Insect pest and their control - The Mediterranean fruit fly

C.F. H. Jenkins
D. G. Shedley

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THE MEDITERRANEAN FRUIT FLY

The Mediterranean fruit fly (Ceratitis capitata Wied) is without doubt the most serious insect pest with which Western Australian orchardists have to contend. Its ravages can, however, be greatly reduced if control measures are applied correctly.

The creature has been known to science for nearly 140 years, and in that time has spread to almost every important fruit-growing country in the world.

In this State the insect is known as far north as Carnarvon, where it was first found in 1934. The permanent home of the pest, however, may be regarded as that area of the State westward of a line running from Gingin south-eastwards to include Northam and York, and thence southwards to Balingup and Busselton. Seasonal outbreaks occur at Bridgetown, Albany, Mt. Barker, Kalgoorlie, Sandstone, and other outlying localities, where the pest has failed to become established.

In the case of the southern fruitgrowing areas, failure is probably due to the stringent control measures adopted and relatively unfavourable climatic conditions, whereas in other districts the scarcity and lack of continuity of suitable host fruits accounts for its spasmodic appearances.

DESCRIPTION AND LIFE HISTORY

The Adults.

The Mediterranean fruit fly is a two-winged insect a little smaller than the house fly. The general colour is yellowish or light brown. The wings bear brownish bands and spots, and the abdomen has two light coloured rings. The pattern on the thorax or back consists of irregular white markings on a black background, giving a mosaic appearance. In the sunlight this pattern often shows a metallic sheen. The wings are normally held in a drooping and what appears to be a semi-spread position, and are never folded flat on the back as in the case of the housefly.

Mating and egg-laying does not take place in the young flies until they are about a week old.
During this period the flies can be most successfully attacked. Investigations into the food requirements have revealed that in addition to sugars the flies are attracted to materials which result from the breakdown of the proteins occurring in yeast, soya bean meal, etc. (Steiner: 1952.)

These hydrolysed proteins are used to attract the flies in the recently developed baits. The flies are unable to live longer than about four days without food and consequently if baiting is regularly carried out by all growers it would be possible to poison off many flies before they reach the egg laying stage.

The flies seldom stray far from the protecting foliage of fruit trees, although marked flies have been recovered up to two miles downwind from the release site. Local trapping experiments have revealed that movement from an orchard into host free areas is extremely limited. When suitable hosts are available a puncture is made in the skin of the ripe or ripening fruit by the female fly and six to eight eggs are deposited in the cavity made.

The Eggs.

The eggs, which measure approximately 1/25th inch in length and are a creamy white colour, hatch in summer in from two to four days. In winter, however, the time required may be as long as 20 days.

The Larvae.

The tiny maggots, upon hatching, immediately commence feeding and burrowing into the fruit. This activity causes the tissue to break down, soft spots to form and in some instances the complete decomposition of the fruit. The maggot when fully grown is about 1/3rd of an inch in length and creamy white in colour. In fact, it resembles very much in general appearance a house fly maggot or an under-sized blowfly maggot.

The time spent in the fruit will vary according to the weather conditions and the type of fruit, but the period in summer is about 14 days and in winter sometimes as long as 45 days. One interesting feature about the fruit fly maggot is its ability to jump. When placed on a dry surface it can, by a sudden muscular action, skip to a distance of a foot or more. This is not however a characteristic of the fruit fly maggot alone for various fly larvae, including “cheese jumpers” and the maggots of the tomato fly, possess this ability.
When fully developed, the maggot leaves the fruit, drops to the ground, if the fruit has not already fallen, and burrows into the soil.

The Pupae.

As soon as it burrows into the ground the maggot changes into a rounded barrel-shaped pupa looking not unlike a rather dark swollen grain of wheat. The pupal or resting stage varies from 12 to 50 days according to the time of year after which the fully developed fly emerges and forces it way up to the surface of the ground.

**LIFE SPAN OF FRUIT FLY STAGES IN WESTERN AUSTRALIA**

<table>
<thead>
<tr>
<th></th>
<th>Adult Fly</th>
<th>Egg</th>
<th>Larva</th>
<th>Pupa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>28-112 days</td>
<td>2-4  days</td>
<td>14-16 days</td>
<td>12-14 days</td>
</tr>
<tr>
<td>Winter</td>
<td>17-112 days</td>
<td>10-20 days</td>
<td>25-45 days</td>
<td>25-50 days</td>
</tr>
</tbody>
</table>

Fig. 3.—An orange showing numerous fruit fly punctures in the skin

**FRUITS ATTACKED**

Well over 100 fruits, nuts and vegetables have been recorded as hosts for the fly in different parts of the world. Many of these records have, however, been secured under artificial conditions and certain hosts are definitely more susceptible to attack than others.

