551·577·37(54)

Confidence limits of expected Monthly Rainfall for the Agricultural College and Research Institute, Coimbatore

C. M. BAKTHAVATHSALU and C. BALASUBRAMANIYAN

Agricultural College and Research Institute, Coimbatore

(*Received 19 June 1952*)

1. Introduction

From adequate statistics of rainfall distribution the limits, within which the expected monthly rainfall will lie, can be calculated. These are known as *Confidence or Fiducial limits*. The limits within which the rainfall may be expected to lie in nine years out of ten (90 per cent fiducial probability) were chosen as being of practical interest to farmers by Manning (1951).

Generally frequency distribution of rainfall often exhibit skewness, with the mode lower than the mean. So if no account is taken of factors such as skewness, the means and standard deviations calculated from such statistics will lack the necessary precision and may often be misleading. So it is necessary to adopt suitable method for transforming skew data to give an approximately normal distribution, from which ' Confidence Limits ' may be estimated and afterwards reconverted to the original units.

2. Material and Methods

The rainfall data collected continuously during a period of 43 years in the observatory attached to the Agricultural College and Research Institute, Coimbatore were taken for statistical analysis. The raingauge which is situated 146½ ft to the east of the Agricultural College and Research Institute building which is 38 ft high was not shifted from that place since its installation in 1908. The exposure is good with no trees nearby and no crop was raised near about since its inception. The plan of analysis was designed on the model suggested by Manning (1951).

3. Analysis of the data

Histogram of monthly rainfall was prepared using a class interval of 0·5 inch (Fig. 1). In this case the class frequencies almost run upto a maximum at one end of the range, indicating thereby the extremely skew nature of the distribution. The rainfall range was 16·02 inches over the 456 rainy months.

The first four moments were calculated for the frequency distribution (Arkin and Colton 1948). From these moments, the criteria β_1 and β_2 were computed. Values of β_1 and β_2 for the normal distribution are taken as 0 and 3 respectively (Yule and Kendall 1945). Small deviations from the above values would, of course, be inconsequential, but the constants, of the rainfall data given in Fig. 1, namely, $\beta_1=4{\cdot}518$ and $\beta_2=9{\cdot}118$ demonstrate the extreme departure of the curve from normality. The values of β_1 and β_2 indicate that a Type X Pearsonian curve may give a reasonably good fit, for the rainfall data under study (Elderton 1927, Pearson 1930). The distribution of the rainfall data about its mean is asymmetrical and hence statements of probability derived from the actual data may lack precision. So a suitable method of transforming the skew data to get an approximately normal distribution as given by Manning (1951) was used for the data under study. The function, namely $Y=\log\ (x+c)$ adopted by Kleczkowski is satisfactory in correcting skewness. The constant c is derived from $c=\frac{s}{b}-\bar{x}$, where s is the average standard deviation for monthly rainfall, b is the regression co-efficient of standard deviation on mean monthly rainfall and $\bar{x}$ is the average of the mean monthly rainfall values. If b, the regression co-efficient of standard deviation on mean monthly rainfall is found

to be statistically significant, Kleczkowski's formula can be applied with advantage for transforming the skew data. For the data under study the regression co-efficient was found to be statistically significant (Table 1).

Therefore, the entire rainfall data were transformed by applying Kleczkowski's formula. Then these transformed data were grouped and analysed as before. Sheppard's correction for grouping was applied (Yule and Kendall 1945). Values of β_1 and β_2 were worked out and found to be 0·411 and 2·964 respectively. They indicate that the data after transformation tend towards normality. Histogram and theoretical curve from the data on the new scale are shown in Fig. 2. Normal curve was derived from the appropriate function (Goulden 1936, Pearson 1930). Manning has emphasized that the distribution on the new scale of log $(x+c)$ need only to have an approximate approach to the normal distribution. If it is so, fiducial limits may be estimated. Comparison of skewness of monthly rainfall data with the actual data has shown that the skewness is appreciably less for the transformed than for the actual data except for the months of January and February as indicated by the data presented in Table 2.

Means and standard deviations were computed for the individual months for the transformed data. Then confidence or fiducial limits of monthly rainfall on the new scale were calculated for $p=0·1$ (Snedecor 1946). Actual units were obtained by reconversion and they are given in Table 3.

