THE SEASONAL MARCH OF SURFACE PRESSURE GRADIENTS ACROSS INDIA AND THE SOUTH-WEST MONSOON

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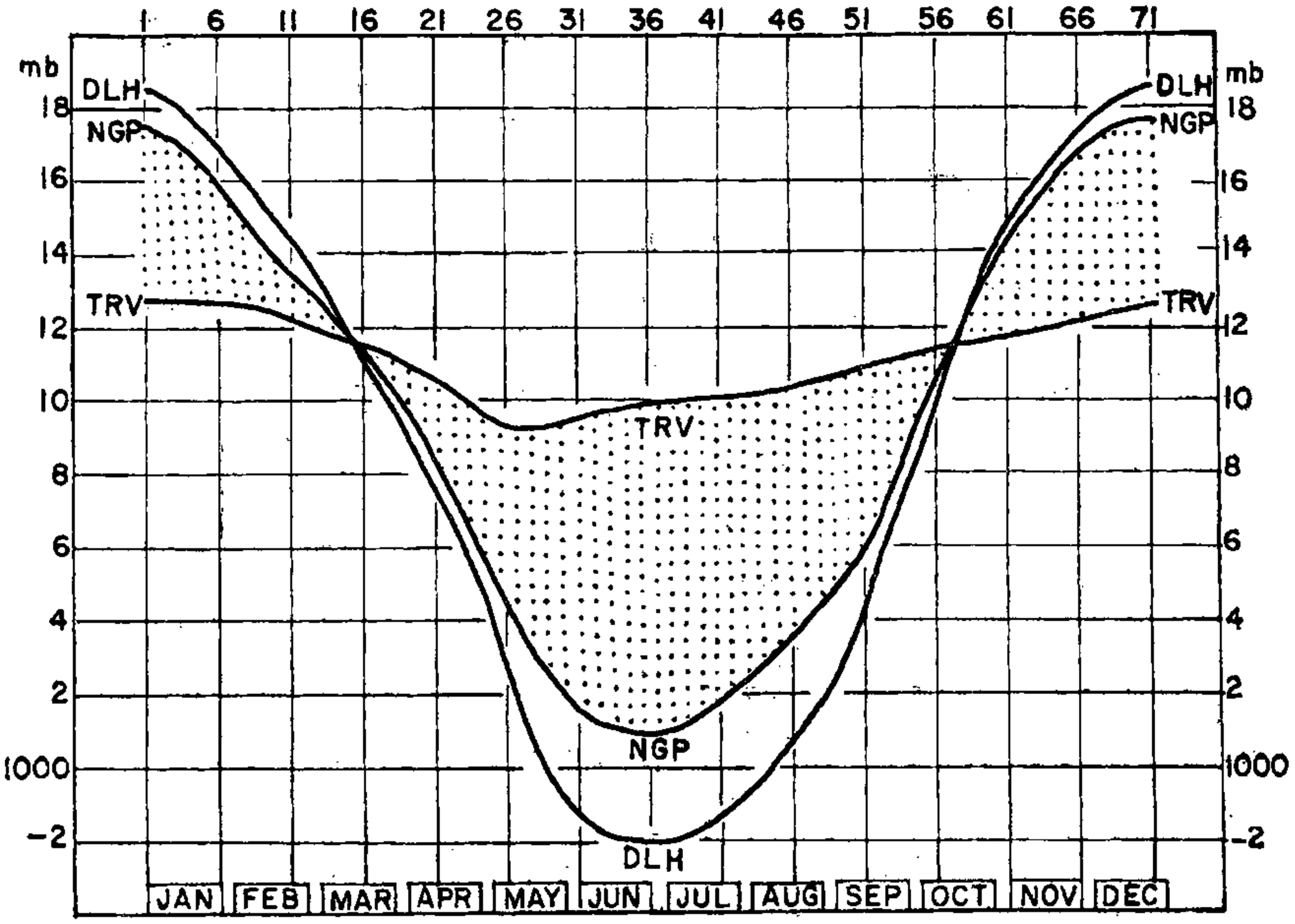
IT is well known that the seasonal weather features of the Indian sub-continent are associated with corresponding changes in the pressure gradients across the country. In the summer monsoon months the surface pressure increases from north to south while in the winter months the reverse situation obtains. March and October are the transitional months.

