Israel Journal of Entomology Vol. V, 1970

TEMPERATURE DEPENDENCE OF SPODOPTERA LITTORALIS (BOISD.) POPULATIONS IN ISRAEL

E. Rivnay

ABSTRACT

Spodoptera littoralis is more numerous in sites where large fields of summer crops are under irrigation. Crops may be irrigated till late in the summer, therefore the peak in the population of this pest is reached in the autumn, about four months later than in Egypt,

The population of the moth is subject to temperature fluctuations throughout the year, hence no distinct prediction can be made. However, from the records presented herewith, it is apparent that a winter temperature lower than the 15 year average retards the first appearance of the pest, and a spring and summer cooler than the average favour outbreaks.

In recent years Spodoptera littoralis has become more numerous in Israel, resulting in serious outbreaks which caused considerable damage to various crops. Consequently, the status of this pest was definitely altered.
Though there is little doubt that this increase in the population in Israel is due to the extension of irrigated areas, the causes of these outbreaks in certain years need elucidation.

Seasonal temperature changes affect the density of Spodoptera population throughout the year; but does temperature affect also changes of the population densities from year to year and in what way?

This paper is concerned with descriptions of Spodoptera populations over a period of nine years, and aims also at pointing a way to forecast outbreaks.

Methods:

The present study is based on trapping records of adults in various parts of the country. Due to the lack of electrical facilities, the trap was hung in every locality in exposed sites near buildings, and not in the fields. The source of light for traps were mercury vapor bulbs of 125 watts each. The bulb was placed over a funnel to which four perpendicular wings were attached to hinder the escape of the moths. A small fan was installed over the funnel to drive the hovering moths into the container; below the funnel a jar containing insecticide was placed. The average number for every 10 nights is calculated for each site. These records are presented in forms of curves or columns in logarithmic values. The curves depicting the general trend of the Spodoptera population in a given locality (Fig. 1) are based upon the averages calculated from all the years of observation in each of the sites where trapping was made.

Ten-day averages of maximum and minimum temperatures are presented as curves for each particular site and year. In each of these diagrams the average temperatures for 15 years are presented in curves.

Factors affecting population densities of Spodoptera littoralis in Israel.

The food factor: Constant availability of food is the main factor affecting populations of any active insect. Spodoptera littoralis depends on fresh succulent leaves or fruit of several kinds of annual plants for its food. In a semi-arid country like Israel, with no rains during the greater part of the summer, food is not always available. For this reason S. littoralis was less abundant in the early years of this country's colonization than it is today with irrigation extended over large areas, resulting in the availability of succulent plants throughout the summer.

Therefore, sites where large areas are under irrigation have denser populations than sites where no such conditions exist.

Biotic factors: From the moment eggs are laid, to the end of the larval and pupal periods, they are subject to predation and parasitation. How many are devoured and how many are parasitized in the field? We have no definite answers to these questions. According to the observations of Vermes (1961) and those of Egyptian entomologists (Bishara, 1934 and Kamal 1952) some predators, especially in spring, and to a lesser extent in summer attack this pest. However, they never abound in sufficiently large numbers to suppress the host population. Predators usually occur in certain sites and are not uniformly distributed throughout the country.

In a recent study by Gerling (1969) five parasites were reared from Spodoptera larvae taken from cotton fields. They were three Braconid wasps, primary parasites, one Chalcid, a Hyperparasite, and one Tachinid. Only the Braconid Chelonus submuticus Wesm persists throughout the Spodoptera period. Gerling concluded that under prevailing conditions none of the parasites can be considered an agent to check Spodoptera populations.

The virus disease, which on certain occasions caused a high mortality of Spodoptera larvae, occurs as a rule during summer when the insect population has grown. The intensity of a virus attack depends a great deal upon temperature, humidity and density of the population. If these factors persist, the virus may be transmitted from generation to generation (Harpaz et al., 1964) and thus the entire population of a certain field may be exterminated.

Climatic factors: Second to food, climatic factors, (in particular temperature) affect the density of Spodoptera populations in Israel. Unfavourable low temperatures retard the development and induce the mortality of immature stages; in addition, the reproduction of adults is reduced or inhibited. Unfavourable high temperatures (above 26°C) increase the mortality of the existing population of all stages. In addition Rivany & Meisner (1966) found in laboratory studies that temperature and humidity may also have a delayed effect on later stages. Thus detrimental factors which affect larval and pupal stages influence the life span and productivity of adults. It was also found that certain detrimental factors may spare the affected individual but may harm its offspring. Unfavourable climatic conditions may thus affect future populations.

The following is a description of how the Spodoptera populations are affected by temperature fluctuations throughout the year.

Results:

The difference in population densities in the various sites in Israel.

There is a striking difference in the density of Spodoptera populations in various sites as seen in Fig. 1. Large populations occur in the inner valleys, namely; the Jezreel Valley (trap located at Ein Harod) - (Table 1) and the upper Jordan Valley (trap located at Sdeh Nehemia) - (Table 2). In these localities hundreds of moths were trapped during one night, at the height of the season, in years of dense Spodoptera populations.

In Jerusalem the population is smaller - (Table 3). Very seldom were there more than 100 moths caught in one night. Populations along the coastal plain, (Rehovoth and Dor), are smaller still, although the season of activity extends over six months. (Tables 4 & 5). At Elat the moth is on the wing only at the end of the summer and autumn, when only a few moths may be caught in one night (Table 6).

Trapping at Ein Harod.

Ein Harod (traps were installed at Bet Sturman) records are for five years (1964-68). The trap at this site caught the largest number of Spodoptera moths - (Fig. 1, Table 1). Unlike other localities, in this site, moths were caught in considerable numbers also during the winter months. In poor Spodoptera years 1964, '65 & '68) the average nightly catch in October, a peak month, ranged from 18 to 88; the nightly average in the outbreak years (1966 & 67) was 266 and 613 moths respectively. As a rule, October was the peak month (except for 1964 when more moths were caught in November).

In our effort to study the causes for population discrepancies in two different years both temperature and populations of 1965 & 66 were compared (for Ein Harod). 1965 was a poor Spodoptera year; whereas in 1966 there was a denser population (Figs. 2 & 3 and Table 1).

As we compare the two curves depicting the temperature fluctuations during the two years, we find three probable factors, responsible for the discrepancies in the densities of the populations:

1) January, 1965 was cooler than that in 1966 (averages 12.4°C and 13°C, respectively); the population development in 1965 was retarded thereby.

2) April 1965 was also colder than that of 1966 (18.9°C as compared with 20.8°C).

3) The maximum temperatures of June 1965 were more detrimental to the moth than in 1966. (Fig. 3). As a result, the number of trapped moths decreased in 1965 but increased in 1966. Thus in August, 1966 the population was nine fold that of 1965 (Table 1).

The cause for the difference in the population densities in 1967, the outbreak year, and 1968, the poor Spodoptera year lies also in the differences in the temperatures in spring and summer of the two years (Fig. 4 & 5). As a result, the population in 1967 from April continued to rise till October; whereas that of 1968 which in June was only a third that of June 1967 - decreased still further (Table 1).

Trapping in the Hula Valley.

Hula Valley (trap installed at Sdeh Nehemia) records extended for six years (and partial records for two additional years). It is evident from the records of this period (1963-1968) that in some years remains from the population of the previous year continued to be on the wing during January-March. (As a rule a fraction of one moth per night.). In February, moths were trapped only in years when the average temperature rose above 13°C. In April new moths began to appear and their number increased steadily so that by July & August tens of moths were caught each night. In August, 1963, over 1000 moths were caught every night. The occurrence of the peak of the population varied each year.

In the Hula Valley the outbreak of the decade occurred in 1966, and not in 1967 as was the case in the Jezreel Valley, Jerusalem and other sites. 1963 was a rich year in Spodoptera, a fact which was not especially noticed in other sites.

