

PFR SPTS No. 18590

BS19017 Spotted lanternfly – Chinese papers on the impact of spotted lanternfly to kiwifruit

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September 2019



Confidential report for:

Zespri Group Limited
Client ref: BS19017-30-A

Zespri information:

Milestone No.	BS19017-30-A
Contract No.	BS19017
Project Name:	Chinese papers on the impact of spotted lanternfly to kiwifruit

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PUBLICATION DATA

Xu G, Teulon D. September 2019. BS19017 Spotted lanternfly – Chinese papers on the impact of spotted lanternfly to kiwifruit. A Plant & Food Research report prepared for: Zespri Group Limited. Milestone No. NA. Contract No. 36583 var. Job code: P/310136/01. SPTS No. 18590.

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EXECUTIVE SUMMARY

BS19017 Spotted lanternfly – Chinese papers on the impact of spotted lanternfly to kiwifruit

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September 2019

This report provides a collation of the translations of six Chinese publications pertaining the spotted lanternfly (SLF) *Lycorma delicatula* (Heteroptera: Fulgoridae) on kiwifruit in China through searches of the CNKI database. SLF is native to Asia and has recently spread to the United States causing damage to a number of valued crop and tree species. SLF has not established in New Zealand but is considered a significant biosecurity threat to NZ's valued crop species including kiwifruit. However, English sourced references about SLF damage to kiwifruit are very sparse, possibly due to its pest status in China. In a Chinese database, China National Knowledge Infrastructure (CNKI) database, we identified 18 Chinese language publications providing direct evidence indicating SLF is one of the important kiwifruit pests. This report includes the translations of six most relevant publications among our searched results.

In the translations below, text highlighted in grey (usually the scientific name) has been added by us to provide greater understanding of the meaning of the text.

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Du Xuewu¹, Zhao Xueqing¹, Zhou Yongqiang¹, Chen Guodian¹ and Wang Jianchun¹. (2010). Main pest and disease control techniques for kiwifruit in southwestern Henan, China. *Deciduous Fruits (05)*: 32-34.

(¹Xixia County Forestry Bureau, Henan Province, 474500)

Abstract: This paper introduces the characteristics and control techniques of kiwifruit pests and diseases including (蛀果虫) *Zhu guo chong* (possibly *Grapholita molesta*)¹, (斑衣蜡蝉) *Ban yi la chan* (i.e. *Lycorma delicatula*)², (根结线虫病) *Gen jie xian chong bing* (i.e. root-knot nematode)³, (软腐病) *Ruan fu bing* (i.e. rot disease)⁴, (黑斑病) *Hei ban bing* (i.e. black spot)⁵, (根腐病) *Gen fu bing* (i.e. root rot)⁶, (溃疡病) *Kui yang bing* (i.e. bacterial canker)⁷, and (立枯病) *Li ku bing* (i.e. wilt disease)⁸.

Keywords: southwestern Henan province; kiwifruit; pest and disease; control

The southwestern Henan province is the most suitable area for growing kiwifruit in China. This region has eight new kiwifruit cultivars and over 5000 hm² (1 hm² = 1 ha) of kiwifruit cultivation areas with an annual production of more than 150,000 tonnes. The southwest region has been ranked as the top kiwifruit production region in Henan province, and its main production county, Xixia, is considered 'the hometown of kiwifruit' – a part of the China high-quality economic forests⁹. In recent years, with the expansion of the kiwifruit cultivation area, the appearance and effect of pests and diseases are increasing. We have taken some measures to prevent and control kiwifruit pests and diseases and these approaches have achieved good outcomes.

1. (猕猴桃蛀果虫) *Mi hou tao zhu guo chong*¹⁰ (possibly *Grapholita molesta*)

1.1 Characteristics and symptoms

This pest often bores into the mid-portion of fruit and the infested sites appeared to be sunken with slightly raised surrounds. The infested site is dark brown with some free liquid. In southwestern Henan province, the average infestation caused by this pest is approximately 20–30%, and it can reach higher than 50% in severely infested orchards. This pest has three to four generations per year. The first-generation larvae have a major effect on young shoots and fruits. In June, the adults start to appear in the orchard and lay eggs on the fruit bud. The hatched second-generation larvae bore into fruit and feed inside the fruit. When the second-generation larvae reach the later stage of their lifecycle, they emerge from the fruit and build white cocoons at the base of stalk, vine bark or inside the wilted leaves. The third-generation larvae begin infestation from mid-July to August.

¹ No direct information is available for this Chinese name. According to Li et al. 2017, the Chinese name is the synonym of (梨小食心虫) *Li xiao shi xin chong*, and Li et al. 2017 also indicate this is a kiwifruit pest. According to Yu 2015, the scientific name of *Li xiao shi xin chong* is *Grapholita molesta*.

² *Lycorma delicatula*, according to Liu et al. 2006, where the scientific name and the Chinese common name are used together.

³ Root-knot nematode disease, according to Jiang and Shao 1990, where the scientific name and the Chinese common name are used together.

⁴ "Rot disease", is directly translated from Chinese characters, need more information to identify the formal disease name.

⁵ "Black spot", is directly translated from Chinese characters, need more information to identify the formal disease name.

⁶ "Root rot", is directly translated from Chinese characters, need more information to identify the formal disease name.

⁷ "Bacterial canker", according to Liu et al. 2007, where the English and Chinese names are used together.

⁸ "Wilt disease", is directly translated from Chinese characters, need more information to identify the formal disease name.

⁹ Direct translation from Chinese, a ranking list of top growth regions for high value crops.

¹⁰ Possibly *Grapholita molesta*, see footnote 1 above, the extra part in the Chinese name (*mi hou tao*) refers to kiwifruit.

1.2 Control methods

Spray (灭扫利) *Mie sao li*¹¹, (功夫菊酯) *Gong fu ju zhi*¹², (菊马乳油) *Ju ma ru you*¹³ or (氟氰锌乳油) *Lv qing xin ru you*¹⁴ (diluted 1:2000) once every 10–15 days during the adult period. Alternatively, use sugar-vinegar liquid or sex attractant to attract and kill adults.

2. (斑衣蜡蝉) *Ban yi la chan* (i.e. *Lycorma delicatula*)²

2.1 Characteristics and symptoms

Both larva and adult of *Ban yi la chan*² damage kiwifruit by sucking sap from leaves and canes. The excretion of the pest often leads to the growth of (煤霉病) *Mei mei bing*¹⁵ and reduces the vine vigour. In severe cases, cracked bark and death of the plant can also occur. This pest has one generation per year and overwinters as eggs. Eggs often hatch in April and the hatched nymphs start to damage young leaves during this period. The nymphs moult four times to become adults in mid-June, which causes more serious damage. The adults often mate and lay eggs in mid-August.

2.2 Control methods

1. Avoid planting the preferred hosts of *Ban yi la chan*² including (臭椿) *Chou chun*¹⁶ and (苦楝) *Ku lian*¹⁷ around kiwifruit orchards to reduce the pest source.
2. Remove infested canes and egg masses when pruning in spring or winter.
3. During the adult and nymphal period, apply 20% (磷胺乳油) *Lin an ru you*¹⁸ (diluted 1:1500–2000), 50% (久效磷) *Jiu xiao lin*¹⁹ liquid formula (diluted 1:2000–3000), 20% (烈神) *Lie shen*²⁰ emulsifiable concentrate or 20% (定杀净) *Ding sha jing*²¹ emulsifiable concentrate (diluted 1:3000) to control pests. Stop spraying any chemicals approximately 15 days before harvest.

