NSW GOVERNMENT | Department of Primary Industries

Fruitspotting bugs 2016

NSW DPI MANAGEMENT GUIDE

Ruth Huwer, Craig Maddox, Jeremy Bright, Mark Hickey, Ian Newton & Stephanie Alt

Horticulture Innovation Australia

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Front cover photos: (large photo) a fruitspotting bug on a damaged custard apple shoot, (small photos) damage from fruitspotting bugs on a dissected avocado, macadamia nuts in husk, cut open to check for fruitspotting bug damage, adult fruitspotting bugs on lychee fruit (photo Ian Groves).

Back cover photos: (clockwise from top left) An adult fruitspotting bug, open orchards with canopy structures that allow good spray coverage have less risk of fruitspotting bug damage, a 5th instar fruitspotting bug nymph, collaboration can achieve better control of fruitspotting bugs for everyone, spraying based on action thresholds is best practice in using chemical controls, inspecting crops for fruitspotting bugs and damaged fruit.

Department of Primary Industries

Fruitspotting bugs 2016

NSW DPI MANAGEMENT GUIDE

Integrating fruitspotting bug (FSB) management options for better outcomes on farms.

This guide provides up-to-date information relating to fruitspotting bugs (FSB), the management options available, and how to integrate these for the most benefit.

SUPPORTING ORGANISATIONS

Foreword

Figure 1. Growers, Keith and Judy Paxton.

It was a pleasure to represent my industries on the Fruitspotting bug (FSB) Project steering committee, and to be an active collaborator on the research on my farm. I am happy to see this guide has been produced as a result of the project's activities, so that what has been learned can be used by more growers to manage what remains one of our most serious pests.

Past research efforts tended to only address chemical control, which should be just one aspect of pest management. The need to find more successful strategies for controlling FSB called for a large, multi-faceted project that considered all management options. This unique project brought together several industries and R&D providers to address one of Australian horticulture's major pests.The collaboration resulted in a truly integrated approach to management involving:

» better understanding of life cycles

» the development of new, better targeted chemicals

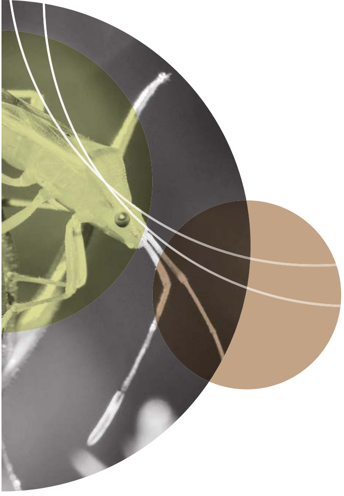
» improved monitoring techniques including pheromone traps and trap crops

» improved spray application and timing

» better integration of monitoring information and controls

» the possibility of continuing the search for a biological control.

We commend the researchers and their staff for their hard work and dedication to finding solutions to the problems horticulture is facing due to FSB.



Contents

Introduction

Fruitspotting bugs (FSB) are native to Australia. They live in rainforest regions from 30° latitude and north. FSB feed on the fruit, flowers and very young shoots of fruiting plants. Many horticultural crops and garden plants attract FSB, and FSB readily move from their core native habitat.

Figure 2. An adult FSB and smaller FSB nymphs on a mango stem. Photo Leonie Wittenberg.

FSB are a major impediment to the commercial production of most tree fruits and nuts, and some vine fruits. Crops are affected in the coastal and sub-coastal areas of Queensland, northern NSW, the Northern Territory and north-western Western Australia. Growers have recorded crop losses of well over 50% due to FSB damage.

FSB attack at least 22 different types of commercial fruits and nuts. Economic losses from FSB could amount to tens of millions of dollars each year in the Australian fruit and nut industries. The commercial crops most affected are avocados, macadamias, custard apples, lychee (litchi), passionfruit, papaya (pawpaw), citrus and mango. Other crops that can suffer FSB damage include grapes, figs, longan, carambola, stone fruit, cashew, pecan, mangosteen, kiwi fruit, cucurbits, pistachio, persimmon, lemon aspen, rambutan, tamarillo, raspberry, blueberry and almond.

FSB is currently regarded as the most significant pest of macadamias. The economic impact of FSB on the Australian macadamia industry was estimated at $8.9M per annum[1] in 2011 from:

» reduced farm gate production

» increased production costs (more crop protection)

» reduced recovery of kernel in processing

» increased processing costs

» reduced kernel quality, shelf life and final product value due to increased handling during processing.

1 Andrew Starkey, Australian Macadamia Society, personal communication.

An integrated pest and disease management (IPDM) framework

Across horticultural crops, integrated approaches to managing pests and diseases are seen as best practice. An integrated pest and disease management (IPDM) framework means creating management systems that incorporates as many useful strategies as practical to:

» reduce risks of pest and disease outbreaks

» detect pest and disease problems early

» treat problems effectively with minimum pesticides used.

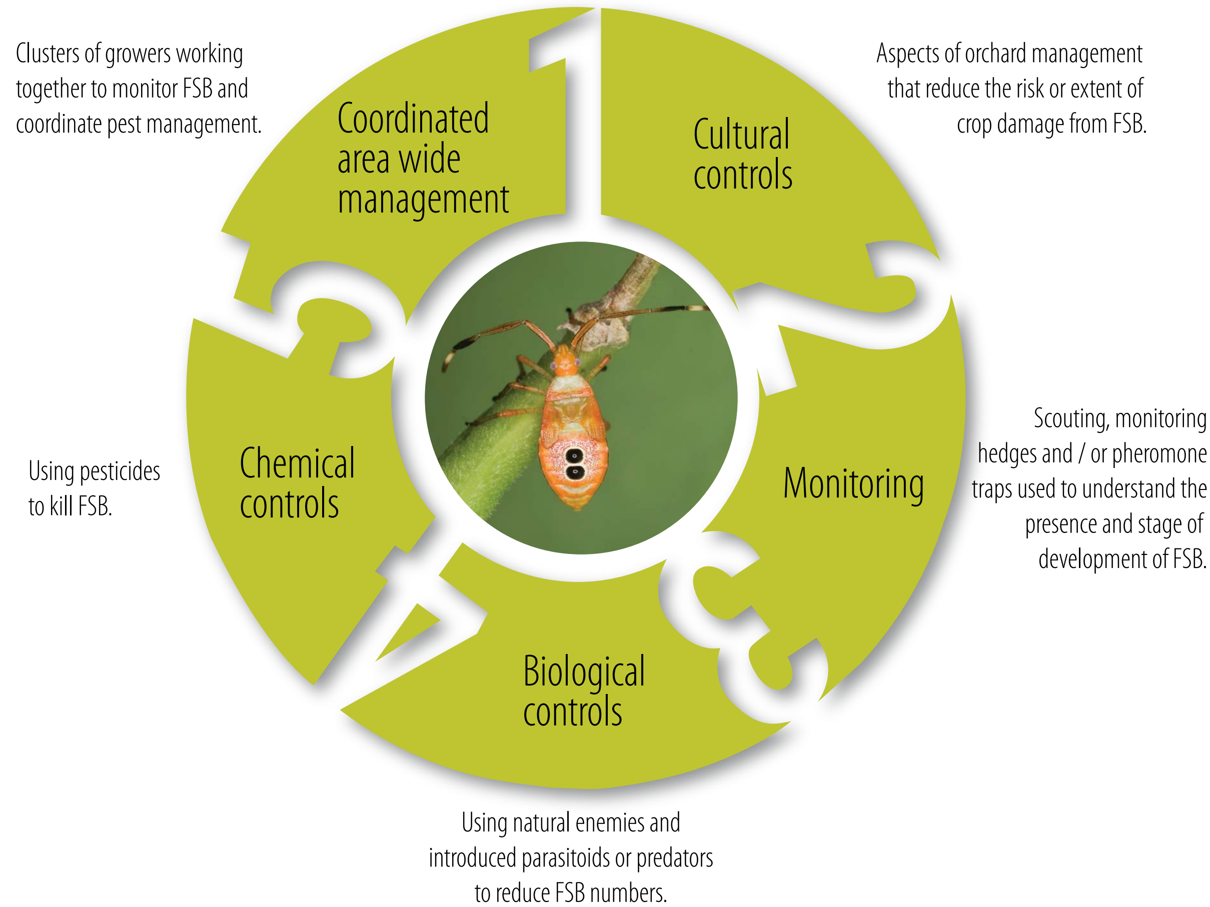


Figure 3. An integrated pest and disease management system most likely to achieve long-term control of FSB will include cultural controls, monitoring, biological controls, chemical controls and participating in coordinated area wide management.

How to be FSB ready

Know what to look for

- Be able to **identify FSB damage** in your crop.
- Be able to **identify FSB.**
- Be able to **identify the 5th instar stage of FSB nymphs** (they are an important indicator for chemical control action thresholds).
- **Know where to look.** The crop is not always the easiest or most strategic place to look for FSB.

Figure 4. 5th instar nymph FSB *nitida.*

Figure 5. 5th instar nymph FSB *lutescens.*

Monitor

- Weekly, or at least fortnightly, monitoring is needed during high-risk fruiting periods.
- Be aware of nearby food sources for FSB and include them in your monitoring.
- Use monitoring hedges and pheromone traps to simplify monitoring.
- Plan back-up if you are unable to complete the monitoring yourself.

Figure 6. Looking for FSB in bordering native vegetation.

Be ready to act

- Decide on your action triggers in advance, and your action plans for control practices.
- Have spray equipment functional and ready to use. Be aware it may be difficult to get a contract sprayer at the time of your action trigger.
- Calibrate sprayers at least annually.
- Have competent people available to complete spraying operations.
- Have a back-up plan if something goes wrong with equipment or personnel availability.

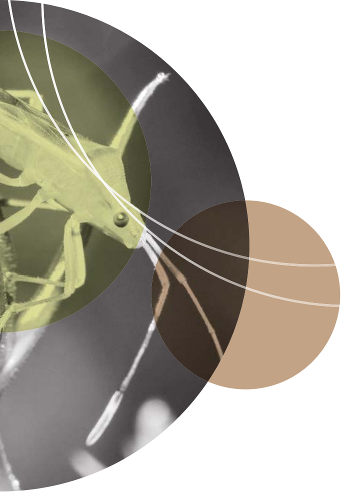
Figure 7. Spray equipment ready to go.

Cooperate with your neighbours

Better control of FSB across broader areas benefits all growers in the area.

- Understand what your neighbours' practices are.
- Share skills, train others in monitoring skills.
- Coordinate chemical control timing to reduce the FSB population over a broader area and minimise FSB migration from unsprayed into recently sprayed orchards.
- Participate in or initiate an area-wide management framework.

Figure 8. Talk to neighbours and other farmers.



What does crop damage look like?

Fruit damage

Premature drop

Small, immature fruits are usually dropped within days of an FSB attack. In some crops no external marks are evident and the fruit must be dissected to observe the lesions.

Figure 9. Mangoes dropped prematurely after FSB damage (right). Photo DAF.

Damaged fruit

The signs and extent of visible damage vary between crops. The colloquial term 'sting' is used by farmers to describe the lesion formed on fruit after FSB have fed.

Figure 10. FSB lesions on a skinned avocado (above).

Figure 11. FSB lesions on macadamia husk (top right) and dissected macadamia (bottom right).

Growing point damage

Damage is visible as dieback, lesions and sometimes distorted growth. In papaya, FSB damage can shorten internode growth at the growing tips, causing the leaf to look 'bunched up'. Sometimes black or brown feeding marks can be seen.

