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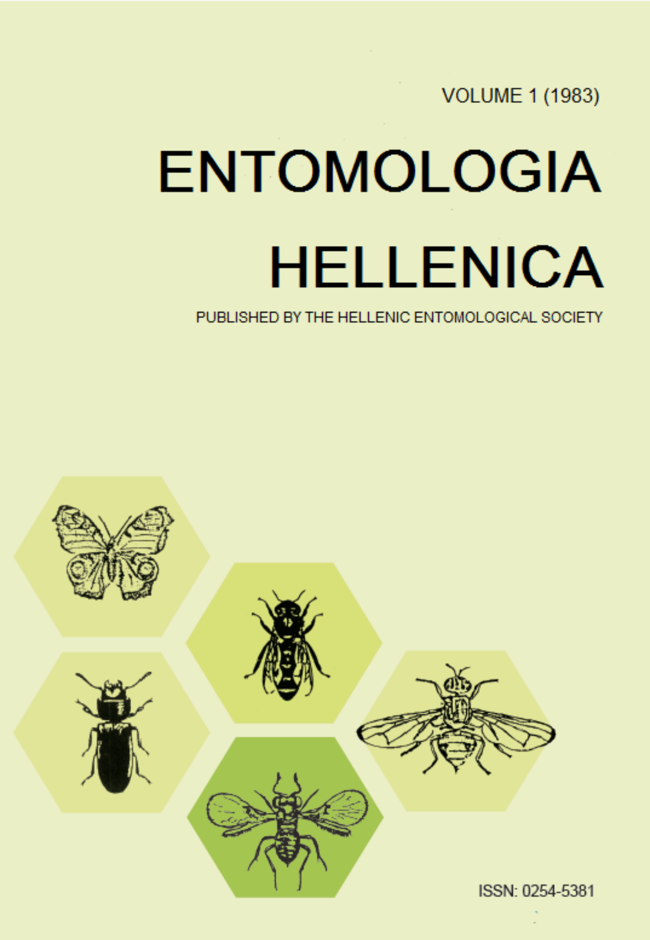

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An Assessment of Components of Crop Loss due to Infestation by *Dacus oleae*, in Corfu[1 2]

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ABSTRACT

An assessment of components of crop loss caused by the olive fly, *Dacus oleae*, was carried out in Corfu during the years 1976-1979.

The results indicate that the most important component of crop loss due to *D. oleae* infestation is the preharvest fruit drop induced, mainly, by the third stage larva. Using three starting dates, which coincided with the main periods of infestation between July and October, estimates were made of the proportions of infested fruits induced to fall prematurely before the start of harvesting in November.

The larva of *D. oleae* consumes only a small proportion of the fruit pulp (on average 4.48 %). The effect of infestation on the acidity of the oil is indirect and it is important only when the fruits remain for over a week on the ground before they are collected. Compensation by the tree for premature fruit drop caused by *D. oleae* infestation does not appear to be of any significance in assessing crop loss.

Introduction

The olive fruit fly, *Dacus oleae* (Gmelin) (Diptera: Tephritidae), is considered to be the most important pest on olives in Greece and other Mediterranean countries. The various methods of control applied against this insect rely on insecticides and in places where conditions are favourable for *D. oleae*, the olive trees need to be treated several times for full protection. As the pressure against the use of insecticides is gradually increasing, insecticidal control should always be justified by a cost benefit study based on an accurate assessment of crop losses. Data available for such a cost benefit analysis are limited and refer mainly to Crete (Neuenschwander and Michelakis 1978) and deal with different varieties. Therefore, detailed studies were carried out in Corfu between 1976 and 1979 to assess the crop losses caused by the olive fly on the fruit of the Corfu variety "Lianolia". The approach used was to identify the components of damage due to the direct or indirect effects of *D. oleae* and to quantify them so that they can be used in developing control strategies.

For oil producing olive varieties, three components of crop loss due to *D. oleae* can be recognized: a) Premature fruit drop prior to harvest, which is considered to be the most serious (Arambourg 1968, Monastero 1968) and is a total loss to the grower; b) The consumption of a certain amount of pulp by the larvae causing a reduction in the quantity of the olive oil; c) A possible reduction in the quality of the oil in infested fruits due to increased acidity. Because the fruits which drop before harvesting are a total loss as they are not collected, losses due to components b and c are only important when considering infestations in that part of the crop still on the tree at harvesting. Also, it is possible that a part of the crop loss due to premature fruit drop may be compensated for by the tree, through an increase in weight of the remaining fruits.

The components of damage discussed so far refer specifically to olive oil producing varieties which are the only ones of any impor-

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tance on Corfu. In table olive varieties, every puncture of *D. oleae* causes a reduction in the value of the crop. Therefore, in these varieties the problem of assessing crop losses would have to be approached in a different way.