In Western Australia, the fly has been found attacking peaches, figs, apricots, pears, all citrus fruits, nectarines, apples, grapes, plums, persimmons, quinces, loquats, plantains, passion fruit, bananas, mulberries, olives, walnuts, tomatoes and the sapodilla. Such ornamentals as the guava, feijoa, pomegranate, clerodendron, lilypilly, chilli, rose, Irish strawberry, Barbados gooseberry, prickly pear, Osage orange and Natal plum, are also known hosts, and to complete the list must be added the following weeds: African box thorn, apple of Sodom, and black-berried nightshade.

An examination of this list will show that not a single native plant is included. The importance of this cannot be too fully emphasized, for it means that with the exception of relatively unimportant weeds, all the hosts of the fruit fly in Western Australia are cultivated plants. This simplifies, or should simplify, the problem of control very considerably. It means that if all growers were fully alive to their responsibilities the fruit fly menace could be, if not eradicated, so reduced as to be of little importance. In countries where native fruits harbour the pest the task is very different. There every care may be taken in the orchard only to be nullified by an invasion from bush or jungle, but in Western Australia a man can only blame either himself or his neighbour (of course it is usually the latter) for the presence of fruit fly in his orchard.

**RELATIVE IMPORTANCE OF DIFFERENT HOST FRUITS**

All host plants are, of course, not equally attractive to the fly or suitable for its development. In the passion fruit, for instance, fully-developed maggots have never been found in this State, although damage is caused by the disfiguring wart-like growths which arise on the skin following egg-laying. Maggots have been found working in pomegranates but no flies have been reared from such fruits. Although not normally regarded as a host when picked under commercial conditions, bananas have been found infested with fruit fly and adult flies have been bred from fruit infested in the field. Tomatoes, olives and walnuts were all found infested with fruit fly for the first time in Western Australia in 1955, (Jenkins 1955). Development in lemons only occurs in very ripe fruit and normally then only when the skin has been split or broken. Many plums and grapes are apparently too watery to
form suitable homes for the maggots. Peaches, apricots, pears and figs, on the other hand, are notorious breeders of the fly.

Although citrus growers suffer comparatively little loss from fruit fly, citrus are amongst the most important hosts of the pest. The reason for this is that when the summer soft fruits are finished the fly is able to carry over the winter in the citrus orchards. Grape-fruits are amongst the most susceptible varieties to infestation, but it is an interesting fact that only a low percentage of the eggs laid in citrus develop successfully. It is believed that the oil in the rind seals the egg cavity, or in some way interferes with normal hatching.

The attractiveness of oranges to the fly is amply exemplified by the number of punctures which may be seen on fruits in any infested orchards. These punctures are readily observed, for a discoloration of the surrounding skin results, and such marks are popularly known as "stings."

Another host plant which must receive attention is the loquat. This fruit is very important because it serves as a link between the winter citrus and the early stone fruits, and the bigger build up of population there is in the loquats, the earlier will losses occur in apricots and other soft fruits.

POWERS OF REPRODUCTION

As an illustration of the great reproductive powers of this fruit pest, the following figures are illuminating. From one pair of flies laying on September 1, the possible progeny by the middle of January, a period of 4½ months, would amount to 6,750,000 flies. Such a calculation is based upon each female laying 300 eggs, 150 of which would produce female flies, and so on. Of course, this hypothetical reproduction never takes place in actual practice, but the potentialities are sufficient to make it clear to everyone that the pest is not one to be trifled with.

ECONOMIC IMPORTANCE

The financial loss to fruit growers in this State generally caused by the fruit fly each year is difficult to calculate; that it is considerable none will deny. In addition to the actual value of the fruit lost and the expense and labour of constantly fighting the pest, the indirect loss caused by the fact that the cultivation of certain

Fig. 4.—Peaches showing typical fruit fly damage
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Man, in recent years, has made fantastic and almost unbelievable advances in Science and the conquest of Outer Space. Despite such progress there remains the indisputable fact that Man's greatest invention is the Wheel!

