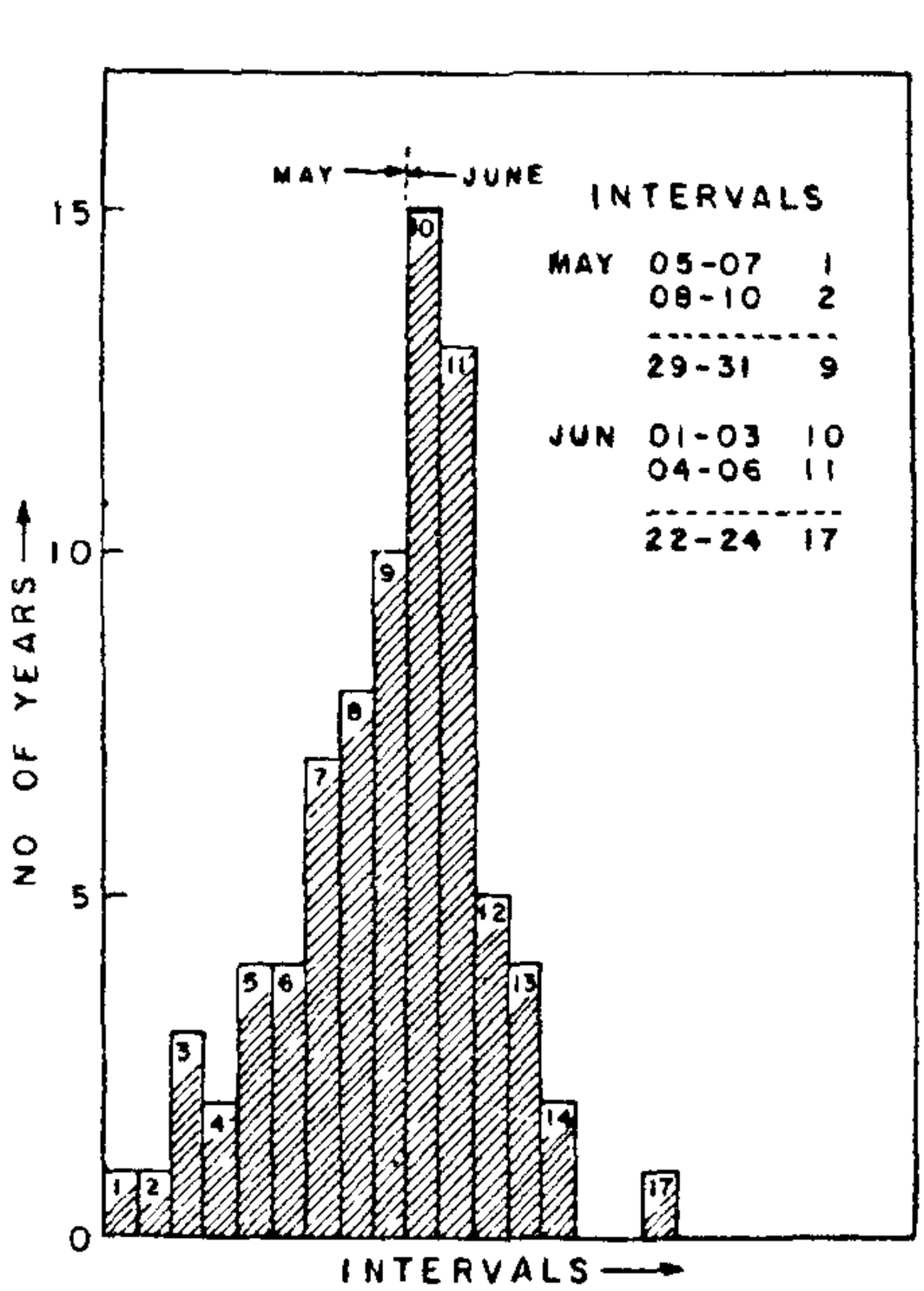

Figure 1. Frequency distribution of onset dates of southwest monsoon over south Kerala (1901–1980).

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NORMAL DATES OF ONSET OF THE SOUTHWEST MONSOON

Figure 2 taken from one of the IMD publications[1] shows isolines of the mean onset dates of the southwest monsoon over different parts of the country. Starting from 20 May over the Andaman group of islands in the Bay of Bengal, the isolines show a rough southeast-northwest progression of the monsoon rains, covering the entire sub-continent by mid-July. For our present purpose we note that the mean onset date over Kerala is around 1 June.

We shall consider briefly how figure 2 was constructed as this has a bearing on the theme of the present contribution. Normal pentad rainfall of individual observatory stations for the period up to 1940 forms the basis of the diagram. It has been stated that a sharp increase in the rainfall, signifying the onset of the monsoon was noticed in the pentad rainfall curves of individual stations; the middle date of the pentad in which such increase was noticed was taken as the onset date for each station. Such dates were depicted on a chart and isolines were drawn as shown in figure 2.

Although, over four decades have elapsed since the publication of the IMD diagram no one appears to have examined whether the technique of picking up the mean onset dates for individual stations as stated is realistic. This question came into focus some time ago, during an examination of the pentad rainfall diagrams of a large number of stations over India and adjacent areas prepared on the basis of more recent data[2,3]. None of the rainfall diagrams showed a sharp increase which could be identified as the onset of monsoon. On the other hand, all the diagrams showed a progressive increase of rainfall starting from low values and reaching a maximum.