3. (根结线虫) *Gen jie xian chong* (i.e. root-knot nematode)³

3.1 Characteristics and symptoms

*Gen jie xian chong*³ is a parasitic pest that damages tissue between root bark and the central cylinder. The damage symptoms include excessive growth of young root tissue, the formation of small bean-sized root nodules and fewer root hairs. The young root nodules often firstly have a white colour and gradually turn into a brownish-yellow or brownish-black colour. This pest mainly damages the fine roots and small secondary roots, sometimes it can also damage the primary root and large secondary roots. Damaged fine roots often develop root nodules. Damaged small secondary roots not only have root nodules, but also exhibit symptoms including swelling, distortion and shortening. The infested primary root only develops root nodules and generally does not have other damage symptoms. In severe cases, secondary nodules may appear. A large number of excessive small roots may also appear, causing tangled root systems that can further cause rot root or the death of root.

¹¹ Meothrin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹² Cyhalothrin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹³ Fenvalerate-malathion emulsifiable concentrates, according to Baidu Encyclopedia where the English and Chinese names are used together.

¹⁴ No information is available for this chemical.

¹⁵ Need more information to identify the scientific name of the disease.

¹⁶ *Ailanthus altissima*, according to Li et al. 2018 where the scientific name and the Chinese common name are used together.

¹⁷ *Melia azedarach*, according to He et al. 2018 where the scientific name and the Chinese common name are used together.

¹⁸ No information is available for this chemical.

¹⁹ Monocrotophos, according to Baidu Encyclopedia where the English and the Chinese names are used together.

²⁰ No information is available for this chemical.

²¹ No information is available for this chemical.

3.2 Control methods

1. Strengthen orchard quarantine. The infested plants should not be taken out of the orchard and ban the transfer of plants from infested regions. New seedling plants need to be inspected to avoid infestation.
2. Establish pest-free plants. Approximately 15 days prior to planting, apply 5–10 kg of 10% (克线磷) *Ke xian lin*²² granules, or 4–5 kg of 15% (铁灭克) *Tie mie ke*²³ granules, or 3–4 kg of 10% (克线丹) *ke xian dan*²⁴ granules, or 5–7 kg of 80% (二氟异丙醚) *Er lv yi bing m*²⁵ with water in every 666.7 m² of field. Deep turn-over of the soil to kill pests in the soil.
3. Control infestation. Increase organic fertiliser appropriately based on the soil condition. Strengthen fertiliser and water management, develop a good drainage system and improve sandy soil.
4. (软腐病) *Ruan fu bing* (i.e. rot disease)⁴

4.1 Characteristics and symptoms

This disease mainly affects the flower and fruit of kiwifruit. Infected male flowers initially develop a water-stain shaped lesion and then the infected flow becomes soft, decayed and becomes brown in colour. The infected female flower has a brown bud and often fails to bloom, and eventually wilts. During the wet season, lesions can develop white mildew. Infected fruit initially has white water-stain shaped lesions. Later, the lesions become sunken and gradually turn into soft rot. Infected fruit quickly rot and cannot be stored or transported. In severe cases, infected fruit drops early. Some infected fruit may have symptoms including rotting flesh, cracking peel and juice leakage. Later, irregular black bacteria particles develop on the fruit skin.

4.2 Control methods

- 1 Use a disease-resistant variety.
 2. After the orchard clean and fertilisation in winter, deep turn over the surface soil to approximately 10–15 m deep, which can effectively reduce the quantity of initial pathogens.
 3. Chemical control. Spray a fog mixture of 50% (乙烯菌核利) *Yi xi jun he li*²⁶ or (异菌脉) *Yi jun niao*²⁷ wettable powder (diluted 1: 1500–2000) once before flower dropping and prior to harvest can effectively control the infection.
5. (黑斑病) *Hei ban bing* (i.e. black spot)⁵

5.1 Characteristics and symptoms

This disease mainly damages leaves, canes and fruit. Initially, the infected leaves often have grey mildew spots on the underside. Later, the lesions expand and become grey, dark grey or black coloured mould. In severe cases, hundreds of small lesions may appear on the underside of leaves. At the later stage, these small lesions join together to form large lesions and cause wilting and leaf drop. The lesions on the undersides of the infected leaves also have yellow chlorotic spots on the surface. These spots on the surface gradually turn into yellowish-brown or brown-coloured necrosis. The necrosis usually has round or irregular shapes with unclear edges. The infected canes initially have yellowish-brown or red-brown lesions with water-stain,

²² Fernamiphos, according to Baidu Encyclopedia where the English and the Chinese names are used together.

²³ Aldicarb, according to Baidu Encyclopedia where the English and the Chinese names are used together.

²⁴ No information is available for this chemical.

²⁵ Nemamort, according to Baidu Encyclopedia where the English and the Chinese names are used together.

²⁶ Vinclozolin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

²⁷ Iprodione, according to Baidu Encyclopedia where the English and the Chinese names are used together.

in spindle or elliptical shapes. These lesions are slightly sunken and then longitudinally expand into large ulcerous lesions. The surface of the lesions become covered with small black spots or a grey mildew layer. The infected fruit often has lesions on the skin in early June. The initial lesions on the fruit surface are grey mildew spots that further develop into grey or dark grey large mildew spots. Then, the mildew layer starts to fall off and a round sunken lesion appears with a length of 0.2–1 cm. During the ripening season, the fleshy tissue with lesions quickly becomes soft, fermented and inedible. Finally, the whole infected fruit rots.

5.2 Control methods

1. Strengthen seedling inspection and conduct field quarantine to reduce the risks of disease spreading.
2. Clean and remove infected plant parts. Remove and burn the infected canes, and apply once 5° Be²⁸ scale of (石硫合剂) *Shi liu he ji*²⁹ before and after winter, respectively.
3. During the infection period from April to May, remove the infected canes and leaves to stop disease spreading.
4. For orchards with continuous disease infections, spray chemicals to treat the infection. Starts spraying in early May and spray once every 10–15 days. Repeat the spray treatment for three or four times. The spray chemicals include 70% (甲基托布津) *Jia ji tuo bu jin*³⁰ wettable powder (diluted 1:1000), or 50% (退菌特) *Tui jun te*³¹ wettable powder (diluted in 1:800), or 80% (炭疽福美) *Tan ju fu mei*³² wettable powder (diluted 1:800), or 50% (胶体硫) *Jiao ti liu*³³ (diluted 1:400).

6. (根腐病) *Gen fu bing* (i.e. root rot)⁶

6.1 Characteristics and symptoms

The initial symptom caused by the disease is a dark brown water-stained lesion appearing on the root neck. The initial lesions gradually expand and develop a large number of white hyphae. The infected cortex and xylem tissue gradually rots with a fermented smell. The large quantity of hyphae forms a light-yellow coloured, rapeseed-sized sclerotium after 8–9 days of development. In the end, the infected roots become black and rot, and cause the death of the whole plant.

6.2 Control methods

Select orchard sites with good ventilation and well-drained soil to avoid flooding and reducing the risk of infection. Apply 15 g of 50% (敌克松) *Di ke song*³⁴ wettable powder when planting seedlings and thereafter once per month. The peak fruiting season often encounters frequent infections. Remove any infected parts and apply 50–100 g *Di ke song*³⁴ mixed with 10 kg of water to the roots once an infection is identified. In addition, add a small amount of plant growth regulator such as (赤霉素) *Chi mei su*³⁵ for better results. It is recommended to apply more organic fertiliser for soil improvement. Also consider increasing the amount of phosphorus and potassium with a suitable amount of zinc, sulphur and boron.

