

FURTHER INVESTIGATIONS ON THE ECOLOGY OF THE OLIVE FLY (*DACUS OLEAE*, GMEL.) IN ISRAEL ¹⁾

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The Olive fly is the most important pest of olives in Israel as well as in other Mediterranean countries. Some aspects of the bionomics of this pest have already been uncovered and records of the fly's occurrence in different regions of this country have been published elsewhere (5). In the course of this work, it soon became evident that only by a long range research program with a wide scope could some light be thrown on the many obscure aspects of the pest's occurrence in this country.

While the bionomics of the Olive fly are still being investigated, substantial information has been gathered these last few years on the pest's ecology in the coastal plain of this country. In view of this, the discussion to follow will be mainly concerned with ecology rather than biology. Also, since research is to continue for some years yet, the results presented here and the conclusions drawn from them are preliminary.

A. NUMBER OF GENERATIONS AND LENGTH OF THEIR LIFE-CYCLES

During the years 1950—1951, infested olives were collected at weekly intervals from groves situated in the coastal plain. Such olives were those presenting exit holes or "panes" of intact epidermis hiding pupae or larvae close to pupation. Collecting started in June and continued until mid December, the olives being brought each time to the laboratory for rearing purposes. From the rearing jars the dates of emergence of the different generations of the Olive fly were obtained. Thus it was concluded that in the coastal plain this pest generally raises four generations per year. The dates of emergence for the different generations were as follows:

First generation	first two weeks of July
Second "	last two weeks of August
Third "	last two weeks of September
Fourth "	from the beginning of November until the beginning of February.

Naturally, each year there were slight differences in the dates of first emergence, particularly as regards the second and third generations.

During the period 1952—1953, olives were again collected at weekly intervals and their infestation assessed starting from the beginning of June. Each puncture was examined with great care under the stereoscopic microscope and the presence of eggs or maggots ascertained. Thus it was seen that for the period concerned, oviposition started on the 10th of June or thereabouts. In view of this it was concluded that the life-cycle of the second and third generations lasts about 30 days, while the first and fourth generations require approximately 40 days to complete their development.

Since flies belonging to a given generation do not emerge during the same week, there are differences in the duration of the life-cycle in each generation, particularly so as regards the fourth. Also, some individuals may produce only three generations per year, while under certain conditions, others may produce as many as five.

¹⁾ Agricultural Research Station, Rehovot, 1954 Series, No. 54.

TABLE 1. — MONTHLY EMERGENCE FROM BREEDINGS

<i>Olives collected in</i>	<i>Numbers infested</i>	<i>Numbers of flies emerging</i>	<i>Percentage of emergence</i>
VII	250	90	36.0
VIII	250	51	20.4
IX	115	10	8.7
X	60	7	11.7
XI	265	67	25.3
XII	130	5	3.8

During the span of a season many last stage larvae or pupae do not reach the adult stage. Thus it was seen that flies of the first generation emerged from scarcely one third of the infested olives, and emergence was even less as regards the second and third generations (20 and 9% respectively). However, the percentage of emergence of fourth generation flies was somewhat higher, viz. an average of 17% for the period October-December (table 1).

On a yearly average the number of males emerging from infested olives equalled that of the females (table 2). This was also true as regards the first generation, but females of the second generation made up slightly more than a third of the aggregate of the flies that emerged. As regards the last two generations, the percentage of females steadily increased until it eventually became larger than that of the males.

TABLE 2. — SEX-RATIO IN LABORATORY BREEDINGS

<i>Generation</i>	<i>Month of emergence</i>	<i>Total number of flies</i>	<i>Percentage of females</i>
First	VII	156	50.0
Second	VIII	114	36.8
Third	IX	16	62.5
"	X	22	36.3
Fourth	XI	26	61.5
"	XII	100	48.0
"	I	44	81.8
"	II	10	60.0
		488	50.0

B. LONGEVITY

During the period 1950–1953, flies were specially bred in order to determine the life-span of individuals emerging during the different months of the year. A large number of olives containing maggots were kept in the laboratory, and the flies emerging from the pupae were transferred to breeding jars and fed by means of cotton wool soaked in a solution of sugar in water.

