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European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes PM 7/144 (1)

Diagnostics

PM 7/144 (1) *Lycorma delicatula*

Specific scope

This Standard describes a diagnostic protocol for *Lycorma delicatula*.[1]

This Standard should be used in conjunction with PM 7/76 *Use of EPPO diagnostic protocols*.

Specific approval and amendment

Approved in 2020-08.

1. Introduction

Lycorma delicatula (White, 1845) (spotted lanternfly) is a planthopper indigenous to China, Taiwan and Vietnam where it is not a major pest, but damage has been reported in forests on *Ailanthus altissima* (tree of heaven) and on various fruit trees such as *Actinidia* (kiwi, etc.), *Malus* (apple, etc.), *Prunus* (plum, etc.). It has been introduced into the Republic of Korea, Japan and the United States of America where it is considered to be showing invasive behaviour and causing economic damage. *Lycorma delicatula* is a polyphagous pest that causes direct damage to plants by feeding on the phloem, with large numbers of individuals that may feed on the same plant. Direct damage is caused by sucking plant sap, and indirect damage by producing honeydew on which fungi and sooty moulds may grow, causing reduced photosynthesis. Direct damage may result in wilting and the death of twigs, e.g. on *A. altissima* (Han *et al*., 2008), but also in the death of branches and plants (Chou, 1946). Mortality is also reported as a result of secondary fungal infection (Chou, 1946, *Teichospora oxystomoides* mentioned). Serious damage is recorded in vineyards (Park *et al*., 2013).

Given the distribution of the pest in very different climatic zones, the existence of subspecies or cryptic species of *L. delicatula* cannot be excluded. In particular, two subspecies were described in the past: *Lycorma delicatula jole* Stål, 1863 and *Lycorma delicatula operosa* (Walker, 1858). Their validity needs to be confirmed (T. Bourgoin, pers. comm.).

[1]Use of brand names of chemicals or equipment in these EPPO Standards implies no approval of them to the exclusion of others that may also be suitable.

2. Identity

Preferred name: *Lycorma delicatula* (White, 1845).
Other names: *Aphaena delicatula* White, 1845, *Lycorma delicatulum* (White, 1845).
Taxonomic position: Hemiptera, Auchenorrhyncha, Fulgoridae, *Lycorma*.
EPPO Code: LYCMDE.
Phytosanitary categorization: EPPO A1 list.

3. Detection

3.1. Eggs

In the area of its distribution where it has been studied (i.e. China, the Republic of Korea, Japan and the United States), *L. delicatula* has one generation per year and overwinters as eggs.

Egg masses (30–50 eggs) are covered in a yellowish-brown waxy deposit (ootheca) resembling mud (Figs 1 and 2). Eggs are laid on woody plants or other material. Substrates for egg-laying are referred to by several publications as 'smooth' (e.g. Barringer, 2014; Kim *et al*., 2011). However, *L. delicatula* appears to preferentially lay eggs on surfaces with as little topography as they can find, although they will settle for any surface with a small patch (approximately 2.5 cm or larger) that is relatively smooth (L. Donovall, pers. comm.), such as the inner surface of bark on trees with deep fissures in the bark. Eggs may be found on small to large woody plants (Kim *et al*., 2011; Cai & Wu,

Fig. 1 Fresh egg masses of *L. delicatula*. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

Fig. 2 Egg masses of *L. delicatula*. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

2013; Tomisawa *et al*., 2013). Herbaceous plants would not provide the size and stability needed for egg-laying. However, eggs may also be found on surfaces such as bricks, stones, cables or dead plants (Umemura *et al*., 2013; Cai & Wu, 2013; Pennsylvania Department of Agriculture, 2014; Zhai *et al*., 2014). Colour is probably a factor in the choice of egg-laying substrates (red, brown and grey seem to be preferred, Fig. 3) (EPPO, 2016).

As *A. altissima* is a preferred host for egg-laying adults, it can be used to monitor this species. The remnants of egg masses after hatching (Fig. 3) may be observed on trees for 1 year or more (Dara *et al*., 2015).