2. An insight into the manner in which the reversal of pressure gradients across the country is effected is obtained by studying the pressure variations at the three stations Trivandrum (08° 29′ N, 76° 57′ E.), Nagpur (21° 09′ N, 79° 07′ E.) and New Delhi (28° 35′ N, 77° 12′ E.), which lie close to the central meridian of 77° E, across India. The choice of these stations is not entirely arbitrary. Trivandrum in the extreme south and Nagpur in the central parts of the country taken together give an idea of the pressure gradient across peninsular India. Similarly New Delhi in the north and Nagpur in the centre of the country provide a measure of the pressure gradient over north India.

3. The annual march of sea-level pressure at the three stations is shown in Fig. 1. The curves are based on normal pentad values of pressure reduced to sea-level at the three stations (IMD, 1965). The following points are noteworthy:



PENTAD MSL PRESSURE VARIATIONS AT TRIVANDRUM, NAGPUR AND NEW DELHI

FIG. 1

(*i*) The lowest and highest values of sea-level pressure, the epochs at which they occur

and the annual range of pressure at the three stations are as given below :

Station	PPP (Max.) (mb)	Date	PPP (Min.) (mb)	Date	Range (mb)
Trivandrum	1012·7	15 Jan.	1009·1	15 May	3·6
Nagpur ..	1017·6	23 Dec.	1000·9	30 Jun.	16·7
New Delhi ..	1018·6	23 Dec.	998·0	30 Jun.	20·6

It is interesting to note that surface pressure continues to fall at Nagpur and New Delhi for one and a half months more after it has reached the minimum value at Trivandrum by the middle of May. This has an important bearing on the onset and advance of the south-west monsoon over the country.

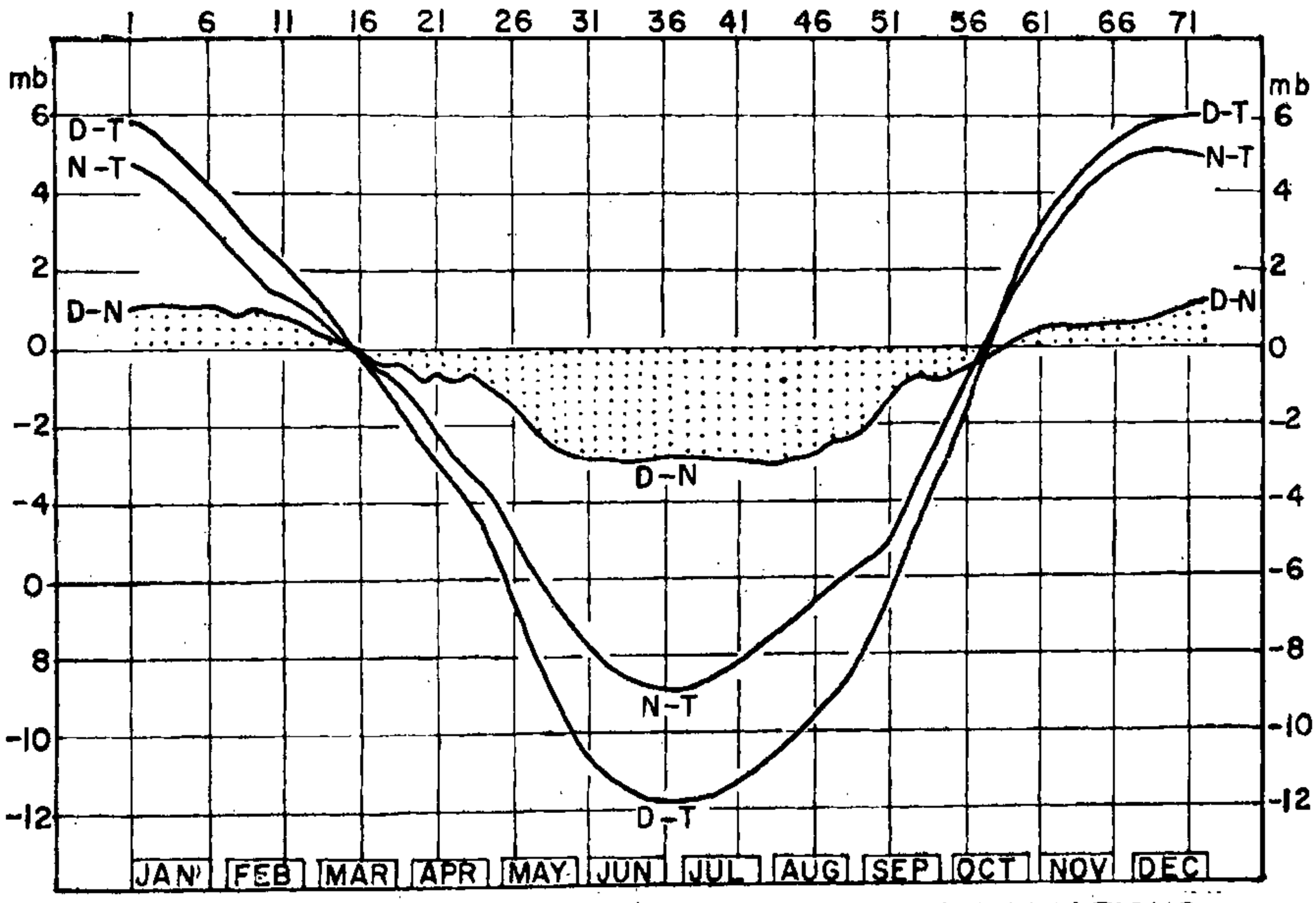
(*ii*) All the three pressure curves pass practically through a common point about the middle of March and again about the middle of October. Hence, pressure gradients across the country are practically zero at and near these two transitional epochs. These two epochs correspond to the transition from the winter to the summer type of pressure distribution and *vice versa*. The actual magnitudes of m.s.l. pressure at the three stations are :

