# National Diagnostic Protocol for Glassy Winged Sharpshooter, *Homalodisca vitripennis* (Germar)

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|---|---|
| PEST STATUS | Not present in Australia |
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Australian Government
Department of Agriculture

# Prepared for the Subcommittee on Plant Health Diagnostic Standards (SPHDS)

This version of the National Diagnostic Protocol (NDP) for Glassy Winged Sharpshooter, *Homalodisca vitripennis* (Germar) is current as at the date contained in the version control box on the front of this document.

NDPs are updated every 5 years or before this time if required (i.e. when new techniques become available).

The most current version of this document is available from the National Plant Biosecurity Diagnostic Network (NPBDN) website: http://plantbiosecuritydiagnostics.net.au/resource-hub/priority-pest-diagnostic-resources/

# Contents

# 1 Introduction

The glassy winged sharpshooter (GWSS) is an insect native to the south-eastern United States. It is a large leafhopper (13-14 mm long) that obtains its nutrients by feeding on fluids from the water conducting plant xylem tissue. GWSS attacks a wide variety of ornamental and crop plants, and in most cases it feeds on the stems of plants rather than leaves. Among the wide host range are grapevines, citrus, almond, stone fruit and oleanders. Because of the large number of hosts, GWSS populations can flourish in both agricultural and urban areas. The GWSS feeding activity rarely causes significant damage by itself, even though the insect excretes copious amounts of liquid that can make leaves and fruit appear white washed when dry.

Their feeding method, along with their voracious appetite for so many different hosts, makes glassy-winged sharpshooters an effective vector for the *Xylella fastidiosa* bacterium. This bacterium is the causal agent of many devastating plant diseases, including Pierce's disease of grape, oleander leaf scorch, almond leaf scorch, mulberry leaf scorch, phony peach disease, plum leaf scald, leaf scorches in sycamore, elm, maple, oak and variegated citrus.

An incursion of GWSS into Australia, without a contemporaneous or subsequent incursion of *Xylella fastidiosa,* may have minimal consequences. It will, however, ensure that Australia has more immediate consequences of any future incursion of *X. fastidiosa* and therefore place Australia at greater risk of economic damage from such an incursion.

An incursion of *X. fastidiosa* into Australia may have serious consequences even without a contemporaneous or subsequent incursion of GWSS. This is because the capacity of xylem-feeding Auchenorrhyncha already present in Australia, including leafhoppers of the tribe Cicadellini, spittlebugs and their relatives (Cercopoidea) and cicadas (Cicadoidea), to transmit *X. fastidiosa* is unknown, although current studies are investigating the likelihood of other suitable vectors being present in Australia. Considering the number of species that are known to transmit the pathogen in North America, it is highly likely that at least some of the Australian species are also capable of transmitting it. However, it is only GWSS, which feeds on woody tissue, that has created infections of *X. fastidiosa* in grapevines that are difficult to control and potentially fatal. In addition, few of the Australian species have been collected in grapevines although small cicadas are known to use vineyards in SW Australia.

## 1.1 Host range

More than 150 species of plants can host the glassy winged sharpshooter (GWSS)(see Appendix). GWSS has approximately 175 feeding and breeding hosts, all except one are present in Australia. The natural habitat of the GWSS is forest margins, however it feeds on commercial crops (e.g. citrus, avocado and grape), ornamentals (e.g. oak, sycamore, crepe myrtle) and natural vegetation (e.g. eucalyptus, Anon 2000)

## 1.2 Effect on hosts

Adults and nymphs feed on xylem in stem, trunk, branch and petiole, and excretes copious amounts of liquid that can make leaves and fruit appear white washed when dry (Figure 1a).

Egg masses can be found laid into the undersurfaces of leaves (Figure 1b). When the Nymphs hatch they split the leaf open on one side and the leaf will start to turn brown leaving an "egg scar" which can stay until the leaf falls from the plant. The egg mass can also leave an egg scar after parasitisation which can be useful to detect if GWSS has been present.

GWSS is an effective vector of *Xylella fastidiosa*, the causative agent of several plant diseases including Pierce's disease of grapevines, Phony peach disease and Citrus variegated chlorosis. When a glassy-winged sharpshooter feeds on a plant that is infected with *X. fastidiosa*, it acquires the bacteria, which multiplies within the insect's mouthparts. The sharpshooter then transfers the bacteria to another plant when it feeds. Unlike other vectors in North America, GWSS feeds on

woody tissue, including stems and branches of grapevines. It will even feed on the wood of dormant vines. Transmission of *Xylella* into these tissues means that infected parts of a grapevine cannot be pruned away as part of standard vineyard maintenance which is the case with infections transmitted by other species of sharpshooters.


**Figure 1.** (a) White washed appearance of citrus fruit covered in GWSS excrement, (b) Egg mass on underside of leaf (Photos: The Regents of The University of California, USA).

# 2 Taxonomic Information

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Family: Cicadellidae

Species: *Homalodisca vitripennis* (Germar 1821)

**Synonyms**

*Tettigonia vitripennis* Germar 1821

*Tettigonia coagulata* Say 1832

*Homalodisca coagulata* (Say), Stål 1869

*Homalodisca triquetra* (Young, 1958)

**Common names**

Glassy winged sharpshooter (GWSS)

# 3 Detection

## 3.1 Sampling and handling procedures

**a. Number of specimens to be collected**

At least two specimens of the largest specimens available. The aim is to obtain an adult male. Adult females are identifiable as belonging to tribe Proconiini but males are needed to confirm species identification

**b. Preferred stage to be collected**

Adults, identifiable by the presence of wings.

**c. How to collect.**

Hand collecting into glass vials or vacuum collecting either with vacuum sampler or pooter (aspirator). Adults and nymphs are normally found on the trunk and stems of the host plant. Eggs are laid into underside of leaf in a ovoid or quadrate group (Figure 1b).

**d. How to collect plant sample if required**

Leaves with suspect egg masses should be picked and refrigerated (not frozen). Transfer to diagnostic centre to be carried out as soon as possible for examination.

**e. How to preserve plant sample.**

Leaves with suspect egg masses can be stored for a few days between moist newspaper and kept refrigerated (not frozen).

**f. How to preserve GWSS**

Adults and nymphs can be placed in 70% and 100% (for molecular testing) ethanol and stored indefinitely. Adults can also be stored dried but may become brittle and may be damaged in transit.