History does not record the origin of the wheel, the subject remaining a matter for assumption and conjecture. The generally accepted theory is, however, that "log-rollers" were the first mode of "wheel" transport, being later developed into circular discs or wheels formed of separate planks of wood fastened together and then cut into a circular shape. Such wheels may still be seen in use among primitive peoples today.

Metaphorically, the organisation of Elders may be compared to the wheel, the smooth running of which can be attributed to the carefully maintained Hub of administration. From this Hub the Branches, Sub-branches and Agents emanate as "spokes" to contribute at all times a well-balanced and practical "rim" of endless service to our clientele.

It is as this wheel continuously turns, that increasing numbers of farmers are convinced . . .
profitable crops is prevented or limited must be borne in mind. When it is remembered that the average value of the fruit industry to Western Australia is several million pounds per annum, the necessity for doing everything possible to control the pest will be evident. Not only must it be checked in areas where it is now present, but its spread to clean districts must be prevented.

CONTROL MEASURES

REGULATIONS gazetted under the Plant Diseases Act make it compulsory to take action against fruit fly. The first thing to be realised is that for really satisfactory results concerted action is necessary. A few careless individuals in a district can do much to nullify the work of their neighbours and perhaps jeopardise their livelihood. Although foliage baiting and orchard hygiene are still the mainstay of the control programme, cover sprays and the use of a fruit fumigant have their place in the overall attack against this pest.

TRAPPING

For many years trapping by means of lures such as pollard and borax, “Clensel” and “Beeco” solutions in glass jars and tins was widely advocated, and when intensively carried out was quite effective. In recent years research has been intensified in this field, especially by American workers, who have found that oil extracted from Angelica seed and similar synthesised materials are very attractive to male flies. (Steiner et al 1957.) These materials attract more flies than any of the general lures but the consequent reduction in male population cannot be expected to have a very marked effect on the total infestation. Their main use, therefore is as indicators. Some of the protein hydrolysates, which are used as foliage baits, when mixed with water and ammonium chloride in traps attract fruit flies of both sexes as well as a range of other insects.

BAITING

The replacement of traps by foliage baits was first recommended in this State in 1936 (Newman and Jenkins 1936) their advantage being increased efficiency and ease of application. Although such insecticides as DDT, BHC Parathion and HETP (“Hexone”) were all tested as they became available, they showed no improvement on sodium fluosilicate and no real advance in baiting methods was made until the development of mixtures containing malathion plus hydrolysed yeast and malathion plus sugar.

Bait Formulae Recommended.

<table>
<thead>
<tr>
<th>1. Orchard Backyard Garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion 50% emulsion (or its equivalent)</td>
</tr>
<tr>
<td>Yeast hydrolysate</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>This formula should not be stored after mixing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Orchard Backyard Garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Malathion 50% emulsion (or its equivalent)</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>This formula should not be stored after mixing.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Orchard Backyard Garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium fluosilicate</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>For backyard gardens a stock solution can be made using: Sodium fluosilicate</td>
</tr>
<tr>
<td>Water</td>
</tr>
</tbody>
</table>

* Growers using wettable powder preparations of Malathion should avoid the fruit as disfiguring residues may occur.

PROPRIETARY MIXTURES

A number of yeast and other protein materials in paste, powder and liquid form suitable for use in malathion baits have recently appeared on the market. Certain proprietary mixtures of sodium fluosilicate and sugar also comply with Departmental recommendations.

How to Apply Bait

In a large orchard or vineyard the use of some type of spray pump fitted with a coarse nozzle will usually be found the most convenient way of applying the spray. Where such expensive equipment is not warranted, however, the bait can be splashed on the foliage with a whitewash brush or applied through a container with a perforated lid such as a shaker-topped bottle.
When to Apply Bait.

The maximum period between treatments should be six days, but, of course, if heavy rain washes the bait off before this time has elapsed, a second treatment should be given. As the fruit fly frequently attacks fruit before it is ripe baiting should be commenced at least six weeks before the crop is ready to pick and continued right through the season until a couple of weeks after the trees have been stripped, just to make sure that any straggling flies are not allowed to escape.

Particular attention should be paid to the baiting of citrus during fine spells in winter. Orange and lemon trees provide the flies with food and shelter and play an important part in carrying over the pest from season to season.

Warning

In mixing and applying any of the formulae the quantities stated should be rigidly adhered to, thus reducing the chance of any possible injury to the foliage or harmful deposits of poison on the fruit. Some people apply a complete cover spray to their trees when baiting in the belief that they are fulfilling requirements. The object should be to have a quantity of bait here and there on two or more sides of the tree, avoiding the fruit as much as possible. Wandering flies will then have a good opportunity of feeding.

