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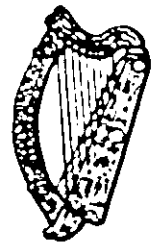

THE CLIMATE OF NORTH MUNSTER

BY

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THE CLIMATE OF NORTH MUNSTER

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PREFACE

The purpose of this note is to present a description of the climate of an area in Ireland, using available records from long-established stations in the area and from a more dense network of stations established in the last 25 years.

Much of the data used has been published in the Monthly Weather Reports of the Irish Meteorological Service. Other data were derived from charts and records in the Irish Meteorological Service. In addition, the Climatological Division of the Irish Meteorological Service has supplied me with a considerable amount of information. The interpretation given in the paper to these data is the author's responsibility.

This is the first effort to give a descriptive climatology of a part of Ireland using recent data. The treatment is not exhaustive. In particular, no attempt was made to obtain for examination private records or diaries giving additional information on the weather of the district. Neither have old newspapers or public records been examined. Insofar as possible the period to which records refer are quoted in Tables and Figures in the paper.

The author's thanks go to a number of members of the staff of the Meteorological Office at Shannon Airport for assistance in extracting and tabulating data. Thanks are also due to colleagues in the Irish Meteorological Service for a number of helpful suggestions.

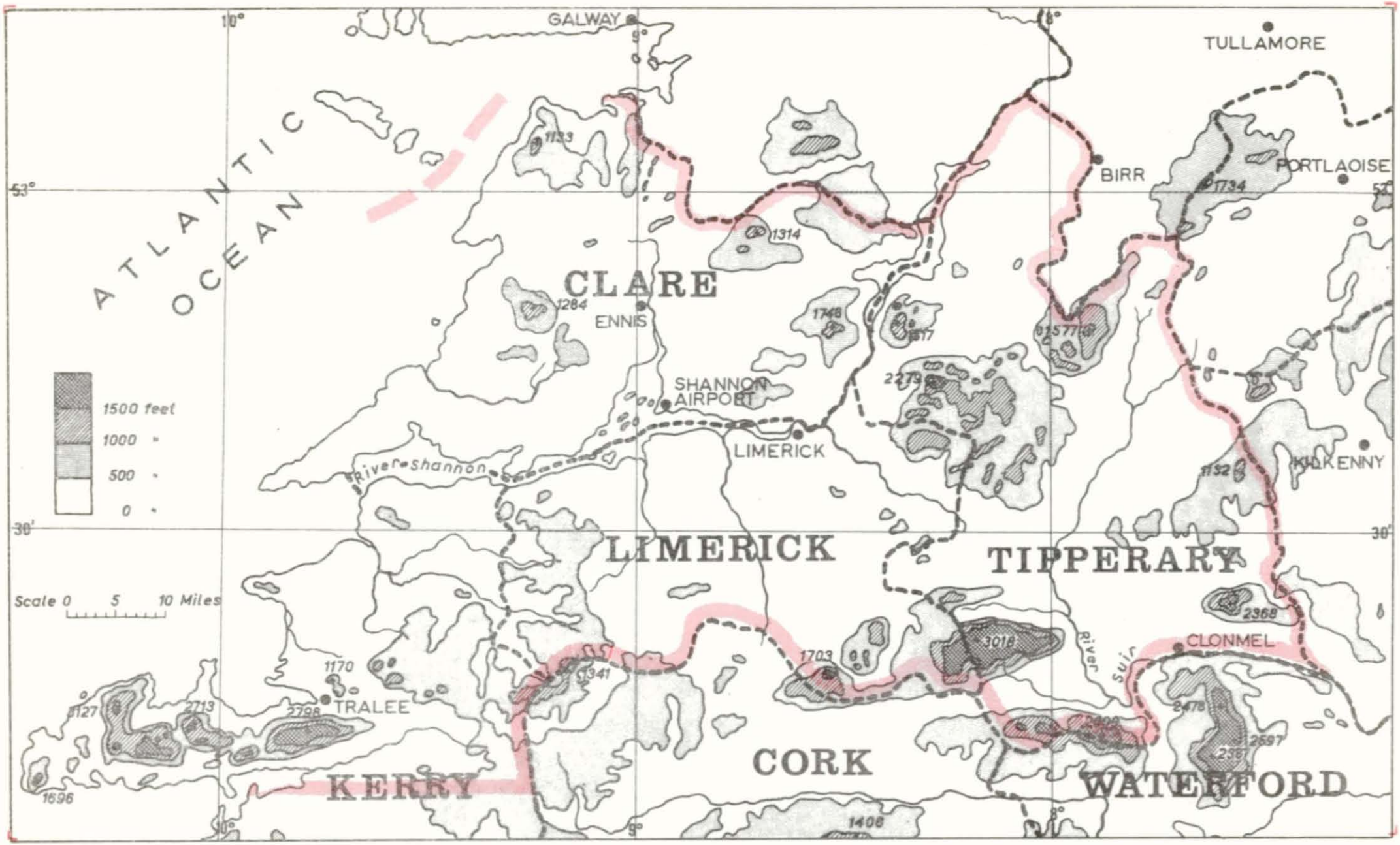


Fig. 1. Topography of North Munster

THE CLIMATE OF NORTH MUNSTER

CHAPTER I

GENERAL

1.1. Introduction

For the purposes of this study, North Munster consists of the Counties of Clare, Limerick and Tipperary and the northern part of Kerry. Its geographical boundaries lie within latitudes 52°10'N and 53°15'N and longitudes 07°20'W and 10°30'W approximately. The boundary of the area is indicated in Figure 1. Most of the area lies in the catchment areas of the Shannon and Suir rivers.

The amount of meteorological records available from North Munster covering a period of useful length (i.e. more than 20 years) is relatively small. Some long period records going back without break into the mid 19th century are available for stations in North Munster and records covering periods of over 30 years are available from a number of locations. For some elements, continuous records from stations within the area cover shorter periods and considerable use had to be made of records from stations outside the area to give an indication of the climate of North Munster.

1.2. General Climatic Influences Affecting North Munster

North Munster is bounded on the west by the Atlantic Ocean which at this point is strongly influenced by the relatively warm North Atlantic Drift. With prevailing westerly winds and no high mountains to the west, the climate is distinctly oceanic.

The most frequently travelled tracks of depressions in the eastern North Atlantic lie to the north-west of Ireland and associated frontal systems which reach Ireland usually separate different polar air masses. Tropical and Arctic air masses are relatively rare and the polar air reaching the south-west of Ireland is usually maritime in origin or in recent history.

An examination of the Irish Meteorological Service's surface weather charts prepared four times daily for the 10 years 1951 to 1960, inclusive, shows that on the average 170 fronts which could be identified as associated with the general synoptic situation over the eastern North Atlantic and Western Europe reached North Munster each year in the period. Minor fronts making short but relatively minor changes of air masses were not included in the count. The totals for each month are given in Table 1.

TABLE 1

Number of fronts which arrived in North Munster in each month in the 10 years 1951-1960, inclusive

Month	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	Mean
Jan.	16	18	12	10	17	21	29	18	10	11	16.2
Feb.	8	7	13	18	7	10	9	17	10	15	11.4
Mar.	13	11	6	17	11	13	22	12	18	11	13.4
Apr.	12	7	10	8	13	8	11	14	18	15	11.6
May	5	8	14	11	11	23	16	15	7	10	12.0
June	9	17	14	18	19	16	6	10	11	13	13.3
July	9	13	14	22	10	11	13	14	13	15	13.4
Aug.	12	11	23	13	14	12	15	14	16	13	14.3
Sept.	13	17	14	20	16	18	18	12	8	15	15.1
Oct.	10	13	14	21	12	12	20	13	19	8	14.2
Nov.	15	22	15	24	8	11	5	13	18	21	15.2
Dec.	24	20	17	25	14	21	22	15	23	13	19.4
ANNUAL TOTALS	146	164	166	207	152	176	186	167	171	160	169.5

Fronts which reached North Munster, became stationary and later receded were generally excluded, but fronts which passed through the area and returned over the area again were counted each time they arrived.

Of the 1,695 fronts, 631 were warm fronts, 841 were cold fronts and 223 were recently occluded fronts.

1.3. Physical Features

The area is sheltered to the south by a series of hills stretching from the Comeragh Mountains in Co. Waterford to the mountains in the Dingle Peninsula. Heights of peaks range from slightly over 3,000 feet downwards. North of these hills, much of North Munster is in the catchment area of the Shannon or the Suir. The boundaries between these catchment areas include two marked hilly areas, the Galtee Mountains rising to 3,018 feet (above Irish Ordnance Survey Datum) and the Silvermine Mountains rising to 2,279 feet. On the left side

of the Suir there is one notable peak - Slievenamon (2,368 feet) - in South Tipperary. In the Shannon catchment area, hills on both sides of the river near Killaloe rise to over 1,000 feet and have a highest peak of 1,748 feet on the Clare side. In Clare to the west-northwest of Limerick city a smaller range of hills rises to just over 1,000 feet. County Clare has a number of other hills exceeding 1,000 feet - mainly to the north and west of the county. The highest peak in the west of Co. Clare is Mount Callan (1,284 feet). Maghera (1,314 feet) near Lough Graney is the highest peak in North Clare. Near the Limerick-Kerry border a range of hills has peaks over 1,000 feet. Mount Brandon (3,127 feet) in the Dingle Peninsula is the highest peak in the entire area.

The Shannon River forms the boundary between Munster and Connaught at the extreme north-east of Munster. It widens into Lough Derg a little further south, narrows and changes into what was formerly a rapid-flowing river near Killaloe. This rapid flow has been harnessed to work a hydroelectric generating station. From Limerick onwards the river is tidal. The Suir has no particularly notable physical features within the area of which we treat.

1.4. Industrial Influences

The principal industry in North Munster is agriculture. There is no large industrial area constituting a major source area of atmospheric pollution. The largest urban population is concentrated in Limerick City which has a population of some 55,000 to 60,000 people.

CHAPTER 2

SUNSHINE, CLOUDINESS AND FOG

2.1. Sunshine

The study of sunshine in Ireland is based on data obtained by means of Campbell-Stokes sunshine recorders. (See Appendix). Only sunshine bright enough to make a scorch mark on the chart is recorded and the sunshine measured in this way is described as "bright sunshine".

The maximum possible duration of sunshine at a location on any day varies with the time of the year and the latitude of the observing station. For a station at 52°N with an unobstructed horizon, the duration of maximum possible sunshine varies from a mean value of 7.8 hours in December to 16.6 hours in June. For stations with obstructions on the horizon, deductions have to be made for the configuration of the sky-line since such obstructions reduce the possible amount of direct sunshine which can reach a location.

The actual bright sunshine experienced over an area varies for the reasons stated above and also varies with the extent to which cloud cover or fog obscures the sun. Also it is true of Munster that, as has been established in comparable conditions elsewhere (e.g. Ben Nevis), hill country gets less sunshine than neighbouring lowlands due to increased cloud cover over hills in humid situations.

The amount of sunshine data available from stations in North Munster is not sufficient to give a reliable representation of the sunshine regime over the area throughout the year. To get a good indication it is necessary to consider also data available from stations in adjoining areas. Figure 2 shows the monthly averages of mean daily duration of bright sunshine (in hours) over the whole country in the period 1931-1960. The maps were prepared by the Climatological Division of the Irish Meteorological Service.

It can be seen from these charts that, as in most other parts of the country December is the dullest month. May is generally the sunniest month in North Munster. It may be noted that in the resort areas on the west coast of North Munster there are on the average 1 to 1.5 hours more sunshine per day in May than in the more popular holiday months of July and August.

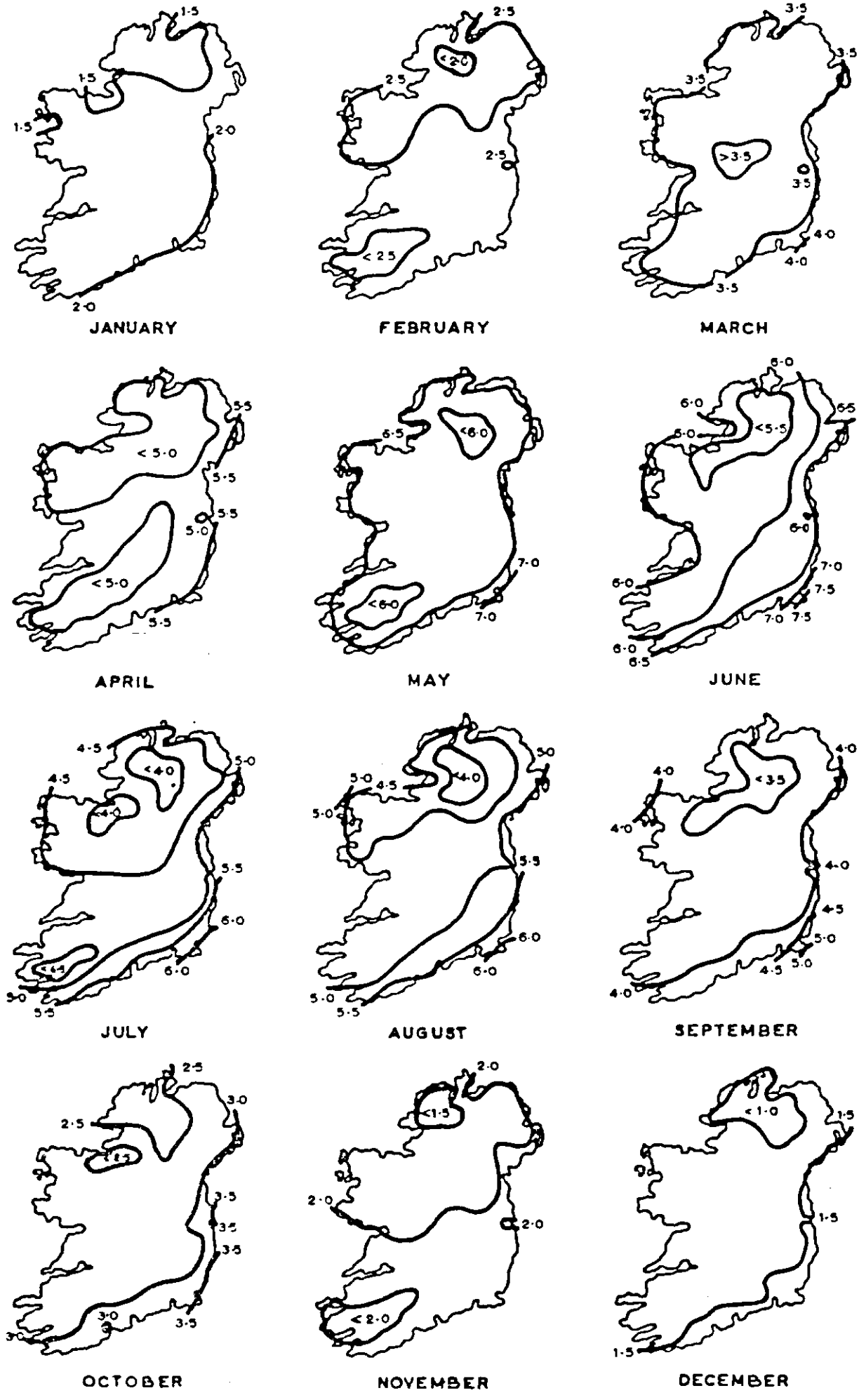


Fig. 2 Mean daily duration of bright sunshine (hours), monthly averages over the period 1931 - 1960.

Studied in relation to the records of other stations, the records for Shannon Airport are fairly representative of conditions generally near sea level and at unobstructed sites in North Munster. Records for Shannon Airport are not available for the full 30-year period 1931-1960. The mean daily duration of bright sunshine (in hours) at Shannon Airport for each month of the year in the period September, 1945, to December, 1960, inclusive, is shown in graphical form in Figure 3.

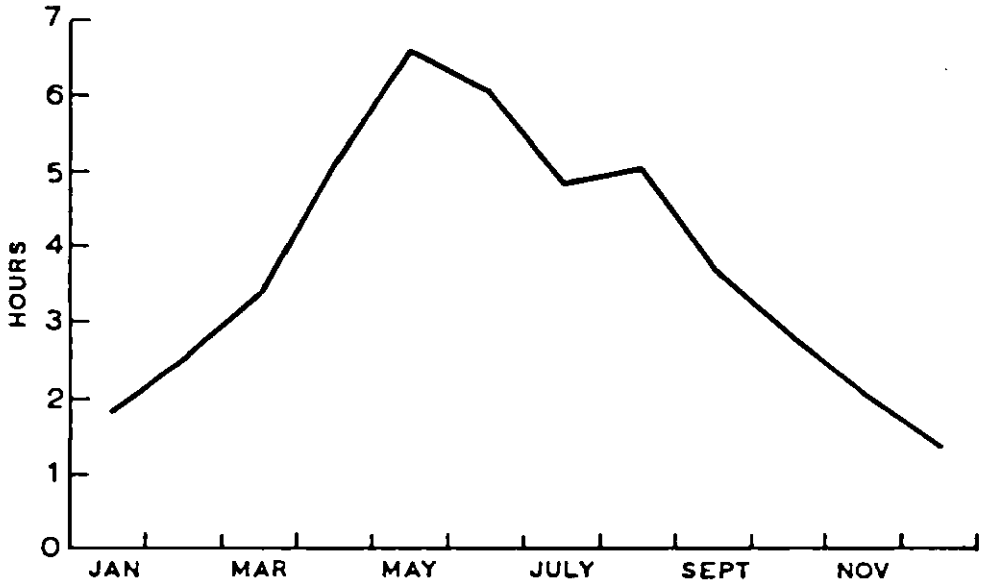


Fig. 3. Mean daily duration of bright sunshine at Shannon Airport over the period September, 1945, to December, 1960, inclusive.

The sunniest month at Shannon Airport in the twenty-year period September 1945 to August 1965 was July, 1955, with a total bright sunshine duration of 255.3 hours. The dullest month in the same period was December, 1953, when 29.1 hours of bright sunshine were recorded. The average over the period September, 1945 to December, 1960 inclusive was 3.8 hours per day.

2.2. Cloudiness

Cloud cover is of general interest since cloud reduces the amount of bright sunshine in the day time and its presence or absence affects the extent of night cooling particularly at land stations.

Cloud amount is observed and estimated visually at fixed times, usually only once daily. Hourly observations do not provide a continuous record of cloud amount and no suitable equipment is available for the continuous recording of cloud amount.

It has been found for complete years that the relationship 100-S = C, where S is the percentage of possible bright sunshine and C the percentage of cloudiness, holds reasonably well in some countries. It is claimed to have been particularly good in summer but in winter, with the short days and with the general tendency at all times of the year for cloud cover to be at a minimum at night time, estimates of cloudiness based on sunshine may be substantially different from the actual cloudiness.

Using the Shannon sunshine figures the relationship 100-S = C yields for the month of December (dullest) and May (sunniest) the values of 82% and 58% mean cloudiness respectively. Examination of sunshine figures for 5 years at Thurles (Co. Tipperary) gives average values of cloudiness for each month similar to those at Shannon. However, it seems quite likely that the cloud conditions at each side of the Silvermine Mountains would not be identical in different weather conditions. In particular, WNW moist warm airflow would probably give less cloud in Co. Tipperary than in Clare, Limerick or North Kerry while the opposite pattern would obtain in the case of moist easterly or north-easterly flow associated with a depression over the Irish Sea or to the south-east of Ireland. Also, the extreme north of Tipperary would tend to be cloudier than the rest of North Munster in moist north-easterly situations and less cloudy in south-westerly situations.

Height of cloud is of interest to aeronautical interests and statistics on cloud height are usually coupled with statistics of poor visibility. Transport flights are concerned with cloud height and visibility

at aerodromes, but private fliers have an interest in these elements in all locations for visual flying, particularly in the vicinity of high ground and of airfields.

Examination of observations at Shannon Airport for the 12-year period from March, 1948, to February, 1960, from the aeronautical aspect by Daly and Fitzgerald (1) showed that 5,451 half-hourly observations had cloud in excess of half the sky coverage at a height below 500 feet and/or below 1 mile visibility, which is roughly 19 hours per month. This figure shows a lower frequency of marginal landing conditions than is experienced in most European airports. The months of January and November together contribute more than 1/3rd of the poor conditions. There is marked diurnal variation in poor conditions except in mid-winter, the maximum frequency occurring about sunrise and the minimum between 1200 GMT and sunset.

2.3. Fog

Fog, in the sense in which the term is used in meteorology, consists of very small water droplets or minute ice crystals suspended in the air near the surface of the earth and which generally reduce the horizontal visibility to less than 1,100 yards (1 kilometre).

The occurrence of fog is of major concern to people who have to travel or are engaged in transport business. In industrial areas or large cities, it can, when polluted by industrial gases or smoke, be of serious concern to the health of many people.

The more common cause of fog in the area dealt with in this paper is cooling of the air due to night radiation. Sometimes this fog drifts from the area of formation over flat country and may be advected to an area where the fog ultimately dissipates. This small-scale local advection is a common occurrence in the Shannon Estuary.

Sea fog is relatively infrequent off the coast of North Munster, largely because the sea there is quite warm for the latitude. It rarely penetrates beyond the high ground inland from the Kerry/Clare coast.

As most fog in North Munster is caused by night radiation, it has a marked diurnal variation with maximum in early morning and minimum during late forenoon and afternoon, in all seasons except in mid-winter.

The average number of days with fog at Shannon Airport for each month of the year in the 13 years 1948 to 1960, inclusive, is shown in figure 4. The frequency

of occurrence of fog at Shannon is believed to be fairly representative of conditions in the lower Shannon Estuary. A comparison between fog occurrence at Shannon Airport and at Foynes some 11 miles to the S.W. in the Estuary points to the conclusion that fog is less frequent further to the west along the river. Fog is probably more frequent in the flatter terrain near sea level to the east and north of Shannon Airport than at the Airport itself. It is probable that the incidence of fog in anticyclonic conditions in the winter half-year is generally higher in the eastern part of North Munster than at Shannon Airport.

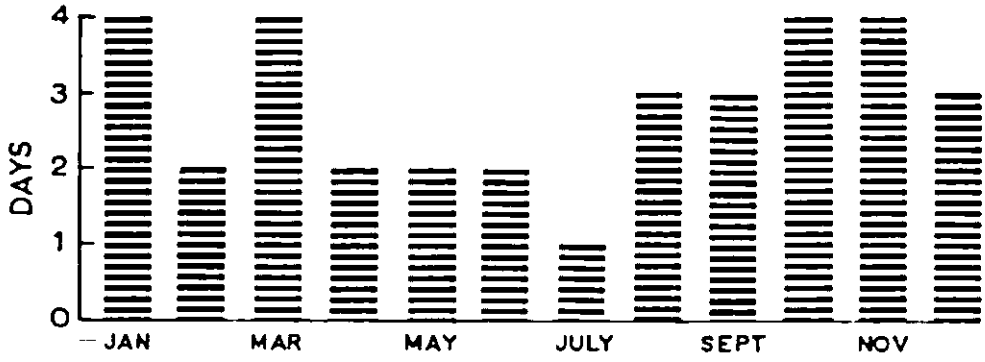


Fig. 4. Number of days with fog at Shannon Airport for each month of the year averaged over the period 1948 - 1960, inclusive.

Hill fog in the form of low stratus cloud occurs when radiation fog is lifting and breaking-up and also when there is a layer of low stratus cloud in a warm moist current with turbulent flow at ground level.

Fog due to the mixing of warm and cold air such as takes place in a frontal zone is rare at sea level in North Munster. Studies of frontal passages at Shannon Airport show that the vast majority of such passages are not accompanied by fog. Frontal low cloud however often causes fog on high ground.

Fog which is markedly polluted by smoke or industrial gases is rarely observed in the urban area of Limerick.

CHAPTER 3

TEMPERATURE

3.1. General

North Munster enjoys the moderating influence of the North Atlantic ocean which to the west of Ireland has a high mean temperature for that latitude. The sea temperature to the west of Munster ranges from an average of 8.5°C in February to almost 15.0°C in August-September.

The mean annual air temperature in the south west coast of Ireland is higher than that of continental areas in the same latitude in the northern hemisphere. The mean annual air temperature at Shannon Airport for the period 1941 to 1960 inclusive, is 10.2°C. Table 2 gives comparable figures for a selection of stations at approximately the same latitude in the northern hemisphere.