²⁸ Baume, a unit.

²⁹ Lime sulphur, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁰ Thiophanate-Methyl, according to Baidu Encyclopedia where Chinese name and English name are used together.

³¹ Need more information to identify the English name.

³² Thiram, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³³ Colloidal sulphur, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁴ Sodium p – (dimethylamino) benzenediazo sulfonate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁵ Gibberelin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

7. (溃瘍病) *Kui yang bing* (i.e. bacterial canker)⁷

7.1 Characteristics and symptoms

The symptoms often appear on the vine, canes and vine forks. At the initial infection stage, a slightly raised cortex appears and the infected tissue becomes reddish brown and soft with an irregular shape. The infection gradually spreads to the xylem and the xylem tissue becomes rotten, slightly shrunken and sunken. If the infection is not treated in time, the whole orchard could be destroyed within 2–3 years.

7.2 Control methods

Apply integrated control methods including selecting disease-resistant cultivars; strengthen fertiliser and irrigation management to improve tree vigour; paint 50% *Jia ji tuo bu jin*³⁰ or 65% (代森锌) *Dai sen xin*³⁶ (diluted 1:50–100) at the vine during early spring and late autumn; spray *Dai sen xin*³⁶ on grafted and cut parts; remove lesions and apply *Dai sen xin*³⁶ (diluted 1: 50–100) solution to the parts where lesions are removed.

8. (立枯病) *Li ku bing* (i.e. wilt disease)⁸

8.1 Characteristics and symptoms

This disease mainly affects the base of stem and the leaves. The infection often starts from the leaf margin and the lesion appears as a semi-circular or an irregular shape with a light brown colour. In severe cases, the infected leaf becomes rotten or wilts and a large amount of white hypha appears at the lesions. The large amount of hypha gradually develops into a white circular sclerotium. Finally, the sclerotium turns brown or black brown, and can further kill young seedlings.

8.2 Control methods

The control of this disease focuses on prevention. Enhancing the disease-resistance ability of plants requires a careful selection of orchard site, a good turn-over of soil, soil disinfection, seed selection and suitable planting technology. The principle of enhancing disease resistance is to create a suitable situation that encourages the growth of the plant but does not suit the disease. During the seedling period, spray (植保素) *Zhi bao su*³⁷ (diluted 1:7500–9000) or 0.1–0.2% (磷酸二氢钾) *Lin suan er qing jia*³⁸ to improve disease resistance. The chemical control of the disease includes: applying at 10 cm soil depth 100 kg of ground (硫酸亚铁) *Liu suan ya tie*³⁹ for every 666.7 m² of area; before planting, apply 8 g of a mixture of 40% (五氯硝基苯) *Wu lv xiao ji ben*⁴⁰ powder and 50% (福美双) *Fu mei shuang*⁴¹ powder with a 1:1 ratio, or 40% (拌种双粉剂) *Ban zhong shuang fen ji*⁴² for every square meter. It is also suggested to mix with 4.0–4.5 kg of fine soil when applying the chemicals. Spread one-third of the soil-chemical mixture on the planting sites and spread the remaining mixture on the seeds. This method could effectively prevent infection for months. During the early stage of infection, spray 20% (甲基立枯磷) *Jia ji li ku lin*⁴³ emulsifiable oil (diluted 1:1200), or 36% (甲基硫菌灵) *Jia ji liu jun lin*⁴⁴ liquid suspension (diluted 1:500), or 5% (井冈霉素) *Jin gang mei su*⁴⁵ liquid (diluted 1:1500), or 15% (恶霉灵) *E mei ling*⁴⁶ liquid (diluted 1:450) to control the disease.

³⁶ Dithane z-78, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁷ Phytoalexin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁸ Potassium phosphate monobasic, according to Baidu Encyclopedia where the English and the Chinese names are used together.

³⁹ Ferrous sulphate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴⁰ Quintozene, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴¹ Thiram, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴² Need more information to identify the English name

⁴³ Tolclofos-methyl, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴⁴ Thiophanate-methyl, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴⁵ Validamycin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁴⁶ Hymexazol, according to Baidu Encyclopedia where the English and the Chinese names are used together.

Guibang Wu¹ (2012). Preliminary investigation of kiwifruit pests and the control methods. Sichuan Agricultural Technology (07): 45.

¹Yuanba Plant Protection Station, Guangyuan City, Sichuan Province, China. 628000

Kiwifruit is a vine plant and the growth condition of kiwifruit has varied considerably since it transited from wild plants through to commercialised cultivation. As the scale of kiwifruit cultivation in China continuously expands, the number of issues due to kiwifruit pest and disease has increased dramatically. Kiwifruit pests and diseases have become severe threats to the kiwifruit production in China. Kiwifruit is a popular fruit in China and draws great interest globally due to its high nutritional value and a variety of vitamins and amino acids.

China is the native home to (中华猕猴桃) *Zhong hua mi hou tao*⁴⁷, but the development of the kiwifruit industry in China has been slow. To improve the current kiwifruit cultivation and accelerate the development of the kiwifruit industry, as well as strengthen the current cultivation management and quarantine measures when transferring plant material, it is important to control and prevent the various kiwifruit pests and diseases. This report (by the author) aims to provide a preliminary study of kiwifruit pests and diseases.

- The major kiwifruit pests and their damaging characteristics

The investigation and observation identified 12 major kiwifruit pests belonging to seven different families. The family (金龟子) *Jin gui zi*⁴⁸ includes six pest species, with one species belonging to the (硬蚱科) *Ying jie ke*⁴⁹, (鸡科) *Ji ke*⁵⁰, (天蛾科) *Tian e ke*⁵¹, (蓑蛾科) *Suo e ke*⁵², (蝻科) *Chun ke*⁵³ and (毒蛾科) *Du e ke*⁵⁴, respectively. Among all the pests, (斑衣蜡蝉) *Ban yi la chan* (i.e. *Lycorma delicatula*)⁵⁵ and (草履绵蚧) *Cao lv mian jie*⁵⁶ are considered the most important kiwifruit pests.

1. The pest species

Various pests appear at different growth stages of kiwifruit. During the flower period (May), the major pests that damage flowers all belong to the *Jin gui zi*⁴⁸ group and include (苹毛金龟子) *Ping mao jin gui zi*⁵⁷ (i.e. *Proagopertha lucidula*), (小青花金龟子) *Xiao qing hua jin gui zi*⁵⁸ (i.e. *Oxycetonia jucunda*), (白星金龟子) *Bai xing jin gui zi*⁵⁹; the pests that damage leaves and

⁴⁷ *Actinida chinensis*, according to Liu 2003 where the scientific name and the Chinese common name are used together.

⁴⁸ Scarabs, according to Yan et al. 2015 where the scientific name and the Chinese common name are used together.

⁴⁹ No direct information is available for this Chinese word, might be a synonym of Margarodidae according to the information in Duan et al. 2009 and Pei 2017.

⁵⁰ Need more information for identifying the scientific name.

⁵¹ Spingidae, according to Li et al. 2011 where the scientific name and the Chinese common name are used together.

⁵² Psychidae, according to Jiang and Zhong 1995 where the scientific name and the Chinese common name are used together.

