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NSW DEPARTMENT OF
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Citrus leafminer

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Citrus leafminer, *Phyllocnistis citrella*, is a small moth pest of citrus. Damage is caused by the larvae as they mine immature foliage. Twisted and curled leaves are generally the first symptoms noticed. Severe infestations—an average of two or more mines per leaf—can retard the growth and yield of nursery and newly planted trees, but their effect on mature trees is less serious. Such infestations usually only occur in late summer and autumn, and are often related to low natural enemy activity. They rarely occur in spring because the production of new growth is prolific and synchronised, and quickly becomes immune to attack.

Severe damage on heavily infested pummelo leaves.

Leafminer is native to eastern and southern Asia and is now widely distributed where citrus is grown in Asia, Papua New Guinea, Australia, northern and central Africa, and Florida in the United States of America. It has been linked to the severity of citrus canker (*Xanthomonas axonopodis* pv. *citri*), a serious disease of citrus.

The moth was first recorded in Australia in and around Darwin in the Northern Territory in 1912. It was probably present several or more years earlier and was apparently eliminated in 1922 after a five-year campaign to eradicate citrus canker. During the campaign all citrus trees north of the nineteenth parallel in the territory were destroyed. Since then rigorous quarantine measures have been in force to prevent establishment of the disease in Australia.

In 1940 citrus leafminer was again found in Darwin and in 1965 it was recorded at Cairns in Queensland. Between 1965 and 1985 it spread slowly southwards along the east coast of the continent to the NSW south coast. In 1988 it was still only found in the Northern Territory and in the coastal districts of NSW and Queensland, and was affecting less than 20% of the Australian citrus industry.

In 1989 it was recorded in inland NSW for the first time in orchards and home gardens from Dubbo north. Between 1989 and 1992 it spread westward into the Murrumbidgee Irrigation Areas, to Hillston, and to the NSW and Victorian River Murray districts east of and including Swan Hill. By January 1993 it had reached the NSW/Victorian Sunraysia and South Australian Riverland districts. By April 1995 it had spread across the continent to south-western Western Australia.

DESCRIPTION AND BIOLOGY

Under favourable summer and autumn conditions a generation (adult to adult) is completed in 14 to 17 days. In late autumn, winter and spring it can take two or three times longer.

Adults. The adults are small, delicate moths with narrow paired forewings and hindwings fringed with long hairs. The upper surface of each forewing has a black dot at the tip, and an irregular dark line separating an inner region (covered with silvery scales) from an outer region (with silver, light yellow and brown scales). The hindwings are narrower than the forewings and are covered with silvery scales.

At rest, with their wings folded lengthwise, the moths are about 2 mm long. In flight, their wingspan is about 4.5 mm.

Because flight generally occurs at night, the adults are rarely seen in daylight except when they are disturbed, generally by human activities. When this occurs, flight is short and rapid. Females are slightly more common than males. Both sexes emerge from their pupal stage during the early morning hours. Mating generally occurs at dusk and in the early evening about 9 to 12 hours after emergence.

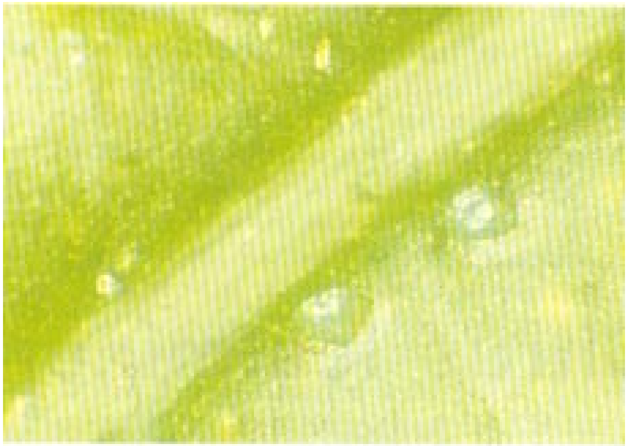
Adult female moths start laying eggs about 24 hours after mating. A female can lay more than 50 eggs during her life and as many as 20 per night. Most adults live for less than a week but they can live for up to 20 days.

