

## **BS20154: Field assessment of seasonal occurrence of *Lycorma delicatula* (White 1845) (Hemiptera: Fulgoridae), the spotted lanternfly, and its potential impacts on kiwifruit**

### **Cover Note**

#### **Background**

The spotted lanternfly (SLF), *Lycorma delicatula* (Hemiptera: Fulgoridae), is not yet present in New Zealand. The species is native to China, India and Vietnam, but has spread rapidly outside its native range into South Korea, Japan and more recently the USA. The primary host of the SLF is tree of heaven (*Ailanthus altissima*) but it is polyphagous. SLF is a phloem feeder and is known to feed on over 70 species of woody plants and vines from 25 families. A high abundance of SLF feeding causes large amounts of honeydew to shower down, coating plants and promoting the growth of sooty mould, which blocks photosynthesis and causes plants to wilt and die. The pest has been reported to be a significant pest for grapes and apples in USA and South Korea. In South Korea and China, it has also been reported to be a pest of Kiwifruit. Zespri's recent work on Chinese literature translation also suggests SLF is a 'major pest' of kiwifruit, although the level of impact is unknown.

#### **Aim**

To provide a better understating of the seasonal phenology (i.e. life cycle events) and potential impact spotted lantern fly could pose to kiwifruit orchards

#### **Method**

This study was conducted in an organic kiwifruit orchard located at an experimental field station at Northwest Agricultural and Forestry University in Mei County, Shaanxi Province, China. Two kiwifruit orchards - one 'Hayward' (green-fleshed) block (2 ha) and one 'Nongda Jinmi' (yellow-fleshed) block (0.5 ha), were monitored. In total, 20 kiwifruit vines were selected for visual inspections of SLF (i.e. egg masses, nymphs and adults) in each orchard using a 'W' shaped path method. Inspections were conducted weekly from mid-March to October. Alternative host plants in the surrounding areas were also monitored for the presence of SLF, and all different developmental stages observed (i.e. eggs, nymphs, and adults) were counted and recorded. This provided additional information on alternative host plants acting as SLF reservoirs.

#### **Main findings**

- SLF was present in both 'Nongda Jinmi' yellow-fleshed and Hayward kiwifruit orchards throughout the growing season, with first-instar nymphs starting to be found in mid-April and adults from late June, and eggs starting to be laid in early October. Late-instar nymphs and adults were found in the kiwifruit orchards until late September and late October, respectively.
- All life stages of SLF were more abundant in the 'Nongda Jinmi' yellow-fleshed block than the 'Hayward' block.
- In both blocks, nymphs were mainly observed on shoots and branches, whereas adults were observed most frequently on the trunk of host plants.

- After the first observations of SLF adults on 28 June, they were not observed in either experimental block until 20 September (autumn). Adults were observed in alternative host plants during this time. since SLF was observed during this time window in alternative host plants in the vicinity, as well as a 'Xuxiang' kiwifruit block, suggests that SLF is likely to complete its lifecycle in kiwifruit.
- No sooty mould nor visible feeding damage (in leaves, branches, fruits) that could be attributed to SLF was observed in the 'Hayward' and 'Nongda Jinmi' yellow-fleshed blocks during the visual inspections.

**Limitations of study:**

The study conducted in pest's native range in China and only on two orchards so may not fully represent impact of SLF on kiwifruit if an incursion was to occur in New Zealand.

**Future perspectives:**

Further research in laboratory and field setups should be conducted to assess the potential damage that SLF could pose to kiwifruit and on behavioural aspects of the pest (e.g. dispersal ability, landscape utilisation) that might contribute to developing effective pest management practices.



PFR SPTS No. 23738

## **BS20154 Field assessment of seasonal occurrence of *Lycorma delicatula* White(Hemiptera: Fulgoridae), the spotted lanternfly, and its potential impacts on kiwifruit**

Avila G, Zhang J, Mi Q-Q, Zhang F

April 2023

## Confidential report for:

Zespri Group Limited

### Zespri information:

Milestone No. **BS20154-D**

Contract No. **BS20154**

Project Name: **Field assessment of seasonal occurrence of *Lycorma delicatula***

### DISCLAIMER

The New Zealand Institute for Plant and Food Research Limited does not give any prediction, warranty or assurance in relation to the accuracy of or fitness for any particular use or application of, any information or scientific or other result contained in this report. Neither The New Zealand Institute for Plant and Food Research Limited nor any of its employees, students, contractors, subcontractors or agents shall be liable for any cost (including legal costs), claim, liability, loss, damage, injury or the like, which may be suffered or incurred as a direct or indirect result of the reliance by any person on any information contained in this report.

### LIMITED PROTECTION

This report may be reproduced in full, but not in part, without the prior written permission of The New Zealand Institute for Plant and Food Research Limited. To request permission to reproduce the report in part, write to: The Science Publication Office, The New Zealand Institute for Plant and Food Research Limited – Postal Address: Private Bag 92169, Victoria Street West, Auckland 1142, New Zealand; Email: SPO-Team@plantandfood.co.nz.

