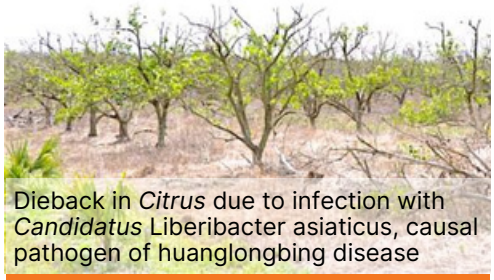
INFORMATION GUIDE

Exotic citrus psyllids

Two exotic citrus psyllid species have a high risk of entering and establishing in Australia, and of causing significant harm to businesses associated with Australian citrus production. A major reason why these two psyllid species have the potential to cause high economic damage is due to their role in vectoring harmful pathogens that can cause serious citrus diseases. This information guide provides an overview of their lifecycle and impact.



Dieback in *Citrus* due to infection with *Candidatus* Liberibacter asiaticus, causal pathogen of huanglongbing disease

Overview

Diaphorina citri
Asian citrus psyllid

Trioza erytreae
African citrus psyllid

Diaphorina citri Kuwayama (Hemiptera: Psyllidae) is commonly known as Asian citrus psyllid (ACP). It is a vector for a bacterium known as '*Candidatus* Liberibacter asiaticus' (and in some cases a related bacteria known as '*Candidatus* Liberibacter americanus'). These bacteria are the cause of a serious citrus disease called huanglongbing (HLB). Over the past decade ACP has been found across a growing number of regions worldwide. This includes multiple states in the United States, such as the major *Citrus* production states of Florida and California, multiple African countries, and Brazil. Importantly, ACP is also now found in close proximity to Australia, in Timor Leste and Papua New Guinea.

Trioza erytreae (Del Guercio) (Hemiptera: Triozidae) is commonly known as the African citrus psyllid (AfCP). It is a vector of the bacterium, '*Candidatus* Liberibacter africanus', which causes a disease called African citrus greening. This psyllid was first described in Eritrea, but has been reported in Portugal, Saudi Arabia, and several other African countries including Ethiopia, Cameroon, Kenya, Madagascar, Malawi, Reunion, Rwanda, South Africa, Tanzania and Zimbabwe. In 2002, it was reported on Tenerife Island in the Canary Islands and in 2014 it was found in Spain.

Huanglongbing disease

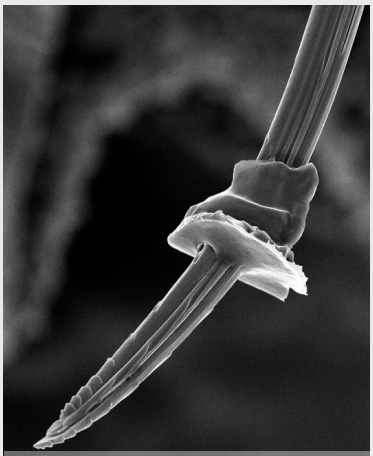
Also known as 'citrus greening', huanglongbing disease can devastate *Citrus* production in affected areas worldwide. HLB can kill a citrus tree in as little as 5 years, and there is no known cure. All commonly grown citrus varieties are susceptible to the disease.

The only way to protect trees is to prevent the spread of the HLB pathogen by controlling psyllid populations and destroying any infected trees. Since HLB was detected in Florida in 2005, citrus production has progressively declined resulting in $4.55 billion in lost revenue and > 8000 job losses since 2011.

Biology

Citrus psyllids undergo an egg-nymph-adult life cycle. They feed on the phloem (sap) of host plants during development and as adults. These psyllids can feed on a variety of species within the plant family Rutaceae, which includes *Citrus* as well as other genera, such as *Murraya*, *Fortunella* and *Correa*. In diverse habitats citrus psyllid population levels generally remain low, however populations can become large in host monoculture situations, such as *Citrus* orchards.

The following pages provide greater detail on the lifecycles and feeding habits of each psyllid species.



Serrated tip of an ACP nymph stylet at 8000x magnification

How do psyllids feed?