In order to appreciate how crop loss assessment due to *D. oleae* was approached, it must be noted that in Corfu harvesting starts in November and the fruits are allowed to fall naturally to the ground or plastic nets placed underneath the trees from where they are collected at intervals (2-3 weeks). The harvesting period may thus last from November to the following spring (April-May).

Materials and Methods

a. Losses due to preharvest fruit drop

In order to determine which particular stages of *D. oleae* cause premature fruit drop and to estimate this component of damage, data from population studies carried out at Ropa (Kapatos 1981) were mainly used. In these studies, the fruits from a number of trees were sampled regularly (usually every week) from July to the end of the fruiting season. The fruits were dissected and all stages of *D. oleae* (both living and dead) were recorded.

At the same time the number of fruits that fell from the trees between sampling dates was estimated by using two techniques. In 1976, nets of the type used for olive collection were placed beneath the trees at the beginning of the infestation period (August). All the fruits that fell from each tree were collected and counted at the same time as fruit samples were taken. This technique, however, proved to be very time consuming and therefore for the 1977 season a modification of this technique, in which only a proportion of the fruits that fell were collected, was used. Four wooden sided mesh bottom trays were placed beneath the trees. These were placed randomly between the trunk and the outer edge of the canopy and each collected the fruits that fell within $0.25 m^2$ area. Then, the area of the ground beneath the canopy of each tree was calculated and the number of fruits per tray was converted to an estimate of the number of fruits that had fallen from the tree during each sampling interval. Thus, at the end of the season it was possible to calculate the total number of fruits that were present on the trees at the beginning of the season and the rate at which they fell. From these data it was possible to calculate the number of fruits remaining on the tree at any particular time. Also, the fruits that fell to the ground between samplings were also sampled and examined in the same way as the fruits taken from the trees.

In the 1976/7 season 63 % of the trees of the experimental site at Ropa produced fruits (56910 fruits per tree) and the level of infestation by *D. oleae* ranged from 33 % (in August) to 70 % (in November). In the 1977/8 season only 39 % of the trees had fruits (36150 fruits per tree) and the level of infestation ranged from 30 % to 81 %.

Each individual fruit of the samples taken both from the tree and the ground was classified after dissection into one of the following classes: a) Non infested fruits, b) Fruits having symptoms of fruit spot disease (i.e. *Sphaeropsis dalmatica* type symptoms), c) Fruits having *D. oleae* stages from egg to L 2 (living or dead second stage larva), d) Fruits having a living L 3 (third stage larva), e) Fruits with a dead L 3, f) Fruits having a pupa or an exit hole. Fruits with more than one stages of *D. oleae* were classified according to the more advanced one. Fruits with both olive spot disease and egg or young larval instar (i.e. egg- L 2) were classified into the former class while fruits with olive spot disease and third stage larva or more advanced stage were classified into the latter.

From these data the rate at which each class of fruits fell between two sampling dates was calculated as follows: For each class of fruits (j) (where j = a, b, c, d, e, f) the rate of fruit fall (r) between sampling dates t and t + 1 was obtained from the following parameters.

1) P_jT (t, t+1): The average proportion of fruits on the tree belonging to the jth class during the sampling interval t-t+1 so that

$$\sum_{j=a}^{f} P_jT\,(t,\ t+1) = 1$$

This was obtained by averaging the proportions of fruits of each class of two consecutive sampling dates. This was done because the infestation on the tree changes during the sampling interval, as new eggs are laid and individuals of the already existing infestation develop.

2) P_jG (t, t+1): The proportion of fruits on the ground belonging to the jth class at the time of t+1 sampling (i.e. of the fruits that fell between t and t+1).

3) FT (t): The total number of fruits on the tree at time t.

4) FG (t, t+1): The total number of fruits that fell between the sampling period t and t+1.

Then, K_jG (t, t+1) which equals the total number of fruits of that class that fell during the period between samples t and t+1 can be obtained by multiplying 2 with 4 i.e.

5) $K_jG\,(t,\ t+1) = P_jG\,(t,\ t+1) \times FG\,(t,\ t+1)$ and K_jT (t) which equals the total number of fruits of the class present on the tree at time t can be obtained by multiplying 1 with 3 i.e.

6) $K_jT\,(t) = P_jT\,(t,\ t+1) \times FT\,(t)$

Finally, r_j(t, t+1) which is the rate of fall of fruits in the jth class between samplings t and t+1 is obtained by dividing 5 by 6 i.e.

$r_j(t,\ t+1) = K_jG\,(t,\ t+1) \div K_jT\,(t)$

It is important to notice that these fruit fall rates are expressed as proportions of the number of fruits present on the tree at the beginning of each sampling interval and not as proportions of the original number of fruits present on the tree at the beginning of the season.

In order to examine whether fruits from the tree fall randomly, regardless of the stage of infestation, or fruit-fall is induced by some stages only, the rates of fruit fall of each class were compared with the rate of fruit-fall of the noninfested fruits using a test for equality of two percentages (Sokal and Rohlf 1969). This type of analysis and statistical treatment was preferred to that of directly comparing proportions of fruits of each class on the tree with those on the ground. This was because they are not statistically independent as they are based on the total number of fruits that have fallen and this total is affected by the number of fruits of the greatest fruit-fall inducing class that fell.