Temperature curves for the Hula during 1966 & 67 are presented in Fig. 6 & 7. It can be seen that the winter months of 1966 were quite warm, permitting the development of a fair initial population. A mild July and early August caused a boost in the population, when over 300 moths per night were caught. September & October, were also mild thus causing a catch of 450 moths per night in November. In 1967, on the other hand, winter was too cold and spring was also cool enough to prevent a build up of the population. January March temperatures were 10.1, 10.7° and 11.9°C, respectively. In fact, no moths were caught till June. Early July was cool and the increase of moths was slow. From August, temperatures were more favourable and the number of moths increased but was still lower than in August, 1966 - only 12 moths were caught in a night in 1967 as against 300 in 1966. Late October was more favourable in 1966 than it was in 1967, hence the big discrepencies in the populations of the two years.

In 1963 a cool October (aver 13.6°C), and too warm April (18°C) caused a build up of dense populations which continued to increase throughout May, June and the first half of July. Temperatures were then below the 15 years average and thus two generations developed. The already existing dense population in August was allowed to increase during the mild September and warm October, attaining a record number at the end of that month. The cause for the exceptional increase was therefore a warm winter, mild favourable spring and favourably warm autumn.

It was stated before that the cool spring in 1967 at Ein Harod was a factor which promoted the increase of the Spodoptera population; whereas in the Hula it prevented it. Comparing the data for these two localities, we find a difference of a few degrees between the temperatures in the two localities. In other words, in the Hula the temperature was too cool to favour its development.

Trapping in Jerusalem.

The climax of the moth population is usually in September - October. Often it is earlier, as happened in 1959, 1963, and 1968.

As to the comparative abundance of the population each year, we find "poor" Spodoptera years in which the monthly average at the height of the season ranged from a fraction of a moth to one moth per night as was the case in 1961, 1962, 1964 and 1965. In 1959 and 1963, 8-21 moths per night was the monthly average. In the rich Spodoptera years 1960, 1966 and 1967 over 30 moths per night were caught at the height of the season. Of these, 1967 was an outbreak year, over 100 moths per night were caught in September.

Table 3 presents the catches of Spodoptera moths for the years in Jerusalem. Each figure gives the monthly average number of moths caught each night. It is apparent that no moths were caught during the winter months January-March, when the average temperature did not rise above 14°C. Occasionally, in cooler years this quiescence extended to include April, as was the case in 1967 and 1968, when the average temperature remained below 11°C. In 1964 cool temperatures persisted (18° C) in May causing a longer quiescence.

Fig. 8 & 9 present temperatures during 1960, a rich Spodoptera year, and that of 1961, a poor Spodoptera year. Comparing the temperatures we find no significant difference in summer temperatures. The difference in temperatures of the winter and early summer may occount for the discrepancies of

Spodoptera populations in these years. The 1960 winter and early spring was very mild and warm (the average temperatures for January - March were 10.3, 12.5 and 12.9°C, respectively), thus giving a boost to the initial Spodoptera population whereby one moth was caught each night in June, and 58 each night in the peak months - September. The winter of 1961 on the other hand, was extremely cold and prolonged, (the average temperature January, February and March was 9, 7.8 & 10.4°C respectively), thus checking and retarding the activity of the moth. In addition, the too low population in May 1961 received a severe blow in early June when several Khamsene days occurred; the average maximum temperature being 32.31 (absolute maximum - 37.5°C), coupled with a low relative humidity of about 40% (In 1960 the average maximum temperature in that period was 30°C, absolute maximum - 34.8°C). Thus the population remained low so that only one moth was caught in the peak month - September.

The temperature for 1967, a Spodoptera year, and 1965 a poor Spodoptera year, are presented in Fig. 10-11. In these years winter temperature were not responsible for the discrepancies in the population; in fact the winter temperature of the Spodoptera year 1967 was colder than that of 1965. It is more likely that the cause was in the summer temperatures which were milder in 1967 than in 1965. Throughout the summer of 1967 the temperature remained below average; (The temperatures for May, June and July were 18, 21 and 22.9°C, respectively) as compared with 19.3, 24.7 and 24°C for 1965. There were no severe "Khamsene" days in 1967, and the absolute maximum temperature for June 1967 was 35.5 as compared with 38.3 of 1965. Thus during the peak month - September - 96 moths were caught each night in 1967 and only 3 in 1965.

Trapping in Rehobot. (Table 4)

The differences in moth trappings during the various years are not outstanding different, so that no effects of temperature on the populations can be deduced.

Trapping in Dor (Tantura) (Table 5).

The population of S. littoralis at Dor was, with the exception of 1967 low throughout the period of study and no distinct differences were observed.

Trapping in Elat (Table 6).

The moths caught at Elat did not develop there, and therefore should not serve as a criterion for a climatic influence.

Discussion:

The effects of the Israeli climate on the population densities of S. littoralis will be better understood if we recall here the reactions of this moth to temperature fluctuations. Optimal temperatures for the insect are between 22-26°C. Temperatures above 27°C became detrimental to the moth at all stages of development. At high temperatures, mortality increases and rate of reproduction drops.. Furthermore, reproduction is impaired even if only immature stages are subjected to detrimental temperatures. Exposure of immature stages to temperatures above 34°C increase the number of sterile females, and many of the eggs that are laid are nonviable. (Rivnay & Meisner 1966). As to temperatures below the optimum, at 15°C no reproduction takes place. At 10-12°C no development takes place as the insect is in a state of quiescence.

During winter in the coastal plain, with temperatures fluctuating between 2°C to 30°C, averaging 15°C, the development from hatching to emergence of adults lasted over 50 days, but only one percent of all individuals survived (Rivnay, - unpublished).

These values explain the scarcity or absence of moths during winter in various parts of Israel.

In other words the population of the insect in Israel is subject to temperature changes throughout the year.

Hosny and Ishak (1968) suggested a formula enabling prediction of outbreaks of Spodoptera. According to these authors there is a critical period - namely February-April, at which temperatures control the density of Spodoptera population of that year. They found that during the outbreak years 1934, 1948, 1961 and 1967, the temperature during the critical period was relatively lower than during normal years. This formula applied to provinces in Egypt and is based on counts taken there. But a formula with such a vague description "relatively low" can not be useful. Thus, that "low temperature" which may have been favourable for this pest in certain localities in Egypt, could be unfavourable in other sites where the pest abounds.

Furthermore, the peak of the Spodoptera population in Egypt occurs in June (Bishara 1934); whether due to too high temperature in July and August, or whether due to the lack of food, after the termination of the cotton growing period, a drastic drop in the population in Egypt starts in July continuing to the end of the season. In view of this, April temperature in Egypt may have an influence upon populations in June.

In Israel, on the other hand, Spodoptera continues to develop and change till the end of the summer - the peak occurring in September or October, and sometimes even as late as November. This may be due to irrigation of cotton and subsequent crops which continues till late in summer. In Israel from the various records presented in the foregoing paragraphs it may be seen that temperature in spring and later in June & July affect insect populations that survived after the winter. A mild temperature during these months will cause an increase in numbers; whereas too high temperature will suppress the Spodoptera populations. Also conditions in October and November will influence the onset of the end of the season.

In view of this one cannot predict the conditions of the Spodoptera population for the entire season, because there are no weather forecasts for periods longer than a few days. However, fortelling conditions for two or three months can be made under certain conditions. For instance a cold winter will cause a reduction in the number of the first moths emerging in the season and a retardation in their appearance. A mild or cool May-June will boost the population which will be on the wing in July-August. Too cool a winter and spring may retard and interfere with the normal development of the pest. A good illustration for this one may be found comparing the temperature conditions of and population numbers for the year 1967 in the Jezreel and Hula Valleys. The temperature that year was "cool" and favorable for the moth in the Jezreel Valley, but too cold for it in the Hula Valley.