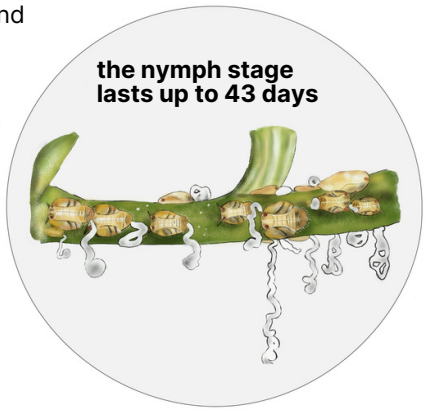
Phloem-feeding insects, such as psyllids, rely on highly modified mouthparts (stylets) to reach specific cells within the plant tissue. A generic stylet contains cutting blades and a two-channelled tube. After cutting into the plant tissue a hemipteran insect will then send saliva down one of the tubes to aid in digestion of plant tissue. The liquid food is then sucked up the other tube.

Through feeding on plant hosts and injection of saliva, they can also uptake pathogenic microbes, and these pathogens can be transferred to other plant hosts during feeding. Many hemipterans are economically important as pests of major agricultural crops.

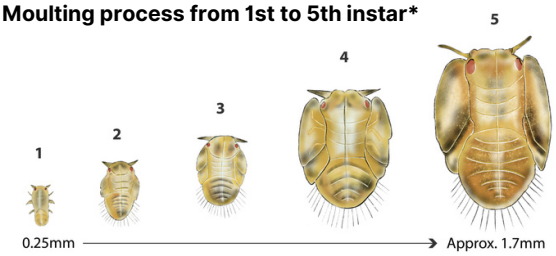
Images of ACP and AfCP: Mike Lewis, UC Riverside
Image of HLB: University of California
Image of stylet: Ammar, El-Desouky (2015). SEM of serrated tip of the stylet bundle in nymphs of Asian citrus psyllid. 10.13140/RG.2.1.4261.0086

Asian citrus psyllid life cycle

ACP nymphs undergo 5 instars and are between 0.25-1.7mm long. Nymphs are wingless and are mainly found on buds, leaves and stems of young citrus leaves during a growth flush. Nymphs excrete white, string-like honeydew (this excretion is not always evident).



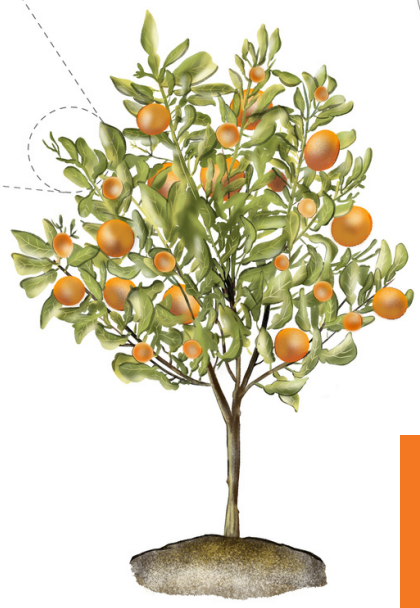
Moulting process from 1st to 5th instar*



*Nymphs look similar at each instar but increase in size after each moult.

*The developmental stage of an arthropod between moults.

Depending on temperature and season, a single lifecycle takes 15-47 days.



Citrus sp., Rutaceae

Female ACP can lay more than 800 eggs on tips of young citrus leaves and between furling leaves during a growth flush.

Eggs are elongated, approximately 0.3mm long and almond shaped. Fresh eggs are pale but turn yellowish orange before hatching.

0.1mm

Adult psyllids are 3-4mm long and may live for several months.

Development and reproduction stops or greatly slows down during cool weather, and hot weather can suppress population growth.

Adults are poor fliers rarely flying for more than 100m at one time, while nymphs do not fly and remain on the host plant until maturity.

Long range spread of ACP occurs by wind and via trade or illegal importation of plant material.

ACP eggs laid on the node of a new leaf during a growth flush.

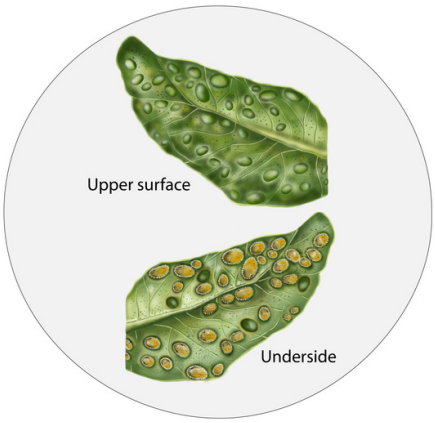
ACP nymphs excreting honeydew in the form of characteristic waxy tubules.

The ACP adult has a characteristic pose, holding itself at a 45 degree angle.