Figure 12. Dieback on a custard apple growing tip.

Figure 13. Lesions on a mango growing tip. Photo DAF.

Figure 14. FSB damage can deform the new growth of papaya, giving a 'bunchy' appearance to the top.

Flower damage

Damage is visible as a wilting flower or flower panicle. Sometimes black or brown lesions will be visible on the petals.

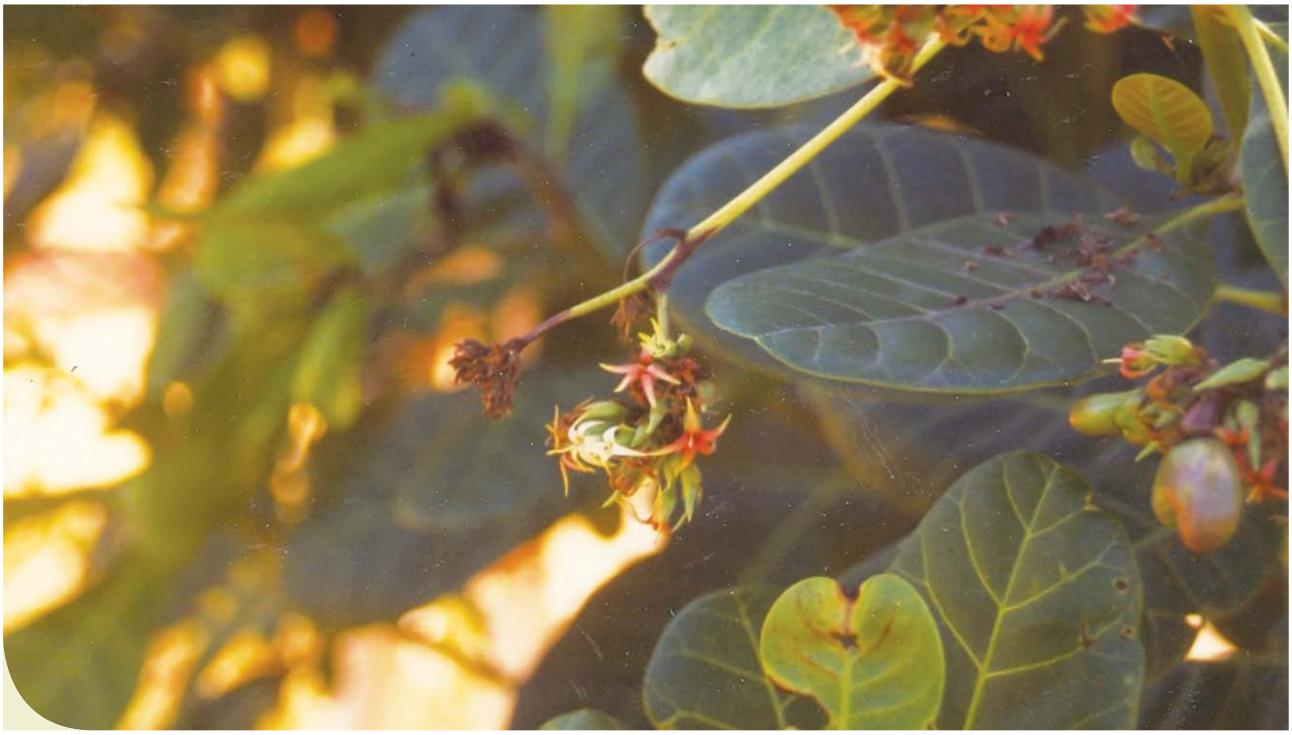


Figure 15. FSB damage to cashew flowers.

Check it isn't something else

Queensland fruit fly damage

Damage from FSB is often confused with damage caused by Queensland fruit fly. Fruit fly damage can be usually identified by cutting through the entry point and searching for the curved, banana-shaped white 1 mm long fruit fly eggs or for the white or cream-coloured fruit fly maggots (6–8 mm long when fully grown).

Fruit fly damage is superficial compared with FSB damage, extending no more than 3 mm into the flesh and producing a hard, pear-shaped callus. Damage is more common on the lower half of the fruit that hangs closest to the ground. Fruit fly can sometimes take advantage of FSB damage so fruit fly eggs can be found in FSB wounds.

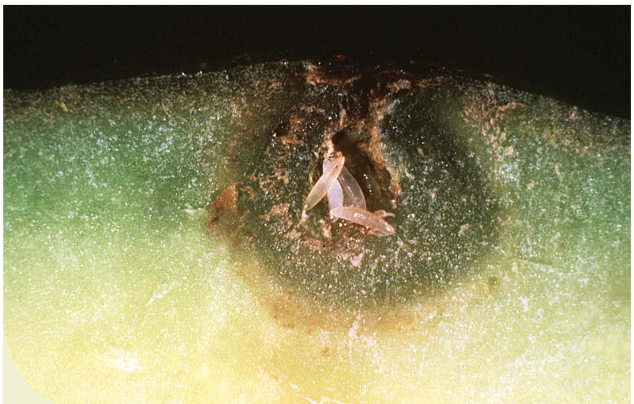


Figure 16. Fruit fly maggots in a mango at an FSB damage site. Photo Leonie Wittenberg.

Green vegetable bug damage

Most common in macadamias, damage is not obvious until the nut is shelled. The lesions cased by green vegetable bugs are usually not as deep as early or mid season FSB lesions but are very much like late season FSB lesion, and very difficult to distinguish. Green vegetable bugs usually inflict a larger number of sting marks on an individual nut.

Figure 17. Macadamias damaged by green vegetable bug.

Stem end cavity in mangoes

Mature mango fruit can show damage that looks like stem end cavity – a nutritional disorder of mangoes. FSB damage has a clear boundary where the damaged fruit meets the healthy tissue, which is absent in true stem end cavity disorder. The external lesions from FSB tend to be rounded, firm and dark brown–black in colour, compared with soft and grey in true stem end cavity.

Figure 18. FSB damage near the stem. Photo DAF.

Figure 19. Fallen green macadamia nuts, dissected to show the internal damage.

Crop-specific damage

Macadamias

FSB can damage nuts of all sizes and maturity levels. Depending on the variety and shell thickness, FSB can penetrate hard macadamia shells to feed on the kernel. Thin-shelled macadamias are most affected by FSB damage.

Immature macadamia nuts damaged by FSB generally fall prematurely. Marks on the outside of the husk are often not obvious. The green nuts inside have slightly sunken, dark spots.

More mature nuts do not drop when attacked, but can be unmarketable. Mature nuts can present as a 'blind sting', where damage on the outside of the shell is not visible although the kernel is damaged. Blind stings might not be detected until processing.

Damage to mature nuts can be visible as:

» dark, slightly sunken spots on the husk

» soft, misshapen and brown testa (the membrane surrounding the kernel that eventually becomes the hardened shell)

» deformed kernels that can be brown, greyish or transparent, may be shrivelled or have signs of mould.

Figure 20. FSB damage in macadamia nuts on the northern rivers.

Figure 21. FSB damaged macadamia kernels, early season damage to left, later season damage to right.

Figure 22. Small, immature avocados usually fall from the tree after being stung by FSB. Photo DAF.

Avocados

Both adult and nymph FSB can damage avocado fruit. Smooth and thin-skinned varieties such as the Fuerte are most vulnerable to FSB damage. Fruit smaller than 5 cm in diameter (golf ball size) are usually dropped soon after being stung by FSB. Young fruit can show 'blind stings' – dark sunken spots without noticeable cracking.

Larger avocado fruit usually remain on the tree after FSB damage, which appears as:

» lesions that show up as **craters** – water-soaked areas that exude a sap which dries to a white powder; the flesh beneath the lesions is discoloured

» **star-shaped cracks** that form as the fruit expands around the dead tissue where FSB have fed

» lesions that become infected with the fungus *Glomerella cingulata*, causing Anthracnose disease – fruit becomes unmarketable even if FSB damage was relatively minor

» **blind stings** where the feeding site is almost or totally invisible externally (especially on thick-skinned varieties such as Hass) but lesions are visible when the fruit is peeled

» stings that also result in **small, hard, woody lumps** in the fruit (often referred to as stones) in the flesh just under the skin.

Figure 23. Avocado fruit may exude sap from FSB stings, which dries to a white colour.

Figure 24. Cracks form in the avocado skin around scarring from FSB stings earlier in the season. Photo DAF.

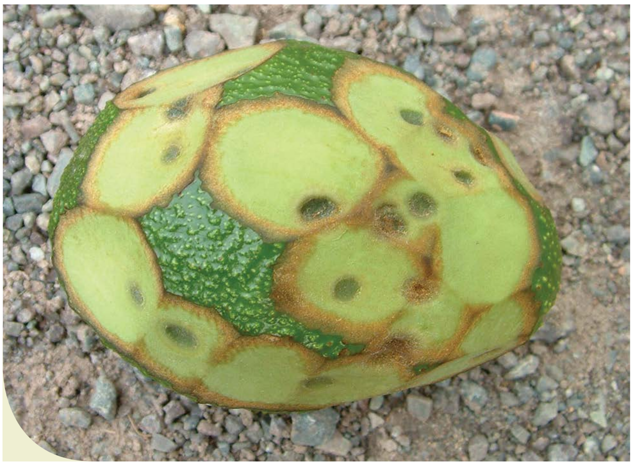


Figure 25. The damage from blind stings can be seen once the fruit is peeled. Photo DAF.

Figure 26. 'Stones' - woody lumps form under the skin at FSB sting sites. Photo DAF.

Other crops

Over 90% of green **lychee** fruit can be lost in heavy FSB infestations. Often no external marks are visible and the fruit must be dissected to see the FSB damage. Look for brown lesions on the seed and small black pin pricks on the internal white surface of the skin. Nymphs from eggs laid late in the lychee's green fruit phase can survive on mature lychee fruit, but adult bugs are less attracted to the orchard once fruit is mature. This fruit does not fall; the damage has little effect on fruit quality and might not be detected at harvest.

Figure 27. Lesions from FSB damage on immature blueberries.

Longans are subject to continuous attack at any time between fruit set and ripening stage. Berry crops, including **raspberries** and **blueberries** are attacked by FSB, which target fruit and flowers.

Dark, sunken lesions, sometimes oozing sap when the lesions are fresh, are visible in **custard apple** and **mango**. Skins crack as the fruit matures. A dimple in the skin might be visible where the damage has occurred and large lesions often develop around the feeding site, making the fruit unmarketable.

Figure 28. FSB damage on passionfruit.

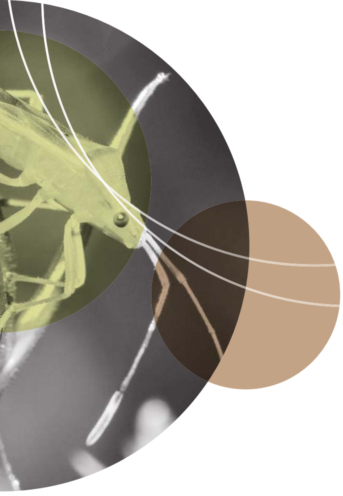
Figure 29. FSB damaged custard apple oozing sap.

Figure 30. FSB have fed over most of the surface of this custard apple.

The terminal growth of several hosts is attacked. **Papaya, mango** and **cassava** are most commonly affected. Papaya trees can be killed through repeated attack on the growing point. Mango terminals die back and are induced to branch, disrupting flower and fruit production. In **passionfruit**, wilting shoots are visible after FSB feeding.