48 out of the 184 flies used for these observations having died within 5 days of their emergence (approximately 32%), they were not included in table 3, nor were they taken into account in the calculations that follow. Thus there remained 68 males and 68 females.

Males of the first two generations (July and August) lived slightly longer than females, while the reverse was true for the third generation (September). The mean longevity of fourth generation males (November-February) was 60 days as compared with 64 days for females.

TABLE 3. — EMERGENCE DATA AND CORRESPONDING LONGEVITY, IN DAYS

Month of emergence	Male longevity		Female longevity	
	Maximum	Mean	Maximum	Mean
VII	22	11.3	14	8.1
VIII	73	32.5	52	25.2
IX	49	31.2	79	43.3
XI	123	62.7	168	69.9
XII	149	66.7	140	61.0
I	44	25.2	122	63.4
II	59	36.5	98	98.0

On a seasonal scale and without distinction between the sexes, it appears that flies of the first generation scarcely live ten days, while those of the second and third generations live one month and more. Flies of the fourth generation survive more than two months on an average.

Maximum longevity was 22 days for flies of the first generation, 73 days for those of the second, 79 for third generation flies and 168 days for those of the fourth generation.

Starting from mid February emergence ceased completely, and the last flies to emerge during the winter all died by the middle of May. From this it was concluded that under the conditions prevailing in this country, the Olive fly overwinters in its adult stage.

According to observations carried out in olive groves of the coastal plain, fruit setting occurs in that region starting from mid April and continues until the end of that month (according to the variety). 3 to 4 weeks later, that is by the middle of May, the volume of olives belonging to the irrigated European varieties reaches 0.5 mls. approximately.

As stated previously, oviposition starts in the grove as late as the first two weeks of June. Thus there is an apparent time lag between the death date of fourth generation flies as observed in the laboratory and their first oviposition as observed in the grove. However, it can hardly be doubted that under natural conditions flies live longer than in the laboratory since more adequate food is at their disposal, particularly as regards proteins which were not supplied the laboratory bred flies.

C. ACTIVITY TESTS

At the end of February breeding jars containing overwintering flies were transferred from the laboratory to an open verandah. The activity of the flies, as well as the ambient temperature inside the jars, was recorded every half hour. These observations were made from 8 a.m. to 4 p.m. and only on sunny days. Under these conditions it was seen that while the morning temperature was 16 °C., the flies were motionless and stayed on the bottom and walls of the jars or under the cloth covering them. When the temperature rose above 17 °C. there was slight motion among some of the flies; this motion increased somewhat when the temperature reached 20 °C. and between that temperature and 23° all the flies were moving to and fro in the jars. There was a further increase in activity between 23° and 26°; above 26° and up to 28° activity was very great. A large number of the flies took flight between 24° and 29 °C. When the temperature rose above 29° the flies became frantic; they ran swiftly from one end of the jar to the other, took off to fall immediately afterwards, and so forth. When at noon the temperature neared 35°

most of the flies remained completely motionless. During the afternoon all the above stages were observed in the reverse order.

These observations show that the activity of the Olive fly fluctuates within set boundaries:

- (a) below 17 °C. there is no motion at all;
- (b) normal activity and flight occur between 23° and 29°, and these are the conditions required for oviposition;
- (c) above 29° the flies become frantic and this prevents oviposition;
- (d) at 35° and above activity ceases.

It can be concluded from this that oviposition is not to be expected on days which do not include some hours with a temperature of at least 20° C. On the other hand, on days including many hours with temperatures above 30°, again there is no danger of oviposition. It should also be taken into account that the Olive fly is active only during daylight hours and not during the night, even if the required temperature conditions may then prevail. Results from experiments show that oviposition will take place mainly during the days which include many hours of daylight with temperatures of 20° to 30° C., and it is within this set of conditions that infestation is likely to occur. This was the criterion used in investigating the occurrence of the pest in different parts of Israel. The daily mean number of hours adequate for activity prevailing each month within different sectors of the country were obtained from Ashbel's data (1,2) and are recorded in table 4.