Table 1

Average nightly number of moths trapped at Ein Harod

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1964	0.2	0.1	0.5	0.9	0.7	4.3	2.7	9	23.5	92.2	46	3.23
1965	0.15	0.5	2	1.5	5.74	8.0	6.3	10	28	88.25	102	20.5
1966	1.65	0.6	3	4.87	14.7	23	50.85	94	112.6	266	269	28.6
1967	1.1	0.4	0.3	1.0	2.25	28.6	55.0	263	491.4	613.4	244.2	20.5
1968	0.3	0.25	0.4	0.5	10.6	12.5	5.86	2.3	12.5	18.7	24.63	3.6
Average	0.9	0.37	1.24	1.75	6.66	15.3	15.2	75.6	133.6	215.6	137	15.2

Average nightly number of moths trapped at the Hula valley

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1959									46.4	68.8	19	2
1960				2.15	12	6.74	62.8	92.7	40.15	43	18	13
1961-62				trap	not	functioning						
1963	0.25	0.05	0.3	2	13	50	55.4	105	159.3	54.66	74.5	2
1964	0.25	0.0	0.08	0.43	2.43	3.2	7.77	36	77.4	129.2	107	5.4
1965	0.06	0.0	0.76	2.32	5.25	22.8	32.8	63.6	86.8	74.2	42.2	25.4
1966	0.5	0.1	0.5	1.4	2.5	9.5	26.15	140	151.4	321.6	351	29.5
1967	0.2	0.0	0.0	0.0	0.0	2.4	10	12.4	35.5	211.5	48	6.15
1968	0.1	0.0	0.0	0.08	0.53	1.2	1.5	9	22	19.1	16.1	3.2
Average	0.226	0.025	0.27	1.2	5.09	13.4	28.6	88.6	77.36	176.75	97.5	3.2

Table 3

Average nightly number of moths trapped in Jerusalem

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1959						0.7	10.3	21.0	13.6	14.2	1.6	0.02
1960	0	0	0	0.03	0.45	1.2	5	37.4	58.0	16.0	6.75	0.05
1961	0	0	0	0.03	0.06	0.06	0.13	0.66	1.0	0.33	0.2	0.0
1962	0	0	0	0.03	0.3	0.00	0.1	0.03	1.0	0.7	0.5	0.0
1963	0.0	0	0	0.03	0.03	0.3	0.15	17.0	8.5	9.5	6.1	0.6
1964	0.3	0	0	0	0	0	0.25	0.35	1.0	1.1	2.0	0.0
1965	0	0	0	0.1	0.25	0.2	0.6	0.3	3.0	1.1	1.0	0.3
1966	0	0	0.03	0.12	0.6	2.7	8	11.0	34.0	33	0.0	0.8
1967	-	-	-	0.	1.3	3.4	9.7	17.5	104.0	68.0	4.2	0.2
1968	0	0	0	0	2.5	5.5	5.7	34.5	17.0	0.7	0.0	0.0
Average	0.03	0	0	0.03	0.54	1.4	4.0	14.0	24.12	14.63	2.25	0.2

Table 4

Average nightly number of moths trapped at Rehobot

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1960		0.5	0.3	0.2	0.9	3.86	5.3	4.75	1.5	0.73	3.7	1.3
1961	0.35	0.0	0.1	0.2	0.6	1.5	1.5	2.3	2.2	1.15	1.5	1.2
1962	0.03	0.0	0.03	0.1	0.3	1.3	1.1	1.5	0.8	4.1	9.5	1.6
1963	0.16	0.06	0.2	0.6	0.75	0.87	4.0	6.0	2.1	4.3	1.0	0.25
1964	0.0	0.0	0.0	0.0	0.06	0.5	0.6	1.65	1.85	3.25	1.7	0.03
1965	0.0	0.0	0.0	0.15	0.75	0.8	0.3	1.6	2.7	2.4	5	3.7
1966	0.3	0.05	0.06	0.3	0.45	2.0	1.2	1.78	1.8	1.8	9.0	2.0
1967	0.3	0.0	0.0	0.0	0.0	0.3	0.82	8.0	40.1	32	18.0	1.0
1968	0.0	0.0	0.0	0.03	0.7	1.3	1.0	0.5	6.5	7.7	0.83	0.06
Average	0.15	0.06	0.1	0.2	0.5	1.36	1.8	3.3	6.6	6.3	6.0	1.1

Table 5

Average nightly number of moths trapped at Dor

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1960	0	0.4	0.43	0.2	0.9	3.83	5.3	4.36	1.6	0.68	3.3	1.25
1961	0.2	0.03	0.1	0.2	0.7	1.4	1.0	1.85	2.2	1.2	1.0	0.2
1962	0.03	0.0	0.03	0.03	0.34	1.3	1.1	1.3	0.8	4.13	9.0	1.5
1963	0.2	0.15	0.2	0.6	0.7	9.2	4.0	5.9	4.0	4.0	1.0	0.3
1964	0	0	0	0	0.1	0.5	0.6	1.6	1.4	3.2	1.8	0.03
1965	0	0	0	0.2	0.7	0.6	0.3	1.65	2.7	2.5	4.75	3.0
1966	0.3	0.06	0.13	0.33	0.45	2.0	1.2	1.8	2.0	1.8	8.9	2.0
1967	0.3	0	0	0	0	0.3	0.8	8.0	41	31.7	18.4	1.0
1968	0	0	0	0	1.1	1.7	1.1	0.5	6.5	7.0	2.7	0.08
Average	0.1	0.07	0.1	0.17	0.9	2.3	2.	3.	6.9	6.1	5.6	0.9

Table 6

Average nightly number of moths trapped at Eilat

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1959	0	0	0	0	0	0	0	0	1.25	1.3	0.	0
1960	0	0	0	0	0	0	0.85	1.15	4.2	1.58	0.03	0
1961	0	0	0	0	0	0.03	0.1	5.0	7.4	1.6	0	0
1962	0	0	0	0	0	0	0	0	4.3	0.3	0	0
1963	0	0	0	0	0	0.2	0.3	0.5	3	2.87	0	0.08
1964	0	0	0	0	0	0	0	0	1.6	0.65	0	0
1965	0	0	0	0	0	0	0	0	1.5	0.3	0.03	0
Average	0	0	0	0	0	0.03	0.2	1	3.3	1.2	0.01	0.01

