The Rainfall Rhythm in Ceylon

' It never rains but pours '

PERHAPS no other epithet is expressive of the feelings of the average visitor who steps ashore our island, especially during the Monsoonal period. Thus to him, the 'Monsoonal Shower' epitomises the climate of Ceylon. In fact, on his return to his own country, perhaps the one unforgettable memory of the island would undoubtably be the 'Monsoon' with its associated ' deluges'. Even to the average Ceylonese the 'Monsoon' is synonymous with the accompanying rainfall, though meteorologically it is only a wind. However, it is rainfall, more than any other phenomenon that dominates the climatic scene in the island. In fact, even the island's economy-agrarian as it is—is immutably bound up with this climatic attribute. The revenue of this country—the major proportion of which is realized by her undiversified export (plantation) economy—is again dependant upon the rainfall factor. Throughout the island's history, the rôle of rainfall, expressed indirectly through rivers and ground water, has been very significant. In the tank-myriad landscape in the so-called ' Dry Zone ' flourished the ' Glory that was Lanka '. Some even maintain that the decline of the Sinhalese Kingdoms of Lanka and the ' southward migration ' was due to the changing climate—namely the onset of a period of desiccation; this contention however has not yet even assumed the guise of scientific truth. It must be realized though, that periods of ' drought spells ' have been a common feature in the ' Dry Zone' ; this is true even today.[1] The emphasis on rainfall in the climate of Ceylon, is even revealed in the attempts to demarcate ' climatic regions' and in designating them, ' Wet', ' Dry ' and ' Arid ' Zones. Even in the island's future ' industrial ' developments, rainfall in the form of running water and waterfalls, would form the ' power potential '. The country's food supply, deficient in terms of the requirements, can hope for increase by the control of running water in the new trends of hydrographic developments, namely the multi-purpose projects, like the Gal Oya Valley and the Walawe Ganga schemes. It needs no further elaboration therefore, to emphasise the vital rôle of rainfall in the present and future development of our island.

It is very often not realized that rainfall is but one of the many forms of precipitation.[2] In Ceylon, however, besides sporadic occurrences of hail,[3] rainfall may be considered the only form of precipitation. This is quite natural,

1. The writer is, in fact, engaged upon this interesting aspect of climatic changes in Ceylon, purely from a climatological standpoint. The results of this investigation, however, will not be available for some time.

2. Other forms of precipitation are Snow, Sleet, Glaze, Hail, etc.

3. George Thambyahpillay, ' Thunderstorm Phenomena in Ceylon ', *Ceylon University Review*, XII, 3 (July, 1954), 174.

considering the geographical location of the island in terms of latitudinal position. The altitudinal factor would have rendered possible other forms of precipitation, such as snow; but, since the highest elevation in Ceylon is only 8,291 feet (Pidurutalagala) the altitudinal factor does not counteract the latitudinal factor. In other words, no part of Ceylon is high enough to render the precipitation of snow.

Rainfall is the ultimate stage in a series of meteorologic sequences—the initial stage paradoxically being thermal.[4] Detailed consideration of the ' sequences ' in one type of rainfall in Ceylon—convectional—has already been made in an earlier paper.[5] There are three other rainfall types occurring in the island, namely, monsoonal, depressional or cyclonic and orographic. These however, might occur singly or in combination.[6] As mentioned earlier, in Ceylon all rainfall seem to be associated only with the Monsoon ; this however is unwarranted climatologically. This can perhaps be understood, because of the significance of the Monsoon to the people in their economic pursuits—farming and fishing particularly. It is granted that these two pursuits are closely associated with the Southwest and the Northeast Monsoonal periods ; but, it is not realised that the Monsoon is but one of the climatic features of the island and by no means the basic.

A study of the rainfall in the island reveals a certain seasonal regularity ; this might be termed a ' rhythm ' because the sequence is repeated year after year and is so well reflected in the island's economic activities and in the agricultural landscape. And it is this rhythm which is eventually expressed in the contrasting character of the geographical *landschaft*[7] of such a relatively small area as that of Ceylon ; the geographical *landschaft* of any region is an expression of the integration of a series of factors—both physical and cultural. Very often the physical factors act, as ' influences ' in the development of the cultural aspect; climate forms one of these physical factors. And in Ceylon, rainfall may be considered one of the major factors that has ' influenced ' the evolution and development of the geographical *landschaft*.

4. Solar Radiation is the fundament of weather ; acting indirectly through terrestrial radiation it is responsible for the ' mechanics ' in the atmosphere. Cooling of warm moisture laden air eventually leads to precipitation.

5. Thambyahpillay, ibid., 164-176.

6. These will be discussed in detail at a later stage. For an excellent analysis of clouds and rainfall associated with these types, reference may be made to, R. D. Kreltszheim, ' Rain Clouds and Rain in Ceylon ', *The Tropical Agriculturist* CII, 3 (July-Sept. 1946), 160-165 and CIII, 1 (January-March, 1947), 26-33.

7. This simply refers to the ' landscape ' meaning ' an integrated, coherent region ' with a specific character so as to distinguish, one *landschaft* from the other. It also corresponds to the *paysage* of Brunhes. For further elucidation refer, Richard Hartshorne, *Nature of Geography* (U.S.A. : Assoc. of Am. Geogs., 1939), 159-174.

Since Rainfall forms but one of the climatic expressions of the island, it is necessary to consider briefly[8] the factors that determine the climatic ' scene '. In effect, these factors or controls are geographical ; the meteorological phenomena—one of which is Rainfall—are thus geographically determined. The atmospheric circulation, for example, is the resultant of the Solar radiation acting upon the geographical base. Thus, for Ceylon too, it is the geographical location that is most important in determining its climate (and therefore its rainfall) characteristics.

In terms of the island's latitudinal position (within ten degrees north of the Equator) the controlling atmospheric phenomena would be ' equatorial '; thus, the ' Doldrum Belt ' with its variable winds would characterise the island's weather. This is the meteorologically determined ' equatorial trough ', bound on either side by the ' subtropical highs ' ; the ' trough ' is centred near 5° S in January and near 12-15°N in July ; it therefore migrates through 20° of latitude between seasons, and in turn influences the seasonal march of cloudiness and rainfall. In the annual mean, this ' trough ' lies near 5°N than on the geographical equator. Accompanying the ' thermal or meteorological ' equator, the wind belts would also migrate accordingly. During the northern and southern Soltices the island would thus come under the influence of the Northeast Trades and the Southeast Trades, respectively ; otherwise the island would be characterized by ' equatorial weather ' associated with the equinoxes. On a planetary basis the island would be conditioned by the Inter-tropical Convergence Zone. From a detailed study of this zone between the converging Trades, Crowe concludes that it is far from being a simple entity as is normally supposed. Referring to the ' Indian environs ' of this zone he says, ' Even when, between November and February, this zone if flanked to north and south by converging air streams, it maintains a mean width of not less than 15 degrees of latitude or approximately a thousand miles. In March and April and again in October the area is even larger. From May to September, on the other hand, it undergoes profound modification through the development of the Monsoon but is, nevertheless, far from liquidated '.[9] Since the Trades originate as subsiding air, they are warmed and blow as dry winds : these would therefore bring rainless winds to the island. This character of ' rainless winds ' was noted even as early as 1856 by Maury, who states, ' we know from observation that the trade-wind region of the ocean, beyond the immediate vicinity of the land, are for the most part rainless regions '.[10] Crowe in his recent studies presented in

8. Detailed considerations have been made in an earlier paper. Refer, George Thambyahpillay ' Climatic controls in Ceylon ', *Ceylon University Review*, XI, 3 and 4 (July-October, 1954), 171-180.

9. P. R. Crowe, ' Wind and Weather in the Equatorial Zone ', *Trans. Inst. Brit. Geogs.*, 17 (1951), 26. The inter-tropical front will be considered at a later stage.

10. M. F. Maury, *The Physical Geography of the Sea* (London : Sampson Low, 1856), 122.

three papers,[11] concludes, ' we now confirm not only that the trades are normally relatively rainless winds, but that the stronger they are the drier they are. This is, of course, what is to be anticipated from a dynamic system driven mainly by subsidence from aloft but a clear appreciation of the facts has been obscured by a number of noteworthy exceptions to the general rule '.[12] So that, while from a planetary consideration the island should be rainless, other circumstances have rendered it otherwise. Five considerations may be cited as responsible for rendering the island rainy :—

(*a*) Crowe suggests that rain falls due to either a north-south or a west-east migration of the Trades. When the system is fully established precipitation has been found to decrease, but when the migration takes place the Trade wind comes into opposition against the Doldrum air ; hence, Crowe pictures the rainfall zone, ' along the advancing inter-tropical front but the front thus pictured is not so much a zone of conflicting trades as a boundary surface between relatively stagnant doldrum air and the fresh surge of the trade which underruns it '.[13] Rain also occurs well within the margin of the advancing system. This might be referred to as ' *depressional* ' rain.

(*b*) Within the Doldrum zone with ' calm ' conditions and because of the insular character (no part of the island is more than 70 miles from the coast) diurnal ' thermal centres ' activate *convectional* phenomena[14] ; the land-sea breeze phenomena thus dominate. The Trades under certain conditions may interact with the sea breeze to precipitate rain.

(*c*) When the trade-wind system is thrust across the equator into the opposite belt and due to the operation of Ferrel's Law the deflected Trades (which later forms the Southwest *Monsoon*) bring rain. Because of Ceylon's close proximity to the Indian sub-continent the island is not insulated from the Indian atmospherics ; thus Ceylon comes under the influence of the Southwest Monsoon.[15] At this stage the inter-tropical front plays a different role, namely, that of a relatively impenetrable barrier, walling off the rains from the north.

11. (i) P. R. Crowe, ibid., 21-76.
(ii) ' The Trade Wind Circulation of the World ', *Trans. Inst. Brit. Geogs.*, 15 (1949), 39-56.
(iii) ' Seasonal Variation in the Strength of the Trades ', *Trans. Inst. Brit. Geogs.*, 16 (1950), 25-47.

12. P. R. Crowe, ' Wind and Weather in the Equatorial Zone ', op. cit., 67.

13. Ibid., 68.

14. Thambyahpillay, ' Thunderstorm Phenomena in Ceylon ', op.cit., 164-176.

15. Detailed considerations will be made at a later stage.

(d) The Trades are capable of producing *orographic* rains, thus contrasting the rainy windward side from the rainless leeward side.

(e) During certain times of the year, especially October to January, when the ocean east of the island lies towards the margin of the doldrum zone, conditions are created for the development of local 'disturbances' and eventually some *frontal* activity which results in cyclonic phenomena. These cyclones or strictly speaking, the Tropical Revolving Storms bring in their wake, sudden, intense and localized zonal rainfall. The inter-tropical front does not always persist in the Island's environs; it is dominant only when certain atmospheric conditions are fulfilled, as for example, during the 'winter' months, when 'polar' air streaming out from the Siberian High, reaches the Convergence zone. Crowe maintains the inter-tropical front to be, 'no more than a mobile, evanescent feature of a synoptic situation '.[16] Other cyclonic features do occur during the pre-Southwest Monsoonal transition period, but are really 'depressional' phenomena.

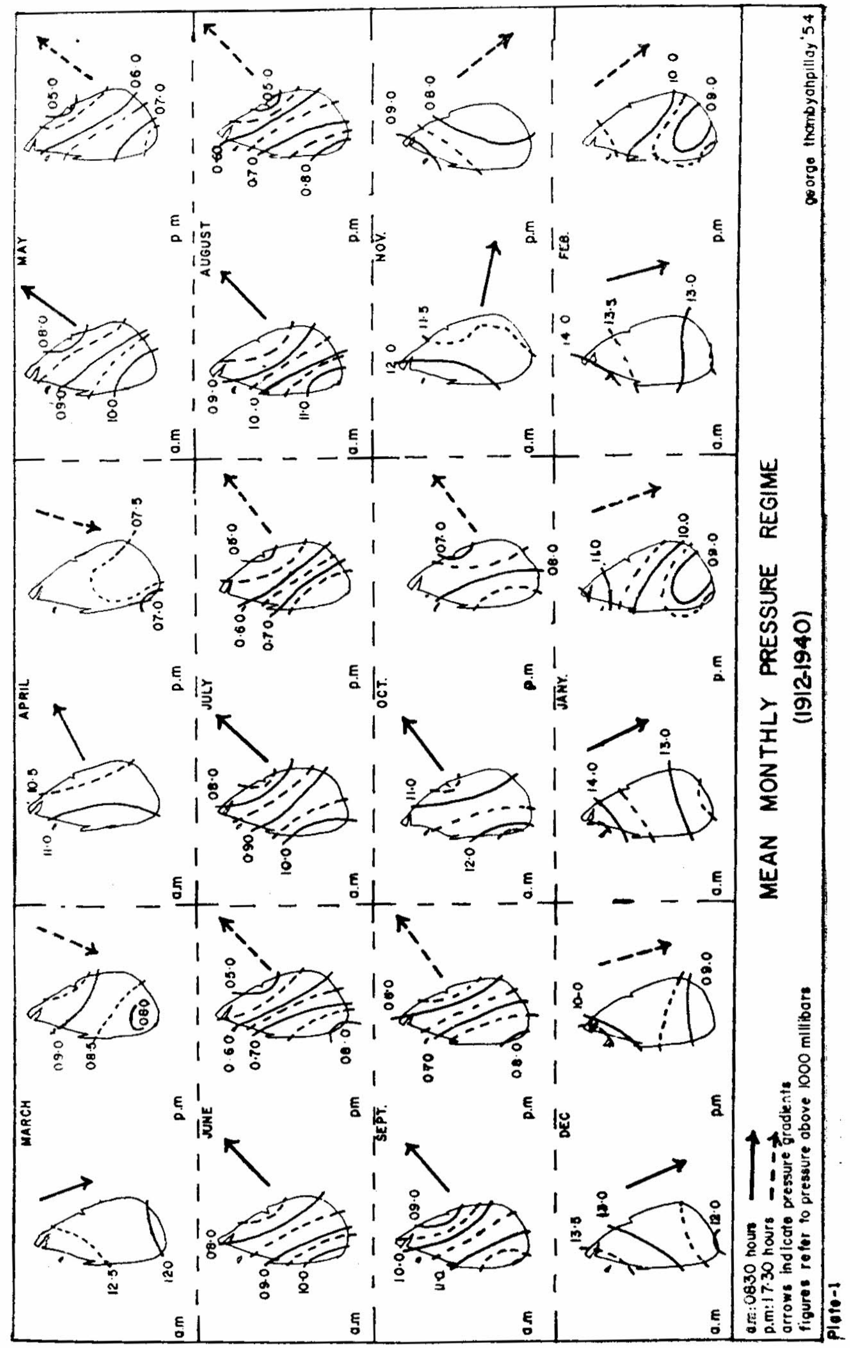
Recent work in this study of the atmospherics of the Convergence Zone and its relation to weather that affects Ceylon[17] reveals the development of the Equatorial Air ('Equatorial Westerlics') as a distinct air mass, with its own characteristics. Jayamaha, discards the Classical theory of equatorial meteorology, namely that air from the northern or southern hemisphere after being deflected at the equator came into opposition with the air of the opposite hemisphere; instead, he feels that the equatorial air stream, 'forms two clear zones of demarcation, one with the northern hemisphere air and the other with southern hemisphere air. These two boundaries appear almost invariably in the day to day synoptic charts. One of these zones is found to remain between 05°N and 05°S while the other oscillates between 25°N (July-August) and 10 or 15°S (January-February)'.[18] And it is when this convergence (northern) zone is inactive that local 'thermal centres' develop to produce intense convectional activity; 'It could, therefore, be assumed that the weather during an inter-monsoon season would possess frontal characteristics whenever the convergence zone is active. On the other hand, the weather over the island would be diurnally controlled if the zone is inactive '.[19]

16. Crowe, 'Wind and Weather in the Equatorial Zone', op.cit., 23. A number of theories have been put forward to explain the genesis of these Revolving Storms. A brief discussion of these will be made at a later stage, in this paper; however, they would warrant a special study and therefore will be considered in a subsequent paper. 'Depressional' phenomena also will be considered elsewhere in the present paper.

17. G. S. Jayamaha, 'A Synoptic Analysis of the Ceylon Weather'. This unpublished paper will appear sometime this year, in the monthly issue of the *Weather* (published by the Royal Meteorological Society, London).