**g. How to transport GWSS**

Dried specimens can be packed in tissue in a vial, which is then packed with cushioning material in a strong box. Transport in ethanol should conform to UN requirements for transport of dangerous goods.

**h. How to transport plant sample**

Leaves with egg masses should be mailed as a flat package between sheets of moist newspaper. Mail earlier in the week to avoid weekend delays.

# 4 Identification

## 4.1 Specimen preparation

Confirmation of GWSS identification requires an examination of the structures of the male genitalia. In order to do this, the apex of the abdomen, or preferably the whole abdomen, is carefully removed and heated in 10% KOH* (Potassium hydroxide, caustic potash) for a varying period of time depending on the size and degree of sclerotisation of the genital capsule. This process, known as maceration, removes the muscle and soft connective tissue and leaves the abdomen sufficiently transparent to see the internal structures. Take care not to heat the genitalia for too long since this will result in the genitalia becoming too transparent to see.

**Take great care in using KOH because, even at 10%, it is corrosive and will cause burns if it contacts your skin. Avoid contact with the skin and avoid breathing the vapour.*

Once cleared, the genitalia are removed from the KOH and washed thoroughly at least twice in distilled water to ensure that all traces of the KOH are removed. The genitalia are then transferred to 70% ethanol for examination and eventually into a small rubber-topped plastic tube of glycerine for storage. The pin on which the rest of the specimen is mounted should be passed through the rubber top so that the macerated genitalia and the specimen from which they came are not separated in the collection (*http://www1.dpi.nsw.gov.au/keys/auch/methods.htm)*

Figure 2 provides line drawings of the diagnostic parts, particularly the aedeagus, taken from Young (1958).

## 4.2 Morphological methods

### 4.2.1 Electronic keys

GWSS has been incorporated into electronic keys published on the Industry & Investment NSW website (Fletcher 2009 + updates). This key distinguishes GWSS from all native Australian Auchenorrhyncha (leafhoppers, planthoppers, spittlebugs and cicadas).

GWSS has the following combination of characters which will differentiate it from all other leafhoppers occurring in Australia (see Figure 3 and 4).

1. Length of adult: males approximately 11-13 mm, females generally large (12-14 mm).
2. Colour: dark brown, usually with some reddish coloration along the veins of the tegmen and some minute yellow flecking on the head and thorax (Figure 3). Nymph dark brown.
3. Head, in dorsal view (Figure 4), triangular in outline with prominent eyes which clearly extend laterally beyond the pronotum.
4. Face of head roundly swollen (Figures 3 and 4) (typical of xylem-feeding insects, see Figures 11-14).
5. Tegmina (fore wings), in normal position, not covering lateral margins of the abdomen.

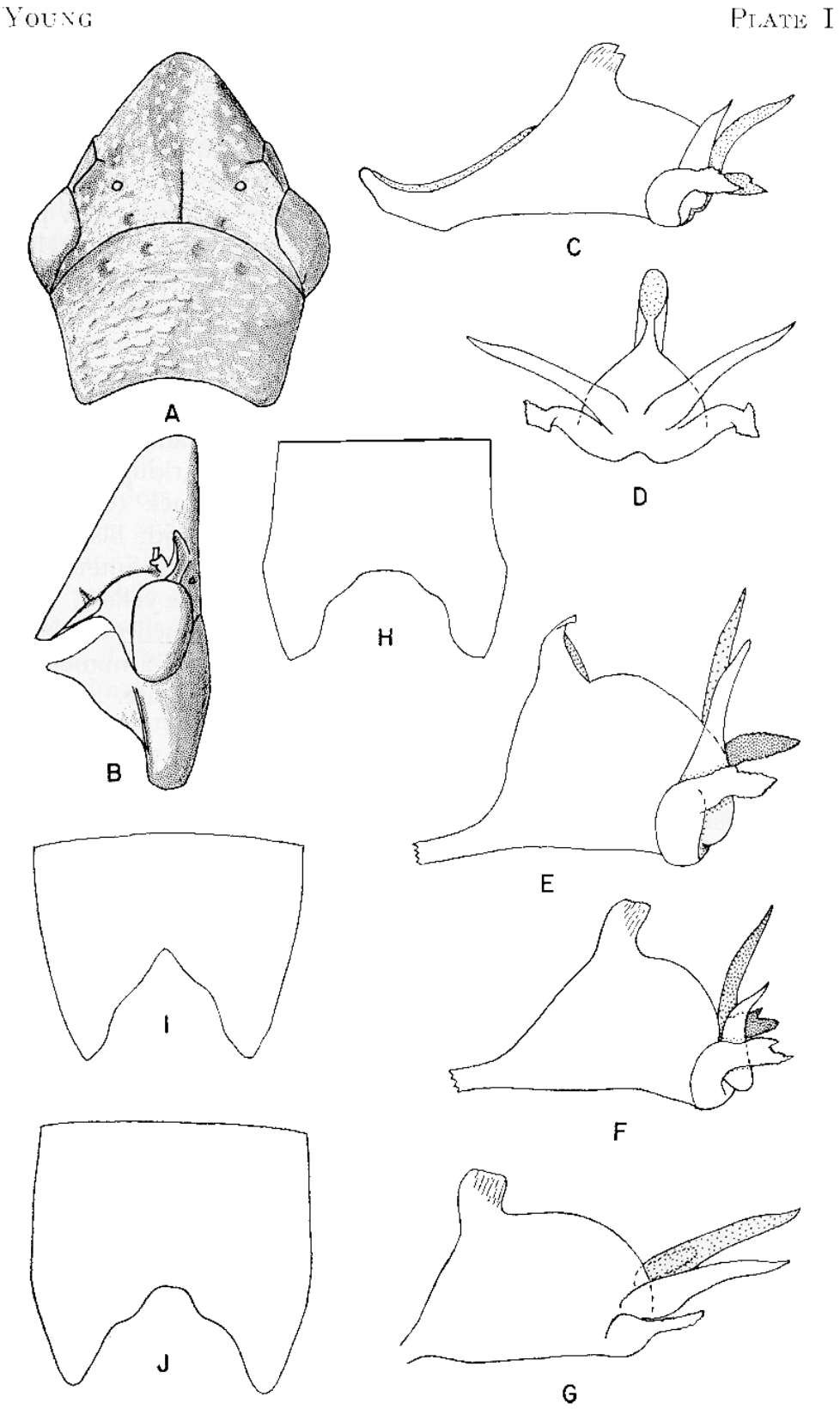


**Figure 2**. Illustrations of male genitalia of GWSS from Young (1958).Legend: A: Head and pronotum, dorsal aspect; B: same, lateral aspect; C, E, F, G: Aedeagus, lateral aspect, variations; D: Aedeagus, posteroventral aspect; H. I. J: female sternite 7 variations.

