CHAPTER -V

PATTERN OF DAILY RAINFALL

5.1 INTRODUCTION

The knowledge of weather, in general, of rainfall in particular for performing the pre-cultivation operations and sound crop planning needs much emphasis. Mostly the work in this direction is confined to the total rainfall, maximum and minimum amount of rainfall and its ranges etc. However, not only the inadequacy of rainfall but also excess or deficiency is harmful to a particular crop . It is also natural to imagine that for the total agricultural production the total amount of rainfall is not of much importance but the pattern of its occurrence such as spell of rainy and dry days, expected number of dry days between two rainy days and their repetitions are of much use for the rainfed crops in this region. The repetitive behaviour of weather during seasonal months has always fascinated meteorologists and Statisticians. Meteorologists seek physical explanations for such phenomena and statisticians explore possibilities of model building to explain random phenomena. Such models serve the important function of providing an orderly basis and permit further use of the deductive power of mathematics to reach conclusions that may even provide clues to physical understanding of the complex phenomena.

Among the earlier studies may be mentioned the work of Cochran (1938) who proposed a probability model, based on the "Theory of Runs" to study the "persistancy" behaviour of rainy days while others like Gabriel and Neumann(1957) suggested geometric distribution as a suitable model for wet and dry weather spells. Gabriel and Neumann (1962) considered empirical evidence to find out the suitability of the pattern of occurrence of rainfall with the help of Markov chain model. With respect to the precipitation phenomena,a major thrust of this stochastic approach has been to predict the behaviour of spell distribution and subsequently the weather cycle under the assumption that the probability of occurrence of precipitation of any day depends upon the previous observation and only on it. So,Markov chain model has been used to serve this purpose.

To be precise,the main objectives of this section are :

i) To fit the Markov chain model to daily rainfall data.

ii) To determine the distribution of dry spells and wet spells and dry-wet and wet-dry cycles.

iii) To estimate the average lengths of dry spells and wet spells and the expected length of weather cycle.

5.2. MARKOV CHAIN MODEL OF DAY'S WEATHER.

For the purpose of the present study this daily rainfall data are based on the daily rainfall during the period 30th April to 30th September in each year.Each day is classified as wet day if the day receives the amount of rainfall greater than or equal to 2.5 mm or a dry day if the amount of rainfall is less than 2.5 mm.

This classification gives a sequence of wet and dry days which can be regarded as a two-state Markov chain with wet and dry days. Each day of this sequence is classified as one of the following possibilities.

i) A dry day preceded by a dry day.

ii) A wet day preceded by a dry day.

iii) A dry day preceded by a wet day.

iv) A wet day preceded by a wet day.

Thus , for each year, the 30th April which is regarded as the initial day may be considered for classifying the 1st May for each year. Thus, for each year, the nature of a day is classified as one of the four possibilities depending on the previous day is dry or wet.

Repeating the process each cell frequencies for the above four possibilities are obtained.

Let these frequencies be f(D/D), f(W/D), f(D/W), f(W/W) respectively with

$$f(D/D) + f(W/D) = n_1$$

and

$$f(D/W) + f(W/W) = n_2$$

The cell frequencies are arranged in the matrix form for the month of May , June, July, August and September based on daily rainfall data at Cooch Behar. These cell frequencies for each month separately are given in Table 5.1. And the corresponding cell frequencies of all the months are pooled and we get a new form of matrix computed by pooling the corresponding frequencies for May, June, July, August and September.

These pooled or total frequencies are also reported in the same Table.

It is obvious that the two conditional probabilities,

p_{12} and p_{22} which have to be estimated,are required for describing the two state Markov chain model.

The maximum likelihood methods have been applied to estimate these parameters of the model.

The conditional probabilities can be estimated as below :

$$P_{12} = \frac{f(W/D)}{n_1} \quad \text{and} \quad P_{22} = \frac{f(W/W)}{n_2}$$

So, under the two-state Markov chain model the other two conditional probabilities are easily obtained as

$$P_{11} = 1-P_{12} \quad \text{and,} \quad P_{21} = 1-P_{22}$$

Given that the previous day is dry,let the transition probabilities of a day being dry and wet be respectively

P_{11} and P_{12} with $P_{11} + P_{12} = 1$.

Similarly given that the previous day is wet, let the transition probabilities of a day being dry and wet are respectively P_{21} and P_{22} with $P_{21} + P_{22} = 1$

The transition probability matrix,in such a case can be arranged as

$$P = \begin{vmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{vmatrix}$$

Since the sequence of dry and wet days can be regarded here as a finite sequence on the time axis,we can take the starting day i.e. the 30th April as an initial day, as dry or wet. The process is then expected to settle down to a two-state Markov chain model for each month as well as their pooled estimates. The stochastic matrix of each month i.e. May, June, July, August and September and the pooled one are also reported in Table **5.2**. It is indicated in Table 5.2 that the transition probability of the occurrence of a wet day preceded by a wet day for each month at Cooch Behar is always the highest among all the conditional probabilities during the monsoon months. But the conditional probability for the occurrence of a dry day preceded by a dry day is the highest among the other conditional probabilities in the month of May at Cooch Behar.

5.2.1. TEST OF INDEPENDENCE :

For determining whether,the occurrence of a wet day and a dry day depends only on the immediately preceding day's weather, we test the hypothesis of independence against Markov dependence.