In order to assess the effects of premature fruit-fall on crop loss more precisely, the estimates of the rates of fruit-fall of fruits having stages of *D. oleae* older than L 2 (the stages that were found to cause premature fruit-drop) were used to calculate the proportion of such fruits that actually drop before harvesting. This was done by calculating the proportion of a given number of fruits (i.e. 100) of this combined class (i.e. d+e+f in the tables) present on a tree at a particular time (starting point) that would be expected to drop during each successive sampling interval based on the estimated rates of fruit-fall of this class for each of the sampling intervals. In order to simplify procedures, three starting points were used for each year (1976 and 1977). The first was in the middle of August when the peak of the L 3 stages of *D. oleae* for the first period of infestation (middle July-August) usually occurs. The second was in late September which approximates to the time when a second peak of individuals of *D. oleae* laid as eggs at the beginning of September reach the L 3 stage. The third was in late October which is the approximate time when individuals that started as eggs at the beginning of October reach a stage advanced enough to cause fruit-fall.

For each of the six starting points (three per year), the cumulative rates of expected fruit-fall were calculated for each sampling interval, and expressed as percentages of the number of fruits of this class present at the starting point. These were plotted against time, after an angular transformation, and regression equations were calculated for each case.

b. Losses due to larval feeding

In order to estimate the amount of fruit pulp consumed by the larva, uninfested olive fruits were collected from several areas. From these, a random sample of 300 fruits was taken and infested in the laboratory by placing the fruits in cages containing mature females for one or two hours. An extra sample of 100 fruits was left uninfested. All fruits (infested and non infested) were then weighed, numbered and kept in plastic containers designed to prevent dessication of the fruits. The upper section containing the fruits had a wire-mesh bottom and this fitted tightly over a lower compartment which contained water so when the lid was closed the relative humidity inside the container quickly reached 100 %. Two days before the expected date of pupation all fruits were removed from the containers and placed in tightly closed glass tubes. Three days later, from fruits where development occured successfully, the mature third stage larvae emerged and pupated within the tubes. These fruits were then removed from the tubes and were weighed again. After weighing, they were dissected and those containing a larva which had not completed development and those from which more than a single pupa was produced were disregarded. The uninfested fruits were also removed from the glass tubes at the same time and weighed again. In fifty fruits of each class the relative oil content of the fruit was determined. This was done to examine the possibility that the larva of *D. oleae* in addition to consuming an amount of fruit pulp, may also affect the relative oil content of the fruit. In the other fruits, the kernel and pulp weights were determined by removing the pulp with a scalpel and weighing both separately.

The difference in pulp weights of the uninfested fruits before and after the experiment was used to calculate a correction factor due to the loss in weight from experimental conditions. The difference between the pulp weights of the infested fruits measured at the beginning of the experiment and after the mature third stage larvae had emerged, corrected for the loss in weight due to experimental conditions, represented the amount of fruit pulp consumed by the larva.

c. Effect of infestation on oil quality

In order to estimate the effect of *D. oleae* infestation on the acidity of the olive oil, olive fruits were collected from many places in Corfu and separated under the binocular microscope without dissection into three classes: a) Uninfested fruits; b) Fruits containing oviposition punctures and larval galleries; c) Fruits having larval or adult exit holes. Each class was then divided into batches of 100 fruits and six batches of each class (a total of 18 batches) were placed on plastic nets underneath olive trees in an orchard adjacent to the Olive Institute. This was done to simulate the usual conditions of harvesting in Corfu. To avoid losses from birds and other causes, they were protected with rectangular wooden frames which had a screen nylon mesh on the top. For two other samples of each class (a total of six batches), the olive oil was extracted and the acidity determined after extraction of the olive oil. The data obtained were analysed with a two-way analysis of variance.

d. Compensatory responce of the olive tree to premature fruit drop

In order to investigate whether a part of crop loss due to preharvest fruit drop is compensated for by the olive tree by an increase in the average weight of the remaining fruits, the data from the experimental site at Ropa (Kapatos 1981) were used. At this site, which was left untreated against *D. oleae*, the level of infestation on some trees was high and caused considerable fruit drop. The trees which were sampled regularly were divided into three classes according to the infestation levels observed in August (i.e. 0-15 %, 16-30 % and >30 %). The mean weights of fruits on trees of the different classes were recorded in August and November and the percentage increase in fruit weight for each class during the intervening period calculated. The data were analysed with an analysis of variance and Duncan multiple range test.

Results and Discussion

a. Preharvest fruit drop

The calculated rates of fruit fall (expressed as percentages) of the various classes of fruits for Ropa in 1976 and 1977 are given in Tables 1 and 2. The statistical comparison of the overall rate of fruit fall of infested fruits and for the different classes separately, with that for non infested fruits is given in Tables 3 and 4.