18. Ibid.

19. Ibid.



Thus, it is seen that because of other circumstances—meteorological and geographical—Ceylon, lying within the Trade-wind belt, has acquired a rainy character. A detailed analysis of the rainfall sequence and distribution, must needs be preceded by a consideration of the meteorologic conditions that create the 'stage' upon which the 'drama' of rainfall is enacted.

It was maintained earlier that solar radiation forms the fundament of weather; but this thermal base acting only through some other medium can perform its fundamental rôle. It is elementary meteorologic knowledge that thermal differences find expression in the form of pressure differences, which in turn initiate atmospheric movements called winds. Hence, it is the winds which directly reflect the initial thermal control, and in turn, are responsible for the dynamic processes which eventually produce rainfall. It might therefore be considered axiomatic that all meteorologic processes are the ultimate products of a series of thermo-dynamic sequences; in fact, the atmospheric envelope which affects—in some way or other—the whole of humanity, is maintained in a state of balance by the thermo-dynamic relationship.

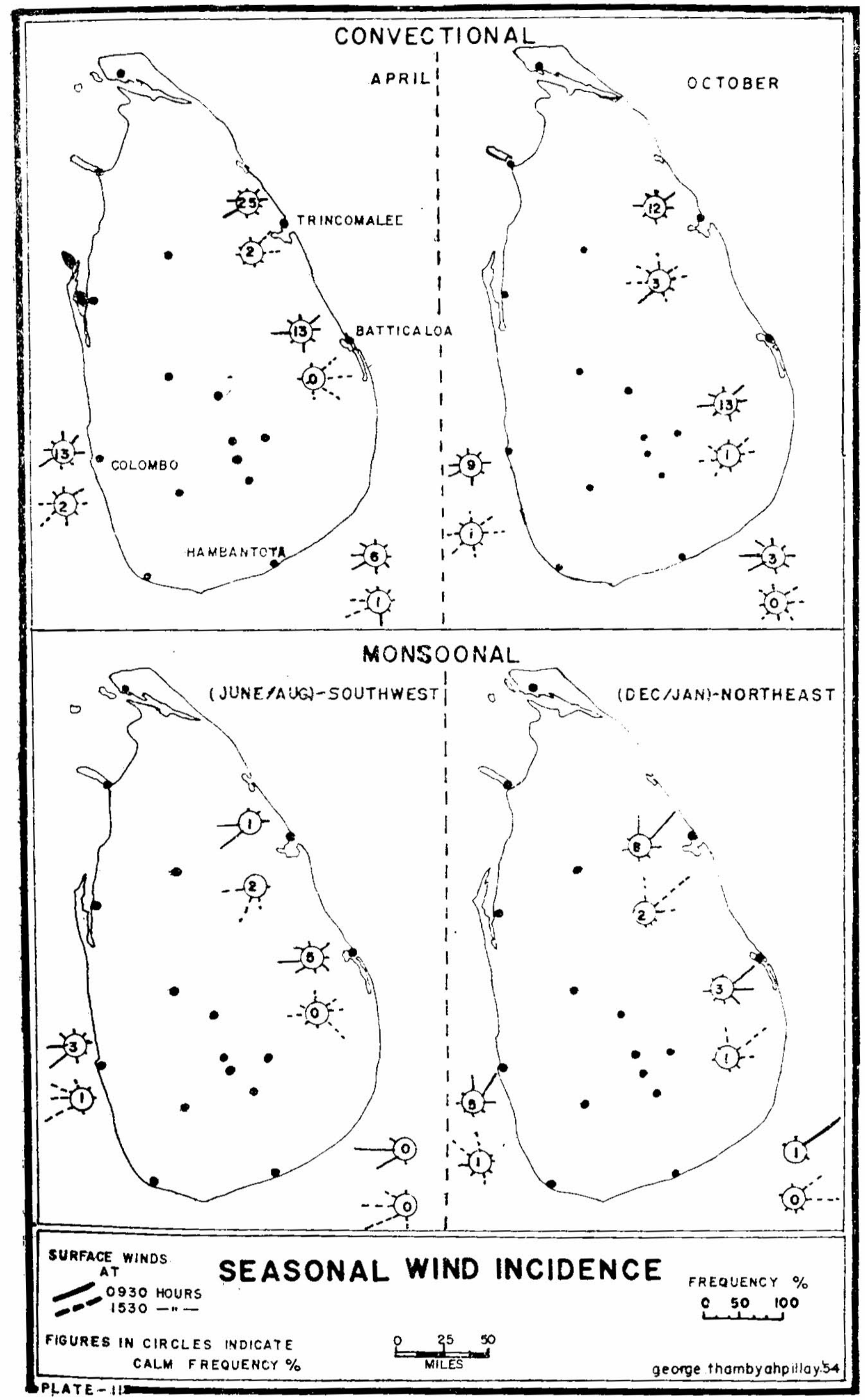
The latitudinal position of the island warrants it high insolation throughout the year; slight variations, however, are reflected due to the seasonal shift of the 'thermal or meteorologic equator'. In March-April and late September-October when the island comes under equinoctial thermal conditions (overhead Sun)[20] insolation is uniform; during other periods of the year insolation is less (during the northern winter) or more (during the northern summer). Because of the small areal extent[21] of the island, the thermal conditions are not reflected in any marked pressure conditions; it has hence been asserted that local pressure conditions do not assume such magnitude as to determine weather conditions. However, they do play their rôle at least during short periods of the year. During the March-April and late September-October months, because of equinoctial conditions localized pressure control is reflected in marked convectional activity, producing the characteristic afternoon thunderstorm rains.[22]

It is also a fact, that it is during these months that Doldrum conditions prevail over the island environment, which therefore facilitates intense convectional activity, provided that the 'Convergence zone', as shown by Jayamaha, is inactive. Generally considered, the island's pressure conditions are not very marked to be responsible for major wind movements, unless one includes the land-sea breeze phenomena under this category. In terms of Ceylon's low-latitudinal position pressure is usually around 1,000 millibars varying seasonally

20. The Sun is overhead at noon at Colombo on April 8th and September 5th; at Colombo the longest day (June 22nd) is only 48 minutes longer that the shortest day (December 22nd).

21. 25,532 square miles.

22. Thambyahpillay, 'Thunderstorm Phenomena in Ceylon', op. cit., 164.



between 1,014 and 1,007; altitudinal effect is reflected in lower pressures ranging between 960 and 810 millibars. The monthly rhythm of pressure (Plate 1; here, for purposes of emphasis the highland stations are not considered) reveal interesting features during the mornings and afternoons and also during the Monsoonal and non-Monsoonal months. During the March-April months,[23] there is no marked pressure gradients, never amounting to more than 0·5 millibars; beginning from May until September (when the Southwest Monsoonal conditions prevail) the gradient amounts to between 2·0 and 3·0 millibars and characteristically from southwest to northeast. By October once again with convectional conditions the gradients are generally indeterminate; this is true in November as well. But from December to February a northwest-southeast gradient prevails with the setting in of the Northeast Monsoonal conditions. It is also interesting to note that the morning-evening pressure gradient directions differ only during convectional conditions.[24] Thus, it is undoubtedly evident that, it is when Doldrum atmospheric conditions prevail that local pressure conditions exert the control; for, during other periods other meteorologic features dominate and obscure the real picture, as so effectively shown by Crowe[25] and Jayamaha.[26] Therefore, to understand the dominant atmospheric circulations during certain periods of the year, recourse must be made to the consideration of planetary pressure conditions.

The basic pressure pattern is that maintained over the island in respect of its latitudinal position, namely, the Equatorial Low Pressure Belt or the Doldrum Belt; the high thermal incidence within this geographical zone create conditions of 'calm' so characteristic. In other words, no regular pressure gradients prevail and therefore correspondingly there is an absence of any wind system; this zone is thus referred to as 'the zone of calms and variable winds' and is reflected in the wind-roses shown for the months of April and October (Plate 11). As mentioned earlier, it is during these months that strong local wind movements (land-sea breeze) dominate to create convectional weather conditions. However, because of the location of the island north[27] of the Equator, at certain times of the year, the Trade-wind systems dominate

23. This period may be justifiably considered the beginning of the *climatic year* in Ceylon. For further elucidation refer Thambyahpillay, *Climates of Ceylon*, (University of California, 1952), 258 pp. and also subsequent discussions in the present paper.

24. Note (Plate 1) the change in directions in March between the following two observations :—0830 hours :— northwest; 1530 hours :— northeast; in April the corresponding observations are southwest and northeast respectively. The gradients also are low, the corresponding figures being, for March 0·5 and 1.0 and for April 0·5 millibars, respectively.

25. Crowe, 'Wind and Weather in the Equatorial Zone', op.cit., 67.

26. Jayamaha, op.cit..

27. The latitudinal extensions of Ceylon are 5°55′ to 9°50′ N.L.

the island environment; blowing from the sub-tropical high pressure belts, these winds which are subsiding outblowing air bring 'drying' conditions. But as shown by Crowe earlier, other geographical features render these winds 'rain-bearing' to the island. Corresponding to the northerly and southerly shift of the 'thermal equator' these wind-belts too reflect this movement; the island, thus, comes under the influence of the northeast Trades and the southeast Trades, during the Summer and Winter Solstices respectively. The southeast Trades when it crosses the equator in response to the northward migrating 'thermal equator' conforms to Ferrel's[28] Law and acquires a southwesterly direction; this is clearly revealed in the wind records for the month of May. Subsequently with the creation of certain pressure conditions over the Indian sub-continent the southwesterly component of the original southeast Trades receives accentuation and is then termed the *Monsoon*. When the two Trade wind systems come into opposition with the Equatorial Westerlies there is said to develop the Inter-Tropical Front which is, in turn responsible for the creation of definite weather phenomena. However, Crowe[29] prefers to use the term 'inter-tropical Convergence zone'[30] instead of the term 'Inter-Tropical Front', to describe prevailing weather because the latter is considered to be only a special feature within the convergence zone.

Beginning about May, with the northward migration of the 'thermal equator' certain new conditions seem to be set up culminating in what is so well-known in the meteorologic context of the Indian environment, namely, the '*burst of the Monsoon*'. Since there seem to be erroneous ideas about the Monsoon, it is felt that a detailed consideration of this meteorologic phenomenon would not be out of place here. The Monsoon, is strictly a wind and does not refer to the rain associated with it; the rainfall in fact is only incidental. The Arabic origin of the term '*Monsoon*' referred to two specific wind movements which blow in the Arabian environment. Thus, 'the name is derived from an Arabic word for "season" and originally referred to the winds of the Arabian Sea, which blow for six months from the NE, and six months from the SW'.[31] In meteorological parlance, the term Monsoon is of significance because of the seasonal attribute and so often designates 'seasonality'. It is also used for any wind system blowing towards a continent that develops a low pressure centre due to intense thermal heating in summer. Sir Napier

28. This law states that in the Northern hemisphere winds blow to their right and in the southern to their left.

29. More reference to this phenomenon would be made later.

30. Crowe, ibid., 23. While Jayamaha himself prefers the term 'zone' others (for example, Bergeron) maintain that it is of a 'frontal' character. Refer, Reviews of Modern Meteorology—12: T. Bergeron, 'The Problem of Tropical Hurricanes', *Quart. Jour. Royal Met. Soc.*, LXXX, 344 (April, 1954), 131-164.

31. *Meteorological Glossary* (London: Air Ministry, 1940), 134.

Shaw deplores the misuse of the term in synonymity with seasonal effect, ' the word monsoon really means season and is associated with the winds and rains of India, because they are seasonal. From that circumstance, there has developed a habit among meteorologists of calling any marked seasonal variation in wind directions with the corresponding rainfall "monsoonal". It is unnecessary and an unfortunate habit, not only because practically everything meteorological is seasonal, but is not on that account monsoonal '.[32] In this paper the term ' monsoon ' would refer strictly to the Monsoons of Southern Asia or rather the Indian Monsoon. The monsoons that dominate Ceylon's weather and climate are not the creation of meteorological conditions within the island but due to circumstances from without.[33] As mentioned earlier, the island though insular is not insulated from the climatic features of the Indian sub-continent; the island's close proximity to India thus renders it susceptible to many of the meteorologic phenomena of the neighbouring landmass. To clearly understand the ' onset ' of Monsoonal conditions over the island, a brief analysis of the atmospheric ' field ' in India must needs precede.

Beginning with the March-equinox, thermal intensity over India increases gradually northwards; in April eastern India and Burma have two ' heat centres ' developed. Except for local wind movements, this does not involve the south-Asian environment. Pressure conditions are little changed from those in March, the gradients are slight, and the winds still variable, though a slight north-easterly trend is discernible. By the beginning of May conditions begin to change and it might be said that ' conditions are beginning to intensify '; the thermal and pressure conditions seem to epitomise the ultimate picture. The isotherms are concentric about the 95°F thermal centre, which by now has moved from its eastern position to central India and average temperatures over India amount to about 85°F. June is the penultimate stage in the culmination of the ' intensifying process ' of the conditions that have been trying to establish themselves for some time, ever since the spring equinoctial period. By July the ' heat centre ' has moved into its northwestern position over the Thar Desert. As these atmospheric conditions were being established, the pressure conditions as far south as the Equator were also undergoing modification. Since the whole wind-belt systems too have been migrating northwards in accordance with the movement of the ' thermal equator ', by May-June the southeast Trades has established itself in the northern hemisphere (just north of the Equator) and is now blowing as southwesterly winds. Their goal is the Equatorial Low Pressure Belt; thus by early June the southwesterly winds have yet not attained maximum strength. Soon the intensified low ' centre ' over the Thar Desert acts as a magnet to exercise a ' pull ' on the deflected

32. Napier Shaw, (Sir), *Manual of Meteorology*, II (Cambridge : University Press, 1936), 251-252.

33. W. G Kendrew, *Climate of the Continents*, (Oxford: Clarendon Press, 1937), 107-122.

southeast Trades. This is now the Southwest Monsoon, which lasts till September; the Monsoon blows over India as ' streamlines ' which bifurcate into two branches, namely the Arabian Sea and the Bay of Bengal branches, respectively.[34] And Ceylon, lying athwart the Monsoonal ' streamlines ' comes directly under its influence. But because of its southerly location with reference to India, Ceylon receives the impact earlier than the Indian sub-continent. The explanation for the ' burst ' of the Monsoon as well as the whole mechanism of the development of the Monsoon is lacking sufficient meteorologic reasoning, though widely accepted for a long time. Recent investigations[35] have raised certain objectionable viewpoints in connection with the *raison d' etre* of the Monsoon. Thompson considers that the ' *modus operandi* ' of this most significant meteorologic phenomenon in India, is far from being so simple as it has so far been accepted; his contention is that the ' heat centre ' of northwest India (Thar Desert) and the resulting pressure gradient *per se* cannot cause the generally light southeast Trades to attain such strength as evidenced in the Monsoon. From his study of this phenomenon as a meteorologist, he suggests that the strength of the Monsoonal currents is due to the upper air currents or *Westerlies* (which above the normal Northeast Trades blow from the southwest as the Anti-Trades or called the Upper Westerlies) combining with the southwesterly surface (deflected Southeast Trades) winds and thereby producing the high velocity Southwest Monsoon. Jayamaha, from his work in Ceylon[36] concedes that the initial southwesterly winds in early May is not ' Monsoonal ' but simply the ' Equatorial Westerlies ' or the ' Southwest Monsoon streams ' associated with the movement of the Northern Convergence Zone. The ' burst ' of the Southwest Monsoon can be attributed to the occurrence of such a ' disturbance ' along the northern Convergence zone in May (in Ceylon).[37] Again Riehl[38] has shown that the upper air circulation is more responsible for the onset of the Monsoon, than the ' Thar heat centre '. In conclusion (of his discussion) he says, ' it follows that the change in the upper air circulation can explain the pattern of the advance of the monsoon. This hypothesis permits us to relegate the heat low over northwestern India-Pakistan, often cited as a primary factor in the advance of the monsoon, to a more secondary rôle. The heat low arises from intense insolation under clear skies over a

34. G. C. Simpson, ' The South-West Monsoon ', *Quart. Jour. Royal Met. Soc.*, XLVII, 199 (July 1921), 422-431.

35. B. W. Thompson, ' An Essay on the General Circulation of the Atmosphere Over South-East Asia and the West Pacific ', *Quart. Jour. Royal Met. Soc.*, LXXVII, 334 (October, 1951), 569-597.