Eggs. The flat, slightly oval eggs are about 0.3 mm long. They are translucent but appear light green because of the leaf surface. Eggs are laid singly, generally during the evening, on the underside of leaves near the midrib; egg deposition on the upper leaf surface is usually associated with very humid conditions and moderate or severe infestations. Hatching can occur within 1 day in summer and the young larva immediately burrows under the surface of the leaf. Young leaves 10 to 20 mm in length are preferred sites for egg laying. Eggs are rarely laid on leaves longer than 40 mm.

Larvae. There are four larval instars (stages). The first three feed only on sap from epidermal cells ruptured by their blade-like, finely toothed mouthparts. Each pale green larva forms, due to air and condensed water vapour, a characteristic silvery, serpentine mine with a raised parchment-like skin lined centrally with dark excreta. These larvae never leave their mines to form other mines or move between lower and upper sides of leaves. Development of three stages takes about five or six days in summer. Mature third instar larvae are about 3 mm long.

The fourth instar (prepupa) is yellowish-brown and resembles the third instar larva but it does not feed. It lasts for about one day in summer and uses silk produced from its mouthparts to form a pupal chamber. This chamber is usually located on the leaf margin, the edge of which is rolled over so that three sides of the chamber are formed from fresh leaf tissue and one by a thin layer of mined tissue. The chamber is formed as the delicate layer of silk produced by the prepupa dries and contracts. The exposed portion of the chamber often has a distinct orange colour but is otherwise similar to the colour of the mined leaf surface.

Pupae. The yellowish-brown pupae are about 2.5 mm long. After about six days a small opening is made at the anterior end of the pupal chamber and the pupae force themselves partially through the openings. The adults then emerge and the cast pupal skins usually remain protruding from the chambers.



Two eggs adjacent to the midrib on the lower surface of a leaf.

Mature third instar larva feeding on sap from ruptured epidermal cells; note silvery appearance of mine lined centrally with excreta (magnifications: 5.75× and life size).

Pupa removed from pupal chamber and leaf edge rolled inwards to form a pupal chamber.

CONTROL

Cultural control

Because infestations are restricted to flush growth, particularly in late summer and autumn, their severity can be reduced by:

- fertilising in winter to promote flush growth in spring when the pest is either absent or relatively scarce, and
- limiting flush growth in late summer and autumn by not fertilising and irrigating during summer and autumn in excess of the amount needed for normal growth.

Pruning of late summer and autumn flush growth can also be used to limit and remove unsightly infestations on home garden trees.

Natural enemies

These include small parasitic wasps and predators such as lacewings. The predators are generally associated with heavy infestations.

Three of the most effective wasps are *Ageniaspis citricola* and *Cirrospilus quadristriatus* (both introduced from South-East Asia in 1990–92) and *Semiolacher petiolatus*, a native species. Parasitism by other wasps native to Australia (*Cirrospilus* near *ingenuus*, *Sympiesis* sp. and *Zaommomentedon brevipetiolatus*) has also been observed.

In the Riverina, the Sunraysia and the Riverland, *S. petiolatus* is the major parasite. Parasitism levels are generally below 20% of all larvae in January–February, but build to 50% or more in March–May. In Queensland, the levels of parasitism of larvae by *A. citricola* reach 90% by February-March, but *S. petiolatus* and *C. quadristiriatus* are also important.

Chemical control

Effective control using chemicals is difficult because larvae are protected by their mines and pupae are protected by their pupal chambers. Insecticides, such

Semielacher petiolatus **(adult female).**

Ageniaspis citricola **(female and three pupae).**

Cirrospilus quadristriatus **(adult female and pupa).**

as organophosphates, carbamates, and pyrethroids, also disrupt the activity of natural enemies. Such disruption can lead to outbreaks of other pests (e.g. scales and mites).

Sprays are usually only required for control on young or vigorous trees in summer and autumn. Spraying immature flush on mature trees is generally only warranted for aesthetic reasons or to protect prolific growth that may occur if trees are heavily pruned in summer.

Spraying should commence as soon as the summer flush commences in mid to late January, before the first flushes produced by trees attain a length of 10 mm. This strategy will prevent rapid growth of leafminer populations and reduce the risk of heavy infestations during peak periods of flush growth later in the season. Spraying should cease when most of the leaves produced within a flush cycle start to harden or are longer than 40 mm.

Sprays should be applied thoroughly to the upper and lower surfaces of susceptible leaves. They should generally be applied at 7-day intervals during warm to hot weather, and every 10 to 14 days during cooler periods. The number of sprays required depends on the citrus cultivar being treated and the duration of flushing. Lemon trees will generally require more sprays than orange, mandarin or grapefruit trees.