Banana is not a favoured host of FSB for breeding. FSB usually only attack commercial bananas if deprived of their normal hosts. **Cashews** are affected by FSB feeding on shoot, flower, cashew nut and cashew apple. The **carambola** (starfruit) variety Thai Knight is particularly susceptible to FSB damage.

Figure 31. A mango flower showing damage from FSB. Photo DAF.



What are the fruitspotting bugs?

FSB are insects of the order Hemiptera, the true bugs, a large family of sucking insects that includes stinkbugs and the human parasite bedbugs.

Two distinct species affect crops in tropical and subtropical Australia. The full names of the pest species of FSB are *Amblypelta lutescens lutescens* and *Amblypelta nitida*. For this guide where we discuss these species individually, we refer to them as **FSB *lutescens*** and **FSB *nitida*.**

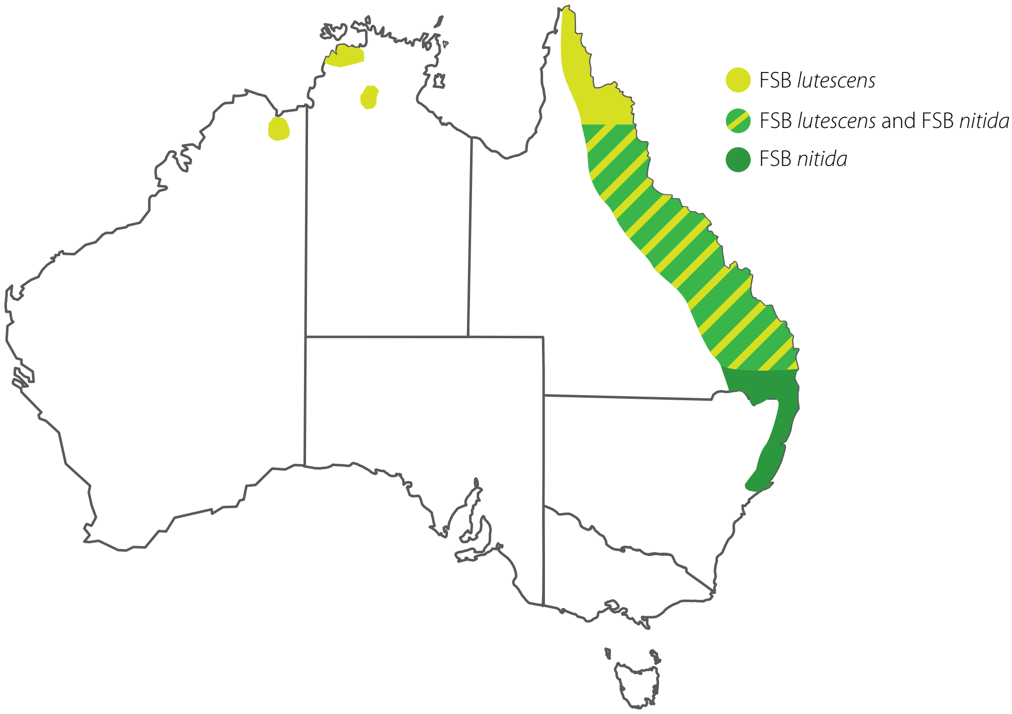


Figure 32. FSB *nitida* are found from 17° S to 30° S; FSB *lutescens* from 11° S to 27° S. Map adapted from Danne 2014.

Feeding mechanisms

FSB have piercing–sucking mouthparts. They feed by inserting two pairs of stylets – slender, piercing tube structures – into the plant tissue. They inject salivary fluid containing enzymes including a strong sucrase. This generates a high glucose concentration within the plant tissue. The cell contents are driven by osmotic pressure to flow out through intact cell membranes and are lapped up by the bug. The mouthparts of adults and 5th instar nymphs are larger, and can penetrate deeper into tissues. Plant cells can be emptied from up to 3.5 mm in all directions from the point of the mouthparts' penetration.

FSB *lutescens* feeds mainly on fruit, and on the new shoot growth of some host plants. FSB *nitida* feeds mostly on green fruit and on flowers.

Figure 33. FSB mouthparts close up.

Lifecycle

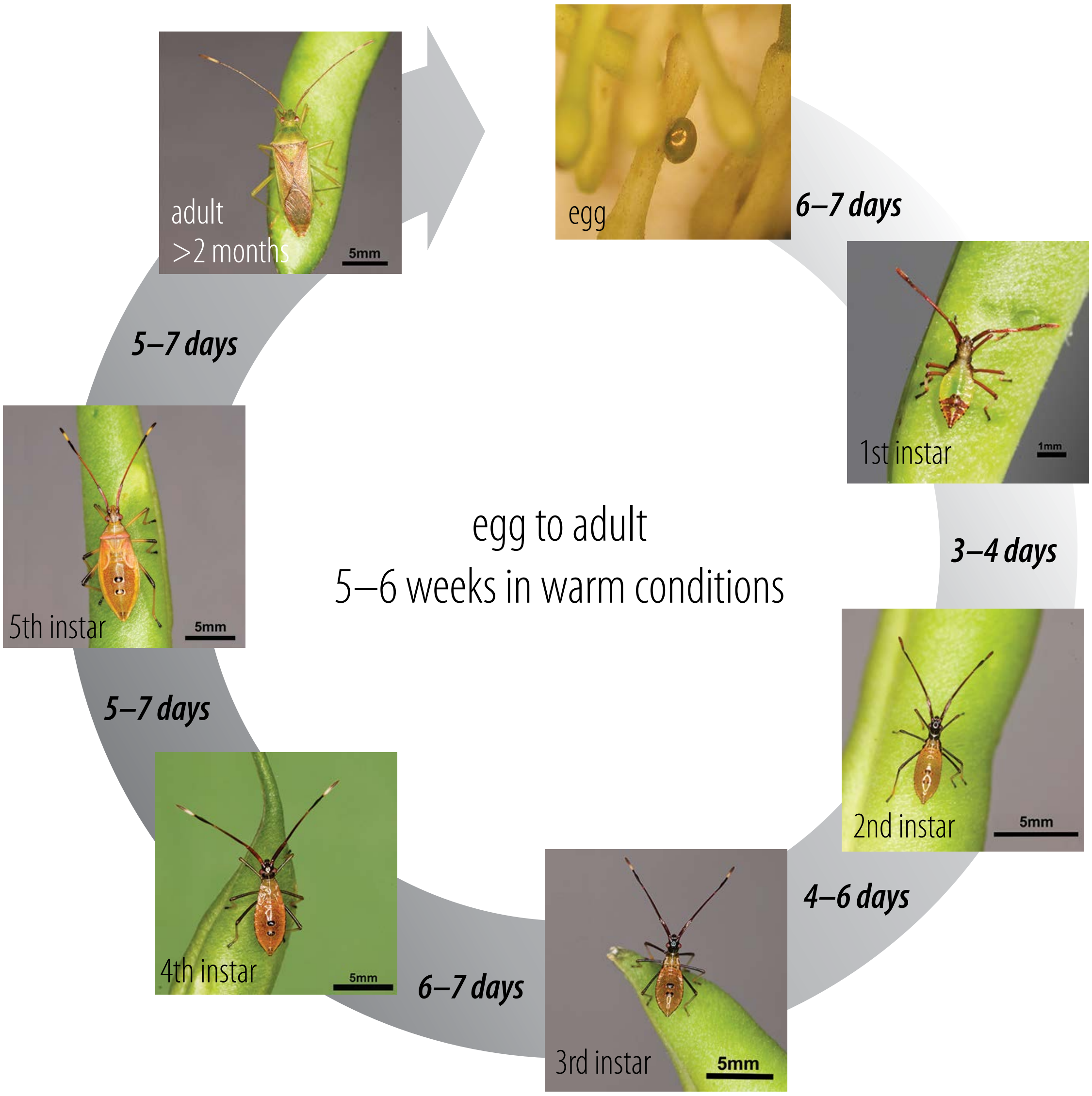


Figure 34. The development time between FSB stages of development. Photos Alana Govender.

FSB complete 3–4 generations in a year – one in spring, one or two in summer and one in autumn. Seasonality controls how many generations each species of FSB will complete in a calendar year.The time it takes for FSB to develop through its life stages depends on temperature. FSB *lutescens* is a little quicker than FSB *nitida* to complete a generation. Development time can also vary according to the food the FSB consume.

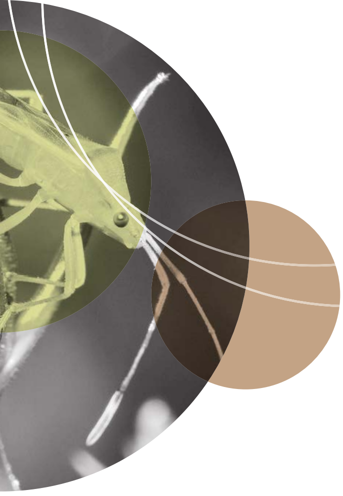
Table 1. Development time for FSB at different temperatures

Species	FSB *lutescens*	FSB *nitida*
Days to develop from egg to adult		
at 20 °C	63 days	79 days
at 25 °C	45 days	50 days
at 30 °C	30 days	41 days

Source: A. Govender *nee* Danne

Most eggs are laid between November and March, some eggs are laid from April to July. During its life, an adult female FSB can lay over 150 eggs, but only a few each day. Adults can survive the winter and begin a new generation in spring when temperature and humidity increases.

Figure 35. FSB nymphs increase in size with each instar stage.



Monitoring FSB

Having some information about the presence, prevalence and stage of development of FSB in and around the orchard informs management. Limiting the search for FSB to just the commercial crop is not sufficient to inform effective control decisions. FSB are highly mobile and tend to spend a lot of time in the top halves of trees – making in-crop monitoring difficult from ground level.

Developing a plan for the timing and methods of monitoring ensures useful information is gathered.

» Identify and **monitor bordering vegetation** that might host FSB (especially at their flowering and fruiting times) and adjacent entry points into the crop.

» **Use monitoring hedges or pheromone traps** to detect early flights of adult FSB and monitor the nymphs' development.

» **Identify hotspots** (areas where FSB concentrate) in the crop from historical data and observations, and including these in monitoring. Check at least 10 trees in known hotspots.

» **Search for fresh damage** on at least 20 random crop trees not covered by other monitoring. In crops where significant damage can occur from feeding on terminal shoots (e.g. papaya) it can be important to monitor up to 10% of crop plants.

Where both FSB species (FSB *lutescens* and FSB *nitida*) occur together even more frequent monitoring could be needed. Each species takes a different amount of time to complete their generations and will not be synchronised.

In future, sharing monitoring information online should become more commonplace and more accessible. This kind of information will complement individual farm monitoring and can be an important part of an area-wide management program. An upcoming integrated pest and disease management project for macadamias will start to build resources for sharing information gathered from monitoring FSB.

Identifying FSB

Being able to identify FSB, and their developmental stage is essential for obtaining useful monitoring information.

Eggs

FSB eggs are oval shaped and 1.5–1.7 mm long. Eggs are initially pale green and slightly opalescent. The developing eggs are translucent and the nymph can be seen within. Eggs are laid singularly rather than in groups, most commonly on the surface of florets, fruit, and young shoots, or on bark.

Figure 36. Freshly laid FSB eggs to left, progressing to almost hatching at right.

