Department of Primary Industries

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QUEENSLAND FRUIT FLY AND WINE GRAPES

Information manual for Hunter Valley grape growers

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Adrian Englefield – Development Officer Viticulture

Introduction

Queensland fruit fly (QFF), *Bactrocera tryoni*, is the most serious insect pest of Australian horticulture. QFF is found in parts of the Northern Territory, Queensland, New South Wales, Victoria and occasionally in South Australia.

The damaging stage is the larva, which feeds within the fruit. Fruit can also rot through fungal decay around wounds in the fruit surface caused by the adult female stinging and laying eggs (Figure 1).

Figure 1. Bunch of grapes affected by Queensland fruit fly. Note the sting marks on fruit and the discolouration indicating internal rotting as a result of larval feeding. Photo: A. Loch

Grapes as a host for QFF

Most publications do not list grapes as a host for QFF, or at best a very occasional host for QFF. Table grapes are regarded as a poor host for QFF, although QFF is able to complete development in many table grape varieties. The significant QFF damage recorded in the Hunter Valley during 2007–2008, coupled with successful QFF development in several wine grape varieties, confirms wine grapes as a suitable host for QFF development.

However, it is highly likely that wine grapes are not a preferred host for QFF. Several red and white varieties have been damaged by QFF, but research is required to test the suitability and preference of different varieties of wine grapes versus other known QFF host fruits.

The most likely cause of the QFF problem in the Hunter Valley during 2007–2008 is that elevated QFF populations (outbreaks) developed because of higher survival rates of QFF under mild and wet winter conditions. Enhanced development and survival during humid summer conditions and the availability of many host fruits in the area during spring also led to increased QFF levels.

Although other host fruits are available in the Hunter Valley when wine grapes are developing and maturing, it appears likely that the QFF population was so large that even lesser preferred hosts such as wine grapes were attacked.

Host list for QFF

Host suitability and preference for QFF varies greatly between different fruit species. In general, fruit is most susceptible to attack as it approaches maturity.

Table 1. Potential QFF hosts growing in the Hunter Valley region

African boxthorn	Passionfruit
Avocado	Persimmon
Banana	Pome fruit (apple, pear, nashi)
Berry fruit (blueberry, blackberry, mulberry, raspberry, strawberry)	Pomegranate
Citrus (grapefruit, orange, lemon, mandarin, lime, kumquat)	Prickly pear/cactus
Eugenia/Syzygium spp. (e.g. lillypilly)	Quince
Feijoa	Rose hip – Genus: Rosa various species
Fig	Solanaceous fruits/vegetables (tomato, capsicum, chilli, eggplant, pepino)
Grapes (table and wine)	Solanaceous weeds (wild tobacco)
Guava	Stone fruit (peach, nectarine, apricot, plum)
Loquat	Walnut
Olive	

QFF has been known to lay eggs into punctured ping pong balls when nothing else is available.