	Mean sea-level pressure (mb) at		
	Trivandrum	Nagpur	New Delhi
15 March ..	1011·4	1011·3	1011·2
15 October ..	1011·4	1011·4	1011·1

It is seen that at the two transitional epochs the m.s.l. pressure at the three stations has practically the same value.

(*iii*) The summer type of pressure distribution obtains for about 7 months (mid-March to mid-October) and the winter type of gradient for 5 months.

4. The seasonal march of the pressure difference between pairs of stations which may be taken as a measure of the pressure gradients is depicted in Fig. 2. The figure shows that



PENTAD MSL PRESSURE DIFFERENCE VARIATIONS
BETWEEN TRIVANDRUM, NAGPUR AND NEW DELHI

FIG. 2

much larger pressure gradients prevail across India in the summer monsoon months of June, July and August as compared with the winter

months of December, January and February. The following points are noteworthy :

(*i*) The pressure difference between Nagpur and Trivandrum (N-T) which is positive in the winter months attains its maximum value of 5·1 mb in the middle of December. From January till the end of April (N-T) decreases almost uniformly changing from positive to negative value by the middle of March. From the end of April till the beginning of June there is a steeper increase in the pressure gradient between Nagpur and Trivandrum. Even after the monsoon has set in on the Kerala coast by 1 June (the normal date of onset), the pressure gradient continues to increase over the peninsula although at a smaller rate. The maximum negative value of 9 mb for (N-T) is reached by the end of June or the beginning of July.

(*ii*) The positive pressure difference between Delhi and Nagpur (D-N) in winter attains the maximum value of 1·1 mb by the end of December. It remains nearly constant at this value till the end of February after which it begins to fall more or less uniformly till the end of April changing sign by mid-March. A steeper rate of fall of (D-N) occurs from the end of April till the end of May.

(*iii*) By the beginning of June (pentad 31) the pressure difference between Delhi and Nagpur reaches the maximum negative value of about 3 mb. It stays at this value till pentad 46 (mid-August) after which it begins to decrease. *The constancy of the pressure difference between Delhi and Nagpur from the beginning of June till the middle of August is a significant feature of the climatological pressure distribution over north India during the SW monsoon season.* During the first half of this period pressures are falling both at Delhi and Nagpur while during the second half pressures are rising. The rate of fall/rise of the pressure is the same at both the places during the period 1 June to 15 August so that the difference of pressure between the two stations remains constant.

(*iv*) From the middle of August the pressure gradient between Delhi and Nagpur begins to weaken rapidly till the middle of September ; thereafter the gradient decreases at a slower rate reaching zero value by mid-October. Between Nagpur and Trivandrum the decrease of gradient is at a slower rate from mid-August to mid-September and at a steeper rate thereafter till mid-October.

5. The above facts lead to the following conclusions about the association between changes of sea-level pressure gradient across India and the south-west monsoon. The onset of the south-west monsoon over the Kerala coast occurs when the north-south pressure gradient across north India has reached its maximum value by the beginning of June. The pressure gradient across the peninsula continues to build up till about the first week of July, while the gradient between Delhi and Nagpur remains practically constant. During this period the monsoon advances northwards and westwards and establishes itself over the entire country. Thus the maximum pressure gradient across the country is reached in the first week of July which may, therefore, be regarded as the peak of the south-west monsoon season.