36. Jayamaha, op.cit.

37. Detailed consideration will be made in connection with the South-West Monsoonal rains in Ceylon, at a later stage.

38. Herbert Riehl, *Tropical Meteorology*. (New York : McGraw-Hill, 1954), 392 pp.

wide area. However, the clear skies cannot be considered as an *a priori* factor in any Monsoon theory; it is just another way of saying that the Monsoon is retarded. A common cause must be sought for the retardation and the resulting clear skies; the upper current, moving from west-northwest toward the trough near 90°E with subsidence can provide such a cause '.[39] This also explains the sudden 'burst' and the following lull with occasional strong 'phases'. In Ceylon recent investigations have proved the existence of two phases of the Monsoonal winds, namely a 'shallow and a deep phase' respectively.[40] Since the context in this paper is to the climatological significance of the Monsoon as far as it affects Ceylon's rainfall the need for further discussion of the meteorologic character does not seem justifiable.

During the northern winter the central region of the Asiatic landmass develops into an intense stable centre of outblowing winds; these form part of the Winter Monsoon. The effect of the centrifugal cold winds are felt as far as China, Japan, into the Pacific and even into parts of Europe. It has been common place to attribute the 'winter weather' in the Indian Ocean environs to this Winter Monsoon and as such the period November to February has been designated the Northeast Monsoon season. While it is true that occasional 'Siberian streamlines' find their way into the Indian climatic environs, it is the contention of many that, basically the Northeast Monsoon over the Indian sub-continent is not the product of the Asiatic Winter Monsoon, but is an expression of local 'thermal centres'; the resulting winds therefore serving to accentuate the normal Northeast Trades. A brief discussion to clear the erroneous notions of the so-called Northeast Monsoon seems warranted at this stage.

The Himalayan Range, it is claimed acts as an effective barrier preventing the cold Siberian Monsoon winds reaching India; 'India, cut off as it is from the rest of Asia by high mountains and plateaus, has a Monsoon system of local origin, quite distinct from that of the rest of the continent'.[41] Kendrew[42] holds this view, namely that the Asiatic Monsoon does not affect the Indian environment. More definite emphasis on this contention has been made by Byers, 'it is sometimes said that the Indian monsoon is an ideal monsoon.

39. Riehl, ibid., 259.

40. R. D. Kreltszheim, 'The setting in of the South-West Monsoon over Ceylon', unpublished paper; read before the Seventh Annual Sessions of the Association of Science, November 29th to December 1st, 1951. Further detailed reference to data from this paper will be made at a later stage. In the *Marine Observer* of April 1937, appeared an account of 'The "Burst" of the South-West Monsoon', by H. Jameson (of the Colombo Observatory).

41. Vernor, C. Finch and G. T. Trewartha, *Elements of Geography* (New York: McGraw-Hill, 1942), 84.

42. W. G. Kendrew, *Climatology* (Oxford: Clarendon Press, 1949), 145. See also *Climate of the Continents* (Oxford: Clarendon Press, 1937), 113-114.

However, the summer monsoon only is present in India. The Himalayas to the north and the mountains of Burma, Yunan and Indo-China, to the east prevent the winter monsoon from reaching India'.[43] However, one cannot dismiss the possibility of the upper monsoonal currents from central Asia streaming through favourable gaps in the Himalayan-Arakan-Yunan mountainous wall, to arrive eventually in the Indian environs. Also, there is the possibility of such 'streamlines' flowing in from the Pacific along with the Pacific Trades (after having entered the Trade zone in the Pacific across from Asia). Yet the relatively lower wind speeds (only about 8 knots) as compared with the Southwest Monsoonal currents (that attain even up to 24 knots)[44] suggest that the so-called Northeast Monsoon is merely the Northeast Trades accentuated by locally active quasi-Monsoonal currents; the latter may be traced to the local 'high cells' forming over the Indian sub-continent, the best example being the Kashmir-Jammu-Punjab 'cell'. Local 'Monsoonal streamlines' blowing centrifugally from this 'cell' attain strength as they stream southeasterly along the Ganges Valley gradient. The heavy rainfall during the so-called Northeast Monsoonal period may be due more to other causes, such as 'frontogenesis' rather than purely to the Monsoon and so differs from the Southwest Monsoon. It is felt therefore, that because the so-called Northeast Monsoon is not a comparable counterpart of the Southwest Monsoon (both in terms of evolution and characteristics) some other term be used to designate what is really the Northeast Trades accentuated by local 'quasi-Monsoonal streamlines'; the term '*trademonsoon*' seems more justifiable. This is suggested also because of the unfortunate habit among meteorologists to designate 'Monsoonal', 'any marked seasonal variation in wind directions with the corresponding rainfall'.[45] Thus, briefly the following reasons may be adduced for suggesting that it is the Northeast Trades rather than the so-called Northeast Monsoon that prevails in the Indian environs (and therefore over Ceylon) during the period, late November to early February:—

(i) this is the period of the normal planetary wind circulation, namely the Northeast Trades and hence basically it prevails without any thermal or dynamic modification; in this respect, it differs from the Southwest Monsoon which as shown earlier, undergoes marked thermo-dynamic changes; thus, in terms of wind directions, wind speeds, moisture content, etc., it differs from its counterpart of the May-September period;

43. Horace, R. Byers. *General Meteorology* (New York: McGraw-Hill, 1944), 231.

44. Riehl, op.cit., 8-12.

45. Shaw, op.cit., 251.

(ii) it is not part of the Siberian Monsoon except for possible 'polar characteristics' introduced into the circulation by occasional 'Siberian and Pacific streamlines'; since these are 'interlopers' they are not a constant feature of the so-called Northeast Monsoon. The local 'high cell' in the Kashmir-Jammu-Punjab region does cause centrifugal cold 'streamlines' to impinge into the Northeast Trade system, slightly modifying to contribute 'quasi-Monsoonal' characteristics;

(iii) the heavy rainfall may be due to purely 'orographic lifting' of the Trades, which is always possible, as is shown by Crowe with reference to the rainfall regimes of 'Trade-wind islands'; further, some of the heavy rainfall may be due to 'frontal activity' induced by 'polar outbreaks' converging on the Equatorial Westerlies, or by any other 'discontinuity' developments. Incidence of 'frontal' or 'cyclonic' activity substantiates this view, as this period of the so-called northeast Monsoon (November to February) seem most favoured in this respect.

However, to prevent confusion and uniformity with existing literature on the climate of the island, the term 'Northeast Monsoon' will be used throughout in this paper.

As mentioned earlier during the October-November-December-January months there have been observed certain localized high-velocity wind systems accompanied by sudden and intense fall of rain; these have been seen to be highly localized and when they occur, to be 'aligned' along a narrow zone, generally trending southeast/northwest in the northern and eastern coasts of the island. The genesis of these Tropical Revolving Storms[46] seems still in the controversial stage in spite of the many theories propounded;

(a) *the thermal convectional hypothesis*: this is the classical hypothesis and invokes the simple requirement of thunderstorm development by thermal convection with the resulting coalescence of the rain-clouds; then by a process of convergence, cyclonic circulation is initiated. This hypothesis is considered deficient as it does not explain the fall of pressure, the starting mechanism and mentions no cooling system:

(b) *the frontal hypothesis*: following the 'polar front' hypothesis (which successfully explained the 'temperate cyclogenesis') the Norwegian School, about 1920, suggested that convergence of the two opposed Trades facilitated the development of shearing instability (along inclined discontinuities or 'fronts'). This hypothesis while providing the starting mechanism (an energy source) is unsatisfactory because it lacks the existence of a cooling system and further, it has been observed that not all storms in this zone initiate with an equatorial shear line:

(c) *dynamic instability hypothesis*: here the pressure gradient plays an important rôle in facilitating continuance of certain flow patterns in the upper atmosphere; this has not been accepted in finality due to certain unproven assumptions:

(d) *the 'waves in a baroclinic current' hypothesis*: a basic easterly current increasing with height, with temperature warmer on the poleward than on the equatorial side of the current, would eventually facilitate the development of divergence which by intensifying would set the stage for 'cyclogenesis'.

In spite of the controversies about their genesis, there is no doubt that these cyclones prevail during the aforementioned period; milder varieties of these prevail even during other periods entering the island from the Arabian Sea side of the island.[47]

While these meteorological conditions determine the rainfall character in general, it is the geographical factor of orography that determines the distribution of rainfall in Ceylon The chief control that orography exercises is to provide the 'lifting' agency so essential sometimes to induce instability and thus rainfall. Hence even when the Monsoonal currents dominate the atmospheric environment of the island, it is the local topographical features that determine the main area of precipitation; for the Monsoon is only a wind and therefore some 'agency' has to perform this vital requisite, namely, that of inducing the Monsoonal currents to release their 'potential burden'. All types of rainfall that may occur in the island (convectional, monsoonal, depressional, cyclonic, etc.) to some extent depend upon a 'lifting' agency; the convectional and cyclonic are, to the least extent so dependant. A detailed analysis of the distribution of rainfall over the island would at once reveal this unmistakeable rainfall-topography relationship. Thus, while the atmospheric conditions control the 'rainfall rhythm' in the island, it is the geographic features (exposure, topography, 'aspect' etc.) which determine the regional pattern of rainfall.

The average annual rainfall map (Plate III) reveals that by world standards, no part of the island can be considered 'dry', since the amount varies from about 35 inches in the northwest to over 200 inches in the southwest. On a world rainfall map, therefore, the island would be shown to receive, 'heavy precipitation' and classed as a 'rainy' climate. Except for two NE/SW

46. Riehl, op.cit., 281-358; further reference may be made to, M. A. Garbell. *Tropical and Equatorial Meteorology* (New York: Pitman, 1947), 237 pp.

47. Further reference will be made at a later stage.

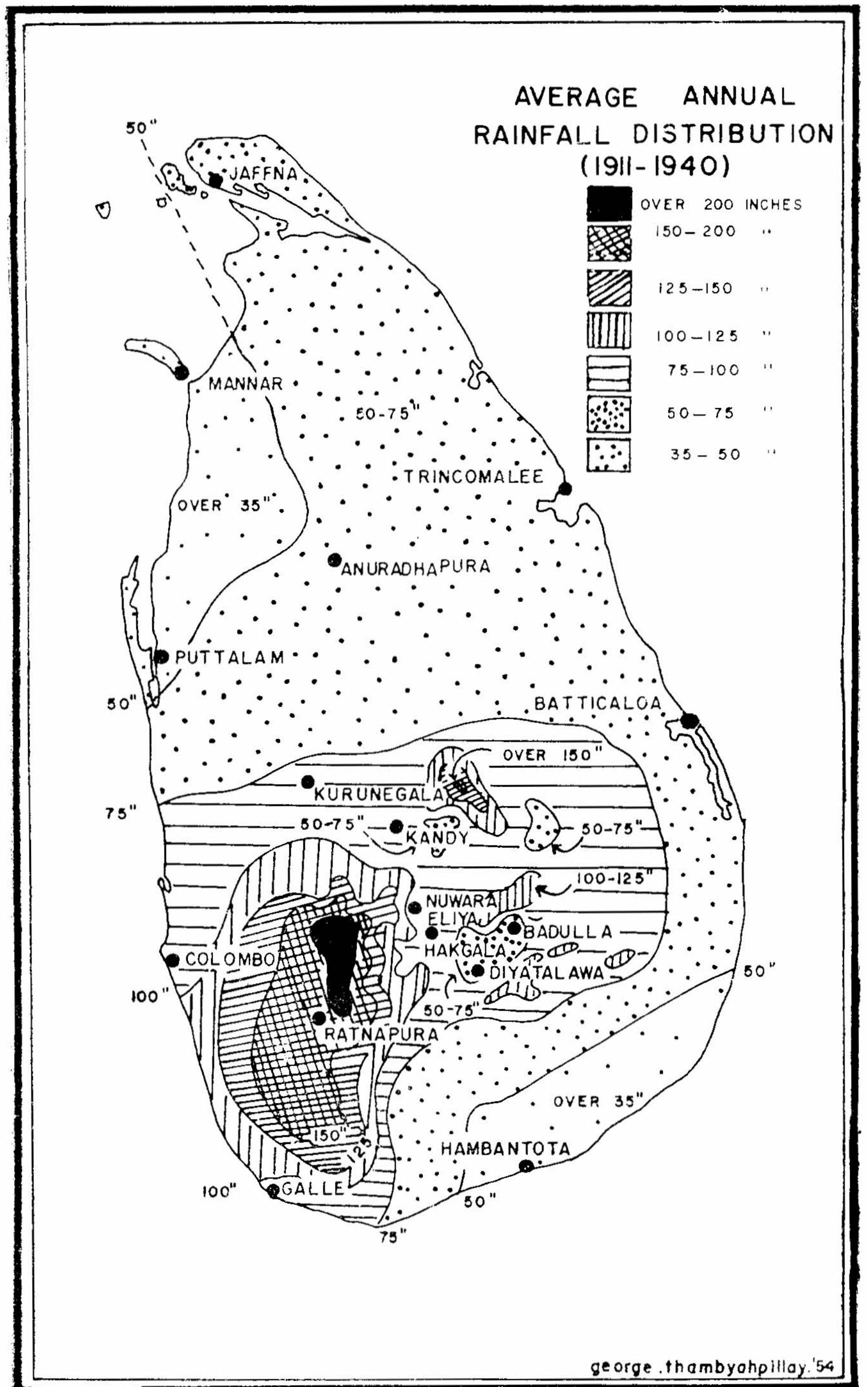


PLATE-III

aligned narrow zones in the northwest and southeast, no area receives less than 50 inches and almost half the island receives over 75 inches. However, a detailed study of this distribution would indicate interesting features, both with regards to seasonal variations in the amounts and the types of rainfall; a rhythmic character can be easily discerned in this distribution, and may be grouped in the following form:—

· **Spring ' Convectional-Convergence period** (March to mid-April). The month of March may justifiably be chosen to begin the analysis, because the island would then be presenting in its atmospheric setting ' normal conditions ' : in other words, this month may be considered to mark the beginning of the ' climatic year ' in Ceylon.[48] The atmospheric environment of the island begins to reveal the setting-in of conditions, which permits of the establishment of local controls: this, however, is facilitated by ideal planetary features which affects the island very little. Thus, weather conditions are the product *per se* of atmospherics within the island; but, it is not till early April that they are best exemplified.

In March, the island comes within the ' Equatorial Low Pressure ' belt, referred to commonly as the ' Doldrums '—a state of conditions when planetary pressure controls are absent and significant because meteorologically ' calm atmospheric conditions ' dominate; such a region has come to be designated, the ' equatorial trough ' towards which the outblowing Trades from the Sub-tropical anticyclonic cells, converge. Generally being a period of inactivity in the upper atmosphere (except when the Convergence zone is active) local thermal conditions assume control to produce the weather and therefore the rainfall pattern. This period is then a month of ' afternoon-thunderstorm showers ' produced by convectional activity and rain is received in all parts of the island, depending of course on the local thermal conditions. Since this is the equinoctial period (with the ' meteorologic or thermal equator ' migrating northwards) high insolation, facilitates such convectional activity.[49] Two regions of marked convectional currents are the Sabaragamuva (around Ratnapura) and the Uva (around Diyatalawa) environs; these two areas have been observed to be the ' source regions ' of the cumuli that eventually develop into the rain-bearing cumulo-nimbus clouds which migrate towards the coast precipitating rain during their passage. It has also been observed that marked convectional rainfall have a regular sequence in conformity with the diurnal rhythm; the clear mornings, when insolation is performing its active rôle of creating the ' potential ' atmospheric conditions for convectional movements contrast with the afternoons and evenings, exemplified by the overcast sky and the intense, short-period ' deluges '. The repetition of this

48. Thambyahpillay, ' Thunderstorm Phenomena in Ceylon ', op.cit., 164.
49. Ibid., 164-170.

daily sequence often becomes a monotonous weather 'scene', though to the climatologically inclined this phenomenon is certainly full of meaning and interest; the very fact of 'repetitive weather' is of great advantage, especially in the planning of social activity. No part of the island is devoid of coming under this weather sequence and rainfall (Table I). It would be interesting to briefly recall to mind a typical 'convectional weather scene', as seen from the lowland and the highland respectively, since these two areas present contrasts in this respect; this is of interest, because often the one area creates atmospheric conditions that eventually affect the other.