**It will also key out in the following sequence in Fletcher (2009):**
Commencing at *http://www1.dpi.nsw.gov.au/keys/leafhop/index.html*

- cica01.htm - Hind femora with no more than 1 spine preapically (if difficult to see, take either option. Both will reach GWSS (ie go to cica25.htm below)
- cica62.htm - Pronotum usually a simple transverse plate
- cica02.htm - Pronotal paranota absent
- cica03.htm - Hind tibia at least 1.5 times as long as mid tibia
- cica05.htm - Tegmen with three preapical cells
- cica09.htm - Hind femur with 2 macrosetae at apex
- cica13.htm - Cu1 in tegmen with 2 branches
- cica66.htm - Anal veins united medially; large insects with broad head and swollen face = Proconiini possibly GWSS
- gwss.htm

If cica01.htm is inconclusive (ie. if there appears to be more than one preapical spine on the hind femur), the species will still key to GWSS in Fletcher (2009) using the following sequence:

- cica01.htm – Hind tibia with at least two spines preapically
- cica25.htm – Tegmen with three preapical cells
- cica30.htm – Ocelli and antennae situated closer to antennae than to apex of head
- cica29.htm – Tegmen with appendix moderately to well developed
- cica32.htm – Crown and face level with eye, not raised or carinate
- cica33.htm – Antennal ledges well developed, carinate
- cica39.htm – Hindwing with veins Rs and M1+2 separate apically
- cica64.htm – Abdomen not extending beyond apices of folded tegmina
- cica42.htm – Ocelli on crown
- cica43.htm – Antennae not nearly as long as length of whole insect
- cica44.htm – Crown horizontal, meeting swollen frons some distance from apex of head
- cica70.htm – Crown without submarginal transverse carinae in front of ocelli
- cica71.htm – Crown triangular; tegmina narrow leaving sides of abdomen exposed
- gwss.htm

### 4.2.2 Specialist emergency diagnosis

Definitive diagnosis of GWSS requires examination of male genitalia and comparison with either voucher material or illustrations provided by Young (1958). Experience with identification of Cicadellidae, particularly Proconiini, and the ability to relate structures to line illustrations in Young (1958) should be demonstrated.

CO1 gene sequences of *H. vitripennis* are available from GenBank and BOLD to support diagnostics of *H. vitripennis* females, nymphs and egg masses (Smith, 2005).

**Proposed methodology for diagnosis:**

1. Select adult male specimen.

   Males are 11-13 mm in length, females slightly larger up to 14 mm.

2. Use Fletcher's (2009) key to identify specimen to Tribe.

   GWSS keys in the sequences given above:

   If specimen keys to gwss.htm, carefully detach abdomen from specimen

3. Heat abdomen in 10% KOH following directions given in Methods.htm by Fletcher (2009)

4. When cleared, and in glycerine, compare lateral and caudal views of aedeagus with illustrations provided by Young (1958, Figure 4). Aedeagus must have two pairs of apical processes matching those in the figures and the shape of the aedeagus itself must match that illustrated, within the limits of the variation shown in the figures. Young (1968) differentiates *H. vitripennis* (as *H. coagulata*) from other species of *Homalodisca* in the following sequence:

   - Couplet 1 - Forewing mostly hyaline, not opaque
   - Couplet 5 - Aedeagus with two pairs of processes, not three
   - Couplet 7 - Aedeagus with dorsal processes linear, not shaped like a bird in lateral aspect
   - Couplet 8 - Aedeagus with dorsal processes linear, not falcate apically
   - Couplet 9 - Crown of head without distinct linear markings; aedeagus with ventral pair of processes not very short
   - Couplet 10 - Aedeagus with ventral aedeagal processes not as long as dorsal processes and not evenly curved throughout their length
   - Couplet 11 - Aedeagus lacking a deep concavity between shaft and bases of aedeagal processes

5. Specimens from Australia suspected to be GWSS can be sent to Dr M.J. Fletcher, Orange Agricultural Institute, Forest Road, Orange NSW 2800 for confirmation.

N.B. Morphological characteristics of eggs and nymphs cannot be used to correctly diagnose GWSS. First instar nymphs are approximately 2 mm long and 1 mm wide across the head. There are a total of five nymphal instars with the final (5th) instar reaching a length of about 8 mm and a width across the eyes of 3 mm. The shape and colouration of the nymphs are generally similar to those of the adult, including the bulging eyes and prominent frons.

### 4.2.3 Diagnostic images of GWSS

**Figure 3.** *Homalodisca vitripennis* (Germar), the Glassy Winged Sharpshooter. Length: 12 mm (lateral view, note swollen face of head and abdomen exposed below tegmen at side)