COVER SPRAYS

Many materials have been tested as complete cover sprays to kill the fruit fly on contact. Insecticides such as parathion, malathion and Hexone will give a rapid knock-down to flies present at or very soon after the application of the spray. However, the comparatively short life of these insecticides, particularly when not used in conjunction with a lure, renders their value somewhat limited.

The high toxicity of parathion is another serious disadvantage to its use, but when other pests such as citrus white fly or aphis are present in addition to fruit fly an application of malathion would be useful against all three.

DDT has been used against various fruit flies in other parts of the world, but trials locally have given little success.

Dieldrin is another insecticide which has been used as a cover spray against fruit fly. However the danger of contaminating ripening fruit and the increase in mite populations which may occur make the general use of dieldrin undesirable.
Dipterex.

The action of Dipterex offers a new and interesting approach to fruit fly control, for besides being toxic to the flies on contact it penetrates the fruit and kills both eggs and maggots. By applying the material before the strikes have developed most fruit can be harvested in a sound condition even though the puncture marks are still apparent.

Recommendations.

**Stone Fruit.**—1 fluid ounce in 6 gallons of water (1 pint in 120 gallons).

**Pears.**—1 fluid ounce in 3 gallons of water (1 pint in 60 gallons).

Note.—1 pint of Dipterex liquid concentrate is equivalent to 1 lb. of Dipterex soluble powder.

It is advisable to double the concentration for the first spray particularly if any larval development has occurred. Spraying should be repeated at no more than 10 day intervals. Results are often proportional to the completeness of cover so a thorough application is essential and the addition of a wetting agent for very smooth or waxy-skinned fruit is advised. Local experience has shown that better control is normally achieved on stone fruit than on pears. This spray is not recommended for citrus.

**ORCHARD SANITATION AND DISPOSAL OF INFESTED FRUIT**

Although insecticidal methods are important factors in fruit fly control they can only hope to be really effective when carried out in conjunction with strict orchard hygiene.

As the fruit becomes mature, it should be picked. Fruit left on the tree is a potential breeding ground for the pest which will develop rapidly in the ripe material. Infested fruit should never be allowed to lie on the ground, and should be disposed of by boiling, burning or soaking in water and kerosene. Burying is not recommended and when the life history of the pest is recalled the reason will be clear. The maggot naturally burrows into the soil to pupate, so that by burying maggoty fruit the flies' normal development is only being assisted. Certainly, if the fruit is buried deeply enough no insects can emerge, but when it is remembered that fruit flies have successfully pushed their way through four feet of dry sand the weakness of this method is obvious. It has been found that infested fruit placed in a pit and liberally treated with BHC dust before filling in will prevent fruit fly development (Ryan 1950). This technique may be of value where disposal of large quantities of infested fruit is necessary and where other means of disposal would be too difficult.

In order to simplify the work of sanitation, growers, and this especially applies to back yard growers, are advised not to let their trees attain such proportions that the fruit cannot be easily reached. Special attention should be paid to fig trees and loquats for often these are neglected and allowed to carry far more fruit than can possibly be used. Such trees should be cut back to a height of say 10 feet, so that they can be baited easily and so that the fruit can be conveniently picked. When allowed to grow unchecked they become a menace to neighbours and perhaps to the owner when the Fruit Fly Inspector calls.
GROUND TREATMENT

Dusting or spraying the soil surface under infested trees with insecticides such as dieldrin and BHC has been used on a number of occasions to assist in control measures. Although these materials prevent emergence of many flies when applied in large enough quantities they do not give sufficiently reliable results to warrant the time and expense of application under normal conditions.

FUMIGATION

There are two main applications for the fumigation of fruit. Firstly as a quarantine measure, fumigated fruit may be passed for movement into fly-free areas. Secondly as a further control measure enabling the grower to market fruit with an assurance that there will be no fruit fly development. When used for quarantine purposes strict compliance with the instructions set out below is necessary.

1. Material: Ethylene dibromide (EDB) concentrated. HANDLE WITH CARE (see instruction 12).

2. Quantity: Citrus fruit 1 lb. (7 1/2 fluid oz.) per 1,000 cubic feet, other fruit 1/2 lb. (5 1/2 fluid oz.) per 1,000 cubic feet. (The 1 lb. dose for citrus will not harm other fruit.)