Lifecycle

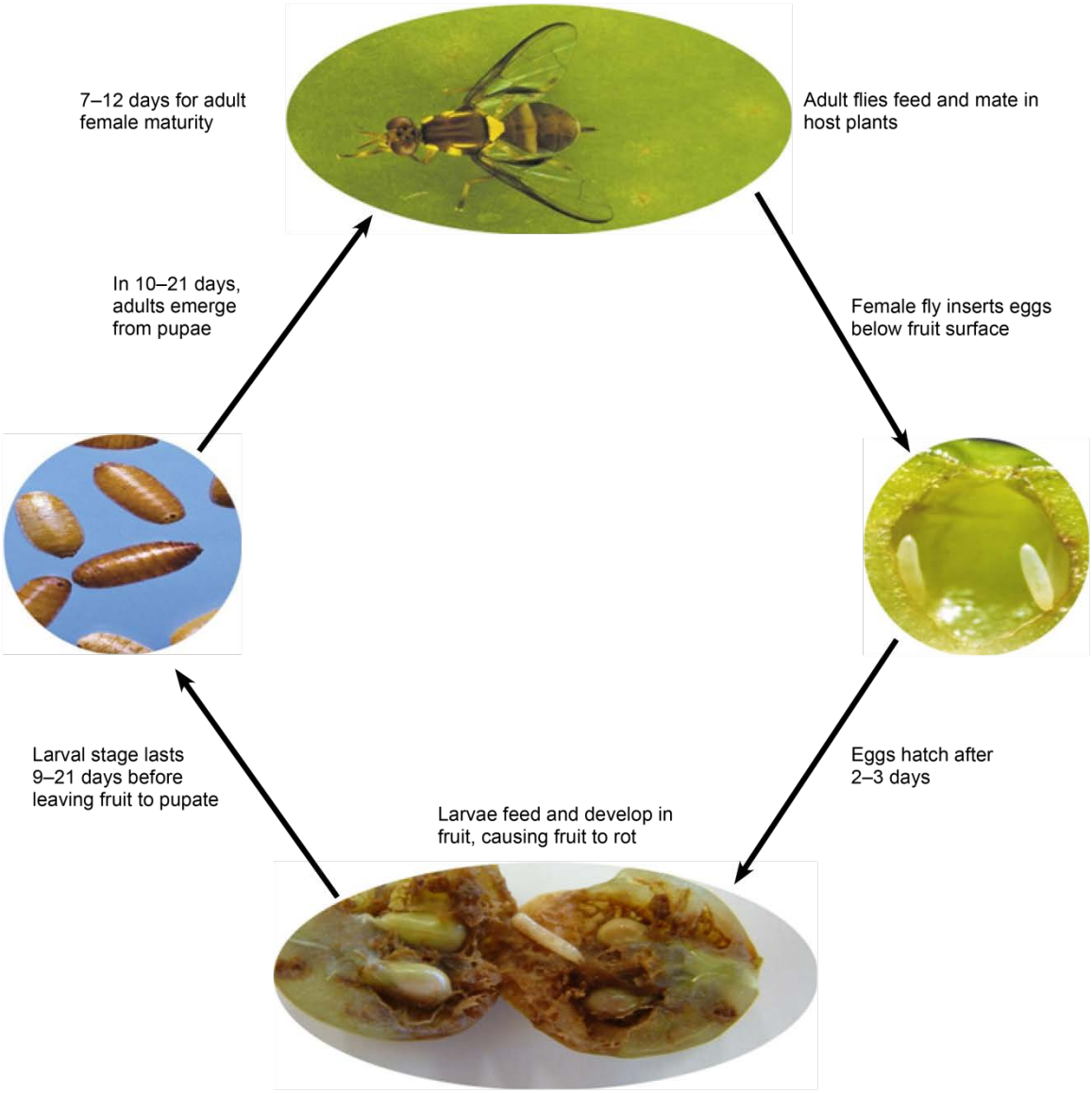

Figure 2. QFF lifecycle

Adults

Adults are approximately 7 mm long and are brown–black coloured with yellow markings (Figure 3). Adult flies are not likely to be seen except in situations where a high population is present. However, adults might be seen in the early morning, walking on foliage. Adults can live for many weeks depending on environmental conditions, predation and food availability.

Adults might live for only two weeks during summer, but can over-winter for up to five months. Adult flies are known to feed on natural protein sources (such as bird faeces), microbes (fungi and bacteria), and sugary substances (insect honeydew). Adults are able to mate within one week of emergence, and female flies begin laying eggs shortly after mating.

Adult females have an ovipositor on the tip of the abdomen that is used to pierce the fruit's surface and lay eggs. Each separate piercing into a fruit is called a sting, and females typically lay 1–3 eggs into each chamber and can sting the same piece of fruit multiple times. Females have the capacity to produce up to several hundred eggs throughout their lifetime.

Figure 3. Dorsal and lateral views of an adult female (left) and male (right) Queensland fruit fly. Photos: M. Hill

Eggs

Eggs are nearly 1 mm long, white and cylindrical to banana shaped (Figure 4). Eggs are laid just beneath the fruit's surface or skin. Eggs hatch in around 2–3 days depending on temperature.