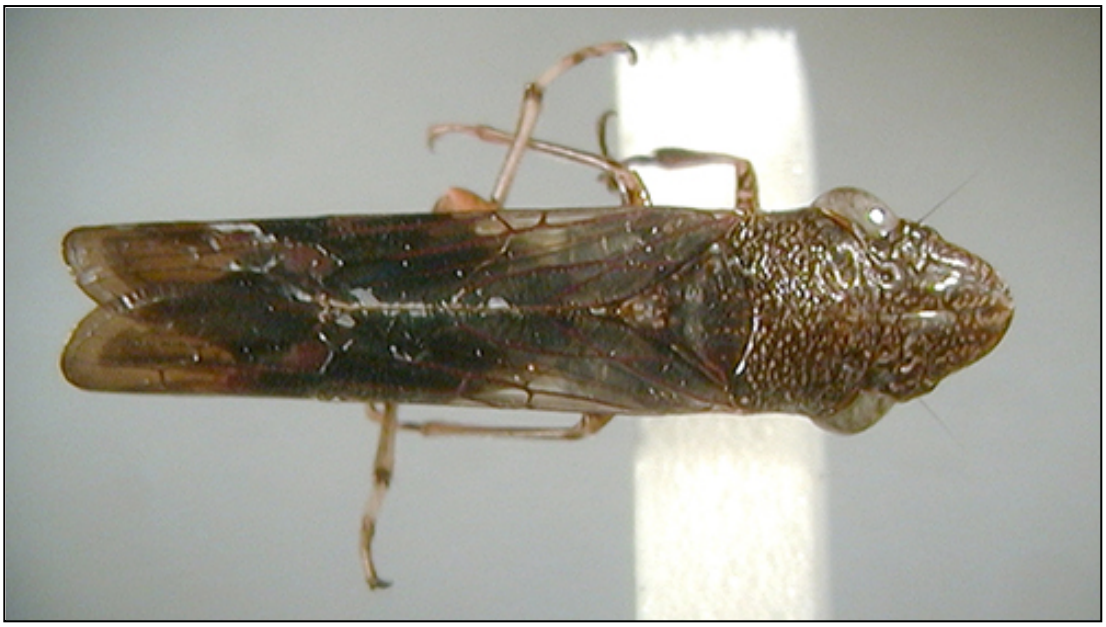

**Figure 4.** *Homalodisca vitripennis* (Germar), the Glassy Winged Sharpshooter (dorsal view, note prominent eyes, triangular vertex and narrow tegmina)

### 4.2.4 Organisms that occur in Australia with which GWSS may be confused

The Australian Auchenorrhyncha can be differentiated using web keys provided by Industry & Investment NSW Agriculture (Fletcher 2009 + updates). In order to facilitate rapid and reliable diagnosis of GWSS, this species has also been incorporated into the keys. The characters used by the keys, which are fully illustrated with colour photographs, are sufficient to differentiate GWSS from all Australian leafhoppers.

The following species share some features with GWSS, including larger size, brown colouration and large head with prominent eyes.

**Cicadellidae: Tartessinae: Thymbrini** (Figure 5). Species of this tribe sometimes have an expanded head with prominent eyes although the face is not swollen as in GWSS. Also, the tegmina are opaque and cover the sides of the abdomen laterally.

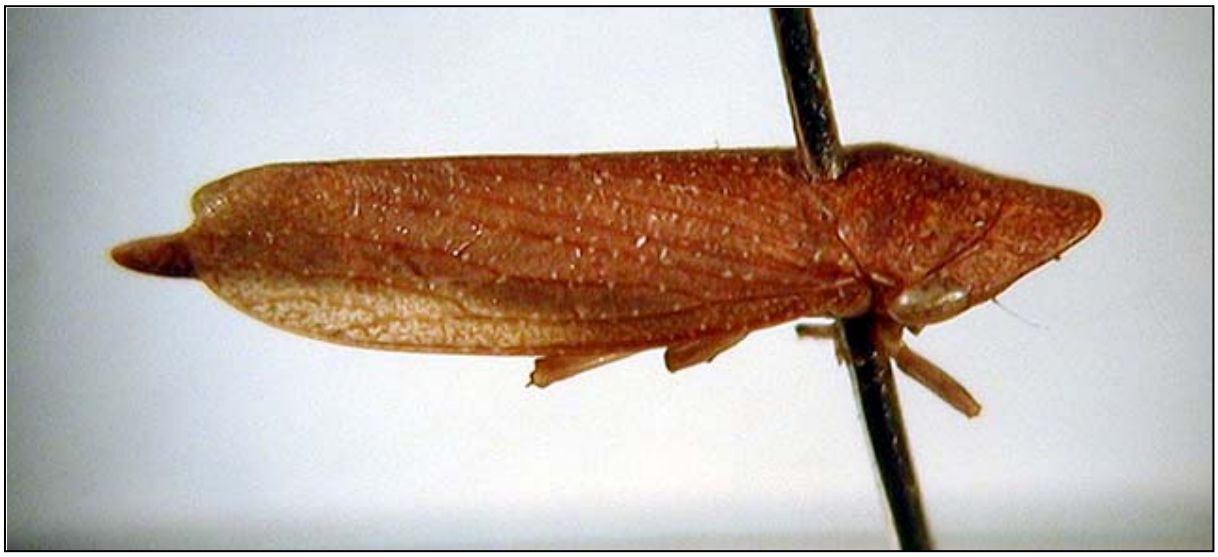

**Figure 5.** *Rhotidus teleformis* (Walker) expanded head with prominent eyes (Cicadellidae: Tartessinae: Thymbrini). Length: 12-16 mm. (Note the expanded prominent eyes. Head is flattened on face and not swollen and tegmina cover the sides of the abdomen).

**Cicadellidae: Tartessinae: Stenocotini** (Figures 6 and 7). Stenocotini often have the tegmina glassy transparent between the veins although, in those species, the anterior expansion of the head is due to an expanded pronotum rather than an expanded head. In *Ledracotis gunnensis* Evans, it is the head that is expanded and this species can also have the face medially bulging, although not swollen. *L. gunnensis* can easily be differentiated from GWSS by having tegmina which are opaque and cover the sides of the abdomen laterally.

**Figure 6.** *Ledracotis gunnensis* Evans (Cicadellidae: Tartessinae, Stenocotini). Length: 15-17 mm (Note the expanded head with prominent eyes. Face may bulge medially but is not swollen. Tegmina cover the sides of the abdomen laterally and are opaque).

**Figure 7.** *Stenocotis depressa* (Walker) (Cicadellidae: Tartessinae: Stenocotini). Length 10-24 mm.

**Cicadellidae: Tartessinae: Tartessini** (Figure 8). Some Tartessini are brown and large but do not have the head expanded and swollen like GWSS. One species, *Tartessoides griseus*, has the male large with an expanded head although it is not swollen and it has a dense covering of hairs. Expansion of head anteriorly is due to prominence of pronotum rather than an expanded head as in GWSS. Tartessini all have the appendix (the apical membrane beyond the apical crossveins) extending around the apex of the tegmen.Tegmina cover the abdomen laterally. Proconiini can be separated from Stenocotini by key characters provided by Fletcher 2009.

**Figure 8.** Male of *Tartessoides griseus* F. Evans (Cicadellidae: Tartessinae: Tartessini). Length: 12-13 mm

**Cicadellidae: Ledrinae: Ledrini** (Figure 9). The ledrines have the head expanded, sometimes quite markedly, but the face is always flattened or even concave to enable the leafhoppers to fit against the stems on which they feed. The tegmina cover the sides of the abdomen laterally, the head is not swollen dorsoventrally and the face is covered with dense hairs. Although often large and brown, tartessines do not have the head expanded, the tegmina are usually opaque and cover the sides of the abdomen laterally and the appendix extends around the apex of the tegmen.