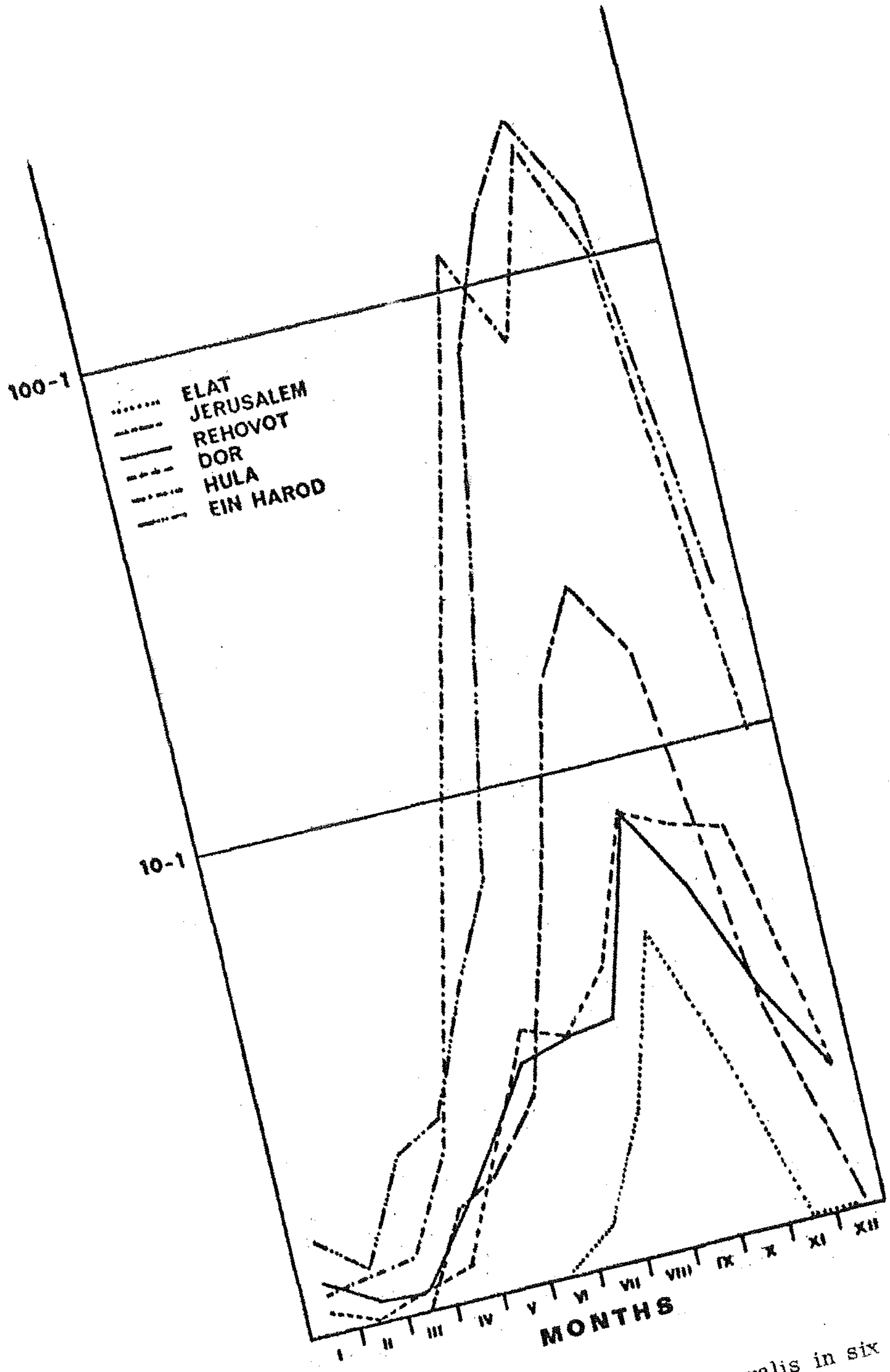


Fig. 1. Population densities of Spodoptera littoralis in six different localities in Israel (5 - 10 years monthly average).

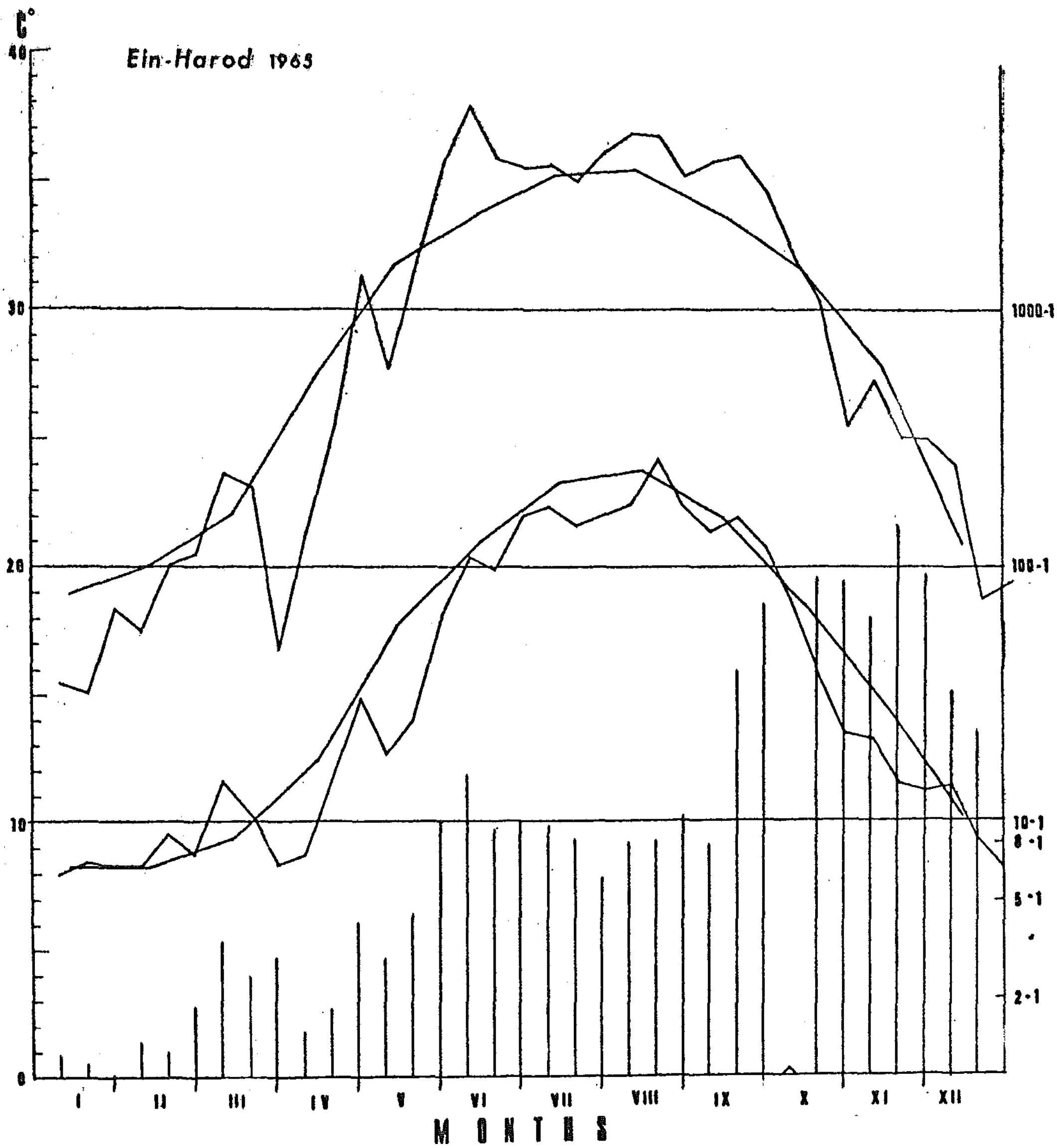
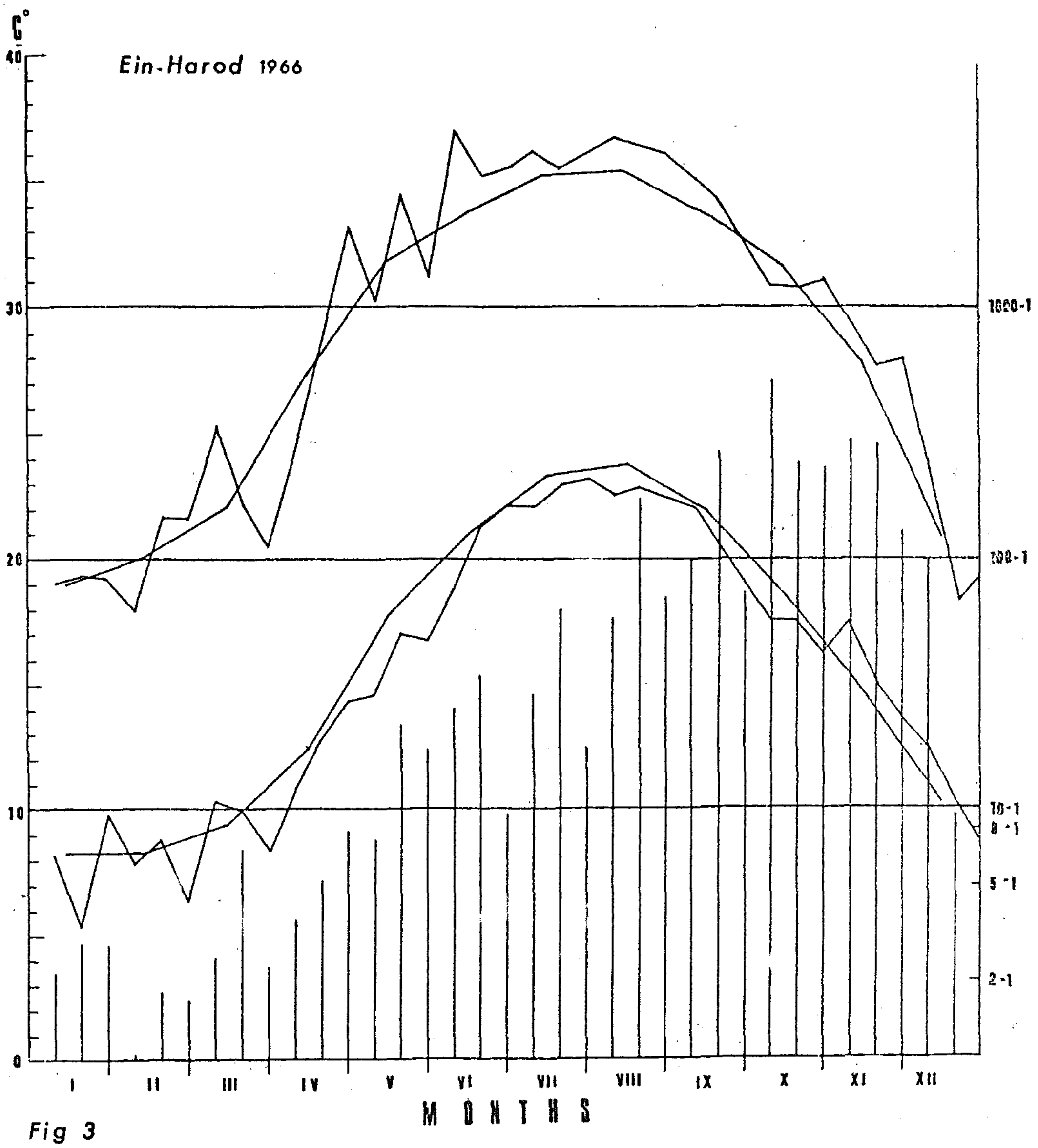


Fig 2

Fig. 2.-11. Annual population densities of Spodoptera littoralis in different localities and years as written on the left side of each graph. The smooth curves indicate the average monthly maximal and minimal temperatures (15 years average) at the locality. The spiked curves record the maximal and minimal temperature (average of 19 days) of the year indicated. The vertical lines give the number of moths caught during 10 nights at a logarithmic scale.