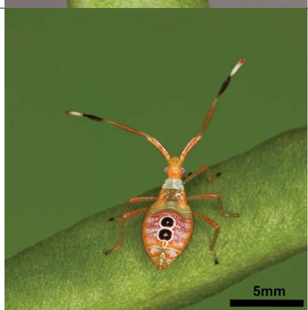
Figure 37. FSB adult with freshly laid eggs on bark and stem.

Nymphs

FSB nymphs are 2–10 mm long. Their clearest identifying feature is two black spots on the abdomen. Nymphs are distinguished from adults by the absence of external wings.

The development of FSB nymphs is broken up into five stages called instars. During the first instar it is difficult to distinguish between the two species. Differences become more obvious as FSB mature. To use a monitoring hedge you need to be able to identify 5th instar nymphs.

Table 2. The instar stages of FSB nymphal development. Being able to confidently identify the 5th instar is an important monitoring skill.

Species	FSB *lutescens* (broad body shape)	FSB *nitida* (narrow body shape)	
1. Clear bicolour pattern on abdomen, green upper section, brown lower section.			
2. Median band on thorax clear and noticeable. Centrally paired raised areas inconspicuous and like blunt spines.			
3. Conspicuous middle band. Pair of black spots almost merged. Slight swelling representing wing buds evident.			
4. Distinct clear middle band. Distinct pair of black spots. Wing buds distinct.			
5. **Large wing pads.** Body 8–10 mm long. Distinct pair of black spots.			The action threshold from the monitoring hedge is >30% of FSB at the 5th instar stage.
	A pair of prominent white bands encircling two large black spots on the abdomen.	**A pair of small black spots on the abdomen. Black antennae, black 'knees' and wing buds.**	Photos: Alana Govender

Adults

Adults FSB are approximately 11–15 mm in body length, and slender in build. The presence of wings distinguishes adult FSB from nymphs.

Adult FSB *nitida* usually have a green body. FSB *lutescens* often have a yellow/orange tinted body, but mostly appear with similar colouring to FSB *nitida*.

Figure 38. Adult FSB *lutescens*. Photo Alana Govender.

Figure 39. Adult FSB *nitida*. Photo Alana Govender.

Likely sources of FSB

Almost any fruiting plant in the vicinity of your orchard might be harbouring FSB. Other orchards, gardens and native vegetation can all be sources of FSB.

Whenever eucalypts fruit well in winter and spring, higher levels of FSB will be seen in crops. Wetter seasons often produce higher invading levels of FSB from native vegetation.

Unmanaged fruit trees are a source of FSB pressure. Most citrus can be a source, especially limes where FSB are often tolerated as they do little damage to the limes themselves. Garden mangoes are another likely source.

Figure 40. FSB on a Tahitian lime. Photo Karel Lindsay.

Hotspots

Adult FSB tend to concentrate in hotspots in orchards. Growers have long observed that FSB colonise a certain tree on which they breed and feed, then radiate through an orchard as the rest of the crop comes on. These hotspots are often consistent year after year.

Gaining familiarity with orchard hotspots gives an opportunity to more easily monitor late season FSB activity. FSB are likely to return to trees carrying early season damage.

Experimental work at the NSW DPI Centre for Tropical Horticulture, Alstonville, has developed an understanding of the very high degree to which FSB are selective in which trees they attack. A macadamia trial investigating crop losses to the macadamia nutborer (MNB) revealed critical information about:

» FSB clearly targeting their preferred varieties

» how much crop damage occurred in FSB preferred varieties late in the season.

Figure 41. FSB return to guava fruit marked with older FSB damage.

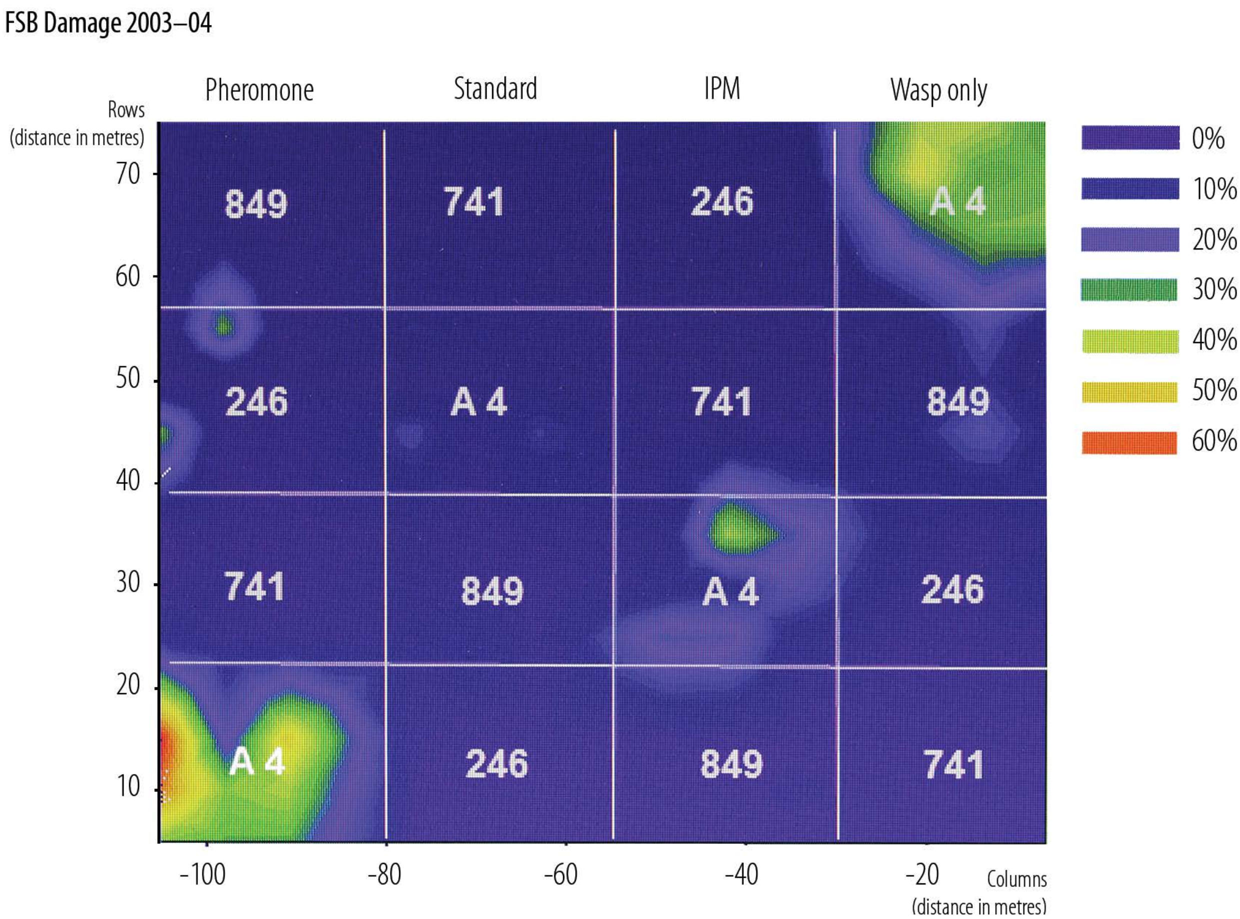


Figure 42. The spatial distribution map of % FSB damage in macadamia kernel in 2003-04 at the CTH Alstonville macadamia plot. Colours show the level of crop damage to individual trees. Each square on the diagram contains nine trees, seven years old, planted at 7 m × 5 m spacing. The number in the square is the macadamia variety. Each treatment runs from top to bottom, and all lines represent a buffer row of trees.
Spray timing is crucial in preventing crop damage. The standard treatment (Nov, Dec, Jan and Feb pesticide applications) was the only one where A4 nuts were not damaged. Observations from other seasons have also shown A4 to be a highly susceptible variety for FSB damage.

Pheromone traps

A pheromone-based trap for FSB *lutescens* promises to revolutionise FSB monitoring. The pheromone lure is an aggregation chemical that attracts adult males, females and nymphs. The lure attracts only FSB *lutescens*, and not FSB *nitida*.

The pheromone traps consist of a small rubber plug impregnated with a chemical lure, suspended into a cut-out area in the centre of a sticky panel. The chemical attractant remains effective for six weeks, while the sticky panels are replaced fortnightly. The traps work better with larger spacings between traps. At smaller distances they trap less bugs per trap.

Figure 43. A pheromone lure with trapped bugs. Photo Donna Chambers.

Queensland Department of Agriculture and Fisheries (DAF) monitoring protocol for the FSB *lutescens* pheromone trap:

1. Use at least 10 traps spaced at least 20–30 m apart.
2. Place traps within shaded canopy at a height of about 2 m (or within reach).
3. Monitor at least once per fortnight, by counting and recording adult and nymph spotting bugs.
4. Change the sticky panel each fortnight and the pheromone lure at six weeks.
5. If bug density reaches 0.5 bugs per fortnight (five bugs for every 10 traps) apply a chemical control.*

* This treatment threshold was established with avocados and custard apples.

More FSB damaged fruit occurs in trees carrying the pheromone traps. The value of the monitoring information is expected to outweigh the damage to fruit on the trap trees.

The FSB *lutescens* pheromone trap is expected to be available commercially by late 2016. Work on a pheromone trap for FSB *nitida* continues.

Monitoring hedges

A monitoring hedge is a small group of non-crop fruiting plants maintained to understand pest activity in the vicinity of the orchard. Monitoring hedges can be useful in reducing late season damage that is very difficult to monitor in crop. The right mix of plant species in a monitoring hedge can provide a good indication of FSB activity throughout the year.

In the north coast of NSW using three species provides fruit resources to monitor FSB year round:

» *Dimocarpus longan* – December to February

» *Murraya paniculata* – March to October

» *Macadamia ternifolia* – August to February

A monitoring hedge is planted as a line or group of plants between an identified FSB source and the crop. Pruning to keep the hedge small and limiting the number of plants to 5–9 per hedge reduces time spent monitoring.

The monitoring hedge helps predict when adult bugs are moving into an orchard so control treatments can target when the FSB are about to cause the most damage. This achieves **acceptable control with the most strategic and minimum chemical applications.**

FSB nymphs stay within the monitoring hedge once they start feeding. FSB move to new plants when they first reach adulthood. FSB numbers (particularly 5th instar nymphs) on the hedge usually increase just before adults move into crops. Adult FSB flights out of the monitoring hedge, and into commercial crops, occur 10 to 14 days after 30% of the bugs in the trap crop reach the 5th instar nymph stage.

Within 10 days of the first observation of ≥30% of 5th instar nymphs is the optimal spray treatment time for the first wave of FSB in the season. This is an evidence-based action threshold established in macadamias, avocados and custard apples.

Figure 44. Looking for FSB on a monitoring hedge.

How to monitor a monitoring hedge

Check the hedge weekly, or at least fortnightly, during crop fruiting and the main movement time for FSB into crop – Oct/Nov through to Apr/May. Best weather conditions for monitoring are warm, sunny and calm. FSB are difficult to observe in cold, wet or windy conditions, as they tend to seek shelter and hide.

Monitoring should take 10–15 minutes once techniques and identification is familiar.

» Inspect the whole hedge, focussing on plants with fruit, looking for FSB.

» Choose a small section of a fruiting hedge plant where FSB were sighted and inspect carefully, counting all FSB present, and the number of 5th instar nymphs. Experienced monitors can count sample a larger portion of the hedge. The more bugs counted the more reliable the information gained.

» Calculate the percentage of 5th instar nymphs as a proportion of the total number of other instar and adult FSB.

» Adult FSB can be removed from the hedge; nymphs should be left on the hedge plants.