3. Exposure Time: Two hours, excluding evaporation time. (See instruction 9.)

4. Temperature in Chamber: Not less than 70° F.

5. Load: Volume of fruit not to exceed 35 per cent. of total space, i.e. 350 three-quarter bushel cases per 1,000 cubic feet.

6. Stacking: Cases to be stacked to allow adequate air circulation. Optimum conditions are a compact stack with horizontal battens between each layer in line with direction of circulation.

7. Packing: Fruit to be in standard cases and not wrapped.

8. Chamber: Any room, tent or similar situation which can be effectively sealed.

9. Evaporation: Care should be taken that the liquid EDB does not come in contact with the fruit. The fumigant should be evaporated in a flat-bottomed dish on an electric hot plate or similar heating apparatus. The fumigant should not be deeper than 1 inch in the container which should have sides from 2 to 4 inches above the surface of liquid. Evaporation time should be between 10 and 30 minutes and is additional to the 2 hour exposure time. The longer evaporation time may be an advantage in securing more even dispersion of the fumigant.

10. Position of Hot Plate: The evaporation should be carried out in an elevated position and in such a manner that the circulation of air will provide rapid dispersion of the heavy gas. The hot plate should not be in such a position that a large proportion of the vapour will come in contact with a limited number of cases. Where the hot plate is used on the top of a stack of fruit this danger will be reduced by placing the plate in the centre of an iron tray or asbestos sheet 2 feet square.

11. Circulation: A fan or other device is necessary to provide adequate circulation.

12. Health Hazard: Although EDB is a relatively non volatile liquid at normal temperatures, care must be taken in handling this material. The gas is highly toxic to humans and the liquid is a severe skin irritant. After fumigation the chamber should be evacuated by means of a suitably placed exhaust fan. The interior surface of the chamber may become saturated with EDB and if so it will give off toxic fumes after apparent exhaustion. This could be a hazard if the chamber were exhausted, then closed and entered again some time later without further exhaustion. The exhaust should therefore be in operation before entering the fumigation chamber, and also while anyone is in it.

PARASITES

Since 1904 seven attempts have been made to establish various fruit fly parasites in Western Australia. The first six of these met with complete failure, for although some of the parasites were carried through several generations in the laboratory, no field recoveries were made (Jenkins 1948). The most recent attempt involving the introduction of four different parasitic wasps from Hawaii, shows slightly more promise as a number of wasps have been reared from fruit collected in the field. The egg parasites offer the greatest chance of success, although at present there seems little likelihood of biological control methods superceding more orthodox treatments.
LEGISLATION

To aid in the control of fruit fly, it has been found necessary to introduce certain regulations including compulsory baiting in certain areas and the restriction of movement of fruit within the State.

Registration.

All fruit trees must be registered with the Department of Agriculture and a registration fee paid. The details supplied enable inspectors to check on the most susceptible types of fruit at various seasons of the year and to advise on control measures where these are not being carried out efficiently.

Compulsory Baiting.

Where fruit fly occurs it is compulsory to carry out control measures including the application of one of the baits recom-
mended in this article and the regular gathering of fallen fruit.

In districts where more than 60 per cent. of the growers voting in a poll agree, the baiting may be carried out on a community basis.

Movement of Fruit.

The main fruit growing districts of the State have been divided into three areas. Area 1, which includes the Metropolitan Area, the coastal plain as far south as Cookernup and the associated Hills districts, is considered to be regularly infested and fruit movement from this area is restricted. Area No. 3 which embraces that part of the State south of Katanning and Kirup is considered normally to be free of fruit fly and movement of fruit into this area is restricted. Area No. 2, which is the zone between Areas 1 and 3, has certain restrictions limiting both the inward and outward movement of fruit.

Free movement of fruit throughout the State is allowed after it has been fumigated under the supervision of an inspector and according to the instructions set out in the appropriate section of this article.

Further details concerning these Regulations can be obtained by referring to the relevant portions of the Plant Diseases Act, copies of which are available on application from the Department of Agriculture.

SUMMARY OF CONTROL MEASURES

1. Prune trees to a manageable size.
2. Bait regularly with an approved foliage bait.
3. Spray with Dipterex if necessary.
4. Pick fruit as it ripens.
5. Destroy properly all infested fruit.

REFERENCES


Stiener, L. F. (1952).—“Fruit Fly Control in Hawaii with Poison-Bait Sprays Containing Protein Hydrolysates.” J. Econ. Ent. 45: 838-43.


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