TABLE 4. — NUMBER OF DAY-LIGHT HOURS WITH 20-30°C. IN DIFFERENT LOCALITIES

Locality	Altitude (metres)	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Jerusalem (Hills)	827	—	—	—	5	11	14	13	12	12	10	—	—
Rehovot Coastal plain)	55	—	—	—	9	12	14	10	9	12	11	8	—
Nahalal (Jezreel Valley, Western part)	100	—	—	—	9	12	14	8	6	7	11	6	—
Ain Harod (Jezreel Valley, Eastern part)	20	—	—	7	11	13	8	5	5	6	6	9	—
Kinnereth (Jordan Valley)	— 160	—	—	4	11	7	5	3	3	4	5	10	—
Tirath-Zvi (Beisan)	— 245	—	—	4	11	6	4	3	3	2	5	8	—

In the main, suitable conditions for activity (i.e. oviposition) prevail in the coastal plain and the hills from spring to autumn. Naturally, in the case of the hills the period of activity lags one month behind the coastal plain.

In the valleys of the interior, namely the Jordan and the eastern part of the

Jezreel Valley, there are 6 and 4 months respectively during which the number of suitable hours for activity is so small that no infestation is likely to occur. In the Beisan area, the number of suitable hours during each of the months of the growing period of the olives (from May to October) is even smaller than in the localities previously mentioned.

Observations made systematically during many years in the olive groves of the different areas mentioned above show that:

- (a) In the Jerusalem area the fly's attack usually starts as late as July. The groves of this area consist almost exclusively of local varieties with small olives growing slowly at the beginning of their development.
- (b) In the coastal plain and the western part of the Jezreel Valley, there is a large number of olives belonging to the European varieties. These are attacked starting from June and sometimes — according to the time of flowering and fruit set — even as early as May. These olives generally incur continuous infestation until they are picked (during the period end of August — beginning of September), except for years when hot and dry eastern desert winds blow for prolonged periods. On the other hand olives of the local varieties usually incur their first attack as late as August. These local olives are picked for green pickling during the period September-October and for oil extraction from November to December.
- (c) The Jezreel Valley is planted mainly with irrigated European varieties. These are sometimes quite heavily infested during May and June, but the fly's attack ceases completely starting from July, and at picking time (August-September) practically no infested olives are to be found on the trees.
- (d) In the Jordan Valley, the irrigated European varieties are usually infested to a small extent in May (sometimes as early as the end of April) but as from the beginning of June infestation is practically nil.
- (e) No substantial infestation by the Olive fly has as yet been reported from the Beisan area where some highly developed groves exist.

Thus it became evident that a knowledge of the number of day-light hours with temperatures fluctuating between 20° and 30 °C. could be used in order to forecast the likelihood and/or extent of Olive fly infestation.

The meteorological data given in table 4 are averages for several years. There are of course differences between years as regards temperatures, and as a sequel the number of hours with conditions adequate for oviposition will vary from region to region. Extremes of temperature during June-July and for periods as short as a fortnight may have a decisive influence on the population of the pest in general, and its activity in particular.

D. LURING

In order to obtain information on the fly's occurrence and its population trends, trapping jars were suspended in the grove of Mikveh-Israel on a number of trees belonging to different varieties, and at the rate of one jar per tree. These jars were examined at weekly intervals. A short account of trapping results for the period 1947—1949 was published in 1951 (3). Since then luring has been continued, and the results for the period 1947—1952 are given below.

1. *Experiments with attractants.*

The attractant used during the period 1947—1949 was a 5% aqueous solution of ammonium sulphate. Trapping such as this has been carried out for some considerable time in several Mediterranean countries, but the attractants and the

vessels containing them were widely different. In 1949 the proposal was put forward (4) to use a standardized trap and attractant for all the countries concerned in order to facilitate the comparison of ecological records and, instead of ammonium sulphate, a 5% solution of biammonium phosphate was recommended. In some countries wide aluminium dishes are used, while in others glass lures are the rule. During the post-1949 period, the above mentioned attractants were used in glass lures, and for some time aluminium dishes were also operated for comparison purposes.

The yearly mean figures of catch obtained with those two attractants used in jars were as follows:

	<i>Total number of flies</i>	<i>% of females</i>
ammonium sulphate	359	37.2
biammonium phosphate	369	33.3

The figures thus fail to show any significant difference between attractants, and their aggregate will be used in the discussion to follow.