### CONFIDENTIALITY

This report contains valuable information in relation to the Field assessment of seasonal occurrence of *Lycorma delicatula* programme that is confidential to the business of The New Zealand Institute for Plant and Food Research Limited and Zespri Group Limited. This report is provided solely for the purpose of advising on the progress of the Field assessment of seasonal occurrence of *Lycorma delicatula* programme, and the information it contains should be treated as “Confidential Information” in accordance with The New Zealand Institute for Plant and Food Research Limited's Agreement with Zespri Group Limited.

### PUBLICATION DATA

Avila G. April 2023. BS20154 Field assessment of seasonal occurrence of *Lycorma delicatula* White (Hemiptera: Fulgoridae), the spotted lanternfly, and its potential impacts on kiwifruit. A Plant & Food Research report prepared for: Zespri Group Limited. Milestone No. 87694. Contract No. 38084 var2. Job code: P/337010/01. PFR SPTS No. 23738.

**KEYWORDS:** Phenology, sooty mould, feeding damage, pest, invasive species.

### Report prepared by:

Gonzalo Avila  
Science Team Leader, Biological Control & Insect Rearing  
April 2023

### Report approved by:

Dave Bellamy  
Science Group Leader, Adaptive Entomology  
April 2023

# Contents

---

<b>Executive summary .....</b>	<b>1</b>
<b>1     Introduction .....</b>	<b>3</b>
<b>2     Methods and materials.....</b>	<b>5</b>
2.1   Experimental sites .....	5
2.2   Visual inspections of SLF in experimental sites .....	5
<b>3     Results.....</b>	<b>7</b>
3.1   Seasonal occurrence of SLF in experimental kiwifruit blocks.....	7
3.1.1   Occurrence of SLF eggs .....	7
3.1.2   Occurrence of SLF nymphs .....	8
3.1.3   Occurrence of SLF adults .....	9
3.1.4   Sooty mould occurrence .....	10
3.2   Observed seasonal phenology of SLF in experimental kiwifruit blocks .....	10
<b>4     Conclusion .....</b>	<b>13</b>
<b>5     References .....</b>	<b>15</b>

## Executive summary

### BS20154 Field assessment of seasonal occurrence of *Lycorma delicatula* White(Hemiptera: Fulgoridae), the spotted lanternfly, and its potential impacts on kiwifruit

Avila G, Zhang J, Mi Q-Q, Zhang F  
Plant & Food Research Auckland

April 2023

The spotted lanternfly (SLF), *Lycorma delicatula* (Hemiptera: Fulgoridae), is a polyphagous invasive species native to China, India and Vietnam, known to feed on over 70 species of woody plants and vines in 25 families. Adventive populations of this pest are known to occur in South Korea, Japan, and most recently in the USA, where it is causing great concern to fruit growers and winegrowers.

SLF is not yet present in New Zealand; however, its polyphagous nature categorises it as a high-risk pest that could potentially jeopardise the country's multi-billion-dollar export markets for fresh produce. In its invaded ranges in South Korea and the USA, significant problems have been reported in grapes and apples as a result of large infestations of SLF. Information about the impacts of SLF on kiwifruit is very scarce in both its native and adventive ranges. Kiwifruit exports are the most valuable horticultural export in New Zealand, which would be potentially at risk if SLF arrives in the country.

This project aimed to determine the seasonal phenology of SLF and its potential impacts on kiwifruit orchards in China by conducting visual inspections in one *Actinidia chinensis* var. *deliciosa* 'Hayward' (green-fleshed) block, and one *A. chinensis* var. *chinensis* 'Nongda Jinmi' (yellow-fleshed) block, both located in Mei County, Shaanxi Province, China. Results from monitoring activities showed that SLF was present in both experimental kiwifruit station throughout the growing season, with first-instar nymphs starting to be found in mid-April and adults from late June, and eggs starting to be laid in early October. Late-instar nymphs and adults were found in the kiwifruit orchards until late September and late October, respectively. All developmental stages of SLF were more abundant in the 'Nongda Jinmi' block than the 'Hayward' block. In both blocks, nymphs were mainly observed on shoots and branches, whereas adults were observed most frequently on the trunk of host plants. During the monitoring activities, none of the kiwifruit vines inspected in both 'Hayward' and 'Nongda Jinmi' blocks showed the presence of sooty mould.

The monitoring activities conducted in the two experimental kiwifruit orchards provided the necessary baseline information to determine the seasonal phenology of SLF in kiwifruit orchards in the study site in China. The monitoring also provided essential information on the potential development of sooty mould on kiwifruit vines because of SLF feeding. However, further research in laboratory and field setups should be conducted to assess the potential damage that SLF could pose to kiwifruit and on behavioural aspects of the pest (e.g. dispersal ability, landscape utilisation) that might contribute to developing effective pest management practices.

