Yellow Spotted Stink Bug Literature Review

Final Report (BS20093-B)

Qianqian MI, Jinping ZHANG, Juhong CHEN, Feng ZHANG

12 February 2020

www.cabi.org

KNOWLEDGE FOR LIFE

Qianqian Mi[1,2], Jinping Zhang[1,2], Juhong Chen[1,2], Feng Zhang[1,2*]

[1] CABI East Asia, c/o CAAS Internal Post Box 85, 12 South Street of Zhong-Guan-Cun, Beijing 100081, China

[2] MARA-CABI Joint Laboratory for Bio-safety, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, 2 West Yuan-ming-yuan Road, Beijing 100193, China

[*] Correspondence: f.zhang@cabi.org

Contents

Executive Summary

The yellow spotted stink bug (YSSB), *Erthesina fullo* Thunberg, is one of the most widely distributed phytophagous pests in Asia. Its host range in China includes more than 57 plants belonging to 29 families, with the largest group of species from Rosaceae. This highly polyphagous pest is a major threat to many economically important fruit crops and is also known to develop on a wide variety of natural host plants. YSSB shares many biological characteristics with the brown marmorated stink bug, *Halyomorpha halys* Stål, a successful global invader introduced from Asia into the United States, Canada, a number of European countries, and Chile. With a primarily *r*-selected life history strategy, reproductive diapause, wider host range, high dispersal capacity, and association with human-modified ecosystems, YSSB would be a potential invasive species with significant biosecurity threats to other countries outside its native range, including New Zealand. If YSSB arrives in New Zealand, it could potentially infect species of economic importance to New Zealand, such as stone fruit, apples and kiwifruit. Although it has not established in New Zealand, understanding of basic and applied knowledge on YSSB in its native range would help stakeholders conduct proper biosecurity risk assessment and develop sound surveillance and emergence response programmes or plans for government agencies and industry sectors in New Zealand. Therefore, it is timely for Zespri to fund a literature review study on YSSB, with special focus on kiwifruit and China.

Literature searches were conducted in three Chinese platforms, Chinese National Knowledge Infrastructure (CNKI) Platform, Wanfang Data Knowledge Service Platform and Weipu using Chinese characters for YSSB (麻皮蝽, 黄斑蝽, 麻纹蝽, 黄霜蝽, or 麻蝽象), and also in English, in two international platforms, Ovid Research Platform and Web of Science. We identified totally 87 publications related to YSSB, including 66 in Chinese and 21 in English. Even though there are only five Chinese language publications and one English publication covering both YSSB and kiwifruit, YSSB is listed as a major insect pest of kiwifruit and cause 10-30% yield losses and economic loss of 100-200 CNY (at the money value in 1999) per mu (15 mu equal to 1 ha) in kiwifruit orchards, Zhouzhi county, Shaanxi province.

This review report summarized basic and applied knowledge on the biology, ecology, and management of YSSB in China, with specific emphasis on life history, host range, damage and impacts on kiwifruit or other economically important horticulture crops, and integrated pest management approaches. This information from Chinese literatures provides greater context and understanding of YSSB biology, ecology, and

management in China, which would be very useful for biosecurity risk assessment and development of a sound surveillance programme and an emergence response plan in New Zealand and other countries with concerns.

In the end of this report, we also identify key research questions as well as Chinese articles related to both YSSB and kiwifruit to be fully translated into English for Zespri to consider and if possible provide funding support to carry out these tasks in the future.

.