**Figure 9.** *Platyledra acuminata* (Distant) (Cicadellidae: Ledrinae: Ledrini). Length: 14 mm.

**Cicadellidae: Euacanthellinae: Euacanthellini** (Figure 10). *Euacanthella palustris* Evans is normally brachypterous but occasionally occurs in a macropterous form which has certain similarities to GWSS. However, the tegmina are opaque and cover the sides of the abdomen laterally. All Australian Ledrini have the head expanded anteriorly with the eyes situated laterally at the base. In all species, however, the face is concave or flattened in order that the leafhoppers can fit against the branches on which they feed.

**Figure 10.** *Euacanthella palustris* Evans (Cicadellidae: Euacanthellinae: Euacanthellini). Length: 5-8 mm (Macropterous form. Head is expanded and may be convex facially. Tegmina are opaque and cover the sides of the abdomen laterally. This species is also smaller than GWSS.

**Cercopoidea** (Figures 11 and 12). Spittlebugs and their relatives are xylem feeders and therefore have the frons expanded to enclose the muscles of the feeding pump similar to GWSS. However, the general structure of spittlebugs is quite different from GWSS. The head is not triangularly expanded, the tegmina are coloured, often quite brightly, and cover the abdomen laterally and the pronotum is often convex giving the insects a humped appearance quite different to the generally flattened and elongate appearance of GWSS.

**Figure 11.** *Petyllis deprivata* (Walker) (Cercopoidea: Cercopidae) Length 7-9 mm.

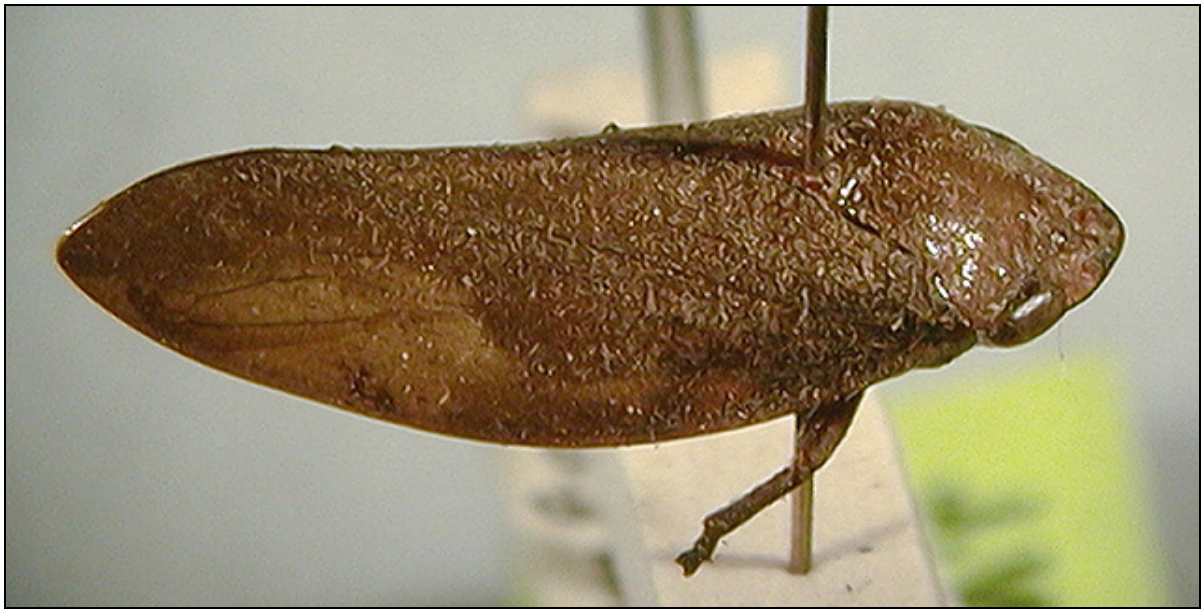

**Figure 12.** *Amarusa australis* (Jacobi) (Cercopoidea: Aphrophoridae) Length: 12-17 mm. (The comparative note under Figure 10 also applies to this spittlebug)

**Australian Cicadellinae** all belong to the **Tribe Cicadellini** (Figures 13 and 14) and differ from GWSS in lacking the broadly triangular vertex and in coloration. Species of *Ishidaella* Matsumura (Figure 14) have blue-black tegmina and yellow bodies with black markings while Australian species in other genera (e.g. Figure 12) are whitish or pale yellow, usually with dark markings. These belong to the same leafhopper subfamily as GWSS although, as with *C. spectra* in Figure 13, a different tribe. The face of the head is swollen as with all xylem feeders but in general appearance and colour, species of *Ishidaella* are quite distinctive. They are also appreciably smaller than GWSS. There are nine species of *Ishidaella* recognised in Australia and all have similar coloration. Some species are very common in suburban garden.

**Figure 13.** *Cofana spectra* (Distant) (Cicadellidae: Cicadellinae: Cicadellini) Length: 7-9 mm.

**Figure 14.** *Ishidaella albomarginata* (Signoret) (Cicadellidae: Cicadellinae: Cicadellini) Length: 6-8 mm.

**Contact points for further information**
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# 5 Acknowledgements

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Photo credits: Dr Murray Fletcher, Industry & Investment NSW, except for Figure 7: David Gray.


This diagnostic protocol was sourced from information prepared by Dr Murray Fletcher for the Plant Health Australia GWSS Contingency Plan.

This protocol was reviewed and verified by Dr Linda Semeraro, Department of Primary Industries, Victoria.

# 6 References


Anon. (2000) Report of the PD Research and Emergency Response Task Force. University of California Office of the President 35pp.

Fletcher, M.J. (2009 and updates). Identification Keys and checklists for the leafhoppers, planthoppers and their relatives occurring in Australia and neighbouring areas (Hemiptera: Auchenorrhyncha). *http://www1.dpi.nsw.gov.au/keys/leafhop/index.html* (Note: GWSS has been included in these keys in order to assist in differentiation of this species from native species which may resemble it)

Purcell, A,H, and Feil, H. (2001) Glassy-winged sharpshooter. *Pesticide Outlook* October 2001: 199-203.

Smith, P.T. (2005). Mitochondrial DNA variation among populations of the glassy-winged sharpshooter, *Homalodisca coagulata* Journal of Insect Science, **5**: 41.

Turner, W.F. and Pollard, H.N. (1959), Life Histories and Behaviour of Five Insect Vectors of Phony Peach Disease. *USDA Technical Bulletin* **1188**: 1-28. (Provides detailed life history details for GWSS and four other sharpshooter vectors of *Xylella*).