On the west coast (e.g., Colombo) during the early morning, the air is exceptionally clear with the sun shining brightly; the calm conditions are remarkable, with very little horizontal movement of air (wind) as is evidenced by the extremely small 'breakers' on the sea. Soon a very light breeze from the sea is sensible as the palm-fringed shore seems to stir into life when the lofty palms gently sway. The sky is still uncommonly a clear blue, while visibility is exceptionally clear, so that the uneven crestline of the central highland, almost 50 miles away is silhouetted[50] against the cloudless canvas. Beginning about 8 a.m. with the increasing heating of the land, the vertical currents are activated, creating instability in the lower levels of the atmosphere; the rising air begins to cool adiabatically and reaching the level of condensation, form clouds.[51] In an hour or so white billowy cloudlets dot the once spotless blue sky; these increase in size and density as the day advances and the cumulative effect of convection takes dominance. The view from the highland presents a still more interesting scene.[52] Over the lowland a thin 'veil' persists, above which rise white billowy structures; these 'towers' seem to emerge out of the spread-out level of (saturation) condensation. By about noon the lowland is no more seen as the cloud mass thickens, obliterating everything from sight. The occasional 'towers' that project out of this sea of cloud, is an expression of the stronger vertical currents that are produced by the localized thermal centres. Returning now to the coast, the view on the eastern horizon presents, a mass of 'cauliflower' clouds which are the further development of the humilis cumuli; the 'towering effect gains dominance and soon the potentiality of the rain-cloud is revealed by the development of 'anvils'. By now the sea breeze has strengthened and the sky above the coast is dotted with widely dispersed cumuli.

50. Adam's Peak (7,360 feet) over 40 miles away and the Haycock Range in the Sabaragamuva region are distinctly visible from the coast.

51. For detailed considerations of the thermo-dynamics of this convectional circulation, reference may be made to an earlier paper, . . . ' Thunderstorm Phenomena in Ceylon', op.cit., 164-176.

52. The writer has had occasion to be on Adam's Peak during this period and was thus able to observe the 'atmospheric scene'.

By late afternoon, in the eastern horizon, the dark, ominously-hanging cloud mass portends the 'deluge' that is soon to set upon the coastal zone. The cloud mass gradually spreads towards the coast, having reached the level of the upper coastal-bound air stream; in the highland however, the 'thunderstorm' drama is already being inacted. The 'growing' cumuli having reached the mature stage in the sequence of convectional atmospherics, have been made to 'precipitate' their 'burden'.[53] By about four or five o'clock, the sky over the coast darkens and soon the low sheets of nimbo-stratus discharge with suddenness a violet downpour, accompanied by a heavy squall and thunder and lightning; these downpours are often remarkably straight, and may last from about quarter of an hour to as long as three hours. The rains may cease by about seven or eight (depending on the potential unstable conditions during the late morning and early afternoon) and soon the sky is clear and fine weather sets in; the night therefore is a contrast to the forenoon and the late afternoon.[54] In the clear night the land radiates heat rapidly and so a cool land breeze sets in within an hour or so. These are months of high diurnal temperature ranges (Table IV); thus the sequence of a hot morning followed by a cool night is inaugurated. Some of the highest diurnal ranges are noticeable, ranging from about 12° to about 25°F :—

Station	Diurnal temperature ranges (°F)	
	March —	*April*
Anuradhapura	19·3°	16·8°
Diyatalawa	19·1°	17·4°
Hakgala	21·3°	19·0°
Kandy	19·9°	18·2°
Kurunegala	20·6°	16·5°
Nuwara Eliya	24·6°	21·6°

The land breeze reaches its maximum strength by about three or four o'clock in the morning, when the ocean and land temperatures are at their extremes because of the cumulative effects. Early morning showers are therefore expected, as the cool air from the land blows over the relatively warmer ocean; thus, it is that rainfall is experienced out in the sea and occasionally along the coastal 'fringe'. The land breeze is of significance to the fisherman who begins his 'day's' work

53. The stages in the development of the fair-weather humilis cumuli into the eventual anvil cumulo-nimbus or the 'thundercloud' producing the thunderstorm have been set out in detail by the writer in '. . . Thunderstorm Phenomena in Ceylon. op.cit.

54. During this period varied social activities are planned; religious ceremonies of the Hindus and Buddhists take place in the night and the clear blue sky forms a perfect canopy for the myriads of flickering lamps in the temple compounds.

at nightfall.[55] It is interesting to analyse the rainfall falling during this period in terms of time of occurrence; a diagram has been prepared in this connection based on data from Bamford (Plate VII).[56] The early morning and late evening rain concentration is clearly evident both at Colombo and Trincomalee, though the latter has lesser incidence because the convectional 'source region' is farther away than for Colombo. Other work in this connection has brought out the rainfall sequence in terms of amount and time of occurrence for Colombo and Labugama.[57] Thus:

Average amount of rain in inches falling in each three-hourly interval of the day during the (spring) Convectional period

	Colombo		Labugama	
	March	April	March	April
Midnight - 3 a.m.	0·16	1·05	0·39	0·27
3 a.m. - 6 a.m.	0·02	0·58	0·12	0·24
6 a.m. - 9 a.m.	0·10	1·40	0·02	0·30
9 a.m. - 12 noon.. ..	0·06	0·59	0·03	0·57
Noon - 3 p.m.	0·25	0·39	0·72	1·57
3 p.m. - 6 p.m.	1·03	2·27	7·45	7·74
6 p.m. - 9 p.m.	1·63	2·18	2·46	2·70
9 p.m. - Midnight ..	0·90	1·02	0·42	0·93

These figures show that Labugama being within the convectional 'source region' receives higher falls and also earlier in the afternoon; thus the intensification of convectional activity reaches between 3 and 6 p.m. when highest falls occur, namely, over 7 inches and then soon decreases with the coastward movement of the 'rainclouds'. Colombo on the other hand receives early morning showers, being the coastal expression, and receives higher falls between 3 and 9 p.m., notably after the Labugama 'deluge'; Labugama lacks early falls because of its inland location, which the weak sea-breeze does not reach.

The regional picture (Plate IV) reveals that the 5-inch rainfall zone is concentrated in the southwest of the island, while northward the rain-tendency is low (Jaffna 1·5 inches and Mannar 1·9 inches). The highest concentration, however, is about the western slopes of the southwestern ridges, where one of

55. The white sails, filled with the land-breeze, are seen for a while on the sea, only soon to be lost in the vastness of the ocean; but the flicker of lights on the distant horizon indicate the positions of the frail fishing craft and facinates the visitor on the shore. The boats return home with the initial onset of the sea-breeze. This cycle of fishing-activity is repeated in daily sequence during this time.

56. A. J. Bamford, 'On the general circulation of the air over Ceylon with special reference to the time of day of rainfall', *Bull. Colombo Observatory*, 4 (1922), 1-7.

57. A. J. Bamford, 'Notes on the Climate of Western Ceylon with special reference to the Upper winds at Colombo', *Cey. Jour. of Science*, Section E, 1, 3 (July 5th, 1929), 173-206.

the major convectional 'source regions' is located; Ratnapura with 10·3 and 10·5 inches in March and April, respectively also has very high thunderstorm potential (Plate VIII). Other stations with high thunderstorm potential are Colombo, Diyatalawa, Hambantota and Galle.

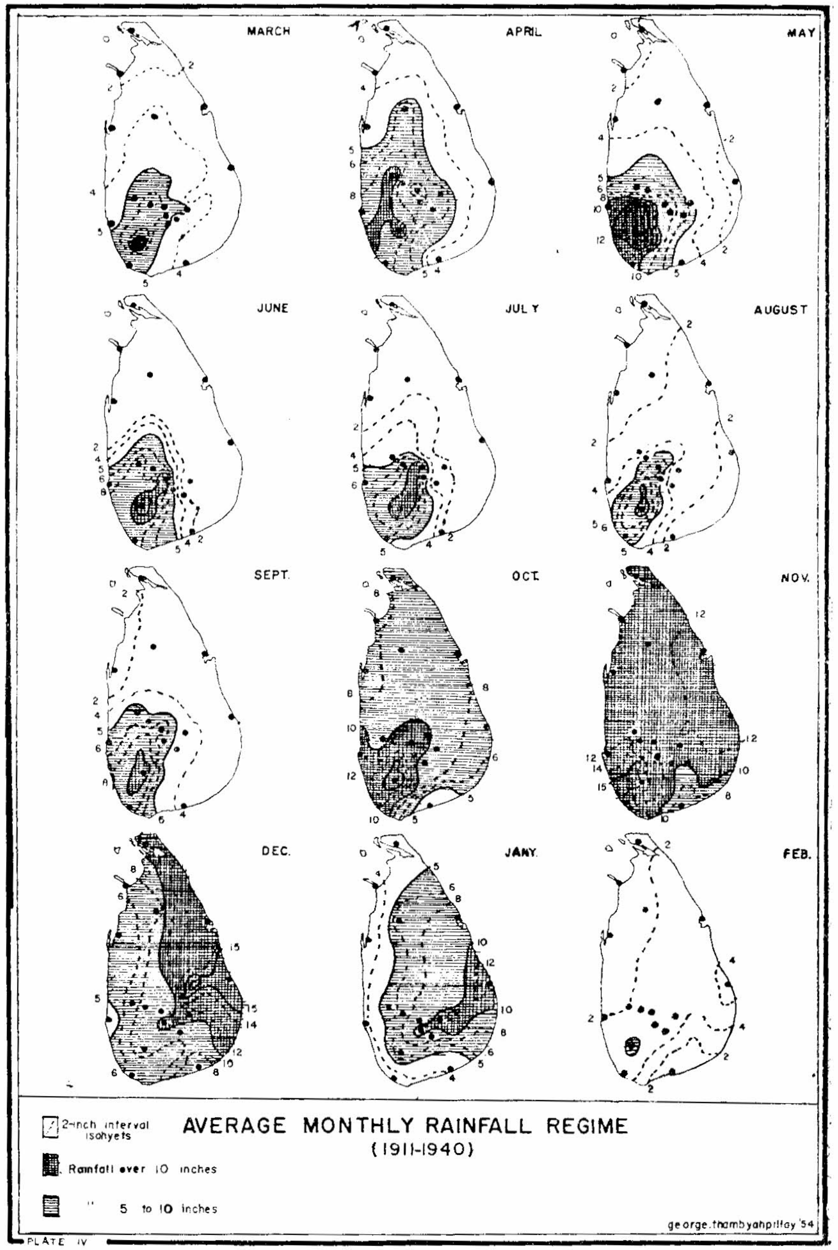
	Thunderstorm Incidence (days)		Rainfall (inches)		Rainy Incidence (days)	
	March	April	March	April	March	April
Badulla	4	11	5·0	7·0	12	16
Colombo	13	17	4·4	8·5	11	17
Diyatalawa	10	18	4·8	6·6	13	17
Galle	11	12	5·2	8·7	12	16
Ratnapura	14	16	10·3	10·5	19	21

All stations reflect high thunderstorm potential (Table V) though the amount of rainfall differs because of the topographical control; this explains the lower falls on the eastern side of the island. A detailed study of the rainfall of this period has brought out the effectiveness of topographical control, where very slight undulations standing in opposition to the rainclouds have caused 'forced ascent' and therefore localized heavier falls.[58] This effect is also reflected in the number of rainy days; while Trincomalee and Batticaloa have only 6-6 and 7-6 days during March and April, respectively, Ratnapura (19-21), Watawala (10-19), St. Martin's, Rangala (13-15) and Hakgala (13-16) have greater number of rainy days during the corresponding period.

By April, with convectional conditions well established, the 5-inch and 10-inch rainfall zones have been extended, so that a larger area of the island receives heavier falls; the east coast, however is still a low-rainfall region. The total rainfall received during this convectional period is small compared to the Monsoonal months; this is to be expected because the inducement 'to rain' are entirely locally initiated and the general winds are variable over Ceylon. Temperatures do not present much of anomalies (Table III), though, as mentioned earlier, diurnal ranges are very marked. Higher temperatures are on the other hand, the rule because of the equinoctial incidence and also because the diurnal sequence is 'sustained' by high insolation during the first half of the day. Recent studies[59] of the atmosphere over the island have revealed that during March and April, the weather phenomena are not always the function entirely of local thermal controls, but that part of the planetary features are responsible. Jayamaha mentions the Northern Convergence Zone as being responsible for certain weather characteristics which were till now not explained satisfactorily; it is only when this Convergence Zone is

58. A. J. Bamford, 'Ceylon Rainfall', *Quart. Jour. Royal Met. Soc.*, LXVIII, 202 (April, 1922), 206-207.

59. Jayamaha, op.cit.



AVERAGE MONTHLY RAINFALL REGIME (1911-1940)

PLATE IV

inactive over the island, that the thermal control determines Ceylon's weather. At this period, ' the Northern Convergence Zone is lying either across the island or in its vicinity. The northerly air stream converges with the Equatorial Westerlies to produce large banks of cumulus and cumulo-nimbus and several layers of altostratus and cirrostratus. The weather deteriorates and results in frequent thundery showers. If convergence occurs only at some distance to the north or south of Ceylon, only stratiform medium and high clouds will be present over the island or part of it. The resulting precipitation over the affected area will then be in the form of an occasional shower '.[60] Thus, not all thunderstorm or rainy activity during these months can be attributed to the ' thermal control ' of convectional atmospherics. It is also maintained that when the Convergence Zone is active over the Ceylon environs, frontal features may also develop.[61]

Pre-SW Monsoonal period (mid-April to late May). Beginning in May the island comes under conditions differing slightly from the convectional period ; the atmospherics over the Indian sub-continent gradually begin to affect the island.[62] The northward 'march' of the thermal and pressure conditions in India initiate the ' break-up ' of the ' Doldrum ' to eventually create an entirely new atmospheric setting in the Indian Ocean-Arabian Sea-Bay of Bengal environs. The Monsoonal phenomenon is yet to be established ; but, conditions are now being set up to facilitate the ultimate meteorologic feature,—the ' Monsoon ' of the Indian environs.

The convectional circulation and the accompanying diurnal rainfall sequence gradually become less characteristic a feature of the climatic 'scene', and an irregularity in the period and intensity of rainfall is observed ; there is no ' afternoon-rain ' persistency. Rain occurs at irregular times, though the rains in the afternoon are still prevalent and heavier. This state of 'unsettled' precipitation conditions is soon absent by about mid-May (on the average) when other rainfall characteristics are established. The regular sequence of diurnal events: the clear blue sky in the morning—the gentle sea breeze—the cloud-patterned sky—the convectional currents including progressive cumuli development—and then the dark thunder clouds, bringing in their wake, the violent downpours accompanied by thunder and lightning—and followed by the 'lull' with the clear sky in the night . . ., all these are things of the past.

60. Ibid. This feature has been observed in the University Park, i.e., overcast sky but only drizzle.

61. One of the most violent and disastrous ' cyclones ' occurred on 10th March, 1907. Refer, ' Papers Relating to the Cyclone at Batticaloa in March, 1907 ', *Sessional Papers*, 1906-1907, XLI (1907), 577-589.