Now under the null hypothesis the likelihood ratio statistic has been used for the testing. The test statistic is given by

$$\lambda^* = -2 \operatorname{Log} \lambda = 2 \sum_{i=1}^{2} \sum_{j=1}^{2} n_{ij} \log \frac{(n) n_{ij}}{n_{i} n_{j}}$$

Usual notations have been used here,i.e. n_{ij} = cell frequency of ith raw and jth column, n_{i} = total of ith row, n_{j} = total of jth column and $n = \sum^{2} n_{i} = \sum_{j}^{2} n_{j}$

The test statistic has an asymptotic Chi-square distribution with one degree of freedom for the two-state Markov chain model. The calculated values of test statistic (λ^*)are given in Table 5.3. for each of the months and for the pool of these months. The test of independence strongly suggests that the probability of the occurrence of rainfall of any day is dependent on the weather of the previous day as the calculated values of the test statistic are much greater than the tabulated value of chi-square at one percent level of significance. This indicates that the Markov chain model is very much effective on the weather of a day at Cooch Behar during the premonsoon month like May and effective monsoon months June to September as well as the pooled observations for all these months.

Therefore,we come to the conclusion that the hypothesis of independence of weather of consecutive days is to be rejected and therefore,the occurrence of a wet or dry day is influenced by the previous day's weather only.

5.3. SPELL AND WEATHER CYCLE DISTRIBUTION

A rainfall event is described by two sets of meteorological data representing wet and dry phases. In a sequence of wet and dry days, there are possibilities of the occurrence of wet days and dry days in succession. A number of successive wet days preceded and followed by a dry day is regarded as the length of a wet spell. Subsequently a dry spell is defined in the similar way. A weather cycle is defined as the combination of a wet spell with the immediate successive dry spell (wet-dry cycle) or a dry spell with the immediate successive wet spell (dry-wet cycle). The following criteria are fixed in the analysis for classification of a wet day,wet/dry spell and weather cycle.

i) A day is defined to be a wet day if it receives rainfall more than or equal to 2.5.mm .

ii) A wet spell is included in a month if any day of this particular spell falls within that month,no matter if the wet spell does not end in the month.

iii) A dry spell is included in a month only if the immediately following wet spell is included in that particular month. In case,a month ends with a dry day the dry spell including that dry day should be accounted in the following month.

iv) In case of weather cycles,the whole length of the cycle which overlaps two adjacent months is assigned to that month which shares more than half its length.In case of equality,it is arbitrarily assigned to the previous month.

In adopting above rules for the assignment of spells and cycles to all the months,we are likely to introduce little or no bias in the long run as a result of the random characteristics associated with the mid-points of the spells and cycle lengths.

Following the above procedure the observed frequencies of dry and wet spells of various lengths during the rainy months are shown in Tables 5.4 and 5.5 respectively. It is seen from the Table 5.4 that the observed frequency for the duration of a dry spell is seen up to eleven days in the months of May and August but seven,eight and twelve days in the months of July,June and September respectively. The dry spells of twelve days during the month of September are observed twice while the dry spells of eleven days during the months of May and August occur thrice and twice respectively. However,it is mostly observed that the frequency of the duration of a dry spell decreases as the size of the dry spell increases for all the rainy months at Cooch Behar.

From Table 5.5 the observed frequency of wet spells is seen up to sixteen days in the month of July followed by thirteen days in the month of September. The same for twelve days in the months of May and June and that of nine days in the month of August are also observed during the study period. Though a wet spell of sixteen days during the month of July is observed once but in this month,the long wet spells are observed frequently.

Table 5.6 shows the observed frequency of dry-wet cycles for all the rainy months. It is seen from Table 5.6 that dry-wet cycles of longer durations occur in the month of July followed by the months of May,August and then by september and June respectively. This is probably because of longer wet spell during these rainy months.

From Table 5.7 the wet-dry cycle of longer duration occur once in 25 days during the month of September followed by July,June , August and May. This is due to the longer wet and dry spells during these months.

The probabilities of obtaining these three events, a wet spell of length w-day,a dry spell of length d-days and a weather cycle of length n-days can be constructed from the Markov dependent geometric models. The probability generating expression for wet spell length (x) , dry spell length (y) and the weather cycle length (z) are given below :

$$P\ (x=w) = (p_{22})^{w-1}(1 - p_{22}).$$

$$P(y=d) = (p_{11})^{d-1}\ (1-p_{11})$$

$$P(z=n) = (p_{12}\ X\ p_{21})\ X \left[\frac{p_{22}^{n-1} - p_{11}^{n-1}}{p_{22} - p_{11}} \right]$$

Here

$P(x=w)$ = Probability of a wet-spell of length w days.

$P(y=d)$ = *Probability of a dry-spell of length d days*

$P(z=n)$ = Probability of a weather cycle of length n days

p_{11}, p_{12}, p_{21} and p_{22} are defined in sub-section 5.2.

The conditional probabilities p_{11}, p_{12}, p_{21} and p_{22} which serve as the basic elements to construct the Markov dependent geometric model, are already estimated separately for each month May to September as well as the pooled estimates of these months. These values are given in Table **5.2.** These conditional probabilities are based on 18 years daily rainfall observations at Cooch Behar during these rainy months.