⁵³ Pentatomidae, according to Bu and Zheng, 2004 where the scientific name and the Chinese common name are used together.

⁵⁴ Lymantriidae, according to Liu et al. 2016 where the scientific name and the Chinese common name are used together.

⁵⁵ *Lycorma delicatula*, according to Liu et al. 2006 where the scientific name and the Chinese common name are used together.

⁵⁶ No direct information is available for the Chinese common name, but this might be a synonym of *Drosicha corpulenta*. *D. corpulenta* is mentioned in our previous translations and the Chinese common name is very similar to the Chinese common name here.

⁵⁷ *Proagopertha lucidula* according to Meng and Wang, 2008 where the scientific and Chinese common names are used together.

⁵⁸ *Oxycetonia jucunda* according to Song et al. 1998 where the scientific and the Chinese common names are used together.

⁵⁹ No scientific name information is available for this Chinese name, might be the synonym of (白星花金龟) *Bai xing hua jin gui* (*Protaetia brevitarsis*) because the Chinese names are really similar. The scientific name for the later species was identified in Yang, 2014

vines are *Ban yi la chan*⁵⁵ and *Cao lv mian jie*⁵⁶: the pests that only damage leaves are (葡萄天蛾) *Pu tao tian e*⁶⁰ (i.e. *Ampelophaga rubiginosa*), (蓑蛾) *Suo e*⁵², (黄尾毒蛾) *Huang wei du e*⁶¹ (i.e. *Porthesia similis*), (华北大黑鳃金龟子) *Hua bei da hei sai gui zi*⁶² (*Holotrichia oblita*) and (花蝽) *Hua chun*⁶³(i.e. *Anthocoridae sensu lato*) .

2. Damage period

The pests often cause damage from May to September with severe damage occurring between May and June. During this period, a variety of pests that damage flowers, leaves and canes appear at the same including the three species of *Jin gui zi*⁴⁸; a large number of *Ban yi la chan*⁵⁵ nymphs which mainly damage leaves and canes; the adults and nymphs of *Cao lv mian jie*⁵⁶ which damage shoots and leaves; and those that only damage leaves such as *Suo e*⁵², *Pu tao tian e*⁶⁰ and *Huang wei du e*⁶¹. The large quantity and wide variety of pests that appear during this particular period are the major reasons for the severe damage.

3. Damage condition

There is a wide variety of leaf pests; most of these are chewing pests, but the quantity is in general small and the damage caused by them is relatively minor.

4. Damage characteristics of *Ban yi la chan* (i.e. *Lycorma delicatula*)⁵⁵

This pest is one of the important kiwifruit pests and its damage characteristics are: early appearance, high densities and a long damage period. *Ban yi la chan*⁵⁵ in general does not lay eggs on the canes or vines. Instead, they lay eggs at the sunny side of the kiwifruit pergola. The eggs often cluster together and are arranged evenly with an obvious brown wax cover. Eggs often hatch in middle and late May. The adults start to appear in late July and cause damage to kiwifruit till early September. Both adults and nymphs can cause damage over a period of 3 months. *Ban yi la chan*⁵⁵ causes severe damage during the growth period of a kiwifruit vine. In late May, a large number of nymphs cluster at the leaves or the back side of leaves. The infested leaves and canes start to have grey or white spot symptoms when dozens and up to hundreds of nymphs occupy a single plant. An early infestation occurs as a large number of nymphs appear during the leaf growth period, and such an infestation can cause serious impact to the growth of the kiwifruit vine.

5. Damage characteristics of *Cao lv mian jie* (possibly *Drosicha corpulenta*)⁵⁶

*Cao lv mian jie*⁵⁶ is also one of the major kiwifruit pests. This pest generally appears early and causes severe damage. The overwintering eggs hatch in the soil, and the nymphs cause damage in mid-April when they move to the young shoots from the soil. They often cluster together and suck sap from the kiwifruit vine using their mouthparts. Adults often appear in late May and cause greater impact on the early development of kiwifruit.

6. Control methods

Both *Ban yi la chan*⁵⁵ and *Cao lv mian jie*⁵⁶ are considered the major control targets when comparing their damage characteristics with other pest species. It is also suggested to pay close attention to the occurrence of *Jin gui zi*⁴⁸ and *Pu tao tian e*⁶⁰ as well as other pests, especially monitoring the changes in their numbers. A combination of manual and chemical controls could avoid serious impact to the kiwifruit quality.

⁶⁰ *Ampelophaga rubiginosa* according to Jiang et al. 2012 where the scientific and the Chinese common names are used together.

⁶¹ *Porthesia similis* according to Li and Chen, 1983 where the scientific and the Chinese common names are used together.

⁶² *Holotrichia oblita* according to Hua et al. 2013 where the scientific and the Chinese common names are used together.

⁶³ *Anthocoridae sensu lato* according to Liang and Wei, 2006 where the scientific and the Chinese common names are used together.

a. Manual control

- Winter and Spring (October to the following March) periods, manually remove the overwintering eggs of *Ban yi la chan*⁵⁵ from the pergola by using a wire brush; or destroy the pest eggs by using a stone, stick or iron equipment. This is a simple and effective way to eliminate the overwintering eggs.
- Spray a 0.07 to 1.0 m wide band of motor oil around the vine base when nymphs of *Cao lv mian jie*⁵⁶ start to appear. The oil could prevent nymphs climbing up the vines.
- Carry out once or twice manual hunting of *Jin gui zi*⁴⁸ during its peak period between early May and July. The hunting is recommended when the pest is at its suspended animation stage.

b. Chemical control

- After the flower period in late May, spray (敌敌畏) *Di di wei*⁶⁴ (diluted 1:1500) or (氧化乐果) *Yang hua le guo*⁶⁵ (diluted 1: 1000) fog to mainly control *Ban yi la chan*⁵⁵ nymphs and *Cao lv mian jie*⁵⁶. Such a chemical fog is also useful for controlling *Jin gui zi*⁴⁸ and other pests.
- During July and early August, spray (敌百虫) *Di bai chong*⁶⁶ (diluted 1:1000) when a large number of *Jin gui zi*⁴⁸, *Tian e*⁵¹ and *Du e*⁵⁴ occurs. Spraying is not necessary if only a small amount of pests occur during this period.

c. Biological control

- Natural enemies — collect the eggs of *Ban yi la chan*⁵⁵ in a container and allow parasitic wasps to attack the pest eggs.
- Use black light or normal light to attract and kill adult pests.

⁶⁴ Dichlorvos, according to Baidu Encyclopeida where the English and the Chinese names are used together.

⁶⁵ Omethoate, according to Baidu Encyclopeida where the English and the Chinese names are used together.

⁶⁶ Diptorex, according to Baidu Encyclopeida where the English and the Chinese names are used together.

Hong, Hailin¹; Li, Babao² and Rao, Huifu³. (1994). The occurrence and control of major pests of kiwifruit. *Deciduous Fruits*. 3: 17–18.