The results indicated that infested fruits drop faster than non infested fruits from August until the beginning of winter. By then, fruit maturity is at an advanced stage in all fruits and there are no significant differences in the rate at which they drop.

Early stages of *D. oleae* (i.e. Eggs, L 1, L 2) do not cause premature fruit drop. On the contrary, it appears that at the end of the season fruits infested with these stages drop at a lower rate than the non infested fruits. However, this effect may be due to sampling difficulties at the end of the season, as it is difficult to detect all the early larval galleries and punctures in the fruits that have been on the ground for a period of time, due to deterioration of the fruits. Therefore, the frequency of these stages at the end of the season was possibly underestimated. Also, it appears that living third stage larvae not only do not cause premature fruit drop but induce fruits to drop at a lower rate. This again, however, is almost certainly an artifact because the living L 3 larvae in fruit on the ground may have died or entered the pupal stage before sampling (the sampling interval was longer than time of development from August to November) and were therefore recorded as dead third stage larvae or pupal stages.

The data indicate that *Sphaeropsis dalmatica,* a fungus that enters the fruits through the oviposition punctures and exit holes made by *D. oleae* and forms characteristic spots, causes considerable premature fruit drop at the beginning of the season. However, in most parts of Corfu, it rarely occurs at high levels. Moreover, its occurence in fruits on the ground could possibly have been overestimated because the fungus can easily enter the fruits after they have fallen to the ground even due to

TABLE 1. Calculated rates of fruit-drop of non infested and infested fruits and fruits with one of the following stages of infestation: 1) *Sphaeropsis dalmatica* type symptoms, 2) Egg-L 2, 3) Living L 3, 4) Dead L 3, 5) Pupa or exit hole, expressed as percentage of the total number of fruits of that class present on the tree at the beginning of the sampling period, for Ropa 1976.

Sampling interval	Non inf. fruit (a)	Inf. fruit (b+c+d+e+f)	*Sphaeropsis* (b)	E-L 2 (c)	Liv. L 3 (d)	Dead L 3 (e)	Pupae, holes (f)	Pupae + L 3 (d+e+f)
17/8-25/8	0.23	1.14	53.91	0.31	0.12	0.69	0.35	0.33
25/8-1/9	0.21	4.28	12.82	2.62	0.00	0.74	5.58	4.41
1/9-8/9	0.03	11.34	28.73	0.64	3.18	1.45	20.17	15.54
8/9-15/9	0.32	3.30	8.86	0.51	4.20	4.44	7.52	6.11
15/9-22/9	0.79	14.62	4.94	1.24	3.54	4.76	29.22	20.12
22/9-29/9	0.49	1.99	1.39	0.16	0.30	0.63	6.59	1.91
29/9-8/10	0.88	9.86	38.38	1.51	3.00	6.93	49.08	15.01
8/10-18/10	14.51	24.67	100.00	15.41	2.06	16.20	66.95	25.34
18/10-29/10	4.25	33.78	100.00	14.54	4.12	23.84	100.00	41.58
29/10-6/11	9.19	11.59	61.70	3.49	4.30	8.18	53.24	15.27
6/11-23/11	3.66	12.81	36.24	1.99	2.97	19.57	42.31	18.34
23/11-4/12	14.49	40.75	88.40	5.97	4.61	77.25	100.00	61.32
4/12-14/12	5.12	15.19	50.63	6.76	1.79	16.78	47.61	19.09
14/12-29/12	25.55	11.49	100.00	6.84	0.00	16.45	13.36	11.44
29/12-15/1	45.99	33.90	58.49	8.40	5.45	75.23	56.86	48.67
15/1-29/1	50.96	54.19	100.00	7.83	7.30	49.29	100.00	68.05
29/1-19/2	98.53	69.63	100.00	31.63	60.49	58.66	100.00	85.71

TABLE 2. Calculated rates of fruit-drop of non infested and infested fruits and fruits with one of the following stages of infestation: 1) *Sphaeropsis dalmatica* type symptoms, 2) Egg-L 2, 3) Living L 3, 4) Dead L 3, 5) Pupa or exit hole, expressed as percentage of the total number of fruits of that class present on the tree at the beginning of the sampling period, for Ropa 1977.