» Apply control treatments used in the crop to the monitoring hedge only if the last fruit are about to fall from the hedge plants*.

* When these fruit fall, FSB are forced to move in search of food, possibly into the crop.

Action threshold:
>30% of FSB at 5th instar nymph stage.

Action required:
Apply a control treatment to crop within 10 days.

Maintaining a monitoring hedge

A monitoring hedge requires some management effort for it to continue as an effective monitoring tool.

» Prune to maintain tree height at an easy level for visual inspection.

» Control bird feeding to ensure fruit is present to attract FSB, using netting if required.

» Control wood-boring beetles (Cerambycidae), if necessary, early in spring to minimise the pesticide treatment's effect on FSB.

» Control the spread / propagation of *Murraya paniculata* by reducing bird access to the fruit with coarse netting.

Figure 45. Collecting FSB from *Murraya paniculata* fruit on the monitoring hedge.

Figure 46. Adult FSB arriving on *Macadamia ternifolia* in a monitoring hedge.

Monitoring FSB

Case study: The Centre for Tropical Horticulture Alstonville monitoring hedge

NSW DPI maintains a series of monitoring hedges at the Centre for Tropical Horticulture (CTH), Alstonville. These hedges are the basis for the protocol strategy for monitoring hedges in this guide. The monitoring hedge was developed to offer FSB food sources year round and monitor all subtropical fruit and nut crops. Many species were reviewed for their suitability in monitoring hedges. The most reliable plants found in NSW to attract and allow monitoring of FSB *nitida* year round are *Dimocarpus longan*, *Murraya paniculata* and *Macadamia ternifolia*.

Figure 47. One of the monitoring hedges at the Centre for Tropical Horticulture, Alstonville NSW.

NSW DPI staff monitor the hedges weekly as part of their research. Information from the monitoring is used to identify action triggers for optimum control treatments and predict population peak timing for the following generation.

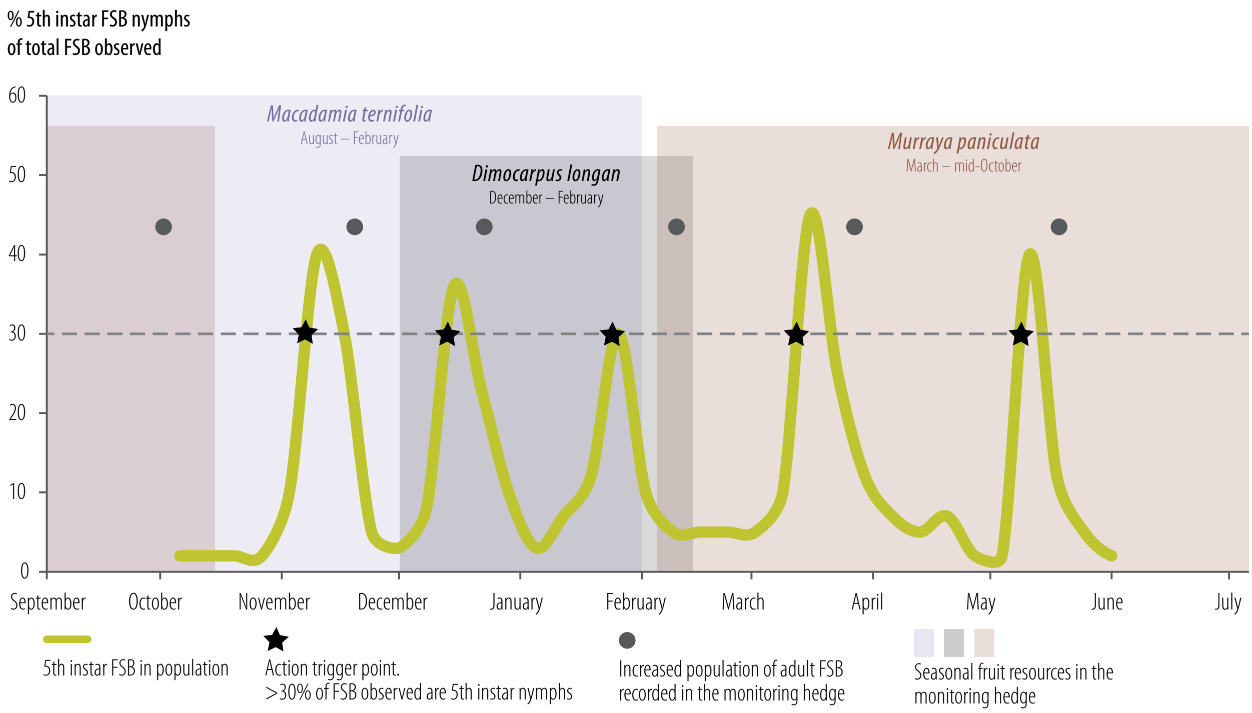


Figure 48. A stylised view of monitoring information from the Alstonville CTH hedge based on 2011–16 data shows 6 steep rises in the proportion of 5th instar FSB nitida nymphs, triggering a chemical control recommendation when this exceeds 30% of the FSB population. The number of 5th instar proportion peaks, and action triggers varies year to year, as does the precise timing of those peaks. There are also occasions when invading adult FSB numbers can be of concern, and trigger an alternate action threshold being used in the research program.

Case study: Custard apples

Fresh damage from FSB can be distinguished quickly in custard apples. NSW DPI researchers worked closely with a custard apple grower at Victoria Park on FSB for four years.

Strategic pruning created a tree canopy structure that enabled excellent spray coverage. Control of FSB became extremely effective as the optimum spray timing for pesticides (within 10 days of detection of >30% 5th instar nymphs) was identified and implemented.

Crop damage at the custard apple orchard has been reduced by a factor of 10 and sprays have been reduced to one or two per season. Observing FSB on the monitoring hedge informed the spray timing that achieved effective control of FSB in the custard apple crop. The critical period for control moved each season, so routine calendar sprays would not have been effective.

Figure 49. Immature custard apple fruit attacked by FSB.

Case study: Avocados

NSW DPI is testing spray decisions based on hedge activity in crops where FSB damage is more difficult to see. In the 2015–16 season, an avocado grower in Bundaberg, Queensland monitored FSB using a combination of a monitoring hedge, in-crop monitoring of fruit damage, and FSB *lutescens* pheromone traps.

FSB *nitida* observed on the monitoring hedge reached the action threshold (30% of bugs reached the 5th Instar nymph stage) in November. Some damage was seen in the crop at this time too. FSB *lutescens* numbers recorded on the pheromone traps didn't reach the action threshold (0.5 FSB per trap within a fortnight) during the season.

The number of sprays applied was reduced from seven the previous season to three sprays up until the end of March, with no significant difference in damage levels to fruit. Although 2015–16 was a relatively light season for FSB, the trial demonstrated the benefit of using the new tools of trap cropping and/or pheromone traps to monitor FSB to guide chemical applications.

Figure 50. The monitoring hedge for the avocado farm trialling spray decisions based on monitoring.

Controlling FSB

Figure 51. An open orchard with diverse living groundcover.

Cultural controls

Growers can structure orchards to reduce the incidence and extent of damage from FSB through managing:

» **plant density** to maintain light to the orchard floor

» **tree height** to maintain spray access

» **living groundcovers** to promote habitat for natural enemies (flowering grasses, legumes and herbs). Known host plants of pests should be avoided.

» selection of **less sensitive cultivars**.

Orchards with more light and living groundcovers have less FSB damage. More light and biodiversity in the orchard supports more natural enemies.

FSB tend to prefer the top of the trees. Trials in macadamias showed FSB damage could be significantly decreased by limiting tree height to six metres. Smaller trees gave the specific spray equipment used better access, and better coverage with chemical controls was achieved.

FSB are more prevalent in coastal orchards, particularly those close to rainforest, the natural habitat of FSB. Continuously flowering and fruiting crops are the most challenging for FSB management.

Chemical controls

The available insecticides currently registered for FSB are not selective. They affect beneficial insects as well as the targeted pests. Reducing the frequency of chemical treatment is important to limit the impact on natural enemies and other beneficial insects in the orchard.

Optimising spray timing to reduce the number of treatments across the season is the current best practice in using chemical controls for FSB.

Calendar sprays are applications of chemical pesticides based on the time of the year, and the time the effectiveness of a spray treatment is expected to last. On this basis some growers may find themselves applying sprays as frequently as fortnightly in the fruiting period.

Action triggers are when monitoring information about the level of FSB presence and maturity sets the timing for spray treatments. Action triggers often enable fewer sprays in a season.

Hotspot sprays

Early in the season chemical applications can be scaled down by limiting treatment to known FSB hotspots. See Hotspots section for identifying hotspots within orchards.

The end of endosulfan

In the past, the mainstay of FSB control was endosulfan. This chemical had its Australian registrations withdrawn in October 2010, eliminating it as an option for horticultural producers after October 2012. All the available replacement chemicals for endosulfan are broad-spectrum, more expensive and potentially more disruptive to natural enemies. For more information of the relative toxicities of pesticides refer to the Macadamia plant protection guide 2015–16. The secondary benefits that endosulfan offered at flowering and with mite control are not available.

Registered chemicals for FSB control

Table 3. The chemicals approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for use to control FSB in specific horticultural crops.

Chemical	Industries						APVMA review status*
	Avocado	Macadamia	Lychee	Custard Apple	Papaya	Passionfruit	
Acephate	✗	✓	✗	✗	✗	✗	Priority list
Azinphos-methyl	✗	✓	✓	✗	✗	✗	Review completed
Beta-cyfluthrin	✓	✓	✗	✗	✗	✗	Not listed for review
Methidathion	✓	✓	✗	✓	✗	✗	Under review
Trichlorfon	✓	✓	✓	✓	✓	✓	Priority list

* The APVMA periodically reviews registrations and permit conditions for pesticides used in horticultural crops. Chemicals appearing on the priority list indicate a significant concern for public health, worker safety and/or environmental safety.

New chemicals for controlling FSB

Development of new chemicals to control FSB is underway. Once registered, the following new chemicals will be available for FSB control in tropical fruit and nut crops:

» Transform™ (Sulfoxaflor, from Dow AgroSciences)

» Trivor™ (Acetamprid and Pyriproxyfen, from Adama).

Pesticide resistance strategy

When a chemical is used repeatedly, pests are more likely to develop resistance. This renders the chemical, and sometimes others in the same chemical group, less effective in controlling the pests.

Rotating chemical applications to ensure that pests are not continually exposed to chemicals of the same group and reduces the risk of pests developing resistance. The goal is to **use chemicals from a particular group only once, or as few times as possible**, in a season. If repeated use of chemicals from the same group is required, it's good practice to alternate with a chemical from another group in between sprays.

Pesticides are grouped according to their molecular structure and mode of action. All registered pesticides are labelled with an activity group identification symbol, e.g. 1B, 11, 18. Registered chemicals from different groups should be used in a rotation if several pesticide applications are required.

Table 4. The different chemical classes of the pesticides registered for control of FSB.

Group	Chemical Class	Common name	Example trade name
1B	Organophosphate	Acephate	Lancer®
		Azinphos-methyl	Gusathion®
		Methidathion	Suprathion®
		Trichlorfon	Lepidex®
3A	Pyrethroid	Beta-cyfluthrin	Bulldock®

Source: NSW DPI, Macadamia plant protection guide 2015–16.