C°
40
30
20
10
0
Ein-Harod 1966
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 3

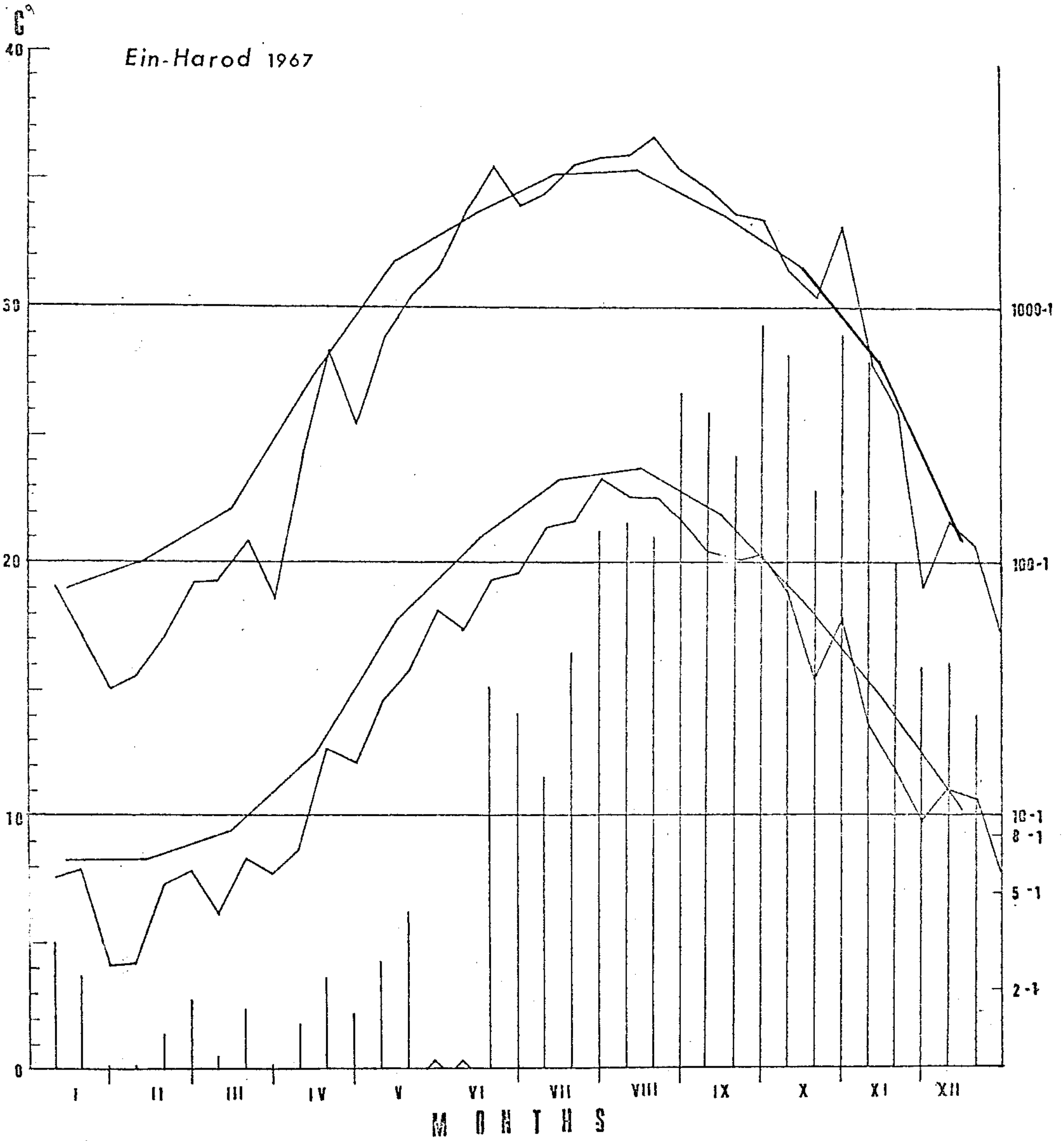

C°
40
30
20
10
0
Ein-Harod 1967
1000-1
100-1
10-1
8 -1
5 -1
2 -1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 4