¹Xianning Plant Protection Station; ²Xianning Forestry College; ³Xianning Agriculture Institute, 437100)

(中华猕猴桃) *Zhong hua mi hou tao*⁶⁷ (i.e. *Actinidia chinensis*) is one of the local specialities in Xianning, Hu bei province. According to the author's investigation, the major pests of *Zhong hua mi hou tao*⁶⁷ in Xianning are (大黑鳃金龟) *Da hei sai jin gu*⁶⁸ (i.e. *Holotrichia diomphalia*), (铜绿丽金龟) *Tong lv li jin gu*⁶⁹ (i.e. *Anomala corpulenta*), (黄守瓜) *Huang shou gua*⁷⁰ (i.e. *Aulacophora femoralis*), (斑衣蜡蝉) *Ban yi la chan*⁷¹ (i.e. *Lycorma delicatula*), (葡萄天蛾) *Pu tao tian e*⁷² (i.e. *Ampelophaga rubiginosa*), (小绿叶蝉) *Xiao lv ye chan*⁷³ (i.e. *Empoasca flavescens*), (黑尾大叶蝉) *Hei wei da ye chan*⁷⁴ (i.e. *Bothrogonia ferruginea*), (吹绵蚧) *Chui mian jie*⁷⁵ (i.e. *Icerya purchasi*), and (红蜡蚧) *Hong la jie*⁷⁶ (i.e. *Ceroplastes rubens*).

1. The occurrence and impacts of major kiwifruit pests

1.1 *Da hei sai jin gu*⁶⁸ (i.e. *Holotrichia diomphalia*) and *Tong lv li jin gu*⁶⁹ (i.e. *Anomala corpulenta*)

*Da hei sai jin gu*⁶⁸ has one generation every 2 years. *Tong lv li jin gu*⁶⁹ has one generation per year. Both of them overwinter as larvae and adults in soil. The adults usually appear during the night time and have a death-feigning behaviour. *Tong lv li jin gu*⁶⁹ has a strong phototaxis. The peak adult period of *Da hei sai jin gu*⁶⁸ is from early to mid-June and *Tong lv li jin gu*⁶⁹ has a peak period from late June to early or mid-July. The adult pests feed on leaves causing leaf perforation. Sometimes they consume the whole leaf with only a petiole left. The infestation has a great impact on young seedlings.

1.2 *Huang shou gua*⁷⁰ (i.e. *Aulacophora femoralis*)

*Huang shou gua*⁷⁰ has one generation per year and overwinters as an adult, which hides in the soil, weeds or under stones on the sunny side of hill slopes. The pests often cluster together as a group and each group usually has dozens of insects. The adults are more active on sunny days, but not so active on the cloudy days. During wet days, the adults are usually inactive and cause severe damage afterwards due to long-term hunger. The adults have a death-feigning behaviour. The overwintering adults start to appear from late April to early May and the peak period of larvae occur in July. Both adults and larvae feed on leaves, with only the layer of epidermis left at the underside of leaves. The damaged leaves are riddled with holes which can then cause cracked leaves.

1.3 *Ban yi la chan*⁷¹ (i.e. *Lycorma delicatula*)

This pest has one generation per year and overwinters as eggs attached to kiwifruit vines. It hatches in early April and the adult appears in June. Both adults and nymphs suck sap from canes and leaves. *Ban yi la chan*⁷¹ often cluster together and peak damage occurs during

⁶⁷ *Actinidia chinensis*, according to Liu 2003 where the scientific and the Chinese names are used together.

⁶⁸ *Holotrichia diomphalia*, according to Yang et al. 2014 where the scientific and the Chinese names are used together.

⁶⁹ *Anomala corpulenta*, according to Yang et al. 2014 where the scientific and the Chinese names are used together.

⁷⁰ *Aulacophora femoralis*, according to Liu et al. 2006 where the scientific and the Chinese names are used together.

⁷¹ *Lycorma delicatula*, according to Song et al. 1998 where the scientific and the Chinese names are used together.

⁷² *Ampelophaga rubiginosa* according to Jiang et al. 2012 where the scientific and the Chinese common names are used together.

⁷³ *Empoasca flavescens*, according to Chen et al. 1990 where the scientific and the Chinese common names are used together.

⁷⁴ *Bothrogonia ferruginea*, according to Yang and Li, 1980 where the scientific and the Chinese common names are used together.

⁷⁵ *Icerya purchasi*, according to Ma and Wang, 2012 where the scientific and the Chinese common names are used together.

⁷⁶ *Ceroplastes rubens*, according to Song and Wang, 1998 where the scientific and the Chinese common names are used together.

August and September. The infested leaves become dehydrated and wilt. The excrement of the pest can induce mildew disease and increase the degree of damage.

1.4 *Pu tao tian e*⁷² (i.e. *Ampelophaga rubiginosa*)

This pest has two generations per year and overwinters as a pupa in the soil. The overwintering adults appear in late May to late June in the following year. The first generation larval period is in July and the first adults occur from August to September. The second generation larvae appear from August to September. The adults are often inactive during the day time and start to become active during the evening. The adults have phototaxis. The larvae are also inactive during the day time and feed during the night time. In severe cases, the larvae can eat the whole leaf.

1.5 *Xiao lv ye chan*⁷³ (i.e. *Empoasca flavescens*) and *Hei wei da ye chan*⁷⁴ (i.e. *Bothrogonia ferruginea*)

*Xiao lv ye chan*⁷³ has 10 to 13 generations a year. *Hei wei da ye chan*⁷⁴ has five to six generations a year. Both of them overwinter as adults on kiwifruit vines or surrounding weeds or crops. *Xiao lv ye chan*⁷³ has negative phototaxis and it can be affected by direct sunlight. The numbers of *Xiao lv ye chan*⁷³ reduce quickly under hot and dry conditions. Continuous rainfall or drought can affect the reproduction of *Xiao lv ye chan*⁷³, changeable weather conditions are suitable for them. The peak number of *Xiao lv ye chan*⁷³ often occurs in June and July, followed by October. *Hei wei da ye chan*⁷⁴ has strong phototaxis. Dry and hot conditions are suitable for its occurrence. *Hei wei da ye chan*⁷⁴ numbers peak during the hot July and August months. Both adults and nymphs of *Xiao lv ye chan*⁷³ and *Hei wei da ye chan*⁷⁴ suck sap on the underside of kiwifruit leaves. The infested leaves often have chlorotic spots. In severe cases the whole leaf turns yellow-white, causing an early drop and reduced vine vigour.

1.6 *Chui mian jie*⁷⁵ (i.e. *Icerya purchasi*) and *Hong la jie*⁷⁶ (i.e. *Ceroplastes rubens*)

*Chui mian jie*⁷⁵ has two or three generations a year and overwinters as a nymph or a female adult on kiwifruit leaves or canes. The peak period of the first instar of *Chui mian jie*⁷⁵ is from late April to June. The peak period of the second instar starts in late July and ends in early September. The third instar occurs from September to November. The hatched instars often stay inside the egg sac for a short period before moving out. Most of them cluster at both sides of the central vein of young leaves. They only change locations during the moulting period. The second instar gradually moves to the shady side of canes and causes damage. The female adults usually stop moving after they find their feeding sites. They produce egg sacs and lay eggs inside. The male nymphs are more active than females, but they stop infestation after the second moult due to their mouthparts degrading. *Hong la jie*⁷⁶ has one generation a year and overwinters as a female adult on canes. The females lay eggs in late May and nymphs start to appear in early June. The emergence of male adults appear during late August and early September. The adults and nymphs of *Chui mian jie*⁷⁵ and *Hong la jie*⁷⁶ suck sap from leaves and canes. The infested canes and leaves become wilted. In severe cases, an early drop of leaf and the death of kiwifruit plants could occur.