As an example, the normal pentad rainfall curves for three stations along the Kerala coast, Kozhi-

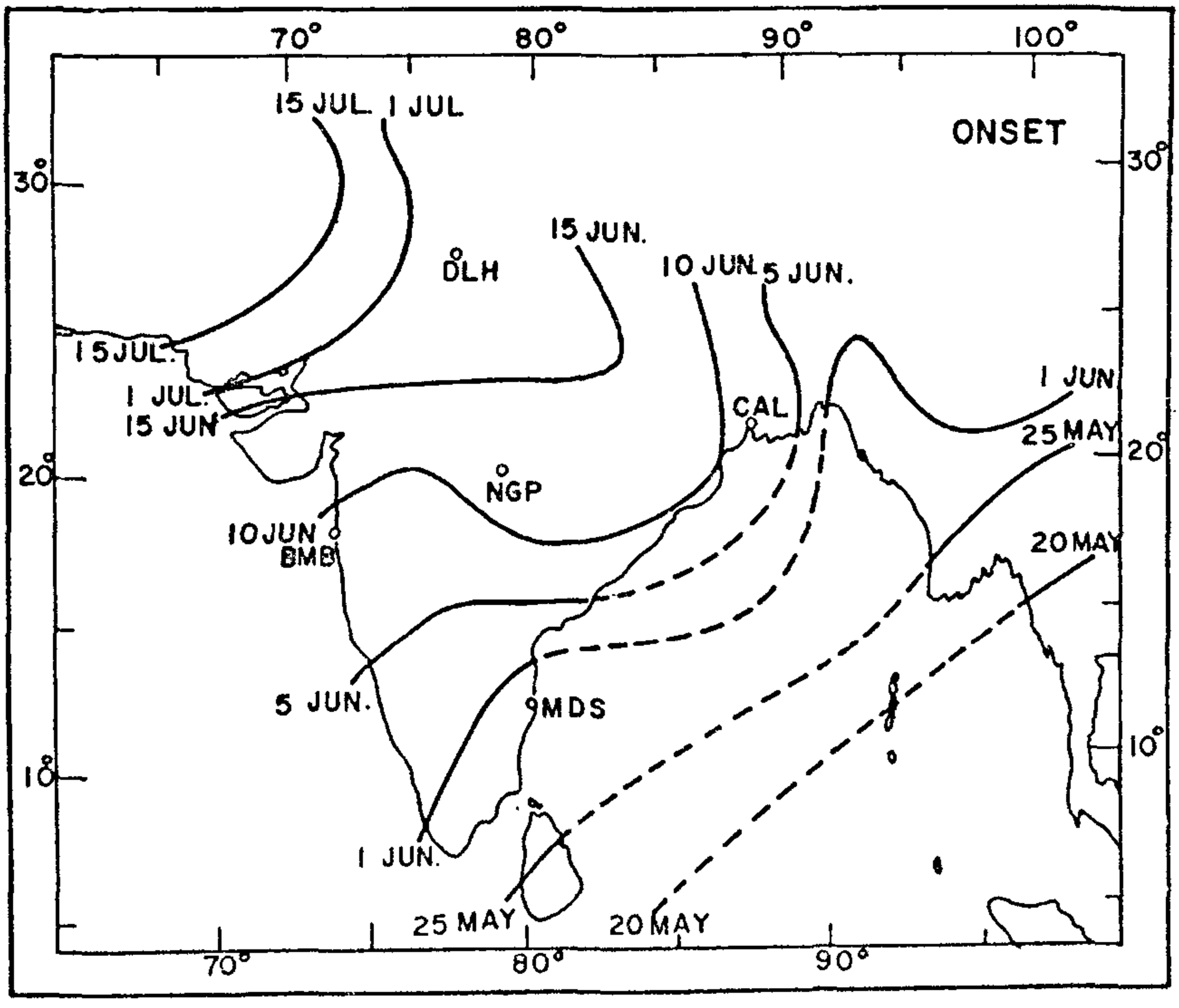
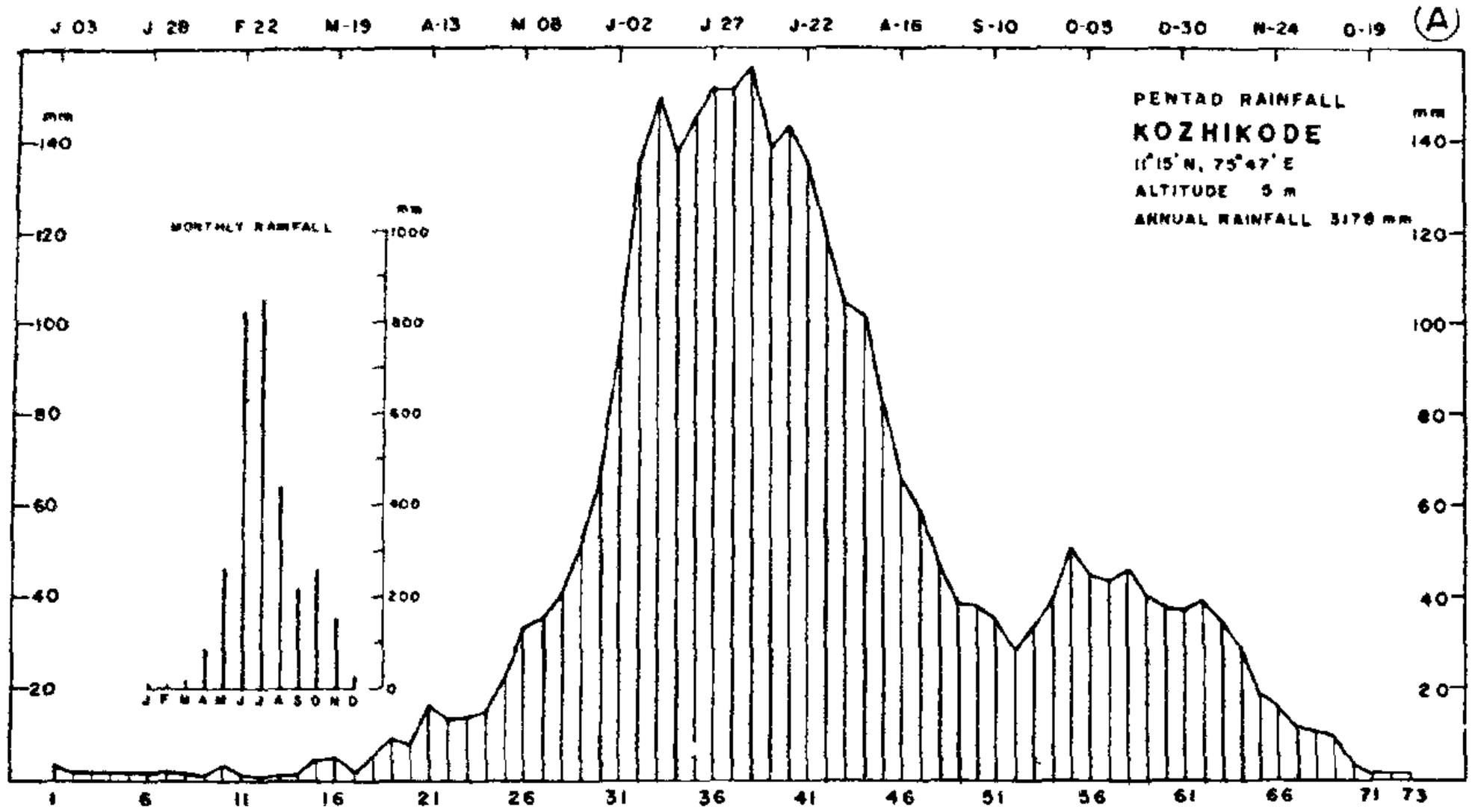