Fig. 3 Empty egg masses of *L. delicatula*. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

3.2. Nymphs

Nymphs emerge in spring. In Jincheon (Republic of Korea), nymphs were observed from late May to August (Lee *et al*., 2011). In Pennsylvania (United States), the emergence of nymphs is delayed by 2 weeks compared to Jincheon, according to Park *et al*. (2009).

There are four larval instars (nymphs). The first three instar nymphs are black with white spots (Fig. 4). The fourth instar develops red patches in addition to the white spots (Fig. 5). Figure 6 gives an overview of all stages of *L. delicatula*.

Sticky bands placed around the base of the trunks of susceptible trees may be used to capture nymphs as they climb from the ground onto stems (Kim *et al*., 2011). Brown sticky bands have been shown to be more effective than blue and yellow sticky bands (Choi *et al*., 2012; EPPO, 2016) (Fig. 7). Circle trunk traps have been shown to be effective at capturing nymphs of *L. delicatula* and are easy to use and reusable (Francese *et al*., 2020). The tree

Fig. 4 Immature stages of *L. delicatula* are black with white spots. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

Fig. 5 The fourth-instar nymph of *L. delicatula* is black with white spots but develops red patches. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

Fig. 6 All development stages of *L. delicatula*, from first- to fourth-instar nymphs to adult. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US).

kairomone methyl salicylate has been shown to be highly attractive in both laboratory and field trials (Cooperband *et al*., 2019).

3.3. Adults

Adults emerge in late summer and can be seen on the trunk (Fig. 8). In Jincheon (Republic of Korea), adults were observed from late July to November (Lee *et al*., 2011). Adults die off when the weather gets cold towards the end of the year after one or two episodes of hard frost (temperatures below 0°C) (Han *et al*., 2008; Tomisawa *et al*., 2013).

Adult males are 20.5–22.0 mm long (from head to end of folded wings) and females are 24.0–26.5 mm long (Fig. 9). Forewings are pink-greyish with black spots and their tips are darker and reticulated (Fig. 11). The basal part of the hind wing is red with black spots, followed by a blue-greyish band and an apical black part. The abdomen is laterally yellowish, with transverse black bands, although

Fig. 7 Trapping of *L. delicatula* nymphs on the trunk with brown sticky bands. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

the yellow lateral bands can be reduced significantly in older specimens and vanish after storage in ethanol. (Fig. 10).

Sticky bands are not used to capture fourth-instar nymphs and adults, as these are strong enough to leave the adhesive

Fig. 8 Adults of *L. delicatula*. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

Fig. 9 Adult of *L. delicatula*. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

(OEPP/EPPO, 2016; Francese *et al*., 2020). Circle trunk traps are more effective than sticky traps in catching third- and fourth-instar nymphs and adults of *L. delicatula* (Francese *et al*., 2020).

4. Identification

Identification is commonly based on the examination of adult specimens, however molecular identification on all life stages can be carried out using conventional PCR followed by Sanger sequencing analysis.

4.1. Morphological identification

The genus *Lycorma* Stål, 1863 does not occur in Europe. In addition to *L. delicatula*, there are three other known species in this genus: *Lycorma imperialis* (White, 1846) (Fig. 11), *Lycorma meliae* Kato, 1929 (Fig. 12 and 13) and *Lycorma olivacea* Kato, 1929 (Fig. 14), which look clearly different in pattern and colours. In the European context, examination of the habitus is sufficient for the identification of these species.

Detailed morphological descriptions are given in Lieu (1934).

The **two sexes** of *L. delicatula* are very similar to each other and differ only in size. The wingspan of the female (50 mm) is wider than that of the male (43 mm). The abdomen of the female (10 mm) is wider than that of the male (7 mm).

Fig. 10 Adults of *L. delicatula* with typical pattern on the wings and abdomen. Upper figure, courtesy of L. Barringer, Pennsylvania Department of Agiculture (US), Bugwood.org; lower figure, courtesy of C. Malumphy, Fera Science Ltd (GB).

Fig. 11 *L. imperialis*. Courtesy of T. Popp, Staatliche Naturwissenschaftliche Sammlungen Bayerns – Zoologische Staatssammlung München, (DE).