Young, D.A. (1958). A synopsis of the species of *Homalodisca* in the United States (Homoptera: Cicadellidae). *Bulletin of the Brooklyn Entomological Society* **53**(1): 7-13. (Taxonomic study of GWSS and its congeners, including key to species and detailed illustrations of the male genitalia).

Young, D.A. (1968). Taxonomic Study of the Cicadellinae (Homoptera: Cicadellidae) Part 1 Proconiini. *United States National Museum Bulletin* **261**: 1-287. (Part of a comprehensive study of the subfamily Cicadellinae worldwide, including keys to tribes and genera and taxonomic treatment of most species).


**Other useful references**


Takiya DM, McKamey SH, Cavichioli RR - (2006). Validity of Homalodisca and of H. vitripennis as the name for glassy-winged sharpshooter (Hemiptera: Cicadellidae: Cicadellinae). Annals of the Entomological Society of America, Vol. **99** (4): 648 - 655.


## 6.1 Further Reading

**Glassy-Winged Sharp Shooter *(Homalodisca vitripennis)* Pest and Diseases Image Library**

*http://www.padil.gov.au/pests-and-diseases/Pest/Main/136082*

**University of California Berkeley Xylella Website**

*http://nature.berkeley.edu/xylella*

(Provides images, links and a summary of the spread of GWSS into California. Also available is a powerpoint presentation prepared by Dr A. Purcell providing an assessment of the impact of GWSS on the transmission of Pierce's disease in California)

**California Department of Food and Agriculture Website**

*http://plant.cdfa.ca.gov/gwss/gwpics.htm*
(Provides comprehensive information on GWSS and illustrations of adults and egg masses)

*http://pi.cdfa.ca.gov/pqm/manual/454.htm*
(Californian Department of Food and Agriculture - Plant Health and Pest Prevention Services. Provides detailed host list and other details. No images)

**European and Mediterranean Plant Protection Organisation Website**

*http://www.eppo.org/QUARANTINE/insects/Homalodisca_coagulata/HOMLTR-a.htm*
(Provides summary of GWSS risk to Europe, including diagnostic details.)

# 7 Appendix

## 7.1 Host range

All taxa listed are regarded as oviposition hosts for GWSS, except for those marked with an asterisk*. The list includes ferns, gymnosperms, dicots and monocots (Californian Dept. Food and Agriculture - Plant Health and Pest Prevention Services website, pi.cdfa.ca.gov/pqm/manual/454.htm).

**Glassy winged Sharpshooter Host List by Common Name**

| Common Name | Scientific Name |
|---|---|
| Abelia | *Abelia* spp. |
| Acacia | *Acacia* spp. |
| Aeonium | *Aeonium* spp. |
| Agapanthus | *Agapanthus* spp. |
| Albizzia | *Albizia* spp. |
| Alder | *Alnus* spp. |
| Aleurites | *Aleurites* spp. * |
| Aloe plant | *Aloe* spp. |
| Amaranth | *Amaranthus* spp. |
| Ananas | *Ananas* spp. |
| Annona (cherimoya) | *Annona* spp. |
| Apple | *Malus* spp.* |
| Aptenia | *Aptenia* spp. |
| Aralia ivy | *Fatshedera* spp. |
| Arborvitae | *Thuja* spp.* |
| Arizona rosewood | *Vauquelinia* spp. |
| Ash | *Fraxinus* spp. |
| Asparagus | *Asparagus* spp. * |
| Aspidistra | *Aspidistra* spp. |
| Aucuba | *Aucuba* spp. |
| Avocado | *Persea* spp. |
| Azalea | *Rhododendron* spp. |
| Baccharis | *Baccharis* spp. * |
| Banana | *Musa* spp. |
| Barbados Gooseberry | *Pereskia* spp. |
| Barberry | *Berberis* spp. |
| Basket plant | *Aeschynanthus* spp. |
| Bauhinia | *Bauhinia* spp. |
| Beard-tongue | *Penstemon* spp. |
| Begonia | *Begonia* spp. |
| Bignonia | *Bignonia* spp. |
| Birch | *Betula* spp. |
| Bird-of-paradise | *Strelitzia* spp. |
| Blackberry | *Rubus* spp.* |
| Blood-trumpet | *Distictus* spp. |
| Boneset | *Eupatorium* spp.* |
| Bottle tree | *Brachychiton* spp. |
| Bottlebrush | *Callistemon* spp. |
| Bougainvillea | *Bougainvillea* spp. |
| Boxwood | *Buxus* spp. |
| Brunfelsia | *Brunfelsia* spp. |
| Buckthorn | *Rhamnus* spp. |
| Bugleweed | *Ajuga* spp. |
| Butterfly bush | *Buddleja* spp. |
| Cactus | *Opuntia* spp. |
| Calla lily | *Zantedeschia* spp. |
| Camellia | *Camellia* spp. |
| Canna | *Canna* spp. |
| Cape chestnut | *Calodendrum* spp. |