Figure 2. Normal dates of onset of the southwest monsoon. (India Met. Dept.).



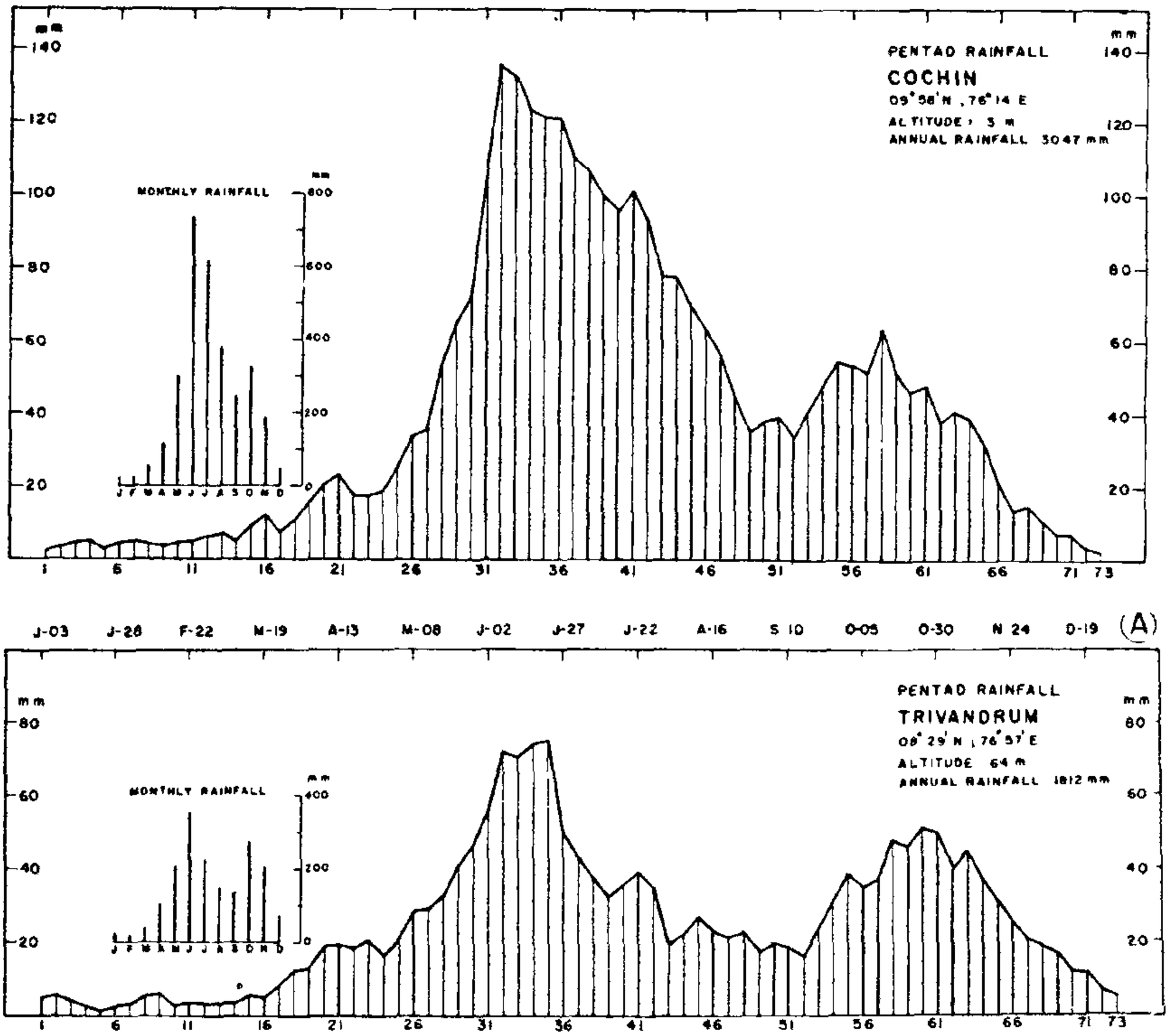


Figure 3. Normal pentad rainfall diagrams for Kozhikode, Cochin and Trivandrum.

kode, Cochin and Trivandrum are shown in figure 3. It may be noted that it is not possible to fix unambiguously the pentad of monsoon onset from these rainfall curves. The middle date of pentad 30 is 28 May and that of pentad 31 is 2 June. At Trivandrum and Cochin (south Kerala) the rainfall has already crossed 50% of the maximum by pentad 30, while by pentad 31 the rainfall has reached about 75% of the maximum. Thus the rainfall of the south Kerala stations has already crossed 70% of the maximum by the normal onset date of 1 June. A similar examination of the pentad rainfall curves of more than 100 stations across the country vis-a-vis the normal dates of monsoon onset as given in figure 2 showed a wide scatter of the ratio of the actual rainfall during the onset pentad to the peak station rainfall, varying from about 75 to 15%; the lowest values were noticed over the Saurashtra-Kutch region and the largest values over Kerala and northeast India[3].