2. The control of major pests

2.1 Physical control

2.1.1 Manual control

Both (金龟子) *Jin gui zi*⁷⁷ and *Huang shou gua*⁷⁰ exhibit death-feigning behaviour. These pests could be manually killed during their death-feigning status. *Jin gui zi*⁷⁷ can be manually killed from June to July. *Huang shou gua*⁷⁰ could be manually killed in May.

⁷⁷ Scarabs, according to Yan et al. 2015 where the English common and the Chinese names are used together.

2.1.2 Attractant control

(铜丽绿金龟子) *Tong lv jin gui zi*⁷⁸, *Pu tao tian e*⁷² and *Hei wei da ye chan*⁷⁴ are positively phototactic. Use lights to attract and kill *Tong lv jin gui zi*⁷⁸ during late June and mid-July. The *Pu tao tian e*⁷² could be controlled using lights from early May to late June. *Hei wei da ye chan*⁷⁴ could be controlled with lights from July to August.

2.1.3 Remove eggs

The egg masses of *Ban yi la chan*⁷¹ should be removed in winter and spring. The simple and effective way of controlling *Ban yi la chan*⁷¹ is manually removing egg masses in October and the following March.

2.1.4 Kill weeds

Both *Xiao lv ye chan*⁷³ and *Hei wei da ye chan*⁷⁴ overwinter and breed in weeds. Destruction of weeds could help to reduce numbers of these pests.

2.2 Chemical control

2.2.1 In mid-May, use 50% (敌敌畏乳油) *Di di wei ru you*⁷⁹ or 40% (氧化乐果乳油) *Yang hua le guo ru you*⁸⁰ (diluted 1: 1000) to control *Chui mian jie*⁷⁵, *Hong la jie*⁷⁶ and the first instars of *Ban yi la chan*⁷¹.

2.2.2 During July and August, spray 30 ppm of 2.5% (敌杀死) *Di sha si*⁸¹ to control *Pu tao tian e*⁷², *Ban yi la chan*⁷¹, *Chui mian jie*⁷⁵ and *Hong la jie*⁷⁶. Alternatively, use *Yang hua le guo*⁸⁰ and *Di di wei*⁷⁹ to control *Xiao lv ye chan*⁷³, *Hei wei da ye chan*⁷⁴, *Jin gui zi*⁷⁷ and *Huang shou gua*⁷⁰.

2.3 Biological control

Natural enemies including (瓢虫) *Piao chong*⁸², (大红瓢虫) *Da hong piao chong*⁸³, (澳洲瓢虫) *Ao zhou piao chong*⁸⁴, (红点瓢虫) *Hong dian piao chong*⁸⁵ and parasitic wasps can control (介壳虫) *Jie ke chong*⁸⁶ and *Ban yi la chan*⁷¹.

⁷⁸ *Anomala corpulenta*, according to Song et al. 1998 where the scientific and the Chinese names are used together.

⁷⁹ Dichlorvos emulsifiable concentrate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁸⁰ Omethoate emulsifiable concentrate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁸¹ Deltamethrin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁸² Ladybird beetles, according to Xie and Pang, 2016 where the English and the Chinese names are used together.

⁸³ *Rodolia rufopilosa*, according to Xiao, 2015 where the scientific and the Chinese names are used together.

⁸⁴ *Rodolia cardinalis*, according to Zeng and Pang, 2000 where the scientific and the Chinese names are used together.

⁸⁵ *Chilocorus kuwanae*, according to Ma et al. 1997 where the scientific and the Chinese names are used together.

⁸⁶ Scale insects, according to Tian, 2013 where the English and the Chinese names are used together.

Liu, N. (2013). "Prevention and control of (斑衣蜡蝉) *Ban yi la chan* (i.e. *Lycorma delicatula*)⁸⁷ for kiwifruit." Pesticide Market News (15)

Ban yi la chan (i.e. *Lycorma delicatula*)⁸⁷ belongs to the (蜡蝉科) *La chan ke*⁸⁷ and is one of the major pests of kiwifruit. Both nymphs and adults of *Ban yi la chan*⁸⁷ suck the sap of kiwifruit stems and leaves. Their feeding causes small yellow spots on infested leaves, and the small yellow spots can turn into dark-brown coloured, polygon-shaped and necrotic spots. The necrotic spots subsequently become perforated and several holes join together to cause damaged leaves. Symptoms of backward-curling leaves can sometimes also be identified as being caused by this pest. The excrement of *Ban yi la chan*⁸⁷ is similar to the honeydew which often attracts other insects such as bees and flies. The excrement can also lead to the growth of (霉菌) *Mei jun* (i.e. moulds)⁸⁸, and the *Mei jun*⁸⁹ infection can cause the branches to become dark brown with cracked bark. In severe cases, the *Mei jun*³ infection can cause the death of the host plants.

*Ban yi la chan*⁸⁷ has one generation a year, and overwinters as eggs. Eggs are mostly deposited on the sunny side of the vines or in the hidden part of vine forks. The adults and nymphs are often clustered. The eggs are clustered into egg masses and usually arranged in parallel lines. Each egg mass has 40 to 50 eggs with a grey cover-layer. The hatching period is between late-April and early-May. Peak impacts caused by nymphs occurs in late-May, and the nymphs are often found clustering under the young leaves or on the young shoots. The nymph period is approximately 60 days which is also the critical period for control.

Control method:

Use 2.5% of (氯氟氰菊酯) *Lv fu qing ju zhi*⁸⁹ emulsifiable concentrate (diluted 1: 1500), 48% of (毒死蜱) *Du si pi*⁹⁰ emulsifiable concentrate (diluted 1: 2000) or apply fog treatment with 2.5% of (溴氰菊酯) *Xiu qing ju zhi*⁹¹ emulsifiable concentrates (diluted 1: 2000) for controlling the pests.

⁸⁷ *Lycorma delicatula*, according to Song et al. 1998 and Liu et al. 2006 where the Chinese common name and the scientific name are used together.

⁸⁸ Moulds, according to Duan et al. 2012 where the English name and the Chinese name are used together.

⁸⁹ Cyhalothrin, according to Baidu Encyclopedia where the Chinese and the English names are used together.

⁹⁰ Chlorpyrifos, according to Baidu Encyclopedia where the Chinese and the English names are used together.

⁹¹ Deltamethrin, according to Baidu Encyclopedia where the Chinese and the English names are used together.

Wang Lei. (2018). Advances in research about the occurrence and control of (斑衣蜡蝉) *Ban yi la chan* (*Lycorma delicatula*). *Jiangxi Agriculture* 22: 84.

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Abstract *Ban yi la chan* (*Lycorma delicatula*) is a widely distributed pest that feeds on a variety of host plants. This study summarizes the latest research progress on the biological characteristics, occurrence and control of *Ban yi la chan* China, and aims to provide a further research direction that has practical value in effectively controlling *Ban yi la chan*.

(斑衣蜡蝉) *Ban yi la chan* (*Lycorma delicatula* white), also known as (樗鸡) *Chu ji*, (花姑娘) *Hua gu niang*, (花蹦蹦) *Hua beng beng*, (花大姐) *Hua da jie*, etc., is a sucking pest which is widely distributed in China and feeds on numerous host plants (Li et al. 2009). This insect is also known to be an important ingredient of traditional Chinese medicine and (斑蝥素) *Ban ao su*⁹² extracts (Hou, 2013). The severe impact of *Ban yi la chan* on important ornamental trees and commercial crops including (臭椿) *Chou chun*⁹³ and grapes has received increasing attention. This further draws research interests to the biological characteristics and control methods for *Ban yi la chan* (Li et al. 2009; Hou, 2013; Yang, 2014; Zheng, 2015; Sun et al. 2017). This study summarized the current research progress on the occurrence and control of *Ban yi la chan* and provides indications for future research to prevent and control this pest.