In 1950, three aluminium dishes with a diameter of 20 cm. and a depth of 5 cm. were suspended, each containing a 5% aqueous solution of biammonium phosphate. This solution was renewed at weekly intervals. The average number of flies trapped per lure was as follows:

	<i>April</i>	<i>May</i>	<i>June</i>
glass lure	12.7	53.3	103.7
aluminium dish	1.3	7.0	0.0

In view of these results and because of the high cost of operation of dishes as compared with jars, it was decided to discontinue trapping by dishes.

2. Population trends

For the period 1947-1952, trapping results were obtained from 11 luring jars suspended in the grove of Mikveh-Israel. This grove consists mainly of olive trees belonging to European varieties. The jars were suspended on trees of the Greek, Ascolano and Manzanillo varieties. These varieties being picked for green pickling, they are harvested during the period August-September, i.e. comparatively early.

The figures recorded in table 5 are averages of the numbers of flies caught per trap and per 30 days for a period of six years. The yearly average of flies trapped during the period concerned was 240, the minimum being 65 flies for 1952, and the maximum 340 for 1949. During the winter months January-March, the number of flies trapped was practically nil but increased starting from April and reached a maximum in June. During the hot summer months, trapping decreased, and climbed to another peak in October, which however, was smaller than the previous one. Thereafter it again decreased reaching negligible proportions by the end of the year. During the month of maximum catch (June), about 30% of the aggregate number of flies trapped per year were caught, while for the period May-July, this ratio was slightly more than 50%. However, the October maximum represented only 18% of the yearly catch. Thus the population level at the beginning of summer may serve as an indicator of the extent of the damage likely to be incurred by the European varieties.

TABLE 5. — MEAN FLY-CATCH PER TRAP

Month	Flies trapped	Number of females	Number of gravid females	Day-light hours with 20-30°C.
I	1.9	0.6	0.0	0
II	1.1	0.3	0.0	0
III	1.1	0.3	0.0	0
IV	10.6	3.9	0.1	9
V	29.1	8.0	0.5	12
VI	72.3	31.6	11.6	14
VII	26.2	10.5	5.6	10
VIII	12.2	5.0	1.5	9
IX	20.1	10.3	4.4	12
X	44.2	16.6	5.5	11
XI	15.3	5.1	0.7	8
XII	6.4	3.0	0.1	0
Total	240.5	95.2	30.0	

It should be noted here that the June maximum in the population occurs when climatic conditions are particularly favourable to the fly's activity since there are 14 hours of day-light with temperatures between 20—30°C. during that month. Furthermore, if European variety olives were to be left on the trees until fully mature, i.e. until November, they would undoubtedly incur further damage during the autumn months.

Since no practical importance can be attached to the numbers of flies trapped during the period December—March, the figures shown in table 6 are averages per trap for the period April—November only of each of the observation years.

The average number of flies caught per year for the period 1947—1952 was 231 with standard error 37.8. However, the total for 1952 was exceptionally low, because the numbers of flies caught that year in July and later were small. Apparently this is a result of the control operations which were carried out for the first time in that grove and in which the majority of the trees were sprayed.

The population curve differed greatly from year to year. In 1947, 90% of the aggregate of the flies trapped were caught during the period April—July, and only a few during the other months. In 1948, two pronounced maxima were observed (in June and October), and the number of flies trapped during the first four months of the season was equal to that caught during the last four. In 1949, there was only one maximum in October, and during the period April—July less than 20% of the aggregate of the flies caught were trapped, the remaining 80% being distributed over the other months. In 1950, trapping followed a reverse sequence than in 1949, the only peak observed being in June, and 75% of the total number of flies caught being trapped during the first four months of the warm season. Trapping results for 1951 and 1952 were similar to those of 1947 and 1950. In each of these two years, the population curve showed only one peak situated at the beginning of summer, the difference residing in the fact that in 1951 and 1952 the percentages of the total number of flies trapped during the first four months were 88 and 62 respectively.

As regards the population curve, three different types can be distinguished: a) two peaks occurring, one at the beginning of summer, and the other in autumn (1948); b) one peak in autumn (1949); c) one peak at the beginning of summer (the other four years).

