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Kingsley Thomas Fisher

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ERADICATING FRUIT FLY FROM CARNARVON

By K. T. Fisher, Entomologist, Entomology Branch

Late last year the Mediterranean fruit fly (Ceratitis capitata Weidemann) was eradicated from Carnarvon, Western Australia by using an integrated programme of sterile insect releases and bait spraying.

The eradication marked the end of a four-year study on the use and effectiveness of the Sterile Insect Technique, a biological control technique which uses an insect pest against itself. Such a study can be used as a basis for treating other threatening insect pests, such as the serious cattle pest screw-worm fly, should they be found in Australia.

Western Australia is only the third area in the world to successfully eradicate fruit fly from a mainland area. Although California and Mexico have eliminated the pest in some areas, the situation in Carnarvon was different to either of these situations because of the intensive year-round irrigation production system.

Mediterranean fruit fly is one of the world’s most destructive fruit pests. Since its unfortunate introduction into this State, the fruit fly has been partly controlled by chemicals, but these have not been sufficient to eradicate it.

Being a biological control method, the Sterile Insect Technique is an excellent supplement to chemical control. The technique has none of the harmful, residual effects of chemicals and it works on that part of the pest population which chemicals have failed to control.

Sterile Insect Technique

Millions of insects of the pest species are reared under controlled laboratory conditions and sterilised by irradiation so that they cannot reproduce. Large numbers of sterile insects are then released into an area infested by the pest insect. The sterile insects mate with fertile pest insects and no progeny is produced to supply the next generations.

The technique relies on releasing such large numbers of sterile insects that only a few wild, fertile pest insects ever chance to mate with one another. With continual releases, each pest generation is reduced further until the pest species has been eliminated.

Study area

Carnarvon was chosen as a test area for the Sterile Insect Technique project which was funded by the State Government. Carnarvon has a $16 million fruit and vegetable growing industry with a persistent fruit fly problem. The area’s isolation—1000 kilometres north of Perth, well away from other horticultural areas—prevented outside influences from interfering with the test.

Because insufficient sterile fruit flies could be reared in the laboratories for release in Carnarvon to flood the wild flies, chemical control methods were carefully integrated with the Sterile Insect Technique first to lower the...
number of wild flies. This integration was managed in such a way that chemicals reduced wild fly numbers but did not seriously interfere with the released sterile flies. The surviving wild flies were then outnumbered by the sterile flies, leading to their eventual eradication.

**Breeding fruit fly in the laboratory**

The breeding of vast numbers of Mediterranean fruit flies started in mid 1978 with research into sterilising techniques. By 1980, the level of sterility needed for the fly releases was determined and, at the end of that year, the first experimental releases were made in the Carnarvon plantation area. During mid 1981 facilities and sterilising techniques were significantly improved and more effective releases were achieved by the end of that year.

Millions of fruit flies must be reared each week for the technique to be effective. In the Department of Agriculture's South Perth laboratories, fertile adult flies laid enough eggs to produce 12 to 13 million fruit flies a week for sterilisation and release.

The eggs, which female flies laid through fine gauze walls of specially-designed cages, were collected in troughs of water. The water was treated with a chloramide solution to prevent harmful viruses and bacteria from attacking the eggs. Each cage contained up to 250,000 flies and produced one to two million eggs a day.

The eggs were incubated in aerated water for several hours before being placed on trays of a moist, artificial rearing mixture of straw, yeast (for protein), sugar (carbohydrate) and preservatives (to prevent fungal and bacterial decay). These ingredients replaced the fruit into which female flies normally would lay their eggs.

The eggs hatched into small larvae which immediately fed on the mixture. As they grew the surrounding metabolic temperature rapidly increased. To prevent the larvae becoming too hot, the trays of larvae were moved from the incubation room (26°C) to a cooler room (20°C) five days after the eggs had hatched. Water was sprayed onto the mixture daily to replace moisture lost through evaporation.

Nine days after the eggs were placed on the mixture, the fully-grown larvae jumped from it and were collected in pans of water. The water served to harmlessly suspend larval activity, allowing larvae to become of similar age and development. Each day the larvae were strained from the water and placed on a special rack. As they dried, they became active again and moved off the rack onto a cloth tray where they pupated within 24 hours. The pupae were collected and placed on shallow galvanised trays in an incubation room where they continued to develop for eight days.

**Sterilising fruit fly**

Eight day old fruit fly pupae which would emerge as adult flies within two days were considered mature enough to sterilise.

The pupae were placed into special containers (1.4 litres capacity or about 90,000 pupae in each container) and flushed for 10 minutes with nitrogen. The container of pupae was then placed into a Gammacell 220 cobalt irradiator and exposed to 18.5 kilorads of radiation for 1.5 minutes. Up to 50 containers of pupae were sterilised each day.

The nitrogen treatment made the sterile flies more sexually vigorous or competitive than if they were irradiated in air. The nitrogen replaced the oxygen around and within the fruit fly pupae during irradiation, and effectively reduced radiation burns to the insects' vital tissues. These burns would have reduced their sexual activity.
Extensive testing had shown that this sterilising refinement increased the effectiveness of sterile flies in the field by more than four fold, assuming a fertile laboratory fly was 100 per cent competitive.

