



ALL ABOUT ALMONDS

AUSTRALIAN ALMONDS
www.australionalmonds.com.au

Carob moth in almonds: Monitoring guidelines

David Madge, Cathy Taylor and David Williams,
Department of Economic Development, Jobs, Transport and Resources, Victoria

Introduction

Carob moth *Apomyelois* (= *Ectomyelois*) *ceratoniae* attacks numerous tree crops worldwide and causes economic damage by feeding on fruits or nuts, contaminating them with frass (excreta) and rendering them unfit for human consumption. It has been considered a serious pest of almonds in Australia in recent years.

To make informed decisions regarding the treatment of orchards against carob moth, producers need some basic information regarding its presence and population levels. To help producers monitor carob moth effectively, this fact sheet describes some simple monitoring techniques. The information will be revised as more local knowledge is developed. The development and behaviour of carob moth in almonds is addressed in a separate fact sheet.

Description & lifecycle

Carob moth eggs (Figure 1a, b) are about 0.7 mm long, white when fresh, changing

to pink as they mature. The larvae are typically pale to dark pink and range from about 1 mm long when newly hatched to 15-20mm long when fully mature (Figure 1c, d). The top side of carob moth pupae are marked with a dark ridge and double row of 'teeth' (Figure 1e) which help to distinguish them from the otherwise similar pupae of Indian meal moth.

Adult carob moths (Figure 1f) are a medium-dark grey colour with a wingspan of about 13-20mm. A wavy pattern crosses the wings about one third of the way down their length. This pattern helps to differentiate carob moth from other similar moths.

In almonds, carob moths survive winter as larvae and pupae inside mummified nuts hanging on trees. The pupae complete their development during late winter/early spring, and mature moths begin to emerge soon after.

After mating, female moths lay their eggs on mummified nuts hanging on trees. This continues until hull split in the new crop, after which some eggs will be laid on new crop nuts (Figure 2a).

Mummified nuts on trees are a critical food and breeding resource for carob moth. Local experience so far indicates that carob moth is more likely to be at very low levels or absent in orchards with very few or no nut mummies present over winter. This relationship may not hold true if heavily-infested orchards are nearby. If nut mummies are present in significant numbers throughout the orchard (i.e. at least several per tree) but no carob moth infestations are found, it is possible that carob moth is absent from that orchard. In contrast, where a reasonably high proportion of the mummies are infested, there is potential for a significant carob moth population to develop and damage the new season's crop.

Monitoring

The purpose of monitoring for carob moth is to determine whether it is present in a particular orchard and whether its population level is concerning enough to warrant management action.

The following approaches to monitoring may be useful for producers to develop a better understanding of the pest.



Figure 1a: Newly laid carob moth eggs are white (above) and turn pink when mature (Figure 1b below).



Figure 1b



Figure 1c: Recently hatched larvae are about 1 mm long (above) and grow to 15-20 mm (Figure 1d below).



Figure 1d



Figure 1e: Pupal cases are about 10 mm long and carry a dark ridge and double row of 'teeth'.



Figure 1f: Adult carob moths are grey, about 8-12 mm long with wings folded and have a 13-20 mm wing span and a wavy pattern across their wings (arrowed).

Table 1: Nut assessments for carob moth in almonds

Timing	Nut type	Sample type	Look for	Purpose of inspection
Late winter	Mummies	At least 100 intact nuts from across the block	Larvae and pupae between hull & shell and in kernel	Determine if CM is present and assist decision making on the need for control action in the new season
Prior to hull split	Mummies	At least 100 intact nuts from across the block	Fresh eggs anywhere, larvae and pupae between hull and shell and in kernel	Monitor population development and impacts of adverse weather and natural enemies, and assist decision making on the need for control action at hull split
Just prior to harvest	New crop	At least 100 intact nuts from across the block	Fresh eggs anywhere, larvae and pupae between hull and shell and in kernel	Assess effectiveness of any control actions applied earlier and assist decision making on the need for post-harvest control action (e.g.fumigation)

Nut inspections

A regime of nut assessments to monitor carob moth infestation levels is summarised in Table 1. The distribution of carob moth infestation within an orchard block can be patchy, so it is important to collect nuts from as many different locations across the block as practical.

Infested mummified nuts and new crop nuts may have carob moth present only between the hull and shell, or only in the kernel, or both.

By late winter, the infestation of mummified nuts is obvious because of the presence of frass, silken webbing and large pink larvae or pupae (Figure 2b). For this reason, winter

inspections may be done with the naked eye in the orchard.

From early spring onwards, eggs and small larvae may be present. A 10x hand lens will then be required for in-field inspections, or the nuts may be taken to a convenient location for inspection with a hand lens or dissection microscope.

As carob moth is very unlikely to lay eggs on new crop nuts until hull split, there is little value in assessing new nuts until that time.

As would be expected, the more nuts examined, the more accurate the assessment will be. A record should be kept of the number of nuts inspected and the number infested with carob moth in each orchard block.