As regards the European varieties, only the period April—July and the climatic

conditions prevailing then have actual importance. This is so because these varieties, which were the object of all the ecological observations carried out until now, are picked in August or September thus evading the autumn attack.

For a good understanding of the infestation potential of the pest for any given year, it should be borne in mind that under 20 °C. or over 30 °C., there can be no activity, including oviposition. In view of this the correct method for analyzing trapping figures, will be a survey of the number of adequate hours of day-light contributed by each month of the year. Unfortunately, no such data being available, climatic conditions will have to be expressed by means of approximations. Since the monthly means for temperature and relative humidity do not bring out any significant differences between observation years, extreme values will have to be used, viz. maximum temperatures.

TABLE 6. — ANNUAL FLY-CATCH AND CORRESPONDING ABSOLUTE
MAXIMUM TEMPERATURES IN °C

Month	1947		1948		1949		1950		1951		1952	
	Flies	Temp.	Flies	Temp.	Flies	Temp.	Flies	Temp.	Flies	Temp.	Flies	Temp.
IV	20.0	33.5	8.0	35.0	4.0	25.0	7.5	40.0	27.0	36.0	4.9	36.0
V	26.7	36.5	24.0	33.0	8.7	40.0	44.5	39.0	52.2	40.0	18.5	43.0
VI	86.0	34.0	106.0	41.5	26.3	42.0	117.5	33.0	82.3	33.5	15.8	42.0
VII	95.0	36.0	6.0	34.0	19.3	36.0	19.7	34.0	16.7	34.0	0.5	34.0
VIII	9.3	36.0	12.3	34.0	37.3	34.0	6.8	35.0	7.2	36.0	0.2	35.5
IX	3.0	35.5	19.0	32.0	79.3	32.0	11.5	36.0	6.7	36.0	1.3	35.0
X	2.7	34.0	75.7	32.0	133.8	34.0	36.7	35.0	6.0	38.0	10.3	36.0
XI	2.0	32.0	45.7	35.0	19.3	33.0	7.7	30.0	4.2	32.0	12.7	29.5
Total	242.7		296.7		328.0		251.9		202.3		64.2	

Number of days with temperatures above 35 °C						
April-July	6	3	7	7	6	12
Aug.-Nov.	2	0	0	2	6	6

Rehovot being the meteorological station nearest to Mikveh-Israel, the data obtained from it are valid for the latter place and are recorded in table 6. The following conclusions were drawn from an analysis of these data:

In 1947, maximum temperatures were comparatively mild (32.0—36.5 °C.), 8 days with a temperature higher than 35 °C being recorded.

In 1948, temperatures were comparatively low (32—35 °C.), and excepting June when the maximum temperature reached 41.5 °C., only 3 days with temperatures over 35 °C. were recorded.

In 1949, the weather was hot during May and June (40—42 °C.), 7 days with temperatures over 35 °C. were recorded during the first four months of the period April—November, the last four months of that period being particularly mild.

In 1950, temperatures were high in April and May but cool during the rest of the season.

In 1951, high temperatures prevailed in May, they were low in June and July but increased again later; the number of days with temperatures over 35 °C. was 12.

In 1952, the weather was extremely hot in May and June, but cooled off thereafter, 18 days with temperatures over 35 °C. being recorded.

It should be added here that over the period 1947—1952, the number of days with a relative humidity lower than 20% during May—June, was 5, 9, 11, 2, 6, 7 respectively. In May 1952, there were two days when the relative humidity fell as low as zero. In January and February 1949 a prolonged frost prevailed while in February 1950 it was accompanied by snow and lasted but a short while. Apparently, the frost did not kill the Olive fly in 1949, but because of the cold which prevailed in April of that year and which lowered the pest's activity, the number of flies trapped that month was negligible.

A comparison between the columns in table 6 giving the numbers of flies trapped and the columns of the same table where climatic conditions are recorded, shows immediately that the number of flies trapped is inversely proportional to the maximum temperature. June 1948 is an exception to this, since the number of flies trapped that month was considerable in spite of the very high temperature. However, it should be borne in mind that there were only two days with temperatures higher than 35 °C. during that month.