Sampling interval	Non inf. fruit (a)	Inf. fruit (b+c+d+e+f)	*Sphaeropsis* (b)	E-L 2 (c)	Liv. L 3 (d)	Dead L 3 (e)	Pupae, holes (f)	Pupae +L 3 (d+e+f)
10/8-17/8	0.39	14.08	45.22	2.75	0.57	4.98	12.92	4.57
17/8-23/8	1.49	16.78	44.72	6.49	0.00	5.54	15.28	6.25
23/8-30/8	0.19	6.93	14.64	0.39	0.00	2.48	29.37	8.12
30/8-12/9	6.99	25.05	33.99	9.77	10.70	6.99	100.00	42.51
12/9-26/9	6.11	23.96	37.40	7.97	9.52	16.53	100.00	35.96
26/9-4/10	3.50	9.18	5.25	4.67	4.35	17.60	40.39	19.41
4/10-11/10	2.90	9.50	4.33	3.01	0.00	13.43	54.36	24.17
11/10-18/10	4.21	7.60	3.47	2.09	2.05	17.14	29.81	16.74
18/10-25/10	1.79	11.46	5.68	3.21	3.31	13.73	44.02	22.70
25/10-1/11	2.06	11.61	5.70	2.40	0.00	29.74	30.53	24.44
1/11-8/11	5.18	21.54		7.37	0.81	100.00	31.59	34.30
8/11-16/11	8.97	27.60		11.96	1.14	86.28	37.25	36.66
16/11-24/11	23.53	29.04		15.13	3.21	91.60	30.15	35.74
24/11-2/12	28.82	32.73		8.24	5.73	100.00	35.04	48.57
2/12-9/12	39.41	30.51		14.14	9.30	100.00	45.97	43.04
9/12-20/12	31.15	43.86		12.91	0.00	100.00	60.45	56.89
20/12-4/1	66.86	60.00		14.88	16.96	100.00	100.00	93.04

TABLE 3. Statistical significance of the rates of fruit-drop of infested fruits as compared with the rate of fruit-drop of non-infested fruits using a one-tail test for equality ot two percentages, for Ropa 1976.

Date	Infest. fruits (b+c+d+e+f)	*Sphaeropsis* (b)	E-L 2 (c)	Liv. L 3 (d)	Dead L 3 (e)	Pupae, holes (f)	Pupae +L 3 (d+e+f)
25/8	n.s	★★	n.s	n.s	n.s	n.s	n.s
1/9	★★	★★	★★	n.s	n.s	★★	★★
8/9	★★	★★	★	★★	★★	★★	★★
15/9	★★	★★	n.s	★★	★★	★★	★★
22/9	★★	★★	n.s	★★	★★	★★	★★
29/9	★★	★	n.s	n.s	n.s	★★	★★
8/10	★★	★★	n.s	★★	★★	★★	★★
18/10	★★	★★	n.s	n.s	n.s	★★	★★
29/10	★★	★★	★★	n.s	★★	★★	★★
6/11	n.s	★★	n.s	n.s	n.s	★★	★★
23/11	★★	★★	n.s	n.s	★★	★★	★★
4/12	★★	★★	n.s	n.s	★★	★★	★★
14/12	★★	★★	n.s	n.s	★★	★★	★★
29/12	n.s	★★	n.s	n.s	n.s	n.s	n.s
15/1	n.s	★★	n.s	n.s	★★	n.s	n.s
29/1	n.s	★★	n.s	n.s	n.s	★★	★★
19/2	n.s	★★	n.s	n.s	n.s	★★	n.s

n.s Non significant
★ Significant at the 0.05 level
★★ Significant at the 0.01 level

mechanical injuries which break the skin. It is not therefore considered of any importance in causing crop loss due to olive fly attack in the conditions of Corfu.

The presence of dead third stage larvae, pupae and exit holes is related to significant premature fruit fall and it appears that fruits with these stages drop at a much faster rate than the non infested fruits throughout the season. In assessing crop losses, the fruit classes that were found to be related to premature fruit fall (i.e. dead L 3, pupal stages and exit holes) were

TABLE 4. Statistical significance of the rates of fruit-drop of infested fruits as compared with the rate of fruit-drop of non infested fruits using a one-tail test for equality of two percentages, for Ropa 1977.

Date	Infest. fruits (b+c+d+e+f)	*Sphae-ropsis* (b)	E-L 2 (c)	Liv. L 3 (d)	Dead L 3 (e)	Pupae, holes (f)	Pupae +L 3 (d+e+f)
17/8	★★	★★	★★	n.s	★★	★★	★★
23/8	★★	★★	★★	n.s	★★	★★	★★
30/8	★★	★★	n.s	n.s	★★	★★	★★
12/9	★★	★★	n.s	★	n.s	★★	★★
26/9	★★	★★	n.s	n.s	★★	★★	★★
4/10	★★	n.s	n.s	n.s	★★	★★	★★
11/10	★★	n.s	n.s	n.s	★★	★★	★★
18/10	n.s	n.s	n.s	n.s	★★	★★	★★
25/10	★★	★★	n.s	n.s	★★	★★	★★
1/11	★★	n.s	n.s	n.s	★★	★★	★★
8/11	★★		n.s	n.s	★★	★★	★★
16/11	★★		n.s	n.s	★★	★★	★★
24/11	n.s		n.s	n.s	★★	★★	★★
2/12	n.s		n.s	n.s	★★	★★	★★
9/12	n.s		n.s	n.s	★★	n.s	n.s
20/12	n.s		n.s	n.s	★★	★★	★★
4/1	n.s		n.s	n.s	★★	★★	★★

n.s Non significant
★ Significant at the 0.05 level
★★ Significant at the 0.01 level

TABLE 5. Estimated percentage of fruits infested at different times during the fruiting season (late July, early September, early October) that dropped before harvesting due to the advanced stages of *D. oleae* (i.e. L 3, pupae and exit-holes).