As we shall see presently, the procedure for fixing the onset date as stated in the IMD publication is not realistic. It will be valid only if the monsoon onset takes place near about the same date in all the years. However, as we have seen there is a large dispersal of the onset dates spanning a period of some six weeks for south Kerala. This is also the case for other parts of the country. On account of this, the sharp increase in rainfall that characterizes the monsoon onset gets smoothed out when the daily or pentad rainfalls for several years are *chronologically* added. The resulting normal rainfall curve will not show a sharp increase, which can be identified as the onset pentad. This is borne out by the actual normal pentad rainfall curves which show a gradual increase from low values to a peak value over the interval spanning the onset dates in individual years. This point does not appear to have been clearly appreciated by the authors of the IMD publication. This publication also states that for Kerala stations there is some difficulty in uniquely fixing the onset dates because of the monsoon rainfall merging with the pre-monsoon thunderstorm rain. Our recent study shows that this is not correct. There is a clear distinction between pre-monsoon rains associated with sporadic pre-monsoon thunderstorm activity and monsoon rainfall resulting from deep convection accompanying the advance of the ITCZ over Kerala during the monsoon onset phase. As compared with the pre-onset phase there is a spectacular sharp increase of rainfall heralding the monsoon onset if we examine the rainfall data for individual years.

RAINFALL NETWORK AND AREAL RAINFALL SERIES

Our study of the monsoon onset over Kerala is based on the daily average areal rainfall worked out from a dense network of raingauge stations for the years 1901 to 1980. The data of 75 stations, of which 44 are in south and 31 in north Kerala have been utilized (figure 4). Areal rainfall series were constructed separately for south and north Kerala. These series for individual years revealed that the rainfall sequence is characterized by spells of light and heavy amounts of rainfall with distinctly different features. The data showed that the limit of 10 mm per day demarcates the two types of spells. During light spells, the average daily areal rainfall varies from 2 to 7 mm, while during heavy spells it varies from 15 to 50 mm, showing the distinctly different nature of the associated physical mechanisms. The rainfall time series showed that the pre-monsoon thunderstorm season is generally associated with areal rainfall of the light spell category which gives place to heavy spells heralding the monsoon onset. The date of the onset of monsoon is taken as the first day of such transition with the proviso that the heavy spell should have a