As regards infestation at picking time, data concerning the Ascolano variety are available for four of the six experimental years. In 1950 and 1951 infestation at picking time was not assessed, but rankings based on the condition of the olives while still on the trees were obtained. The extent of Olive fly infestation incurred by the Ascolano variety during the period 1947—1952 was as follows:

1947	56.7%
1948	55.6%
1949	16.3%
1950	heavily infested during the whole summer.
1951	heavily infested at the beginning of the season, and less towards the end; yield very low.
1952	8.0%.

As regards the infestation percentage of Ascolano fruits, the trends shown were fairly parallel to those of the population during the first summer months of the period concerned.

3. *Sex ratio.*

At each weekly examination of the traps, male and female flies trapped were segregated. The females were dissected and the number of mature eggs they contained was counted.

Table 5 shows that the numbers of females trapped follow trends similar to those of the aggregate of the flies lured.

On a yearly average, the females made up 40% of the total catch, while, as stated previously, this ratio was 50% as regards emergence from breeding jars. The highest ratio of females obtained from traps (over 50% of the total catch) occurred in September. December not being taken into account because of the small number of flies trapped, the ratio of females for June and August was slightly over 40%. While substantial numbers of flies were baited during the other months, the percentage of females remained lower than 40%, and dropped to a minimum in May, possibly as a result of the Khamsins which are particularly frequent during that month.

More than 50% of the total number of females trapped were lured in May—July and approximately 30% in September—October, the balance being lured during the remaining seven months.

During the first three months of the year, no gravid females were trapped at all, and their number was lowest during spring (April—May) and autumn

(November—December). In July, gravid females made up half the number of females trapped, their percentage was still high in September (more than 40%), and in June, August and October, only a third or less of the females trapped were gravid.

4. *Varietal distribution of catch*

As previously stated, traps were suspended on trees of the Greek, Ascolano and Manzanillo varieties. Table 7 records the number of flies trapped on each of these varieties.

TABLE 7. — VARIETAL RATIO OF FLY-CATCH

<i>Year</i>	<i>Ascolano</i>	<i>Manzanillo</i>	<i>Greek variety</i>
1947	41.6	12.9	45.5
1948	14.6	59.0	26.4
1949	24.5	61.7	13.8
1950	35.4	36.6	28.0
1951	34.7	33.4	31.9
1952	30.7	23.3	46.0
Average	30.3	37.8	31.9

On an average of six years of observations, there were no significant differences between fly-catch of the different varieties; however, on Manzanillo, the catch was slightly more than on the other two varieties. Sometimes the number of flies trapped on a given variety was very small; but this may be the result of the wide fluctuations in fly-catch shown by every variety. No satisfactory explanation for this phenomenon has been found as yet, however, the variation does not seem to be caused by excessive spacing of the traps, since the maximum distance between them was 100 yards.

The monthly distribution of fly-catch by variety was as follows: for the period December—March no comparison could be made because of the small number of flies trapped; in April and May a larger number of flies were trapped on Ascolano than on the other varieties; in June the catch was equally distributed among the three varieties. More flies were trapped on Manzanillo in July and August, while in September—October the fly-catch was larger on the Greek variety. Since there may exist a differential in the fly-catch of these varieties planted in a confined space, it is worth while mentioning that olives of the Ascolano variety have the fastest development, while olives of the Greek variety mature later than those of the other two.

5. *Cardinal-point distribution of catch*

At the beginning of 1950, five traps were suspended on a large tree of the Ascolano variety, one trap to each of the four cardinal points, and one in the center. The attractant used was biammonium phosphate.

TABLE 8. — CARDINAL POINT RATIO OF FLY-CATCH

<i>Year</i>	<i>E</i>	<i>S</i>	<i>W</i>	<i>N</i>	<i>Centre</i>
1950	20.8	23.0	16.2	26.6	13.4
1951	21.7	17.2	21.1	24.6	15.4
1952	27.4	19.8	25.4	10.0	17.4
Average	23.3	20.0	21.2	20.4	15.4

Table 8 shows that on an average of three years the fly-catch was equally distributed among the four cardinal points, the number of flies trapped inside the tree being slightly less. It should be noted here that in pruning olive trees, it is the practice to permit the entrance of light within the tree's crown.