### For further information please contact:

Gonzalo Avila  
Plant & Food Research Auckland  
Private Bag 92169  
Auckland Mail Centre  
Auckland 1142  
NEW ZEALAND

Tel: +64 9 925 7000  
DDI: +64 9 925 7198

Email: [Gonzalo.Avila@plantandfood.co.nz](mailto:Gonzalo.Avila@plantandfood.co.nz)



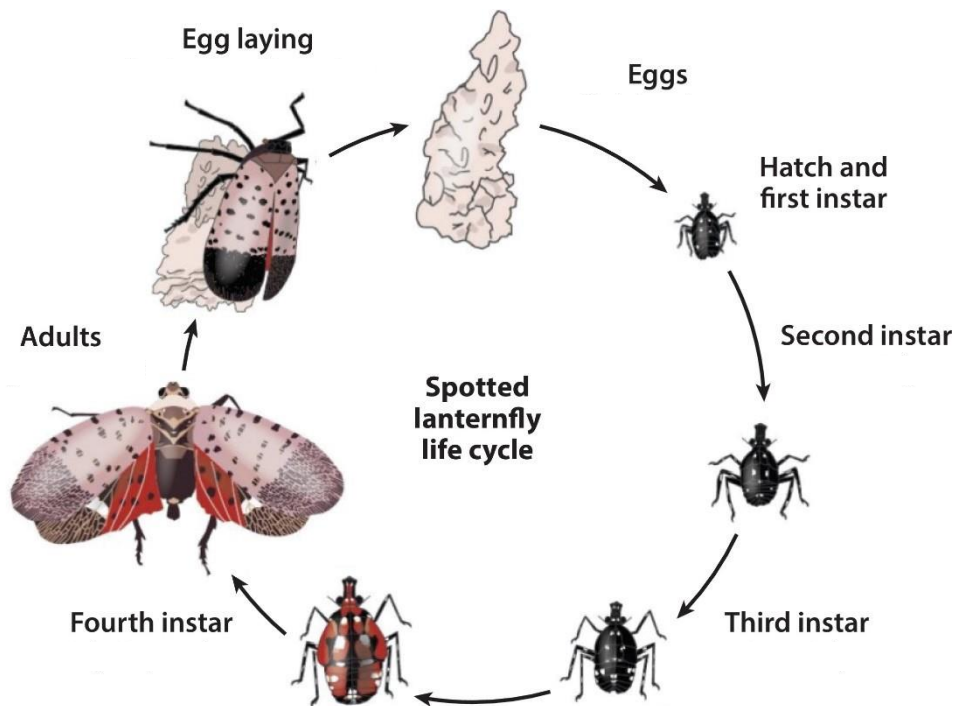
# 1 Introduction

The spotted lanternfly (SLF), *Lycorma delicatula* White (Hemiptera: Fulgoridae), is a polyphagous phloem feeder, native to China (mainland and Taiwan), Vietnam and India, which has been unintentionally introduced to South Korea, Japan, and most recently the United States of America (USA) (Kim & Kim 2005; Choi et al. 2014; Barringer et al. 2015; Cooperband et al. 2018; Lee et al. 2019). In 2004, SLF was first detected as an invasive species in South Korea, rapidly spreading throughout that country only three years after its arrival (Kim et al. 2013; Dara et al. 2015). Similarly, mass occurrences of SLF were reported invading Hakusan, Japan (Kim et al. 2013), in 2008. More recently, in 2014, this pest was found for the first time in Pennsylvania, USA (Barringer et al. 2015; Dara et al. 2015). SLF is rapidly spreading across the USA and is now in multiple counties in Pennsylvania, Virginia, New Jersey, New York, and Delaware (NJDA 2021; DDA 2023; NJDEC 2023; PDA 2023; VCE 2023). The primary host plant of SLF is the tree of heaven, *Ailanthus altissima* Swingle (Sapindales: Simaroubaceae), but it is known to attack over 70 species of woody plants and vines in 25 families (Dara et al. 2015; Urban & Leach 2023), such as apple, birch, grape, kiwifruit, cherry, lilac, maple, poplar, and stone fruits. When SLF is in high abundance, feeding causes large amounts of honeydew to shower down, coating plants and promoting the growth of sooty mould, which blocks photosynthesis and causes plants to wilt and die (Han et al. 2008; Park et al. 2009; Barringer et al. 2015).

In Pennsylvania, USA, this invasive pest has already started spreading and feeding in grape, apple, nectarine and peach crops, and having as yet unknown long-term effects on the production of these crops. SLF directly threatens the state's annual \$US 324 million worth of fruits, nursery and landscape, and hardwood industries. Huge impacts are expected on the livelihoods of local producers and businesses and the residents' quality of life in the infested areas (PDA 2023). The SLF invasion in the USA is spreading very fast. It can be compared to another invasive pest, the brown marmorated stink bug (*Halyomorpha halys*), which caused \$US 37 million in damage to the mid-Atlantic fruit industry in 2010 (Leskey et al. 2012). In South Korea, SLF has been reported to be an urban nuisance and a very serious pest of grapes (Park et al. 2009; Kim et al. 2011; Kim et al. 2013) and has caused substantial economic losses by causing significant wilting, dieback and mortality to grape vines (Kim et al. 2013). Also, in South Korea, SLF has been reported to be a pest in kiwifruit, where the degree of damage caused to this host plant is considered severe (Park et al. 2009). Similarly, in China, SLF has been reported as a pest causing damage to kiwifruit (Hong & Li 1994; Guo & Shi 2003; Wu 2012; Pei & Wang 2021). Unfortunately, little is still known about SLF's biology and phenology, which is essential to develop an effective integrated pest management strategy to control this pest.