1. Introduction

The yellow spotted stink bug (YSSB), *Erthesina fullo* Thunberg (Hemiptera: Pentatomidae) (syn. *Cimex mucoreus* F.), is one of the most widely distributed phytophagous pests in Asia, including Bangladesh, China, India, Java Island of Indonesia, Japan, Myanmar, Sri Lanka and Vietnam (Yang 1962; Walker 2005; Ahmad et al. 2004; CABI ISC 2019; Gao et al. 2019). It feeds on a number of economically important fruits, such as apples, cherries, pears and kiwifruit (Xu & Jiang 1999; Ji et al. 2006; Feng 2007; Zhang 2018; Zhang et al. 2019). Both YSSB and the brown marmorated stink bug (BMSB), *Halyomorpha halys* (Stål), are identified as major pests of kiwifruit in China (David & Xu 2018). BMSB has already established in the United States, Canada, multiple European countries, and Chile, and become a key agricultural pest causing significant damages and losses to tree fruits, small fruits, nuts and vegetables (Leskey & Nielsen 2018). BMSB has not yet established in New Zealand although it is regularly intercepted at its borders (David & Xu 2018). As far as environmental suitability is concerned, New Zealand is highly susceptible to the establishment of the BMSB based on predictions with space distribution models and algorithms (Fraser et al. 2017). The ecological niche, field occurrence and host plants of YSSB are quite similar with those of BMSB, which indicates that YSSB would also become an ecological and economic danger to other parts of the world outside its' area of origin if proper condition and circumstances were provided to facilitate an introduction (Liu et al. 2015).

Known also as a hitchhiker pest, YSSB would be introduced into other areas outside its' current distribution in a variety of ways, e.g., passengers/luggage, containers, general cargo or used machinery and vehicles (Landcare Research 2019). In November 2014, a single female YSSB was discovered in Temuka, New Zealand (Mitchell 2014). Although there was no evidence of more bugs around at that time, another invasion event would be still highly possible considering the extensive trade between New Zealand and the Asian countries such as China and Japan. In order to carry out proper risk analysis and develop corresponding pre-border, at-border and poster border biosecurity activities to prevent the invasion of YSSB or minimize its impact in New Zealand, more in-depth understanding of biology and ecology of YSSB in its native range would provide useful knowledge for researchers, quarantine officers and industry biosecurity specialists. However, little is known about YSSB in English domain while quite a few Chinese literatures related to YSSB were found by David & Xu (2018) in their literature review study focusing on BMSB. Therefore, it is critical to obtain more detailed knowledge and information of YSSB in China and elsewhere.

In this literature review study, we summarized information on YSSB being published with a particular focus on China, including its life history, host range, damage and impacts on kiwifruit or other economically important horticulture crops, and integrated pest management approaches. The aim of the present study is to provide the New Zealand kiwifruit industry and growers a thorough knowledge on the potential impact of YSSB and to improve their preparedness to select appropriate pest management tool against BMSB, prior its arrival and establishment into New Zealand.

2. Materials and methods

2.1 Platforms for literature searches

Literature searches were conducted in three Chinese search platforms including:

1) China National Knowledge Infrastructure (CNKI, https://www.cnki.net/). The CNKI literature databases cover over 86 million scientific records in Chinese from journals, patents, reference books, annals, conference proceedings, newspapers, Master and PhD dissertations, etc (CNKI 2019). It was identified as the best Chinese database for providing biosecurity-related information in China (David & Xu 2018).

2) Wanfang Data Knowledge Service Platform (Wanfang Data, http://www.wanfangdata.com.cn/index.html). A large number of Chinese and international databases can be accessed through Wanfang Data. It covers more than 8000 Chinese journals in the fields of natural science, agriculture, health and medicine, engineering and technology, and social science to name a few (Wanfang Data 2020). It also covers dissertations, conference proceedings, patents, scientific reports, standards, video materials, etc.

3) Weipu or VIP (Chongqing VIP Information Co., Ltd., http://www.cqvip.com/). It hosts China Science and Technology Journal Database (CSTJ), which is China's largest database of digital journals with more than 70 million records from over 12000 Chinese journals (VIP 2020).

Although the above three Chinese search platforms include databases of foreign languages, two other English search platforms were also used for the literature searches in our study:

1) Ovid research platform (Ovid, Wolters Kluwer, The Netherlands). Ovid includes over 100 bibliographic and full–text databases and it covers a wide range of scientific, medical and healthcare disciplines including agriculture and food sciences (Ovid 2020). As one of the biggest

2) Web of Science (WoS, Clarivate Analytics, USA). WoS is a multidisciplinary platform connects regional, specialty, data and patent indexes to the *Web of Science Core Collection*, which contains over 21,100 peer-reviewed, high-quality scholarly journals published worldwide (including Open Access journals) in over 250 sciences, social sciences, and arts & humanities disciplines (WoS Group 2020).