Figure 4. Two Queensland fruit fly eggs beneath the skin of an apple. Photo: L. Turton

Larvae

QFF larvae are also called maggots. Larvae are creamy white in colour, legless and taper at one end where the darkened and hardened hooklike mouthparts are present (figures 5 and 6). Larvae use these mouth hooks to tear through the fruit's internal tissue.

Development occurs through three larval stages, with larvae growing progressively larger until they reach about 9 mm long. The larval development rate depends on temperature and can take as little as nine days at 25 °C or up to several weeks at lower temperatures. Multiple larvae can develop inside each fruit, including quite small hosts such as wine grapes, cherries and olives.

Figure 5. Queensland fruit fly larva and associated feeding damage inside a grape berry. Photo: A. Loch

Figure 6. Queensland fruit fly larvae. Note the taper at one end of the body and hooklike mouthparts. Photo: M. Hill

Pupae

Larvae leave the fruit to pupate and burrow up to 5 cm into the soil. During pupation, the larva shortens and the outer layer hardens and darkens to form a brown protective case (Figure 7).

The final phases of development into the adult fly occur inside the pupal case. Adults emerge from pupae after 10 days at 25 °C or after several weeks at lower temperatures.

Figure 7. Queensland fruit fly pupae. Photo: M. Hill

Seasonal lifecycle and climatic conditions

Queensland fruit fly prefers warm and humid or moist conditions for development and can undergo five or more annual generations, which can overlap. Populations of QFF decline during cooler periods between autumn and winter. Survival of QFF populations during winter is mostly by adults.

QFF adults do not usually sting available host fruits in winter unless periods of warm weather occur. Adults do not fly at low temperatures and need to fly for mating and finding host trees or fruit. As warmer weather returns in early spring, QFF adults increase in activity, begin mating and females begin laying eggs in fruit again.

Maximum temperatures of 16–17 °C are required for adult flies to become active, disperse locally and begin reproducing. Sexually immature adults disperse generally less than half a kilometre. Sexually mature females generally stay near fruiting hosts and only disperse if fruit and canopy are removed. Adult flies require sugar and water to begin the spring cycle and protein for maturation and reproduction. Egg, larval and pupal developmental stages require temperatures of at least 14–15 °C, and the rate of development increases with higher temperatures.

High temperatures above 35 °C lead to increased mortality of all life stages of QFF. Very dry and conversely, very wet, conditions can also lead to increased mortality rates.

Distribution

Queensland fruit fly occurs in most grape-growing areas throughout Queensland, New South Wales and Victoria. The state of South Australia is declared free of QFF, although occasional minor outbreaks do occur, principally around Adelaide.

The Sunraysia area of both New South Wales and Victoria is designated as a Pest Free Area and South Australia's Riverland is also declared a Pest Free Area. Movement of fruit into these zones is generally prohibited or permitted only under specified conditions.

Vinegar or ferment fly (Drosophilidae)

Vinegar or ferment flies (family Drosophilidae) are small, cream and brown flies that are attracted to rotting fruit and are common around wineries during vintage (Figure 8). The vinegar fly is not a true fruit fly as the larvae do not feed directly on the fruit; instead they feed on the bacteria and fungi found in rotting fruit.

Adult vinegar flies lay their eggs in damaged and rotting fruit and, unlike QFF, do not sting fresh, unbroken fruit to lay their eggs. Vinegar flies have a similar lifecycle to QFF. The different life stages are similar in appearance and so confusing the two insects is relatively easy.

Distinguish QFF damage in grapes by searching for stings and looking for internally damaged fruit that show no signs of external damage. The different life stages of vinegar flies are smaller than the corresponding QFF stage.

Adult vinegar or ferment flies are soft bodied, often have red coloured eyes, no yellow markings, and are about 3 mm long (Figure 8). Vinegar flies are much smaller than the typical house fly, whereas QFF is only slightly smaller than the house fly. If you find large numbers of small flies swarming around rotten or broken fruit, then they are almost certainly vinegar flies. If in doubt, collect damaged fruit or adult flies for identification.