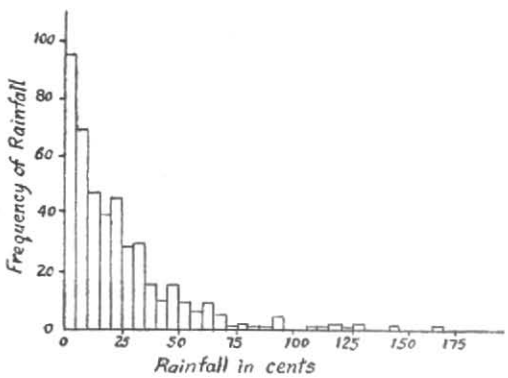

Fig. 1. Histogram of monthly rainfall for the Agricultural College and Research Institute, Coimbatore (43 years)

Distribution constants of actual variable. $N=456$; Mean=2·342; S. D.=2·426; $\beta_1=4·518$; $\beta_2=9·118$

Distribution corresponds to type X Pearsonian curve

TABLE 1

Mean monthly rainfall and standard deviations for the Agricultural College and Research Institute, Coimbatore

Month	Actual data		Transformed data	
	Mean	S.D.	Mean	S.D.
Jan	1·145	1·123	0·4614	0·1533
Feb	0·878	1·373	0·4167	0·1424
Mar	0·899	0·944	0·4312	0·1244
Apr	2·108	1·114	0·5815	0·1436
May	2·387	1·675	0·6030	0·1714
Jun	1·515	1·476	0·5057	0·1575
Jul	1·955	2·085	0·5590	0·1453
Aug	1·399	1·071	0·4999	0·1509
Sep	1·686	1·386	0·5277	0·1661
Oct	6·040	2·955	0·8749	0·1530
Nov	4·654	3·056	0·7750	0·2004
Dec	1·621	1·687	0·5076	0·1873
Total	26·287	19·945	6·7436	1·8947
Mean	2·191	1·662	0·5620	0·1579
Regression Co-efficient (b)	0·4035		0·0690	
'F'	42·97*		2·750 (not significant)	
'c'	1·928		—	

*Highly significant. S.D.—Standard Deviation

NOTE—The degree of independence of the means and standard deviations on the new scale in the case of transformed data, is clearly shown by the regression co-efficient being statistically not significant

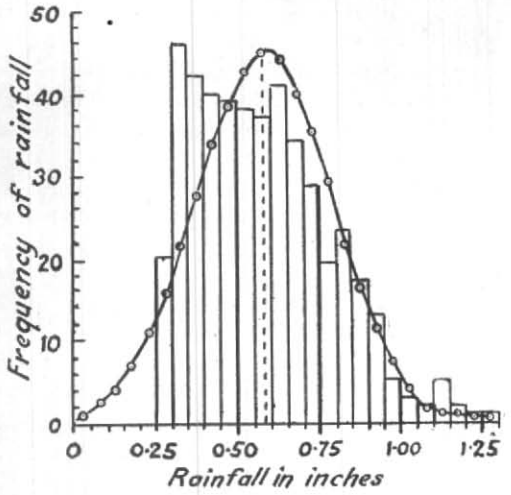

Fig. 2. Histogram and Theoretical curve of monthly rainfall for the Agricultural College and Research Institute, Coimbatore

Distribution constants of transformed variable, $\log(x+c)$. Mean=0·5777; S.D.=0·2056
β_1=0·411; β_2=2·964

TABLE 2

Comparison of skewness of monthly rainfall data at the Agricultural College and Research Institute, Coimbatore for actual and transformed units

Month	Actual Units	Transformed Units
Jan	0·752	0·725
Feb	0·421	0·401
Mar	0·635	0·032
Apr	0·738	0·354
May	0·103	0·041
Jun	0·688	0·196
Jul	0·355	0·096
Aug	0·839	0·667
Sep	0·823	0·355
Oct	0·408	0·163
Nov	0·582	0·250
Dec	0·664	0·578
Means ignoring signs	0·5840	0·3215