Horticultural mineral oils (HMOs) and agricultural mineral oils (AMOs) are generally as effective as insect growth regulators and broad-spectrum organophosphates and carbamates. They are the only products recommended for general use in nurseries, home gardens, and orchards. Following an international conference on spray oils in Sydney in 1999 these names were recommended and adopted to replace 'petroleum spray oils' and 'white oils'. HMOs and AMOs are high quality mineral oils refined from virgin distillates. Sprays applied to both susceptible and mature leaves will control a range of others pests (e.g. armoured scales, mites and some thrips) simultaneously and improve control of citrus leafminer.

The oils are effective because adult female moths avoid sprayed surfaces and this leads to reduced egg laying. Broad-spectrum insecticides and growth regulators are generally used to kill adults and immature stages, or to disrupt the development of some immature stages.

In addition to their effectiveness, the major advantages of using HMOs and AMOs are:

- They can be handled with minimum protective clothing such as overalls, goggles and a facemask.
- They have low toxicity to vertebrate animals—they are almost as pure as the products used for baby and hair oils, skin lotions and creams.
- They have little detrimental effect on beneficial insects and mites.
- They do not stimulate outbreaks of pests.
- Pests have not developed resistance.
- Spray deposits are broken down within weeks by microbes, oxidisation and ultraviolet light to form simple molecules that do not pose a threat to the environment.

Guidelines for using HMOs and AMOs

Use concentrations ranging from 250 mL to 500 mL of oil per 100 L water (25–50 mL per 10 L water; 0.25–0.5%). Use products formulated for dilution in water rather than products formulated for use without mixing in water.

Sprays should be applied at volumes sufficient to wet the upper and lower surfaces of susceptible leaves to the point of run-off. They should be applied at 5 to 7-day intervals during warm to hot weather, and every 10 to 14 days during cooler periods. The number of sprays required depends on the citrus cultivar being treated and the duration of flushing. Lemon trees will generally require more sprays than orange, mandarin or grapefruit trees.

In orchards, rotary atomiser and oscillating boom sprayers are more effective than conventional airblast sprayers. Spray volumes required for effective control will generally be 70% less than those required for control of armoured scales and soft scales.

Precautions and compatibilities

HMOs and AMOs may damage plants (phytotoxicity) but this rarely occurs with modern formulations and can be avoided by correct use.

- Aim to have the oil spray dry on the plant within 1-2 hours of application.
- To prepare an oil spray, fill the spray tank with two-thirds of the water, add the oil whilst agitating the tank, then top up with the remaining water.
- During application oil–water mixtures held in spray tanks or containers must be continually and effectively agitated or stirred to prevent the oil separating from the water. Do not let the spray mix stand longer than 10 minutes. If you do, then rigorously agitate or stir before recommencing spraying.

- Do not apply too much oil annually. At rates recommended under Guidelines for Using HMO's and AMO's do not use more than 3L of oil annually in Queensland and South Australia or more than 4.5L of oil in New South Wales and Victoria. Use less oil if higher spray volumes are used.
- Do not apply oils in temperatures higher than 35°C. Take care when applying sprays when the ambient shade temperature exceeds 32°C.
- Do not apply sprays containing more than 250 mL of oil per 100 L water for at least one month after spraying with sulfur.
- HMOs and AMOs are compatible with copper sprays up to a concentration of 0.5%.
- Do not spray when the soil is dry; trees must not be suffering from moisture stress.
- Always store oils in sealed drums, cans or brown bottles in a cool dark or dimly lit place. Oils stored in clear glass or plastic bottles will oxidise. Acids formed as a result of this process can be phytotoxic and 'burn' foliage and fruit, or, because they are hygroscopic, lead to them accumulating water on sprayed surfaces.
- Excessive use of mineral oil sprays can reduce yields by clogging up the water and food transport systems of the tree.
- Do not use oils that do not meet standards required for HMOs and AMOs. Such products oxidise readily.

For more information on oils, see Agfact H2.AE.5 *Citrus petroleum-based spray oils.*

Old damage on mature leaf.

Acknowledgments

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This publication is based on the second edition of the Agfact by GAC Beattie (when Special Entomologist at NSW Agriculture) and D Smith (Principal Entomologist, Queensland Department of Primary Industries, Maroochy Horticultural Research Station Nambour).

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