Fig. 12 *L. meliae*. Courtesy 李怡儂 Li, Yi-Nong.

Fig. 13 Fourth instar of *L. meliae* with typical orange pattern. Courtesy of 汪威任 Wang, Wei-Ren.

Fig. 14 *L. olivacea*. Courtesy of 黃仕傑 Huang, Shi-Jie.

The **head** is brownish in colour, 3 mm wide and 7 mm long. The antennae consist of three segments: scape, pedicel and flagellum. Sensory plate organs are present in great numbers on the pedicel (Wang *et al*., 2018).

The **labium** is five segmented in adults, heavily chitinized and dark brown. It shelters the paired mandibles and maxillae used by the insect for piercing and sap-sucking host plants.

The **thorax** is brownish. The legs are brown, slender. The tarsus is three-segmented and hind tibia bears 4–6 lateral very visible spines (note that although Lieu (1934) refers to 3–5 lateral spines, recent observations point to 4–6 lateral spines instead, T. Bourgoin, pers. comm., 2020). At the distal end of the hind tibia there are 7 tibial spurs on the posterior surface. The tarsus of the hind leg differs from the fore and mid legs. The first segment is subequal in length to its third segment. The second segment is shorter than the other two. The first and second segments have each a row of short teeth on the distal margin on the caudal surface. The pairs of claws and empodium are similar to the other legs.

The **fore wings** are long and narrow. The basal part is pink-greyish with conspicuous longitudinal veins and black spots (Fig. 10). The distal third of the fore wings is darker and reticulated with black cells. When at rest the fore wings meet in a straight line along the middle and are held roof-like over the body (Fig. 15).

The **hind wings** are slightly shorter (Fig. 10). Its basal half and anal area are red with black spots. The distal portion is black with some parallel veins and cross-veins. A central transverse white band separates both regions. When at rest, the anal areas of the hind wings are folded twice beneath the fore wings.

The **abdomen** is dark brown, with chitinized sclerites, membranes between sclerites are yellowish (Fig. 10).

Fig. 15 Adults of *L. delicatula* with typical pattern on the wing. Courtesy of L. Barringer, Pennsylvania Department of Agriculture (US), Bugwood.org.

4.2. Molecular methods

A protocol for DNA barcoding based on the COI gene is described in PM 7/129 *DNA barcoding as an identification tool for a number of regulated pests* (EPPO, 2016).

5. Reference material

Reference material of *L. delicatula* is hosted by the European Reference Laboratory for Insects and Mites 755 Avenue du Campus Agropolis, CS 30016, FR-34988 Montferrier-sur-Lez Cedex.

6. Reporting and Documentation

Guidelines on reporting and documentation are given in EPPO Standard PM 7/77 *Documentation and reporting on a diagnosis*.

7. Performance characteristics

When performance characteristics are available, these are provided with the description of the test. Validation data are also available in the EPPO Database on Diagnostic Expertise (http://dc.eppo.int), and it is recommended that this database is consulted as additional information may be available there (e.g. more detailed information on analytical specificity, full validation reports, etc.).

8. Further information

Further information on this organism can be obtained from:

P. Baufeld, Julius Kuehn Institute – Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health Messeweg 11/12, D-38104 Braunschweig, Germany.

T. Bourgoin, National Museum of Natural History, CP 50, 57 rue Cuvier, 75005 Paris, France.

9. Feedback on this Diagnostic Protocol

If you have any feedback concerning this Diagnostic Protocol, or any of the tests included, or if you can provide additional validation data for tests included in this protocol that you wish to share please contact diagnostics@eppo.int.

10. Protocol revision

An annual review process is in place to identify the need for revision of diagnostic protocols. Protocols identified as needing revision are marked as such on the EPPO website.

When errata and corrigenda are in press, this will also be marked on the website.

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This protocol was originally drafted by P. Baufeld, Julius Kuehn Institute – Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health Messeweg 11/12, D-38104 Braunschweig, Germany in collaboration with the EPPO Secretariat. Morphological descriptions were reviewed by T. Bourgoin, National Museum of Natural History, CP 50, 57 rue Cuvier, 75005 Paris, France.

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