We can employ these transition probabilities into the foregoing formulae as expressed in this sub-section. The relative probabilities as generated by the Markov dependent model are estimated for each of the rainy months as well as the total of these months. These relative probabilities are multiplied by the appropriate sample sizes,we get the expected frequencies by lengths of wet and dry spells and wet-dry and dry-wet cycle for each of the rainy months as well as the total of these months.

The observed frequencies along with their expected frequencies are given in Table 5.4 for dry spell distribution and Table-5.5 for wet spell distribution.

Now we discuss here separately wet spell,dry spell and dry-wet cycle and wet-dry cycle for the respective months.

5.3.1. DRY SPELL :

Table 5.4 shows the distribution of dry spell for the months May, June, July, August and September and the pooled distribution of these rainy months. The Chi-square goodness of fit test has been applied to test the validity of the model. The values of the test statistic are calculated separately for each distribution of dry spell. These values of the Chi-square are given in Table 5.4 with suitable degrees of freedom along with the table values at five percent level of significance. It is seen that the observed and expected frequencies for dry spells of varying lengths for each distribution fit well since the calculated values of Chi-square are nonsignificant at five percent level. The observed and expected frequencies of dry spells during the months May to September i.e.total of rainy months are shown in Figure.5.1.

Therefore,we come to the conclusion that the dry spells with varying lengths can be considered tofollow Markov dependent geometric model. So,this model is a valid one to the dry spell distribution at Cooch Behar.

5.3.2. WET SPELL

The Chi-square goodness of fit test hasbeen considered to test the reliability in agreement between the observed and the expected frequencies of wet spells to all the distributions of wet spells with varying lengths. The calculated values forthe test statistic are given in Table 5.5 with suitable degrees of freedom at the 5 percent level of significance. The calculated values of Chi-square are less than the table values at 5 percent level with suitable degrees of freedom for all the distributions of wet spell with varying lengths. So,the values of test statistic are not significant at 5 percent level. Hence,there is good agreement between the observed and the expected frequencies for wet spells of varied lengths for each distribution of wet spells under consideration. The observed and the expected frequencies of wet spells during the premonsoon month (May) and the active monsoon months i.e. the total of these months are shown in Figure 5.2.

Therefore,the distribution of wet spells for each month and the rainy months can be considered to follow the Markov dependent geometric model at Cooch Behar.

5.3.3. WEATHER CYCLE :

The distribution of the length of weather cycles consists of two categories as mentioned earlier i.e.dry-wet and wet-dry cycles. Table 5.6 and Table 5.7 report the observed and the expected frequencies for dry-wet and wet-dry cycles. However,it may be noted that due to symmetry of the appropriate formulae by using the p_{11} and p_{22} the probabilities for different lengths of the cycles remain the same for dry-wet and wet-dry cycles, although the actual expected frequencies can be different due to the marginal differences of the sample size. Table **5.6** and Table **5.7** show the observed and the expected frequencies of thesetwo types of weather cycles separately for the consolidated periods.

The calculated values of Chi-square are less than the tabulated values of Chi-square at five percent level of significance. These values are given in Table **5.6** for dry-wet cycles and in Table **5.7** for wet-dry cycles for all the distributions. So,the values of the test statistic are nonsignificant. Figures 5.3 and 5.4. show the observed and the expected frequencies of dry-wet and wet-dry cycles of the period May to September respectively.

As judged solely from the test values,the dry-wet and wet-dry cycles appeared to confirm to follow the Markov dependent geometric model. The findings are similar in the case of dry spells and wet spells.

As observed elsewhere in the case of dry spells, wet spells and weather cycles,the expected frequencies at the long length are adjusted corresponding to the observed ones.

However,for large mass of data of the present type,accumulated over a long period of eighteen years, the influence of many extraneous factors affecting the reliability and uniformity of data cannot be ruled out. Putting all these type of factors together and bearing in mind,some of the inadequacies in the data base itself, the fundamental Markovian assumption and Markov dependent geometric distribution model for weather spells and cycles are not too unreasonable.

Therefore,it may be concluded that the average length of expected dry spell is 2.5 days while that of a wet spell is 3 days. And they constitute a weather cycle of 5.5 days which is as such,the average value of the observed length of a weather cycle. Hence,the spells as well as weather cycles have conformed to the Markov dependent geometric model.

5.4. LENGTH OF SPELLS AND WEATHER CYCLES :

In the foregoing analysis,we have tested the fundamental Markovian assumption involving the daily weather at Cooch Behar for different months. In this section we use the parameters of two State Markov chain model on the daily rainfall for the rainy months and pooled period at Cooch Behar to estimate the length of wet and dry spells and also the length of weather cycles. It is assumed that the geometric model also enables us to examine the number of dry or wet spells and weather cycles. But we have already established that Markov-dependent geometric models are best fitted to the distribution of wet and dry spells and also weather cycles.

Moreover,considering the distribution the expected length of a dry spell of length 'd' days is given by

$$E(d) = \frac{1}{P_{12}}$$

The expected length of a wet spell of 'w' successive wet days followed by a dry day, then is given by

$$E(w) = \frac{1}{(1-p_{22})}$$

The expected length of a weather cycle i.e. a dry spell followed by a wet spell or vice-versa is then given by

$$E(c) = E(d) + E(w)$$

$$= \frac{1}{p_{12}} + \frac{1}{(1-p_{22})}$$

p_{12} and p_{22} are the usual notations as given in earlier sub-section.