CAB Abstracts (CABI, UK) is the leading English-language bibliographic information service providing access to the world's applied life sciences literature. It covers over 9.5 million research records of publications from over 120 countries in 50 languages between 1973 and September 2019, plus an Archive version of over 1.8 million records from 1913 to 1972 (CABI 2020). In this study, CAB Abstracts database was accessed through both the Ovid and WoS platform.

2.2 Literature searches

A range of literature searches were carried out with the platforms and databases as mentioned above in September 2019 to identify publications related to YSSB on kiwifruit in Chinese and English. The literature searching terms and options used for each platform/database were summarized in Table 1. The Chinese characters used in Chinese search platforms included '麻皮蝽', '黄斑蝽', '麻纹蝽', '黄霜蝽', or '麻蝽象', the mostly used Chinese common names for YSSB. These Chinese characters for YSSB were determined initially by matching the scientific name (*Erthesina fullo*) to appropriate Chinese characters within a few peer-reviewed publications where both Chinese and Latin names were used together (Yang 1962; Song & Wang 1993; Zhang et al., 1993; Wang & Qiu 1998; Zhang et al. 2006). As there were only limited number of publications obtained from searches with YSSB and kiwifruit in both Chinese and English, kiwifruit was not included as the search term to extend our coverage of publications related to YSSB.

2.3 Literature analysis

All the publications obtained from above searches were exported to Endnote (Version 9.0, Clarivate Analytics, USA) for further quality control and in-depth analysis. Full content publications were also obtained as much as possible for quality check based on their relevancies to the topic, qualities of contents and breadth of scope. The titles, abstracts and full texts of all collected publications (except those that could not be accessed) were reviewed to ensure YSSB and kiwifruit or other fruits were mentioned in the same document. Repeated literatures were checked out as well as those articles with useless information or not so much relevant to YSSB in the context of pest management.

Table 1 Literature searches for the yellow spotted stink bug in Chinese and English.

Platform	Databases (and extent of coverage)	Search terms in the 'subject' field	Search options	Search results (No. publications)
CNKI	China Academic Journal Network Publishing Database (1951->), PhD Dissertations Database (1984->), Master Dissertations Database (1989->), Domestic Conference Database (1962->)	'麻皮蝽'或'黄斑蝽' 或'黄霜蝽' 或'麻蝽象' 或 '麻纹蝽'	'Subject'	56
Wanfang Data	China Online Journals (1998->), China Dissertations Database (1980->), China Conference Proceedings Database (1982->)	'麻皮蝽' 或'黄斑蝽' 或'黄霜蝽' 或'麻蝽象' 或'麻纹蝽'	'Subject'	69
Weipu	China Science and Technology Journal Database (1992->)	'麻皮蝽' 或'黄斑蝽' 或'黄霜蝽' 或'麻蝽象' 或'麻纹蝽'	'Topic' 'Keyword'	26
Ovid	AGRICOLA (1970-2020), BIOSIS Previews (1987-2011), CAB Abstracts (1973->), CAB Abstracts Archive (1910-1972), Econlit (1886->), ERIC (1965-2019), Food Science and Technology Abstracts (1969->), Ovid MEDLINE(R) and Epub Ahead of Print, In Process & Other Non-Indexed Citations and Daily (1946->), Ovid Mediline(R) (2015->), Zoological Record (2001-2007)	'Yellow marmorated stink bug' OR '*Erthesina fullo*' OR 'Yellow spotted stink bug' OR 'YSSB' OR 'YMSB'	'Keyword'	46
Web of Science	WoS Core Collection (1900->), CAB Abstracts (1973-->), Chinese Science Citation Database (1989->), Derwent Innovation Index (1963->), KCI-Korean Journal Database (1980-->), Russian Science Citation Index (2005->),	'Yellow marmorated stink bug' OR '*Erthesina fullo*' OR 'Yellow spotted stink bug' OR 'YSSB' OR 'YMSB'	'Topic'	41

	SciELO Citation Index (2002->)			

Note: CNKI=Chinese National Knowledge Infrastructure

3. Results

3.1 Literature searches

A Total of 238 publications related to YSSB were collected from the Chinese and international platforms/databases, within which highest number of Chinese publication records obtained from Wanfang Data (Table 1). After reduction of repetition records and those not relevant, 87 publications were identified, including 66 in Chinese and 21 in English (Appendix 1). 75 publications with full texts (66 Chinese and 9 English) were also obtained. There are only five Chinese language publications and one English publication covering both YSSB and kiwifruit. Interestingly, there are over 14 publications targeting both YSSB and BMSB, indicating their similarities or overlaps regarding biological characteristics, host plants and/or control measures.