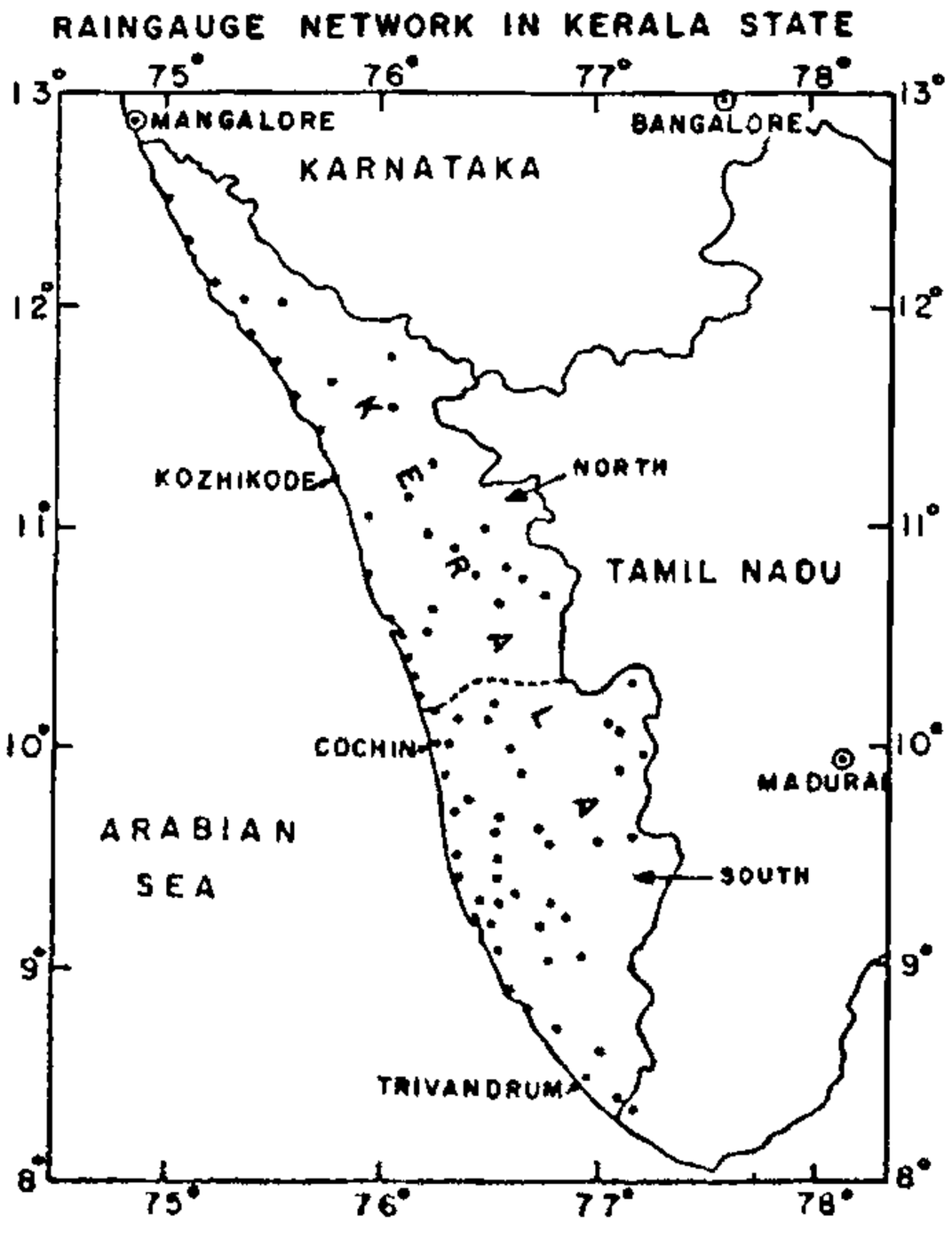


Figure 4. Location of raingauge stations in south and north Kerala.

duration of five days or more. The monsoon onset dates for the years 1901 to 1980 were fixed in this manner. Figure 1 is based on the onset dates for south Kerala thus derived. A comparison of these onset dates with the onset dates given in the records of the IMD shows some differences, the IMD dates being later by 2 to 3 days in many years.

STATISTICS OF MONSOON ONSET FOR SOUTH AND NORTH KERALA

Some statistical parameters relating to the monsoon onset dates for south and north Kerala based on the objective criteria are given in tables 1 and 2 for the period 1901–1980.

Note that during the 80-year period the monsoon onset dates were equally distributed between May and June over south Kerala, while over north Kerala the onset years were distributed in the ratio 3:5. The extreme onset dates were practically the same for both south and north Kerala. The mean onset date was 30 May for south Kerala with a standard deviation of 8.8 days; the corresponding date was 1 June for north Kerala with practically the same standard deviation. Table 1 shows that the 3-day interval 1 to 3 June had the largest number of onset years for south Kerala; the peak interval was 4 to 6 June for north Kerala.

A comparative study of the dates of the onset of the monsoon over south and north Kerala in individual years shows that in 45 years out of 80 the onset date over north Kerala was either the same as for south Kerala or later by 1 to 2 days. However, in about 25% of the years, the onset over north Kerala was delayed by 3 days or more, the extreme value exceeding 10 days in a couple of years. There were also 12 years in which the onset was earlier over north Kerala. This may look anomalous if one is conditioned to look at the monsoon onset with the background of figure 2 in one's mind. The monsoon onset and associated rainfall patterns in individual years are far more complex than what is revealed by figure 2 based on the long-period average pentad rainfall of individual stations. For example, while figure 2 shows that the mean date of onset of the monsoon over the central parts of the country is about a fortnight later than the onset over Kerala, there have been years of nearly simultaneous onset of the monsoon rains over these two regions.

Table 1 *Number of onset years with monsoon onset falling in various 3-day intervals in May and June*

Interval	South Kerala	North Kerala	Interval	South Kerala	North Kerala
May			June		
5–7	1	0	1–3	15	12
8–10	1	2	4–6	13	18
11–13	3	2	7–9	5	7
14–16	2	3	10–12	4	8
17–19	4	1	13–15	2	2
20–22	4	5	16–18	0	1
23–25	7	3	19–21	0	0
26–28	8	8	22–25	1	1
29–31	10	7			
Total	40	31		40	49

Table 2 *Mean, median and standard deviation of onset dates*

Parameter	S. Kerala	N. Kerala
Mean date	30 May	1 June
Standard deviation	8.8 Days	8.9 Days
Median date	1 June	3 June
Earliest onset date	7 May 1918	8 May 1918
Latest onset date	22 June 1972	22 June 1972

SUPERPOSED EPOCH ANALYSIS OF DAILY RAINFALL IN RELATION TO THE MONSOON ONSET

We have already mentioned that the onset of the monsoon is characterized by a sharp increase in rainfall in individual years while this feature is not brought out well when rainfall data are chronologically combined and averaged for a period of several years. To highlight this aspect we present here the results of superposed epoch analysis of the daily rainfall data for south and north Kerala. In this study the onset date is labelled zero day for all the years and the annual daily rainfall data series are arranged with the zero day for all the years superposed. The rainfall data are then averaged to obtain the mean daily rainfall for the zero day and for the days $\pm n$ ($n = 1, 2, 3, \ldots$). Figures 5a and b give a pictorial representation of the superposed epoch daily rainfall data series for south and north Kerala. In these diagrams the zero day which is the onset day is shown by the cross-hatched pillar and daily rainfall data are presented for 70 days before and 90 days after the onset day.

What stands out conspicuously in these diagrams is the steep increase in rainfall on the onset day compared with the pre-onset phase. Thus for south