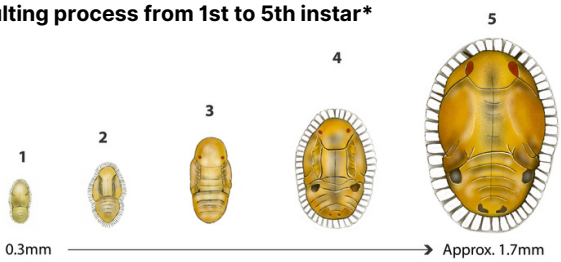
African citrus psyllid life cycle

AfCP nymphs undergo 5 instars and are between 0.3-1.7mm long. After hatching, the wingless nymphs start to find a suitable point to settle and feed on the underside of tender leaves. The nymph feeding activity results in concave open galls in the underside of the leaf, creating protrusions on the upper surface.

the nymph stage lasts up to 40 days



Moulting process from 1st to 5th instar*



*Nymphs look similar at each instar but increase in size after each moult. The later instars have tubular hairs forming dense fringes along the margin of the head, wing pads, and abdomen.

eggs hatch in 5-17 days

Depending on temperature and season, a single lifecycle takes 17-50 days.

adults live 17-50 days

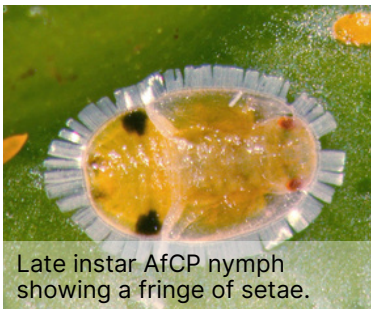
Adult psyllids are about 3-4mm long and may live for several months.

Female AfCP can lay up to 2000 eggs over 4-7 weeks. Eggs are laid on the margins of young leaves and are anchored by short stalks. Eggs are approximately 0.3mm in length with a typical anterior, sharp point. Eggs are pale yellow to dark orange.

Citrus limon, Rutaceae

AfCP is more adapted to cold, moist conditions than ACP, and is generally found at higher altitudes (>500 m above sea level).

AfCP eggs stand upright on short stalks.



Late instar AfCP nymph showing a fringe of setae.

AfCP nymphs are found on the underside of leaves.

Adult AfCP hold themselves at a 35 degree angle.

Recognising the adult Asian citrus psyllid

forewings are broad and are widest near the tip

3-4 mm in length

short antennae (approx 0.48mm), which are pale brown with black tips

band interruption

light brown head and red-dark brown eyes

- brown band extends around periphery of the forewing
- band is slightly interrupted near the wing apex

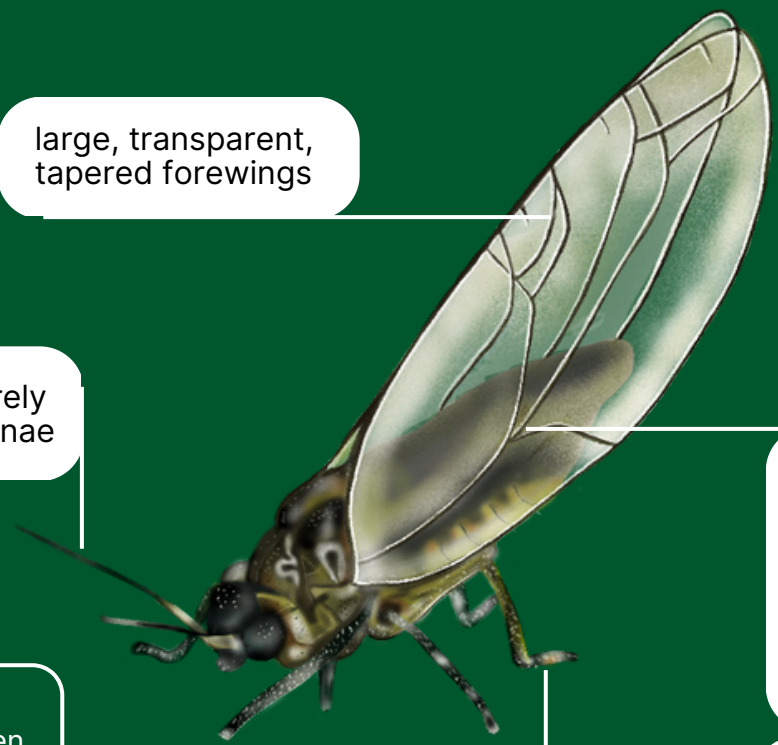
- mottled, yellowish-brown body with brown legs and a light brown head
- ventral side of the abdomen is greenish-white, dorsal side is black
- forewings are transparent with brown patterning

Recognising the adult African citrus psyllid

large, transparent, tapered forewings

- the body is 1.9-2.5 mm in length
- forewings are 2.40–3.45 mm in length

almost entirely black antennae



- clearly outlined wing veins
- branching of three component veins at approximately the same point

Newly emerged adults are pale green, turning to brown to black with maturity.

hindlegs become progressively darker distally (away from body)

Branching of three veins, which are known as 'r', 'm', and 'cu', gives rise to the genus name 'TRI-oza'.