The eggs of SLF are laid as masses (30–50 eggs in each) and are covered by a yellow/brown waxy layer that forms an oothecum that can look similar to a smear of mud (Dara et al. 2015). SLF has four instar stages, where the fourth instar is distinctly different from the first three; it is a bright red colour with red wing pads, black legs, and white/yellow spots on its abdomen (Dara et al. 2015) (Figure 1). The adults are the longest-lived life stage (i.e. 4–5 months total). Females are slightly larger than males and can be visually distinguished by the red colour of the poster-caudal end of the abdomen versus the all-black region of the male (Dara et al. 2015).





Urban JM, Leach H. 2023  
*Annu. Rev. Entomol.* 68:151–67

Figure 1. Spotted lanternfly life cycle (Urban & Leach 2023).

SLF is not yet present in New Zealand, but is currently considered an economic threat and a quarantine-regulated organism (MPI 2023) since it could potentially jeopardise the country's multi-billion-dollar export markets for fresh produce (e.g. kiwifruit, grapes, pipfruit). Major problems caused by SLF have been reported in grapes and apples in countries such as the USA and South Korea. However, little is known about the real impact SLF could have on kiwifruit other than a few reports from China and South Korea. Kiwifruit exports in New Zealand, valued at \$NZ2.7 billion, are the country's most valuable horticultural export (PFR 2021). Therefore, proactive action is needed to prepare for a potential SLF invasion to prevent this pest from limiting New Zealand's economic future as an exporter of fruits, especially kiwifruit, and vegetables.

This project aimed to determine the seasonal phenology of SLF and its potential impacts on kiwifruit orchards.

## 2 Methods and materials

### 2.1 Experimental sites

This study was conducted in an organic kiwifruit orchard located at an experimental field station at Northwest Agricultural and Forestry University (N34° 07' 27"; E107° 59' 31") in Mei County, Shaanxi Province, China. There is a 15-ha kiwifruit growing area at the experimental station, with several cultivars distributed in separate blocks, with a known presence of SLF. We monitored two kiwifruit orchards: one 'Hayward' (green-fleshed) block (2 ha) and one 'Nongda Jinmi' (yellow-fleshed) block (0.5 ha).

### 2.2 Visual inspections of SLF in experimental sites

At each 'Hayward' and 'Nongda Jinmi' experimental block, 20 kiwifruit vines were selected for visual inspections of SLF (i.e. egg masses, nymphs and adults) using a W-shaped path method (Figure 2a). Visual inspections were conducted weekly from 15 March until 25 October 2022 (harvest time) (Figure 2b). Data collected were used to determine the lifecycle of SLF associated with kiwifruit. Kiwifruit vines where an SLF egg mass was found were marked with a pink flagging tape (Figure 3a), and all SLF egg masses observed were marked, recorded, and continuously monitored to fate. Immature developmental stages and observed adults were also counted and recorded. The vines with a confirmed presence of immature and/or adult SLF were marked with red flagging tape (Figure 3b) and were continuously monitored for the development of sooty mould, which could have resulted from SLF infestations.

Due to the nature of the collected data (i.e., observational data and highly variable), no statistical analysis could be conducted. Therefore, differences in the observed number of eggs, nymphs and adults between in 'Hayward' and 'Nongda Jinmi' block should not be taken as statistically significant.

Alternative host plants in the surrounding areas were also monitored for the presence of SLF, and all different developmental stages observed (i.e. eggs, nymphs, and adults) were counted and recorded. This provided additional information on alternative host plants potentially acting as SLF reservoirs.



Figure 2. ‘Hayward’ block showing the W-shaped path used for visual inspections to assess spotted lanternfly (SLF) presence (a) and two team members conducting weekly visual inspections for SLF presence (b).



Figure 3. Kiwifruit vine marked with (a) pink-colour flagging tape (a spotted lanternfly (SLF) egg mass found) and (b) red-colour flagging tape (SLF nymphs and/or adults found).

In addition, we collected meteorological data (i.e., temperature and relative humidity) from the experimental kiwifruit station for the total duration of the experimental season (i.e., March to October 2022), so it can be used as a reference of the climatic conditions of the study area (Table 1).

Table 1. Meteorological information (i.e., temperature and relative humidity) recorded in the experimental kiwifruit station during the SLF survey season in 2022.