| Common Name | Scientific Name |
|---|---|
| Carob | *Ceratonia* spp. |
| Castanospermum | *Castanospermum* spp. |
| Catawba | *Catalpa* spp. |
| Ceratostigma | *Ceratostigma* spp. |
| Champak | *Michelia* spp. |
| Chaste tree | *Vitex* spp. |
| Chinaberry | *Melia* spp.* |
| Chinquapin | *Castanopsis* spp. |
| Chitalpa | *Chitalpa* spp. |
| Chokecherry | *Aronia* spp. |
| Christmas cactus | *Schlumbergera* spp. |
| Chrysanthemum | *Chrysanthemum* spp. |
| Cinnamomum | *Cinnamomum* spp. |
| Citrus | *Citrus* spp. |
| Clytostoma | *Clytostoma* spp. |
| Cocculus | *Cocculus* spp. |
| Cocklebur | *Xanthium* spp.* |
| Cocos | *Cocos* spp. |
| Coffee | *Coffea* spp. |
| Coleus | *Coleus* spp. |
| Coneflower | *Rudbeckia* spp.* |
| Coprosma | *Coprosma* spp. |
| Coral tree | *Erythrina* spp. |
| Coreopsis | *Coreopsis* spp. |
| Cotoneaster | *Cotoneaster* spp. |
| Cotton | *Gossypium* spp. * |
| Cottonwood | *Populus* spp. |
| Cranesbill | *Geranium* spp. |
| Crape myrtle | *Lagerstroemia* spp. |
| Crassula | *Crassula* spp. |
| Cupaniopsis | *Cupaniopsis* spp. |
| Cuphea | *Cuphea* spp. |
| Cycad | *Cycas* spp. |
| Date palm | *Phoenix* spp. |
| Daylily | *Hemerocallis* spp. |
| Deodar cedar | *Cedrus* spp. |
| Desert willow | *Chilopsis* spp. |
| Dianthus | *Dianthus* spp. |
| Dietes | *Dietes* spp. |
| Dodonaea | *Dodonaea* spp. |
| Dogwood | *Cornus* spp. |
| Dracaena | *Dracaena* spp. |
| Elaeagnus | *Elaeagnus* spp. * |
| Elaeocarpus | *Elaeocarpus* spp. |
| Elderberry | *Sambucus* spp. |
| Elm | *Ulmus* spp. |
| Ensete | *Ensete* spp. |
| Eriobotrya | *Eriobotrya* spp. |
| Escallonia | *Escallonia* spp. |
| Eucalyptus | *Eucalyptus* spp. |
| Eugenia | *Eugenia* spp. |
| Euonymus | *Euonymus* spp. |
| Euryops | *Euryops* spp. |
| Evening primrose | *Oenothera* spp.* |
| Evergreen clematis | *Clematis* spp. |
| Feijoa | *Feijoa* spp. |
| Fig | *Ficus* spp. |
| Fishtail | *Caryota* spp. |

| Common Name | Scientific Name |
|---|---|
| Flax lily | *Phormium* spp. |
| Fleabane | *Erigeron* spp. |
| Floss-silk tree | *Chorisia* spp. |
| Fringe tree | *Chionanthus* spp. |
| Frogfruit | *Phyla* spp. |
| Gardenia | *Gardenia* spp. |
| Gazania | *Gazania* spp. |
| Geijera | *Geijera* spp. |
| Giant turf lily | *Liriope* spp. |
| Ginko | *Ginkgo* spp. |
| Gladiolus | *Gladiolus* spp. * |
| Gold dust plant | *Aucuba* spp. |
| Golden dewdrop | *Duranta* spp. |
| Golden-bells | *Forsythia* spp. |
| Golden-rain tree | *Koelreuteria* spp. |
| Goldenrod | *Solidago* spp.* |
| Grape | *Vitis* spp. |
| Grape ivy | *Cissus* spp. |
| Green ebony | *Jacaranda* spp. |
| Grewia | *Grewia* spp. |
| Guava | *Psidium* spp. |
| Hardenbergia | *Hardenbergia* spp. |
| Hibiscus | *Hibiscus* spp.* |
| Holly | *Ilex* spp. |
| Hollyhock | *Althaea* spp. |
| Honey locust | *Gleditsia* spp. |
| Honey myrtle | *Melaleuca* spp. |
| Honeysuckle | *Lonicera* spp. |
| Hydrangea | *Hydrangea* spp. |
| Hymenosporum | *Hymenosporum* spp. |
| Indian Rosewood | *Dalbergia* spp. |
| Itea | *Itea* spp. |
| Ivy | *Hedera* spp. |
| Japanese aralia | *Aralia* spp. |
| Japanese fatsia | *Fatsia* spp. |
| Japanese Maple | *Acer* spp. |
| Jasmine | *Jasminum* spp. |
| Jimsonweed | *Datura* spp. |
| Jojoba | *Simmondsia* spp. |
| Jujube | *Ziziphus* spp. |
| Juniper | *Juniperus* spp. |
| Kaffir plum | *Harpephyllum* spp. |
| Kumquat | *Fortunella* spp. |
| Lambsquarter | *Chenopodium* spp. |
| Laurel | *Laurus* spp. |
| Leadwort | *Plumbago* spp. |
| Leptospermum | *Leptospermum* spp. |
| Lettuce | *Lactuca* spp.* |
| Leucodendron | *Leucodendron* spp. |
| Lilac | *Syringa* spp. |
| Lippia | *Lippia* spp. |
| Liriope | *Liriope* spp. |
| Locust | *Robinia* spp. |
| Loropetalum | *Loropetalum* spp. |
| Luma | *Luma* spp. |
| Lychee | *Litchi* spp. |
| Macadamia | *Macadamia* spp. |
| Magnolia | *Magnolia* spp. |

| Common Name | Scientific Name |
|---|---|
| Mallow | *Malva* spp.* |
| Mandevilla | *Mandevilla* spp. |
| Mango | *Mangifera* spp. |
| Manzanita | *Arctostaphylos* spp. |
| Maytenus | *Maytenus* spp. |
| Mesquite | *Prosopis* spp. |
| Metrosideros | *Metrosideros* spp. |
| Mexican bluebells | *Ruellia* spp. |
| Mexican Palo Verde | *Parkinsonia* spp. |
| Milkweed | *Asclepias* spp. |
| Milkwort | *Polygala* spp. |
| Mock orange | *Philadelphus* spp. |
| Monstera | *Monstera* spp. |
| Morning glory | *Ipomoea* spp. |
| Mountain ash | *Sorbus* spp. |
| Mountain mahogany | *Cercocarpus* spp. |
| Mulberry | *Morus* spp.* |
| Myoporum | *Myoporum* spp. |
| Myrsine | *Myrsine* spp. |
| Myrtle | *Myrtus* spp. |
| Nandina | *Nandina* spp. |
| Natal Plum | *Carissa* spp. |
| Oak | *Quercus* spp. |
| Oleander | *Nerium* spp. |
| Olive | *Olea* spp. |
| Orange jessamine | *Murraya* spp. |
| Oregon grape | *Mahonia* spp. |
| Osmanthus | *Osmanthus* spp. |
| Osteospermum | *Osteospermum* spp.* |
| Palms | *Chamaedorea* spp. |
| Palo Verde | *Cercidium* spp. |
| Pandorea | *Pandorea* spp. |
| Papaya | *Carica* spp. |
| Passion fruit | *Passiflora* spp.* |
| Pear | *Pyrus* spp. |
| Pelargonium | *Pelargonium* spp. |
| Pepper, chile | *Capsicum* spp. |
| Periwinkle | *Vinca* spp. |
| Persimmon | *Diospyros* spp. |
| Peruvian lily | *Alstroemeria* spp. |
| Philodendron | *Philodendron* spp. |
| Phlox | *Phlox* spp. |
| Photinia | *Photinia* spp. |
| Pincushion | *Leucospermum* spp. |
| Pine | *Pinus* spp. |
| Pistachio | *Pistacia* spp. |
| Pittosporum | *Pittosporum* spp. |
| Plectranthus | *Plectranthus* spp. |
| Podocarpus | *Podocarpus* spp. |
| Pokeweed | *Phytolacca* spp.* |
| Polygonum | *Polygonum* spp. |
| Pomegranate | *Punica* spp. |
| Portulacaria | *Portulacaria* spp. |
| Powderpuff | *Calliandra* spp. |
| Privet | *Ligustrum* spp. |
| Protea | *Protea* spp. |
| Prunus | *Prunus* spp. |
| Pyracantha/Firethorn | *Pyracantha* spp. |