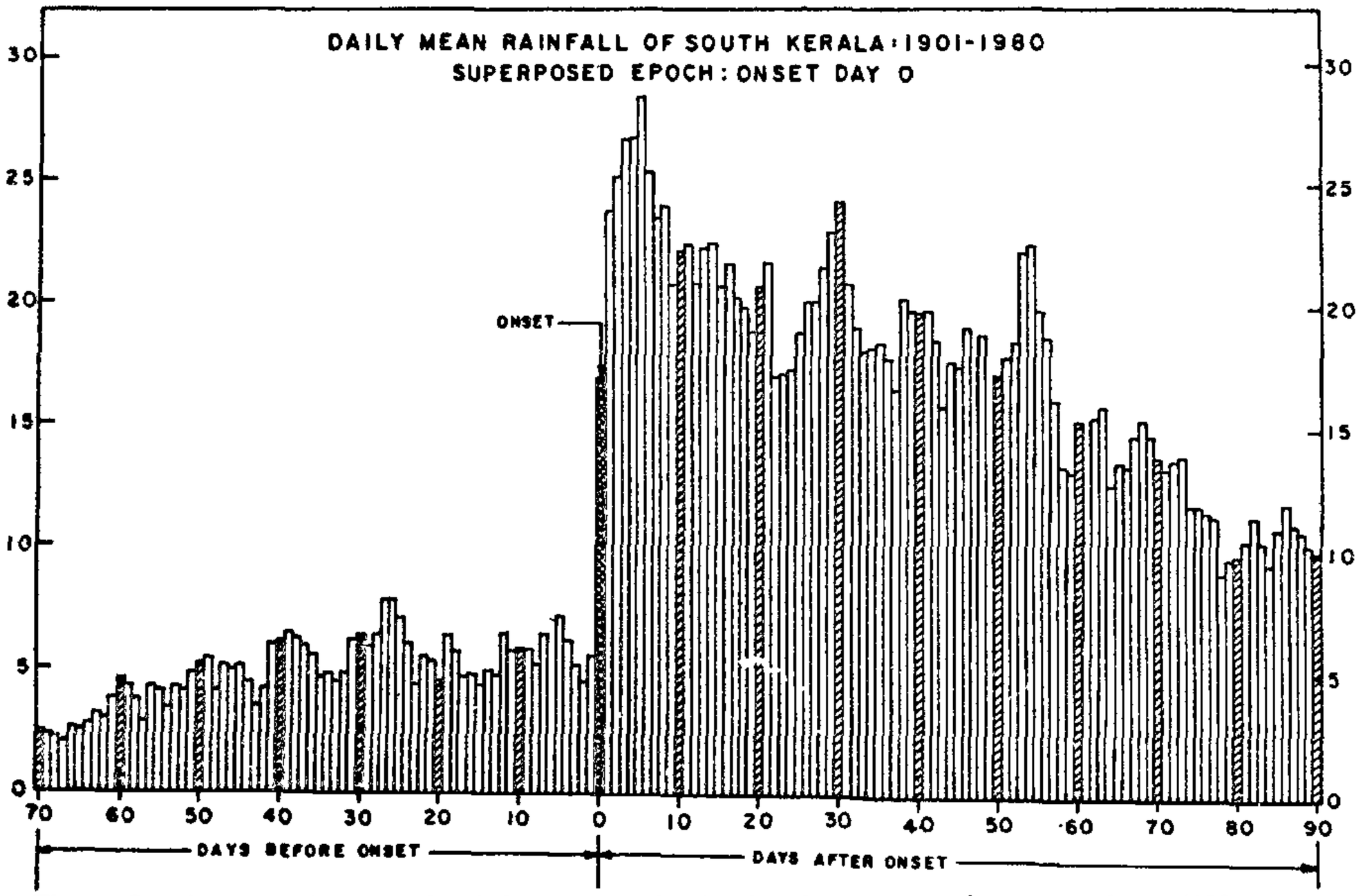


Figure 5a. Average daily areal rainfall for south Kerala after superposing onset dates (1901–1980)