Month	Average Min. Temp (°C)	Average Max Temp. (°C)	Average Temp (°C)	Average RH (%)
March	4.4	24.6	12.4	60.0
April	5.3	30.9	16.0	49.3
May	5.6	31.6	19.5	57.4
June	13.5	39.3	25.9	50.1
July	14.0	38.2	26.0	63.9
August	12.5	41.3	26.1	67.1
September	9.6	34.5	19.9	69.8
October	0.4	27.3	12.9	73.0



## 3 Results

### 3.1 Seasonal occurrence of SLF in experimental kiwifruit blocks

---

#### 3.1.1 Occurrence of SLF eggs

##### **‘Hayward’ block**

A total of 5 SLF egg masses were found in the ‘Hayward’ blocks during visual inspections conducted between March and April 2022 (Figure 4). Then SLF egg masses were not observed in the field until the end of the experimental season, where eight recently laid egg masses were observed in ‘Hayward’ experimental block between mid- and late October. These late-season egg masses were the result of oviposition from SLF adults from the 2022 experimental season.

##### **‘Nongda Jinmi’ block**

A total of SLF egg masses were found in the ‘Nongda Jinmi’ block between March and April 2022 (Figure 4). SLF egg masses were not observed again until the end of the experimental season. Like the ‘Hayward’ block, eight recently laid egg masses were observed in the ‘Nongda Jinmi’ block between mid- and late October. These late-season egg masses were the result of oviposition from SLF adults from the 2022 experimental season.



Figure 4. Spotted lanternfly egg masses found in kiwifruit vines during visual inspections conducted in both ‘Hayward’ and ‘Nongda Jinmi’ blocks.

## Alternative host plants

Two SLF egg masses were observed in a poplar tree located approximately 40m away from the experimental orchards.

### 3.1.2 Occurrence of SLF nymphs

#### ‘Hayward’ block

SLF nymphs were observed in the field from mid-April to late June 2022. A total of 1785 nymphs were found in the ‘Hayward’ (Figure 5). From the total nymphs observed in the ‘Hayward’ block, 159 corresponded to first instar, 161 to second instar, 278 to third instar, and 20 to fourth instar. Nymphal stages were observed more frequently on shoots, branches and leaves.

#### ‘Nongda Jinmi’ block

Similar to observations in the ‘Hayward’ block, SLF nymphs were observed in the ‘Nongda Jinmi’ block from mid-April to late June 2022. A total of 618 nymphs were found in the ‘Nongda Jinmi’ block (Figure 5). From the total nymphs observed, 549 corresponded to first instar, 555 to second instar, 578 to third instar, and 103 to fourth instar. Nymphal stages were observed more frequently on shoots, branches and leaves.

All nymphs observed during the visual inspections in each ‘Hayward’ and ‘Nongda Jinmi’ block are expected to come from egg masses observed in each experimental block. However, they are likely coming from SLF egg masses missed during visual inspections as these are very well camouflaged and, therefore, hard to find.



Figure 5. Spotted lanternfly nymphs found in kiwifruit vines during visual inspections conducted in both ‘Hayward’ and ‘Nongda Jinmi’ blocks.

## Alternative host plants

A total of 345 fourth instar nymphs were observed in tree of heaven saplings located in the main road, approximately 40m away from the experimental orchards

### 3.1.3 Occurrence of SLF adults

#### 'Hayward' block

Two hundred and forty and SLF adults were observed in the 'Hayward' block. The first SLF adults (i.e., three adults) were observed on 28 June. However, after this date, no adults were found during visual inspections until late September. Then adults continued to be found in the 'Hayward' block until the end of October (Figure 6). Adults were observed in all parts of the vines but more frequently on trunks.

#### 'Nongda Jinmi' block

Fifty eight SLF adults were observed in the 'Nongda Jinmi' block. The first eight SLF adults were observed on 28 June. Like observed in the 'Hayward' block, after 28 June, no adults were observed in the 'Nongda Jinmi' experimental block during visual inspections until late September. Then, adults continued to be observed in the experimental blocks until the end of October (Figure 6). Adults were observed in all parts of the vines but more frequently on trunks.



Figure 6. Spotted lanternfly adults found in kiwifruit vines during visual inspections conducted in both 'Hayward' and 'Nongda Jinmi' blocks.

## Alternative host plants

A total of 20 SLF adults were observed in poplar trees located in the vicinity (approx. 40 m away from the experimental orchard) and in a 'Xuxiang' (green-fleshed) kiwifruit block adjacent to the 'Nongda Jinmi' block.

### 3.1.4 Sooty mould occurrence

No sooty mould, honeydew nor visible feeding damage (in leaves, branches, fruits) that could be attributed to SLF was observed in the 'Hayward' and 'Nongda Jinmi' blocks during the visual inspections conducted between 9 March and 25 October. However, some development of sooty mould was observed in a couple of leaves and fruits in a single 'Xuxiang' kiwifruit vine, located in the 'Xuxiang' block adjacent to the 'Nongda Jinmi' block. No sooty mould was observed in tree of heaven nor poplar trees located in the vicinity.

It is important to note that feeding damage is challenging to observe and assess via visual observations. Laboratory assays should be conducted to accurately evaluate the SLF feeding damage in kiwifruit.