Employing these transition probabilities, the expected length of dry and wet spells and also the expected length of weathercycles can be evaluated as shown above. The observed values of lengths of dry and wet spells and the lengths of weather cycles are computed from the observed frequency distribution of the spells and weather cycles for each month from May to September at Cooch Behar,during the study period of eighteen years.

The observed and the expected lengths of spells of dry and wet spells and the lengths of weather cycles are given in Table **5.8.** The observed values of weather cycles are estimated by taking the average of the means of two cycles i.e. wet-dry and dry-wet cycles. These values are estimated for all the rainy months i.e. May to September at Cooch Behar.

It is seen from that table that the variation in the lengths of wet spells is large for all months. It is also observed that the expected length of dry spells varied from 1.96 to 2.91 while in the case of wet spells it varies from 2.54 to 4.02. A note worthy feature is that the expected lengths of dry spells are greater than the observed lengths in all the months expect in

August where it is reversed. And the expected lengths of wet spells are greater than the observed lengths in all the months except in September where it is also reversed.

The observed lengths of weather cycles fluctuated from 5.2 days in the months of June and August to 6.2 days in the month July ,whereas the expected lengths varied from 5.34 in the month of August to 6.35 days in the month of July at Cooch Behar.

5.5 CONCLUSION :

Markov chain models have been fitted to the daily rain fall during the months,May to September separately in this district.The distribution of dry and wet spells as well as dry-wet and wet-dry cycles of the period May to September and rainy season as a whole have been fitted to Markov dependent geometric model over this area. The average expected lengths of dry spells and wet spells are 2.5 and 3 days respectively and they constitute the 5.5 days of the weather cycle which is nearly the same as that of the average observed weather cycle.

T A B L E- 5.1.

TRANSITION FREQUENCIES

(For five months and total)

Month	f(D/D)	f(W/D)	Total(n_1)	f(D/W)	f(W/W)	Total(n_2)
MAY	203	106	309	106	143	249
JUNE	126	96	222	94	224	318
JULY	80	83	163	90	305	395
AUGUST	172	105	277	104	177	281
SEPTEMBER	153	97	250	94	196	290
TOTAL	734	487	1221	488	1045	1933

GRAND TOTAL = (1221 + 1933) 2754

T A B L E - 5.2.

TRANSITION PROBABILITIES

For six stochastic matrices.

	P_{11}	P_{12}	P_{21}	P_{22}
MAY	.656	.344	.426	.574
JUNE	.576	.424	.296	.704
JULY	.491	.509	.228	.772
AUGUST	.621	.379	.37	.63
SEPTEMBER	.612	.388	.324	.676
POOLED	0.6012	.3988	.3183	.6817

T A B L E = 5.3.

VALUES OF TEST STATISTICS

MONTH	CALCULATED TEST STATISTIC	D.F	TABLE VALUE OF
MAY	13.02*	1	χ^2 with 1 df.at
JUNE	17.45*	1	1% level =6.64
JULY	15.72*	1	
AUGUST	15.41*	1	
SEPTEMBER	19.71*	1	
POOLED	96.60*	1	

* Significant at 1% level.

TABLE = 5.4.

Observed (O) and expected (E) frequencies of dry spells :

	MAY		JUNE		JULY		AUGUST		SEPTEMBER		TOTAL	
*	O	E	O	E	O	E	O	E	O	E	O	E
1	48	37.80	48	43.40	46	43.90	41	40.30	45	37.40	228	209.6
2	20	24.80	21	24.80	24	21.50	25	25.00	22	22.80	112	109.7
3	10	16.30	11	14.10	09	10.50	12	15.50	09	13.90	051	71.8
4	12	10.70	13	8.00	02	05.00	10	09.60	03	8.50	040	43.1
5	08	7.00	02	4.60	01	2.80	09	6.70	07	5.20	027	25.9
6	03	4.60	02	2.60	02	1.30	02	3.70	03	3.20	012	15.50
7	01	3.00	03	2.00	02	1.00	01	2.30	04	2.50	011	9.30
8	01	2.50	01	1.50			01	1.40	01	1.50	004	5.60
9	04	2.00					02	.90			006	3.40
10	00	1.00					01	.70			001	2.50
11	03	.50					02	.60			005	1.60
12									02	1.00	002	1.00
Total :												
	110	110	101	101	86	86	106	106	96	96	499	499
X^2(Cal)	6.60		5.65		2.41		2.36		7.87		12.18	
D.F.	5		4		4		5		5		8	
X^2(Tab) at 5%	11.07		9.49		9.49		11.07		11.07		15.507	

* = Dry Spell (Day)

TABLE = 5.5.

Observed and expected frequencies of WET SPELL

	MAY		JUNE		JULY		AUGUST		SEPTEMBER		TOTAL	
*	O	E	O	E	O	E	O	E	O	E	O	E
1	48	45.95	36	31.90	28	22.30	28	22.60	32	30.4	172	150.10
2	26	26.40	20	22.40	16	17.20	13	14.20	20	20.7	95	102.00
3	14	15.15	18	15.80	13	13.25	08	18.95	21	14.05	74	69.40
4	10	8.70	12	11.20	07	10.20	03	5.65	07	9.60	39	47.20
5	5	5.00	5	7.80	5	7.85	1	3.60	07	6.5	23	32.10
6	1	2.90	5	5.50	6	6.05	2	2.25	02	4.4	16	21.80
7	2	1.65	2	3.80	7	4.85	1	1.50	01	3.5	13	14.85
8			3	2.70	5	3.80	4	1.25	03	2.85	15	10.10
9			3	2.50	1	2.80	1	1.00	1	2.00	6	6.90
10	1	1.25	2	2.00	3	2.50					6	4.70
11			1	1.40	2	2.10					3	3.80
12	1	1.00	1	1.00	3	2.00					5	3.00
13									1	1.00	1	2.05
14					1	2.00					1	1.00
Total	108	108	108	108	97	97	61	61	95	95	469	469
X^2 (cal)	0.79		2.18		3.99		2.80		6.70		10.97	
D.F.	5		6		6		4		5		9	
X^2 (at 5% leel)	11.07		12.59		12.59		9.49		11.07		16.92	