Year	Late July	Early September	Early October
1976	84	67	27
1977	99	85	60
Mean	91.5	76	43.5

combined (column d+e+f in Tables 1-4). Fruits with third stage larvae were also included in with the other stages that cause damage because once an individual reaches this stage it must either enter the pupal stage or die, either of which will accelerate fruit fall.

The regressions between the expected cumulative rates of fruit fall of fruits infested by stages older than L 2, expressed as percentages of the number of fruits of this class present on the trees at certain times of the infestation period (middle August, late September, late October), and time are shown in Fig. 1. The correlation coefficients were highly significant ($p < 0.01$).

By solving the regression equations given in Fig. 1 for a time corresponding to 15 November (i.e. the approximate time when harvesting begins) the proportion of the infested fruits that drop before harvesting can be calculated for each of the three main periods of infestation (middle July-beginning August, September, October). These are given for each year in Table 5. The mean estimates for each period of infestation can be used, together with other information, to develop economic injury levels for infestation by *D. oleae* (Kapatos and Fletcher unpublished).

Another parameter that can be calculated from the regression equations in Fig. 1, is the length of time taken for 50 % of the fruits having an advanced stage of *D. oleae* to drop (t_{50}), from the time when the individuals reached the L 3 stage (starting point). These estimates are also given in Fig. 1. Although some variation is observed between the two years for the same period of infestation, the data indicate that the time to fruit-drop decreases significantly as the season progresses. This is not surprising because there is a general increase in fruit maturity during the season and the rate of fruit-drop of all fruits accelerates as the winter approaches. However, it is realized that this study needs to be extended over a number of years to estimate more accurately this parameter, because it is likely to be affected by many factors that can influence fruit-drop, including climatic conditions and crop size.

sumption to that for Lianolia for one variety but not the other. For "Tsounati", which is a medium size variety, the amount of pulp consumed by a larva was estimated to be 50mg,

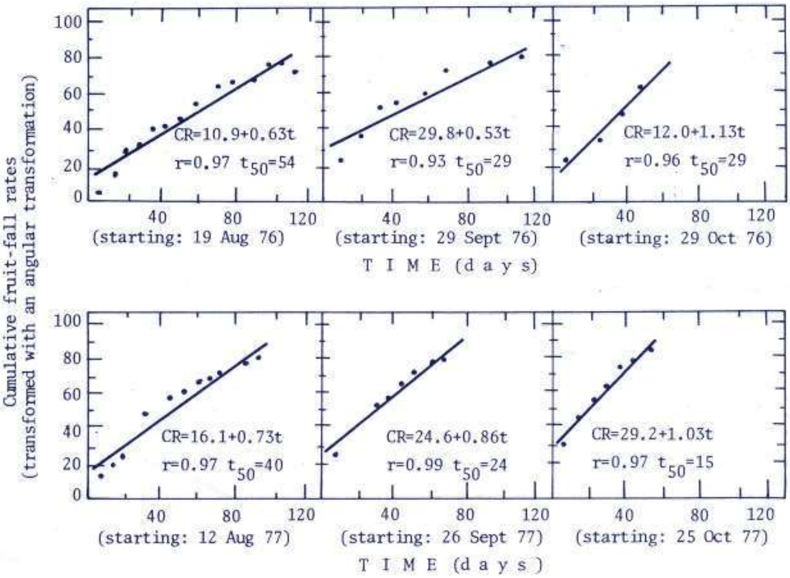

FIG. 1. Relationship between cumulative rates of fruit-drop (CR) of fruits having stages older than L 2 and time during certain periods of the fruiting season (starting from middle August, late September, late October). The mean time taken for 50 % of such fruits to drop (t_{50}) is also given in each case.

b. Amount of pulp consumed by larva

The amount of fruit pulp consumed by a larva of *D. oleae* expressed both in grams and as a proportion of the actual weight of the fruit pulp is given in Table 6. It appears that a larva of *D. oleae* consumes around 45 mg of fruit pulp during its development in olives of the variety "Lianolia". This represents only 4.48 % of the mean weight of the fruit pulp.

Recent work in Crete (Neuenschwander and Michelakis 1978) on larval feeding in two other olive varieties, using an entirely different technique, gave a similar figure for pulp consumption to that for Lianolia for one variety but not the other.

which represents 3 % of the pulp. However, in the very small variety "Koroneiki" the larva consumed 150 mg which is 20 % of the pulp.

The relative importance of the amount ot pulp consumed in reducing the actual yield from each variety might be expected to be different depending upon their fruit weights. Also it is possible, indeed probable, that larvae of *D. oleae* have different nutritional requirement in terms of grams of fruit pulp in each variety because of different food quality.