TABLE 2

Mean Annual Air Temperature at Selected Stations near Latitude 52°N, over Indicated Periods

Station	Country	Position	Altitude (metres)	Period	Temp.
Shannon	Ireland	52°41'N 08°55'W	5	1941-1960	10.2
De Bilt	Nether-lands	52°06'N 05°11'E	2	1931-1960	9.4
Berlin	Germany	52°28'N 13°26'E	50	1931-1960	9.5
Irkutz	U.S.S.R.	52°16'N 104°21'E	485	1931-1960	-0.8
Prince George,B.C.	Canada	53°53'N 122°41'W	691	1931-1960	3.6
Moosonee, Ontario	Canada	51°16'N 80°39'W	9	1941-1960	-0.6

The values of temperature given in Table 2 need some adjustment to make them strictly comparable, as the stations are not all at the same altitude. Air temperature in the lower levels of the atmosphere decreases on an average of about 1°C for each 500 feet increase in altitude. When this correction is applied to reduce the figures in Table 2 to the same level, the mean temperature for Shannon is still higher than that at the other stations.

Temperature at levels within a few inches of the ground is of importance particularly to agricultural interests and construction workers whose work is affected by frost at or near the ground. Soil temperature at various depths in the top few feet of the earth is also of considerable interest.

The air temperature taken at the standard level in a suitably exposed location is much less likely to be influenced by purely local effects than temperatures nearer the ground.

The temperature of the sea off-shore has an important influence on conditions inland as well as having considerable interest to people at the holiday resorts on the coast.

3.2. Air Temperature

Air temperature at a climatological station is the temperature of the air at a height of between 1.25 and 2 metres above ground level. To get a representative reading of air temperature at a station, the thermometer must be protected from radiation from the sky, earth and any surrounding objects, while at the same time being adequately ventilated (see Appendix).

At most climatological stations readings are made once daily at 0900 GMT. Accordingly, mean temperature for the day at these climatological stations is taken as the mean of the maximum and minimum temperatures.

Examination of temperature records for Ireland as a whole shows that in the winter months the average mean of the daily temperature is highest along the south and south-west coast with the lowest values inland in the central plain and in the northern half of the country. In the summer months the variation over the country is less in winter, with highest mean air temperatures to the south and east. Figure 5 presenting copies of maps prepared by the Irish Meteorological Service shows the monthly average mean air temperature reduced to sea level for each month of the year, based on records for the period 1931-1960. In interpreting these maps and relating them to a particular location one must be careful to take account of the fact that the air temperature decreases on the average at the rate of about 1°C for each 500 feet increase in height; consequently, the average mean air temperature at a location 1,000 feet above sea level in North Munster over the year would be about 2°C lower than the mean at a corresponding sea level location.

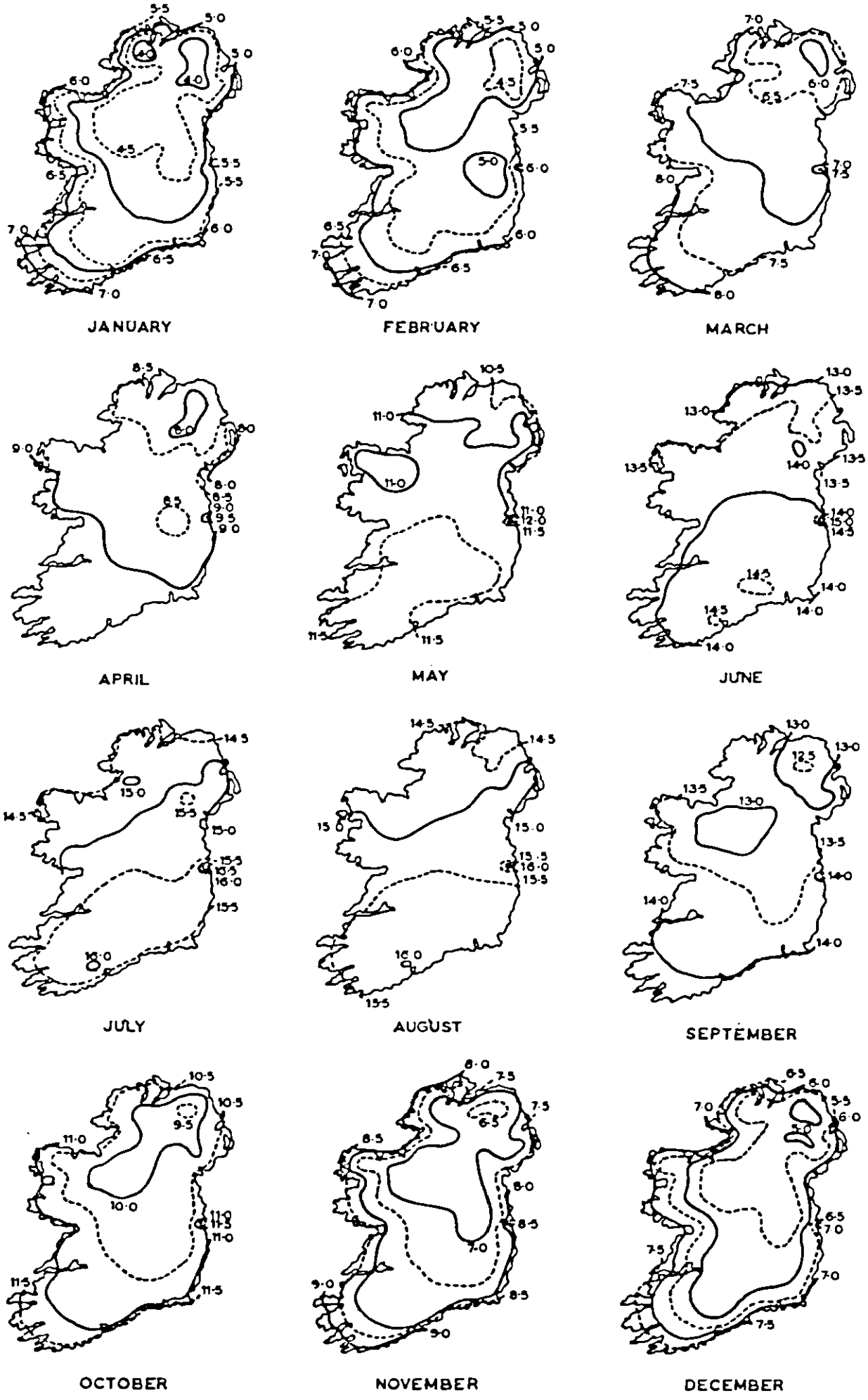


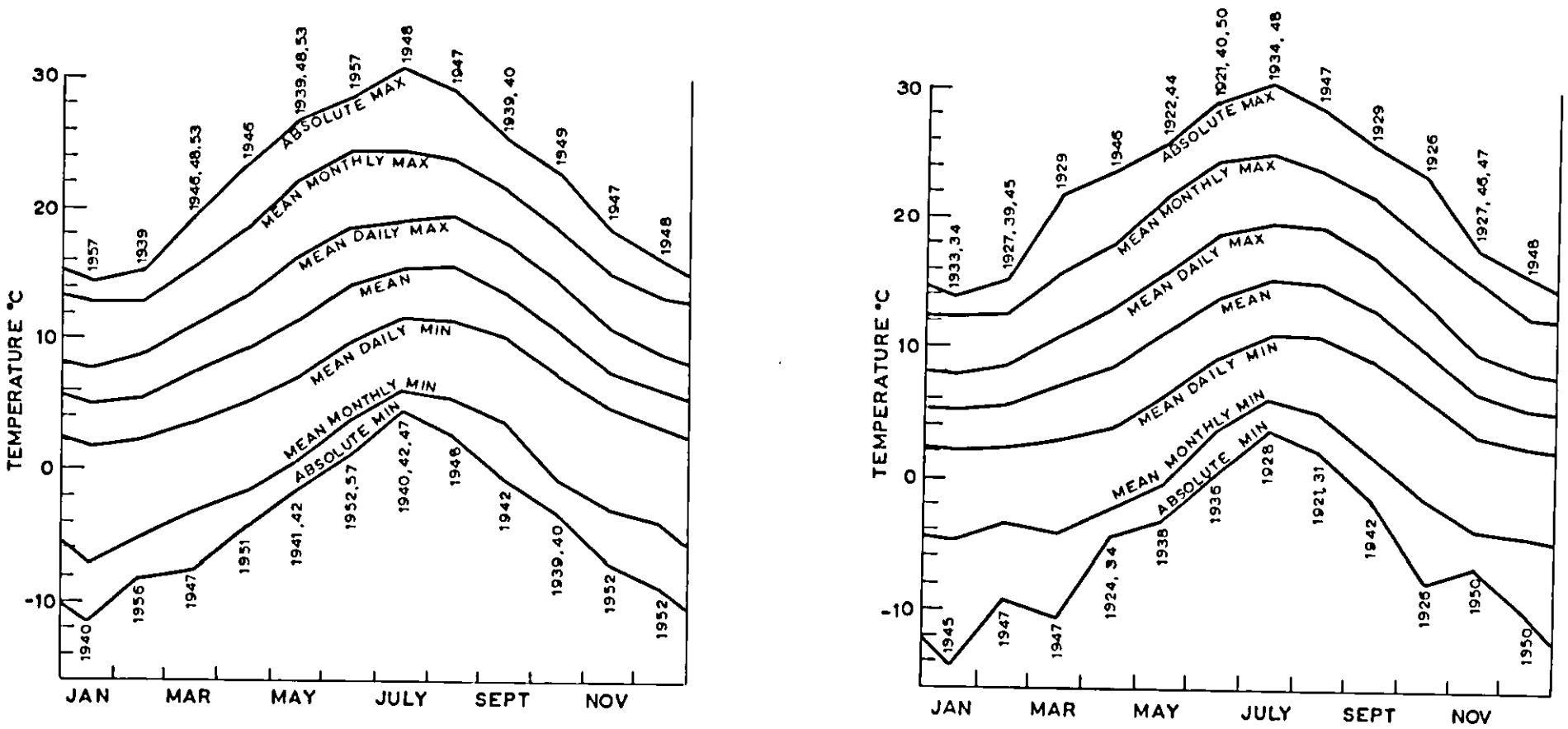
Fig. 5 Mean air temperature (°C) reduced to sea level, monthly averages over the period 1931-1960.

The annual variation of the daily air temperature by month at a number of these stations over a number of years is shown with other related data in Figure 6. The material is taken mainly from "Mean and Extreme Values of Air Temperature for Stations in Ireland 1921-1950", published by the Irish Meteorological Service (2). The data for Shannon Airport are based on observations over the period November 1938 to December 1960 inclusive.

Examination of the diagrams in Figure 6 indicates that, in general, January and February were the coldest months. For four of the six sets of records, July was slightly warmer than August, and for the other two (Shannon Airport and Tralee) August was the warmest month. The late occurrence of the warmest month at these two locations may be a feature of the west of the area and may be influenced by the fact that the sea to the west is warmer in August than in July (15°C in August, 14°C in July).

Although the changes of air temperature over the year in respect of the stations in Figure 6 show a fairly smooth pattern insofar as mean values are concerned, the day to day regime in any year may depart considerably from the mean. Indeed, with a marked oceanic influence in the climate, and the effect of the strong westerlies in the area, prolonged spells with marked characteristics recurring annually, such as is found in the interior of the large continents, are not experienced in the area. However, well-defined features of the general circulation in middle latitudes do produce local effects which have often been noted and have been referred to in the folk-lore of the region, but which do not recur with the regularity or precision which are statistically satisfying or predictable in any one year. The interruption in the regular rise and fall of temperature in the course of the year in Scotland, discussed by Buchan just 100 years ago, correspond to singularities which have been noted in Ireland. Perhaps the better known ones in Ireland are a cold spell in early May (Scairbhin na gCuac) corresponding to Buchan's cold spell in the period 9 - 14th May and the mild days in early December (corresponding to Buchan's warm spell in the period 3 - 14th December). An interesting calendar of weather singularities and related circulation features has been compiled for Great Britain and Ireland by Lamb (3).

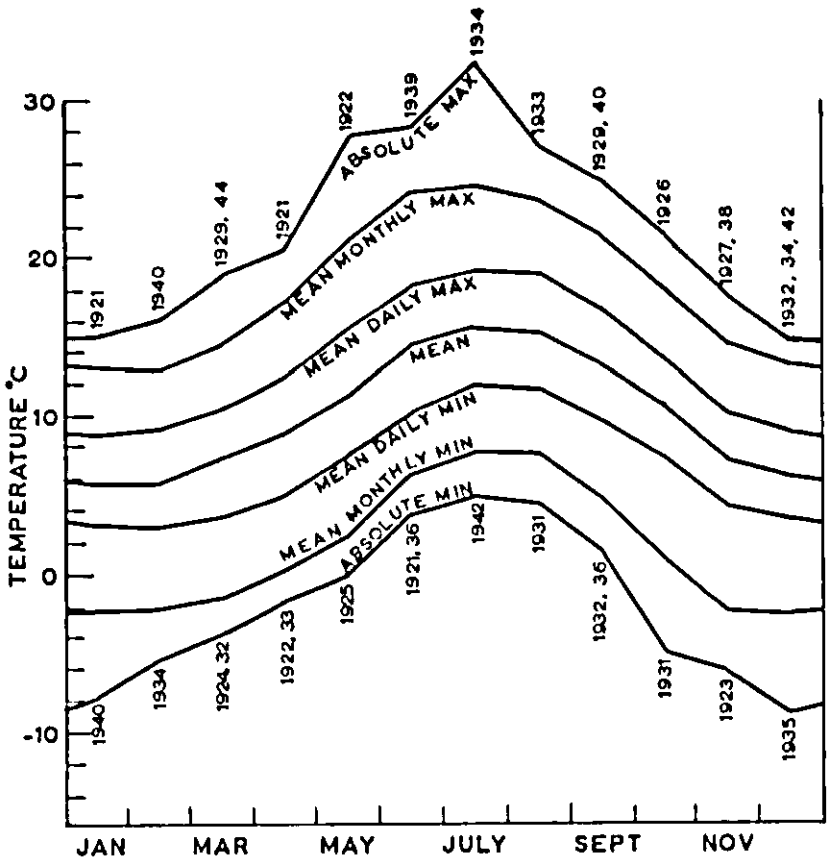
Air frost (minimum air temperature below 0°C) has been reported in North Munster in nine of the twelve months (June, July and August excepted). It is likely that in some "Frost hollows" temperature has fallen



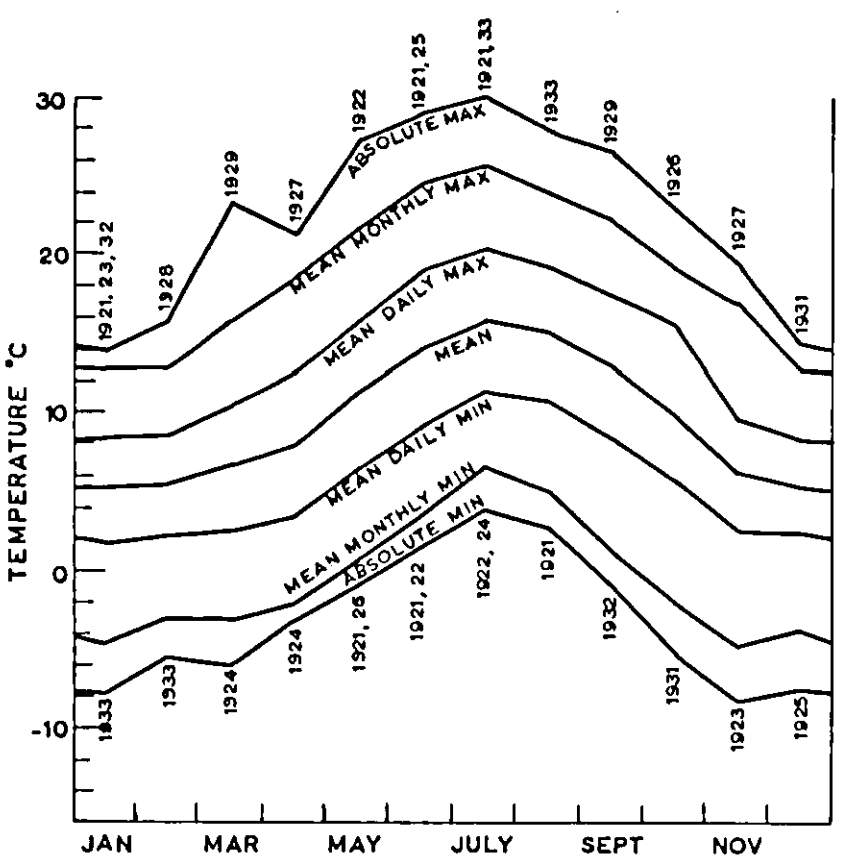
(a) SHANNON AIRPORT (Nov 1938 - Dec 1960)
52° 41' N 8° 55' W

(b) BIRR (1921 - 1950)
53° 06' N 7° 54' W

Fig. 6 Mean and extreme values of air temperature at (a) Shannon Airport and (b) Birr

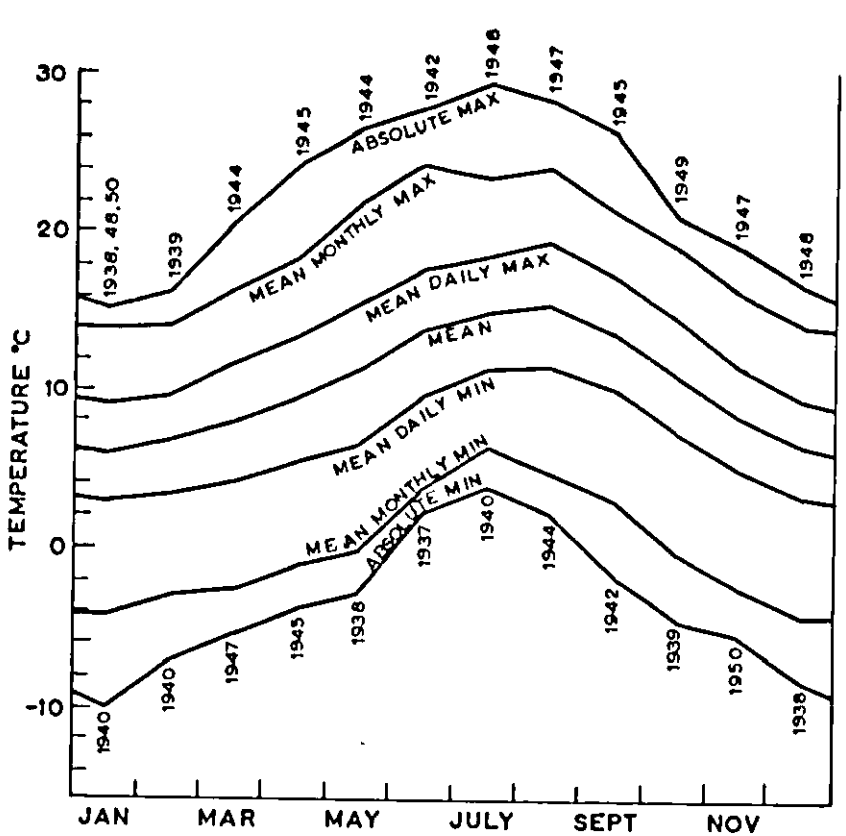


(c) FOYNES (COOLNAVEE) (1921-1944)
52° 36' N 9° 07' W

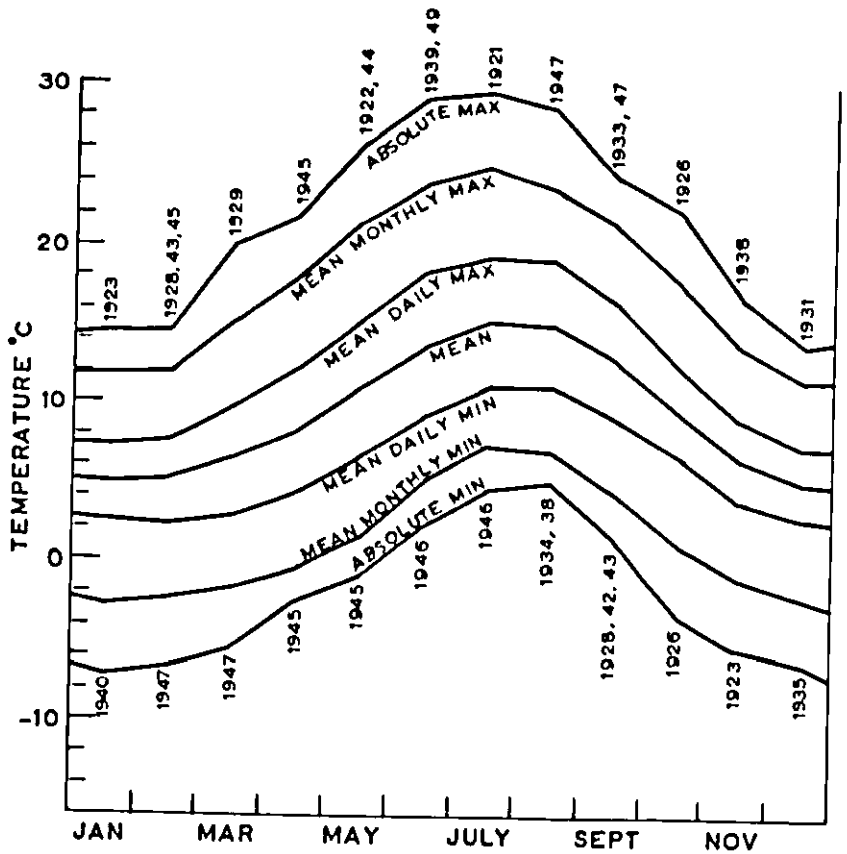


(d) KILKENNY (KILKENNY CASTLE) (1921-1933)
52° 39' N 7° 14'W

Fig. 6. (continued) Mean and extreme values of air temperature at (c) Foynes and (d) Kilkenny



(e) TRALEE (CLASH) (1937 - 1950)
52° 16' N 9° 41' W



(f) CARRICK-ON-SUIR (SESKIN) (1921 - 1950)
52° 20' N 7° 26'W

Fig. 6. (continued) Mean and extreme values of air temperature at (e) Tralee and (f) Carrick - on - Suir

below 0°C in June in extreme cases. On the west coast of Clare and North Kerry air temperatures of 0°C or less do not occur more frequently on average than on ten days a year. The number of occurrences of frost temperature per year increases sharply in coastal areas as distances from the sea increases, and then more slowly reaching an annual rate of about 50 days per year in east North Tipperary which is representative of the central plain of the country in this respect. In addition, locations at increased height above sea level experience air frost on occasions when frost does not occur at lower locations. In the 10-year period from July, 1947, to June, 1957, the average interval between the last occurrence of air temperatures at or below 0.2°C in or about May to the first occurrence in or about October at Birr, Shannon Airport and Tralee is 159, 173 and 175 days, respectively, and these values should be representative of conditions inland in the area. On the actual Atlantic coast and on the low-lying land near the coast the frost-free interval each year is longer, and is probably similar to the regime at Valentia Observatory at Cahirciveen, when the average dates of last and first occurrence of air temperatures of 0.2°C or lower in the same period were 26th March and 1st December (i.e. an interval of 250 days). The lowest air temperature recorded at the stations referred to in Figure 6 in the period reviewed was below -14°C in January, 1945 at Birr.

Temperatures are rarely low enough for sufficiently long periods in winter to have persistent snow or ice within easy reach of centres of population.

As far as summer temperatures are concerned the values of the maximum air temperature are frequently used to determine the number of "summer days" and "tropical days" in any one year. The values of 25°C and 30°C have been most frequently quoted as limiting values for such classification. It would seem to be unrealistic to use the same criteria for a summer day at Aberdeen, Shannon Airport, Paris, Nice, Seville, Washington and Las Vegas at such different latitudes and with different climatic regimes. (The mean July temperatures in degrees Celsius for the stations just given are: 14.0; 15.5; 19.0; 23.3; 26.3; 25.7 and 32.3).

A summer day insofar as Irish climate is concerned might more appropriately be associated with a maximum temperature in excess of 20°C. A day with a maximum temperature in excess of 25°C would be regarded as a very hot day ("tropical day"). Temperatures of 30°C are known to have been exceeded in or near North Munster only at a few stations since records began. A value of 92°F (33°C) was reported as having occurred at Kilkenny on

26th June 1887. Examination of the reports for Shannon Airport over the period 1948-1957 gives an indication of the frequency with which days of certain categories occur in the warmer months.