## 3.2 Observed seasonal phenology of SLF in experimental kiwifruit blocks

---

SLF's observed phenology was the same in both 'Hayward' and 'Nongda Jinmi' blocks (Figure 7), therefore, observed phenology is reported combined for both experimental orchards. SLF egg masses were first observed in the field on 9 March in both blocks and continued to be found until 12 April. Then, first- and second-instar nymphs were observed on 19 April and 3 May, respectively. Third-instar nymphs were first observed on 17 May and continued to be found until 21 June. Fourth-instar nymphs were observed from 14 June until 28 June, and the first adults were observed on 28 June. After the first observations of SLF adults on 28 June, they were not observed in either experimental block until 20 September. Then they continued to be observed in the kiwifruit blocks until 25 October. SLF egg masses started to be found again from 11 October until the end of the experimental season (i.e. 25 October), which is expected to continue over the winter, with hatching starting in April next year.



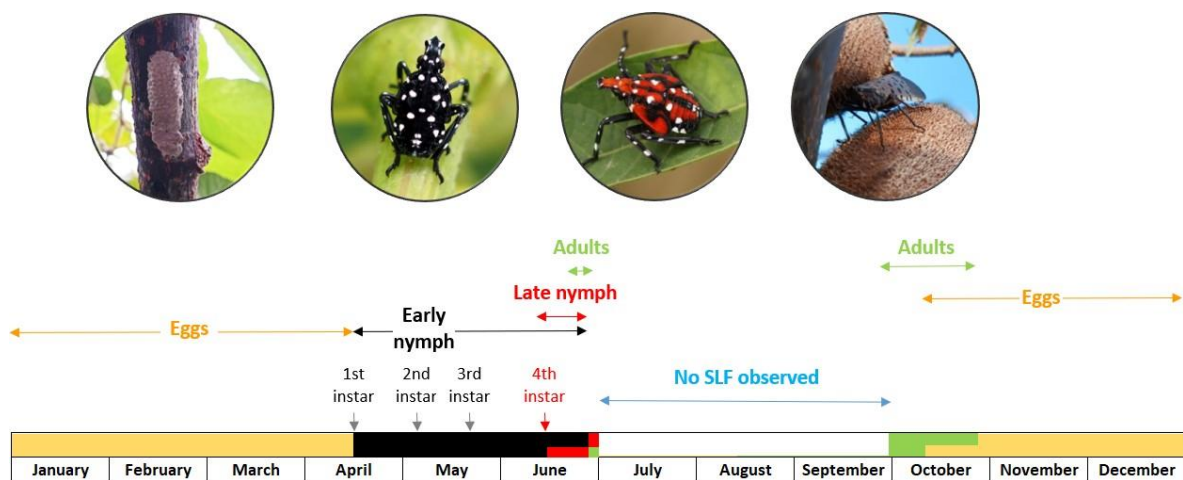


Figure 7. Combined observed seasonal phenology of spotted lanternfly in two experimental kiwifruit blocks (i.e., ‘Hayward’ and ‘Nongda Jinmi’) in Mei County, Shaanxi Province, China.

In addition to SLF observations in both ‘Hayward’ and ‘Nongda Jinmi’ experimental blocks, fourth instar SLF nymphs (Figure 8a) were observed feeding on tree of heaven, and adults on poplar trees (Figure 8b) and in a ‘Xuxiang’ kiwifruit block (Figure 8c), from 28<sup>th</sup> June to 20<sup>th</sup> September. SLF egg masses (Figure 8d) were also observed in poplar trees in mid-October. These additional observations of SLF in alternative hosts, as well as ‘Xuxiang’ kiwifruit block, from late June to late September in the experimental station suggests that SLF is likely to complete its lifecycle in kiwifruit.



Figure 8. Spotted lanternfly fourth-instar nymphs observed in tree of heaven (a), adults observed in poplar tree (b) adult observed in 'Xuxiang' kiwifruit vine (c) and egg mass observed in a poplar tree (d).

## 4 Conclusion

The primary purpose of this study was to determine the seasonal phenology of SLF and its potential impacts on kiwifruit orchards. A single SLF generation was observed during the experimental season (i.e., March to October 2022), where SLF nymphal stages were present in our two experimental kiwifruit orchards (i.e., 'Hayward' and 'Nongda Jinmi') from mid-April to late-June, and then first adults were first observed in the orchards in late-June (Figure 7). Surprisingly, SLF was not observed in the two experimental orchards from 28<sup>th</sup> June until 20<sup>th</sup> September, time when adults were only observed in alternative host plants (i.e. tree of heaven and poplar) as well as a 'Xuxiang' (green-fleshed) kiwifruit block adjacent to the Nongda Jinmi' block. Adult SLF were observed again in the two experimental orchards from late September until late-October, and egg masses from the corresponding generation started to be found in mid-October. During the monitoring activities, none of the kiwifruit vines inspected in both 'Hayward' and 'Nongda Jinmi' blocks showed the presence of sooty mould. Seasonal development observations conducted in our study align with similar studies conducted in the USA (Leach & Leach 2020; Liu 2020; Dechaine et al. 2021), where a single generation of SLF per year was also observed. The fact that neither SLF nymphs nor adults were visually observed in the two experimental kiwifruit orchards during this time, does not mean SLF was truly absent from these orchards. SLF nymphs are highly mobile and good at hiding, and adults quickly fly away when disturbed, and this behaviour may have had an impact on visual inspections. In addition, since SLF was observed during this time window in alternative host plants in the vicinity, as well as a 'Xuxiang' kiwifruit block, suggests that SLF is likely to complete its lifecycle in kiwifruit.