| Common Name | Scientific Name |
|---|---|
| Queen Palm | *Arecastrum (Syagrus)*spp. |
| Ragweed | *Ambrosia* spp.* |
| Raphiolepis | *Raphiolepis* spp. |
| Redbud | *Cercis* spp. |
| Redroot | *Ceanothus* spp. |
| Rock rose | *Cistus* spp. |
| Rose | *Rosa* spp. |
| Sage | *Salvia* spp. |
| Sapium | *Sapium* spp. |
| Sassafras | *Sassafras* spp.* |
| Sawleaf Zelkova | *Zelkova* spp. |
| Scalebroom | *Lepidospartum* spp. |
| Schinus | *Schinus* spp. |
| Seaforthia | *Archontophoenix* spp. |
| Senna | *Cassia* spp. |
| Sentry palm | *Howea* spp. |
| Serviceberry | *Amelanchier* spp. |
| Shrub verbena | *Lantana* spp. |
| Snapdragon | *Antirrhinum* spp. |
| Solanum | *Solanum* spp. |
| Sonchus | *Sonchus* spp.* |
| Sorghum | *Sorghum* spp. |
| Speedwell | *Veronica* spp. |
| Spider flower | *Grevillea* spp. |
| Spiderwort | *Tradescantia* spp. |
| Spurge | *Pachysandra* spp. |
| St. Bernard's lily | *Chlorophytum* spp. |
| St. John's-wort | *Hypericum* spp. |
| Staghorn fern | *Platycerium* spp. |
| Statice | *Limonium* spp. |
| Strawberry tree | *Arbutus* spp. |
| Sumac | *Rhus* spp. |
| Sun king sophora | *Sophora* spp. |
| Sunflower | *Helianthus* spp. |
| Sweet box | *Sarcococca* spp. |
| Sweet gum | *Liquidambar* spp. |
| Sword fern | *Nephrolepis* spp. |
| Sycamore | *Platanus* spp. |
| Syzygium | *Syzygium* spp. |
| Tecomaria | *Tecomaria* spp.* |
| Ternstroemia | *Ternstroemia* spp. |
| Texas Ranger | *Leucophyllum* spp. |
| Thornless hawthorn | *Crataegus* spp. |
| Ti | *Cordyline* spp. |
| Tipu Tree | *Tipuana* spp. |
| Toyon | *Heteromeles* spp. |
| Trachelospermum | *Trachelospermum* spp. |
| Transvaal daisy | *Gerbera* spp. |
| Tree tobacco | *Nicotiana* spp. |
| Tristania | *Tristania* spp. |
| Trumpet creeper | *Campsis* spp. |
| Trumpet tree | *Tabebuia* spp. |
| Tulbaghia | *Tulbaghia* spp. |
| Tulip tree | *Liriodendron* spp. |
| Tupelo | *Nyssa* spp.* |
| Tupidanthus | *Tupidanthus* spp. |
| Umbrella tree | *Schefflera* spp. |
| Umbrella wort | *Mirabilis* spp. |

| Common Name | Scientific Name |
|---|---|
| Viburnum | *Viburnum* spp. |
| Vigna | *Vigna* spp. |
| Violet | *Viola* spp. |
| Walnut | *Juglans* spp.* |
| Washington palm | *Washingtonia* spp. |
| Wild bergamot | *Monarda* spp.* |
| Willow | *Salix* spp. |
| Willow myrtle | *Agonis* spp. |
| Wisteria | *Wisteria* spp. |
| Woodbine | *Parthenocissus* spp. |
| Xylosma | *Xylosma* spp. |
| Yellow jessamine | *Gelsemium* spp. |
| Yellowbells | *Tecoma* spp. |
| Yucca | *Yucca* spp.* |
| Zea | *Zea* spp.* |
| Zinnia | *Zinnia* spp. |

## 7.2 Life cycle / biology

Turner and Pollard (1959) have provided details of the life history of GWSS. The species overwinters as adults which begin to mate and lay eggs as soon as the weather begins warming in early Spring. Eggs are laid in oblong masses in the undersurfaces of leaves (Figure 1b, good images are provided by the University of California, Agriculture and Natural Resources Website, http://gwss.ucanr.org/) and dusted with a layer of whitish powder which is presumed to be brochosomes. These are minute structures produced in the malpighian tubules of leafhoppers and used to release pheromones. Information on brochosomes can be found at http://www.inhs.uiuc.edu/~rakitov/brochosomes.html. Most of the many plants on which GWSS is known to feed are also suitable oviposition hosts (those in which GWSS has not been found to oviposit are marked in the list above with an asterisk).

Eggs hatch into first instar nymphs which are approximately 2 mm long and 1 mm wide across the head. There are a total of five nymphal instars with the final (5th) instar reaching a length of about 8 mm and a width across the eyes of 3 mm. The shape and colouration of the nymphs are generally similar to those of the adult, including the bulging eyes and prominent frons. Younger nymphs feed on the larger veins of leaves, usually on the undersurface. Adults and later instar nymphs feed on stems, branches and on woody petioles and usually orientate themselves with the head downwards.

First generation adults appear from mid-summer and commence a second generation which reaches the adult stage in late summer, or early autumn (September in the Northern Hemisphere). Although capable of flight over considerable distances, particularly if wind-assisted, adult GWSS normally fly only between neighbouring suitable host plants. During a single season, a single adult may feed on a wide range of alternative hosts.

Bacterial numbers in grapevine build up during early summer and only reach levels that can infect leafhoppers by mid-summer (June-July in Northern Hemisphere) and have reached very high levels by late summer. Therefore incursions of GWSS prior to this period each year are less likely to include *X. fastidiosa* (Purcell & Feil 2001).