The first YSSB article was published on 《Formosan Government Agricultural Experiment Station》 in 1916, while the first YSSB article in Chinese was published on 《Journal of Shandong Agricultural College》 in 1963. The number of publications on BMSB has increased rapidly since the 1990s and reached a peak in 2000s (Fig. 1). However, only 25% of these publications were written entirely in English, while the rest were entirely in Chinese languages or a few Chinese publications had partial English text (e.g., abstract, tables, figure captions, and references). Consequently, this review encompasses information from mainly Chinese publications.

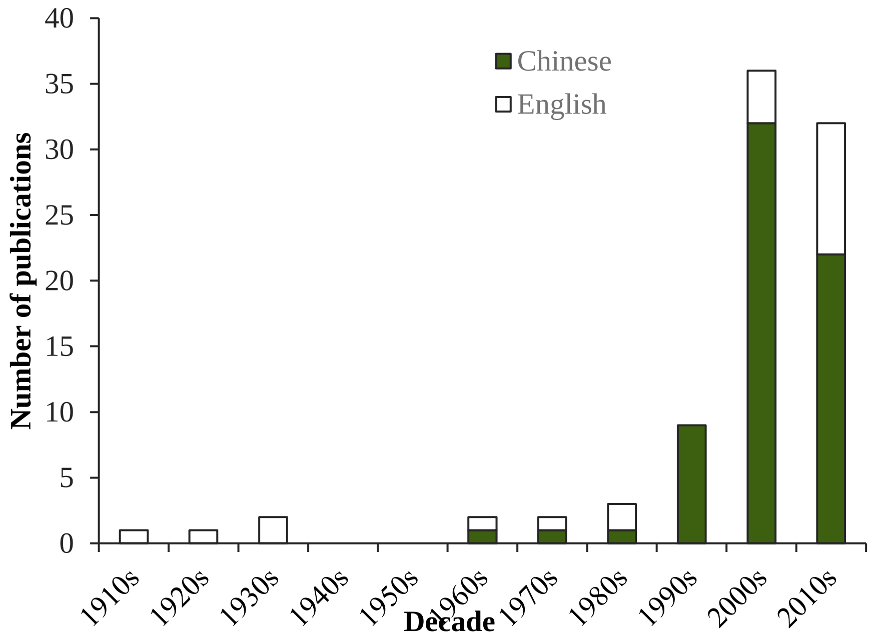

Fig. 1. Number of publications on *Erthesina fullo* published by decade in Chinese and English.

Fig. 2. Life stages of *Erthesina fullo*. A. eggs and first instars; B. eggs on kiwifruit; C. late instar nymph; D. adult.

3.2 Description of life stages

Egg (Fig. 2A & B)

Length approximately 2.9 mm, diameter 1.7 mm, spherical, chorion with fine reticulation. Eggs are light greenish at the time of oviposition and become light brown and then faint yellow prior to eclosion. Operculum in hemispherical shape to permit escape of a nymph. Micropylar projections on the top of center. Egg burster chitinized, blackish and triangle shaped. Egg cluster consisting generally of 12 eggs, arranged more or less regularly (Wang & Kang 2000).

Nymph (Fig. 2A & C)

There are five nymphal instars for YSSB. First instar elliptical with red, white and black stripes. There are three thick black stripes on the back of the abdomen. Later instar reddish brown or dark brown. There is a yellow or yellowish red vertical line from head front to scutellum. Antenna black with four segments. There are four pale red spots in horizontal row in the middle of pronotum. Abdomen with three large drak spots in tandem, and each of spot with two pale red scent gland orifices (Wang 2015).