* = Wet Spell (Day)

T A B L E = 5.6.

Observed and expected frequencies of Dry-Wet cycle :

	MAY		JUNE		JULY		AUGUST		SEPTEMBER		TOTAL	
*	O	E	O	E	O	E	O	E	O	E	O	E
2	22	13.87	17	11.65	13	10.21	14	14.30	13	14.30	79	59.55
3	17	17.08	17	14.89	17	12.86	20	17.98	14	14.50	85	76.25
4	7	15.77	8	14.33	13	12.35	16	16.85	16	14.10	65	73.45
5	9	12.92	11	12.30	08	10.71	19	14.08	15	12.17	62	62.70
6	14	10.45	09	9.92	05	8.87	08	10.95	08	9.75	44	50.20
7	08	7.6	05	7.71	05	7.10	06	8.25	05	7.55	29	37.02
8	04	4.75	07	5.84	04	5.60	02	6.00	08	5.75	25	29.20
9	03	3.8	03	4.34	06	4.40	02	4.30	03	4.25	17	21.30
10	02	2.85	07	3.20	03	3.40	04	3.01	01	3.15	07	15.80
11	02	1.90	03	2.32	02	2.70	03	2.15	02	2.25	02	11.20
12	02	1.24	00	1.67	02	2.10	01	4.45	01	1.60	06	7.90
13	00	.75	01	1.20	03	1.80	05	1.20		1.80	09	5.60
14	01	.51	01	.87	03	1.60	00	.80	02	1.50	08	4.20
15	02	.50	02	.76	1	1.50			01	1.00	06	3.50
16	00	.50							01	1.00	01	2.80
17	02	.51					01	.80		0.60	03	2.50
18											00	
19					02	1.8					02	1.85
Total	95	95	91	91	87	87	102	102	90	90	465	465
χ^2 (cal)	12.08		7.44		5.96		8.31		4.32		20.40	
Df	6		7		7		7		7		12	
χ^2 at 5% level	12.59		14.07		14.07		14.07		14.07		21.03	

* = Dry-Wet Cycles(Days)

TABLE = 5.7.

Observed and expected frequencies of Wet-Dry cycle.

*	MAY O	MAY E	JUNE O	JUNE E	JULY O	JULY E	AUGUST O	AUGUST E	SEPTEMBER O	SEPTEMBER E	TOTAL O	TOTAL E
2	15	13.87	12	11.52	12	10.00	21	14.10	17	11.15	77	58.70
3	18	17.08	20	14.72	17	12.60	21	17.60	11	14.35	82	75.20
4	17	15.77	16	14.20	14	12.10	13	16.50	14	13.00	74	72.50
5	14	12.92	09	12.10	8	10.00	12	13.80	13	11.95	56	62.70
6	11	10.45	5	9.80	9	8.60	7	10.75	7	9.65	39	49.50
7	2	7.6	7	7.30	6	6.90	9	8.10	5	7.50	29	36.70
8	4	4.75	7	5.80	6	5.50	4	5.80	8	5.70	29	28.90
9	3	3.80	3	4.80	4	4.30	1	4.20	5	5.30	16	21.10
10	2	2.85	6	4.00	1	3.40	2	2.95	0	0	11	15.60
11	0		3	3.00	3	2.80	3	2.10	5	4.20	14	11.10
12	4	2.16			2	2.50	1	1.40	0		7	7.80
13	2	1.50	1	1.86	2	2.00	3	1.00	2	3.20	10	5.50
14	1	1.00			4	1.80	1	0.70	0		6	4.10
15									1	2.00	1	2.60
16	1	0.75					1	0.50			2	2.00
17			1	1.00	1	1.50					2	1.80
18					1	1.00					1	1.50
23	1	0.50					1	0.50			2	1.20
25									1	1.00	1	.50
Total	95	95	90	90	85	85	100	100	89	89	459	459
X^2 (Cal)	4.50		5.40		2.90		6.98		6.72		18.14	
D.F.	6		7		7		7		8		12	
X^2 (at 5%)	12.59		14.07		14.07		14.07		15.507		21.03	

* = Wet-Dry Cycles(Days)

TABLE = 5.8

OBSERVED AND EXPECTED LENGTHS OF DRY SPELL, WET SPELL AND WEATHER CYCLES

(Observed and expected length (in days)

	DRY SPELL		WET SPELL		WEATHER CYCLE	
	Oi	Ei	Oi	Ei	Oi	Ei
MAY	2.83	2.91	2.31	3.35	6.06	6.26
JUNE	2.23	2.36	3.16	3.38	5.2	5.74
JULY	1.86	1.96	4.02	4.39	6.2	6.35
AUGUST	2.72	2.64	2.54	2.70	5.20	5.34
SEPTEMBER	2.51	2.58	2.77	2.09	5.35	5.67
AVERAGE	2.43	2.49	2.96	3.18	5.6	5.87