NOTE—Skewness is given as $\frac{\text{Mean—Mode}}{\text{Standard Deviation}}$

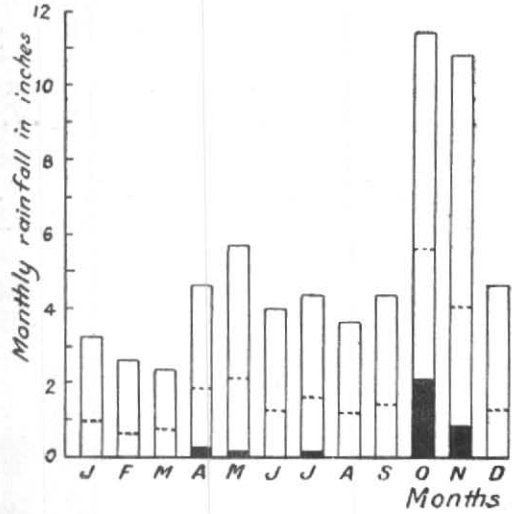

Fig. 3. Fiducial limits (9 : 1) for monthly rainfall at the Agricultural College and Research Institute, Coimbatore

Minimum expected rainfall shown by blocking. Dotted lines indicate the mean

TABLE 3

Confidence or Fiducial limits (9 : 1) for monthly rainfall at the Agricultural College and Research Institute, Coimbatore

Month	Lower Limit	Higher Limit	Mean	Values outside range
Jan	0·00	3·36	0·97	3
Feb	0·00	2·67	0·68	2
Mar	0·00	2·47	0·77	3
Apr	0·26	4·73	1·89	4
May	0·14	5·86	2·08	3
Jun	0·00	3·97	1·28	4
Jul	0·13	4·44	1·69	2
Aug	0·00	3·73	1·23	2
Sep	0·00	4·49	1·44	3
Oct	2·21	11·64	5·57	4
Nov	0·81	11·03	4·03	5
Dec	0·00	4·73	1·29	4
Observed deviations from limits	—	—	—	39
Expected deviations from limits	—	—	—	45·6

NOTE—For the data under study rainfall departures from limits during the whole period may be expected to lie between 45 and 46 occasions. Actual departures are found to be 39. So there is a satisfactory general agreement between the expected and observed data

4. Discussion

The fiducial or confidence limits, unlike the mere means enable the agriculturists to assert with some degree of confidence, the expected minimum rainfall in different months and to adjust their cultural operations suitably. Rainfall pattern (Fig. 3) indicating the monthly upper and lower fiducial limits is of practical value to the agriculturists. In the above figure the minimum expected rainfall is shown by blocking the average by the dotted lines and the maximum by the height of the columns. It indicates that the northeast monsoon period of October to December is the surest rainy period at Coimbatore. In fact, dry sowings depend mainly on the timely receipt of the northeast monsoonic showers early in October (Venkatanarasinga Rao and Balasubramaniyan 1949). The minimum expected rainfall during October is 2·21 inches, and the maximum 11·64 inches. Invariably during all the months the actual mean monthly rainfall fails to emphasize the lower limit or the minimum expected rainfall. Actual mean monthly rainfall values are sometimes misleading as in the case of rainfall during the summer months of April and May. For example, actual mean monthly rainfall for April is 1·89 inches and May 2·08 inches. But the minimum expected rainfall of 0·26 inch for April is greater than that expected during May (0·14 inch). Considering the fiducial limits it may be tentatively inferred that once in ten years rainfall amounts outside the fiducial limits are likely to be recorded (Table 3 and Fig. 3) under the conditions obtainable at the Agricultural College and Research Institute, Coimbatore.

5. Acknowledgement

The authors are highly grateful to Sri M. B. Venkatanarasinga Rao, Paddy Specialist, Coimbatore, for his valuable guidance in the preparation of this paper.

REFERENCES

Arkin, H. and Colton, R. R. (1948). *An outline of Statistical Methods.*

Elderton, W. P. (1927). *Frequency curves and Correlation.*

Goulden, C. H. (1936). *Methods of Statistical Analysis.*

Manning, H. L. (1951). *Res. Mem.*, 9. Empire Cotton Growing Corporation, London.

Pearson, K. (1930). *Tables for Statisticians and Biometricians*, Parts I and II.

Snedecor, G. W. (1946). *Statistical Methods.*

Venkatanarasinga Rao, M. B. and Balasubramaniyan, C. (1949). *Ind. geogr. J.*, **24**, 4.

Yule, G. U. and Kendall, M. G. (1945). *An Introduction to the theory of Statistics.*