62. For a detailed analysis refer, Thambyahpillay, *Climates of Ceylon*, op.cit., 59-63.

Thus, from late April to late May are set up atmospheric conditions which may be designated the pre-Monsoonal circulation and weather. At this time with the Northern Convergence Zone lying to the north of Ceylon, the island comes under the influence of the Equatorial Westerlies, or the Southwest Monsoon Stream.[63] This is also due to the fact, that the Southwest Trades having crossed into the northern hemisphere (following the migration of the 'meteorologic or thermal equator') in keeping with the rotational law of Ferrel, is deflected and blow as the 'Southwesterly Trades'; at most these southwesterly winds may be termed weak 'Monsoonal' currents, for the Monsoon proper is not yet established. But the convectional circulation is not completely absent. As such, this is a period of conflict between these two circulations: in other words, the still prevalent convectionally induced land-sea breeze circulation and the weak 'Monsoonal' or rather the 'Southwest Streamlines' vie *pari passu* to dominate the atmospheric environs of the island. Early morning showers (rain squalls) are common during this short period along the west coast (and rarely affect inland); these are produced when the weak 'streamlines' are cooled by the land breeze. The winds are gaining strength and persist from the SW or WSW though occasional NE winds in the late afternoons may be observed, bearing evidence of the still weakly prevalent convectional circulation; sometimes as the SW winds weaken afternoon thunderstorms are experienced. But the waning in convectional thunderstorm activity is evidenced by the sudden decrease in the incidence of 'thunder days' (Table V). A few examples may be cited—

	Number of days of thunder April	— May
Anuradhapura	14	6
Galle	12	7
Hambantota	14	7
Kurunegala	15	9
Mannar	13	6
Puttalam	8	3

According to investigations already carried out in Ceylon[64] steady southwesterly winds first set-in about April 20th and are light to moderate, fairly moist and extend from the surface to a height between 3,000 and 7,000 feet. It has been shown earlier by Simpson,[65] that the preliminary phase of shallow southwesterly winds usually observed by about the 20th of April is related to the

63. Jayamaha, op.cit.

64. Kreltszheim 'The setting-in of the South-West Monsoon over Ceylon', op.cit.

65. Simpson, op. cit.

shallow circulation that is established around the low pressure zone which forms over the Indian Peninsula before the Monsoon sets in. And it is this low pressure centre which shifts itself to the northwest of India with the establishment of the Southwest Monsoon. On the east coast part of the 'over-spilling' southwesterly currents help to strengthen the sea breeze to thereby facilitate precipitation[66] and delaying its (convectional) break-up in the evening. Therefore afternoon thunder showers are still the order of the day; this is revealed in Plate VII. A study of this diagram reveals the new rainfall sequence along the west coast, namely an all-day persistency with early morning and late evening maxima; however, true Monsoonal conditions in May mask this early May circulation. In terms of the daily rainfall during this period (i.e., between mid-April and late May) Kreltsheim, finds that the setting in of the shallow southwesterly winds about April 20th was preceeded rather than accompanied, by a fairly sharp increase in the widespread rain that prevailed over the island; even the 'surges' in these winds in early May (1st-4th and 9th to 16th) were accompanied by increased rainfall in the southwest quarter of the island. These 'rain spells' are not to be mistaken with the 'heavy rainfall' that accompanies the deeper 'surge' that marks the onset of the true Monsoon.

Southwest Monsoonal Period (late May to late September).

To the layman, the first 'spell' of heavy rainfall in early May (or even in late April) brings to mind the inevitable query, 'has the Southwest Monsoon burst?' Further, the early or late-Monsoon attribute is determined by the time of the occurrence of the 'rainy spell' in the month. The onset of the Southwest Monsoon (hereafter designated SW Monsoon) is indeed of great significance more from the economic standpoint than from the climatological consideration; however this is not to underestimate the climatological importance of this interesting meteorological phenomenon.[67] In India the onset of the Monsoon is characterised by the sudden 'burst'; in Ceylon this aspect loses such significance because of the series of 'surges' accompanied by rainy spells that precede the onset of the real Monsoon. Kreltszheim's interesting study of the 'onset of the SW Monsoon' has thrown much light on this

66. These winds reaching the Jaffna Peninsula are considered the harbingers of the dry scorching Monsoonal conditions that would soon follow; hence the term *poicholOgam* (meaning 'false Monsoon' or strictly 'false Westwind') has been assigned to these winds.

67. Earlier in this paper certain meteorologic aspects of the Monsoon were considered, especially with regard to its onset, subsequent development and characteristics.

aspect ;[68] the following tabulation would help to understand the nature of the 'burst' of the SW Monsoon in Ceylon :—

1951.[69]

Dates of appearance of changes in the wind components.

Observation Station	*'Shallow' phase*	*(Intermediate phases)*	*'Deep' phase*
Little Basses	April 19-20 :	April 30-May 3, 8-15 :	26-30
Hambantota	April 21	----------	----------
Jaffna	April 18-20	----------	----------
Trincomalee		May 3, 9-16 :	30
Colombo (*a*) 1,000 feet	April 21	May 3, 8-14 :	29
(*b*) 3,000 feet	April 20	----------	May 30-June 1
(*c*) 7,000 feet	----------	----------	May 31

Inference :—the 'shallow' phase set in about April 20th while the 'deep' phase about May 30th ; the April 18-20 commencement of 'phase' was marked by a spell of moderate rain and that of the 'deep' phase (May 29-June 1) by a spell of heavy rain.

It is thus seen, that the true SW Monsoon does not set-in until about the latter part of May (often early June), as indicated by the arrival of the first 'deep' phase of steady southwesterly winds. Jayamaha also substantiates this view by a synoptic analysis of Ceylon weather ; he contends that 'Monsoon activity however is not experienced until the latter half of May because an air stream of sufficient depth is necessary for such activity.'[70] He has interesting comments to make with regard to the 'burst of the Monsoon'. Introducing the Convergence Zone into the picture, he considers that 'waves' or 'disturbances' often occur along convergence zones ; these give rise to sudden deterioration in the weather over limited areas and produces the 'burst of the Monsoon'. Thus, for example, the 'burst' would occur over Ceylon, when such a 'wave' exists on the Northern Convergence Zone as it first reaches the island or forms while the Zone is over the island. These 'bursts' naturally are accompanied by heavy rainy spells.[71]

68. Kreltszheim, 'The setting-in of the South-West Monsoon over Ceylon', ibid.

69. The 1951 data is being used as it is the latest available and has been adopted from Kreltszheim's paper ; the absence of the intermediate and 'deep' phase for Hambantota and Jaffna is because the anenometer was not functioning. However, the lack of these data do not seriously affect the inference.

70. Jayamaha, op.cit.

71. Jayamaha cites the 'bursts' on 28th May, 1947, when 19 stations recorded rainfall over five inches in 24 hours ; again on 20th May, 1949, when 17 stations reported such 5-inch rainy spells. In 1951, in addition to the first 'burst' on the 12th (23 stations with over 5 inches) there was a 'secondary burst' on the 30th (22 stations with over 5 inches). In 1946, 1948 and 1950 in the absence of such waves, the Monsoon had set in uneventfully, lacking the 'burst'. The heavy rains of May 28th, 1954 around the Galle environs was due to the development of the convergence of two moist air streams ; this weather extended along a narrow band.

The establishment of the SW Monsoon over the island, could therefore be ascertained by observing the 'deep' phase of the southwesterly (wind speeds ranging between 300 and 500 miles per hour) winds and by the complementary sudden, heavy rain-spell. The pressure gradient between Colombo and Trincomalee reveals a sharp rise about April 20th, with the initial 'surge'; this gradient continues positive, marked by slight increases about the first and second week of May (3rd and 8th-14th) and by June 1st, it is over 2·0 millibars which is maintained until new conditions in October set in. The onset of the SW Monsoon must be reflected in the rainfall incidence of the west-facing side of the island ; this is only too clearly evident.

Station	*April* a	*April* b	*May* a	*May* b	*June* a	*June* b	*July* a	*July* b	*Aug.* a	*Aug.* b	*Sept.* a	*Sept.* b
West Coast												
Colombo (20′)	8·5	17	11·6	23	6·8	22	5·9	16	3·2	14	5·7	17
Galle (70′)	8·7	16	12·6	21	8·4	22	6·3	19	6·2	19	8·8	18
Intermediate												
Watawala (3260′)	11·1	19	25·7	15	38·7	25	29·4	27	25·0	25	25·3	22
W. Highland												
Nuwara Eliya (6170′)	5·0	15	8·5	18	10·4	25	17·0	24	7·5	22	8·2	20

a = rainfall in inches; b = average number of 'rainy' days.

Thus, these stations show sudden increase in rainfall contrasting from the April amounts. By June the Monsoon is well established and is 'taken for granted'; the persistent southwesterly winds blowing day and night, leave no doubt that the Monsoon 'has come to stay'. The rainfall amounts also indicate that in June the 10-inch zone has migrated from the coastal region towards the interior, mainly related to the southwestern slopes of the central highland ; the rainfall in the coastal stations (west) show a decrease after the initial heavy fall in May. During the 'advance' of the Monsoon, coastal stations receive heavy rainfall, because of the 'surge', and the Monsoonal current is still not of sufficient depth to reach the highland. Bamford suggests that the high coastal rainfall incidence during the 'adolescent' stage of the Monsoon is due to the checking effect of the still existing but very weak sea-breeze which therefore provides the 'lifting' impetus to produce precipitation.[72]

72. This theory is not always satisfactory.

As shown earlier, the 'lull' after the initial 'deep surge' may perhaps offer a feasible explanation of the decrease in the coastal rainfall with the full establishment of the Monsoon. Rainfall is widespread with marked intensity between 9 p.m. and 6 a.m. (in Colombo); this is also revealed in Plate VII.

Colombo—Rainfall in May at three-hour intervals

period	inches	period	inches
Midnight-3 a.m.	3·16	12 noon-3 p.m.	1·08
3 a.m.-6 a.m.	2·84	3 p.m.-6 p.m.	2·10
6 a.m.-9 a.m.	1·79	6 p.m.-9 p.m.	1·70
9 a.m.-12 noon	0·86	9 p.m.-1 a.m.	2·66

(Derived from 10 years' observations.)[73]

Thus the 10-inch rainfall zone is coastal with a slight eastward 'bulge' to include the Southwestern Ridge country. Nuwara Eliya receives only 8·5 inches compared to Colombo's 11·6 inches. The rainfall may last for a few hours or for longer periods; but unlike the previous period the 'afternoon-thunderstorm' persistency is absent. In other words a 'rhythm' is not clearly evident; there is an all-day tendency. In the eastern and northern parts of the island rainfall decreases and persists as convectional incidence (Plate VII). However, while Jaffna (2·0 inches) Mannar (1·8 inches) Batticaloa (1·7 inches) show decreased falls, Trincomalee (3·2 inches) shows on the contrary an increase of 1·1 inches from the previous month. This is explained by the fact, that the weak Monsoonal currents may reach Trincomalee directly and so accentuate the convectional circulation; decreased fall in Batticaloa may be due to the Monsoonal 'spill-over' which because of descent is adiabatically warmed to bring 'drying' conditions. However, this is still the 'adolescent' Monsoon, and hence does not yet create conditions to negativate the eastern coast weather. It is the general opinion among students of climatology in Ceylon, that 'cyclonic' activity is noticeable over the island only during the October-December period. However, milder 'depressions' (meaning centres of low pressures) do affect Ceylon even during other months such as between March and May and even in July; in fact because of the geographical position of the island within the migratory inter-tropical Convergence Zones, 'frontal' tendencies can be brought about. Incursions of such 'depressions' have been observed and studied in March[74] and in May.[75] These serve to accentuate and localize heavy rainfall.

73. Adapted from data appearing in, D. T. E. Dassanayake, 'The Weather Along the Direct Air Route from Colombo to Nuwara Eliya', *Bull. Cey. Geog. Soc.*, 3, 1 (June, 1948), 15.

74. A. J. Bamford, 'Cyclonic Movements in Ceylon', *Cey. Jour. Science*, Sec. E, 1, 1, (January 14th, 1926), 29.

75. H. Jameson, 'The Heavy Rains of May, 1933, in Ceylon', *Cey. Jour. Science*, Sec. E, 11, 2 (September 8th, 1937), 77-80.

The next three months of the SW Monsoonal period—June, July and August—reflect rainfall characteristics almost similar; this is because the Monsoon is in full control over the island. These three months reveal accentuation of May—June conditions, in that the belt of heavy rainfall becomes more and more confined to a smaller 'region' in the southwest. While in May and June the 5-inch rainfall zone was fairly spread-out, by July with the full development of the Monsoon, topographic controls begin to take effect. The increase in the depth of the Monsoonal currents does not in any way seem to increase the rainfall everywhere in the southwestern region; Watawala is one of the few stations that reflects increasing rainfall with the establishment of the Monsoon. Most of the other stations, on the contrary show a decrease in rainfall, e.g., Colombo, Galle. As the table (on page 251) indicates, it is the topographical factor that seems to play the rôle of 'concentrating the Monsoonal rainfall'. Thus, the common view that the Monsoon is synonymous with rainfall needs modification; for, while the Monsoonal currents being moisture-laden 'bring potential rain' to the island, it is the orographic character of Ceylon that induces the Monsoon to 'precipitate its burden'. This is clearly evident from the fact that, while Hambantota (which lies directly athwart the Monsoonal Currents) receives only 13 inches of rainfall lasting 47 days (of rain), during the SW Monsoon period Ratnapura, lying in an enclosed valley and over 40 miles from the coast, receives about 80 inches during the same period in 118 days (of rain). Hambantota has not even a coastal forest cover to cause 'lifting' (while the Southern Mountain Wall is too far away); Ratnapura, backed by the southwestern face of the Southern Mountain Wall and also by a NW/SE aligned ridge on its west, experiences heavy rainfall, because of the precipitation induced by the tremendous 'lifting' effect when the winds are forced to ascend against the Mountain Wall as well as by the ridge. Bamford, during his early days in the island drew attention to this fact, 'the monsoon wind that blows over the flat country round Hambantota in June and gives little or no rain there, is just as strong and just as moist as that which reaches the Western Province and Sabaragamuwa and causes floods in the Kelani. . . . We have then at once the explanation of why fully developed monsoon conditions give rain on the windward side of the island, but particularly on the windward faces of the hills'.[76]

By June the 10-inch rainfall belt has 'moved' eastwards towards the highland (Colombo shows a decrease in rainfall from 11·6 inches to 6·8 inches, while Nuwara Eliya shows an increase from 8·5 inches to 10·4 inches in June); in July these trends persist and heavy localized rainfalls have been observed,

76. A. J. Bamford, 'On the Interaction of a Mild Depression and the South-West Monsoon with Special Reference to the Rain of July 7th, 1928', *Cey. Jour. Science*, Sec. E, I, 3 (July 5th, 1929), 207-222. H. Jameson, 'Whirlwind at Veyangoda, Ceylon, 20th July, 1921', *Quart. Jour. Royal Met. Soc.*, LXVIII, (20th January, 1922), 59-60.

when mild ' depressions ' move into the Monsoonal circulation.[77] August reflects a slight decrease everywhere, but rainfall is still in the southwest though the concentration is confined to a smaller zone. Over two-thirds of these months have ' rainy days ' (Table II) and temperatures reflect slight falls in accordance with increasing humid conditions (Table III) and diurnal temperature ranges also have fallen (Table IV) since the whole day is cloudy and diurnal variations in rainfall are not present. By September, conditions are wont to change and it is not until the middle of the month that ' new ' atmospherics are revealed ; this is the period when with equinoctial conditions being re-established the Monsoon begins to ' retreat '. The rainfall everywhere increases slightly (especially in the southwest) because the Monsoon is not any more a persistent wind ; while the depth decreases and ' weakening ' conditions begin to be operative, rainfall is widespread and is comparable to the May conditions. However the area of rainfall is smaller now and is as to be expected ; for in May, the Monsoon was trying to establish itself and hence a ' strengthening wind ', whereas in September it is a ' weakening wind '. Once again this is the period of the incessant struggle between the Monsoon and the convectional circulation (trying to re-establish itself). The number of ' rainy days ' during this period also expresses the ' sequence ' described herein ; coastal maximum in May and highland maximum during post-May period (Table II) of the Monsoon. The 20-inch rainfall zone for this period is confined to the southwestern zone while the pluviometric index (Plate V) reveals over 30 per cent for this area.