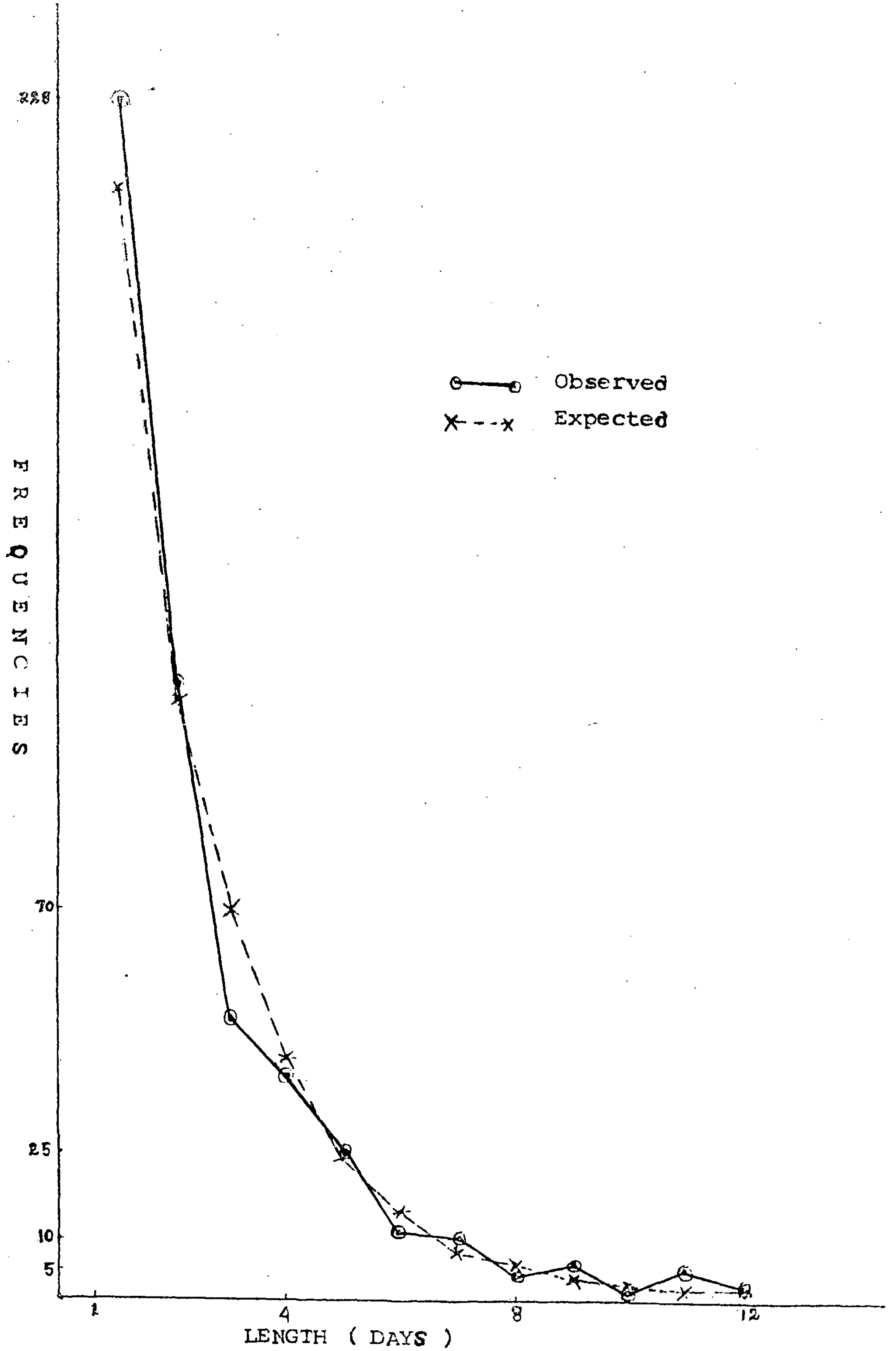

Fig.5.1. Observed and expected frequencies of dry spell (May to September)