Moth trapping

Moth traps provide an easy and useful guide to relative population levels of carob moth at different times of the season and between orchard blocks. Female carob moths produce a sex pheromone to attract males for mating and a synthetic mimic of that pheromone is available as 'lures' - small rubber plugs impregnated with the pheromone mimic. These lures are used to attract male moths into traps. The presence of male moths in traps indicates that females are also likely to be active, mating and laying eggs. A record of the moths trapped each week will show how the population varies over time (Figure 3a).

When trapping for carob moth:

- Use white 'Delta' traps which contain a sticky base to capture insects (Figure 3b) - these are available through most agricultural suppliers
- Store new lures in a refrigerator or freezer, and handle them with clean



Figure 3b: Tent-shaped delta traps (above) are easy to use



Figure 3c: The sticky base can be removed for easy counting of moths and replacement of the lure

tweezers - they can be affected by high temperatures, direct sunshine and contaminants such as nicotine and other chemicals

- Place lures on their side near the centre of the sticky base of the traps, one lure per trap (Figure 3c)
- Position traps as high as is practical where they can be accessed easily for regular inspection
- Place traps so they will be shaded from direct sunlight during the hot summer months and be out of the way of machinery
- Hang the traps by twisting their wire handle around a branch so the trap cannot swing freely in the wind



Figure 2a: Fresh eggs can be found on new crop nuts after hull split.



Figure 2b: An infested nut mummy showing carob moth chewing damage, frass and a silken cocoon enclosing a pupa.



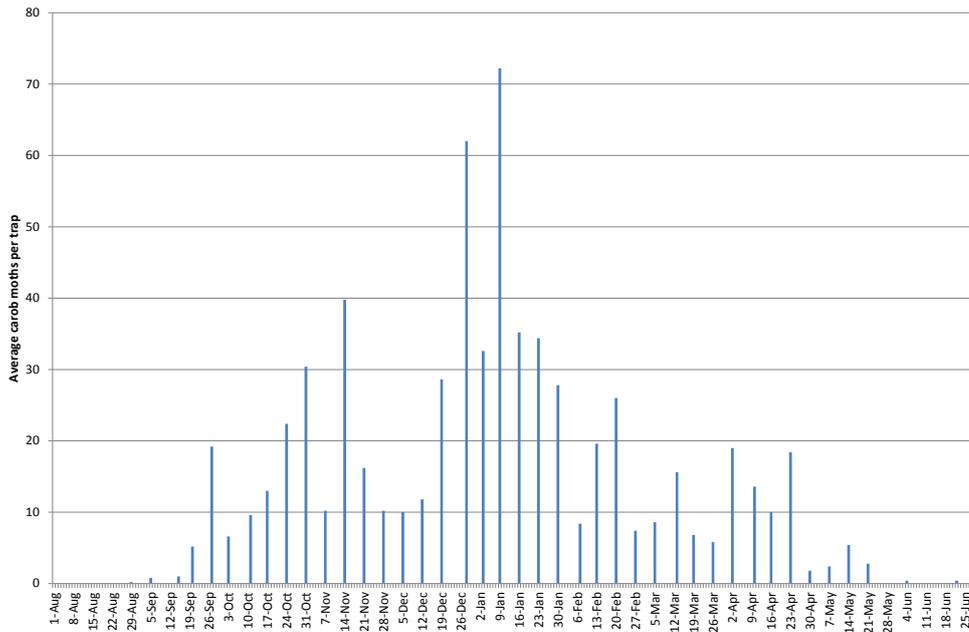


Figure 3a: Record of moths trapped each week demonstrating how population varies over time

- Locate traps in orchard areas that have a history of carob moth damage, or that may be at higher risk, e.g. with other host plants like pistachio and citrus nearby
- Position traps at least 100 metres apart so that each trap is at the centre of a 1 ha patch of trees

indicates that three traps are sufficient to provide accurate data. A single trap will still provide useful data, but its accuracy will be influenced more by the changes in lure age.

Where three traps are used, all three should have new lures installed before the start of the season (late winter). The lure replacement routine in Table 2 will ensure that during the season, the three lures will always be a mix of new, middle-aged and old. The average lure age will therefore not vary much and should not influence the average moth count.

Replace lures about every six weeks during warm weather (mid spring to early autumn), and every eight weeks at other times. Dispose of old lures away from the orchard (e.g. in household garbage).

Table 2: Recommended lure replacement routine.

Week	Lures replaced
0	All traps
1	-
2	Trap 1
3	-
4	Trap 2
5	-
6	Trap 3
7	-
8	Trap 1 etc.

Traps should be checked at least every week. The date and number of moths trapped should be recorded, and the moths then removed from the sticky base to make the next inspection easier.

The attractiveness of lures reduces over time and this may influence trap performance. To minimise this effect, use several traps with lures of different ages and average the moth counts over all traps. Local experience

If a trap's sticky base becomes less effective because of dust, leaves etc, it should be replaced.