During the period of observation, there were some fluctuations in the fly-catch of each of the traps, but these generally remained of feeble amplitude.

On the basis of totals of fly-catch, it might be inferred that the pest shows no preference for any particular part of the tree. However, the monthly distribution of catch for each of the five traps seems to indicate a climate correlated selectivity. The monthly maxima of catch were as follows: for the eastern aspect of the tree in May, September and October; for the southern aspect in November; for the western in April; the northern aspect in June and August; and the inside of the tree in July. The interpretation which seems to fit these facts is as follows: in spring and autumn, flies are attracted towards those parts of the tree which receive maximum light and heat during the morning and late afternoon, that is the western and eastern aspects; in summer they prefer the inside or that part of the tree which is in the shade most of the day, i.e. the north; and in November they choose the warmer south. These results thus bring out once more the pest's tendency to avoid excessive cold or heat.

Over the three observation years, the distribution by cardinal points of the total number of females trapped was as follows: east 18.8%; south 19.4%; west 22.4%; north 21.4% and within the tree 18.0%, i.e. between females trapped the distribution by cardinal points was more or less equal.

S u m m a r y

- 1) During the period 1947—1952, traps were operated in the Mikveh-Israel grove in order to obtain information on the occurrence of the Olive fly and its population trends. Weekly infestation assessments were carried out for several years, and flies were reared in the laboratory in order to uncover diverse obscure aspects of the pest's biology and ecology.
- 2) In the coastal plain of Israel the Olive fly was found to raise four generations per year, the duration of development being 30—40 days according to the season. The spring's first oviposition occurred in June, and the majority of the larvae did not reach the adult stage. On a yearly average the ratio of males to females in the laboratory was one.
- 3) Both sexes were generally found to have the same longevity. The maximum longevity was 22 days for first generation flies, 73 for those of the second generation, 79 for third generation flies and 168 days for flies of the winter generation. The latter observation led to the conclusion that the Olive fly overwinters in its adult stage.
- 4) Activity tests showed that the fly is motionless below 17 °C.; between 23-29 °C. activity increases and oviposition may take place. Above 29 °C. flies become frantic, and at 35 °C. their activity comes to a stand-still. From this it follows that the number of day-light hours with temperatures between 20-30 °C. can be used as an indicator of the pest's epidemiological potential. An analysis of the climatic conditions prevailing in the interior valleys of Israel showed that as regards the European olive varieties, the danger of infestation ceases with the start of the hot season. This is so because in these valleys the number of adequate hours is small during most of the summer month, and these va-

rieties are picked fairly early for green pickling. On the other hand, as regards the coastal plain and the hills of this country, the danger of infestation persists during the whole summer and threatens all varieties, European and local alike. Conditions of infestation are particularly favourable as regards olives left on the trees to ripen fully.

- 5) There was no significant difference between ammonium sulphate and ammonium phosphate used in glass lures as regards trapping results. Luring with the latter attractant and wide aluminium dishes proved unsatisfactory. On the basis of trapping results, two unequal peaks in the population curve were generally observed, the higher one occurring in June. During the six years of observations, a close fit was observed between fluctuations of trapping figures, and climatic conditions adequate for activity. As regards the European varieties, the extent of infestation is determined by climatic conditions during April—July only, because these varieties are picked in August–September while still green. Likewise, infestation of these varieties varies directly with the pest's population during the first months of summer.

On a yearly average females trapped made up no more than 40% of the total catch; thus it can be inferred that females are not attracted to the bait as strongly as males.

The numbers of females trapped during the year fluctuated in close agreement with those of the population as a whole. While half the females trapped in July were gravid, this ratio was much smaller during the rest of the season.

Although at the beginning of the season the degree of fruit-development established a differential in fly-catch between varieties; on a yearly average, however, no significant differences were observed. During spring and autumn, flies were trapped mainly on those parts of the tree sunlit during the morning and late afternoon hours, while during summer most flies were trapped within the tree or on that side of the tree shaded during the whole day. Only in November were flies preferably attracted to that part of the tree irradiated at mid day.

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