TABLE 3

Number of days with maximum air temperature at Shannon Airport above certain values in the months May to September over the years 1948 - 1957

	MAY		JUNE		JULY		AUGUST		SEPTEMBER	
YEAR	20°C	25°C	20°C	25°C	20°C	25°C	20°C	25°C	20°C	25°C
1948	7	1	0	0	8	2	9	0	0	0
1949	2	0	15	5	17	2	16	1	10	0
1950	4	0	10	2	7	0	3	0	0	0
1951	0	0	6	0	13	0	3	0	0	0
1952	8	0	5	0	10	1	11	0	0	0
1953	3	0	12	2	6	0	7	0	3	0
1954	1	0	3	0	0	0	3	0	1	0
1955	1	0	3	0	25	9	26	2	4	0
1956	1	0	5	0	8	0	0	0	1	0
1957	4	0	14	7	12	0	8	1	0	0
TOTAL:	31	1	73	16	106	14	86	4	19	0

It can be seen from the figures in Table 3 that temperatures in excess of 25°C are confined almost completely to the months June, July and August and occurred on the average about three days per year. There is considerable variation in the incidence of high maximum temperatures from year to year. Temperatures in excess of 20°C occurred on an average of over 31 days per year. Maximum temperatures did not exceed 20°C in one of the June months and in one of the August months. There was only one occasion when temperatures exceeded 30°C (29th July, 1948). There is fairly general interest in

records of the maximum air temperature at different locations and Table 4 gives the values of these maxima at a number of locations in or near North Munster over particular periods.

TABLE 4

Values of Absolute Maximum Air Temperatures recorded at Specified Stations over particular periods

County and Station	Absolute Maximum Air Temperature	Date of Occurrence	Period to which Data refer (Inclusive Dates)
CLARE Shannon Airport	87°F (31°C)	29th July, 1948	November, 1938 to December, 1966
CORK Mallow	83°F (28°C)	24th August, 1955	May, 1950 to December, 1966
KERRY Tralee (Clash)	86°F (30°C)	24th August, 1955	March, 1937, to December, 1955 Jan. '62 - Dec. '66
OFFALY Birr	89°F (32°C)	15th July, 1876	May, 1872, to December, 1966
TIPPERARY Clogheen	84°F (29°C)	25th August, 1955	October, 1953, to December, 1962
TIPPERARY Gurteen	84°F (29°C)	25th August, 1955	January, 1952, to December, 1965
TIPPERARY Thurles	83°F (28°C)	25th August, 1955	January, 1953, to December, 1966
WATERFORD Seskin (Carrick-on-Suir)	85°F (29°C)	11th July, 1921	(October, 1913, to (February, 1940; (August, 1944, to (December, 1950

The lowest air temperatures recorded at these same stations over particular intervals of time are given in Table 5.

TABLE 5

Values of Absolute Minimum Air Temperatures recorded at Specified Stations over particular periods

County and Station	Absolute Minimum Air Temperature	Date of Occurrence	Period to which Data refer (Inclusive Dates)
CLARE, Shannon Airport	11°F (-12°C)	28th January, 1945	November, 1938, to December, 1966
CORK Mallow	10°F (-12°C)	14th January, 1963	May, 1950, to December, 1966
KERRY Tralee (Clash)	9°F (-13°C)	1st January, 1962	March, 1937, to December, 1955; January, 1962, to December, 1966
OFFALY Birr	4°F (-16°C)	6th January, 1894	May, 1872 to December, 1966
TIPPERARY Clogheen	15°F (-9°C)	22nd January, 1958	October, 1953 to December, 1962
TIPPERARY Gurteen	12°F (-11°C)	1st January, 1962	January, 1952, to December, 1965
TIPPERARY Thurles	11.6°F (-11°C)	14th January, 1963	January, 1953, to December, 1966
WATERFORD Seskin (Carrick-on-Suir)	19°F (-7°C)	17th January, 1940	October, 1913, to December, 1950

It is of interest that in the case of all the records listed the lowest air temperature for each station was experienced in January. This was not the case in other stations in Ireland over comparable periods, a number of which had their lowest air temperature in February. The lowest recorded air temperature in Ireland which came to notice in this investigation was at Markree Castle, County Sligo, where the air temperature on the 16th January, 1881, fell to -2.3°F (-19°C). The records of Markree Castle over the period 1875 to 1960 were considered.

3.3. Grass Minimum Temperature

The grass minimum temperature is obtained from readings of an ordinary minimum thermometer exposed horizontally over short grass with its bulb touching the tips of the blades of grass. It is of interest mainly as an indication of the occurrence of ground frosts at night.

Although the greatest care is taken to ensure that grass temperatures are as representative as possible, local effects cause marked variation in the minimum grass temperatures of a district. In particular sea-shore areas do not, in general, get as much frost as inland locations while in inland locations sloping land facing south or south-west generally get less frost than flat low-lying ground. Frost hollows and sandy lowlands are more likely to get frost temperatures at night in conditions favourable for radiation.

Table 6 gives an indication of the incidence of ground frost over North Munster for different months of the year.

TABLE 6

Mean number of days with grass minimum temperatures below 0°C at Birr, Shannon Airport and Valentia over the 6-year period 1955-1960 (inclusive)

Station/ Month	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Birr	17	17	12	13	6	3	0.2	0.2	0.5	5	11	14
Shannon Airport	14	15	9	9	3	0.7	0	0	0.2	3	7	9
Valentia	10	11	7	3	0.3	0	0	0	0	1	4	5

/

Table 7 gives the monthly average of the grass minimum temperatures over the same period at the three stations.

TABLE 7

Monthly average of Grass Minimum temperature (°C) at Birr, Shannon Airport and Valentia for the period 1955-1960 (inclusive)

Station/ Month	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Birr	-1°	-1°	2°	2°	3°	7°	9°	9°	8°	5°	2°	1°
Shannon Airport	0°	0°	3°	3°	6°	9°	11°	10°	9°	6°	3°	2°
Valentia	2°	2°	4°	5°	6°	9°	11°	11°	10°	7°	5°	4°

The average grass temperature figures at Birr are probably fairly indicative of the regime in North Munster east and north of the Silvermine Mountains although local effects influence individual values and make readings of grass minimum temperatures less representative of large areas than readings of other elements. The lowest grass minimum temperature which has come to notice in Ireland was observed in Birr (-10°F/-23°C on 6th January 1894). The figures for Shannon should give a good representation of the regime in the lower Shannon basin, while the figures for Valentia, having some similarity to those at the coastal station of Belmullet in the north-west of Ireland, are believed to be representative of conditions on west coastal areas of Clare and North Kerry.

3.4. Soil Temperature

Soil temperature measurements are made at a number of locations in or in the vicinity of North Munster. The depths at which the soil temperature is measured at Irish stations are 2 in. (5 cm.), 4 in. (10 cm.), 8 in. (20 cm.), 1 ft. (30 cm.), 2 ft. (60 cm.) and 4 ft. (120 cm.). Some stations which report soil temperature observe only at a selection of these levels.

For measuring temperatures at 2 inches, 4 inches and 8 inches, the specially-designed thermometers have their bulbs at the appropriate depth below bare soil. For measurements at the 1 ft., 2 ft., and 4 ft. depths, the thermometers are below a grass-covered surface.

At certain stations the mean temperatures at depths of 2 inches, 4 inches and 8 inches are based on readings at 0300, 0900, 1500 and 2100 GMT daily. In all other cases mean values are based on daily readings at 0900 GMT only.

Soil is a poor heat conductor and, as a result, the daily temperature variation in natural undisturbed soil with a vegetation cover does not penetrate very deeply, usually not below 3 ft. according to Landsberg (4), while the annual range has an influence to only about 50 feet.

The cycle of soil temperature changes is influenced by the soil type, thermal conductivity and moisture content. The level of the water-table and the soil structure have also important influences.

Table 8 shows the average of the mean monthly values of the soil temperature at specified depths at Shannon Airport over a recent six-year period. At Shannon Airport the 4 feet thermometer is normally below the water table.

TABLE 8

Average of mean monthly values of soil temperature (°C) at certain depths at Shannon Airport for the years 1955-1960 (inclusive)

DEPTH	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
2"	4.2	4.2	7.1	10.4	13.6	16.7	17.6	16.9	14.6	11.0	7.4	5.7
4"	4.4	4.3	7.1	10.2	13.4	16.4	17.8	17.2	14.7	11.2	7.7	5.9
8"	4.7	4.6	7.2	9.9	13.1	16.0	17.4	17.0	15.0	11.7	8.1	6.4
1'	5.3	5.0	7.2	9.9	13.0	15.7	17.2	17.0	15.2	12.2	8.7	6.7
2'	6.2	5.6	7.1	9.3	12.1	14.8	16.1	16.5	15.2	12.6	9.4	7.3
4'	7.9	6.9	7.3	8.8	10.7	12.8	14.6	15.3	14.9	13.4	11.2	9.2

February is seen as the coldest month at all levels below 2 inches below ground at Shannon Airport while the warmest month was July at shallow levels and August at the deeper levels. In the months October to February the soil is warmer at the deeper levels than at the shallow level while the reverse is true in the months May to August. The annual variation is greater at shallow levels than it is deeper in the soil. Freezing temperature was observed only once in the 6-year period at the 8" level and never at the 1 ft. or 4 feet levels.

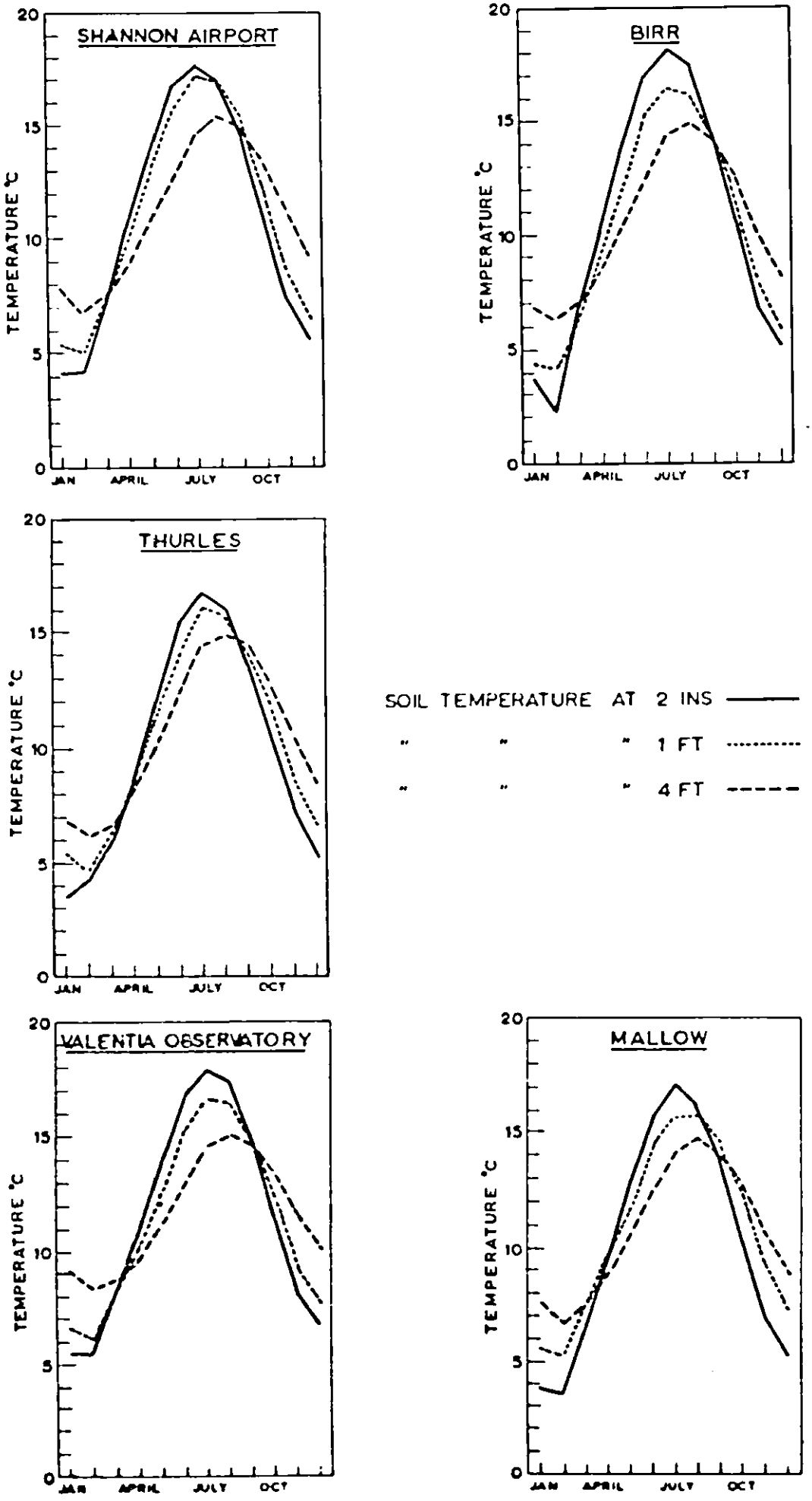


Fig. 7. Annual variation of soil temperature at 5 locations in or near North Munster for the years 1955 to 1980 inclusive.

The lowest monthly mean in soil temperature at Shannon Airport at any level in the period was 2.2°C at the 2" level in February, 1955, while the highest, also at the 2" level, was 21.3°C in July, 1955. The mean air temperature values for Shannon in the same two months were 2.4°C and 17.2°C.

Figure 7 gives an indication of annual variation of soil temperature at five locations (including Shannon Airport) in or near North Munster based on available data for the same six-year period.

The values for Valentia are probably more representative of coastal soil temperature in the west of North Munster than are the corresponding values from the more Northerly but further inland stations.

3.5. Water Temperature:

A limited amount of information is available on the water temperatures of the Shannon estuary. During the period 1948-1952 water temperature was measured daily in mid-stream between Shannon Airport and Foynes. The monthly means for these figures are shown in Figure 8 which gives an indication of the annual variation of the water temperatures in the estuary.

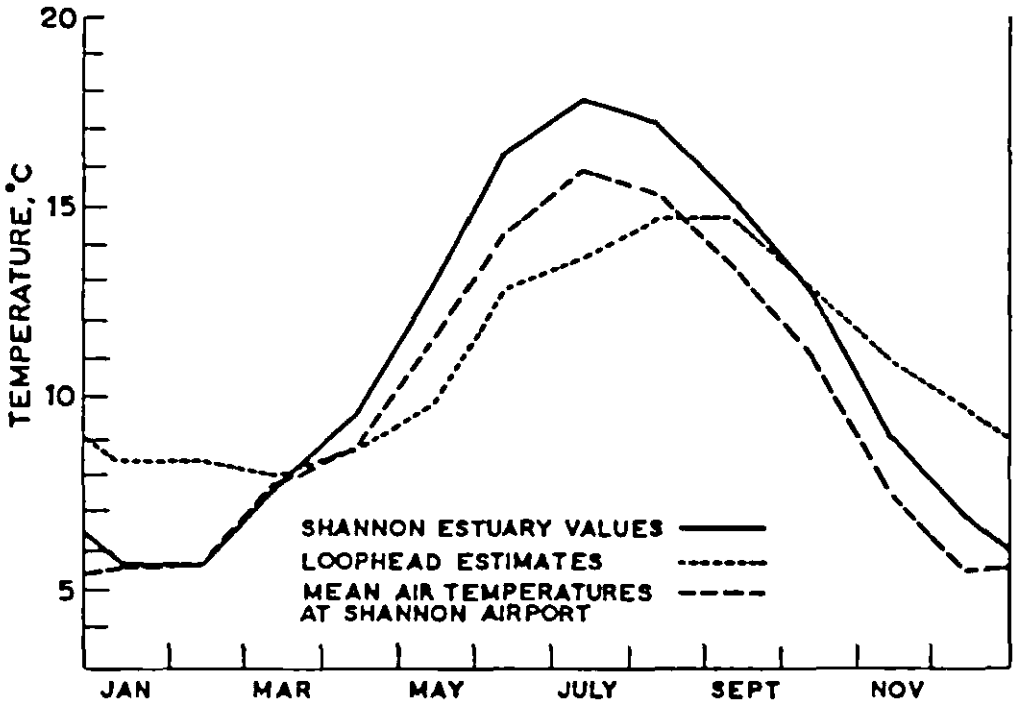


Fig. 8 Monthly mean values of water temperature in Shannon estuary between Shannon Airport and Foynes in the period October, 1948, to September, 1952, inclusive, climatic averages of Sea Temperature off the West coast of Clare (Based on charts in "Klimatologie der Nordwesteuropaischen Gewasser," Einzelveroffentlichungen Nr. 4, Deutcher Weetterdienst, Seewetterant), and Mean Air Temperature at Shannon Airport October 1948 to September 1952 inclusive.

Comparison of these figures with the values given in climatic charts for the water temperature in the sea off the west coast of North Munster indicates that the estuary temperature is about 3°C colder than the open ocean in the months of December to February; both have about the same temperature in the months March, September, October and November and the estuary is warmer in the months April to August, reaching maximum of about 18°C in July, while the west coast water temperature reaches a maximum of slightly less than 15°C in August and September.

CHAPTER 4

PRECIPITATION

4.1. General

For the purposes of this chapter, precipitation includes all water reaching the earth's surface in either the liquid or the solid (frozen) state. By far the greater portion of precipitation in Ireland is in liquid form as rain or drizzle. Snow is relatively uncommon except in high ground in Winter. At lower levels it rarely contributes much to the total rainfall and rarely lasts on the ground for more than a few days even in the most severe snow conditions. In the part of North Munster within a few miles of the Atlantic coast it is less frequent than further east and in some years does not last even for a few hours on the ground. Hail is infrequent and freezing rain is most unusual. A very small fraction of the total precipitation measured in North Munster is due to deposits of dew, hoar frost, rime or wet fog on the collecting surface of the raingauge.

The amounts of precipitation measured daily by means of a suitably exposed standard raingauge are used to provide data on rainfall.

In the case of rainfall stations located in places which are difficult to reach (e.g. mountain stations), accumulated rainfall is measured only once or twice monthly, but in the majority of cases rainfall is measured daily and, in some cases, more frequently. When a raingauge collects solid precipitation the solid precipitation is melted before measurement. Some stations are equipped with recording raingauges which, in addition to total rainfall, give information on the rate of rainfall at any particular time.

In North Munster rainfall records have been maintained over a long period by a number of stations. Prior to April, 1937, rainfall stations in Ireland were controlled by the British Rainfall Organisation. After that time the stations came under the control of the Irish Meteorological Service.

Figure 9, prepared by the Irish Meteorological Service, shows the average annual distribution of rainfall over Ireland over the period 1931-1960. The figure gives a good indication of the rainfall in North Munster in relation to the rest of the country. It can be seen that there is a tendency for rainfall amounts to be greater near the west coast and on high ground.

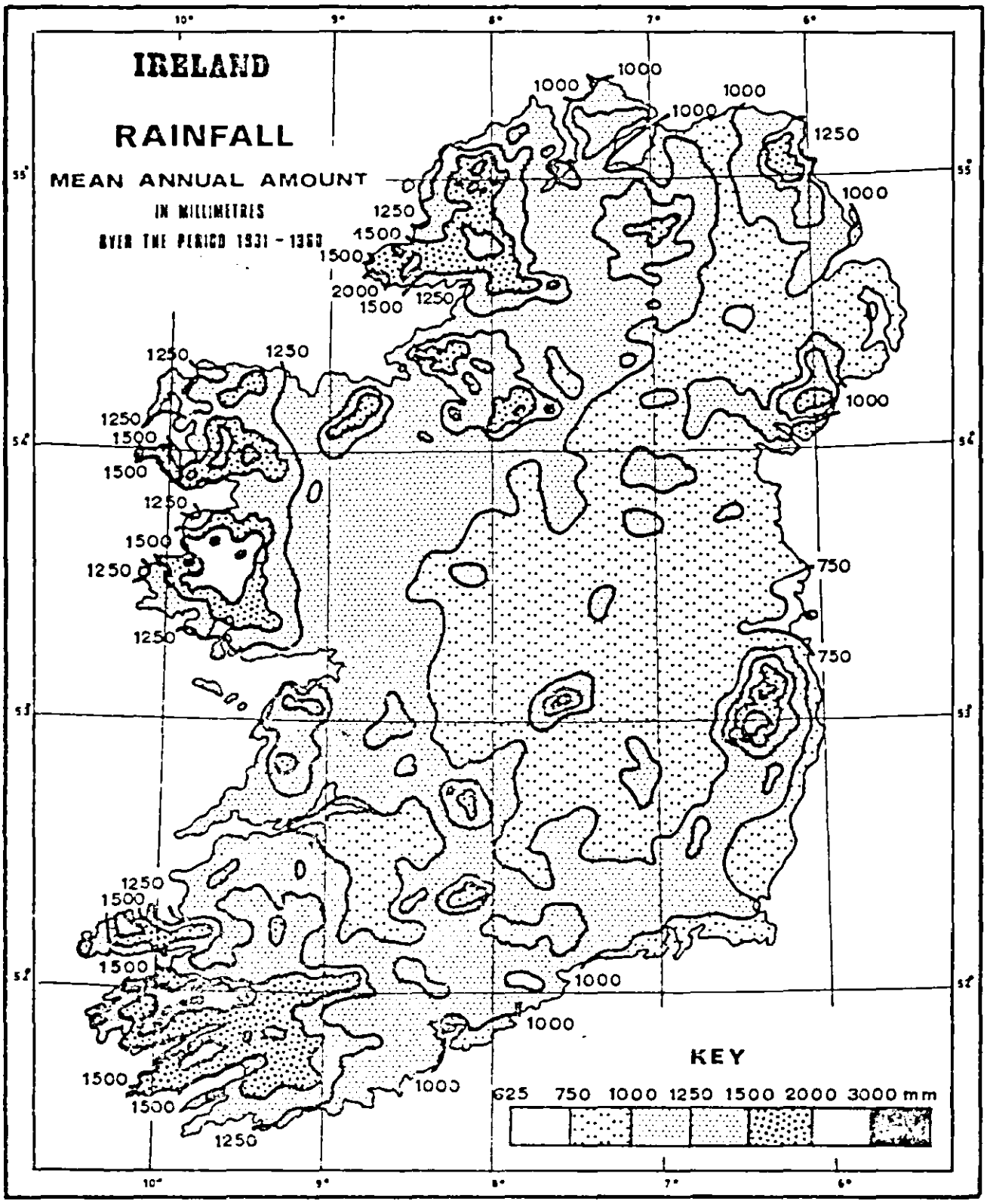

IRELAND
RAINFALL
MEAN ANNUAL AMOUNT
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
KEY
625 750 1000 1250 1500 2000 3000 mm

Fig. 9.