1. Biological characteristics of *Ban yi la chan*
- 1.1 Geographical distribution

The current distribution of *Ban yi la chan* in China includes central, north, east, south and southwest China, as well as some northwest regions including Shaanxi province, Gansu province and Ningxia province. The recent increase of economic activities such as seedling transportation has led to the spread of *Ban yi la chan* in China (Li et al. 2009; Hou, 2013; Zheng, 2015; Sun et al. 2017). In Korea, *Ban yi la chan* is mainly distributed in the south and central regions (Hou, 2013).

- 1.2 Host range

Ban yi la chan feeds on a variety of host plants. Among ornamental tree species, *Chou chun*⁹⁴ is one of the main favourite hosts of *Ban yi la chan*, and the pest also attacks (杨树) *Yang shu*⁹⁴, (刺槐) *Ci hui*⁹⁵, (国槐) *Guo hui*⁹⁶, (苦楝) *Ku lian*⁹⁷, (榆树) *Yu shu*⁹⁸, (枫树) *Feng shu*⁹⁹, (合欢) *He huan*, (黄杨) *Huang yang*¹⁰⁰, (柳树) *Liu shu*¹⁰¹ and (海棠) *Hai tang*¹⁰². Among crops, the pest causes the most damage to grapes and severe damage to kiwifruit, apple, peach, apricot, plum and longan (Hou, 2013).

⁹² Cantharidin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

⁹³ *Ailanthus altissima*, according to Li et al. 2018 where the scientific name and the Chinese common name are used together.

⁹⁴ Poplar tree, according to Lv et al. 2019 where the English and the Chinese common name are used together.

⁹⁵ *Robinia pseudoacacia*, according to Li et al. 2019 where the scientific name and the Chinese common name are used together.

⁹⁶ *Sophora japonica*, according to Sun and Peng, 2018 where the scientific name and the Chinese common name are used together.

⁹⁷ *Melia azedarach*, according to He et al. 2018 where the scientific name and the Chinese common name are used together.

⁹⁸ Siberian elm, according to Wang, 2009 where the English and the Chinese common names are used together.

⁹⁹ *Acer* according to Du et al. 2014 where the scientific and the Chinese common names are used together.

¹⁰⁰ *Buxus* spp. according to Xing et al. 2016 where the scientific and the Chinese names are used together.

¹⁰¹ Willow, according to Ni et al. 2019 where the English and the Chinese common names are used together.

¹⁰² Crab apple (*Malus* spp.), according to Chen, 2007 where the English and the Chinese common names are used together.

1.3 Life history

Ban yi la chan has one generation per year and overwinters as eggs. Egg hatching often starts from mid to late April and reaches a peak in mid-May. The nymph passes through four instars in approx. 60 days. In most regions, adult emergence starts in mid to late June and reaches a peak in late July to mid-August. Mating starts from mid or late August, and death occurs in late October.

1.4 Occurrence and damage characteristics

The damage period of *Ban yi la chan* occurs over approx. half a year. Both nymphs and adults can cause damage to the host plant. The nymphs can jump and prefer to cluster at the young stem or underside of the leaves. The infested young leaves often shrink and become deformed. In severe cases, broken leaves and cracked bark can occur. The adults in general have a weak flying ability and are only able to fly 1–3 meters to avoid predators and other risks. The feeding behaviour of *Ban yi la chan* could lead to the discharge of plant secretions and honeydew excretions. The excretions often induce (霉污病) *Mei wu bing*¹⁰³ and other diseases.

The occurrence of *Ban yi la chan* is closely related to the climate. In autumn, a dry climate condition with a high temperature leads to a large number of *Ban yi la chan* appearing in the following year. On the contrary, a wet climate condition with a low temperature in autumn can greatly reduce the pest density in the following year. The occurrence of *Ban yi la chan* is also closely related to vineyard cultivation and plants around the vineyard.

1.5 Mating and reproductive habits

Mating of *Ban yi la chan* often starts in mid to late August, and eggs are produced in mid to late September. In late October, adults stop mating and die. Mating often occurs from 7:00 to 9:00 a.m. and takes approx. 1 to 3 hours. Females produce eggs in 1 to 3 days, each egg takes approx. 5 minutes to oviposit. Every egg mass has approx. 18 to 60 eggs and egg production takes around 3 to 5 days. In the Ningxia Hui Autonomous Region, eggs of *Ban yi la chan* are mainly laid on the trunk, branches and bark crevices of the host plants including *Chou chun*⁹⁴ and *Yang shu*⁹⁵ etc. A few eggs can be found on brick walls and concrete surfaces. Most of the eggs are produced in the forest margin area (Sun et al. 2017).

1.6 Natural enemies

Current studies of *Ban yi la chan* suggest the following species are natural enemies: (斑衣蜡蝉平腹小蜂) *Ban yi la chan ping fu xiao feng* (*Ananstatus* sp.), (布氏螯蜂) *Bu shi ao feng* (*Dryinus browni* Ashmead), (小黄家蚁) *Xiao huang jia yi* (*Monomorium pharaonis*), (中华大刀螳螂) *Zhong hua da dao tang lang* (*Paratenodera sinensis*), (圆蛛科棒络新妇) *Yuan zhu ke bang luo xin fu* (*Nephila clavata*) and (大腹圆蛛) *Da fu yuan zhu* (*Araneus ventricosus*). Among these species, *Ping fu xiao feng* (*Ananstatus* sp.) and *Bu shi ao feng* (*Dryinus browni* Ashmead) are the dominant natural enemies of *Ban yi la chan*.

2. Control methods of *Ban yi la chan*

2.1 Physical control

Physical control methods often take into account the biological characteristics of *Ban yi la chan* to reduce the number of pests. Methods include capture of adults, scraping-off of egg masses, cutting off branches with egg-mass attached, trunk protector, killing eggs with water blaster and trunk paint.

¹⁰³ A disease, need more information to identify the scientific name of the disease.

2.2 Chemical control

Spray (石硫合剂) *Shi liu he ji*¹⁰⁴ before budburst. The nymph hatching period is important for effectively controlling the pest. Spray organic or biological insecticides (吡虫啉) *Bi chong lin*¹⁰⁵, (菊酯类) *Ju zhi lei*¹⁰⁶ and (苦参碱) *Ku seng jian*¹⁰⁷ during the hatching period. Chemical control is not suitable for controlling adults due to its strong chemical resistance. It is recommended to apply chemicals at the root of host plants (Yang, 2014).

2.3 Biological control

Protect and utilise natural enemies to control *Ban yi la chan*. Artificially breed dominant species such as *Bu shi ao feng* (*Dryinus browni* Ashmead) and *Ban yi la chan ping fu xiao feng* (*Ananstatus sp.*) to control the pest is also suggested.

2.4 Other control methods

Strengthen quarantine to prevent introducing *Ban yi la chan* into new locations. Create mixed-species plantations and avoid monoculture species such as *Chou chun*⁹⁴. Manage plantation density in orchards especially in vineyards.