The SW Monsoon period is a season of marked economic significance to the western parts of the island ; the rain-based agriculture (both subsistence and plantation) are dependant on the Monsoonal rains. This being the rainiest period of the year in the southwest, agriculturally also, therefore it is of importance and is termed the ' *Yala* season ' ; the agricultural cycle is closely bound up with the rainfall cycle. This close relationship explains why so much anxiety is caused when the Monsoonal rains fail to occur at the normally expected time ; for, the agricultural base is carefully prepared in order to receive the rains. The failure of the rains therefore causes much hardship among the agriculturalists. One of many things may happen to the Monsoonal rains : an early or late onset, and an early or late ' departure '. If the ' heavy rains ' set-in early, then the field is not yet prepared to receive the rains and there will be too much moisture more than the germinating seedlings need ; on the other hand if the rains set-in late, then the germinating seedlings will not develop in the maturity sequence, the yield thereby being poor. An early ' departure ' of the rains would mean also insufficient maturity of the crop and thus a poor yield ; a late ' departure ' would mean excess of moisture and the crop will be ruined. These situations have arisen many times and bears

77. Bamford, ' Notes on the Climate of Western Ceylon . . . ', op.cit., 174-175.

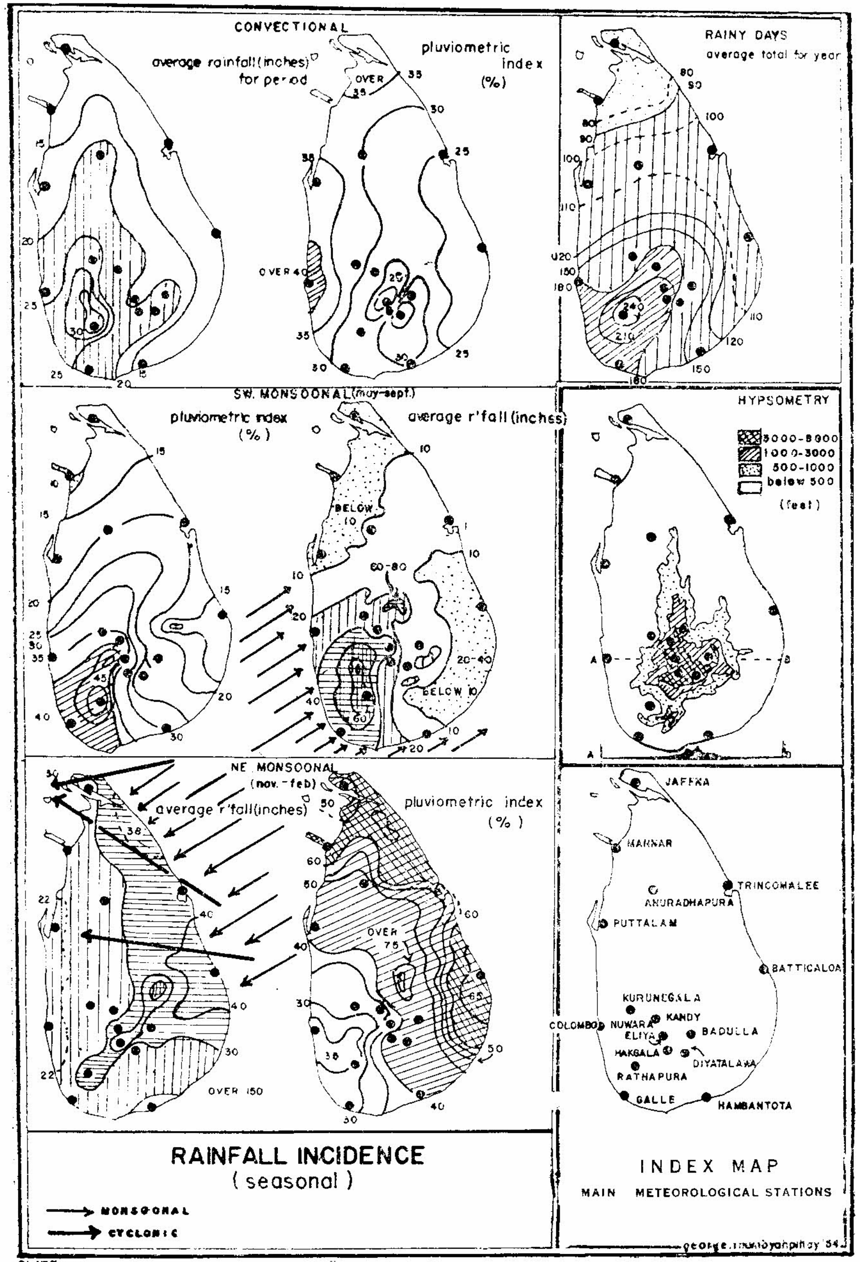


PLATE V

evidence of the vital rôle of the SW Monsoonal rains in the agricultural economy, especially with regard to the food supply produced in the country. Usually the farmer takes his cue from the initial 'shallow'—phase rains about early May and sets about the final tasks of preparing the field-base to receive the rains. If the 'deep' phase does not develop sufficiently to bring rain, then the spectacle of an immature crop awaits the farmer.[78] The SW Monsoon affects the country's economy in still another way, namely in the earning potential of the Port of Colombo. Since most of the cargo handling is still done by shore-ship transport by 'lighters' or barges, during the full fury of the Monsoon, cargo handling activity is very much impeded; the ships would then have to 'skip' the Port without discharging their cargo. Ships may also seek other ports in the Indian sub-continent, especially Madras or other west coast ports with alongside-berthing facilities.[79] Yet another Monsoonal control is that of fishing; at this season no fisherman would dare the ocean in his frail craft and he resorts to other local minor agricultural or 'industrial' pursuits. This respite in his activity however provides him the opportunity for the repairing of his craft and the mending of his nets. Some of the fishermen migrate to the eastern or northern shores,[80] to continue their toil. Undue heavy rainfall during this period often leads to the swelling of the rivers and those that flow to the western coast are often in spate and 'floods' cause tremendous loss of property, crops and even life.[81] Thus all told, that the Monsoon plays a significant rôle in the island in the agricultural-socio-economic life of the country needs no elaboration. Yet, to the average man the Monsoon has come to form part of his heritage and he therefore adapts himself to its vagaries.

While these conditions are typical of the western part of the island, especially more so in the southwestern sector,[82] in the northern and eastern parts, the picture is so very different; paradoxically so, yet the SW Monsoon

78. Since this is normally a period of heavy rains which usually arrive in due regularity, no irrigation facilities have been provided; thus an occasional 'failure' of the Monsoon rains will bring in its wake the inevitable scene of desolation.

79. The new Port Development Programme when completed would provide the Port with adequate alongside-berthing facilities; two of these are already in operation.

80. The seasonal migration of the fishermen from the Negombo-Puttalam zone is a case in point.

81. The Kelani Ganga Flood of 1947 was a good example; usually many of the other west-flowing rivers are in spate after the slightest 'heavy fall' and cause localized inundations of low-lying paddy lands.

82. The Monsoon that reaches Puttalam in spite of being moisture-laden does not precipitate as no 'lifting' agency in the form of orography exists; the total June-August rainfall is only 3 inches. This is true also of Hambantota (lying athwart the full strength of the Monsoon) receiving only 5·7 inches during this period.

in these parts, possesses a 'rainless' attribute. This however is easily understood in the geographical setting of the island's physical framework; the north-south trending central backbone acts as an effective barrier to the SW Monsoonal currents and therefore functions as a 'climatic divide' *par excellence*.[83] The hypsometry map (in Plate V) clearly reveals this; this is even still more effectively seen from the SW and NE Monsoonal pluviometric index maps (Plate V). These months are therefore the 'dry' months and is referred to in local parlance as the '*Kōdaikālam*'.[84] Some rain does fall caused by convectional currents; the amounts received however are very low, Jaffna receiving only 2·0 inches and Trincomalee only 6·4 inches during the June-August period. The strong dry winds that reach the northern coast is designated the '*chōlogam*'.[85] Having deposited their moisture content, the SW Monsoon arrives in this region to inaugurate the period of intense activity, especially in the agriculural pursuits; for, being the 'rainless' season the farmer has to use all available means of raising water from below the surface. This is due not only to the insufficient rainfall but also because of nature's endowment of a limestone base; rivers or any other form of surface flow of water are lacking.

The decrease of rainfall is universal throughout the northern and eastern zone.

Situation	*April* a	b	*May* a	b	*June* a	b	*July* a	b	*Aug.* a	b	*Sept.* a	b
North Coast												
Jaffna (10')	2·2	5	2·0	3	0·4	1	0·5	1	1·1	3	2·5	4
East Coast												
Trincomalee (30')	2·1	6	3·2	6	1·0	3	1·8	3	3·6	7	3·4	8
Intermediate												
Badulla (2220')	7·0	16	4·7	12	1·6	7	2·2	7	3·2	9	4·5	10
E. Highland												
Hakgala (5580')	7·0	16	8·5	17	6·6	21	6·6	20	5·1	19	6·7	18

a = rainfall in inches; b = number of rainy days.

83. Thambyahpillay, 'Climatic Controls in Ceylon', op.cit., 3 and Plates II-V.

84. This strictly means the 'dry season' and is the climatological-opposite of *Mārikālam* (wet season, i.e., NE. Monsoonal period).

85. This is the Tamil-equivalent of 'SW. Monsoon'; but in strict terminology it means south and is derived from *sōlahan* of the same meaning. Strictly therefore the SW. Monsoon is *sōlaka-kachān*.

These figures indicate the gradual onset of 'drying' conditions; in September, with the 'weakening' of the Monsoon, convectional activity gains dominance and hence explains the slight increases comparable to the rainfall received during the 'onset' stage of the Monsoon in May. The late afternoon rains have now come to stay (Plate VII) and this tendency is continued into the next month. These are essentially 'less than 2 inches' rainfall regions during the Monsoonal dominance (Plate IV); the graphical expressions of the rainfall regimes (Plate VI) further indicate this feature. In the so-called Dry Zone the innumerable 'tanks' and irrigation channels (now many of them in an abandoned state) are mute expressions of the rainfall control of agricultural activity in the once 'habited' part of the island; here was once the island's 'granary'. The recent efforts of the governments (during the last half a century) to restore these irrigation works in order to transform this area into the 'rice-bowl' of the island is a reflection of the recognizance of the rôle of rainfall in the country's economy. The SW Monsoon plays a paradoxical rôle in this 'rice bowl' development: while it is responsible for the 'dry' conditions, yet it is by the storage of its surplus waters (from the rivers especially the Mahaweli Ganga) in tanks that it indirectly helps in this 'regeneration'.

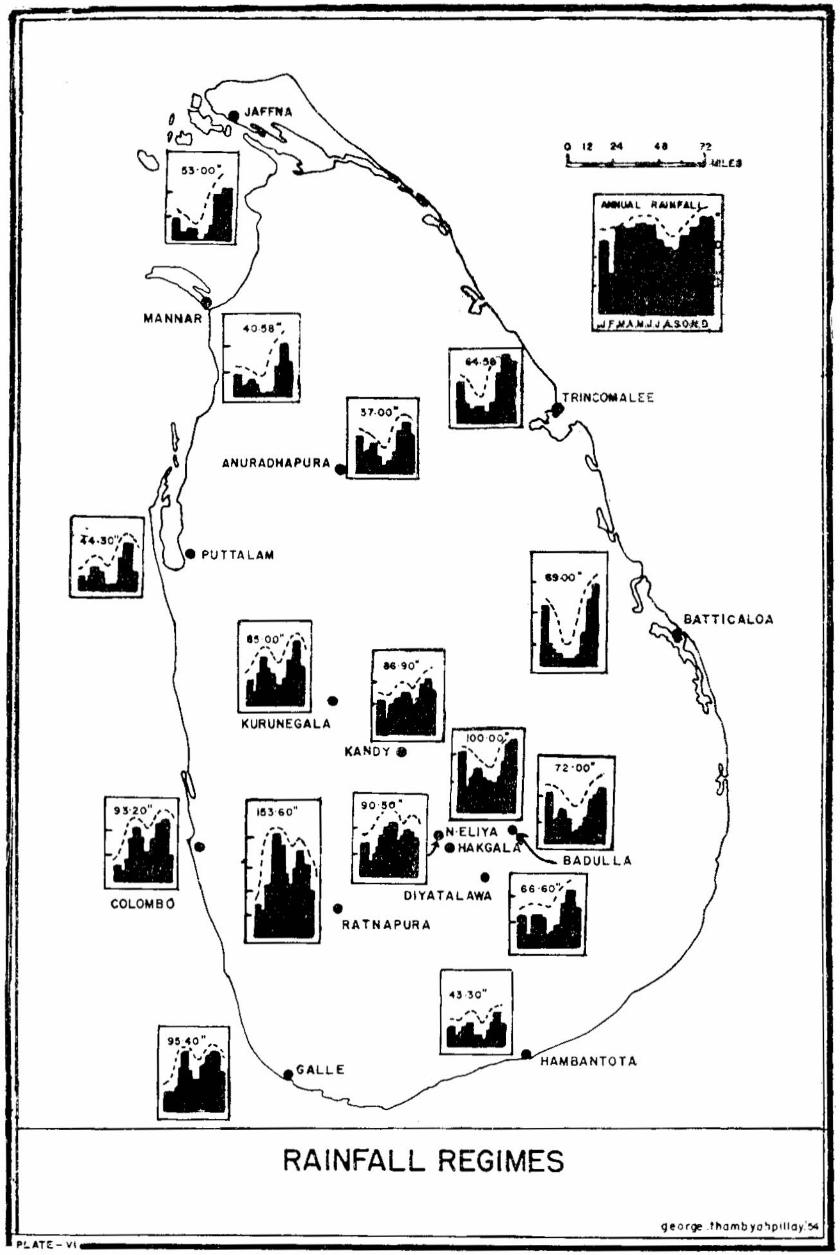
Thus, both in the Jaffna Peninsula and in the so-called Dry Zone, in spite of the adverse rainfall conditions, the efforts of man have and are still in the process of 'regenerating' the land into the 'granary' of the island; the 'green mantle' of the Jaffna Peninsula is entirely the expression of human ingenuity in transforming a negative physical and climatic environment into one of the most fertile in the island. Nor must one fail to see human ingenuity in yet another form in the 'gigantic irrigation works' in the attempt to let 'not a drop of water run waste to the sea'. The '*well-sweep*' in the Jaffna Peninsula and the '*anicut*' in the so-called Dry Zone, are dual expressions of the 'rainfall control' in the agricultural potentiality of the respective *land-shaft*. The agricultural season in Jaffna during this period is the *Elaipōkam* and irrigated crops are grown,[86] while the cropping season is *Pinmāri*.[87]

During this period in Batticaloa there prevails a special wind dominant especially in August and termed the *Kachchān*[88]; it is basically a dry scorching wind. During full strength the SW Monsoon, after having been induced to 'drop its precious cargo' west of the central mountain backbone, 'spills over' into the Welimada (Uva) Plateau as a lee wind. At the time of the 'spill over'

86. Some of the crops are oilseeds, millets, chili and manioc; the *well-sweep* (cf. *Shaduf* in Egypt) is a typical feature of the agricultural landscape.

87. This refers to the post NE. Monsoonal crop and is essentially the irrigated-crop in the north and east. It corresponds to the *yala* crop in the south; *sirupōkam* is also used interchangeably with *pinmāri* which latter is the opposite of *Munmāri*.

88. H. Jameson, 'The Batticaloa Kachchān', *Quart. Jour. Royal Met. Soc.*, LXVIII (January, 1947), 55. Also see, Thambyahpillay, 'Climatic Controls in Ceylon', op.cit., 173-174.



RAINFALL REGIMES

PLATE - VI

it is devoid of moisture and is already a dry wind ; descent into the Plateau causes further ' drying ' because of adiabatic warming and this *katabatic* wind as it continues in its easterly stream reaches the coast, especially around Batticaloa as the *Kachchān*. While temperatures are high at this period on the eastern side (Table III) yet extremely high temperatures have been observed with the onset of a ' sudden west wind ', counteracting the otherwise ameliorating sea breeze. This ' foehn-effect ' wind is initially felt in Diyatalawa before it reaches Batticaloa where it is a characteristic feature of the weather.

Autumnal Convectional-Cyclonic Period (late September to November).

By late September, Monsoonal conditions are on the wane and the stage is set for the establishment of new atmospheric conditions ; often occasional heavy rains have followed in the wake of the retreating Monsoon.[89] But by late September with equinoctial conditions being re-established convectional activity begins to re-assert itself, though the situation is not similar to that which prevailed in early March. Though the sun is over-head Ceylon during September, equinoctial conditions are not established until October because of the nature of the SW Monsoonal Streamlines. There is no doubt that the SW Monsoon with a depth of about 8,000 feet is ' shallow ' (compared to 13,000 feet in July); yet it does not lose its atmospheric influence until in October when the Northern Convergence Zone crosses Ceylon through the lowest layers of the atmosphere and so transmits its influence to the weather in the island. This then is the period of the re-establishment of ' Doldrum ' conditions over the island ; thermal control of local origin and convectional activity should prevail. However, other atmospheric features minimise the convectional circulation while the Northern Convergence Zone exercises its dominance: with occasional ' polar outbreaks ' conditions are created for the generation of ' storms '—which tendency is carried through into the NE Monsoonal months. Thus in October the convectional falls are masked by the incidence of 'depressional activity '[90] which contribute towards the heavier falls so characteristic at this time.

89. H. Jameson, ' The Heavy Rains over Ceylon of September 29th-30th, 1924 ', *Cey. Jour. Science*, Sec. E, 1,1 (January 14th, 1926), 39-48. Jameson attributes this heavy rainfall to the inter-action of a ' depression ' with the late Monsoon in its ' retreat ' stage.