TABLE 9

AVERAGE MONTHLY RAINFALL AND PERCENTAGE OF ANNUAL AMOUNT IN EACH MONTH (1931-1960) FOR SELECTED STATIONS IN OR NEAR NORTH MUNSTER

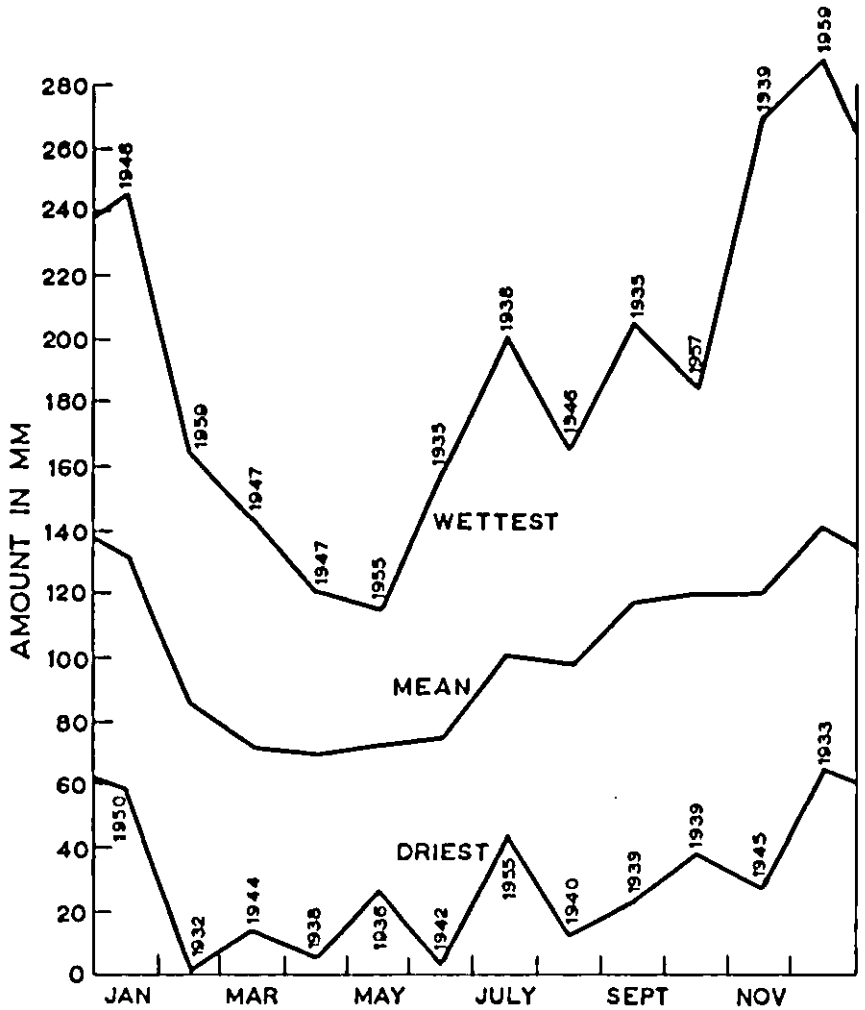
STATION AND COUNTY		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AVERAGE
PORTUMNA (O.P.W.) Galway	Amount	86.1	57.5	52.2	47.0	57.6	62.7	79.0	79.5	84.7	81.9	79.4	93.7	861.3
	% of A.	10.0	6.7	6.0	5.5	6.7	7.3	9.2	9.2	9.8	9.5	9.2	10.9	100.0
BANAGHER (Canal House) Offaly	Amount	84.8	59.2	52.3	48.0	56.3	59.7	78.4	78.8	87.9	84.4	78.5	90.4	858.7
	% of A.	9.9	6.9	6.1	5.6	6.6	7.0	9.1	9.2	10.2	9.8	9.1	10.5	100.0
BIRR Offaly	Amount	84.7	58.7	51.6	48.8	61.9	60.6	85.8	81.9	87.0	84.2	78.2	89.5	872.9
	% of A.	9.7	6.7	5.9	5.6	7.1	6.9	9.8	9.4	10.0	9.7	9.0	10.2	100.0
DROMOLAND CASTLE Clare	Amount	112.5	76.5	64.3	59.7	68.8	69.3	89.4	86.4	106.4	106.9	107.7	124.2	1072.1
	% of A.	10.5	7.1	6.0	5.6	6.4	6.5	8.3	8.1	9.9	9.9	10.1	11.6	100.0
INAGH (Mount Callan) Clare	Amount	168.6	117.6	102.0	83.9	87.4	103.2	159.1	142.9	158.0	163.1	167.2	192.7	1650.7
	% of A.	10.2	7.1	6.2	5.4	5.3	6.2	9.6	8.7	9.6	9.9	10.1	11.7	100.0
TUAMGRANEY (Raheen Ho.) Clare	Amount	132.3	88.6	74.8	70.7	75.5	74.9	95.2	98.5	116.5	117.2	121.7	144.5	1210.4
	% of A.	10.9	7.3	6.2	5.8	6.3	6.2	7.9	8.1	9.6	9.7	10.1	11.9	100.0
BIRDHILL (Parteen Weir) Tipperary	Amount	109.6	73.9	66.5	63.6	73.0	73.5	95.7	95.3	105.4	103.8	106.5	124.6	1091.4
	% of A.	10.0	6.8	6.1	5.8	6.7	6.7	8.8	8.7	9.7	9.5	9.8	11.4	100.0
CLOUGHJORDAN (Modreeny) Tipperary	Amount	89.5	62.2	55.2	51.2	64.4	64.9	89.8	85.0	90.7	90.6	86.9	98.2	928.6
	% of A.	9.6	6.7	5.9	5.5	6.9	7.0	9.7	9.1	9.8	9.8	9.4	10.6	100.0
KILLALOE (Ballina) Tipperary	Amount	131.7	86.4	71.6	69.5	72.8	74.8	100.2	97.4	116.9	120.2	120.9	143.2	1205.6
	% of A.	10.9	7.2	5.9	5.8	6.0	6.2	8.3	8.1	9.7	10.0	10.0	11.9	100.0
NENAGH (Castle Lough) Tipperary	Amount	118.5	76.5	65.3	61.4	70.5	62.2	86.5	87.6	96.4	100.3	102.3	123.9	1051.4
	% of A.	11.3	7.3	6.2	5.9	6.7	5.9	8.2	8.3	9.2	9.5	9.7	11.8	100.0
CAHIR ABBEY Tipperary	Amount	111.9	76.9	68.6	57.5	75.9	63.1	84.4	77.6	92.6	100.0	110.1	117.5	1036.1
	% of A.	10.8	7.4	6.6	5.6	7.3	6.1	8.2	7.5	8.9	9.7	10.6	11.3	100.0
CASHEL (Ballinamona) Tipperary	Amount	97.7	65.8	62.6	51.5	70.0	61.3	80.2	75.1	86.0	84.2	90.4	103.7	928.5
	% of A.	10.5	7.1	6.7	5.6	7.5	6.6	8.6	8.1	9.3	9.1	9.7	11.2	100.0
ABBEYFEALE (Springmount) Limerick	Amount	117.9	80.7	66.1	58.6	59.8	63.4	86.2	94.5	98.5	107.9	118.6	135.5	1087.7
	% of A.	10.8	7.4	6.1	5.4	5.5	5.8	7.9	8.7	9.1	9.9	10.9	12.5	100.0
LIMERICK (Mulgrave St.) Limerick	Amount	97.3	65.5	59.6	56.7	68.9	70.3	93.6	89.0	94.1	94.7	100.6	111.3	1001.6
	% of A.	9.7	6.5	5.9	5.7	6.9	7.0	9.4	8.9	9.4	9.5	10.0	11.1	100.0
KILLORGLIN (Callinafercy) Kerry	Amount	140.6	96.4	80.3	73.6	67.7	72.8	101.6	93.6	108.8	125.0	143.0	158.0	1261.4
	% of A.	11.1	7.7	6.4	5.8	5.4	5.8	8.1	7.4	8.6	9.9	11.3	12.5	100.0
MALLOW (Hazelwood) Cork	Amount	106.4	72.0	70.3	56.0	71.5	56.2	78.2	78.1	91.2	96.7	106.1	114.6	997.3
	% of A.	10.7	7.2	7.1	5.6	7.2	5.6	7.8	7.8	9.1	9.7	10.7	11.5	100.0
PILTOWN (Kildalton Abbey) Kilkenny	Amount	108.6	76.8	82.1	54.4	75.1	66.5	75.7	80.4	94.4	93.0	105.9	115.2	1028.1
	% of A.	10.5	7.5	8.0	5.3	7.3	6.5	7.4	7.8	9.2	9.0	10.3	11.2	100.0
PORTLAW (Mayfield) Waterford	Amount	111.3	76.9	82.2	55.3	75.6	64.4	79.6	80.9	99.2	97.6	103.8	114.5	1041.3
	% of A.	10.7	7.4	7.9	5.3	7.3	6.2	7.6	7.8	9.5	9.5	9.9	11.0	100.0

Specific figures of monthly averages and percentages of annual rainfall in each month for individual stations in North Munster covering the period 1931-1960 are given in Table 9. It can be seen that for a recent 30-year period, December is the month of greatest average rainfall at each of the 18 stations, while April is the month of least average rainfall at 16 of the 18 stations. The slightly lower average values for May at Killorglin and Inagh appear to be due to relatively local effects, as a more dense local network in the vicinity of each station and covering a 10-year period 1951-1960 shows May as being drier on the average than April.

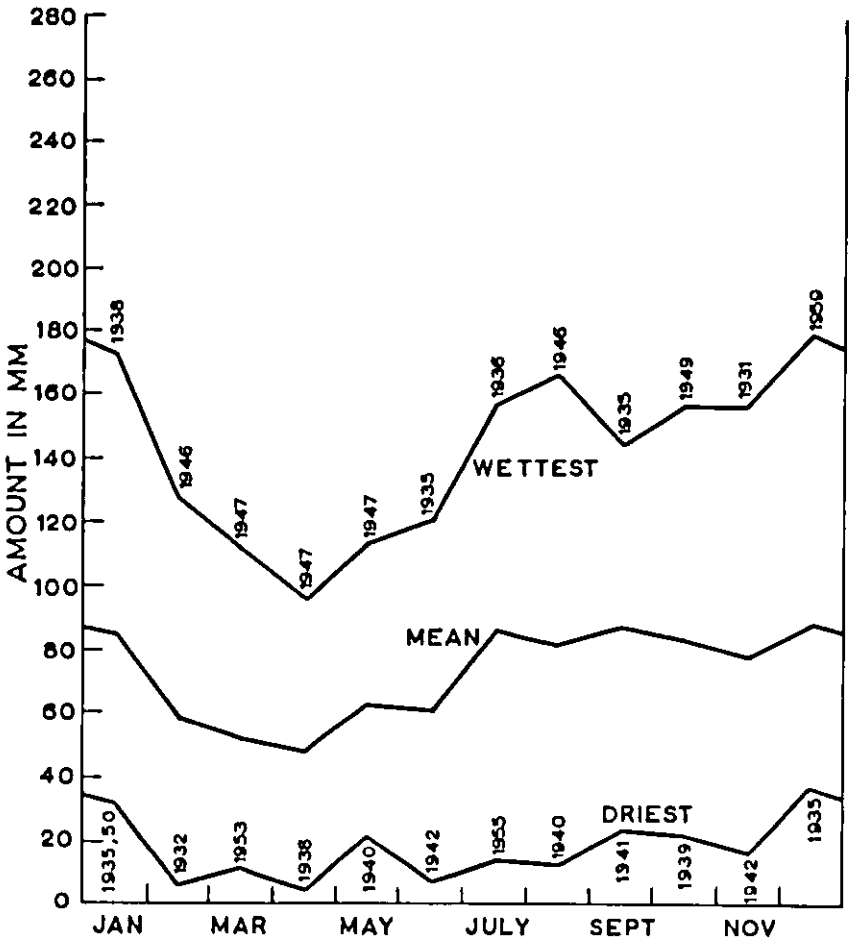
Figure 10 shows the annual variation of average monthly rainfall at six of the 18 stations for which data are tabulated in Table 9. Figure 10 demonstrates the fact that, in general, February to June are the months of lowest average rainfall in North Munster. There is a noticeable rise in the monthly average from June to July. August has a 30-year average comparable to July while the average rises again in September and from then until the end of January the average rainfall for each month is relatively high. It must not be assumed from these figures that the pattern in any year will follow that of the 30-year average. Values for the driest and wettest month at each of the six stations shown in Figure 10 show remarkable variations at each station. Thus, in June, 1935, some 190 mm. of rain was recorded at Dromoland while in November, 1962, the same station had less than 30 mm. Nevertheless, it is of interest to see that the highest rainfall values for each month at five of the six stations from which data are presented in Figure 10 show lower values in the Spring months than at other times. The very high value at Cashel in March, 1947, was exceptional even for what was a very wet month generally in North Munster.

4.2. Rain Days and Wet Days

For many activities average annual or monthly figures taken over a number of years do not give necessary information on the part played by rainfall in the climate of any place. Many stations in North America are regarded as being drier than North Munster; their average annual rainfall is, in fact, similar to that in North Munster. For example, the average annual rainfall over the period 1931-1960 at New York was 1123 mm. and at Montreal was 971 mm. However, much of the rainfall at those stations falls in comparatively heavy outbreaks over rather short periods (often accompanied by thunder) while in SW Ireland much of the total is made up of small amounts spread over a much longer duration. The number of days per year with 1 mm. of rain or more on average at Shannon, New York and Montreal is about 160, 125 and 155, respectively. In Irish rainfall records the number of days at which

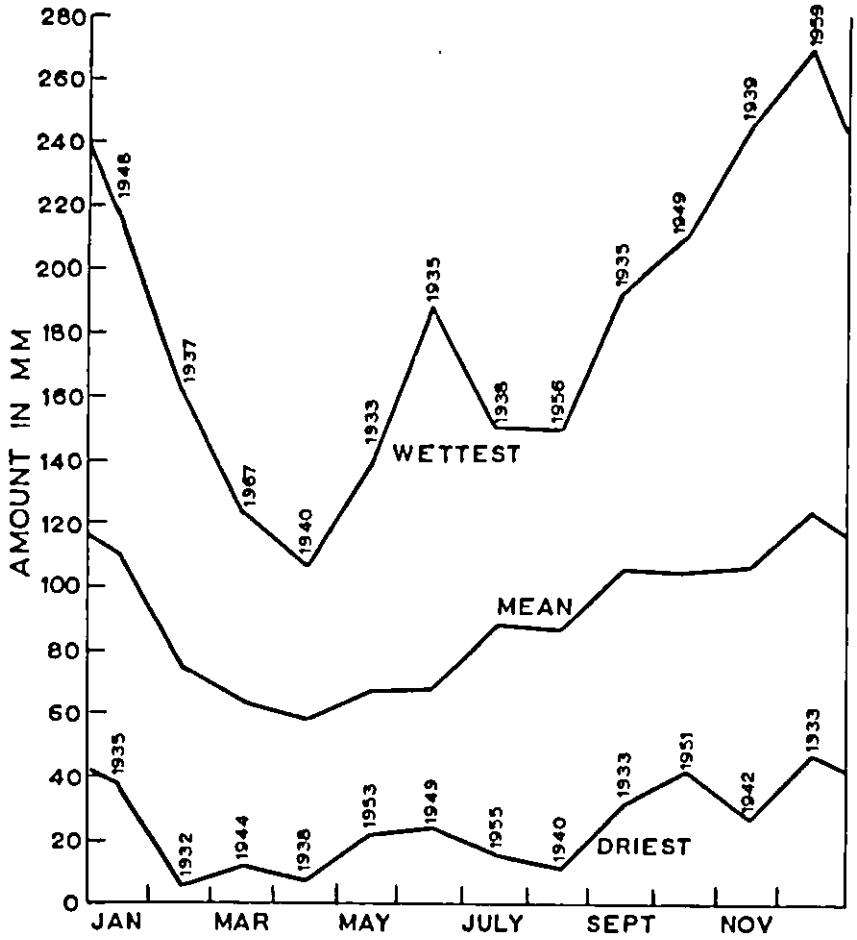


(a) KILLALOE (BALLINA) 1931 - 1960

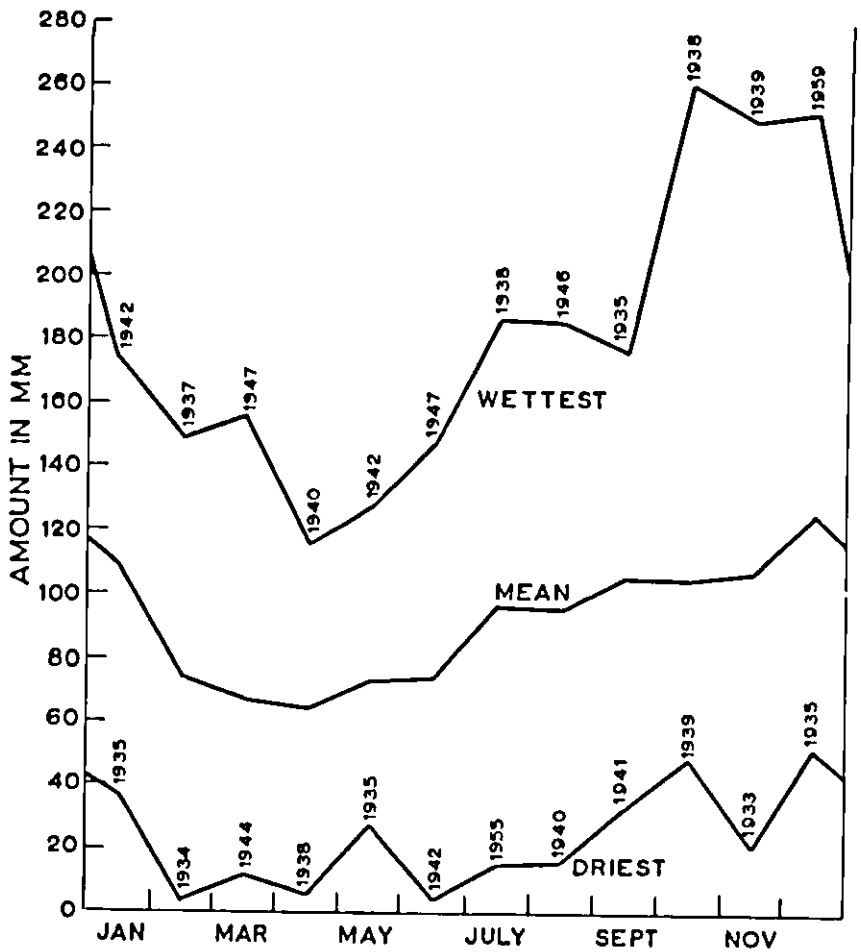


(b) BIRR 1931 - 1960

Fig. 10. Mean and extreme values of rainfall at (a) Killaloe and (b) Birr.

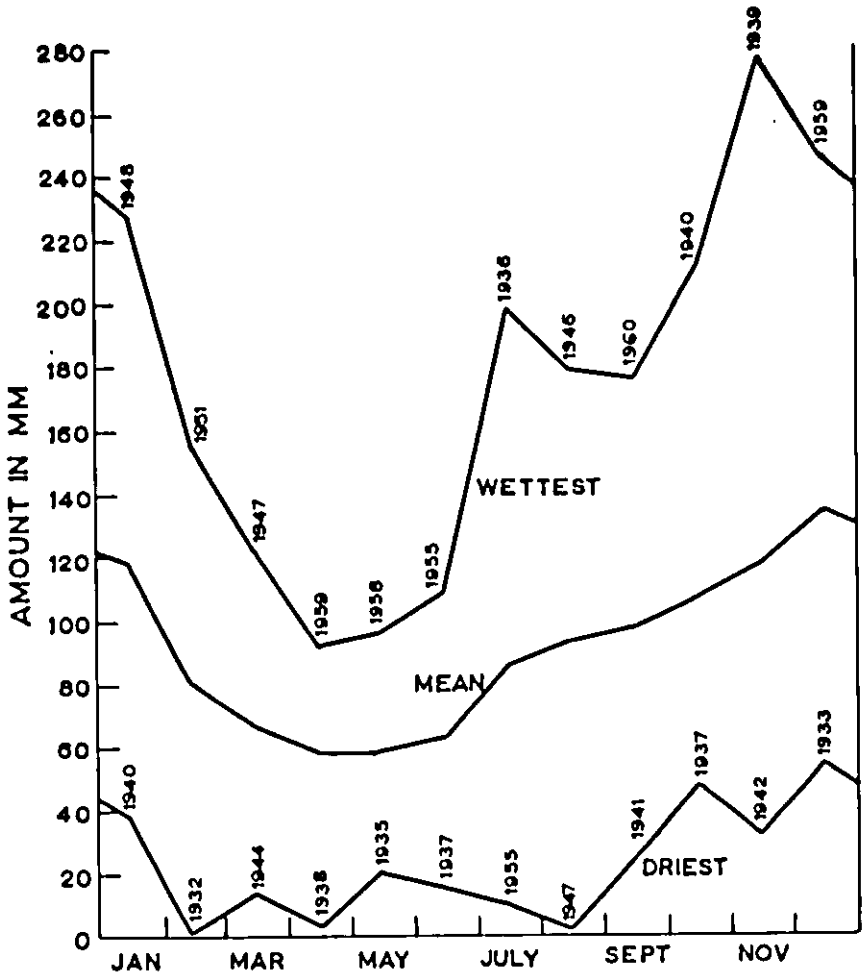


(c) DROMOLAND, 1931 - 1960

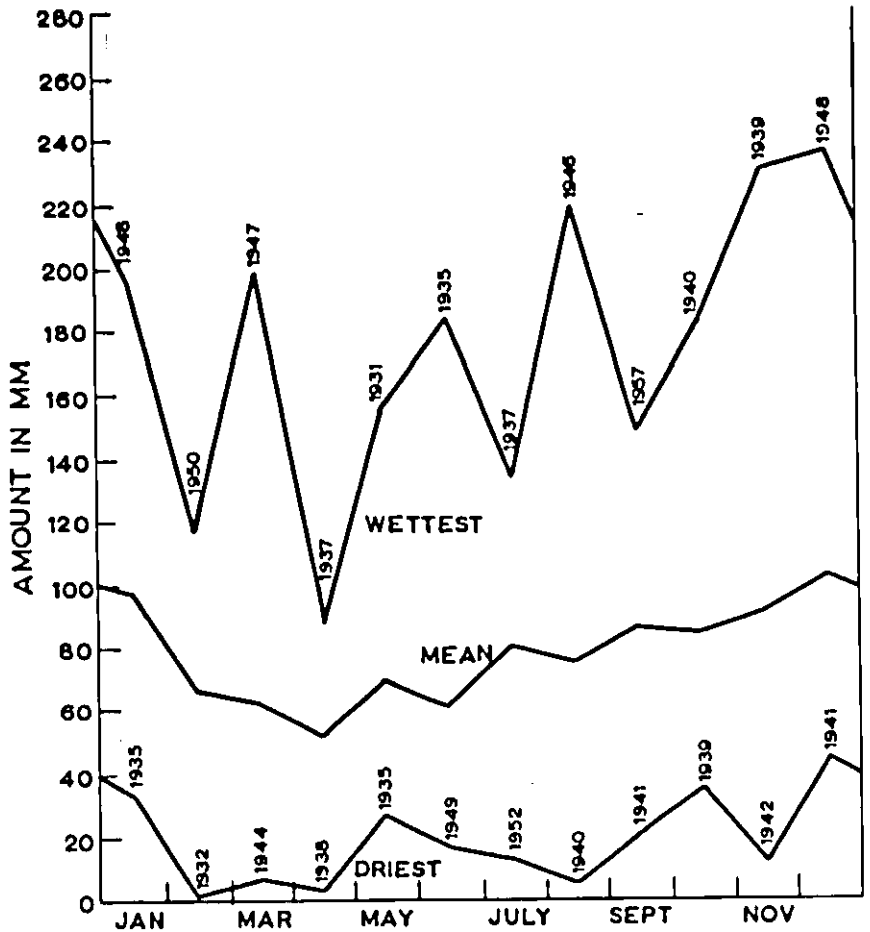


(d) BIRDHILL (PARTEEN WEIR) 1931 - 1960

Fig. 10. (continued) Mean and extreme values of rainfall at (c) Dromoland and (d) Birdhill.



(e) ABBEYFEALE (SPRINGMOUNT) 1931 - 1960



(f) CASHEL (BALLNAMONA) 1931 - 1960

Fig. 10. (continued) Mean and extreme values of rainfall at (e) Abbeyfeale and (f) Cashel.

specified amounts of rain were exceeded are listed in respect of a number of stations. The amounts are 0.2 mm. or more in a day (a rain day) and 1.0 mm. or more in a day (wet day). Examination of records from four stations in the area under study, over a period of 10 years from 1951 to 1960, gives the values shown in Table 10, which also includes the amount of maximum rainfall in a day at each of the stations over the same period.

TABLE 10

Figures relating to daily rainfall at four stations for the period 1951-1960, inclusive

Station	Average No. of days per year with rainfall of indicated amounts		Max. rainfall in a day at the station
	0.2 mm. or more	1.0 mm. or more	
Birr	209	152	39.5 mm.
Shannon Airport	215	162	48.7 mm.
Waterford (Tycor)	194*	141*	94.7*
Mallow	213	156	66.2 mm.

* 1952 - 1960

The unusually high maximum rainfalls for a day at Waterford and Mallow were recorded for 24th September, 1957, and were associated with a depression of tropical origin ("Carrie") which passed east along the south coast of Ireland and gave heavy falls particularly along the south and east coasts of the country.

For the longer period January, 1939, to December, 1960, inclusive, the average figures for number of days with 0.2 mm. and 1.0 mm., respectively, at Shannon were 217 days and 159 days and these were distributed on the average by month as shown in Table 11.

TABLE 11

Mean number of days per month with 0.2 mm. and 1.0 mm. of rainfall at Shannon Airport over the period January, 1939, to December, 1960 inclusive

MONTH

AMOUNT	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
0.2 mm	20	16	16	16	15	16	19	19	19	18	19	24
1.0 mm	15	11	11	11	11	11	14	14	14	14	15	18

It is interesting to note that the popular holiday months of July and August and September are only exceeded in "rain days" by December and January and in "wet days" by November, December and January.

4.3. Duration of Rainfall

Examination of the records of the recording rain-gauge at Shannon Airport over the period 1949-1963 inclusive shows an average annual duration of rainfall of 677 hours. The year 1957 had the greatest duration of rainfall in that period with 874 hours and 1955 with 540 hours rain had the least total duration of rain for a year in that period.

Table 12 shows the mean annual amounts of rain and the average annual duration of rain between exact hours GMT, at Shannon over the period 1949 to 1963 inclusive.