For a Sterile Insect Technique programme to succeed, the reproductive and survival mechanisms of laboratory-reared flies must be as close as possible to those of wild fruit flies to compete well with them.

Criteria for evaluating the quality of laboratory-reared fruit flies concentrated on their mating and flight ability and longevity. These characteristics are essential for effective interaction of sterile flies with wild fertile flies in the field. The development of techniques which monitored certain performance traits gradually improved the quality of mass-reared flies towards the end of the programme.

Transporting sterile pupae

After the pupae were sterilised, they were packaged, 120,000 at a time, into sealed plastic bags. The pupae avoided suffocation and overheating by lowering their metabolic rates. In this way, they could remain safely packaged for up to 24 hours.

The Department’s Carnarvon laboratories received the plastic bags of pupae within 12 to 24 hours of them being irradiated. Immediately they were unpacked, these pupae resumed normal development and adult flies emerged one to two days later.

Distinguishing sterile flies

Sterile fruit flies are identical to wild flies in all their external characteristics. To distinguish between them when samples of flies were trapped, the sterile flies were marked with a fluorescent dye powder. The dye was added to the pupae so that the pupal case became coated with dye powder. Small specks of the dye powder adhered to each adult fly as it emerged from the pupal case. Even after the fly carefully preened itself, enough dye powder remained so that when the fly was examined under ultraviolet light the small dye specks glowed.

When a fly was suspected of being wild and therefore fertile, it was examined under a microscope for minute particles of dye which were trapped on the ptilinum. This is a small membrane which initially sticks out of the head of a fly as it emerges from the pupal case. Later, it is withdrawn to inside the head.

By comparing the number of marked sterile flies to that of unmarked wild flies after each release, entomologists got an indication of by how much the wild flies were being reduced by the sterile flies.

Releasing sterile flies

Carnarvon laboratory staff placed the dye-marked pupae into 45 litre plastic rubbish bins with special lids and roughened interiors, both of which helped the emerging flies to escape quickly. Two days later adult flies were ready for release. Each bin, containing about 25,000 flies, was taken to one of 400 release sites distributed throughout the Carnarvon district. After the lids were removed the marked sterile flies immediately escaped into the surrounding fruit trees.

Use of chemicals

The integration of sterile fly releases (biological control) and chemical control methods has greatly improved the efficiency of the sterile fruit fly technique in Western Australia. The key to the Sterile Insect Technique is to maintain a very high ratio of sterile insects to fertile wild insects in the field.

In areas of heavy wild fly infestation, trichlorfon baiting (0.8 per cent Dipterex® and protein) and fenthion cover sprays (0.08 per cent Lebaycid®) reduced wild fly numbers below a predetermined level. This increased the effectiveness of the released sterile flies against the remainder of the wild fly population.

The most effective integration involved alternating the use of chemicals and sterile fly releases every four to five days. In this way the residual effect of the chemicals had declined before sterile flies were released, and most sterile flies had mated with wild flies by the time the next baiting occurred.

Extreme care was taken with chemical applications. Dipterex®, for example, was not used around trees which were close to cage birds or poultry, where Malathion® was used instead.

Because the baits were highly salty, baiting on most trees was restricted to the cool of the morning or evening when the danger of burning, in the hot Carnarvon climate, was lessened.

Less concentrated baits were put on to the foliage of salt-sensitive trees such as avocados. During the hotter months of January to March sugar was added to the bait to prevent it from drying too quickly and becoming an unattractive powder.

At the start of the project, a well-worn path was formed throughout all Carnarvon properties as each four to five days the baiting team systematically applied the baits to the test zones.

Assessing the project

When using the Sterile Insect Technique it is essential to be able to monitor the whereabouts of both sterile and wild insects.
The sterile fruit fly study was conducted in a number of phases. Phase I established the seasonal abundance of fruit fly in Carnarvon by using trapping methods over an 18-month period before sterile fly releases. Large numbers of fruit flies had existed all year round and a natural rise and fall in the wild fly population was evident even though a community baiting scheme was in operation.

The subsequent phases represented a study of different levels of chemical and Sterile Insect Technique methods, starting with no chemicals, then sterile insects totally integrated with chemical controls and finally sterile insects alone to mop up the remaining wild flies. There were insufficient sterile flies to eradicate the initial wild fly population and this led to the integration of chemical methods.

The results are shown in the figure. Each year fewer wild flies were caught in traps. The most significant effect of the programme can be seen in 1984 when methods developed in previous years reached their peak.

The efficiency of producing, marking and releasing the sterile flies progressively improved throughout the programme, with more than 2000 million sterile flies being released. A team of five people in Carnarvon and 10 in Perth was needed at the height of the programme to achieve the eradication goal.

During October, November and December of 1984 and January 1985, no fruit fly infestation was detected in Carnarvon. This period exceeds the international requirement for an area being declared free of fruit fly which is that no infestation must be found for a period equivalent to three fly generations, or about three months in Carnarvon. The specified time period varies for each area because the fruit fly's life cycle depends on daily temperature.

The future
Trapping and fruit surveys will continue in the Carnarvon area until June 1985 as a final precaution in the eradication programme.

Although the sterile fruit fly programme has ended, the Carnarvon Shire has been advised that their fruit fly baiting scheme should be continued because of the possibility of infested fruit entering Carnarvon from other horticultural areas.