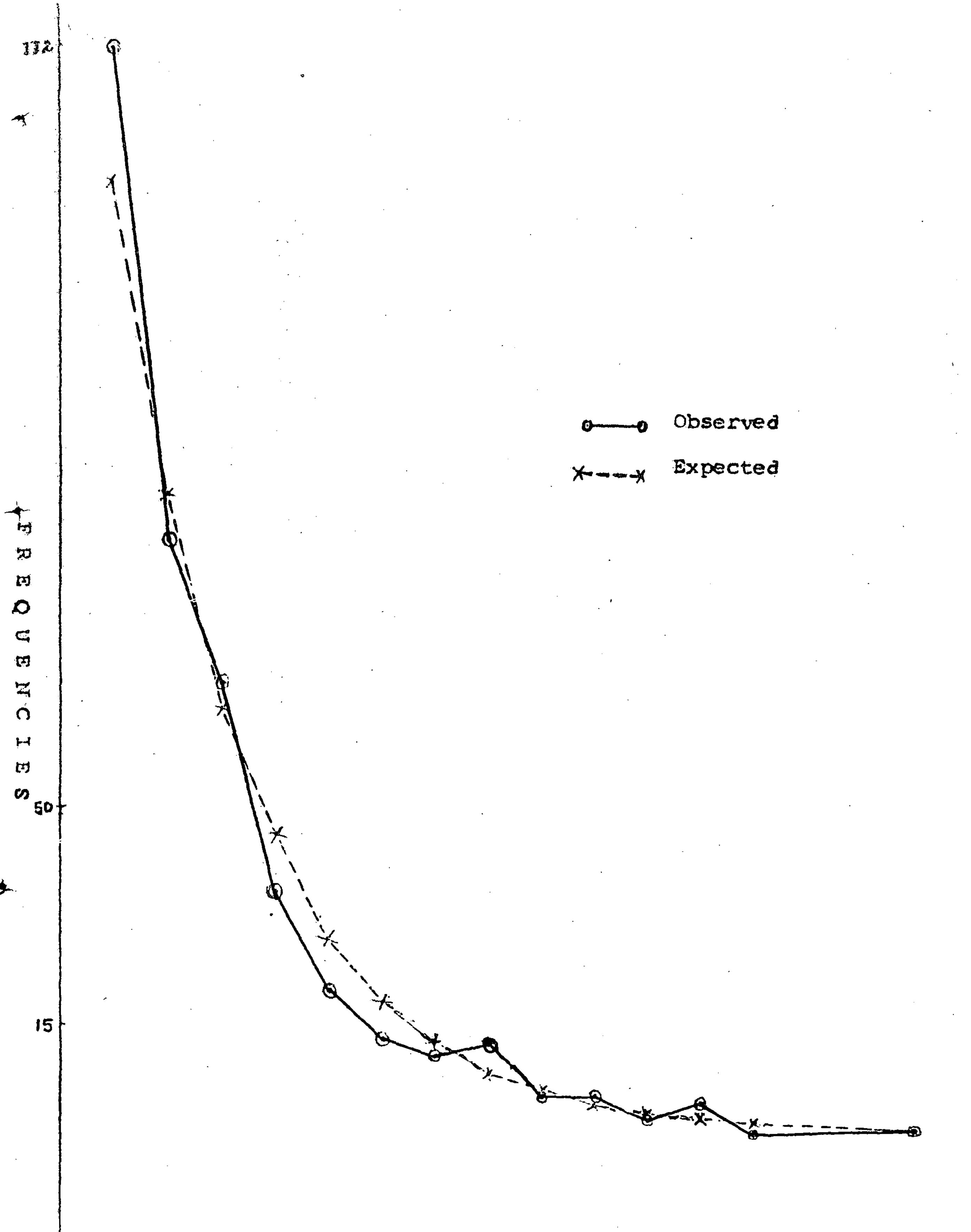

Fig.5.2. Observed and expected frequencies wet-spell (May to September)