Asian citrus psyllid feeding damage

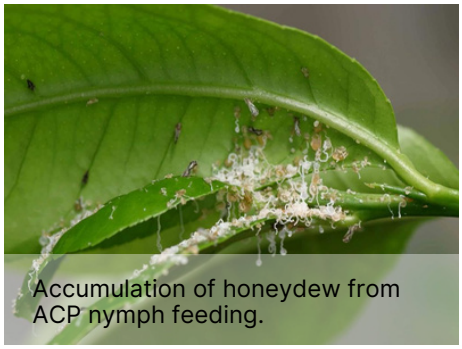
Apart from its potential to transmit pathogens that cause huanglongbing disease, ACP can damage *Citrus* directly by feeding on newly developed leaves (flush). ACP feed mostly from phloem sieve elements, and to a lesser extent they also appear to ingest sap associated with xylem vessels.

When nymphs feed on new shoots and leaves they remove sap from the plant tissue and inject a salivary toxin as they feed. This toxin can inhibit or kill new shoots, deforming new leaves by twisting and curling them. If the leaves mature after sustaining this damage, they will have a characteristic notch as they expand.

Each nymph also produces a waxy tubule from its back end to help clear sugary waste product away from its body. This excretion accumulates on leaf surfaces and promotes the growth of sooty mould.

A leaf notch caused by ACP feeding during leaf development.

Feeding damage to shoots caused by ACP nymphs and adults.



Accumulation of honeydew from ACP nymph feeding.

Growth of sooty mould resulting from honeydew accumulation.

African citrus psyllid feeding damage

After emergence, the first instar nymphs of the AfCP search for a suitable site to feed and settle. Like ACP nymphs, they prefer to feed on the youngest growth available, which includes young leaves and soft stems. Feeding damage symptoms consist of the evident open gall-like structures on leaves, which are diagnostic for the presence of the insect. Leaves can become chlorotic and slightly curled, especially when heavily infested.

Impact on young *Citrus* plants can be severe, with feeding resulting in plant death in most cases in the absence of control actions. Direct damage may also result from honeydew excretion, which appears as soft, white, sticky granules. In severe infestations, these granules give a dusty appearance to the plants and can lead to fungal growth, as well as disrupting the effectiveness of natural enemies.

Examples of gall-like damage arising from African citrus psyllid nymphs feeding on developing leaves.

Image of leaf notching: Michael Rogers, UF-IFAS
Image of damage to young leaves: Regents of the University of California
Images of honeydew: Michael Rogers, University of Florida
Image of sooty mould: Citrus pest and disease prevention program

Huanglongbing and African citrus greening

Transmission

During feeding, exotic citrus psyllids are capable of up-taking the bacteria into its body if the plant is infected. Pathogen transmission is comprised of four main steps: acquisition, replication, translocation and transmission. The '*Ca*. L. asiaticus' pathogen must be acquired from an infected tree during feeding, after which it must cross the gut barrier of the psyllid vector. Once acquired through the gut tissue, the bacterium moves through the haemolymph until passing the salivary gland membranes, where it is inoculated into a new host plant together with the insect's salivary secretions.

The time required for a psyllid to take up the bacterium varies between species. After feeding on an infected plant for 24 hours, AfCP can infect other plants eight to 12 days later with '*Ca*. L. africanus', which causes African citrus greening. In contrast, ACP cannot transmit '*Ca*. L. asiaticus' until approximately 24 days after initial feeding.*

* AfCP has also been shown to transmit *Candidatus* Liberibacter asiaticus and *Candidatus* Liberibacter americanus.

Two bacterial species are known to cause huanglongbing disease:

- '*Candidatus* Liberibacter asiaticus' ('*Ca*. L. asiaticus')
- '*Candidatus* Liberibacter americanus' ('*Ca*. L. americanus')

One bacterial species is known to cause African citrus greening:

- '*Candidatus* Liberibacter africanus' ('*Ca*. L. africanus')

Dieback in an orchard impacted by Huanglongbing.