TABLE 12

Mean annual total amounts and totals of duration of rainfall between exact hours at Shannon Airport over the period January, 1948 to December, 1963 inclusive

Hour GMT	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12
Annual Amount (mm)	41.4	42.6	40.5	40.8	42.0	43.5	38.8	39.4	36.8	35.4	37.3	35.0
Annual Duration (hours)	28.4	31.3	31.8	31.9	33.0	31.8	30.2	30.4	27.6	25.3	23.6	22.8

Hour GMT	12 to 13	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18	18 to 19	19 to 20	20 to 21	21 to 22	22 to 23	23 to 24
Annual Amount (mm)	38.8	38.9	43.3	44.7	43.3	40.8	41.3	40.3	39.9	34.5	37.2	38.6
Annual Duration (hours)	23.7	24.0	26.5	28.2	28.5	28.0	29.4	29.6	28.8	26.7	27.2	28.4

The material in Table 12 is reproduced in pictorial form in Figures 11 and 12.

It would appear from the above material that there is a marked diurnal pattern in the distribution of both amounts and duration of rainfall between exact hours, with maximum values of total amount between 0500 and 0600

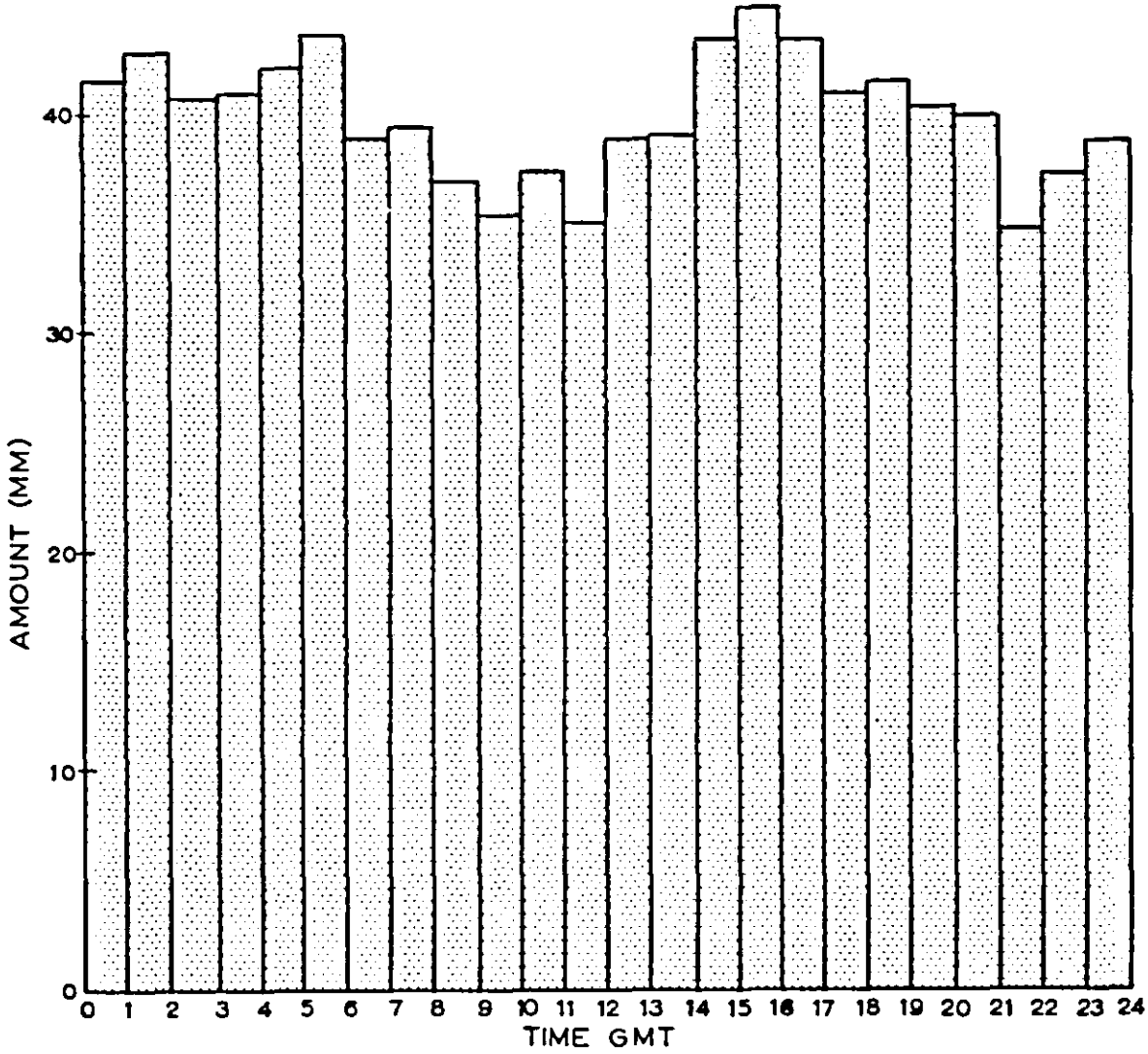


Fig. 11 Mean annual amount of rainfall between exact hours at Shannon Airport over the period January 1948 to December 1963 (inclusive).

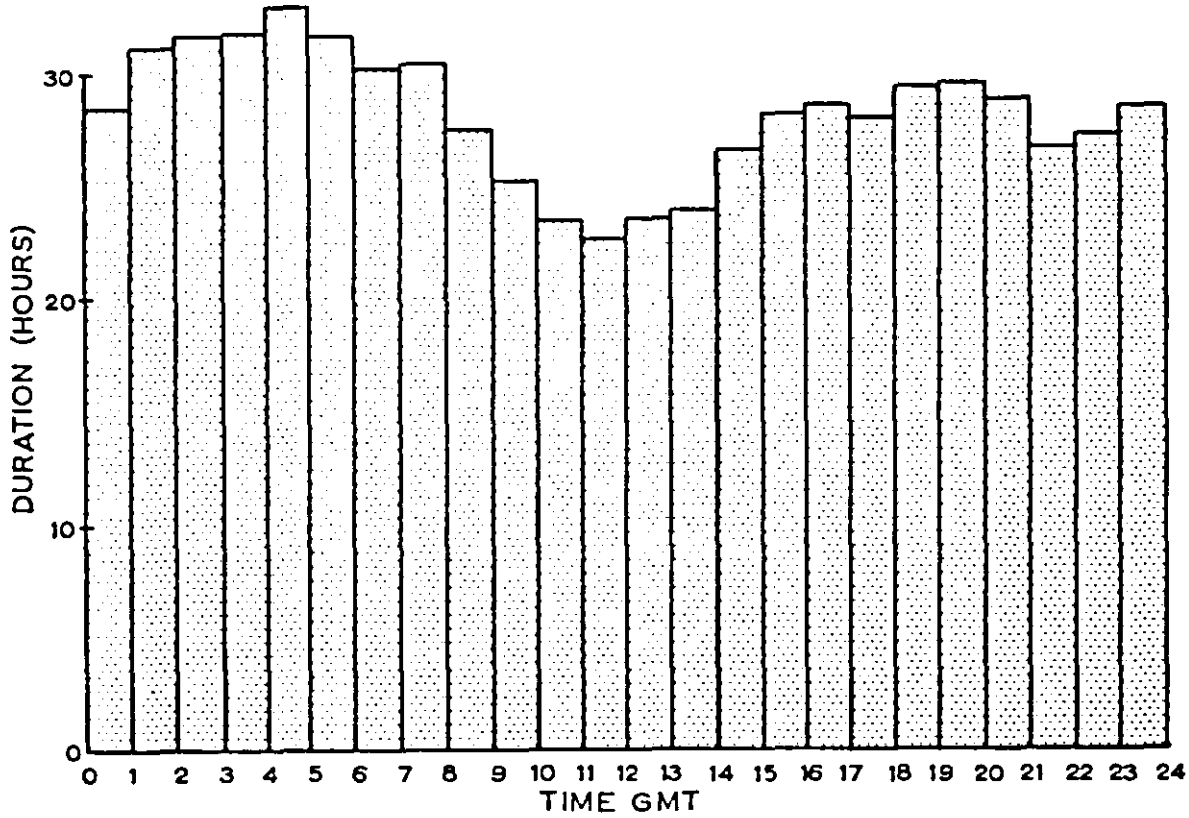


Fig. 12 Mean annual duration of rainfall between exact hours at Shannon Airport over the period January 1948 to December 1963 (inclusive).

and again between 1500 and 1600. Maximum values of total duration occur between 0400 and 0500 and between 1900 and 2000 and minimum values of total duration occur between 1100 and 1200 and 2100 and 2200.

Figure 13 shows the mean monthly duration of rainfall at Shannon Airport over the fifteen year period 1949 to 1963 inclusive.

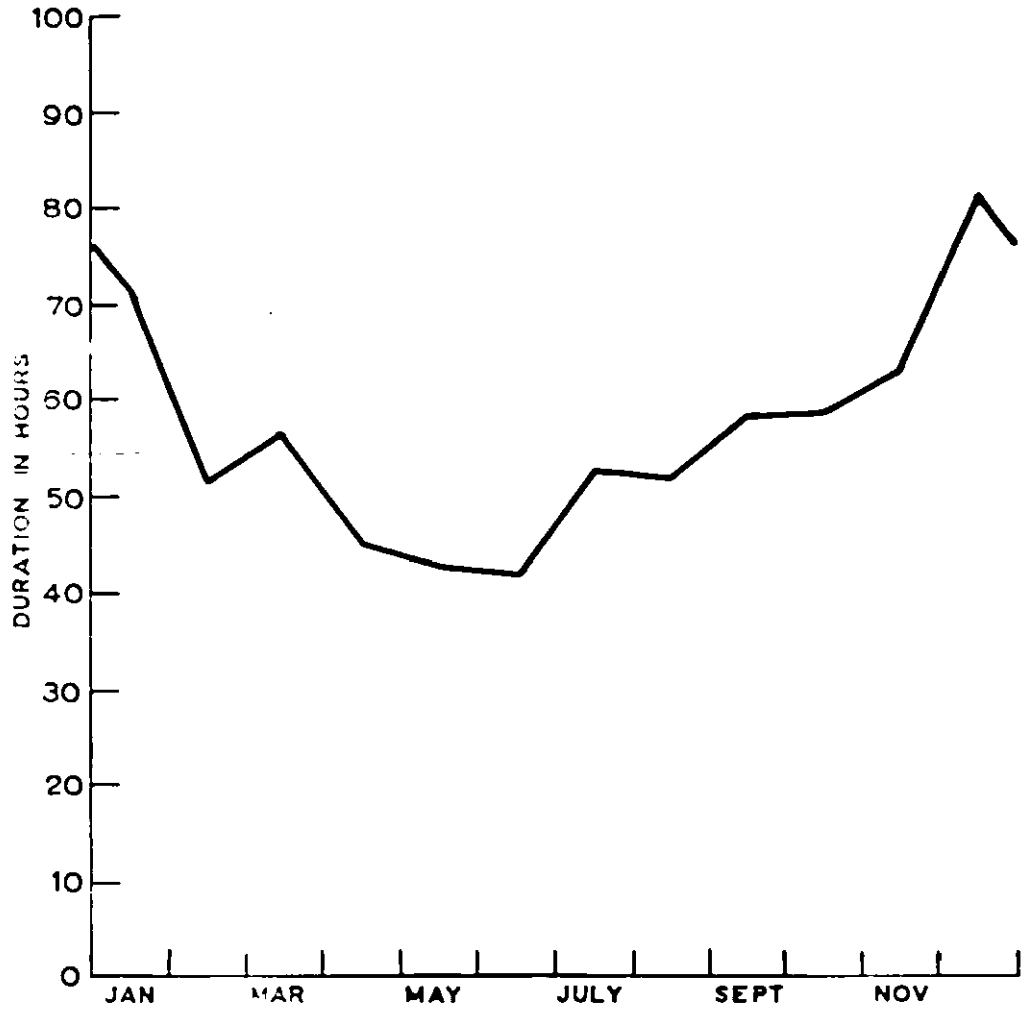


Fig. 13 Mean monthly duration (in hours) of rainfall at Shannon Airport over the period January 1949 to December 1963, inclusive.

It can be seen from Figure 13 that the popular holiday months of July and August have greater duration of rainfall than February, April, May or June, but they compare favourably in this respect with other months of the year.

4.4. Maximum amount of Rainfall in Specified Short Periods

For some purposes (e.g. hydrology) it is necessary to have information on the maximum amount of rain in a specified period less than one day. This information is only obtainable in respect of stations where rainfall is measured more frequently than once per day or is continuously recorded.

A check through the records for Shannon Airport for the period October, 1938, to October, 1958, inclusive, shows extremes over specified intervals and the time of occurrence as indicated in Table 13.

TABLE 13

Extreme values of rainfall for Shannon Airport in specified intervals in the period October, 1938, to October, 1958, inclusive

Interval	Approximate time of commencement of occurrence	Amount recorded
Wettest 24 hours	0840 on 9th November, 1941	65.5 mm.
Wettest 12 hours	2130 on 11th August, 1946	49.6 mm.
Wettest 6 hours	1445 on 26th April, 1940	39.6 mm.
Wettest 1 hour	1445 on 26th April, 1940	34.1 mm.
Wettest ½ hour	1500 on 26th April, 1940	31.6 mm.

The heavy rainfall in November, 1941 was associated with a complex low system which deepened while stationary over Ireland. A quasistationary front lying north to south near Shannon was part of a very active system. The heavy rainfall in August, 1946 was associated with an intense low moving slowly east off the south coast of Ireland. The heavy rainfall in April, 1940 was

associated with a warm moist unstable flow from the South-West. Thunderstorm activity reported at Shannon was associated with developments in this very moist air.

For figures relating to wettest (and driest) calendar months, an idea on conditions more representative of particular locations in North Munster may be got from Figure 10.

4.5. Spells of Dry and Wet Weather

For agricultural work, drainage, water supply and many outdoor activities, it is useful to have information on prolonged spells of particularly dry or wet weather. For climatological purposes, it is usual to classify such spells as follows:

Wet Spell: A period of 15 or more consecutive days on each of which 1.0 mm. or more fell.

Rain Spell: A period of 15 or more consecutive days on each of which 0.2 mm. or more fell.

Dry Spell: A period of 15 or more consecutive days to none of which is credited 1.0 mm. or more.

Absolute Drought: A period of 15 or more consecutive days to none of which is credited 0.2 mm. or more.

Partial Drought: A period of at least 29 consecutive days the mean daily rainfall of which does not exceed 0.2 mm.

Such spells are relatively infrequent in North Munster and the figures relating to Shannon for the period 1950 to 1960, as shown in Figure 14 might be typical of inland areas in North Munster.

The frequent occurrence of prolonged periods of relatively dry weather in the months of March/May is to be noted. Partial droughts are quite unusual. In 1938, very dry weather in North Munster, and particularly in the western part of it, produced a record of unusually long absolute drought which lasted 38 days in Limerick (Mulgrave St.) from April 3 to May 10. Prior to that, since records became available in Great Britain and Ireland, only one longer absolute drought had been recorded in these islands (44 days in March/April, 1893 at Towcester, Northamptonshire). In the period April 3 to May 10, 1938, no rain whatever fell in Limerick (Mulgrave St.).

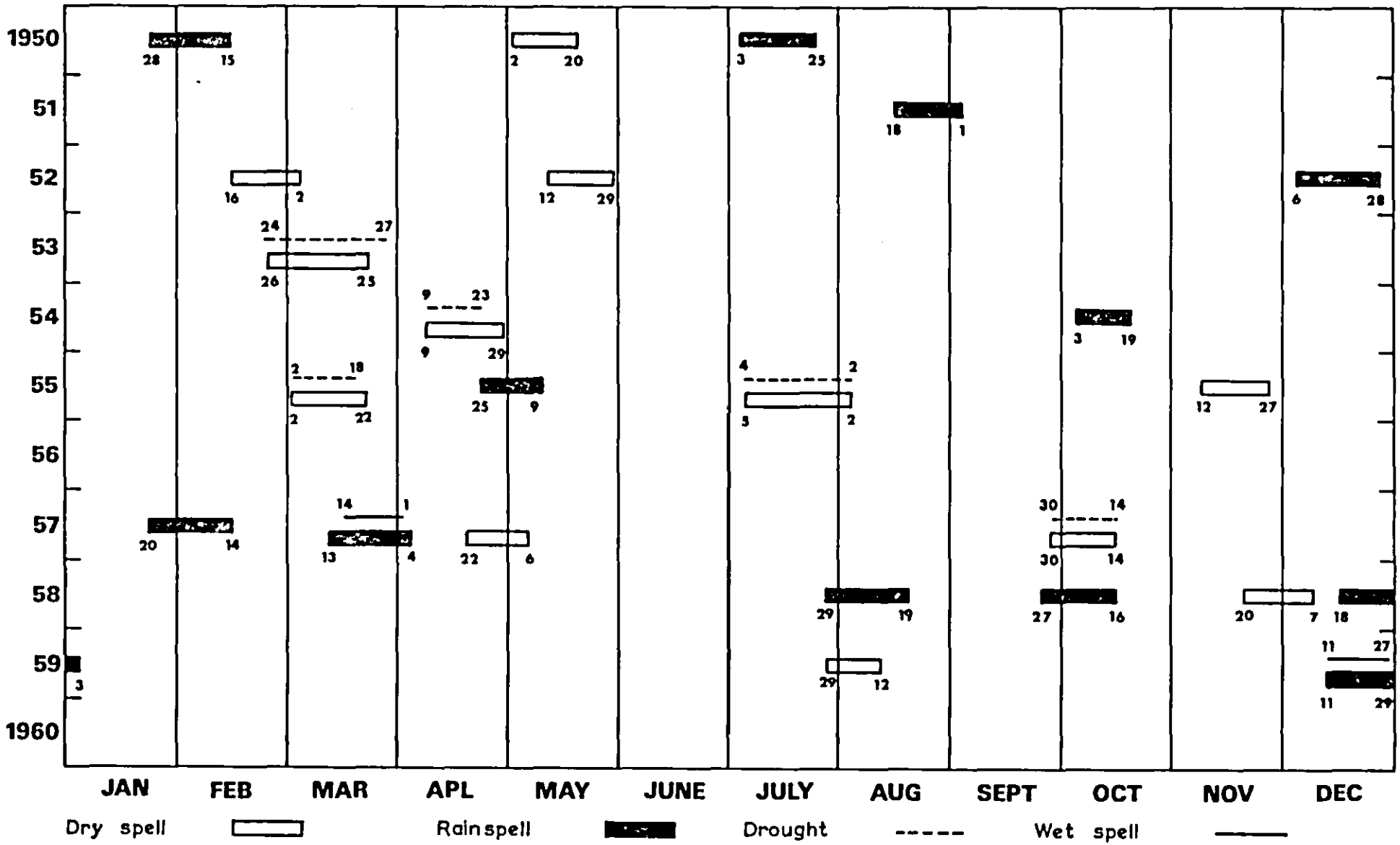


Fig. 14. Occurrence of spells of dry and wet weather at Shannon Airport in the 11 year period 1950 - 1960.

4.6. Geographical Distribution of Rainfall

The material presented thus far relates mostly to data from a selection of stations in widely representative observing locations. However, this form of presentation does not give the best indication of the local distribution of average values of rainfall. Examination of the material in Table 9 shows a wide range of average values at different stations. For example, the figures for Inagh (Mt. Callan) are considerably higher than those for other stations used in that Table. Data for a 30-year period 1931-1960 show that they are much higher than for locations even less than 20 miles away, but at a lower level. The figures for Birdhill (Parteen Weir) are noticeably different from those at Killaloe (Ballina) some 5 miles away and at a comparable level.

The distribution of rainfall over an area is influenced by a number of factors. The extent to which any of a number of factors affect local rainfall varies from place to place and from climatic zone to climatic zone.

In Ireland there is an increase of rainfall with elevation right up to the tops of mountains. Values at stations at high levels are generally higher than at lower stations. At locations on the west, SW and NW coasts rainfall is generally greater than in areas of similar elevation near the east coast. The orientation of ranges of hills in relation to prevailing winds also affect rainfall in and near hill country. Ranges of hills lying across the prevailing wind get more rain than hills of the same order of size lying along the direction of prevailing wind. While the uplift of air on the windward side of hills helps to dry out the air and increase the rainfall on the windward side of hills, the corresponding effect of this drying process does not appear noticeable from climatic records of stations immediately on the lee side of the hills. In fact the rain just to the lee of hills is sometimes noticeably high. A good example of this high rainfall is to be seen in the records of the station at Cloghane which is "sheltered" over three-quarters of the horizon by the mountains of the Dingle peninsula and yet has the highest rainfall reported in North Munster. Nevertheless, the mountains of Kerry, North Cork and North Clare in "drying out" the westerly flow contribute to the reduction of total rainfall over the eastern part of the country as compared to the western part.

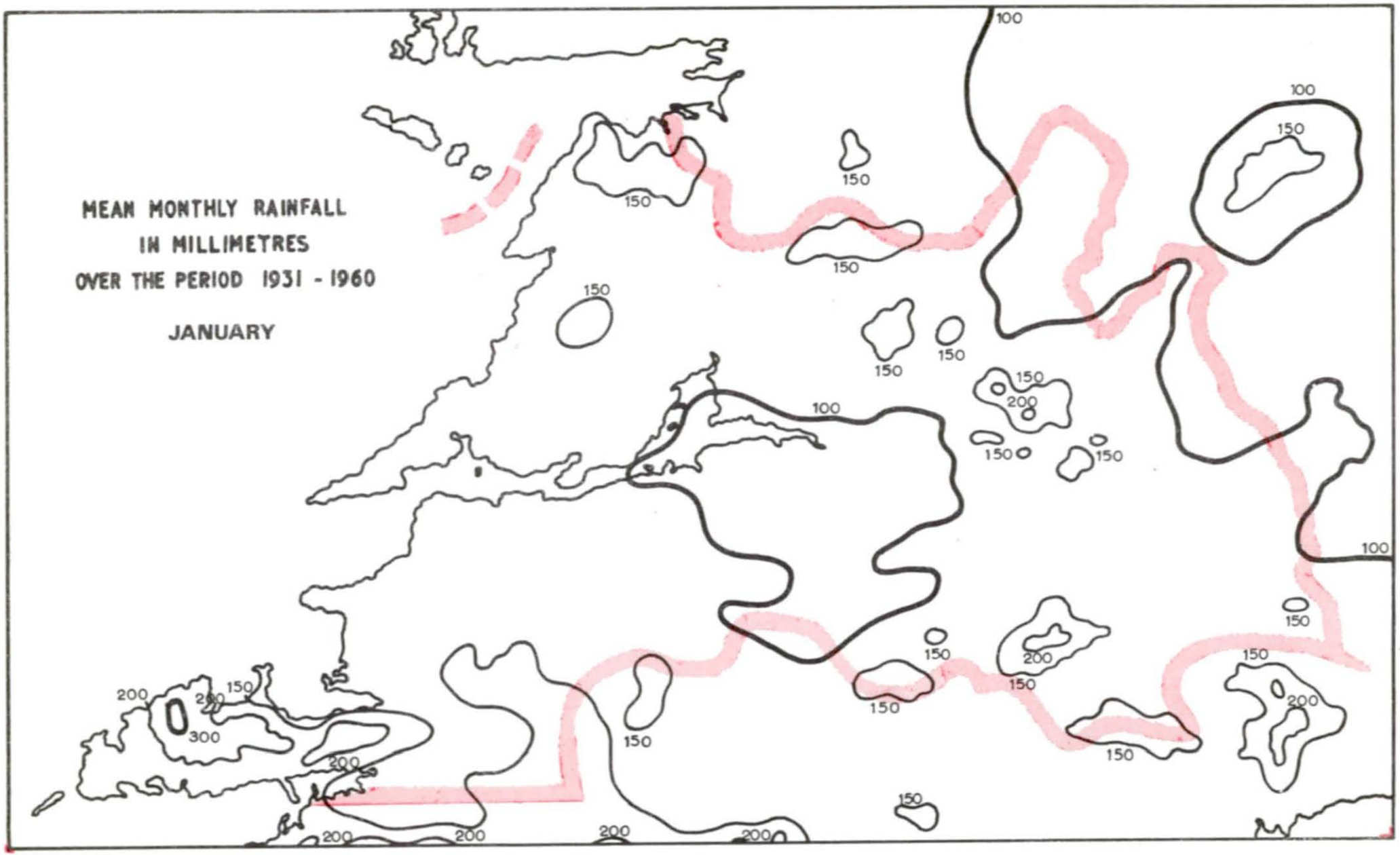

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
JANUARY
100
150
200
300

Fig. 15.