The estimates of the relative oil content for the non infested and the infested fruits, after the third stage larva has emerged, expressed in

TABLE 6. Amount of fruit pulp (in grams and as a percentage of the total) consumed by *D. oleae* larva during its development.

Fruit pulp weight (g)			Fruit pulp consumed	
Initial weight	Final weight	C.F. (g)	(g)	%
1.028	0.823	0.159	0.046	4.48

C.F. = correction factor for the loss of moisture due to the experimental conditions.

terms of dry fruit weight were almost identical (38.01-38.82, respectively) which suggests that larval feeding does not affect the relative oil content of infested fruits. This is in agreement with similar information obtained in Crete (Neuenschwander and Michelakis 1978) and with direct measurements of the oil content of infested and non-infested fruits collected from the field (Kassimis unpublished).

c. Effect of *D. oleae* infestation on olive oil quality

The effect of *D. oleae* infestation on the acidity of the olive oil in relation to the time between fruit drop and harvest is shown in Fig. 2, where the acidities determined for each fruit class are plotted against the time between the exposure and the collection of the fruits. The analysis of variance which was carried out on the data of this experiment is given in Table 7. Highly significant F-values were recorded for all sources of variation i.e. infestation, time between fruit drop and harvest and their interaction.

It appears that the time between fruit drop and harvest is the most important factor in increasing the acidity of the olive oil. This effect is greatest on the infested fruits and especially the fruits with exit holes (Fig. 2). However, acidity also increases in the healthy fruits when these are allowed to remain on the ground for more than two weeks. Therefore, although infestation, particularly the most advanced stage (exit holes), increases acidity, the relative importance of this factor is less significant than the time between fruit-drop and harvest. The difference of 0.5-1.0 degrees of acidity between the healthy fruits and the fruits with exit holes recorded till the end of the first week

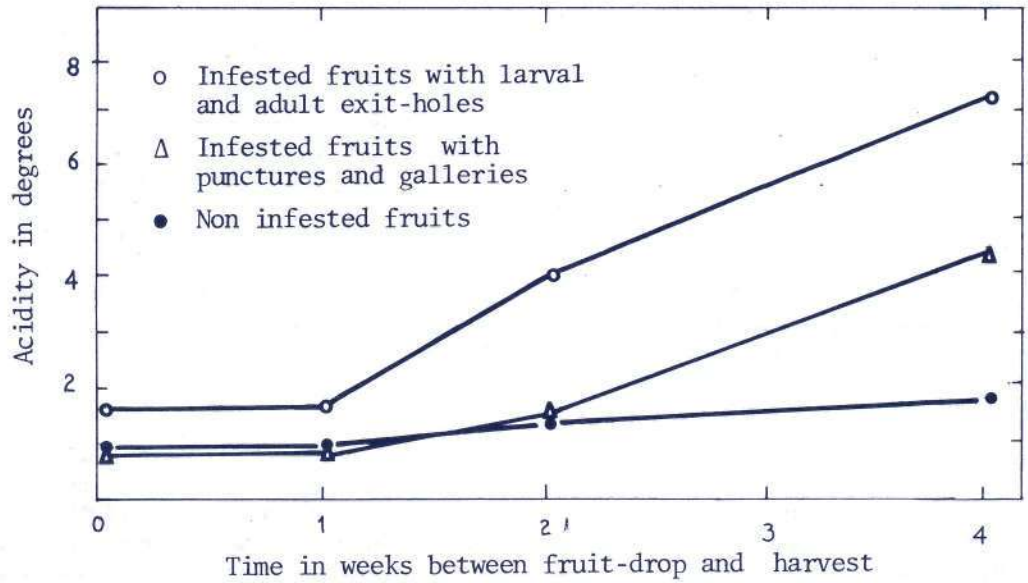

FIG. 2. Effect of *D. oleae* infestation and time between fruit-drop and harvest on the acidity of the olive-oil.

TABLE 7. A two-way analysis of variance of the effect of *D. oleae* infestation and the time between fruit-drop and harvest on the acidity of the olive-oil.

Sources of variation	Degrees of freedom	Sums of squares	Mean squares	F value	Significance
Infestation	2	22.70	11.35	30.2	★★
Time on the ground (weeks)	3	47.55	15.85	42.2	★★
Infest. x Time	6	16.66	2.78	7.4	★★
Res. Error	12	4.51	0.38		

★★ Significant at the 0.01 level

means nothing in terms of revenue, since fruits of the latter category (i.e. with exit holes) may have been exposed to the secondary effects from fungi and bacteria for some time while still on the tree.