Disease symptoms

Huanglongbing disease is caused by ACP to plant transmission of '*Ca*. L. asiaticus' or '*Ca*. L. americanus'. '*Ca*. L. asiaticus', is heat tolerant and symptoms of the disease can develop at temperatures at up to 35 °C. Fruit and tree health symptoms may not begin to appear for 2 or more years after the bacteria infect a tree. An early symptom of huanglongbing disease in *Citrus* is the yellowing of leaves on an individual limb or in one section of the canopy.

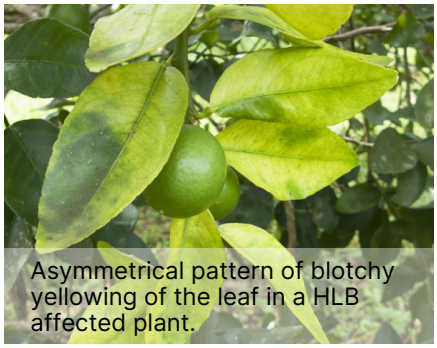
Leaves that turn yellow from huanglongbing disease will show an asymmetrical pattern of blotchy yellowing or mottling of the leaf*. Symptoms of nutrient deficiency, particularly zinc, can also be seen on huanglongbing-affected trees, particularly in the later stages.

*It is important to remember that Citrus leaves can turn yellow for many other reasons and often discolour from deficiencies of zinc or other nutrients. However, the pattern of yellowing caused by nutrient deficiencies typically occur symmetrically (equally on both sides of the midvein), between or along leaf veins.

As the disease progresses, the fruit size becomes smaller, and the juice turns bitter. The fruit may remain partially green, which is why the disease is also called citrus greening. The fruit becomes lopsided, has dark aborted seeds, and tends to drop prematurely.

Chronically infected trees are sparsely foliated with small leaves that point upward, and infected trees have extensive twig and limb dieback. Eventually, the tree stops bearing fruit and dies.

African citrus greening is caused by the AfCP to plant transmission of '*Ca*. L. africanus'. This pathogen is heat sensitive and symptoms only develop when the temperature is in the range 20–25 °C. Like huanglongbing, the disease manifests as a number of symptoms including mottled foliage, yellow leaf veins, sparse foliage, and smaller fruits showing a ripening colour inversion. However, symptoms generally appear as less severe than in huanglongbing affected plants.



Asymmetrical pattern of blotchy yellowing of the leaf in a HLB affected plant.

Development of lopsided fruit is one symptom of huanglongbing.

Images of dieback, leaf blotching, and fruit: Edgloris Marys, Dreamstime.com

Performing a tree inspection

The best way to detect the presence of exotic citrus psyllids is by visually inspecting a *Citrus* tree during a growth flush period, when new leaves are developing. Mature citrus trees typically produce most of their new growth in Autumn and Spring, but young trees and lemons tend to flush periodically year round during warm weather.

Slowly walk around each tree and inspect the newly developing leaves. Look for signs of psyllid feeding and damage, including twisted or notched leaves, nymphs producing waxy deposits, honeydew, sooty mould, or adult psyllids.

If you think psyllids are present, use a hand lens to look for small yellow eggs, psyllid nymphs with their waxy tubules, and adults.

Reporting suspect exotic pests

If you suspect you have found a new pest or disease, please call the Exotic Plant Pest Hotline on 1800 084 881.

Calls to the Exotic Plant Pest Hotline will connect to an automated system that allows the caller to choose the state or territory that the call relates to.

The caller will then be connected to the relevant authority for that jurisdiction where calls will be answered by an experienced person, who will ask some questions to help understand the situation, such as:

- what was seen (describe the pest or send a photo) and when was it first noticed
- where it was found and what it was on
- how many pests are present/how infected is the plant
- how widely distributed it is.

Every report is taken seriously, checked out and treated confidentially.

Sources

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Hall, D. et al. (2012) Asian citrus psyllid, *Diaphorina citri*, vector of citrus huanglongbing disease, mini review. Entomologia Experimentalis et Applicata, 146, 207-223

PHA (2015) Threat specific contingency plan, version 2.0 - Huanglongbing ('*Candidatus* Liberibacter africanus', '*Candidatus* Liberibacter americanus', 'Candidatus Liberibacter asiaticus') and its vectors (African citrus psyllid (*Trioza erytreae*) and Asiatic citrus psyllid (*Diaphorina citri*)). Plant Health Australia, Canberra, ACT.

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