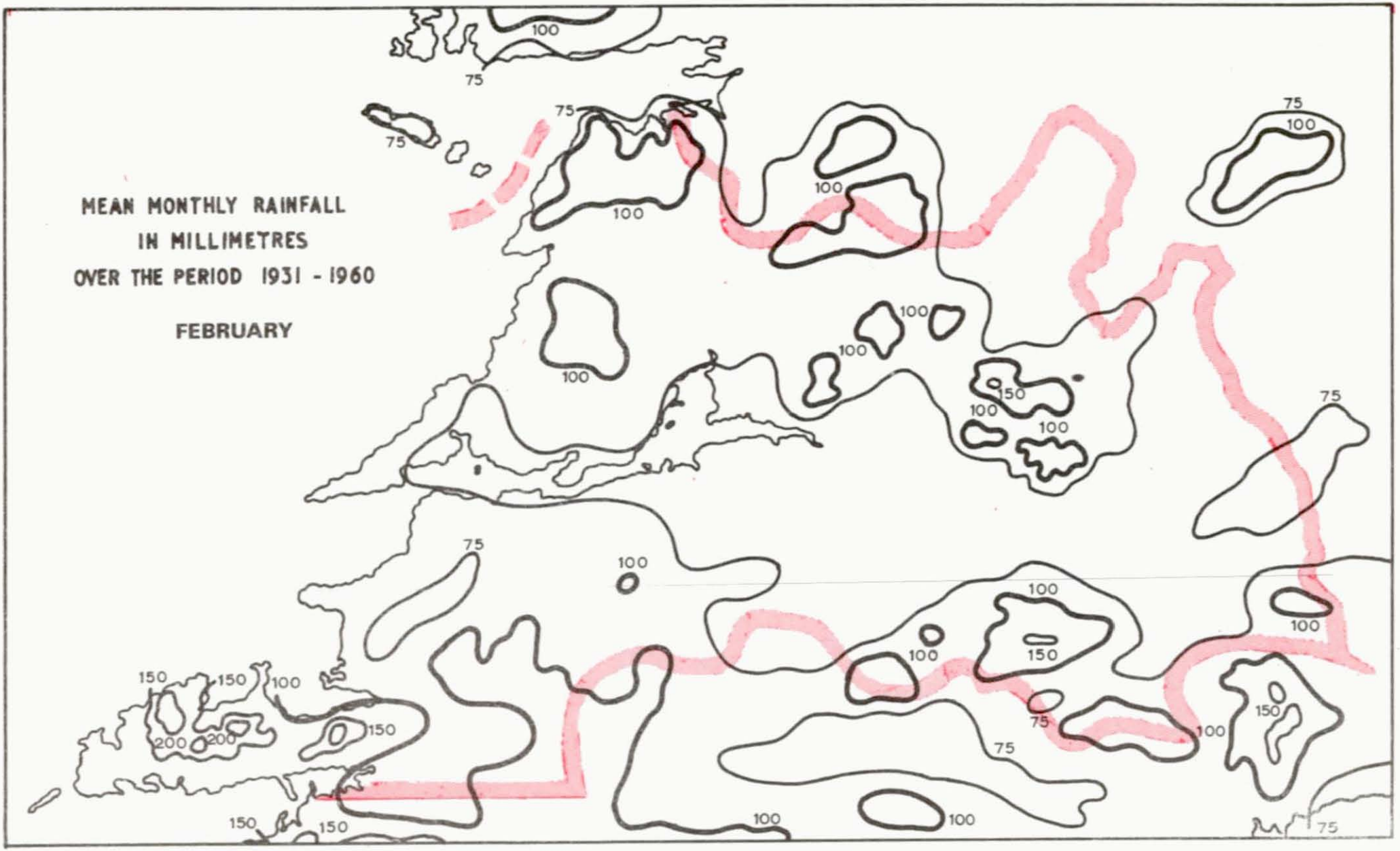

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
FEBRUARY

Fig. 16.

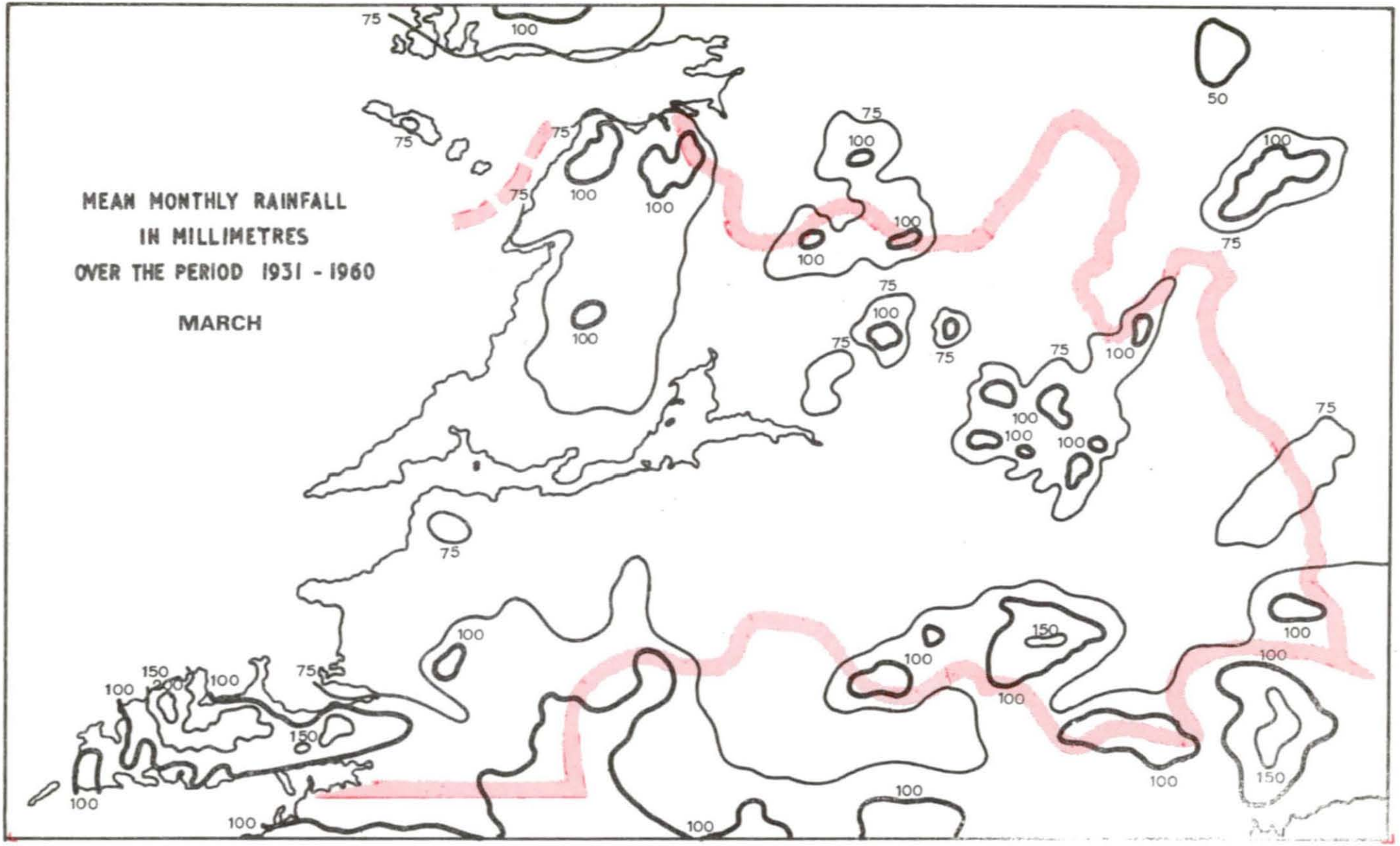

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
MARCH

Fig. 17.

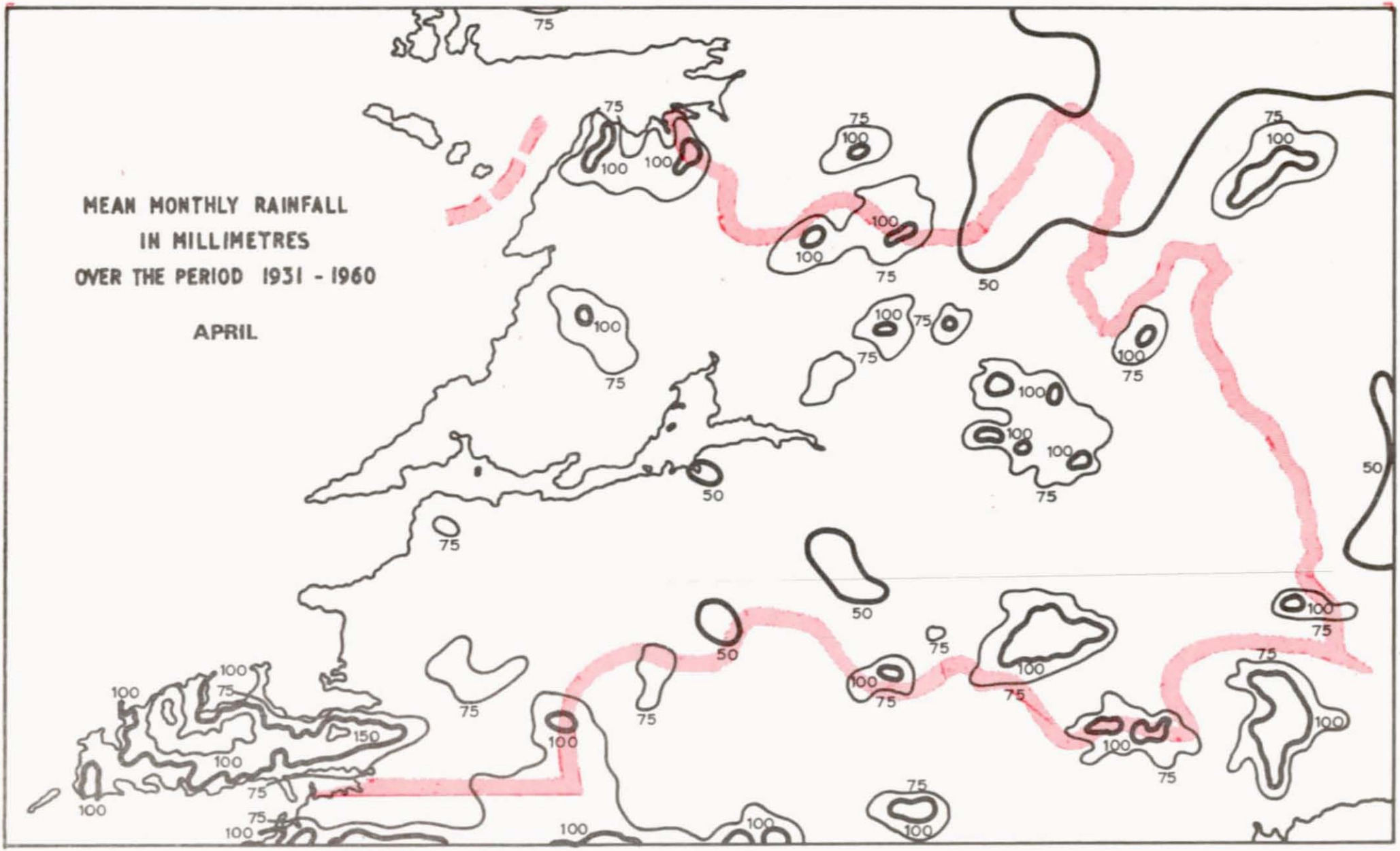

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
APRIL

Fig. 18.

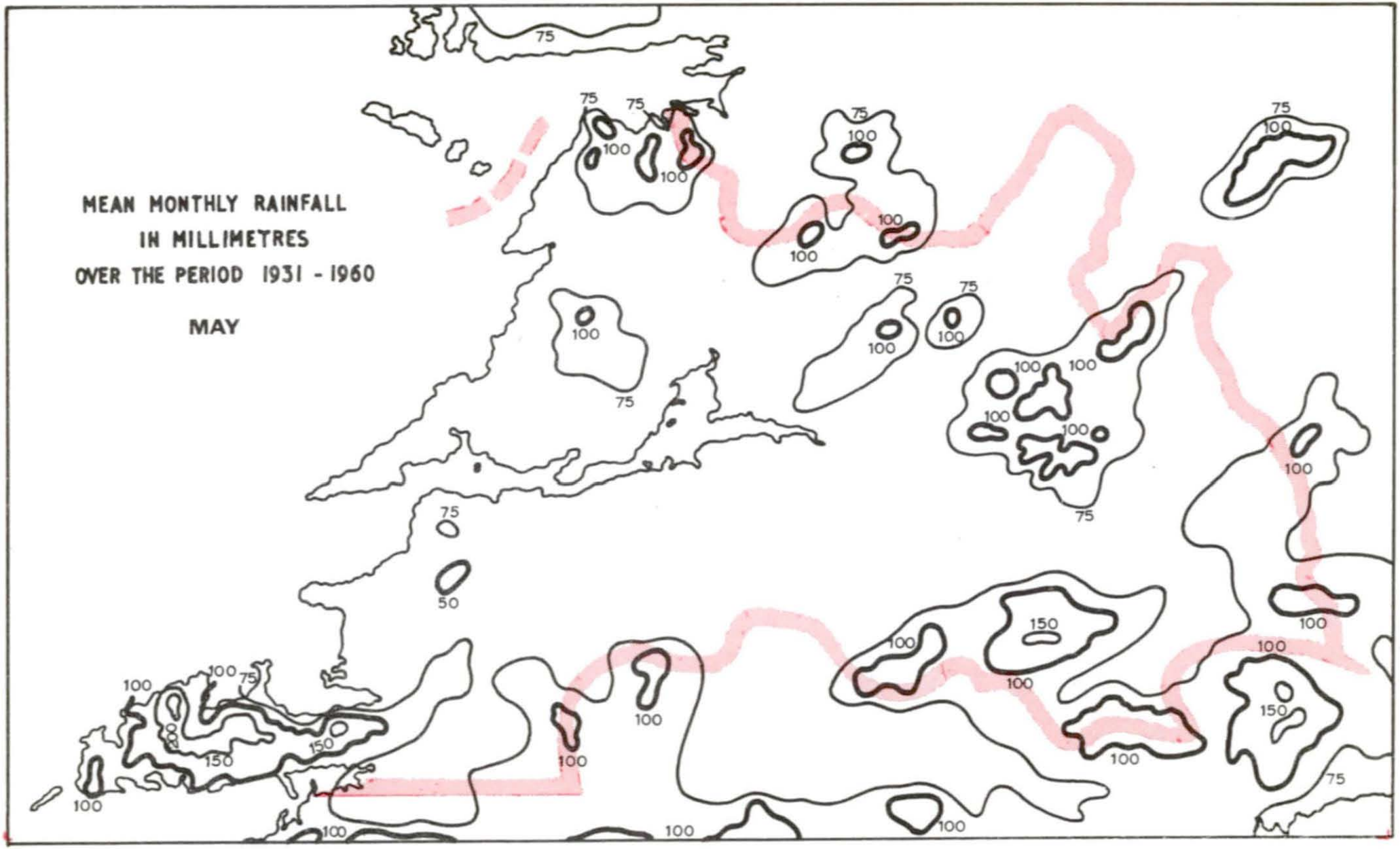

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
MAY

Fig. 19.

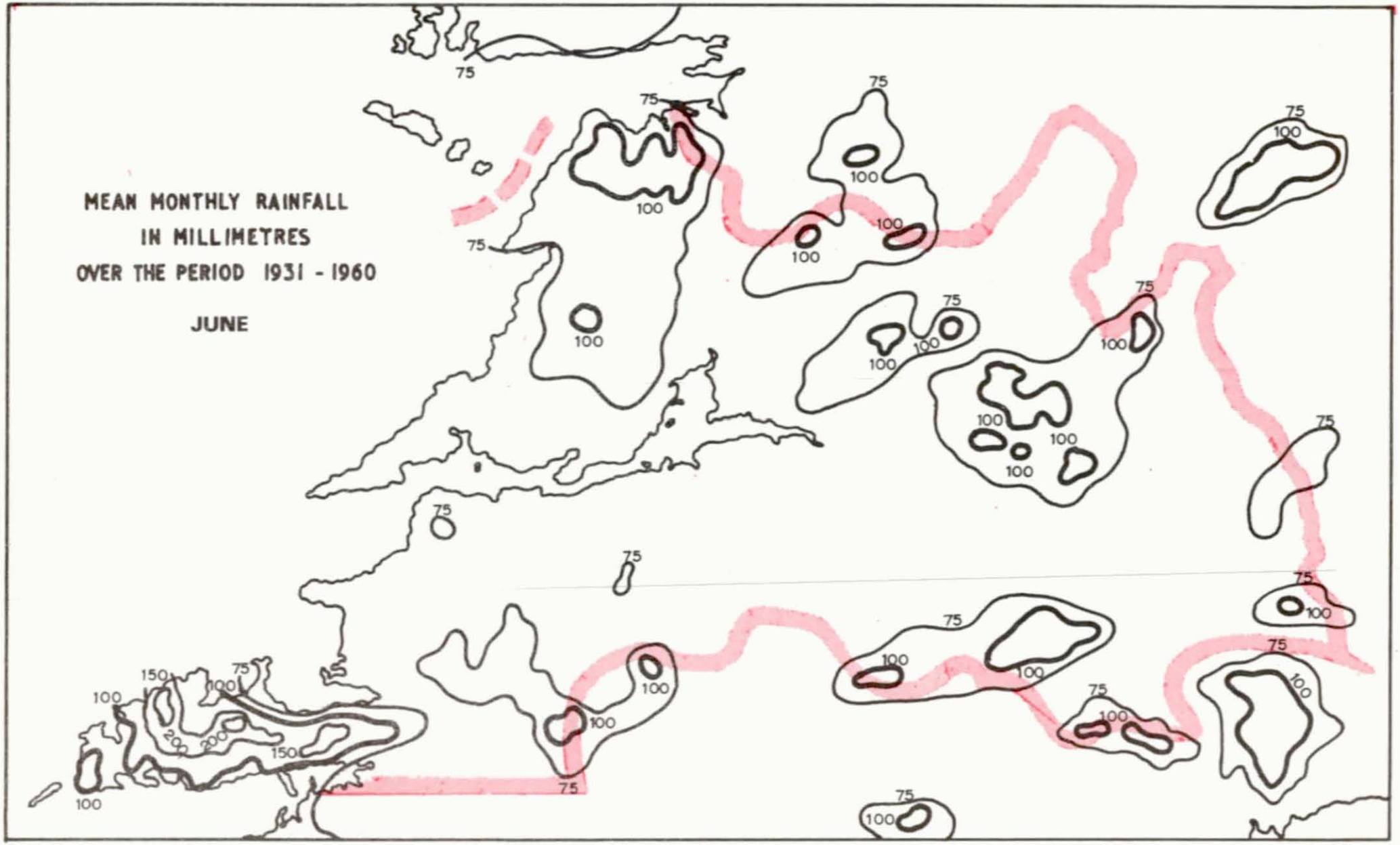

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
JUNE

Fig. 20.

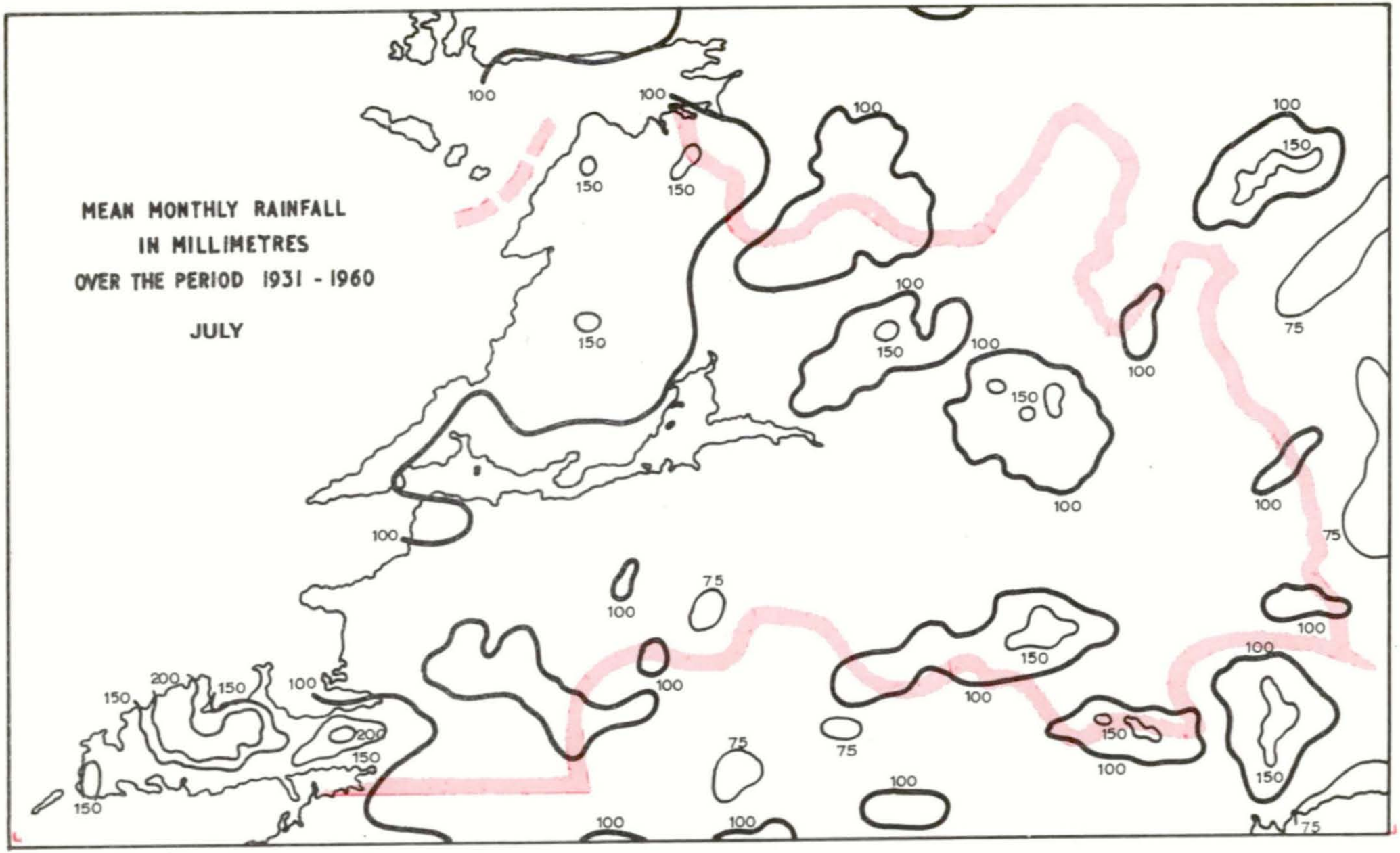

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
JULY

Fig. 21.