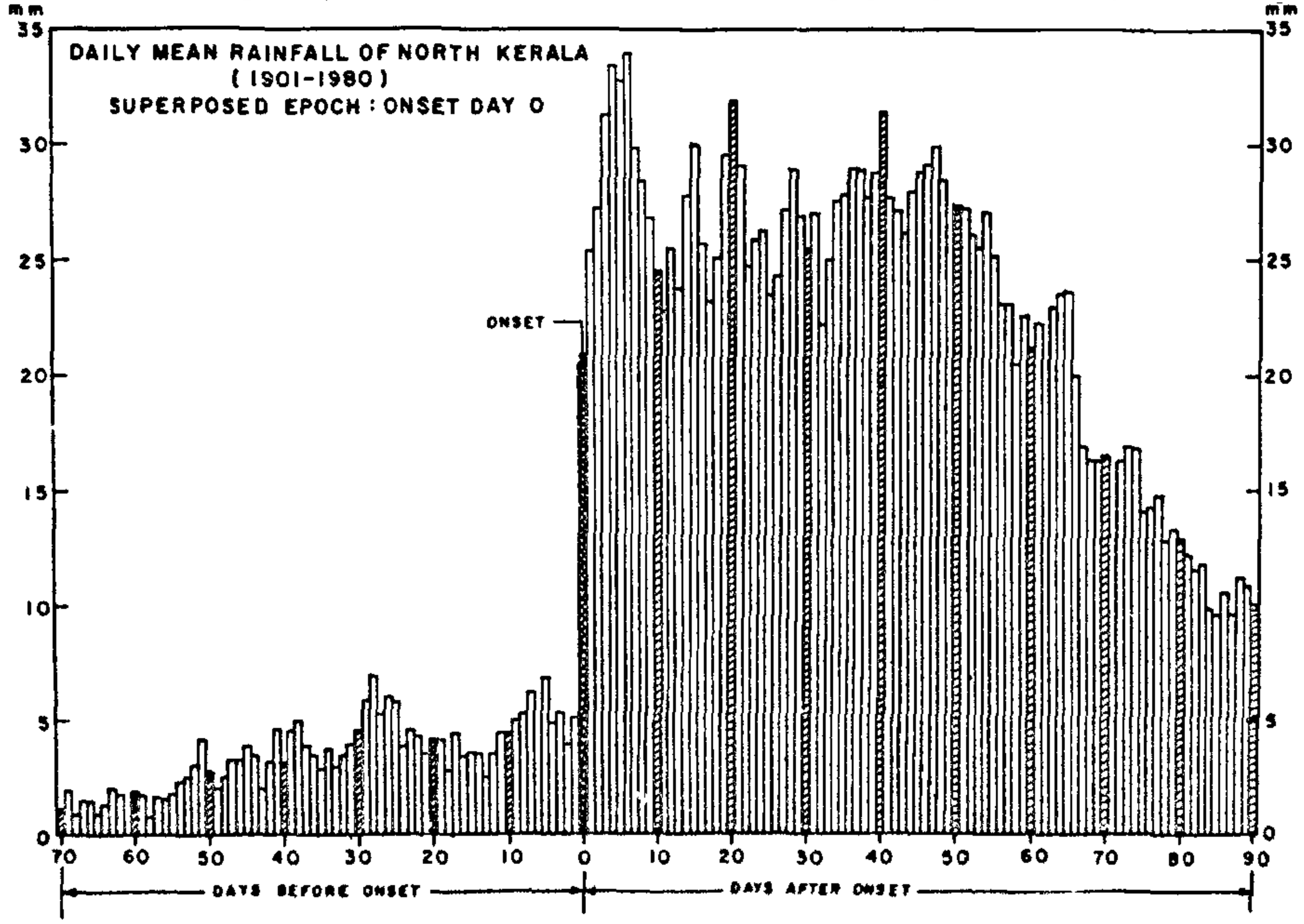


Figure 5b. Average daily areal rainfall for north Kerala after superposing the onset dates (1901–1980).

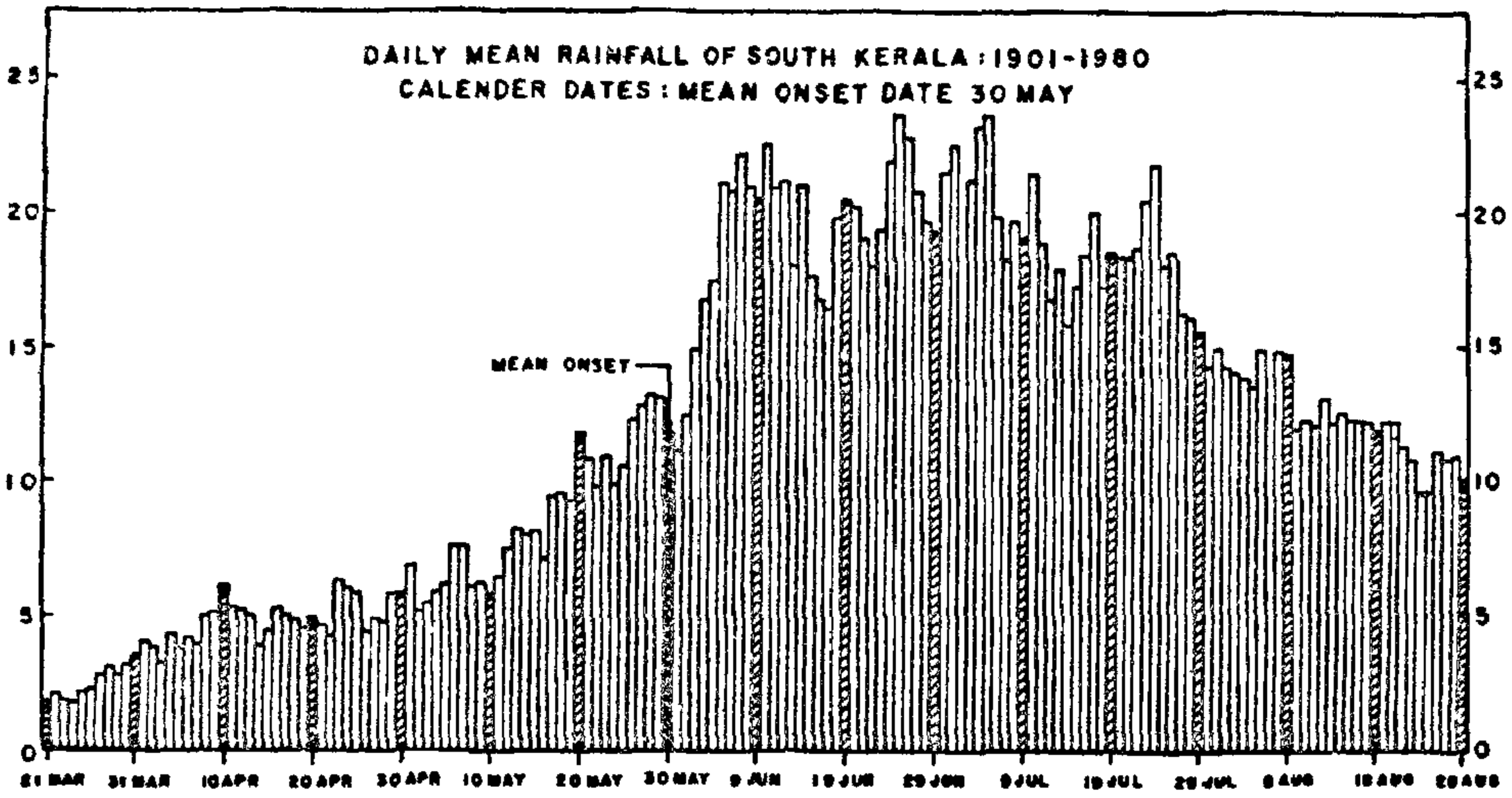


Figure 6a. Chronologically averaged daily areal rainfall for south Kerala (1901–1980).