Figure 8. Adult vinegar or ferment fly, which should not be confused with Queensland fruit fly. Photo: A. Loch.

Monitoring QFF in grapes: Dry traps

The simplest and most effective QFF monitoring dry tool is the Lynfield trap (figures 9 and 10). The lid is coloured yellow to allow easy identification among foliage and also because the colour yellow is known to attract male flies. The container has holes or vents to allow adult male fruit flies to enter, and the lid usually has a hook, allowing the trap to be hung from foliage or wires. Traps typically contain a cotton wick that contains Cue-Lure, the male attractant, and the fast knockdown insecticide: maldison.

Figure 9. Lynfield trap attached to wire in a vineyard. Photo: A. Loch

Figure 10. Inspecting a Lynfield trap in a citrus orchard. Photo: B. Dominiak

Lynfield traps are a monitoring tool only and do not control the fruit fly population. They are useful as an early warning system to alert growers to the presence of, or increase in, QFF populations. Traps are generally placed in a 0.4–1 km-spaced grid pattern. Alternatively, traps should be positioned around, and within, the entire vineyard so that trapping will provide an accurate and representative sample of QFF activity.

Hang Lynfield traps in a shaded position such as in the vine canopy or from vine posts or wire. Take care hanging the traps so that there is no risk of fruit being contaminated with the insecticide contained within the trap. The location of each Lynfield trap should be carefully recorded and marked in the vineyard using brightly coloured flagging tape. Ensure that leaves and vines do not touch the trap as ants and spiders may rob the trap. Anything touching the trap will allow predators into the trap and then the trap results under-estimate the fruit fly population.

Trapping should start in vineyards after a sufficient vine canopy has formed in spring. Traps must be removed before mechanical harvest. Ideally, trapping should also be conducted in fruiting host trees near the vineyard from July to gauge the size of the over-wintering QFF population. Check traps at least weekly throughout the season to provide accurate information on QFF populations (Figure 10).

Figure 11. QFF cone trap. Photo: B. Dominiak

Lynfield traps can be obtained from several commercial providers and may look different to the images provided below. The cone trap (Figure 11) is a new design in traps and is popular in Europe. These are commercially available in Australia.

Wet lure traps

Certified organic grape growers and those growers who do not wish to use traps containing insecticides can use traps containing the solution Wild May. This product is an insecticide-free lure registered as

organic by Biological Farmers of Australia and attracts male flies. Growers use a similar sized and shaped trap as the Lynfield trap, which contains holes for QFF to enter and a wire or hook at the top to attach to the vine or wire.

Traps are filled with about 2 cm of Wild May solution, which is sufficient to attract and drown male QFF. Recommended use is for four traps per hectare. Wild May traps are more work to maintain because trapped flies are difficult to count and dispose of, and the solution must be continually topped up during the season to remain effective.

There are several other wet traps using liquid protein, fruit juice and other commercial formulations to attract and kill fruit flies. Wet traps generally have a shorter distance of attractancy, compared with male pheromones such as Cue-lure. Wet traps are often better at attracting female flies.

Managing and controlling QFF in grapes

The three major reasons why QFF is Australia's most damaging horticultural pest are that:

1. QFF directly damages a wide range of host fruits
2. the insect undergoes multiple (five or more) annual generations
3. female flies have a high reproductive capacity (up to 300 eggs).

For these reasons, QFF populations must not be allowed to increase, or extensive crop losses can occur. Effectively managing QFF typically involves using multiple and complementary management options, and employing them early in the season to suppress QFF numbers and prevent damage from occurring.

Available management options for QFF control vary depending on the type of grapes grown (table or wine), the state where the grapes are grown, and the growth stage of the vine (Table 2). There are basically two different control tactics available for QFF management:

1. Bait sprays containing protein and an insecticide such as Hy-Mal (active maldison), or Naturalure (active spinosad), which contains both the insecticide and the protein.
2. Male annihilation technique/technology (MAT) using Amulet (active fipronil) or MAT cups (active maldison).