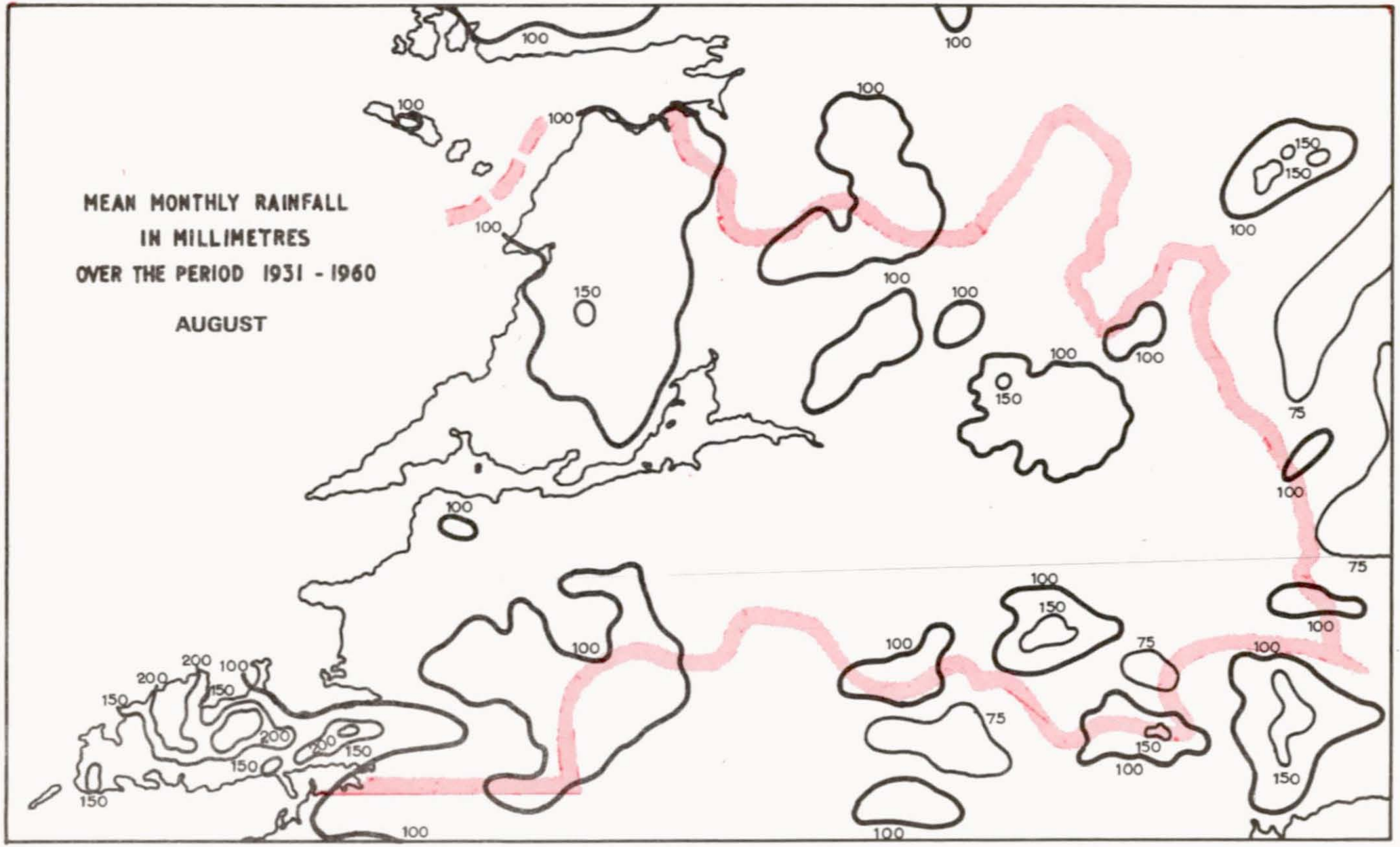

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
AUGUST

Fig. 22.

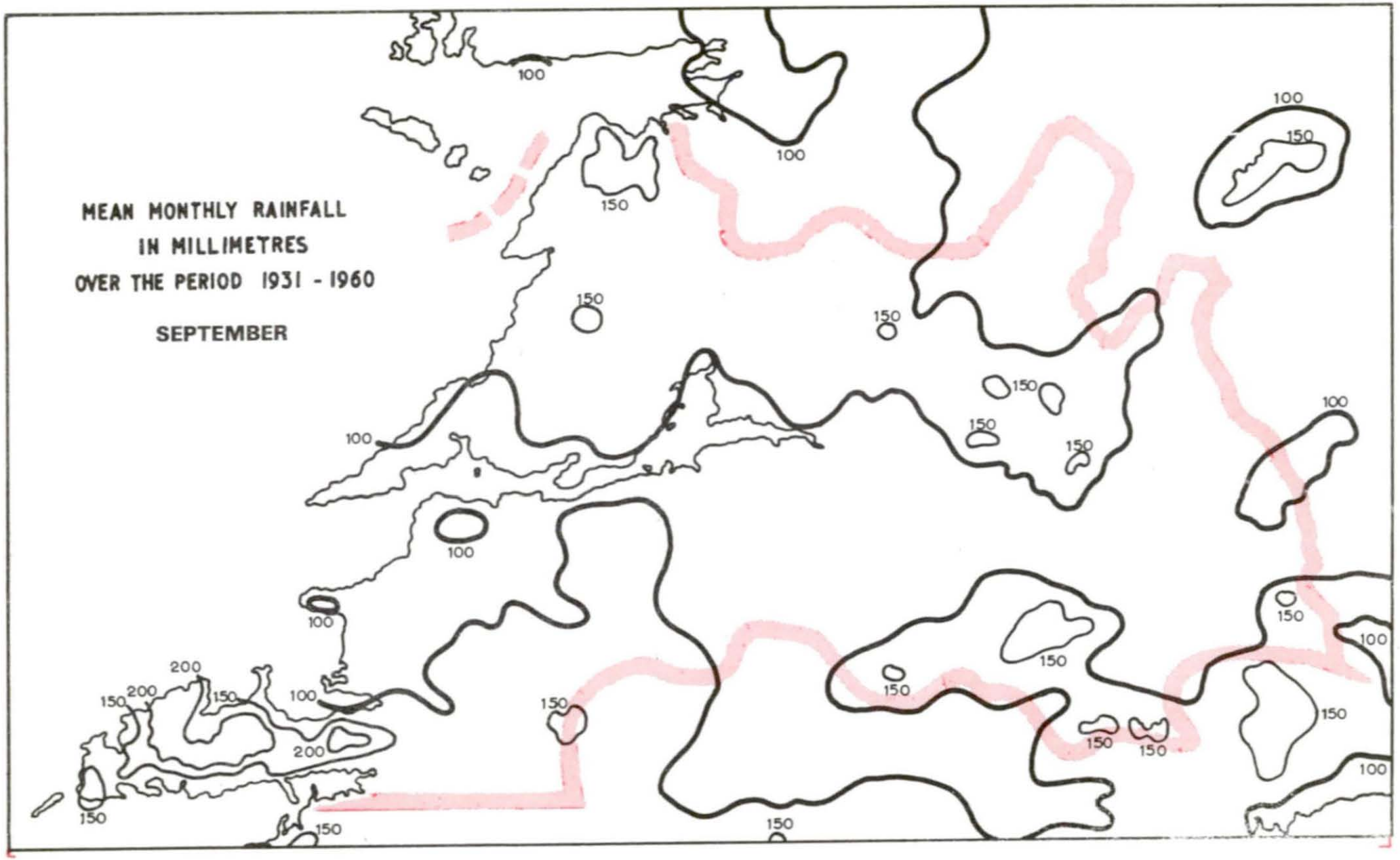

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
SEPTEMBER
100
150
200

Fig. 23.

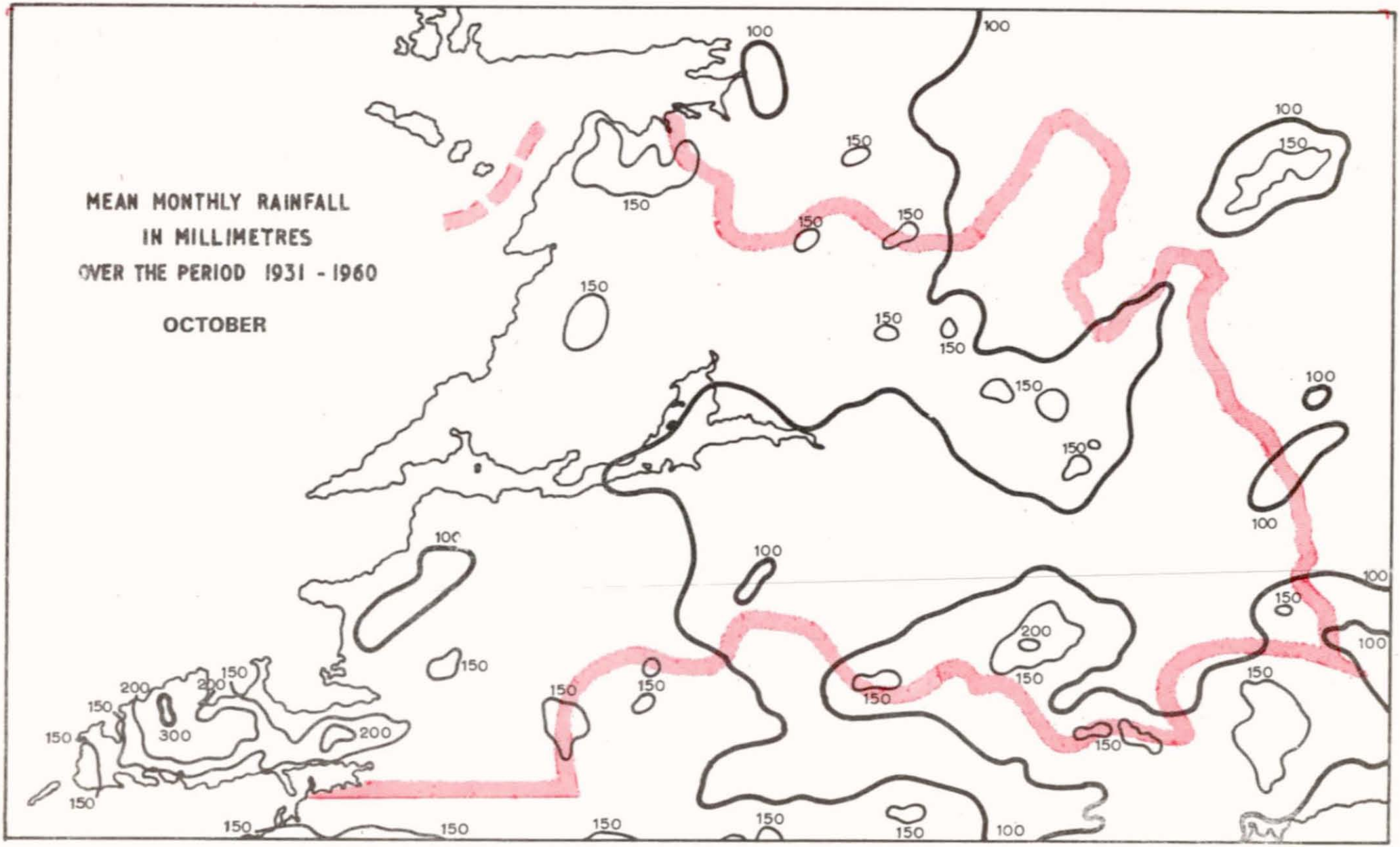

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
OCTOBER

Fig. 24.

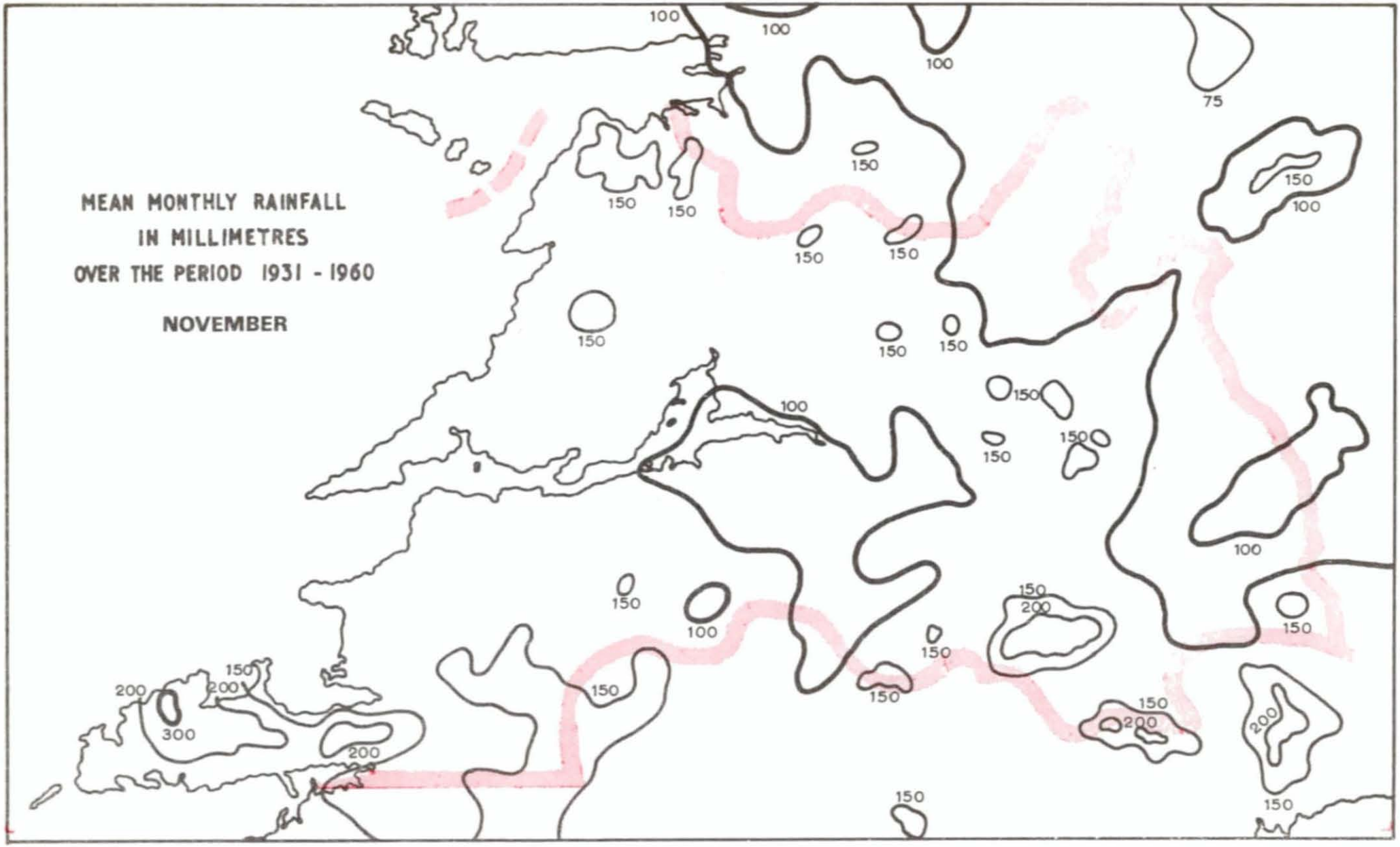

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
NOVEMBER
100
100
100
75
150
150
150
150
150
150
100
150
150
150
150
150
150
150
100
150
150
100
150
150
200
150
150
200
200
300
200
150
150
150
200
200
150
150

Fig. 25.

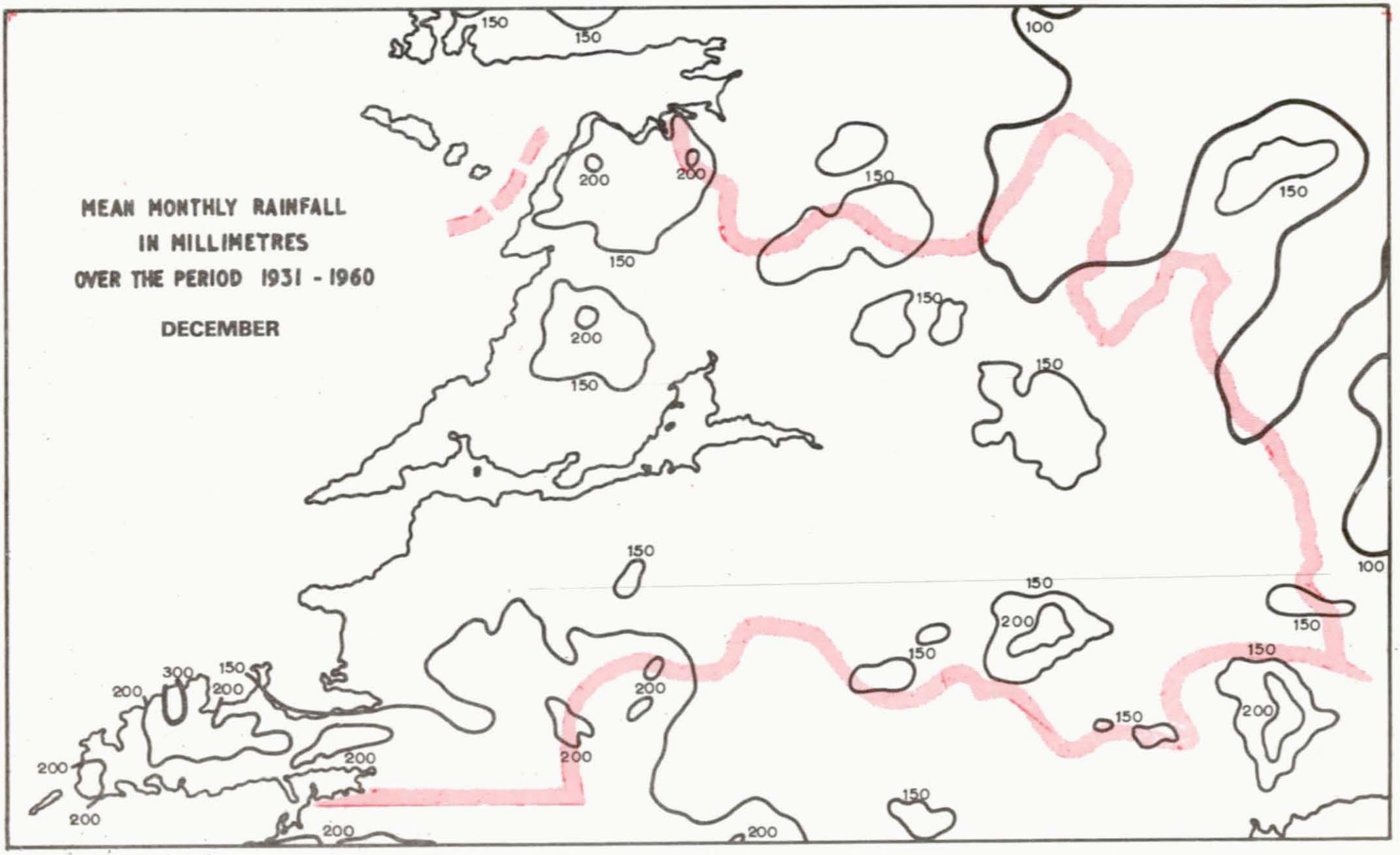

MEAN MONTHLY RAINFALL
IN MILLIMETRES
OVER THE PERIOD 1931 - 1960
DECEMBER
150
150
100
200
200
150
150
200
150
150
150
100
150
150
200
150
150
150
200
300
150
200
200
200
200
200
200
200
200
150
200

Fig. 26.

Figures 15 to 26 show the average monthly rainfall for each month of the year over North Munster for the period 1931 to 1960 and are derived from charts prepared by the Irish Meteorological Service. They are based on the analysis of records for 167 stations in North Munster and the stations in adjoining counties. The records from Cloghane just to the north east of Brandon Mountain with an annual average rainfall of 2186 mm. over the 30 years give the highest average rainfall for each of the twelve months. Although this stations is near to sea-level and sheltered from the prevailing wind, the high rainfall is very localised and results from the influence of Mount Brandon (3,127 ft.). Other locations with conspicuously high values are Bansha (Aherlow Waterworks), Silvermine Mountains (Curreeny) in Tipperary and Inagh (Mount Callan) in Co. Clare, all of which, in hill districts, are influenced by particular hills and have an annual average rainfall of over 1500 mm. In general the effect of high ground - even of the order of 500 feet above sea-level - is well marked in the distribution of rainfall in North Munster. Areas of consistently low rainfall are the low-level land in the middle of Co. Limerick and across the Shannon to Shannon Airport in Co. Clare. The lowest rainfall in Tipperary is generally in the part of the county to the north and north-west of Nenagh towards Lough Derg. There is another area of low rainfall from north-east of Thurles along the Suir catchment area to the foothills of the Galtee Mountains.

In January, the rainfall average exceeds 100 mm. at all stations in North Kerry and Clare with the exception of Shannon Airport and in high ground in Limerick and Tipperary.

The February averages show a marked reduction in all areas from those of January. All areas except the mountain districts have less than 100 mm. and a considerable part of the area averages less than 75 mm. in the month.

In March the 30-year averages show somewhat similar rain distribution to those of February with slightly less rain in West Limerick, Clare and North Kerry.

April is the only month where substantial areas had average rainfall less than 50 mm. in the 30-year period and almost the entire area below 500 feet elevation had average less than 75 mms. A considerable number of the stations averaging between 50 and 75 mm. for April had figures in the fifties rather than sixties of millimetres.

May shows, in general, slightly higher averages at individual stations than April except in the particular cases of the areas around Killorglin in Kerry and Inagh in Co. Clare, where the May averages are marginally lower than those of April.

The more extensive area of average rainfall in excess of 75 mm. in Co. Clare is a noticeable feature of the June pattern compared with May. Rainfall averages from other parts of North Munster were in general lower than for May.

The average rainfall in July is much higher than the June figures at all stations. In some cases the increase is 30 mm.

In August, most high land has an average of over 100 mm. rainfall.

September brings an average of 100 mm. or more of rainfall in almost all locations in Clare and on high ground elsewhere in North Munster.

October has slightly less rainfall than September at a number of stations in Clare, Tipperary and Limerick, while at others it has slightly more. North Kerry gets, in general, slightly more rainfall in October than September.

November, with a day less than October, shows a slight general increase of rain over October, though a small number of stations in North Clare and North Tipperary shows less average rainfall in November than in October.

December is the wettest month in the area and averages well over 100 mm. of rain are shown in the records of most stations. In fact, few stations average less than 100 mm. of rain in December over the 30-year period examined. The exceptions were in the extreme North of Tipperary and one small area in Co. Limerick (Croom).

CHAPTER 5

SNOW, HAIL AND THUNDERSTORMS

5.1. General

In the previous chapter precipitation in all forms was considered from the point of view of the contribution to total deposit of water from the atmosphere on the surface of the earth in particular locations, or over the entire area in specified periods.

Although precipitation in frozen form (snow or hail) or precipitation accompanied by thunder is relatively infrequent in Ireland, the importance of some such occurrences is very great. Snow has on occasions caused almost complete disruption of transport and seriously affected power and communication lines. Hail can, on occasions, cause serious damage to crops if it occurs at a critical time.

Thunderstorms cause some loss of life in Ireland almost every year and, in addition, cause damage to property and loss of livestock. Local flooding also results at times from the intense rain in a short period associated with thunderstorms.

5.2. Snow

Snowfall at sea-level over North Munster seldom persists on the ground for more than a day or so. In most cases it lasts only for a few hours and in many cases the snow melts almost as rapidly as it falls. This is particularly true in coastal areas where frost temperatures in showery or frontal conditions are relatively rare. On low ground snow rarely persists for more than a few hours when it falls after mid-March, due to ground warming. As one goes to higher ground with lower temperatures and more precipitation the incidence and duration of snow increases rapidly. In the higher reaches of the Galtee, Silvermine, Slieve Bloom Mountains and mountains of the Dingle Peninsula, snow drifts lie for prolonged periods in most years. Terrain factors such as aspect, slope, shelter or exposure have an influence on the duration and severity of snow in all districts.

The variation of duration or intensity of snow from North to South in an area the size of Munster is very little and would be completely masked by the greater effects of difference in altitude. Insofar as variation from east to west is concerned, the effects of continentality, which is greater in the east than the west, with lower temperatures in the winter, should give more frequent snow type showers or frontal precipitation in the east, where the snow will remain on the ground

longer. On the other hand, probably due to more marked horizontal temperature gradient at low temperatures, cold spells in severe winters are often accompanied by heavy snowfalls in the west.

An interesting example of severe snow in North Munster was experienced in February, 1933, when snow fell over Ireland for more than 24 hours commencing on the evening of 23rd February.

The snow was associated with a cold low (non-frontal) and main roads in North Munster were impassable for a period of one to three days, while many villages were isolated for a period of up to a week.

The amount of snow and number of days with snow vary from year to year, as is common in most countries where snow is experienced. The figures for number of days with snow over a 10-year period 1951-1960 at locations at low levels in or near North Munster are given in Table 14.

TABLE 14

Number of days with snow in the years 1951-1960 at four stations at low levels

Station	Year										Total
	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	
Shannon Airport	23	16	3	14	15	17	5	12	5	15	125
Birr	15	20	2	13	24	16	8	16	6	16	136
Valentia	9	9	2	9	11	5	1	10	2	9	67
Mallow *	13	13	2	8	N.A.	4	1	5	1	4	51*

* Mallow total for 9 years

The figures in Table 14 include all days when snow was recorded and include some days with only very light snow flurries. In most cases the snow did not last long on the ground. Examination of records from which the figures in Table 14 were extracted show that snow was reported over half the ground representative of the station at the morning observation (0900) on much fewer days than snow was reported.

There was no report of snow lying on the ground from any of these stations in the months of April to October, 1951/60 inclusive. Indeed, snow was not reported as occurring in the months June to October, inclusive, and was very rare in May or November. In March and November it was rarely reported as lying at 0900 (a total of 2 occasions at Birr). Mallow, Birr, Shannon and Valentia is the order in which numbers of cases of snow lying on the ground at other months in the period were reported.

5.3. Hail

Hail occurs in North Munster usually associated with the invasion of cold, unstable air from the Atlantic. It is very rarely as severe as the hail encountered in continental climates with disastrous consequences to fruit-growers. Hail is more frequent in Winter than in Summer and large hail stones are unusual.

Table 15 gives the mean number of days with hail in each month of the year over the period 1948-1960, inclusive, at Shannon Airport.