These conclusions are in agreement with observations in other areas (Sagusta Azpeitia 1976, Neuenschwander and Michelakis 1978) and contradict the existing impression that the infestation by *D. oleae* reduces considerably the quality of the oil when present at high levels during harvesting.

d. Compensation in response to premature fruit drop

The relative increase in fruit weight from August to November, expressed as percentages of the fruit weight in August, in trees which were divided into classes according to the level of infestation are given in Table 8. The analysis indicated that there were no significant differences between the three classes. This result is not surprising because most of the fruits infested in July-August do not fall before October and therefore the time available for compensation by the tree is very short. Also, as indicated earlier, only fruits containing stages older than L 2 drop prematurely and therefore the actual differences in the rates of fruit drop of the trees of these classes were smaller than the differences in the infestation levels.

Recent work on compensation has also been carried out in Crete by detaching fruits at different times of the year and comparing yields. It was observed (Neuenschwander et al. 1980) that a slight compensation in the yield occured, but only when a considerable proportion of the fruits was removed from the trees in summer. In reality however, fruits infested in summer do not fall till autumn and, therefore, this only gives the tree a very small opportunity for compensation. Thus, if it happens at all it would only be likely to occur at very high levels of infestation. At such high levels, decision making about whether or not to apply control procedures against *D. oleae* is not a problem.

Although compensation for fruit drop is an interesting aspect of olive tree physiology, the present evidence suggests that it is not of any importance in assessing crop loss as to be used in the determination of economic thresholds for *D. oleae* control.

TABLE 8. Relative increase in fruit weight from August to November, expressed as percentage of the fruit weight in August, in trees which were divided into classes according to the level of infestation, at Ropa in 1976.

	Infestation 0-15 %			Infestation 16-30 %			Infestation > 30 %		
Tree number	Weight in August (g)	Weight in November (g)	% Increase	Weight in August (g)	Weight in November (g)	% Increase	Weight in August (g)	Weight in November (g)	% Increase
1	0.65	1.19	83	0.67	1.10	64	0.71	1.19	68
2	0.61	1.11	82	0.61	1.08	77	0.72	1.21	68
3	0.69	1.37	100	0.66	1.06	61	0.83	1.35	63
4	0.61	1.25	105	0.74	1.20	62	0.63	1.23	95
Mean	0.64	1.23	92	0.67	1.11	66	0.72	1.25	73

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KEY WORDS: Olive-oil acidity, Olive-crop losses, *Dacus oleae,* Olive-fruit drop, *Sphaeropsis dalmatica*

Εκτίμηση της Οικονομικής Ζημιάς που Προκαλεί ο Δάκος της Ελιάς στην Κέρκυρα

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ΠΕΡΙΛΗΨΗ

Η οικονομική ζημία, που προκαλεί ο δάκος της ελιάς στο καρπό της ελαιοποιήσιμης ποικιλίας «Λιανολιά» στην Κέρκυρα, μελετήθηκε στη διάρκεια των ετών 1976-1979.

Η πτώση του προσβεβλημένου ελαιοκάρπου πριν από την ελαιοσυλλογή συνιστά το μεγαλύτερο μέρος της ζημιάς, που προκαλεί το έντομο αυτό. Καρπόπτωση προκαλείται μόνο απ' τα προχωρημένα στάδια του δάκου (προνύμφες 3ου σταδίου). Νύγματα και μικρές στοές δεν φαίνεται να προκαλούν καρπόπτωση. Καρπόπτωση προκαλεί ακόμη και ο μύκητας *Sphaeropsis dalmatica* χωρίς όμως να έχει ιδιαίτερη σημασία για την Κέρκυρα.

Το μεγαλύτερο μέρος (91,5 %) των καρπών που προσβάλλονται στην περίοδο Ιουλίου-Αυγούστου και που η προσβολή εξελίχτηκε πέρα απ' το δεύτερο προνυμφικό στάδιο, πέφτουν πριν απ' την ελαιοσυλλογή. Τα αντίστοιχα ποσοστά που εκτιμήθηκαν για τον ελαιόκαρπο που προσβάλλεται το Σεπτέμβριο και τον Οκτώβριο ήταν 76 % και 43,5 % αντίστοιχα.

Η μέση ποσότητα της σάρκας του ελαιοκάρπου, που καταναλίσκεται απ' την προνύμφη του δάκου μέχρι να συμπληρώσει την αναπτυξή της, βρέθηκε να είναι 0,046 g. Αυτό αντιπροσωπεύει μόνο ένα μικρό ποσοστό (4,48 %) της σάρκας του ελαιόκαρπου στην ποικιλία αυτή.

Η επίδραση της δακοπροσβολής στην οξύτητα του ελαιολάδου είναι κυρίως έμμεση καί είναι σημαντική μόνον όταν ο καρπός, αφού πέσει, παραμείνει στά δίκτυα ή το έδαφος για αρκετές ημέρες (περισσότερο από μία εβδομάδα) πριν συλλεγεί.

Η αναπλήρωση απ' το δένδρο ενός μέρους της ζημιάς από πρώϊμη καρπόπτωση με την αύξηση του βάρους των καρπών που απομένουν, δεν φαίνεται να έχει ιδιαίτερη σημασία στο προσδιορισμό της οικονομικής ζημίας που προκαλεί ο δάκος.