Monitoring results showed that eggs, nymphs and adults were more abundant in the Nongdajinmi cultivar, and that in both experimental orchards, nymphal stages were more abundant than adults. Similar observations have been made in vineyards in Korea, where nymphs typically outnumber adults (Song 2010; Lee et al. 2011). Unfortunately, to date, there are no studies available in kiwifruit reporting on SLF numbers, and the associated damage, that we can use as a point of comparison to estimate the size of the populations observed in our study. Therefore, we cannot report on the pest pressure posed by SLF on kiwifruit. This highlights the importance to conduct phenology/population studies in multiple/consecutive years, so you can get an understanding of how populations vary between years and their potential impacts.

In both Hayward and Nongdajinmi experimental orchards, nymphs were mainly observed on shoots and branches, whereas adults were observed most frequently on the trunk of host plants. Similar observations have been conducted on SLF monitoring conducted in Japan, and in vineyards in the USA, where SLF adults tended to feed more heavily on the tree trunks than the shoots and branches preferred by nymphs (Tomisawa et al. 2013; Leach & Leach 2020). Phloem movement is typically within the canopy (shoots and fruit) during preharvest, which then moves downward toward the trunk and roots after harvest. This could explain our observations, since SLF is a phloem-feeder, and nymphs and adults may cue in on the direction and quantity of phloem within the plant throughout the growing season (Keller 2015; Leach & Leach 2020). These differences in SLF plant part preference may be meaningful to management decisions. For example, chemical control practices preharvest could be focused on spraying the vine canopy and the trunk later in the season. The latter would maximise the mortality of SLF adults and, therefore, reduce the number of eggs laid in the field.

The monitoring activities conducted in the two experimental kiwifruit orchards from March and October 2022 provided with the necessary baseline information to determine SLF's seasonal phenology in kiwifruit orchards in China, as well as basic information on the potential development of sooty mould on kiwifruit vines because of SLF feeding. However, additional research is needed to understand

better the potential damage that SLF could cause to kiwifruit, as well as on behavioural aspects of the pest within the orchard (e.g. dispersal ability, landscape utilisation) that might contribute to developing effective pest management practices.

#### Proposed future research:

- Repeat SLF visual inspections in other kiwifruit cultivars (e.g. green 'Xuxiang') to see if some cultivars may (or not) be more susceptible to SLF feeding damage.
- Assess SLF feeding damage, and the potential development of sooty mould, over time in different parts of the vine. This should be conducted in a laboratory and field setup, using mesh cage enclosures and potted plants.
- Investigate when and where SLF enters kiwifruit orchards. This would provide essential information to optimise management techniques, including when to release natural enemies or apply insecticides.
- Assess the abundance and diversity of natural enemies that could be contributing to regulating SLF populations in kiwifruit.

#### Acknowledgements

The Northwest A&F University (Mei County, Shaanxi Province, China) for providing access to their kiwifruit experimental station to conduct this study.

## 5 References

- Barringer LE, Donovall LR, Spichiger S-E, Lynch D, Henry D 2015. The first new world record of *Lycorma delicatula* (Insecta: Hemiptera: Fulgoridae). *Entomol News* 125: 20-23.
- Choi M, Yang Z, Wang X, Tang Y, Hou Z, Kim JH, Byeon YW 2014. Parasitism rate of egg parasitoid *Anastatus orientalis* (Hymenoptera: Eupelmidae) on *Lycorma delicatula* (Hemiptera: Fulgoridae) in China. *Korean J Appl Entomol* 53: 135-139.
- Cooperband MF, Mack R, Spichiger S-E 2018. Chipping to destroy egg masses of the spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae). *J Insect Sci* 18: 1-3.
- Dara SK, Barringer L, Arthurs SP 2015. *Lycorma delicatula* (Hemiptera: Fulgoridae): a new invasive pest in the United States. *J Integr Pest Manag* 6: 1-6.
- DDA (Delaware Department of Agriculture) 2023. Spotted lanternfly  
<https://agriculture.delaware.gov/plant-industries/spotted-lanternfly/> [accessed March 2023].
- Dechaine AC, Sutphin M, Leskey TC, Salom SM, Kuhar TP, Pfeiffer DG 2021. Phenology of *Lycorma delicatula* (Hemiptera: Fulgoridae) in Virginia, USA. *Environ Entomol* 50: 1267-1275.
- Guo X, Shi X 2003. The biology and integrated management of important kiwifruit pests in Shaanxi province. *China Fruits* 1: 45-46.
- Han JM, Kim H, Lim EJ, Lee S, Kwon Y-J, Cho S 2008. *Lycorma delicatula* (Hemiptera: Auchenorrhyncha: Fulgoridae: Aphaeninae) finally, but suddenly arrived in Korea. *Entomol Res* 38: 281-286.
- Hong HL, Li BB 1994. Occurrence and control of major insect pests on Chinese kiwi fruit. *Hubei Plant Protec* 3: 17-18.
- Keller M 2015. *The science of grapevines: anatomy and physiology*. 2nd ed. Academic Press, Cambridge.
- Kim H, Kim M, Kwon DH, Park S, Lee Y, Huang J, Kai S, Lee H-S, Hong K-J, Jang Y et al. 2013. Molecular comparison of *Lycorma delicatula* (Hemiptera: Fulgoridae) isolates in Korea, China, and Japan. *J Asia-Pacif Entomol* 16: 503-506.
- Kim I-K, Koh S-H, Lee J-S, Choi WI, Shin S-C 2011. Discovery of an egg parasitoid of *Lycorma delicatula* (Hemiptera: Fulgoridae) an invasive species in South Korea. *J Asia-Pacif Entomol* 14: 213-215.
- Kim S, Kim T 2005. *Lycorma delicatula* (White) (Hemiptera: Fulgoridae) in Korea. *Lucanus* 5: 9-10.
- Leach H, Leach A 2020. Seasonal phenology and activity of spotted lanternfly (*Lycorma delicatula*) in eastern US vineyards. *J Pest Sci* 93: 1215-1224.
- Lee D, Park Y, Leskey T 2019. A review of biology and management of *Lycorma delicatula* (Hemiptera: Fulgoridae), an emerging global invasive species. *J Asia Pac Entomol* 22: 589-596.