90. This explains the all-day rain persistency that prevailed over the University Park in October on the 16th, 17th, 18th and 19th ; because of the depressional inter-action (convergence) the convectional rain sequence was not evident. The generally all-day rain and drizzle, is due to the prevalence of ' depressional ' conditions (often covering hundreds of miles diameter) exemplified by the state of, what might be termed, ' unsettled weather '. Later investigations have revealed that the ' unusual weather ' that prevailed during the second and third weeks of October (1954) was due to a combination of a series of meteorologic circumstances. In early October, as is to be expected, convectional weather prevailed (clear mornings and rainy, thundery afternoons and evenings) ; then ' depressional activity ' off the west coast of Ceylon induced the retreating S.-W. Monsoonal currents to effect a *rifacimento hors de saison*. After a few days there was a temporary re-establishment of true convectional conditions (so well noticeable in the University Campus). But this situation lasted only a day or two, when a new ' depression ' developed north-east of the Island ; once again the Monsoonal currents were drawn northeastwards towards this low pressure centre. By the 21st or thereabouts once again convectional conditions prevailed. A detailed analysis, however, will appear in a subsequent paper, when the rôle of the Northern Convergence Zone in Ceylon's weather will be more substantially considered.

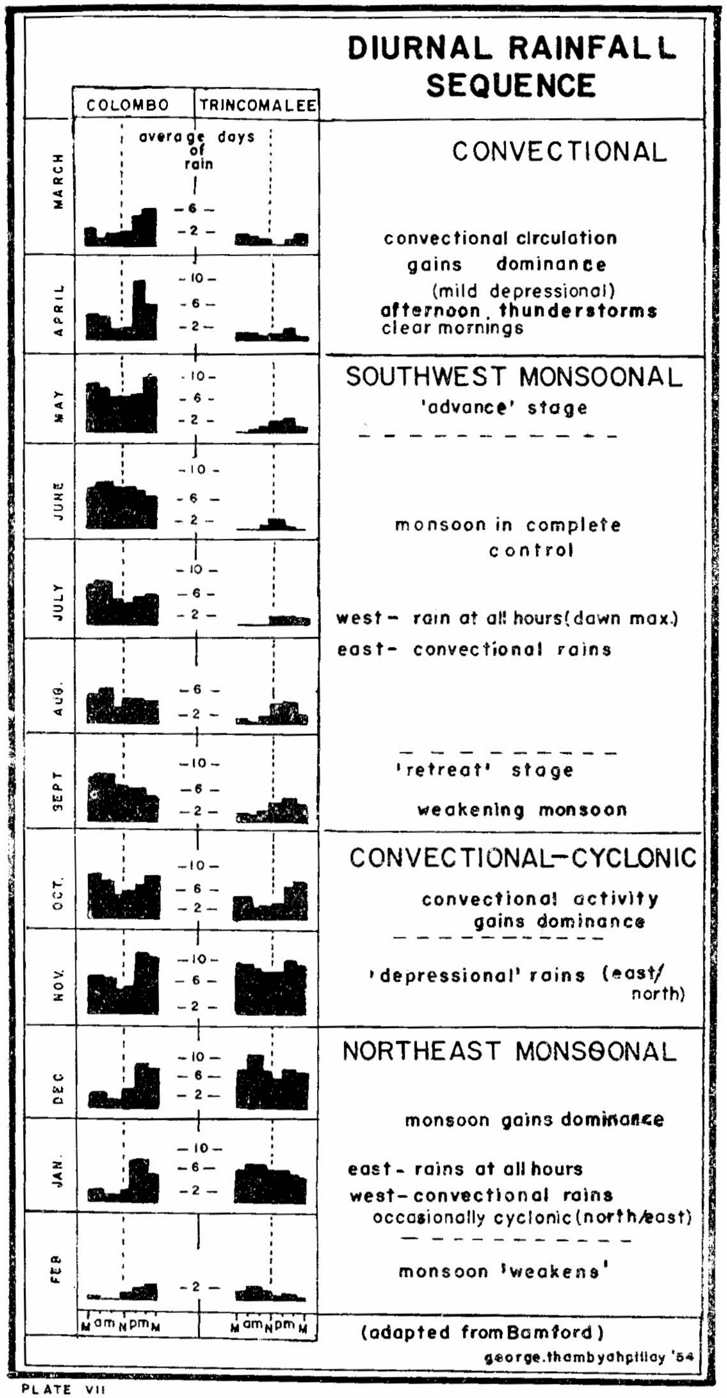


PLATE VII

Station	Date	Rainfall (inches)
Padupola	October 5, 1913	22.00
Watawala	October 5, 1913	20.65

While the rainfall rhythm during this month follows the normal convectional type, yet occasional depressions move into the island to cause sudden heavy falls. All parts of the island receive increased rainfall; no station receives less than 5 inches, except Hambantota. The 10-inch rainfall zone is still in the southwest, the heavier concentration being towards the western slopes. All over the island rainy tendency increases, most of the stations showing such tendency for at least two-thirds of the month (Table II). Temperatures everywhere show marked decrease (ranging from 0·5°F to over 2·0°F; Table III), while diurnal ranges are on the increase (Table IV). Except in inland locations thunderstorm tendency is also on the increase (Table V; Plate VIII). Crowe attributes the first heavy rains received in the island in October as being due to the 'storms' (Colombo receiving a second rainy season).[91] In November conditions that prevailed in October are further accentuated, though rainfall is now due more to the 'depressional' or 'cyclonic' activity rather than to convectional incidence; this is more true on the eastern coast than on the western coast.

Thunderstorm Incidence (days)		
	October	— November
West Coast		
Colombo	10	12
Agalawatte	7	10
Galle	3	6
East Coast		
Batticaloa	9	5
Trincomalee	11	6
Eastern Slopes		
Padulla	8	5
Passara	14	9

On the other hand, 'cyclonic' incidence has increased; out of forty-eight 'cyclones' observed in the island between 1925 and 1944, it is not without any significance that 19 of these occurred in November, and 10 in October.

Cyclonic incidence—Number observed

Jan.	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
3	0	3	3	2	0	1	0	2	10	19	5

91. Crowe, 'Wind and Weather in the Equatorial Zone', op.cit., 62-64.

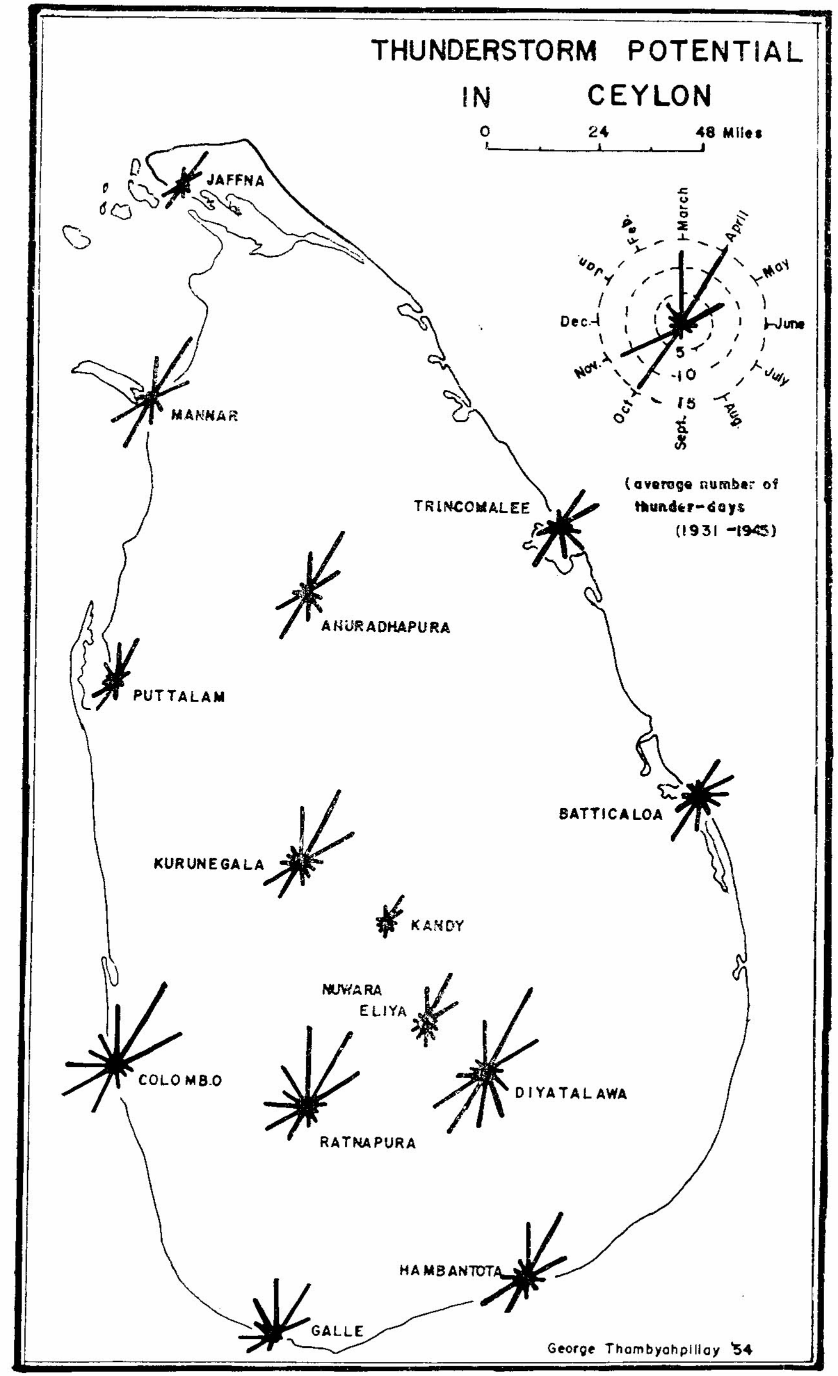


PLATE-VIII

Further some of the heavy cyclonic rainfalls have fallen in this month; such 24-hour falls are often equal to almost 50 per cent of the total annual rainfall.

Station	Date	Amount in 24 hours (inches)	Average annual (inches)
Jaffna	Nov. 17, 1918	20.48	53.00
Chavakachcheri	Nov. 15, 1939	21.17	56.00
Jaffna College Vaddukoddai	Nov. 15, 1939	15.00	55.00

It has been ascertained by Crowe that by this time the Northeast Trades has established itself in the Bay of Bengal and is stronger than the Arabian Sea counterpart, the corresponding wind velocities being 5½—14½ knots and 5—11 knots, respectively. However the heavier falls are more due to the 'disturbances' within the advancing Trades: thus, the rainfall is marginal to the Trades; these heavy falls, according to Crowe's study are, 'frontal rather than orographic'.[92] The rainfall in November everywhere is reflected by the sudden increase while in December they show decreased falls. The abrupt manner in which this November-December rainfall increases and then decreases is seen in Madras as well; the decrease is in keeping with the increasing persistence of the Northeast Trades. There is no doubt therefore that the November rainfall is 'frontal' or 'cyclonic'. Except for Hambantota and Nuwara Eliya, all other major stations receive over 10 inches (Plate V).

A brief consideration of the 'genesis' of these 'cyclonic' storms has already been made: it may be mentioned that since they occur during the 'cool period' (including December and January) it is suspected, that 'polar outbreaks' surging into the Trade wind environment (the northeasterly currents facilitating movement of these 'polar streams') and therefore coming into a warmer zone might be the cause of 'cyclogenesis'. Jayamaha, from his study, suspects that the Polar outbreaks are the 'occasional surges' identifiable during this period—producing a zone of discontinuity with the Indian Continental Air. However, since more study has to be undertaken in these environs, this controversial issue will be left alone at this stage.

The regional concentration reveals a dual zone, one in the northeast (Trincomalee to Batticaloa) and the other in the west (Galle to Colombo including Kurunegala) and there is an all-day persistency with occasional intensification caused by the passage of 'disturbances'. The winds by now are essentially northerly to northeasterly, indicative of the initiation of the North-east Trades persistency. In the north this period corresponds to the 'spring season' heralding in the *Mārikālam*; the 'spring rains' gladden the heart of the farmer who hails the *Vasanthakālam*.[93] Now he can sit at ease and watch the flooding fields and the changing green of the landscape.

92. Ibid., 64. S. W. C. Pack, *Weather Forecasting* (London: Longmans, 1948), 192 pp. According to Pack, the storms develop on the Inter-Tropical Front, probably where two or more air masses are converging at, what is known as the *triple point*. Such a situation is possible where the dry and moist air (colder) masses of the North-East Trades meet the warmer South-East Trades.

Northeast Monsoonal Period (early December to February).

By December there is no doubt that the so-called Northeast Monsoon has set in,[94] as is evidenced by the persistent northeasterly wind gradient. It was maintained earlier that this is the period of the Trades and that the term Monsoon was a misnomer. The heavy rainfalls during this period is due not so much to Monsoonal conditions as to the series of 'cyclones' that traverse the island between December and February; they seem to come into the island off the east or northern coasts.[95] The incidence of cyclonic activity[96] during this period is of significance in terms of the rainfall they contribute and thus masking the real rainfall character of the so-called Northeast Monsoon.

Station	Date	Amount in 24 hours (inches)	Average annual rainfall (inches)
Kannukeni	Dec. 19, 1911	20·00	58·27
Mullaitivu	Dec. 18, 1911	31·18	61·94
Nedunkeni	Dec. 15, 1897	31·72	66·52
Pallai	Dec. 28, 1903	18·00	—
Amparai Tank	Dec. 7, 1881	19·20	72·30
Diwulana Tank	Dec. 8, 1884	19·50	79·30

In terms of total rainfall received, stations in the northeast and north at this period cannot compare with those in the southwest as when the SW Monsoon was operative. However, the rainfall received by these stations

93. The 'spring season' and applied to early November in Jaffna; the scattered rain that accompanies it is one of the welcome signs after the long and dry *kōdaikālam*.

94. H. Jameson, 'The North-East Monsoon Rains of Ceylon 1870-1934', *Ceylon Jour. Science*, Sec. E, II, 1 (May 25th, 1936), 27-34; . . . , 'The North-East Monsoon Rains of January 1933 in Ceylon', ibid., 35-42. It is hoped to make further investigations to determine the 'on set' period.

95. On November 30th, 1952, one of the worst 'cyclones' that ever occurred in Ceylon, entered the Jaffna Peninsula (after having passed through Pondicherry) and caused much damage to property and crops. Perhaps the only other comparable to the Jaffna Cyclone was the Batticaloa Cyclone of March 10th, 1907, which was an unusual one to have occurred in March.

96. Bamford, 'Cyclonic Movements in Ceylon', op.cit., 21-28. The following 'storms' have been analysed in this work: November 22nd, 1920; December 28th, 1921; February 12th, 1922; November 26th-December 2nd, 1922; January 9th-10th, 1923; January 13th, 1925.

shows a more marked preponderance of 'Monsoonal' characteristics than those in the southwest, except perhaps Watawala and Ratnapura (Plate IV). Jaffna, Trincomalee, and Batticaloa exhibit a 50-60 per cent 'rainy' period from November to February, with a corresponding amount of rainfall, in terms of the total. In Plate VII is revealed the type of rainfall during this time of the year; Trincomalee has a marked tendency toward an evenly distributed occurrence while Colombo, on the lee side at this period, exhibits a marked 'afternoon-rain' tendency. Even in February in Trincomalee there is a tendency toward morning rain, although the amount is small; Colombo still has the 'convectional' tendency which persists until March.

This rainfall is vital to the farmer in the north and east of the island. To the period of early rains, considered 'the harbinger of the big rains' the term '*Vasanthakālam*' is used. And as the rains increase the farmer is grateful to the '*Vādaai*'[97] to which he has been looking forward. The wet season brings with it to the north and east, conditions similar to the SW Monsoon period in the southwest, though less dominant. Occasional heavy, intense rainfall is common and is brought by the Bay of Bengal tropical cyclones. To the farmer, however, all that matters is that the '*Mārikālam*' has set in though the '*kālapōkam*' [98] is of more direct significance to him.

The NE Monsoon, therefore, to the north and east of Ceylon is what the SW Monsoon is to the southwest, though not in a directly comparable sense. The former is weak and the rainfall amounts are less; this is due to the differences in their sources of origin; the NE Monsoon (Northeast Trades and therefore 'dry') winds obtain little moisture over the Bay of Bengal (cf. SW Monsoon over the Indian Ocean) and there is no 'centre' of 'pull'; if part of it are outblowing winds from the local 'Kashmir-Jammu-Punjab High', then, they too, are of limited value as rain-bringers. Rainfall from 'cyclones' therefore contribute towards the high rainfall. Rainfall is often continuous with slight abatement, though the effects of the cyclonic movements are reflected in the sudden 'downpours'.