3. Conclusion

At present, few studies are available for *Ban yi la chan* and numerous gaps exist in current research about *Ban yi la chan*. Studies about the biological characteristics of *Ban yi la chan* should be further strengthened for effectively controlling the pest, especially the development and utilisation of natural enemies. It is also suggested to carry out more studies about the host-impact mechanism and the chemical communication among the pests. Such information is useful to develop pheromones for efficient control of *Ban yi la chan*.

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¹⁰⁴ Lime sulphur, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹⁰⁵ Imidacloprid, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹⁰⁶ Pyrethroids, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹⁰⁷ Matrine, according to Baidu Encyclopedia where the English and the Chinese names are used together.

Zheng, Qingwei¹ & Zheng, Yue¹ (2015). The occurrence and control of (斑衣蜡蝉) *Ban yi la chan*¹⁰⁸ (i.e. *Lycorma delicatula*). Deciduous Fruits (06): 69.

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*Ban yi la chan*¹⁰⁹ is commonly known as other Chinese common names include (花媳妇) *Hua xi fu*, (樗鸡) *Chu ji*, (斑衣) *Ban yi*, (灰花蛾) *Hui hua e*, (花娘子) *Hua niang zi*, (蜡皮蜡蝉) *Chun pi la chan*, and it belongs to the (蜡蝉科) *La chan ke*¹⁰⁹, (同翅目) *Tong chi mu*¹¹⁰. This pest is commonly found in the kiwifruit cultivation regions including Beijing, Hebei, Shanxi, Jiangsu, Zhejiang, Anhui, Shandong, Henan, Hubei, Guangdong, Sichuan, Yunnan and Shaanxi provinces, China. The damage caused by *Ban yi la chan*¹⁰⁹ increases each year, resulting in a serious economic loss of Chinese kiwifruit production. In addition to kiwifruit, the pest also causes damage to various fruit and forest trees including apple, (海棠) *Hai tang*¹¹¹, peach, plum, apricot, grape, cherry blossom and (刺槐) *Ci huai*¹¹².

Both adults and nymphs of *Ban yi la chan*¹⁰⁹ often cluster on kiwifruit vines or leaves to suck sap, most commonly on the leaf petiole. Minor symptoms include holes in young-leaves; in severe cases cracks on leaves, early fruit or flower drop can also occur. Neither adults nor nymphs can fully digest the sugar content in sap, and discharge it as excrement. The excrement can lead to the growth of (霉菌) *Mei jun* (i.e. moulds)¹¹³, and the infection can cause cracked bark and the death of the plants. The damage of *Ban yi la chan*¹⁰⁹ seriously affects the quantity and the quality of kiwifruit.

*Ban yi la chan*¹⁰⁹ has one generation per year and overwinters as eggs on branches. The period for hatching of *Ban yi la chan*¹⁰⁹ commences differently across China depending on variation in climate conditions. In general, hatching begins later in the north than in the south of China. In Shandong province, hatching starts from mid to late May; In Wugong, Shaanxi province, hatching starts in mid April. In most regions of southern China, earlier hatching starts from late March to early April. The proportion of successful egg hatch varies substantially on different hosts. It was found that 80% of eggs laid on (臭椿) *Chou chun*¹¹⁴ could hatch successfully; whereas, the successful hatch proportion dropped to 2–3% for eggs deposited on (槐树) *Huai shu*¹¹⁵ or (榆树) *Yu shu*¹¹⁶. The nymphs often cluster on the underside of young leaves or young stems. They suck the sap of host plants with their mouthparts. After being disturbed, the nymphs can immediately jump and escape approximately 1–2m away. The nymphal period is approximately 60 days, and the nymphs often turn into an adult form in mid June after moulting four times. The adult causes more severe damage than a nymph. Adults *Ban yi la chan*¹⁰⁹ mostly mate during the night. In mid or late August, adults start to mate and lay eggs at the south (sunny) side of vines; or the shady side of the vine fork. The eggs are clustered together as egg masses and arranged in columns with a powdery wax cover. The eggs are laid from the right- to left-hand side. Adults often lay eggs in one column and eggs are protected with a waxy

¹⁰⁸ *Lycorma delicatula*, according to Song et al. 1998 and Liu et al. 2006 where the scientific name and the Chinese common name are used together.

¹⁰⁹ Fulgoridae family, according to Hou 2013 where the scientific name and the Chinese name are used together.

¹¹⁰ Homoptera order, according to Yao et al. 2002 where the scientific name and the Chinese name are used together.

¹¹¹ Crab apple (*Malus* spp.), according to Chen, 2007 where the English and the Chinese common names are used together.

¹¹² *Robinia pseudoacacia*, according to Li et al. 2019 where the scientific name and the Chinese common name are used together.

¹¹³ Moulds, according to Duan et al. 2012 where the English and the Chinese names are used together.

¹¹⁴ *Ailanthus altissima*, according to Li et al. 2018 where the scientific name and the Chinese common name are used together.

¹¹⁵ *Sophora*, according to Liu, 2004 where the English and the Chinese common names are used together.

¹¹⁶ Siberian elm, according to Wang, 2009 where the English and the Chinese common names are used together.

powder. They usually rest between each column and an egg mass is finished in 2 to 3 days. The adults can survive up to 120 days with dead adults starting to occur in late October.

Control of *Ban yi la chan*¹

1. Avoid planting *Chou chun*¹¹⁵ and (苦楝) *Ku lian*¹¹⁷ in orchards to reduce pest source and infestation.
2. Change crop variety and create a mixed variety orchard to lower the pest impacts.
3. Remove and burn dead, excessively infested branches when pruning before budburst, to improve ventilation and light penetration. This also helps to reduce the orchard humidity and pest source.
4. Protect and use parasitic natural enemies to control *Ban yi la chan*¹⁰⁹.
5. Use insect nets to catch and kill adults and nymphs.
6. Remove, burn or deep bury egg masses during the winter prune.
7. During the nymph and adult periods, apply 30% (氰戊·马拉松) *Qing wu·ma la song*¹¹⁸, 7.5% (氰戊菊酯) *Qing wu ju zhi*¹¹⁹ plus 22.5% (马拉硫磷) *Ma la liu lin*¹²⁰ emulsifiable concentrate (diluted 1:2000); or 50% (敌敌畏乳油) *Di di wei ru you*¹²¹ (diluted 1:1000); or 2.5% (氯氟氰菊酯) *Lv fu qing ju zhi*¹²² emulsifiable concentrate (diluted 1: 2000); or 90% crystal (敌百虫) *Di bai chong*¹²³ mixed with 0.1% washing powder; or 10% (氯氰菊酯) *Lv qing ju zhi*¹²⁴ emulsifiable concentrate (diluted 1: 2000- 2500); or 50% (杀虫单) *Sha chong dan*¹²⁵ wettable powder (diluted 1: 600).

¹¹⁷ *Melia azedarach*, according to He et al. 2018 where the scientific name and the Chinese common name are used together.

¹¹⁸ Need more information to identify the English name.

¹¹⁹ Fenvalerate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²⁰ Malathion, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²¹ Dichlorvos emulsifiable concentrate, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²² Cyhalothrin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²³ Dipterex, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²⁴ Cypermethrin, according to Baidu Encyclopedia where the English and the Chinese names are used together.

¹²⁵ Monosultap, according to Baidu Encyclopedia where the English and the Chinese names are used together.

APPENDIX 1. REFERENCES FOR SCIENTIFIC NAME IDENTIFICATION

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