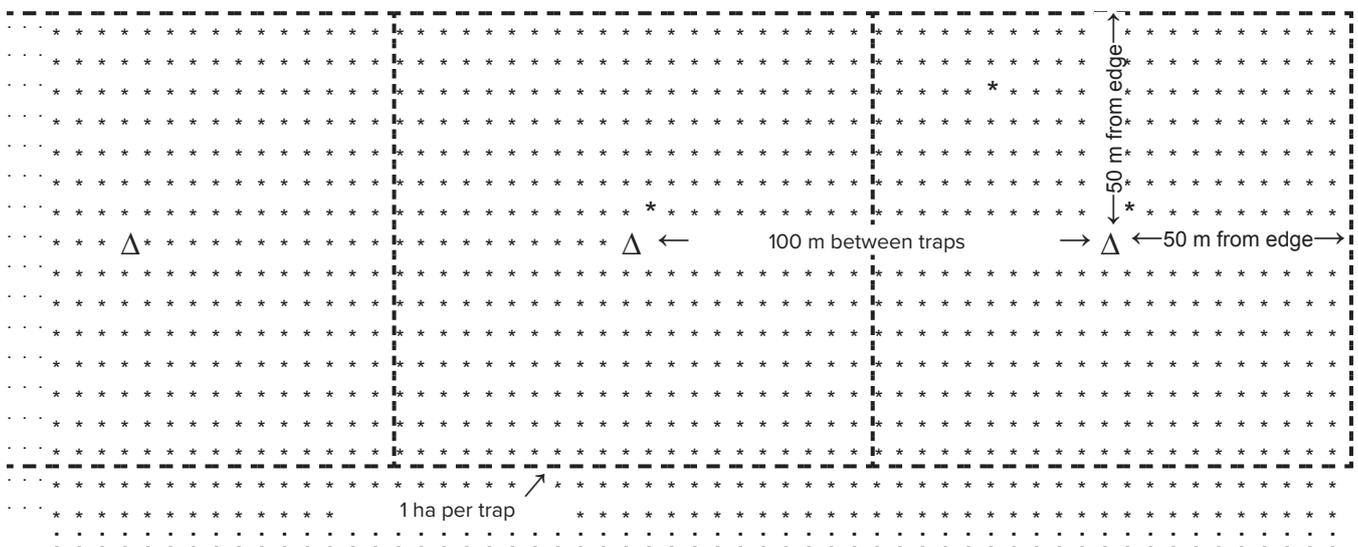


Figure 4: Suggested trap layout at each monitored block.



The pheromone mimic used in carob moth lures is essentially specific to carob moth. However, some producers have reported catching reasonable numbers of a smaller darker moth (most likely Oriental Fruit Moth). These two moths can be differentiated by comparing the figures below (Figure 4).



Figure 4: Oriental fruit moth (left) is dark grey brown, about 7mm long and lacks the wavy wing pattern of carob moth (arrowed, right)

Further reading

Botha J. and J. Hardie (2004) Carob moth. W.A. Department of Agriculture Garden Note #21.

Gothilf S. (1984) Biology of *Spectrobates ceratoniae* [synonym for *Ectomyelois ceratoniae*] on almonds in Israel. *Phytoparasitica*, 12(2): 77-87.

ISCA Technologies (2011) ISCALure-Ceratoniae. Product brochure for carob moth lure. http://www.iscotech.com/exec/DocLib/ISCA_Product_Brochure_-_Carob_Moths.pdf

SCA Technologies (2006) ISCA Technologies successfully establishes the synthetic route and custom synthesizes the carob moth pheromone mimic. Media release. <http://www.iscotech.com/exec/news127.html>

For further information contact Brett Rosenzweig, Industry Development Officer

Published by Almond Board of Australia, PO Box 2246, Berri, South Australia 5343

Telephone (08) 8582 2055 Email admin@australianalmonds.com.au



Department of
Economic Development,
Jobs, Transport & Resources



ACKNOWLEDGEMENTS

Many thanks to the producers who have maintained carob moth traps for DEDJTR Victoria and provided access to their orchards for nut sampling.

All images courtesy of DEDJTR.

Thanks also to the Almond Board of Australia for supporting this project.

This project was funded by Horticulture Innovation Australia Limited using the almond industry levy and funds from the Australian Government. Funding was also provided by the State of Victoria 'Growing Food and Fibre' initiative via the Department of Economic Development, Jobs, Transport and Resources (formerly the Department of Environment and Primary Industries)

©Almond Board of Australia

All rights reserved. No part of this publication can be reproduced or copied without the prior written consent of the Almond Board of Australia unless permitted under the Copyright Act 1968 (Cwlth).

DISCLAIMER

Almond Board of Australia and its employees do not guarantee the use, or results of the use, of the information contained herein as to its correctness, accuracy, reliability, currency or otherwise. The information supplied in the Fact Sheet was the best available at the time of publication. However, the understanding and management of almonds is constantly evolving and recommendations regularly change. As such, the reader should seek professional advice before acting upon any information in this Fact Sheet and should always comply with the relevant processing factory requirements, food safety legislation and the information listed on chemical labels.