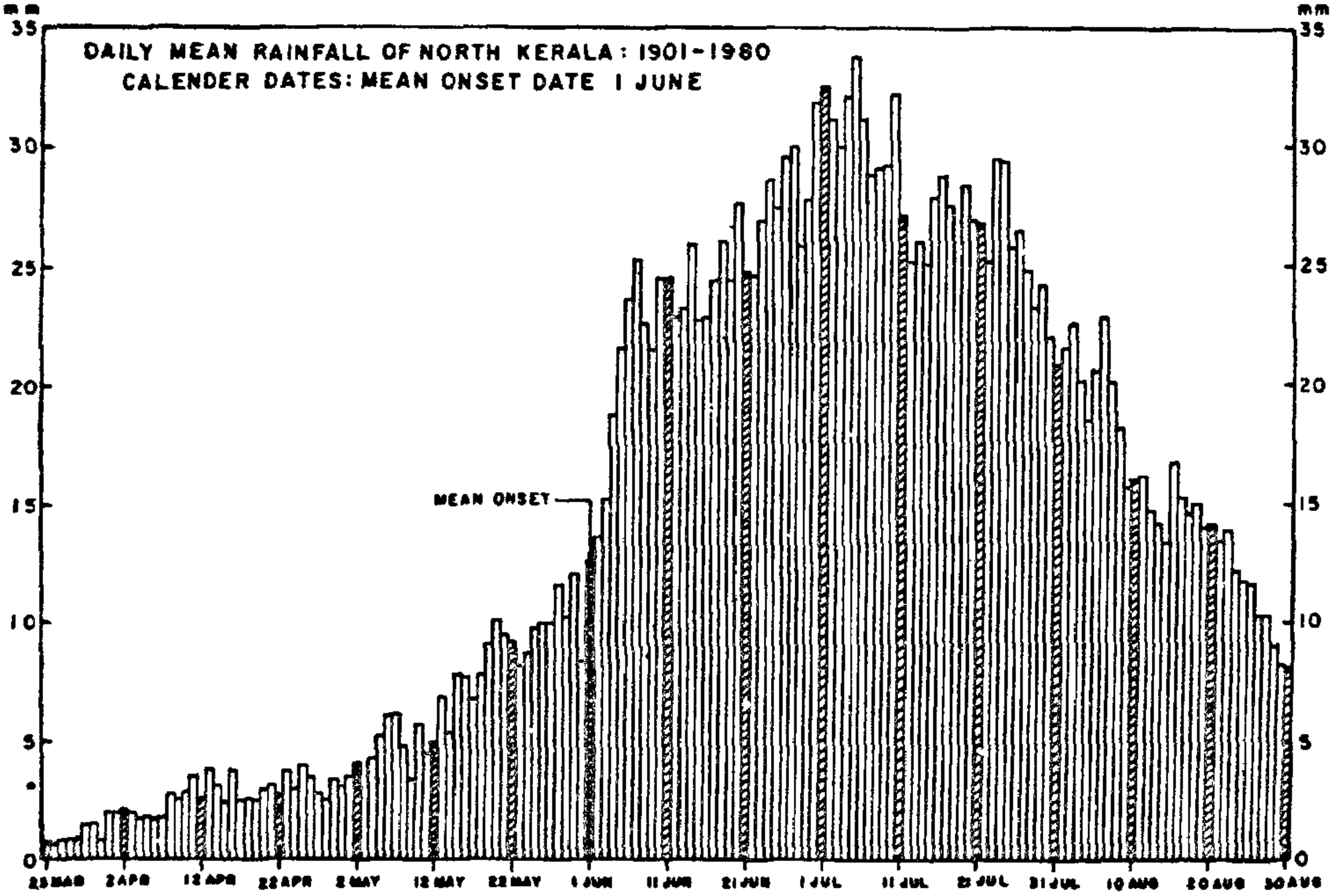


Figure 6b. Chronologically averaged daily areal rainfall for north Kerala (1901–1980).

Kerala, the level of daily rainfall during 30 to 40 days prior to the onset day is around 5 to 6 mm/day. This is the average level of rainfall due to pre-monsoon thunderstorm activity. It is important to note that the rainfall from pre-monsoon thunderstorm activity does not go on progressively increasing but levels off by about the middle of April. On the onset day the rainfall sharply rises to the level of 17 mm/day. The rainfall continues to increase reaching a peak value of about 28 mm/day during the next 5 to 6 days followed by gradual oscillatory decline. Three rainfall peaks separated by about 25 days may be noted during the first 60 days after the onset.

For north Kerala where the level of pre-monsoon thunderstorm activity is less than for south Kerala, the pre-onset rainfall level is about 4 to 5 mm/day. The rainfall on the onset day is a little in excess of 20 mm/day, peaking to about 34 mm/day during the next 5 or 6 days. During the first 50 days after the onset the rainfall level remains nearly steady with oscillatory features. Thereafter, there is a rapid decline, the rainfall reaching the same level as for south Kerala at the end of 90 days after the onset.

As a contrast the chronologically averaged daily rainfall data for the period from the third week of March to about the end of August for south and north Kerala are depicted in figures 6a and b. The rainfall pillars corresponding to the mean onset date as given in table 2 are shown cross-hatched in these diagrams. Notice that from about 10th May till the mean onset there is a progressive increase in the mean daily rainfall. This arises from the superposition of the monsoon rainfall in years of early monsoon onset on the pre-monsoon thunderstorm rain of the remaining years. After the mean onset date there is a steeper increase in mean daily rainfall. This is more pronounced for north Kerala than for the south because of the larger number of onset years after the mean onset date (table 1).

The peak rainfall during the onset phase is higher in the superposed epoch diagrams in figure 5 than for the chronologically averaged data in figure 6. There are also other differences. Note that for north Kerala, figure 5b shows maximum rainfall peak within a week of the onset day. while figure 6b shows rainfall maximum in the first week of July. The superposed epoch diagrams give a more realistic picture of the rainfall behaviour in relation to the monsoon onset in individual years than the long-term choronologically averaged data.

CONCLUSION

Based on objective rainfall criteria the mean dates of onset of the southwest monsoon during the period 1901 to 1980 is found to be 30th May for south Kerala and 1 June for north Kerala with a standard deviation of about 9 days. Analysis of the daily areal rainfall by the superposed epoch method shows that the prevailing notion that the pre-monson thunderstorm rain over Kerala progressively increases and merges with the monsoon rainfall is not correct. The onset of the monsoon is heralded by a sudden spectacular increase in rainfall.

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