TABLE 15

Mean number of days with Hail at Shannon Airport in the period 1948-1960, inclusive

	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean No. of Days	4	3	1	3	0.7	0.2	0.0	0.0	0.2	0.9	1	5

These figures are probably fairly representative of conditions in level country in the area under study. Over high ground it is probable that occurrences are more frequent.

5.4. Thunder

Examination of records of thunderstorms over long periods suggests that the most frequent areas of occurrence of thunder in Ireland is in the North-West of the midland area, where an average of about 10 storms a year occur. In North Munster the occurrences average about 6 per year and they are somewhat less frequent on the coast. Much of the thunder in the west of Ireland is associated with cold front activity rather than with afternoon convection

which is a distinctive feature of the thunder regime in other parts of the world. Consequently, the annual variation of occurrence of thunder does not show a well-defined pattern such as is experienced in many areas with a warm moist climate.

Table 16 shows the mean number of days when thunder was heard at Shannon Airport over a period of 13 years.

TABLE 16

Mean number of days with Thunder at Shannon Airport in the period 1948-1960, inclusive

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean No. of Days	0.8	0.5	0.3	0.6	0.5	0.4	0.5	0.8	0.5	0.2	0.2	0.9

Variation in occurrence of thunder over Ireland is possibly greater than suggested in the introductory remarks above and the figures in Table 16 should be regarded as no more than a sample of experience at one station near sea level in North Munster.

CHAPTER 6

SURFACE WIND

6.1. General

North Munster being on the western seaboard of Europe close to the more common tracks of depressions across the Atlantic Ocean, experiences a greater frequency of moderate, fresh or strong winds than most land areas.

The wind regime at any location is influenced by a number of factors including local sheltering, height above surrounding country, the nature of the terrain and its effect on surface friction, and local convergence. In the case of hills, the actual shape of the hill has influence on the speed.

6.2. Measurement of Surface Wind

The speed of surface wind can be reliably estimated by a human observer observing its effects on the sea surface or on moveable objects on land (flags, tree branches, etc.).

Instruments were developed by Robinson (an Irishman) towards the middle of the last century and the rotating Robinson's Cup anemometers can still be seen at a number of locations in Ireland. Modified Robinson Cup anemometers are still the standard instruments in many parts of the world.

In the Irish Meteorological Service they have been largely replaced by pressure tube anemographs which measure continuously the speed and direction of the wind (see Appendix) at an effective height of 10 metres.

The only location where a standard pressure tube anemometer is exposed in North Munster is at Shannon Airport. Standard instruments are also installed at Birr and Valentia which are just outside the area. A similar installation was maintained on Foynes Island between 1940 and 1946. It had the distinction of recording a gust of at least 98 knots in 1945, which is the highest wind speed recorded from an exposure which was near to the level of open country in Ireland. The exact value of the gust is not known as the recording pen actually went beyond the upper edge of the chart which provided a record up to 98 knots. A velocity unit of a pressure tube anemometer was maintained in Quilty, Co. Clare, from 1911 to 1961. It was installed to give warning of excessive wind on an exposed section of a narrow-gauge railway. The bore of the tube from the orifice was $\frac{1}{2}$-inch diameter as against the one-inch

diameter tube in the standard instrument. Such an instrument had a greater risk of being influenced by the effect of lag in transmitting air pressure. Nevertheless, it experienced a gust in January, 1920, in which the instrument pen went beyond the upper edge of the chart at 97 knots.

The speed of wind for general (synoptic) purposes is determined by taking a mean over a period of 10 minutes while peak gusts are noted when there is an increase of 10 knots or more over the mean wind and lasting for a short period.

6.5. Frequency of winds of different direction and force

Table 17 gives a summary of the annual mean number of occurrences of concurrent wind speed and direction at the surface over a 10-year period for Shannon Airport.

TABLE 17

Annual Mean Number of Occurrences of Concurrent Wind Speed (in Knots) and Direction at the Surface at Three-Hourly Intervals over a ten-year period (1948-1957) at Shannon Airport

Speed / Direction	Less Than 1	1 to 3	4 to 6	7 to 10	11 to 16	17 to 21	22 to 27	28 to 33	34 to 40	41 to 47	Over 47
N		17.5	38.9	49.3	25.5	4.6	1.6	0.7			
NNE		9.5	21.6	27.4	17.2	2.4	0.6				
NE		12.1	25.5	30.1	22.2	2.7	1.3	0.1			
ENE		9.1	14.6	14.8	11.0	2.2	0.8	0.2			
E		12.6	20.5	27.4	26.2	6.7	1.4	0.2			
ESE		12.1	43.1	60.2	41.4	11.8	4.9	0.5			
SE		16.3	40.4	63.1	63.4	25.6	11.9	2.3	0.3		
SSE		11.7	18.7	50.7	80.6	33.4	13.0	2.8	0.3	0.1	
S		10.8	26.5	56.0	79.7	28.7	11.0	3.1	0.5		
SSW		9.5	24.1	47.1	48.8	16.5	4.9	1.0	0.1	0.1	
SW		9.8	30.4	58.2	78.4	36.8	15.2	2.7	0.8	0.1	
WSW		8.1	32.4	68.2	96.5	42.3	18.7	6.0	1.2	0.2	
W		9.5	43.3	81.3	100.8	41.2	17.1	5.4	1.1	0.2	
WNW		11.6	40.6	68.0	78.7	32.6	11.8	3.8	0.6	0.1	
NW		16.4	39.1	61.5	60.8	23.4	8.5	1.2	0.2		
NNW		14.7	42.6	48.6	25.6	7.2	2.3	0.6			
Calm	80.8										
TOTAL	80.8	191.3	502.0	811.9	856.8	318.1	125.0	30.6	5.1	0.8	

It can be seen that the most common direction of wind over the whole year is from west (on a 16-point compass), the modal velocity is in the 11 to 16 knot range and that only 2.8% of the observations show calm conditions. The annual percentage frequency of wind direction over the same period is shown in diagram form in Figure 27 using an 8-point compass.

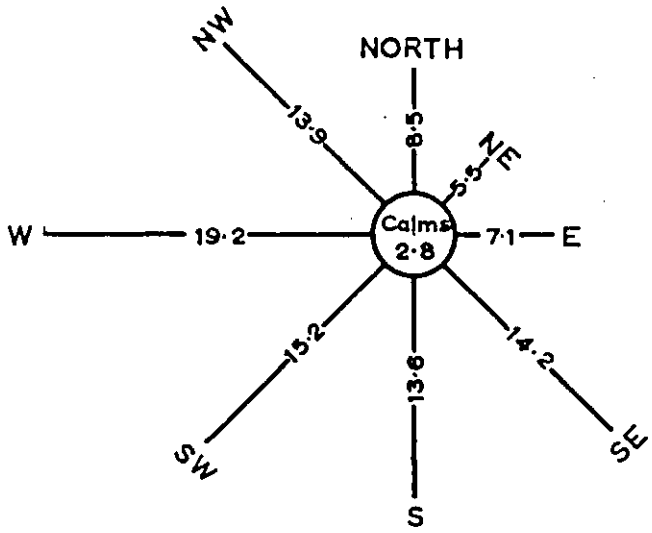


Fig. 27. Percentage frequency of wind directions over the period 1948 - 57 (Shannon Airport)

The pattern is broadly similar to that of other stations near the eastern seaboard of the North Atlantic in middle latitudes. The relative infrequency of south wind to SE and SW at Shannon Airport is possibly in part due to the sheltering effect of the high ground of West Limerick, East Cork and North Kerry.

The records for Shannon Airport which is located in very level terrain near sea-level with no very high ground or local obstacles in the immediate neighbourhood, might nevertheless be regarded as representative of conditions in unsheltered, level areas in North Mumster.

Table 18 shows maximum speeds recorded in gusts at a number of different locations in Ireland and over specified periods. It is probably coincidental that the two highest values of velocity in a gust were recorded in North Munster. The record wind speeds reported from a number of stations on 16th September, 1961 were associated with a tropical storm "Debbie" which passed Northwards along the west coast of Ireland on that day.

For heights other than the standard 10 metres, the influences of boundary layer effects near the earth's surface would give appreciably different results at other levels. At levels nearer the ground the velocities would tend to be less and direction of wind would tend to back while at levels above 10 metres the wind tends to be stronger on average.

6.4. Diurnal Variation of Wind Velocity

The velocity of the winds at Shannon Airport shows an interesting diurnal variation when hourly values are averaged over a period of years. Figure 28 shows the average mean windspeed at each hour over a ten-year period.

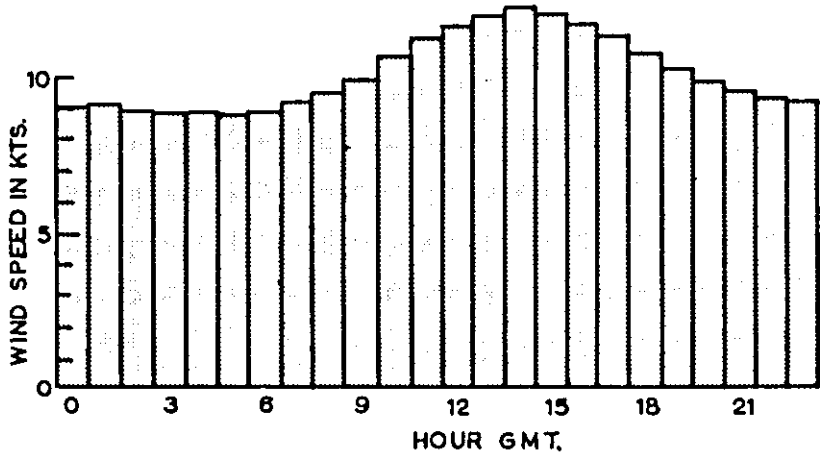


Fig. 28. Mean wind speed at each hour of the day averaged over the 10 year period 1951 - 1960.

TABLE 18

Maximum Wind Speed in a gust (with direction at the time) recorded at effective heights of approximately 10 metres at specified stations over particular periods

Station	Wind		Date of Occurrence	Period of Record
	Speed	Direction		
	kts.	o		
Belmullet, Co. Mayo	94	215	31. 1.1957	16. 9.56 to 31.12.61
Birr, Co. Offaly	81	200	16. 9.1961	1.10.54 to 31.12.61
Claremorris, Co. Mayo	91	225	16. 9.1961	13.11.43 to 31.12.61
Clones, Co. Monaghan	87	195	16. 9.1961	6. 1.50 to 31.12.61
Cork Airport	66	200	22.10.1961	18.10.61 to 31.12.61
Dublin Airport	73 73	200) 240)	4. 2.1957) 22.10.1961)	4. 2.44 to 31.12.61
Glenamoy, Co. Mayo	85	240	16. 9.1961	1. 5.58 to 31.12.61
Kilkenny, Co. Kilkenny	74	215	22.10.1961	1. 6.57 to 31.12.61
Malin Head, Co. Donegal	98	205	16. 9.1961	1. 5.55 to 31.12.61
Mullingar, Co. Westmeath	79	220	16. 9.1961	21. 2.44 to 31.12.61
Quilty, Co. Clare	97*	N/A	27. 1.1920	3. 1.11 to 31. 1.61
Roche's Point, Co. Cork	91	180	4. 2.1957	1. 3.05 to 8. 1.14) 1.12.55 to 31.12.61)
Rosslare, Co. Wexford	87	190	22.10.1961	1.12.56 to 31.12.61
Shannon Airport (Foynes), Co. Limerick	98*	275	18. 1.1945	1. 1.40 to 31. 5.46
Shannon Airport (Rineanna), Co. Clare	93	195	16. 9.1961	31.12.39 to 31.12.61
Valentia Observatory, Co. Kerry	88	235	16. 9.1961	1.12.16 to 31.12.61

N/A indicates value not available. * Exact value not known. Instrument pen went beyond the upper edge of the chart.

The minimum velocity is on average at 0500 but there is very little difference between the averages for 0200 to 0600, inclusive. After 0600 there is a gradually increasing rise of average velocity associated with the increase of turbulent flow in the very low layers with the onset of diurnal heating the rate of increase reaches a maximum between 0900 and 1000. The increase tapers off on approaching the diurnal maximum velocity about 1400 G.M.T. after which the average shows a smooth fall with time until midnight.

The diurnal range of over 3 knots is interesting in a climate where surface heating does not reach great intensity.

CHAPTER 7

EVAPORATION AND HUMIDITY

7.1. General

Water vapour in the atmosphere is supplied mainly by evaporation from the ocean and, to a lesser extent, from lakes and rivers. Some moisture gets into the atmosphere by transpiration from vegetable life. The amount of water evaporated into the atmosphere at any place depends on the availability of the source of water, the surface heating and air temperature and the actual movement of the lower layers of the atmosphere.

The west of Ireland being on the edge of the Atlantic Ocean and with prevailing westerly winds, should have, in general, rather high water vapour content in the air at any temperature.

Evaporation is influenced by the temperature regime which, in Ireland has a relatively small diurnal and annual variation. Evaporation is, of course, also influenced by the moisture content already in the atmosphere.

Evapotranspiration, which is the **total** water vapour evaporated by both soil and plants at **existing** moisture content, although a relatively small contributor to the humidity of the atmosphere, is an important factor in water run-off and in agriculture and has in recent years been receiving increasing attention.

7.2. Methods of Measurement

Evaporation measurements are made directly in three different ways -

(a) by measuring change of weight in a sample of soil;

(b) by measuring loss of water from a wetted porous surface;

(c) by direct observation of change of level in a large tank or pan.

None of the three methods gives very satisfactory measure of evaporation in natural conditions.

Evapotranspiration and potential evapotranspiration are usually calculated from formulae involving the prevailing atmospheric humidity, wind and temperature.

There are numerous ways of expressing the amount of water vapour in a given sample of air. One of the more common measures for meteorological purposes is the relative humidity. The relative humidity is the percentage saturation of the atmosphere.

Relative humidity is normally calculated from readings of a dry bulb and a wet bulb thermometer. It is also measured by the use of a hair hygrograph, the sensitive element of which stretches or contracts with variation in relative humidity.

7.3. Evaporation

Evaporation measurements have been taken at Ardnacrusha since September 1962, using an evaporation tank (a Class A pan). The monthly values of evaporation as measured at Ardnacrusha over a five-year period are given in Table 19.

TABLE 19

Monthly values in millimetres of evaporation at Ardnacrusha over the period January 1963 to December 1967 inclusive

Year / Month	Ardnacrusha (Class A Pan) Evaporation (mm.)					
	1963	1964	1965	1966	1967	Mean
January	0.0	5.1	0.0	5.1	2.5	2.5
February	0.0	17.8	25.4	15.2	12.7	14.2
March	25.4	27.9	38.1	33.0	33.0	31.5
April	38.1	48.3	38.1	48.3	66.0	47.8
May	71.1	81.3	71.1	121.9	78.7	84.8
June	78.7	66.0	83.8	78.7	83.8	78.2
July	61.0	73.7	81.3	94.0	71.1	76.2
August	73.7	66.0	66.0	68.6	66.0	68.1
September	43.2	43.2	27.9	45.7	40.6	40.1
October	5.1	17.8	17.8	17.8	25.4	16.8
November	10.2	7.6	2.5	2.5	10.2	6.6
December	10.2	5.1	0.0	0.0	0.0	3.1
Total	416.7	459.8	452.0	530.8	490.0	

The values for November, December, January are generally very low and in some years no detectable evaporation occurred in these months. The highest values occurred in the months of May/June. Values remain high through July and August but there is a rapid fall off in September and October.

TABLE 20

Monthly and Annual Averages of Relative Humidity * (as a percentage) for specified stations over the 5-year period 1957-1961

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	%	%	%	%	%	%	%	%	%	%	%	%	%
Belmullet, Co. Mayo	84.7	84.3	84.0	81.3	80.0	82.0	85.8	86.1	84.3	83.7	84.6	84.4	83.7
Birr, Co. Offaly	88.9	84.9	83.3	79.7	77.4	78.5	82.5	82.9	83.8	86.6	88.4	88.5	83.8
Claremorris, Co. Mayo	91.7	89.0	86.4	82.4	80.5	82.6	86.5	87.1	88.4	89.1	91.6	91.5	87.2
Clones, Co. Monaghan	90.4	87.5	84.5	80.7	78.7	79.9	84.7	86.1	86.9	88.5	90.6	90.7	85.8
Dublin Airport, Co. Dublin	84.6	82.7	81.4	79.3	77.6	78.0	80.9	82.3	83.0	84.5	84.4	83.9	81.9
Kilkenny ≠	89.9	85.8	83.6	80.6	78.7	78.9	81.8	82.4	85.3	87.1	89.2	89.3	84.4
Malin Head, Co. Donegal	81.8	81.7	81.4	81.5	79.7	80.4	85.2	84.4	81.8	82.0	83.1	82.3	82.1
Mullingar, Co. Westmeath	91.3	88.2	85.1	81.4	79.0	80.8	85.2	86.2	87.2	89.4	91.2	91.7	86.4
Roche's Point, Co. Cork	86.0	85.5	87.1	82.5	81.7	82.6	84.4	85.6	86.0	85.2	85.8	84.9	84.8
Rosslare, Co. Wexford	85.7	85.2	85.9	83.8	82.5	83.2	84.3	85.0	85.5	84.7	84.1	83.9	84.5
Shannon Airport, Co. Clare	89.2	85.4	83.7	80.4	79.0	80.0	82.6	83.5	84.5	86.2	88.2	88.6	84.3
Valentia Observatory, Co. Kerry	82.6	81.3	81.3	79.9	79.6	81.9	85.2	84.9	83.4	83.0	83.3	81.6	82.3

* Mean values are based on simultaneous readings of Dry and Wet Bulb temperatures made at each hour of every day.

≠ Values not available over the period January to May, 1957 inclusive.

TABLE 21

Monthly and annual mean values of Relative Humidity (as a percentage) at Shannon Airport, for the different hours, over the 5-year period 1957-1961

Hour GMT / Month	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	All Hours
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Jan	90.7	91.4	91.9	91.6	91.8	91.9	91.7	91.2	91.3	90.9	90.2	88.7	86.3	83.9	82.9	83.4	85.0	87.3	88.7	89.2	90.2	90.3	90.4	90.8	89.2
Feb	88.8	89.0	88.9	88.5	89.2	89.1	88.7	89.0	89.0	88.3	86.6	83.3	80.5	77.8	76.6	76.0	76.9	79.8	83.6	86.3	87.6	88.1	88.1	88.8	85.4
Mar	87.9	88.7	88.9	89.3	89.5	89.5	89.9	89.6	88.9	86.4	82.7	79.1	77.0	75.0	73.6	73.7	75.2	76.7	79.2	82.3	84.4	85.8	87.0	87.4	83.7
Apr	87.6	88.2	89.3	90.1	90.7	91.2	91.2	90.6	87.9	83.1	78.1	73.5	70.2	68.0	66.7	66.9	67.0	68.8	72.0	75.8	79.9	82.4	85.2	86.3	80.4
May	87.5	88.8	89.8	90.5	91.1	91.3	90.9	87.9	83.6	78.8	74.0	70.8	68.5	67.1	65.1	64.9	65.8	67.1	69.2	72.6	78.0	82.2	84.7	85.9	79.0
June	88.9	89.7	90.3	91.1	91.4	91.7	90.7	87.4	83.3	79.1	74.6	71.6	69.3	67.4	67.5	67.3	67.8	69.8	71.3	73.9	77.6	82.6	85.6	87.7	80.0
July	89.6	90.6	91.2	91.3	91.7	91.9	91.2	89.0	85.6	81.6	78.7	75.9	73.9	72.4	71.8	71.4	72.5	73.6	76.1	78.6	82.3	85.8	87.7	88.7	82.6
Aug	90.6	90.9	91.4	92.0	92.4	92.4	92.2	91.4	88.8	85.2	80.7	76.6	73.9	71.8	71.1	71.5	72.1	73.9	76.2	80.1	84.2	87.2	88.8	89.6	83.5
Sept	90.5	90.9	91.1	91.4	91.9	92.0	91.9	91.7	90.2	86.7	82.7	78.8	75.1	72.7	72.6	72.6	73.1	74.9	79.1	83.3	86.2	88.1	89.4	90.0	84.5
Oct	89.9	90.5	90.5	90.7	90.9	91.2	91.0	91.1	90.1	88.5	85.9	82.1	78.7	77.5	77.2	77.1	78.9	81.4	84.4	86.6	87.8	88.1	88.8	89.3	86.2
Nov	90.5	90.4	90.2	90.5	90.4	90.6	91.0	90.5	90.6	90.4	88.5	86.3	83.9	82.1	81.4	82.2	83.7	86.0	87.9	89.0	89.6	89.9	90.0	90.0	88.2
Dec	89.8	89.9	90.0	89.7	90.1	90.5	90.3	90.1	90.2	90.2	89.4	87.8	86.1	84.8	83.7	84.6	86.1	87.8	88.9	89.0	89.4	89.3	89.1	89.8	88.6
Year	89.4	89.9	90.3	90.6	90.9	91.1	90.9	90.0	88.3	85.8	82.7	79.5	76.9	75.0	74.2	74.3	75.3	77.3	79.7	82.2	84.8	86.6	87.9	88.7	84.3

7.4. Relative Humidity

The monthly averages of relative humidity over Ireland for a selection of stations are given in Table 20 prepared by the Irish Meteorological Service. The rather narrow range over the country in the annual averages is interesting.

The presentations in Table 20 tend to mask the important diurnal variation. Table 21 gives a more detailed break-down of the figures in respect of Shannon Airport showing the fairly constant average high relative humidity during the early hours of the morning and the appreciably lower values in the afternoon, particularly in the months March to October, inclusive.

7.5. Evapotranspiration

Based on the available data, Connaughton (6) has computed estimates of the monthly Potential Evapotranspiration (P.E.) for each of the months May to October, when use of the standard formula for computation of this quantity seems to provide a reasonably reliable guide.

The isopleths of P.E. show relatively low values for the midland counties with higher values towards the coast. A feature of the maps prepared by Connaughton is the relatively high values calculated for the area of Co. Clare and North Kerry for most months. The monthly values reach a maximum of 65/75 mm. in North Munster in June and decrease to 25/05 mm. in October.

- E N D -

References:

1. Daly and Fitzgerald "Operational Weather Conditions at Shannon Airport" - Irish Meteorological Service (IMS) Tech. Note No. 28 (1961)

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3. Lamb, H.H. - "The English Climate" - London 1964

4. Landsberg, H. - "Physical Climatology" - Pennsylvania 1958

5. Deutscher Wetterdienst - "Klimatologie der Nordwesteuropaishen Gewasser"

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APPENDIX I

Instruments used in the Irish Meteorological Service for Measuring and Recording Certain Meteorological Elements

1. Sunshine:

The Campbell-Stokes sunshine recorder which is the type used in the Irish Meteorological Service uses the focussed heat radiation from the sun to burn a trace on a graduated chart or card. It consists essentially of a glass sphere about 10 cm. diameter mounted so as to be concentric with a card held in grooves in a section of a concave bowl at a distance such that the Sun's rays are focussed on the chart. The instrument acts as a sundial and requires no movement of the chart throughout one day.

2. Temperature:

Air temperature is measured by thermometers housed in louvred screens (Stevenson Screen) which are painted white and which are designed in such a way as to ensure that measurements are representative of conditions in the free air circulating in the locality without the thermometer being exposed to radiation or being in contact with precipitation. Each screen is mounted on a stand on a level plot of short grass with the thermometer bulb approximately four feet above the ground. In addition to the dry bulb thermometer which measures the air temperature, the screen normally houses a wet bulb thermometer, a maximum thermometer, a minimum thermometer, a thermograph and a hair hygrograph.

3. Rainfall:

The standard raingauge used in the Irish Meteorological Service provides for the collection of all precipitation which falls into a funnel, the upper edge of which is circular, level, 5 inches in diameter and one foot above ground level. Special care is taken in design and exposure to minimise splashing of the falling droplets. The precipitation falling into the funnel is collected in a special container. The contents accumulated each day are measured and recorded and used for computing monthly totals and other statistics of interest.

4. Surface Wind:

The anemograph used in the Irish Meteorological Service is of the Dines Float type and consists of a pitot tube kept faced into the wind by a wind vane. The exposed head of the instrument uses the pressure and suction effect of the wind to operate a float type of manometer system. The float is specially shaped to give a linear scale record of the wind speed. The instrument also continuously records the direction of wind as sensed by the wind vane.

The standard exposure of anemometers over level open country is 10 metres (33 ft.) above the ground.

The instrument exposure must be as free as possible from the direct influence of local obstacles such as houses, trees, etc.