Adult (Fig. 2D)

YSSB adults are slightly brownish black, and their body sizes are larger than BMSB. Length 18-24.5 mm, width 8-11 mm. Head relatively big, tapering toward the front. There are some yellowish white dots between simple and compound eyes, and the latter is black. Antennae is filamentous with five segments. The anterior areas of anterolateral margins of the pronotum is slightly serrated. Forewing with small yellowish white spots (Wang 2015).

3.3 Life history

YSSB is widely distributed across China, from north to south and from east to west, including Inner Mongolia, Liaoning, Beijing, Tianjin, Hebei, Henan, Shaanxi, Shanxi, Shandong, Anhui, Jiangsu, Shanghai, Zhejiang, Jiangxi, Hubei, Hunan, Sichuan, Guizhou, Yunnan, Guangdong, Guangxi, Hainan and Taiwan (Yang 1962; Gao et al. 2019). YSSB is mostly univoltine (one generation per year) in northern China such as Hebei, Henan, Shandong and Shanxi provinces (Song and Wang 1993; Zhang et al. 1993; Wang & Kang 2000; Zhang et al. 2019). It has one to two generations per year on kiwifruits in Shaanxi province (Wang & Kang 2000; Feng 2007; Zhang 2018). YSSB has two generations per year in Eastern China such as Anhui and Jiangxi provinces (Lu et al 1992; Wang & Qiu 1998). In southern China, YSSB is multivoltine, and it has three generations per year in Yunnan province (Zhou et al. 2000).

Nonreproductive adults overwinter in artificial and natural shelters such as dry crevices of buildings, tree holes, underneath of the fallen leaves or bark of trees (Li et al. 1998). Univoltine populations gradually emerge from overwintering sites in mid-April, and begin laying eggs from late April to late June on kiwifruit in Shaanxi province (Table 2). First generation nymphs start hatching from mid-May and growing up and feeding on host plants through June and July. First generational adults show up in mid-August, with peak populations occurring in September and aggregating to kiwifruit orchard to feed on maturing fruits (Wang & & Kang 2000). As for bivoltine populations, the timing of YSSB emergence from overwintering sites in the spring is earlier than univoltine populations (Table 2). Peak populations of first generation adults occur between late June and mid-August on kiwifruit and feed on young shoots, leaves and fruits, while peak populations of second generation adults occur between August and October and cause major damage to fruits (Feng 2007; Zhang 2018). Thereafter, both univoltine and bivoltine YSSB adults begin moving to overwintering sites in mid-October and continue into November.

Both reproductive and non-reproductive development of YSSB are closely related to photoperiod, temperature, and/or diet. YSSB adults exit overwintering sites in spring when ambient temperatures are >13 °C (Zhang 2018). Mating occurs mostly throughout the day and higher incidences of mating are observed between 12:00 and 14:00, and copulation duration ranges from a few minutes up to three hours (Wang & Kang 2000; Zhou et al. 2000). Multiple copulations were commonly observed for both YSSB males and females (Lu et al. 1992). After mating, YSSB females start to oviposite in about 1-2 days (Zhou et al. 2000) or 3-5 days (Lu et al. 1992). Eggs are typically laid in a mass consisting of 12 eggs, and deposited on the undersides of leaves (Lu et al. 1992; Wang & Kang 2000; Zhou et al. 2000) or the base of kiwifruit (Feng 2007). The life-time fecundity of mated YSSB females was observed in a range of 126-173 eggs per female when the insect was maintained on caged branches of pomegranate, *Punica granatum* L. (Zhou et al. 2000), whereas 36-60 eggs per female were found on the Chinese jujube, *Ziziphus jujuba* Mill. (Lu et al. 1992). Through field cage study, Zhang et al (1993) reported a range of 12-68 eggs with an average of 35 eggs per female. Such a substantial variation in the lifetime fecundity of YSSB females might be attributed to both biotic and abiotic conditions during the testing period, e.g. ambient temperature, quality of food, etc.