These different control tactics are used in conjunction with Lynfield traps and work most effectively when timed to coincide with major peaks in QFF population numbers. Bait sprays and MAT are the most compatible practices with integrated pest management (IPM).

Table 2. Insecticides registered for controlling Queensland fruit fly in Hunter Valley-grown wine and table grapes, restrictions on their use, and withholding periods (WHP).

Active	Products	Restrictions on use	Table and domestic wine grapes WHP	Export wine grapes WHP
Malathion 1150 g/L	Hy-Mal*	Bait spray. Table grapes spray to point of runoff	3 days	3 days
Spinosad 0.24 g/L	Naturalure fruit fly bait concentrate	Vine crops, No states mentioned, Do not spray on fruit	Not required when used as directed	Not required when used as directed
Fipronil 3.4 g/kg	Amulet Cue-Lure fruit fly stations		Not required when used as directed	Not required when used as directed

Insecticide and protein bait sprays

Bait sprays attract and kill QFF using a protein attractant such as yeast autolysate mixed with an insecticide. Female flies are especially attracted to the protein source during maturation and egg development. Flies attracted to the sprays are killed by contact with or ingesting the maldison.

Bait sprays are applied as a series of spot or strip sprays to the upper part of the trellis and should not be applied directly to fruit as damage can occur. Spot or strip sprays must be conducted across the entire

vineyard block for maximum control. Time bait sprays to coincide with high counts of QFF in Lynfield traps.

Bait sprays are best applied in the early morning and re-applications must occur every 5–7 days for maximum control. Baits remain attractive while they are wet. Bait spray activity is typically short lived, especially at high temperatures or during times of rainfall. The advantages of bait sprays include reduced insecticide use and the minimal effect on non-target organisms such as beneficial insects.

Hy-Mal (1150 g/L Maldison)

Hy-Mal insecticide is mixed with a protein source (e.g. yeast autolysate) and applied as a spot or strip spray to the upper part of the trellis. Hy-Mal protein bait sprays are best applied in the early morning and reapplications must occur every 5–7 days for maximum control.

Maldison (malathion) is an organophosphorus, broad-spectrum, non-systemic insecticide that works by contact, stomach or respiratory action. The insecticide is commonly used in QFF Lynfield traps and also in MAT (male annihilation technology) cups.

Naturalure fruit fly bait concentrate (0.24 g/L spinosad)

The registered product Naturalure contains only 0.24 g/L of spinosad and a protein and sugar-based bait. These products are recommended to either spot or row spraying as a dilute or concentrated product. Applying large-sized droplets (4–6 mm) is also recommended to increase the duration of activity.

Spinosad is an insecticide derived from naturally occurring beneficial soil bacteria. It has a novel mode of action that causes rapid excitation of the insect nervous system. Spinosad can work as a contact insecticide, but its main mode of action against fruit flies is through ingestion.

Male annihilation technique/technology (MAT)

MAT involves the area-wide distribution of cups, pads, blocks or stations that contain the male fly attractant Cue-Lure and an insecticide. MAT works similarly to the Lynfield trap by attracting and killing male flies, except that male flies are not trapped for counting purposes.

The aim of MAT is to reduce the male fly population to very low levels, such that levels of mating with female flies are reduced, which leads to population suppression. For maximum QFF control, use MAT in combination with bait sprays.

Amulet Cue-Lure fruit fly stations (3.4 g/kg Fipronil)

Amulet Cue-Lure fruit fly stations attract (via Cue-Lure) and kill male fruit flies (via the insecticide fipronil). Amulet Cue-Lure stations are recommended at grid spacing of 26–32 m or 10–16 stations per hectare.

Fipronil is a broad-spectrum insecticide that disrupts the nervous system and generally causes slow death in insects. Fipronil can act as both a contact and a stomach poison. Although no WHP is applicable for using Amulet in vineyards, fipronil can still contaminate grapes.