6. The next significant date in the history of the south-west monsoon is the middle of August when the pressure gradient across north India begins to weaken while the gradient across the peninsula has been continuously weakening after the first week of July. In a recent study (Ananthakrishnan, 1970) it has been shown that a rainfall minimum occurs at or near pentad 46 (16 August) at several stations over the west coast, central India and north India north of 16° N. It was suggested that this date should be regarded as the epoch of maximum northward extension of the monsoon circulation features before the southward retreat of the monsoon commences. This epoch coincides with the period of maximum frequency of occurrence of 'breaks' in the monsoon (K. Ramamurthi, 1969). During 'breaks' the monsoon trough on the sea-level chart shifts northward to the foot of the Himalayas and there is also a northward shift of the core of strong easterlies in the upper troposphere over the south of the peninsula. At the same time, rainfall decreases in the plains and increases at the foot of the Himalayas.

7. Despite the large number of studies on Indian rainfall, the existence of a minimum in the south-west monsoon rainfall around 16 August at a large number of stations which are widely separated spatially had not been realised till recently. This has been clearly brought out by the study of pentad rainfall curves of observatory stations based on data for the fifty-year period 1901–1950. The two rainfall maxima on either side of this minimum which occur in July/August and August/September are to be associated with the northward advance and southward retreat of the surface and upper air circulation features associated with the south-west monsoon.

8. With the reversal of the pressure gradients across the country by mid-October the south-west monsoon gives place to the north-east monsoon over the south of the peninsula. Pressure gradient between Delhi and Nagpur increases only very gradually after mid-October while it increases steeply between Nagpur and Trivandrum reaching the peak value by mid-December.

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2. Ind. Met. Dept., *Five-Day Normals of Pressure, Maximum and Minimum Temperatures and Relative Humidity*, 1965.
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ON THE OCCURRENCE OF INTERSTITIAL FAUNA IN THE INTERTIDAL SANDS OF SOME ANDAMAN AND NICOBAR GROUP OF ISLANDS

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THE marine interstitial fauna, inhabiting the intertidal zone on Indian coasts, is receiving considerable attention during recent years. Studies on the fauna inhabiting the beach sands of Waltair coast, during the years 1960–1963, have revealed the occurrence of several interesting invertebrate groups of animals. A comprehensive report on the results of the investigation, first of its kind in Indian waters, has already been published (Chandrasekhara Rao and Ganapati, 1968) and several species have been described as new to science.

During a brief faunistic survey of the Andaman and Nicobar group of islands, undertaken by the Zoological Survey of India in February to April 1969, the author had an opportunity to visit the archipelago and examine intertidal sands on the various isles located in the vicinity of North, Middle, South and Little Andamans and Car Nicobar island. No previous records of interstitial fauna are known from the archipelago and a detailed report of the fauna collected in the present survey is being published elsewhere. The present account deals with the preliminary results concerning the nature of the habitat, composition of the fauna and the relationship of the faunal element with the physiography of the islands.

Nature of the Habitat

In the majority of these islands, the coast is mostly rocky, with the cliffs almost descending right into the waters. The rocks and boulders in the intertidal zone are not covered with sufficient algal growths and as such, a rich community of algal fauna characteristic of rocky shores is missing. Some muddy beaches are also encountered, especially near the mangrove swamps located at the mouths of brooks. Except for a few islands, the sandy beaches are limited to certain patches occurring here and there between cliffs. The slope in several beaches is low and the amplitude of the tides is high, with the result a wide intertidal belt is exposed during low tides. The beach sand is mostly composed of silica except in those islands harbouring rich coral growths, where the sand is exclusively coralline. The colour of the sands vary from black and light-yellow to reddish-brown, while the coralline sands are purely white. The shape of sand-grains varies from spherical to angular. Except in a few cases, the sands are relatively heterogeneous, composed of coarse, medium and fine particles with a mean diameter of $> 500\,\mu$, $300–500\,\mu$ and $< 300\,\mu$, respectively. The bulk of the beach sands are fine, although the grain size tends to increase with depth. A small percentage of broken shells is mixed with sand, especially near the water's edge. The compactness of coralline beaches is low, due to the lightness of grains and the lack of cohesion between particles.

The climate is tropical, with heavy gales and rains. The temperature in the interstitial biotopes varied from 26° C. to 30° C. while the salinity of the interstitial water ranged between 29‰ and 33‰. The sands appear sufficiently rich in organic detritus.

Composition of the Fauna

A quantitative estimation of the interstitial fauna inhabiting the various islands is made and an average percentage composition of the density of different groups is given in Table I.