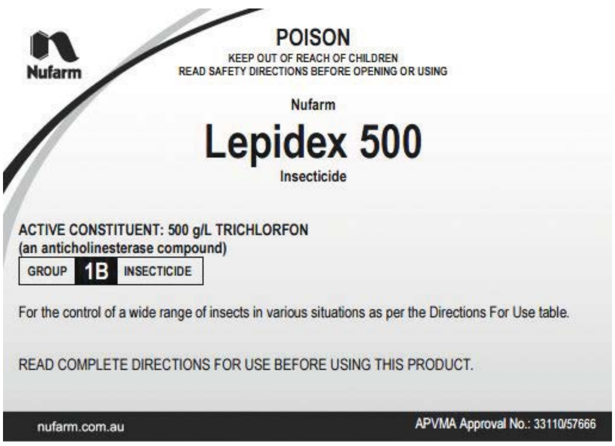


Figure 52. Pesticide activity group label.

Biological controls

Several organisms have shown promising impacts on FSB in greenhouse and small field experiments. It is much more difficult to directly assess biocontrol agents in commercial orchards due to the mobility of FSB and parasitoids, and other variables that affect crop damage.

The egg parasitoid *Anastatus* sp. is commercially available. After several seasons of commercial releases there is anecdotal evidence indicating that *Anastatus* sp. releases can reduce crop damage from FSB under certain conditions, although NSW DPI researchers were not able to quantify any impact of *Anastatus* sp. within the research timeframe.

Research continues into finding effective biological control agents. Methods for captive breeding FSB have been developed and this allows screening of potential control agents. The goal continues to be to demonstrate reliable ways to establish parasitoids and predators in commercial orchard conditions.

Natural enemies

Natural enemies are wild organisms that feed on pest species. Several species of flies, spiders and lacewings are natural enemies to FSB and target different parts of the FSB life cycle. Management systems that promote the persistence of natural enemies in orchards support their role in suppressing FSB populations.

Egg parasitoids inject their own eggs into the eggs of FSB, which then consume the developing FSB nymph.

Known egg parasitoids of FSB include:

- *Anastatus sp. near pentatomidivorus* (Eupelmidae)
- *Ooencyrtus caurus* (Encyrtidae)
- *Gryon* sp. (Scelionidae)
- *Centrodora darwini* (Aphelinidae).

The real benefits of egg parasitoids are in how much they can reduce the invading population. To impact on the damage rate within the crop cycle you need organisms that reduce the adult and nymph FSB numbers as well.

Nymph and adult parasitoids inject their eggs into the bodies of FSB nymphs and adults. Tachinid flies including *Trichopoda pennipes* and *Pentatomophaga bicincta*, are parasites of nymphs and adult FSB.

Figure 53. A Phorid parasitoid fly (*Apocephalid* group) reared from FSB collected in the field.

Figure 54. An Anastatus wasp laying its egg into an FSB egg. Photo Richard Llewellyn.

Predators that hunt and consume FSB include:

- spiders e.g. *Ocrisiona* sp.
- ants e.g. green tree ant *Oecophylla smaragdina*, *Pheidole* sp.
- predatory bugs e.g. assassin bug *Pristhesancus papuensis*
- lacewings e.g. brown lacewing *Micromus tasmaniae*
- General vertebrate predators such as birds and frogs.

Figure 55. White spider – *Thomisus* species attacking and killing FSB adult in murraya.

Area wide management

Area wide management (AWM) is the collaborative effort of a group of growers in a geographic area to manage FSB. Where AWM is functioning well, coordinated monitoring and control treatments should result in less re-infestation of recently sprayed orchards from neighbouring orchards. Collaboration also allows growers to share some of the costs of establishing, managing and monitoring hedges.

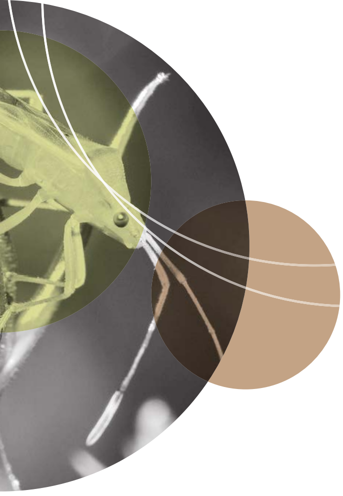
Case study: Macadamias at Tregeagle, NSW

A pilot program for an area wide management group (AWMG) was initiated with a group of macadamia growers and consultants at Tregeagle in September 2015.

- Two strategically located monitoring hedges of *Murraya paniculata* were monitored weekly for FSB. The hedges are about 3 km apart (in linear distance).
- Monitoring information was used as a decision-making tool for timing chemical control treatments for FSB.
- The action trigger was >30% of FSB at 5th instar stage on a monitoring hedge.
- All growers applied chemical controls within 10 days of the action trigger.
- An organic macadamia orchard, not participating in the AWMG, is located within the area.

During the pilot in 2015–2016, action triggers from FSB numbers on the monitoring hedges were in accordance with the recommendations of commercial pest consultants of the group.

Figure 56. The properties included in the Tregeagle, NSW, Area Wide Management group lie within the red perimeter marked on this aerial image.



Crop-specific FSB management – macadamias

Successful FSB management in macadamias relies on detecting and reducing FSB populations early in the season so numbers do not build later in the season. Most FSB damage to macadamia nuts occurs between September and February, with some of the thinner-shelled and later varieties being attacked all year if spotting bug is left unmanaged. On A4 variety macadamia just as much damage occurs after December as in the early season.

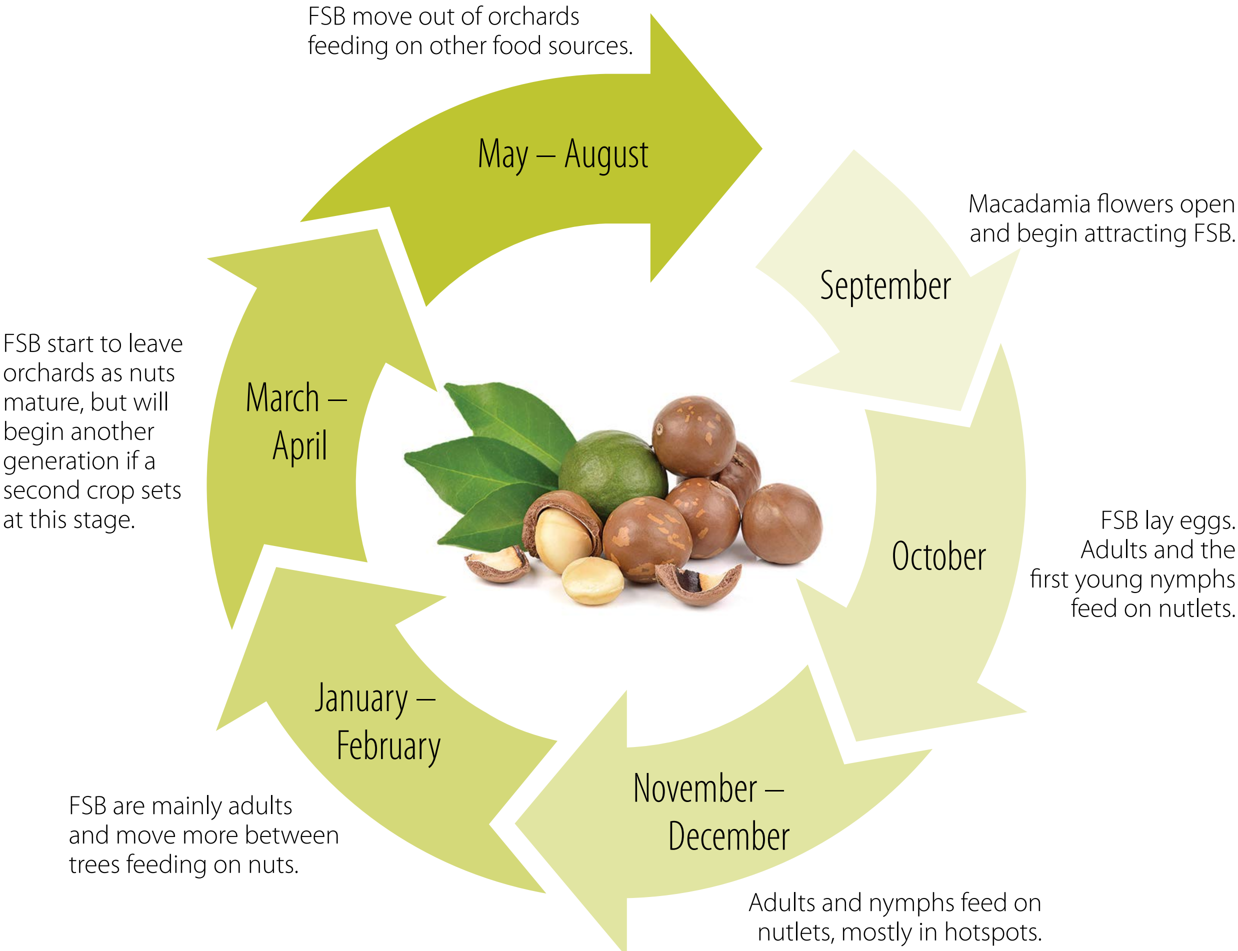


Figure 57. FSB activity in macadamias without control treatments.

Cultural controls

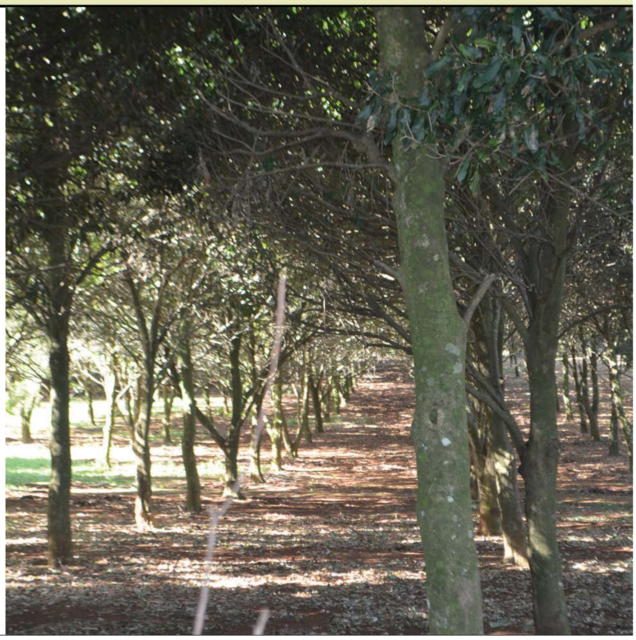
Horticultural techniques can reduce the risk and extent of damage from FSB in macadamia crops.

- » Manage canopy to reduce pest pressures, and enable good spray coverage. Some practices that can help include:
  - reducing tree heights
  - reducing canopy density by selective limb removal or new growing systems
  - reducing tree density by tree removal.
- » Avoid thin-shelled macadamia varieties other than for a trap crop or monitoring hedge if good spray coverage is not feasible.
- » Reduce plant stressors that cause out-of-season flowering in macadamias where possible.
- » Support diverse living groundcovers in the interrow to support natural enemies. This must be balanced with the other pest and disease risks, such as shelter for rats and the development of sigastus weevil in nuts dropped and retained in long groundcover.
- » Manage bordering alternate FSB host vegetation to reduce FSB food sources. Releasing parasitoids into bordering host vegetation reduces FSB invasions into the crop.

Light vs dark orchards

Habitat management in organic macadamia orchards was investigated in a study that compared crop damage and arthropod abundance in macadamia orchards with light and dark areas.