The month of February may be considered the 'month of fine weather'; except for occasional Northeast Monsoonal currents which precipitates rain in favourable topographic environs (e.g. Hakgala: 4·0 inches) the month is generally 'dry'. The rainfall incidence in the east is 'Monsoonal' especially

97. '*Vasanthakālam*' refers to the 'spring' season in early November; the 'spring rains' come as a refreshing phenomenon after the 'dry' interlude that has prevailed since May. '*Vādaai*' strictly means 'the winds from the north' and refers to the setting-in of the NE Monsoon, which to begin with has more of a northerly trend than a northeasterly one.

98. '*Mārikālam*' refers simply to the Wet season, while '*kālapōkam*' is the agricultural season of the NE Monsoon period. They both refer to the same period, but have different connotations, namely, rains and agriculture. The corresponding agricultural season in the South is the *Yala*.

at Batticaloa and Trincomalee, while in the west it is essentially convectional (e.g. Colombo, Galle and Ratnapura). Plate VII reveals these characteristics very well. Late cyclonic activity might also occur to give abnormally high rainfall.[99]

In resumé, it may be said that the rainfall rhythm in Ceylon is the expression of a series of meteorological circumstances which interact to produce the atmospherics over the island; the latter, in turn determine the weather and hence the rainfall characteristics of the island. Basically the atmospheric medium that controls Ceylon's weather is the 'Doldrum' belt and the Tropical Convergence Zones; when these Zones are inactive, then it is that local thermal features exercise control to produce the convectional circulation and the resulting afternoon thunderstorm weather and associated rainfall. At other times of the year due to a combination of meteorologic circumstances—initiated by the migration of the 'thermal equator'—an entirely new atmospheric circulation is established which is so well known as the Southwest Monsoon; the rainfall distribution in the island during this period is the reflection of local physiographic control. At other periods of the year an atmospheric circulation,—only apparently the Southwest Monsoonal counterpart—and termed the Northeast Monsoon prevails; however, in its rainfall characteristics its true nature is masked by precipitation resulting from the passage of certain 'frontal disturbances'. A period of such marked 'frontal precipitation' does prevail; milder 'depressional phenomena' as well as occasional true 'cyclones' (Tropical Revolving Storms) disturb the island's climatic environs at this period as well as other times of the year to produce special weather and precipitation. However, in spite of the seeming confusion presented by the variety of meteorologic circumstances that induce rain to fall within the island, there can yet be clearly visualized a distinct rainfall rhythm.[100]

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99. Bamford, 'Cyclonic Movements in Ceylon', op.cit. The storm of the 12th of February, 1922, was one of these 'late-interlopers'; a narrow zone with rainfall varying from 7 to 11 inches showed a southeast-northwest alignment, from Batticaloa to Mannar. (Mannar: over 11 inches; Batticaloa: over 7 inches; Trincomalee: less than 1.0 inches).

100. An attempt has been made to present in tabulated form the basic features of the rainfall rhythm analysed in detail in this paper.

RAINFALL RHYTHM

Month		West Coast	East Coast
'SPRING' CONVECTIONAL CONVERGENCE	March	Clear early mornings and nights, i.e., late afternoon thunderstorms. Convergence generally overcast skies with drizzle.	convectional rains—activity may produce
	April	Same as in March but heavier falls. First 'surge' of south-westerly currents reflected in 'rainy spell' (mid-April)	Still convectional rains
SOUTH-WEST MONSOONAL	May	(Coastal) Pre-S.-W. Monsoonal and convectional rains, and occasional 'depressional' rains. Monsoonal 'burst' (rainy spell) when disturbance in convergence active	Light convectional rains. Rainfall decreases
	June } July } August }	S.-W. Monsoonal rains heavy rains increasingly concentrated in highland 'surges' reflected in rainy spells during Monsoon with 'trough' development	'Dry very little convectional rains—leeward fohn (*kachchan*) effect, especially Diyatalawa and Batticaloa
'AUTUMN' CONVECTIONAL AND CYCLONIC	October	—Rain widespread— S.-W. concentration, convectional rain-sequence often marked by 'depressional' or cyclonic rains Inter-tropical Front active; 'cyclogenesis' potentiality high	
	November	Over 10″ generally widespead convectional rains	
		Heavy 'fall'	Heavy 'fall' Pre-N.-E. Monsoonal rains; Cyclonic rains
NORTH-EAST MONSOONAL	December	Decreasing rainfall, mainly convectional	N.-E. Monsoonal rains —heavy; Cyclonic rains accentuate; Easterly concentration
	January	Decreasing rains still convectional	Westerly belt concentration Cyclonic-rain incidence high
	February	Occasional light North-East Monsoonal rains; Widespread low convectional rains in west Late-cyclonic 'interlopers' possible	

TABLE I

Average Monthly Returns at the 16 Main Meteorological Stations in Ceylon (1911-1940)
(Rainfall)

Station	Ht. above M.S.L. (feet)	Yrs. Obs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total (Approx.)
			in inches												
Anuradhapura	295	76	7.8	1.7	4.1	6.4	3.5	0.7	1.3	1.6	3.8	9.6	10.7	5.7	57.0
Badulla	2225	73	10.4	3.1	5.0	7.0	4.7	1.6	2.2	3.2	4.5	9.0	10.2	11.5	72.0
Batticaloa	26	76	12.8	4.1	3.5	2.3	1.7	0.9	1.0	2.0	2.3	7.2	13.8	17.0	69.0
Colombo	24	76	3.6	2.1	4.4	8.5	11.6	6.8	5.9	3.2	5.7	12.0	12.0	4.6	93.0
Diyatalawa	4104	45	6.6	2.4	4.8	6.6	6.1	2.0	2.0	3.1	4.4	9.2	10.4	8.0	65.5
Galle	13	77	3.9	3.2	5.2	8.7	12.6	8.4	6.3	6.2	8.8	12.0	12.0	7.8	94.5
Hakgala	5581	62	12.4	4.0	6.3	7.0	8.5	6.6	6.6	5.1	6.7	11.3	12.3	13.0	100.0
Hambantota	61	77	4.0	1.5	3.4	3.9	4.3	2.1	2.1	1.5	2.8	4.8	7.5	5.7	43.0
Jaffna	14	75	4.4	1.5	1.5	2.2	2.0	0.4	0.5	1.1	2.5	9.2	10.5	10.4	53.0
Kandy	1611	76	6.3	2.5	5.9	6.5	7.6	8.8	7.4	5.7	6.4	10.6	11.0	8.5	87.0
Kurunegala	381	66	5.2	2.0	6.1	9.9	7.6	6.9	3.8	3.4	5.6	9.5	12.5	6.8	85.0
Mannar	12	76	3.9	1.7	1.9	3.4	1.8	0.4	0.4	0.7	1.2	6.5	10.2	7.8	40.0
Nuwara Eliya	6170	77	7.0	2.0	4.1	5.0	8.5	10.4	11.0	7.5	8.2	9.7	9.2	7.8	90.5
Puttalam	27	77	3.4	1.4	3.0	4.9	3.8	1.4	1.0	0.6	1.6	7.5	10.1	5.5	44·0
Ratnapura	113	77	6.3	5.3	10.3	10.5	21.0	18.6	12.8	11.4	14.5	18.1	14.8	9.2	153·5
Trincomalee	24	76	8.3	2.7	2.3	2.1	3.2	1.0	1.8	3.6	3.4	9.6	13.9	13.0	65·0
Other Stations															
St. Martin's Estate, Nitre Cave	3800	59	40.0	10.5	7.0	10.7	6.5	4.4	4.1	4.0	6.2	14.0	23.5	66.8	173.4
Watawala	3260	35	5.0	3.5	7.2	11.1	25.7	38.7	29.4	25.0	25.3	24.0	15.4	7.4	218.5

Source: *Report of the Colombo Observatory*, Ceylon, 1951.

TABLE II

Average Number of ' Rainy '* Days (1911-1940)

Station	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Year
Anuradhapura	12	5	8	12	7	4	3	4	7	16	19	16	113
Badulla	18	8	12	16	12	7	7	9	10	19	22	21	161
Batticaloa	16	7	7	6	5	3	4	6	6	13	18	20	111
Colombo	10	6	11	17	23	22	16	14	17	22	20	12	190
Diyatalawa	16	8	13	17	14	8	7	9	11	20	22	20	165
Galle	12	7	12	16	21	22	19	19	18	20	19	14	199
Hakgala	18	10	13	16	17	21	20	19	18	21	23	22	218
Hambantota	10	5	9	10	11	11	8	8	9	13	16	13	123
Jaffna	8	3	3	5	3	1	1	3	4	12	18	14	75
Kandy	12	5	11	14	14	22	21	19	17	21	21	15	192
Kurunegala	10	4	10	15	14	20	15	14	14	20	19	13	168
Mannar	9	3	4	7	4	1	1	2	3	11	17	14	76
Nuwara Eliya	14	7	11	15	18	25	24	22	20	22	22	17	227
Puttalam	9	4	6	10	9	7	3	3	6	14	18	13	102
Ratnapura	14	11	19	21	24	26	24	23	21	23	22	16	244
Trincomalee	13	5	6	6	6	3	3	7	8	16	19	18	110
St. Martin's	21	11	13	15	10	13	13	10	12	20	18	24	184
Watawala	2	3	10	19	15	25	27	25	22	21	26	9	204

*A ' rainy ' day is defined by the Colombo Observatory as a day in which at least 0.01 inch of rain falls.

Source: *Reports of the Colombo Observatory, Ceylon.*

TABLE III

Average Monthly Temperatures
(in °F)

Station	Ht. above M.S.L. (feet)	Yrs. Obs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Anuradhapura	295	17	76.2	78.2	81.2	82.9	83.2	83.0	83.3	83.4	83.2	81.2	78.6	76.6	80.9
Badulla	2225	19	70.0	71.2	73.2	75.2	75.8	75.3	75.2	75.3	75.0	74.2	72.4	70.6	73.5
Batticaloa	26	18	77.5	78.4	80.2	82.2	84.0	84.9	84.7	83.5	83.0	81.2	79.2	77.7	81.4
Colombo	24	18	79.2	79.6	80.9	82.0	82.1	81.3	80.8	80.8	81.0	80.2	79.2	78.9	80.5
Diyatalawa	4104	19	64.6	65.8	67.6	69.1	70.4	70.4	70.4	69.8	69.4	68.5	67.2	65.8	68.2
Galle	13	17	78.4	79.4	80.6	81.5	81.3	80.4	79.8	79.6	79.8	79.2	78.8	78.4	80.0
Hakgala	5581	13	59.2	60.6	62.0	64.6	65.4	63.4	62.8	63.0	63.4	63.0	61.4	59.9	63.1
Hambantota	61	17	78.8	79.6	80.4	82.0	81.8	81.6	82.0	81.4	81.3	80.8	79.6	78.8	80.7
Jaffna	14	19	77.6	79.0	82.2	84.7	84.8	84.6	82.9	82.4	82.6	81.6	79.2	77.6	81.5
Kandy	1611	18	75.4	76.8	78.4	79.1	78.9	77.2	76.6	76.0	76.8	76.4	76.0	75.2	77.0
Kurunegala	381	17	78.2	79.8	82.3	82.8	82.1	81.0	80.8	80.8	81.0	80.3	79.4	77.3	80.6
Mannar	12	21	78.8	80.1	82.2	84.2	85.0	84.4	83.3	83.0	83.2	82.2	80.0	78.8	82.1
Nuwara Eliya	6170	17	57.2	57.4	59.1	60.6	61.8	60.7	60.0	60.2	60.0	59.8	59.6	58.2	59.5
Puttalam	27	19	77.8	79.4	81.3	82.7	83.4	82.7	82.0	82.1	82.2	79.5	79.4	78.0	81.0
Ratnapura	113	18	80.2	81.5	82.2	82.4	81.6	80.6	80.6	80.4	80.4	80.0	79.8	79.8	80.8
Trincomalee	24	18	77.8	79.2	80.9	83.3	85.2	85.4	85.2	84.6	84.4	81.7	79.1	77.9	82.1

Source: *Report of the Colombo Observatory*, Ceylon, 1951.

TABLE IV

Monthly Average Diurnal Temperature Ranges
(in °F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Range	Year
Anuradhapura ..	14.2	17.3	19.3	16.8	14.2	13.3	15.0	16.0	16.5	15.3	11.3	13.0	6.3	15.4
Badulla ..	12.8	15.7	17.9	17.8	18.6	20.0	22.3	21.8	21.5	17.4	13.4	12.4	9.9	17.6
Batticaloa ..	8.0	9.1	10.3	11.1	12.3	14.6	15.4	14.0	13.7	11.8	9.7	8.4	7.4	11.5
Colombo ..	17.4	14.9	13.8	11.9	9.4	8.0	7.7	8.0	8.6	10.1	11.5	13.2	9.7	11.0
Diyatalawa ..	14.7	18.0	19.1	17.4	16.5	14.5	15.7	16.4	17.1	15.6	13.9	13.8	5.3	16.1
Galle ..	11.0	11.5	11.1	9.4	7.0	6.2	5.9	5.8	5.9	7.5	9.0	10.3	5.7	8.4
Hakgala ..	15.9	19.3	21.3	19.0	15.1	10.5	10.7	12.3	13.4	14.2	13.8	14.8	10.8	15.0
Hambantota ..	12.4	12.9	12.5	11.3	9.1	9.6	11.3	11.8	10.4	10.9	11.2	11.7	3.8	11.2
Jaffna ..	11.0	13.2	12.7	9.4	6.5	5.7	6.2	6.7	7.1	8.2	9.0	9.5	7.5	8.8
Kandy ..	16.7	19.5	19.9	18.2	15.6	12.0	12.0	13.2	15.1	15.6	15.5	16.1	7.9	15.8
Kurunegala ..	16.9	20.2	20.6	16.5	13.1	11.0	11.2	12.3	13.3	14.2	14.8	15.7	9.6	15.0
Mannar ..	9.2	12.6	14.3	12.5	8.9	7.7	8.4	8.9	9.1	9.7	8.9	8.0	5.9	9.9
Nuwara Eliya ..	21.5	24.7	24.6	21.6	16.9	10.2	10.5	11.2	13.8	15.7	16.1	19.5	14.5	17.3
Puttalam ..	15.6	18.1	16.8	13.2	9.4	7.0	7.5	8.4	8.9	10.6	12.1	13.6	11.1	11.8
Ratnapura ..	18.5	20.2	19.1	17.1	13.6	11.8	11.9	12.5	13.5	14.3	14.9	16.3	8.4	15.3
Trincomalee ..	5.5	6.7	9.0	11.4	12.9	13.1	14.3	14.9	14.9	12.2	8.6	6.9	9.4	10.8

Source: *Report of the Colombo Observatory*, Ceylon, 1951.

TABLE V

Thunderstorm incidence in Ceylon.
(Number of days on which thunder was reported. Mean for the years 1931-45).

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Anuradhapura	1	1	7	14	6	1	2	4	5	10	8	2	61
Batticaloa	1	3	3	8	8	5	4	6	6	9	5	3	61
Colombo (Obs)	6	8	13	17	13	4	2	2	3	10	12	9	99
Diyatalawa	2	3	10	18	12	4	5	9	9	14	12	5	103
Galle	5	7	11	12	7	1	0	1	1	3	6	7	61
Hambantota	2	3	10	14	7	2	1	1	3	9	10	6	68
Jaffna	0	0	2	7	4	1	1	2	3	6	5	2	33
Kandy	0	1	3	6	3	0	1	1	2	3	2	0	22
Kurunegala	2	3	11	15	9	3	1	2	3	8	8	4	69
Mannar	1	1	8	13	6	1	1	3	5	10	9	2	60
Nuwara Eliya	1	1	6	10	6	1	1	3	3	4	3	2	41
Puttalam	1	2	6	8	3	0	0	1	2	6	5	2	36
Ratnapura	5	9	14	16	12	3	1	2	3	7	8	7	87
Trincomalee	1	1	2	7	6	2	3	7	7	11	6	2	55

Data adapted from information supplied through courtesy of Mr. R. D. Kreltszheim.