- Lee K, Kim S, Kim I, Kim K 2011. Seasonal occurrence of spot clothing wax cicada, *Lycorma delicatula* (Hemiptera: Fulgoridae) and its control efficacy using EFAM at the vineyards. Korean J Pestic Sci 15: 303-309.
- Leskey TC, Short BD, Butler BR, Wright SE 2012. Impact of the invasive brown marmorated stink bug, *Halyomorpha halys* (Stål), in mid-Atlantic tree fruit orchards in the United States: case studies of commercial management. Psyche 2012: 1-14.
- Liu H 2020. Seasonal development, cumulative growing degree-days, and population density of *Spotted lanternfly* (Hemiptera: Fulgoridae) on selected hosts and substrates. Environ Entomol 49: 1171-1184.
- MPI (Ministry for Primary Industries) 2023. Biosecurity organisms register for imported commodities <https://www.mpi.govt.nz/news-and-resources/resources/registers-and-lists/biosecurity-organisms-register-for-imported-commodities> [accessed February 2023].
- NJDA (New Jersey Department of Agriculture) 2021. Spotted lanternfly <https://www.nj.gov/agriculture/divisions/pi/prog/pests-diseases/spotted-lanternfly/> [accessed March 2023].
- NJDEC (New York Department of Environmental Conservation) 2023. Spotted lanternfly <http://www.dec.ny.gov/animals/113303.html> [accessed February 2023].
- Park JD, Kim MY, Lee SG, Shin SC, Kim JH, Park IK 2009. Biological characteristics of *Lycorma delicatula* and the control effects of some insecticides. Korean J Appl Entomol 48: 53-57.
- PDA (Pennsylvania Department of Agriculture) 2023. Spotted lanternfly. What is it & why does it matter? [https://www.agriculture.pa.gov/Plants\\_Land\\_Water/PlantIndustry/Entomology/spotted\\_lanternfly/Pages/default.aspx](https://www.agriculture.pa.gov/Plants_Land_Water/PlantIndustry/Entomology/spotted_lanternfly/Pages/default.aspx) [accessed February 2023].
- Pei ZH, Wang YA 2021. Comprehensive prevention and control of major pests of kiwifruit occurred in the south slope of the Funiu Mountain. Deciduous Fruits 33: 53-54.
- PFR (Plant & Food Research) 2021. FreshFacts - New Zealand horticultural exports 2021 <https://www.freshfacts.co.nz/files/freshfacts-2021.pdf> [accessed February 2023].
- Song M 2010. Damage by *Lycorma delicatula* and chemical control in vineyards, Chunbuk National University, Korea.
- Tomisawa A, Ohmiya S, Fukutomi H, Hayashi K, Ishikawa T 2013. Biological notes on *Lycorma delicatula* (White) (Hemiptera, Fulgoridae) in Ishikawa Prefecture, Japan. Jpn J Entomol 16: 3-14.
- Urban JM, Leach H 2023. Biology and management of the spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae), in the United States. Annu Rev Entomol 68: 151-167.
- VCE (Virginia Cooperative Extension) 2023. Spotted lanternfly in Virginia <https://ext.vt.edu/agriculture/commercial-horticulture/spotted-lanternfly.html> [accessed February 2023].
- Wu BG 2012. Preliminary investigation and control of the pests on kiwi fruit. Sichuan Agric Sci Technol 7: 45.

**A smart  
green  
future.  
Together.**