- » Dark sites had closed mid-row canopies and almost no mid-row groundcover vegetation.
- » Light sites had open mid-row canopies and a mixture of living groundcovers including grasses, flowering herbs and legumes.

Light areas	Dark areas
	
Nut yield higher	Nut yield lower
More **early** season FSB damage	More **late** season FSB damage
More beneficial invertebrates in tree canopies	More pest lace bugs in tree canopies
More beneficial arthropods, parasitoids, spiders and ants on orchard floor	Fewer beneficial or pest organisms on orchard floor
More pest arthropods, leafminers and other Lepidoptera on orchard floor	

Multiple flowerings

Macadamias sometimes flower out of season, or multiple times within a season, when they do not set sufficient nuts in the initial flowering. When an orchard has nuts at different maturities it can make monitoring and managing FSB more complex. There may be overlapping generations of FSB. Multiple flowerings can be triggered by:

» a severe lacebug infestation at flowering

» weather events such as rain washing out the flowers

» dry conditions leading to premature nut drop

» relatively warm conditions through winter

» poor nutrition or soil management not allowing the plant access to sufficient nutrients.

Actions to reduce the occurrence of multiple flowerings helps to reduce FSB damage in macadamias. The risk of multiple flowering is reduced by:

» achieving good control of early season pests

» management to support good soil condition

» an adequate crop nutrition program

» shortening the harvest window by applying ethephon

» supplementary irrigation (if possible) from nutset to oil accumulation.

Monitoring

Monitoring FSB in macadamia should follow the framework presented in the Monitoring FSB chapter of this guide, with the addition of fallen nut counts, a macadamia industry specific monitoring technique.

Fallen nut counts

Counting fallen nutlets in October–November is currently the key monitoring tool that crop scouts in the macadamia industry use. The method is:

» cut open 10 fresh green fallen nuts per tree and separate husk and shell

» check for FSB sting lesions in the husk and shell, and count the number of affected nuts

» identify other insect damage e.g. macadamia nutborer (MNB), Sigastus weevil; repeat fortnightly until nut drop stops in December.

Repeating the process at a minimum of 35 trees is necessary to ensure enough trees are sampled to determine if spotting bugs are present. One option is to monitor 10 trees in known hotspots and then examine 25 trees randomly across the remainder of the block.

Figure 58. Fallen nuts showing marks on husk and internal damage.

Fallen nut counts are another action trigger for control treatments in macadamias. The generally accepted thresholds for control treatments is 3% of nuts falling from the tree, or FSB damage in three or more of the 10 nuts dissected for monitoring.

Monitoring hedges in macadamias

Being aware of how the wild FSB population is progressing is particularly important in mid to late summer when there is a high risk of late damage. Growers of late and thin-shelled macadamia varieties ('A' series & 849 variety macadamias), which are especially susceptible to late crop damage from FSB, can benefit the most from a monitoring hedge.

Chemical control constraints

Repeatedly using synthetic pyrethroids can lead to flare ups of other pests such as mites and thrips. Refer to pesticide resistance strategy section.

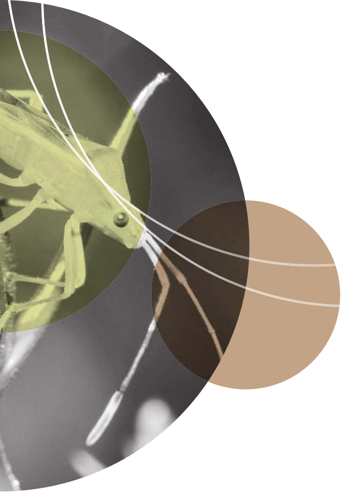
Spray timing can be complicated by the need to control other pests, including macadamia lace bug, sigastus weevil and macadamia nutborer.

The economics of FSB control practices

The Queensland Department of Agriculture and Fisheries macadamia team at Nambour (Maroochy Research Station) has modelled a number of different FSB control scenarios. NSW DPI has used this modelling to explore the economic return on macadamia nut growing. Note that the broad assumptions used in the modelling mean that the results cannot be extrapolated to predict the costs and benefits from implementing the practices on individual farms.

In each scenario the economic return of an FSB control practice was compared with a no FSB control benchmarking practice. Some practices that are helpful for FSB control, and might achieve better yields, might not be economically better because of the costs.

- Thin-shell macadamia varieties delivered poorer economic returns compared with the thick shell industry standard variety under all management scenarios except where two or more extra sprays were applied to the thin shelled varieties compared to no extra sprays applied to the thick shell varieties. Under those circumstances returns were higher on thin shelled varieties due to the substantially higher kernel recovery.
- Using a monitoring hedge appeared a slightly better investment compared with no monitoring hedge practice.
- Using pheromone lures can reduce the number of sprays for FSB control. Monitoring two or three hotspot blocks with 10 pheromone traps in each hotspot block might achieve a better economic return compared with the no-trap practice. However, the costs of monitoring four or more blocks with 10 traps each exceed the benefits.
- Reducing canopy height from 9 m to 6 m improved spray coverage (for a specific orchard sprayer), improving yield, nut quality, and overall returns. The scenario modelled involved contractors being paid to prune. Cash flow over a ten year period showed a net gain from year 3 onwards, although net cash flows are reduced in each year of pruning (years 1 and 6 in the 10 year scenario modelled).
- Lower tree density results in less FSB damage, and so gives a potential to achieve higher yields per hectare. A planting density of 10 m × 10 m was better than 10 m × 5 m which, in turn, was better than 10 m × 3 m in terms of investment return. This does not consider differences between macadamia varieties, or the risk of wind damage to nut laden trees.



Crop-specific FSB management – avocados

Avocado is susceptible to FSB attack throughout the season. Early detection is the key to managing FSB effectively. Assess what level of damage is acceptable before making the decision of whether or not to spray. Netting to exclude FSB sized insects is a technique for non-chemical control, but in some regions the pest pressure is far too high to give satisfactory control. Thinner-skinned varieties are at risk throughout the season. Later damage to fruit is masked by varietal skin traits in cultivars such as Hass.

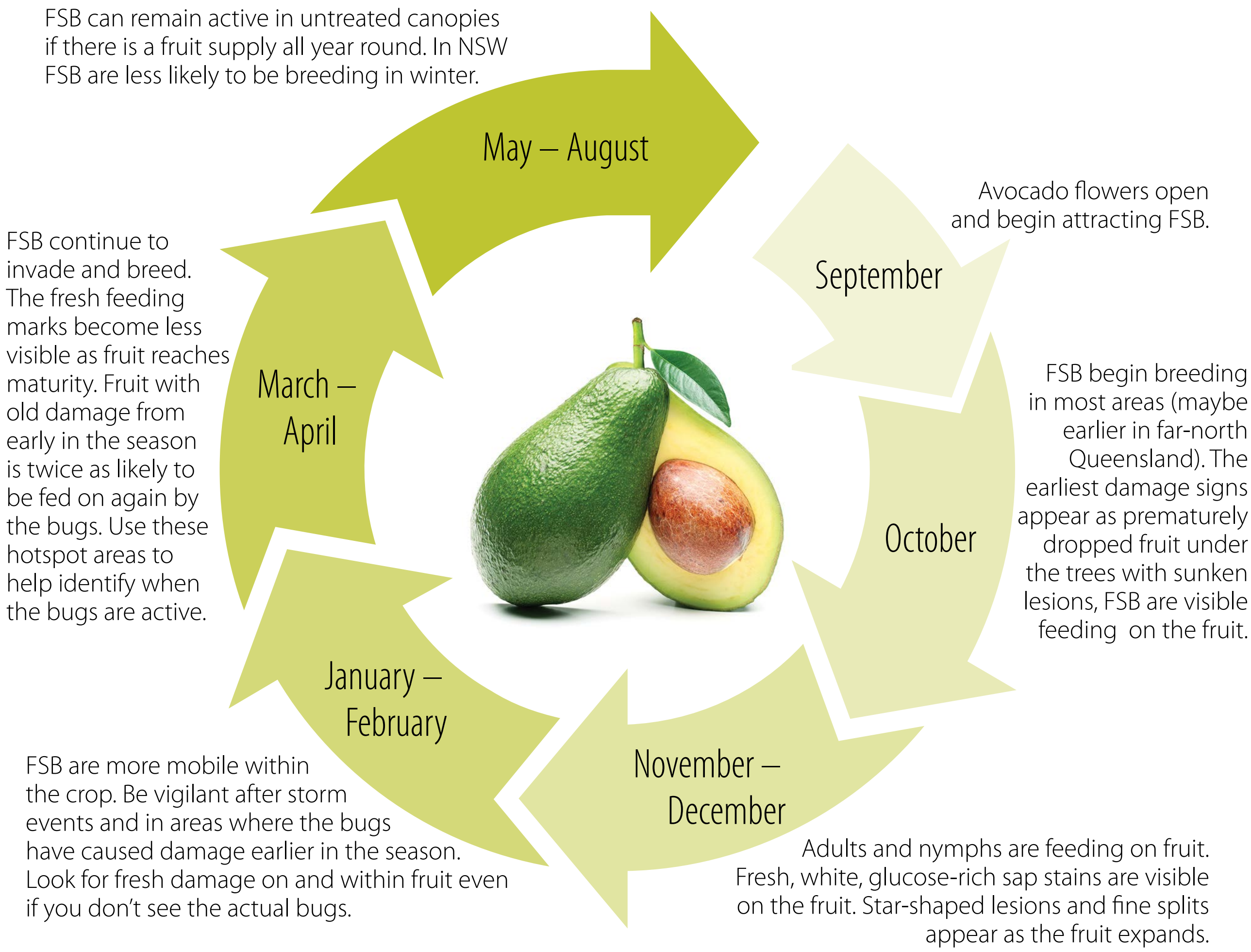


Figure 59. FSB activity in avocados without control treatments.

Cultural controls

Horticultural techniques that may reduce the risk and extent of damage from FSB are similar to those for macadamia management.

» Manage canopy to reduce pest pressures, and enable good spray coverage. Some practices that help include:
  - reducing tree heights
  - reducing canopy density by selective limb removal or new growing systems.

» Selecting varieties less prone to FSB damage is important:
  - FSB damage is much more obvious on the thin-skinned cultivars of Fuerte, Zuttano, Sheppard and Wurtz
  - FSB damage is less obvious on the thick-skinned cultivars of Hass and Sharwil
  - Pinkerton is an exception (and an excellent monitoring tree for early damage). Although Pinkerton has a medium-thick skin, it is prone to FSB attack, possibly because it sets fruit early. Damaged Pinkerton fruit continues to remain attractive to FSB throughout the time it remains on the tree.

» Manage bordering alternate FSB host vegetation to reduce FSB food sources. Releasing parasitoids into bordering host vegetation can reduce FSB invasions into the crop.

Monitoring

Monitoring FSB in avocado should follow the framework presented in the Monitoring FSB chapter of this guide. During the avocado fruiting season there can be 4–6 overlapping generations of FSB *nitida* from early spring through to late autumn, and in QLD another four intermingled generations of FSB *lutescens*.

Start monitoring from flowering, and repeat weekly until harvest is complete. Monitoring FSB in the crop is very difficult as they are well camouflaged. Detecting FSB incursions in taller avocado trees is similar to the problems faced by macadamia growers during the late season. Scouting the canopy with a hydraulic ladder is the best way to obtain reliable in-crop monitoring information. Identify hotspots early in the season and check these more frequently.