Although fipronil is enclosed in the station, it is typically a slow-acting insecticide. Therefore, male flies that come in contact with an Amulet station might not die immediately and could subsequently land on fruit before dying.

MAT cups/wicks (0.1 ml maldison per wick)

MAT cups or wicks attract (via Cue-Lure) and kill (via maldison) male flies. Both Cue-Lure and maldison are enclosed in a cotton wick, which is enclosed in a plastic cup. The plastic cup has a hook for attaching the trap to wires or the vine. The likelihood of insecticide contamination of grapes using MAT cups or wicks is negligible.

Maximum residue limits for grapes (MRLs)

For grapes grown for export wine, the harvest interval is sometimes much longer than the withholding period stated on the chemical label. It has been calculated to minimise the likelihood of residues affecting fermentation, affecting sales of wine and to reduce public exposure to agrochemicals.

Information on MRLs for different agrochemicals can be obtained from the Australian Wine Research Institute website. The AWRI's *Dog Book: Agrochemicals registered for use in Australian viticulture* contains information on the main registered agrochemicals in Australian viticulture and restrictions on their use for export wine.

Growers who only supply grapes for wine in the Australian market may be able to use a greater range of registered insecticides and for a great period during the growing season to control QFF. Grape growers can contact the AWRI or their winery for further information.

For further information please contact the AWRI helpdesk – helpdesk@awri.com.au or call 08 8313 6600.

Vineyard and orchard hygiene

QFF hosts are often abundant and widespread in a grape-growing area. Reducing the availability of these fruits can be an effective means of reducing or limiting these QFF populations. QFF adults do not fly great distances and generally are local problem. Therefore, removing or reducing the availability of host fruits on your property can lead to significant reductions in local QFF numbers. Effectiveness increases if neighbouring properties also participate. Home orchards need to be managed the same as commercial orchards or vineyards.

Possible means of managing or reducing host fruit availability include:

- picking all fruit from trees, particularly from backyard gardens
- collecting all fallen, damaged and rotten fruit (Figure 12) and disposing of it appropriately (e.g. place infested fruit in a sealed bag and put in a bin)
- pruning fruit trees to a manageable height so that fruit can be picked easily
- spraying highly susceptible or QFF-infested fruit trees with a suitable insecticide
- removing unwanted host fruit trees and fruiting feral host plants.

Figure 12. Fallen fruit such as peaches infested with Queensland fruit fly should not be allowed to rot on the ground; they should be collected, bagged and disposed in the bin. Photo: M. Gasparotto

Disposing of QFF-damaged fruit

In the event that a vineyard or part of a vineyard becomes significantly infested or damaged by QFF, all affected fruit should be harvested as soon as possible and destroyed if the grapes are not to be used for winemaking.

Leaving infested fruit on the vine allows QFF to continue developing and leads to increased population numbers. Fungal pathogens can also thrive in this environment leading to increased disease pressure. The resulting increased pest and disease pressure could then spread to later-maturing grape varieties nearby.

Perhaps the simplest and most effective disposal method for QFF-infested grapes is to harvest and dump all fruit onto the ground and then mechanically slash bunches and berries to destroy developing larvae.

Destroying infested fruit does not prevent further damage from occurring because adults and developing pupae in the soil are not killed. Any uninfested fruit-bearing vines in the near vicinity of QFF infestations should be thoroughly and regularly monitored before harvest because they are at the highest risk of infestation. In this situation, Lynfield traps should be used to monitor the QFF population, and developing bunches should be inspected for signs of stings or damage.

Growers considering controlling QFF with insecticide late in the growing season after the relevant withholding period for export wine grapes, must consult their winery before applying.

Biological control of QFF

Although a number of natural enemies have been recorded as parasitising and predating on QFF, none provide effective control.

More information

Adrian Englefield

Development Officer Viticulture.

M: 0428 324 099.

E: Adrian.englefield@dpi.nsw.gov.au

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