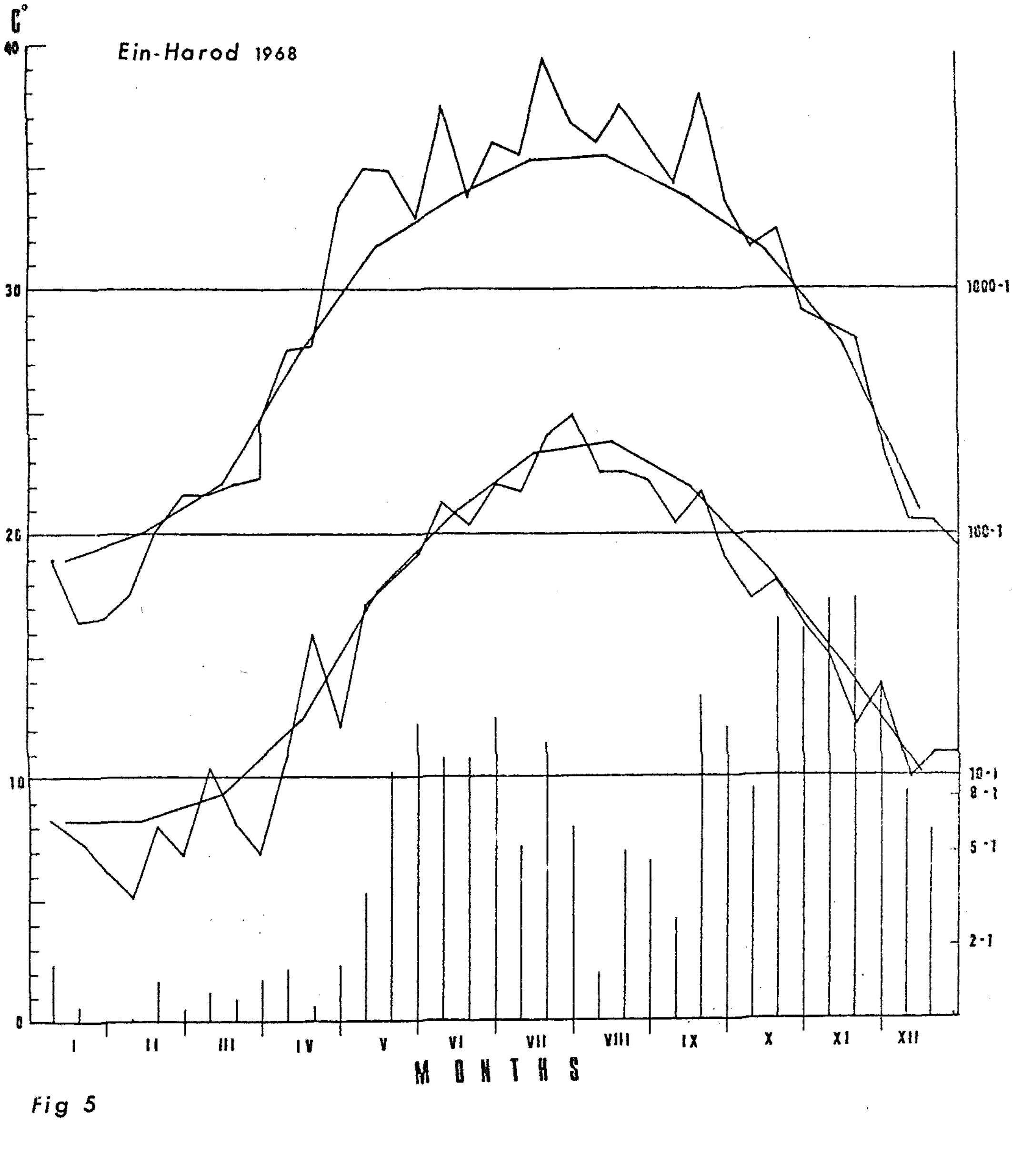

C°
Ein-Harod 1968
40
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 5

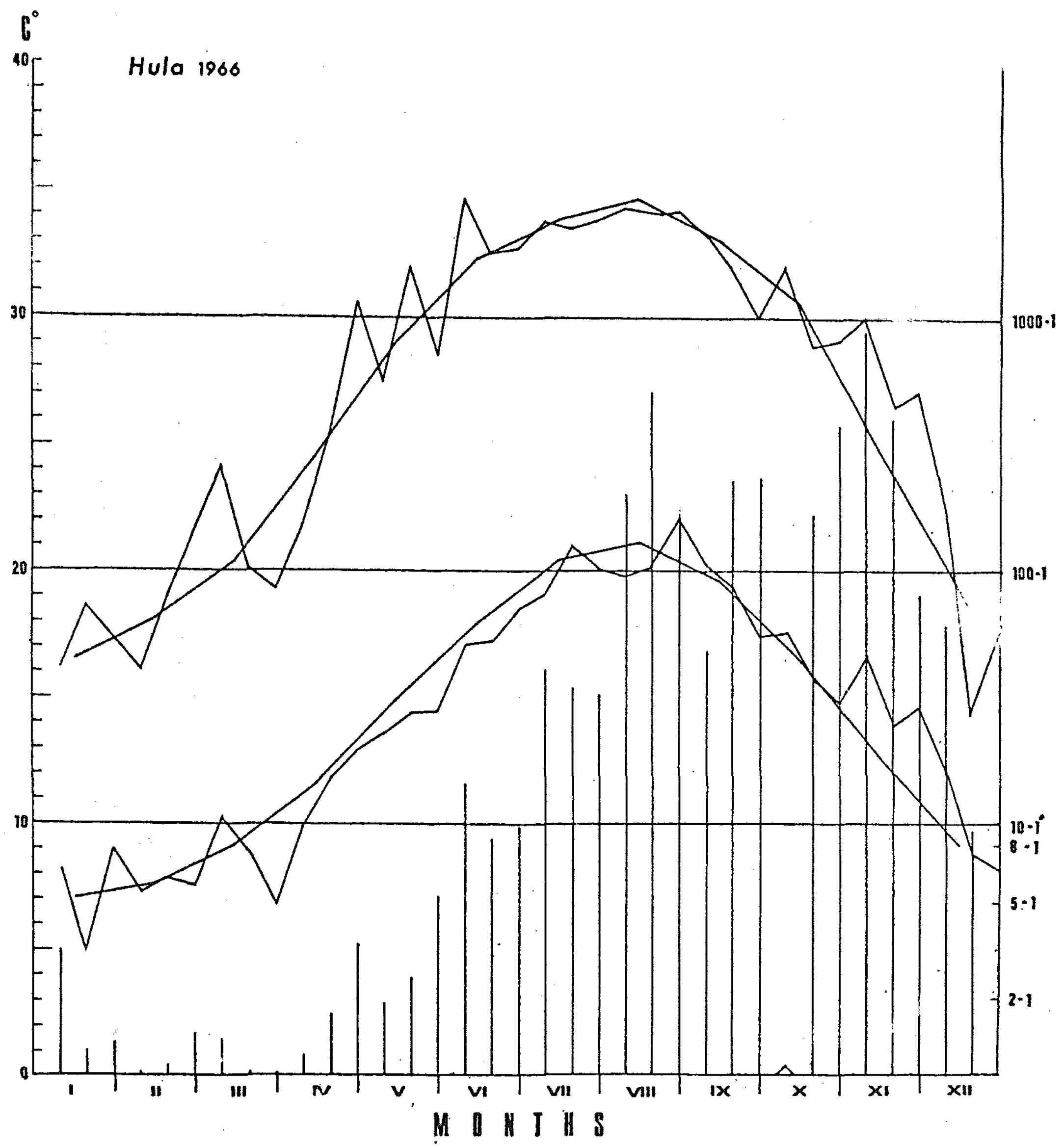

C°
Hula 1966
40
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 6

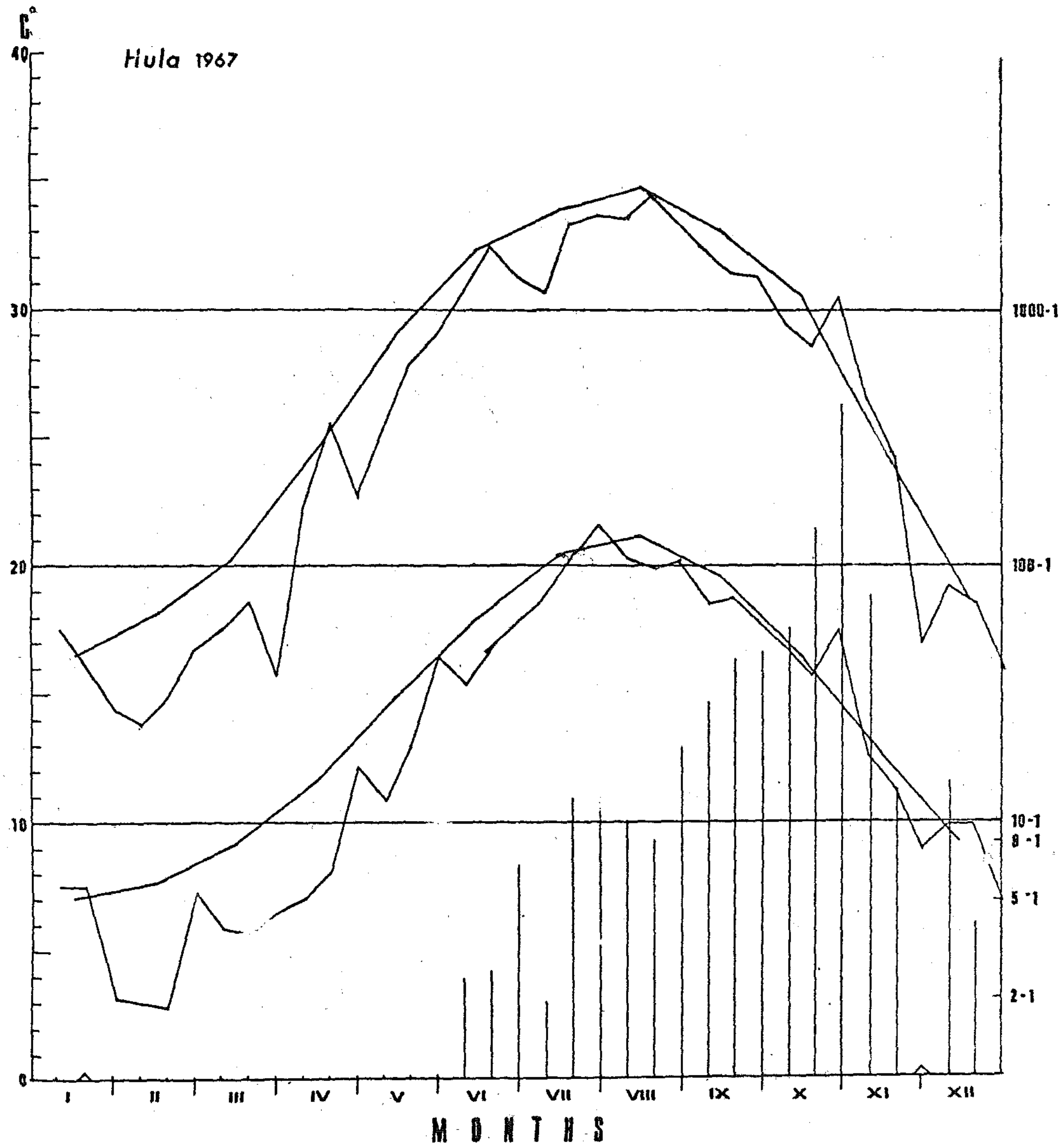

C°
40
Hula 1967
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 7

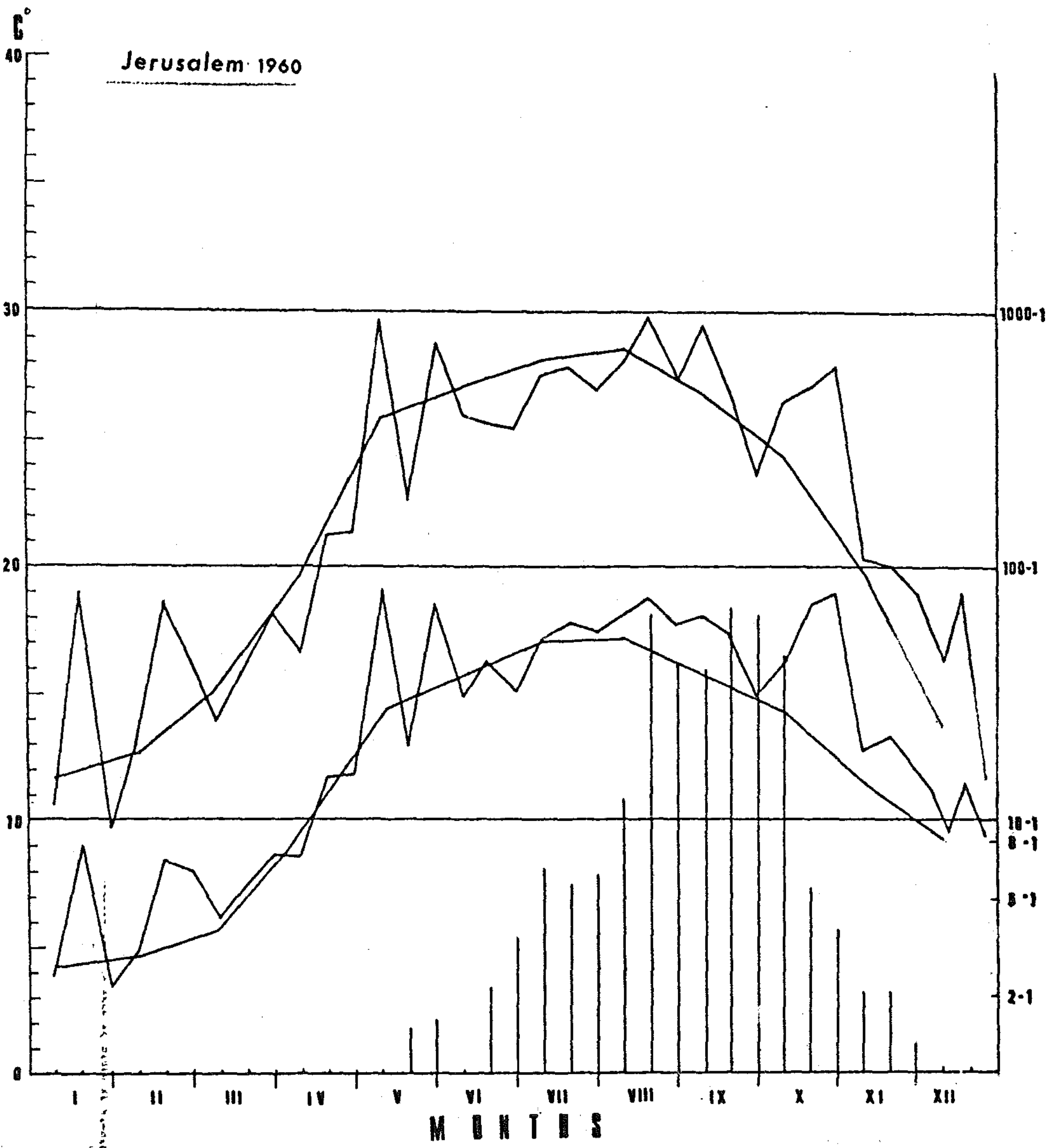

C°
Jerusalem 1960
40
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 8

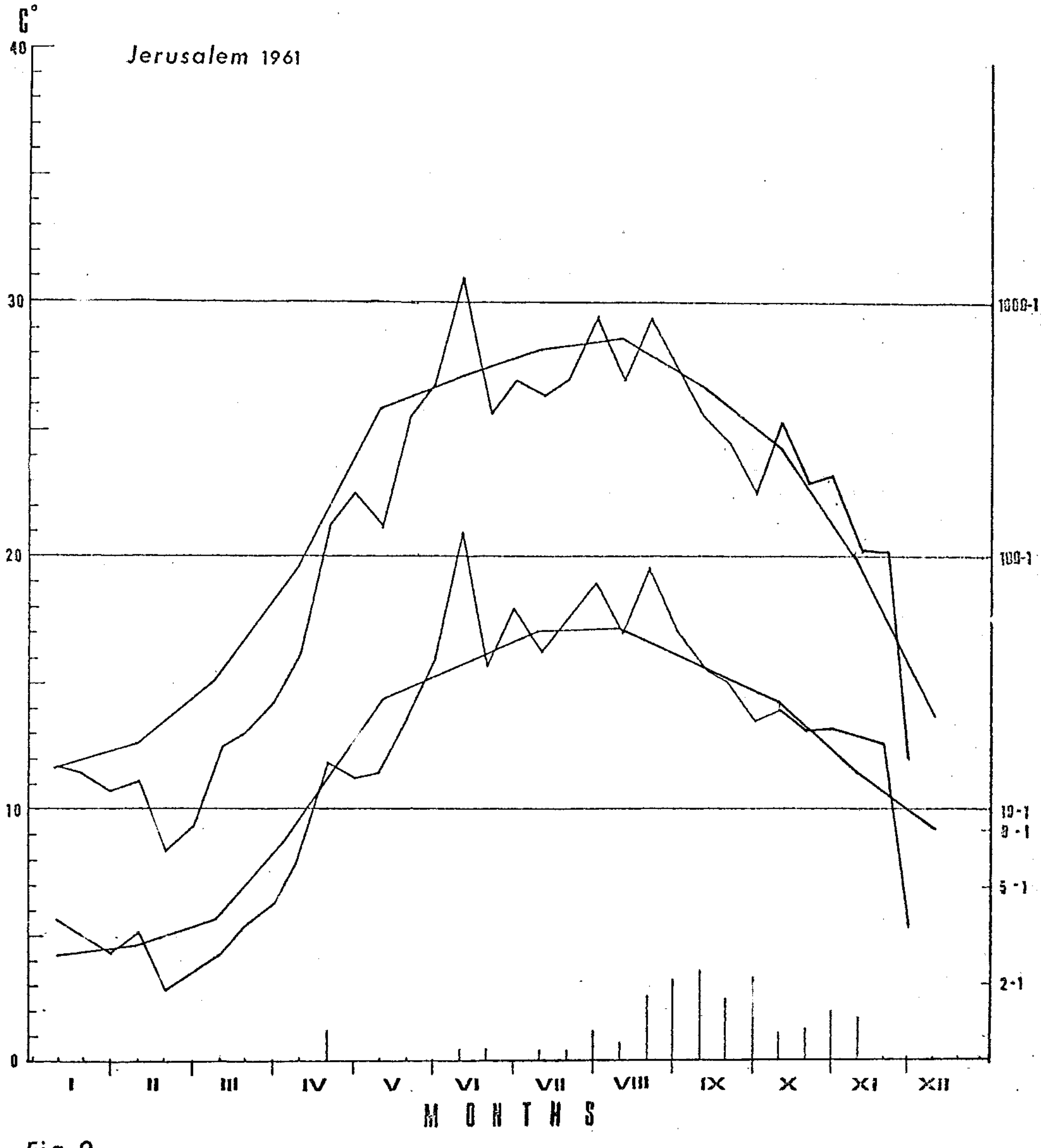

C°
Jerusalem 1961
40
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 9

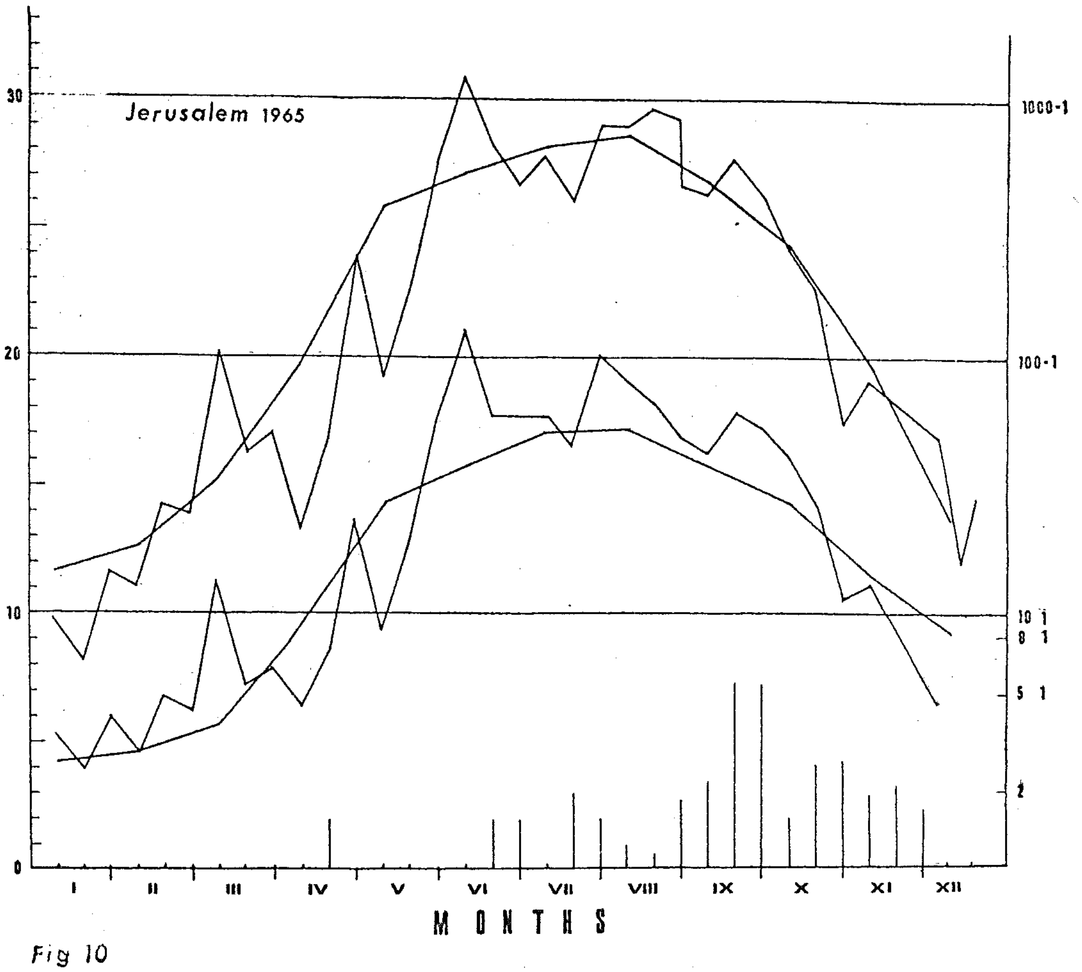

Jerusalem 1965
30
20
10