Check fruit for signs of fresh damage. Smaller fruit dropped early in the season can be checked from the orchard floor. Later in the season fruit must be collected from the upper canopy. An elevated work platform will help collect fruit from higher in the tree. Peel collected fruit to check for internal damage. Damage in the Hass cultivar is very difficult to detect on the surface, but is visible after peeling the skin.

Figure 60. Fruit can be collected more easily from the upper canopy with a cherry picker.

Figure 61. A peeled avocado with damage from multiple FSB stings.

Figure 62. Peeling avocados to examine fruit for damage.

Another monitoring option for avocados is to spread a sheet out under the tree and check it for dead bugs after spraying. This can help determine how effective spraying operations have been. It will also help identify what other insects are in the orchard, including natural enemies.

The pheromone trap for FSB *lutescens* and the monitoring hedge have proven to be useful tools (see sections Pheromone traps and Monitoring hedges). In areas where FSB *nitida* is present as well as FSB *lutescens*, use a monitoring hedge in addition to the pheromone traps.

Monitoring hedges in avocado

Avocado crops at risk of late season damage from FSB *nitida*, can benefit from a monitoring hedge. Growers who stop their spray cycle a little early can be caught out by a late flight while preparing for harvest. Flights of adult FSB have been detected on longan (*Dimocarpus longan*) and *Murraya panniculata* in late January, mid March, late April and early May. If all of these flights are treated, then late season blind stings within the fruit can be eliminated.

The action threshold from the monitoring hedge is >30% of FSB at the 5th instar stage. At present we do not know if FSB *lutescens* flights can be predicted this way.

Where FSB *lutescens* is active, the option of using the pheromone lure trap is becoming a reality. The action threshold from the FSB *lutescens* pheromone lure is 0.5 bugs per trap, in a fortnight.

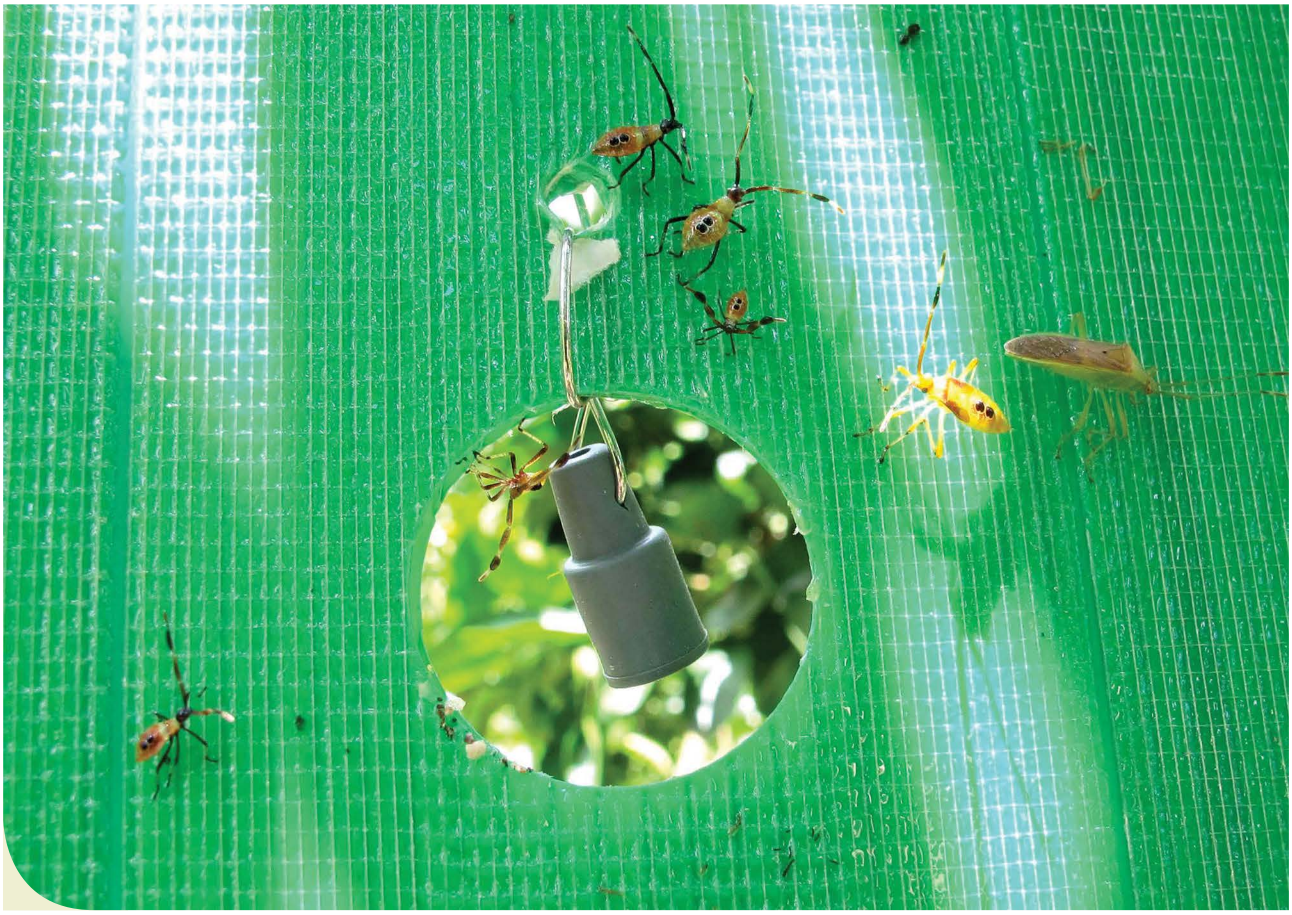


Figure 63. FSB *lutescens* attracted by the pheromone lure (centre) are trapped on the sticky surface of the trap. Photo Donna Chambers.

Best practice chemical control

The further north, the greater the problem of FSB in avocados appears to be. Most Australian avocado regions have relied upon a calendar spray approach with a spray cycle of:

» 10–14 days in far northern Queensland

» 21 days in central Queensland

» 28 days through the NSW/QLD border areas

» 42 days in areas further south where only FSB *nitida* is active

» possibly only one to two sprays required per season south of Coffs Harbour.

Considering the number of chemical applications necessary to protect the avocado crop, rotating chemicals from different groups is very important to reduce the risk of resistance and secondary problems due to mite damage.

Order the chemical rotation by considering:

» trichlorfon at flowering, which can provide good control of other hemipteran and lepidopteran pests, with minimal bee impact during the season

» beta-cyfluthrin is the chemical of choice when FSB populations are heavy (e.g. late November and January/February)

» two new options will be made available (acetamprid and pyriproxyfen in combination and sulfoxaflor), which researchers will test to see how best they might be used in the rotation.

Check the pH of tank mixes after all ingredients have been added and adjust if necessary, as pH effects can reduce the efficacy of treatments. For example, trichlorfon works best with pH between pH 5 and 6. When mixed with alkali compounds, such as copper treatments, trichlorfon's activity may be reduced.

Techniques that can reduce the total amount of chemicals applied are:

» only treating hotspots early in the season

» using action thresholds for spraying; 0.5 bugs/trap/fortnight or ≥30% 5th instar nymphs in the monitoring hedge

» just treating the 'hotspots' throughout the year and only spray the entire orchard when evidence for widespread activity is found.

A trial on a commercial avocado farm in the Bundaberg/Childers area in the 2015/2016 season compared calendar spraying (21 days) with timing spray applications using the action trigger from FSB *lutescens* pheromone traps. In this trial, similar results regarding FSB damage were achieved by using the action trigger, with only three spray applications, instead of seven applications using a 21 day spray interval.

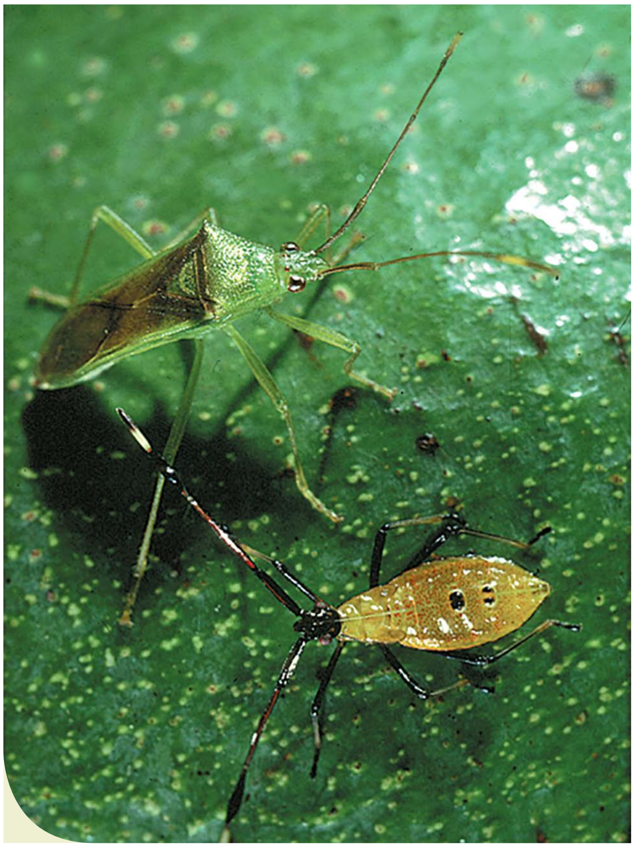
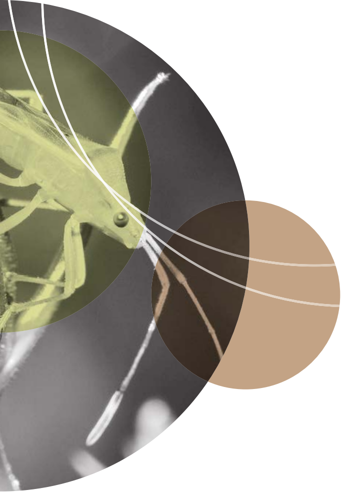


Figure 64. Reducing crop damage depends on controlling FSB throughout fruit development. Understanding the development stages of FSB in the orchard can inform more strategic use of chemical controls. Photos DAF.



Notes

More Information

Click on the titles to access these publications on the web via the electronic version of this guide.

Integrated pest and disease management

A multi target approach to fruitspotting bug management

Ruth Huwer, Craig Maddox, Harry Fay, Richard Llewellyn, Alana Danne, Mark Hickey, Peter Melville, Jolyon Burnett, Antony Allen, Ian Groves.
2011, World Avocado Conference

Macadamias

Macadamia plant protection guide

Jeremy Bright
2015—16 NSW Department of Primary Industries

Macadamia integrated orchard management guides

Jeremy Bright, Stephanie Alt, Robbie Commens
2016 NSW Department of Primary Industries

Australian fruitspotting bugs, Amblypelta nitida Stål and A. lutescens lutescens Distant (Hemiptera: Coreidae), and the potential for their biologically based management in macadamia orchards

Alana Govender *nee* Danne
2015 University of Queensland

Fruit Spotting Bug: Identification and impact on horticulture

video
2013 NSW Department of Primary Industries

Macadamia problem solver and bug identifier

Eric Gallagher, Paul O'Hare, Russ Stephenson, Geoff Waite, Noel Vock
2003 Queensland Department of Primary Industries

Avocados

Avocado problem solver field guide
Simon Newett, Peter Rigden, Matthew Weinert
2013, State of Queensland

Fruitspotting bugs 2016

FSB Ready checklist

☑ I understand the pest problem

☑ I reduce risks

☑ I know what to look for

☑ I monitor

☑ I respond to action thresholds

☑ I talk to my neighbours