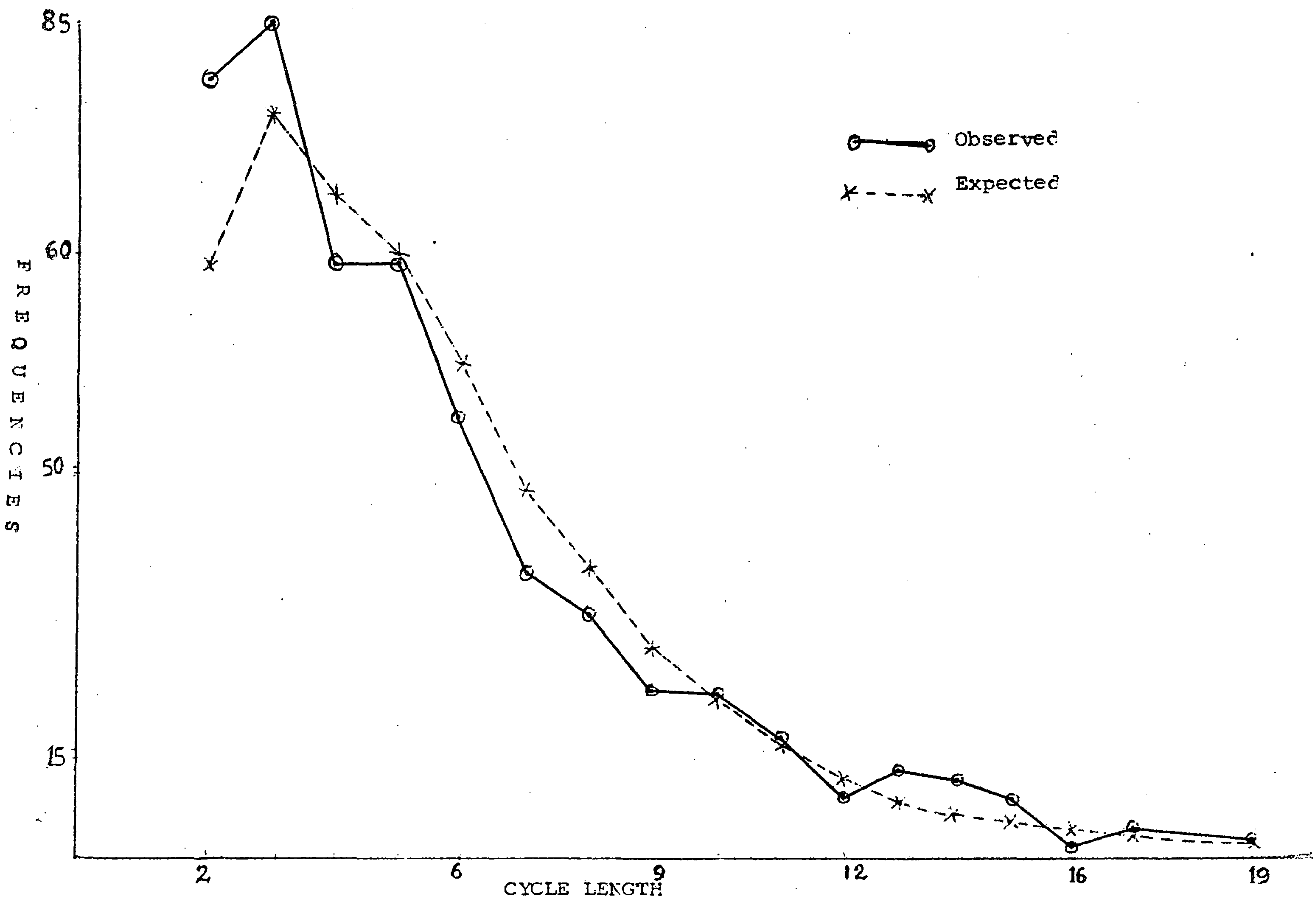

Fig.5.3. Observed and expected frequencies dry-wet cycles during May to September.

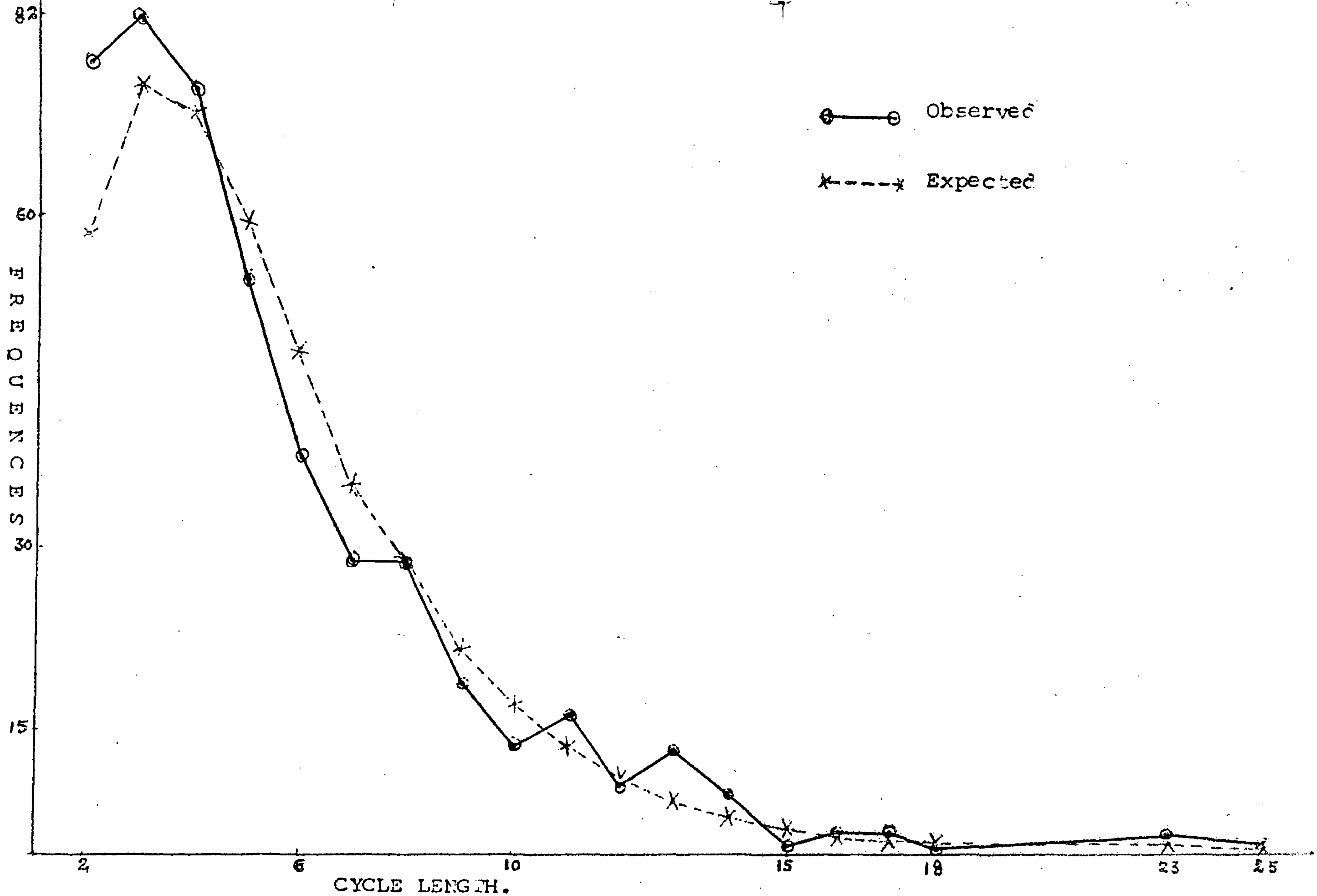

Fig.5.4. Observed and expected frequencies of wet-dry cycles during May to September.