0
1000-1
100-1
10 1
8 1
5 1
2
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 10

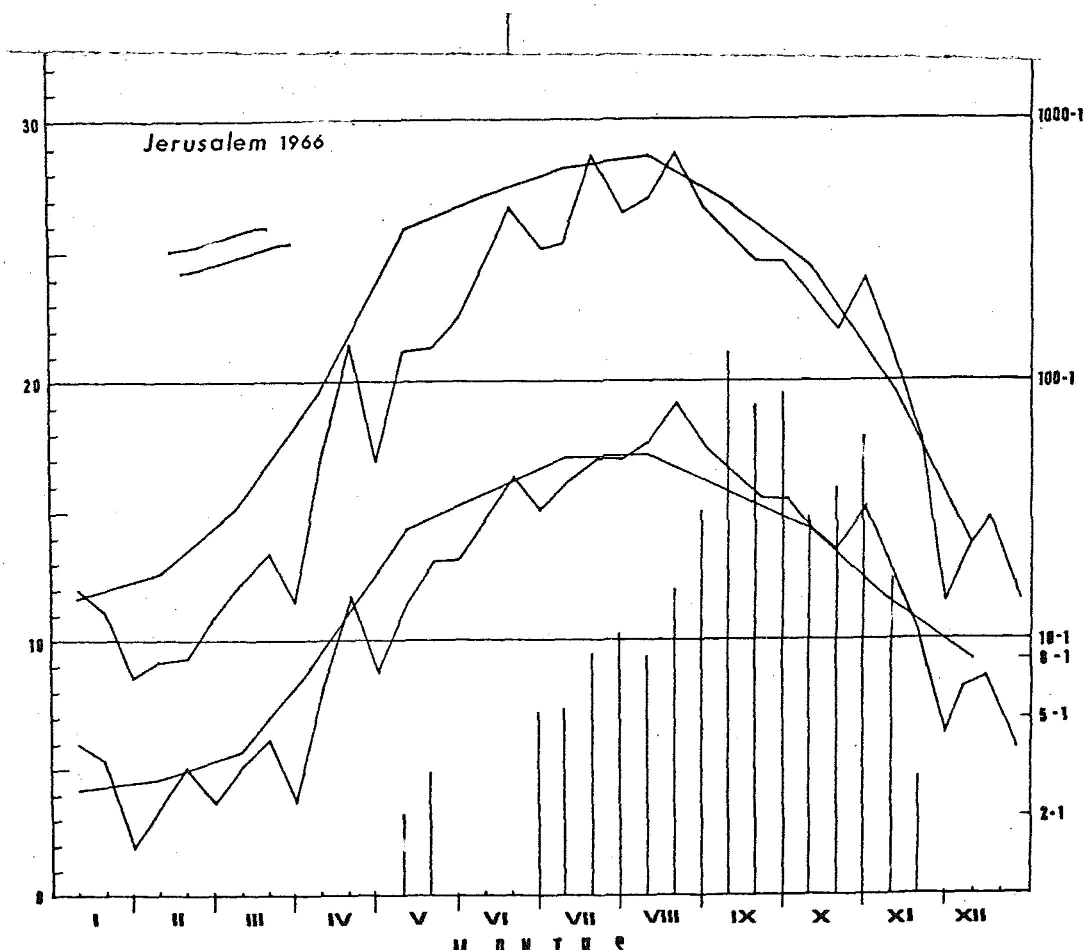

Jerusalem 1966
30
20
10
0
1000-1
100-1
10-1
8-1
5-1
2-1
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
MONTHS

Fig 11

REFERENCES

Bishara, Ibrahim. 1934. The Cotton Worm Prodenia litura F. in Egypt. Bull. Soc. Royale Entomologique d'Egypt 18 : 288-18.

Gerling, D. 1969. The parasites of Spodoptera littoralis Boisd. (Lepidoptera, Noctuidae) eggs and larvae in Israel, Israel Journ. Ent. 4 : 73-81.

Harpaz, I. and Shaked, B 1964. Generation to generation transmission of nuclear polyhedrosis virus of P. litura (Fab.). Journ. Ins. Pathology 6 : 127-130.

Hoshy and Ishak. 1968. Report given at the 2nd circumediterranean Conference on Crop Protection and Phyto-pharmacology. Nice, France IX. 18-20.

Kamal, M. 1952. Investigations on the biological control of the Cotton Leaf Worm Prodenia litura in Egypt. Trans. 9th International Cong. Ent. : 757-765.

Rivnay, E. and Meisner, J. 1966. The effects of rearing condition on the immature stages and adults of Spodoptera littoralis (Boisd.). Bull. ent. Res. 56 : 623-634.

Vermes, P. 1961. Report on a survey of injurious and beneficial insects in cottom fields, in 1961. Submitted to the Cotton Production and Marketing Board.