YSSB eggs can complete the development in a wide range of rearing conditions at 15 - 30 ℃ and 75-95% RH, and the hatching rate is over 97.5%. But the egg hatching rate is lower when the ambient temperature is less than 15 ℃ and the relative humidity is lower than 60% (Zhou et al. 2000). The mean developmental time of YSSB egg and nymphal stages at 25 - 30 ℃ and 80-95% RH was 5.5 d (4 - 7 d) and 27 d (21 – 33 d), respectively (Zhou et al. 2000). In a field cage study in Hebei province of northern China, the developmental time of YSSB eggs decreased with increased temperatures and was in the range of 5 – 12 d between end May and mid-August (Zhang et al. 1993). The mean developmental time of 1st, 2nd, 3rd, 4th and 5th instars was 5.7 d (4 – 8 d), 14.9 d (12 – 21 d), 13 d (12 -15 d), 13.2 d (12 -18 d) and 18.5 d (16 – 22 d), respectively (Zhang et al. 1993).

Table 2. **Seasonal phenology of univoltine and bivoltine populations of *Erthesina fullo* on jujube and kiwifruit in northern China.**

Host plant / Location	Jan	Feb	Mar	Apr			May			Jun			Jul			Aug			Sep			Oct			Nov	Dec
				E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L		
Jujube / Henan[1]	(+)	(+)	(+)	(+)	+	+	+	+	+	+	+	+	+	+	+	+	+	+								
										●	●	●	●	●	●	●	●	●	●							
										–	–	–	–	–	–	–	–	–	–	–	–	–				
											+	+	+	+	+	+	+	+	+	+	+	+	+	(+)	(+)	(+)
Kiwifruit / Shaanxi[2]	(+)	(+)	(+)	(+)	+	+	+	+	+	+	+	+	+	+	+	+	+	+								
						●	●	●	●	●	●	●														
								–	–	–	–	–	–	–	–	–										
																	+	+	+	+	+	+	(+)	(+)	(+)	(+)
Kiwifruit / Xi'an, Shaanxi[3]	(+)	(+)	+	+	+	+	+	+	+	+	+	+														
							●	●	●	●	●	●														
							–	–	–	–	–	–	–	–												
											+	+	+	+	+	+	+									
											●	●	●	●	●											
													–	–	–	–	–	–								
																+	+	+	+	+	+	+	(+)	(+)	(+)	(+)

[1] Univoltine population reported by Song & Wang 1993.
[2] Univoltine population reported by Wang & Kang 2000.
[3] Bivoltine population reported by Feng 2007, and Zhang 2018.
E means the early 10 days of a month; M means the middle 10 days of a month; L means the last 10 days of a month.
(+) Overwintering adult, + Adult, – Nymph, ● Egg.

Table 3 Host plants and pest status of *Erthesina fullo* reported in China

Family	Common name	Scientific name[1]	Pest status[2]	Reference
Actinidiaceae	Kiwifruit	*Actinidia chinensis* Planch	A major pest of kiwifruit in Shaanxi province	Wang & Kang 2000; Feng 2007; Liu & Liu 2017; Zhang 2018; Teulon & Xu 2018
Amaranthaceae	Beet	*Beta vulgaris* L.	-	Gao et al. 2019
Brassicaceae	Rape	-	-	Gao et al. 2019
Cupressaceae	Dawn redwood	*Metasequoia glyptostroboides* Hu & W. C. Cheng	A pest of dawn redwood in Henan province	Su 1997
Ebenaceae	Persimmon	*Diospyros* spp.	A pest of persimmon in Hebei and Henan provinces	Su 1997; Ji et al. 2006
Euphorbiaceae	Castor oil plant	*Ricinus communis* L.	-	Gao et al. 2019
	Chinese tallow tree	*Sapium sebiferum* (L.) Roxb.	-	Gao et al. 2019
	Chinese wood-oil-tree	*Vernicia fordii (Hemsl.) Airy Shaw*	-	Gao et al. 2019
Fabaceae	Black locust	*Robinia pseudoacacia* L.	A pest of black locust in Hebei and Henan provinces	Su 1997; Ji et al. 2006
	Chinese scholar tree	*Sophora japonica* L.	A major pest of Chinese scholar tree in Hebei province	Zhang et al. 1993
	Silk tree	*Albizia julibrissin* Durazz.	A pest of silk tree in Hebei and Henan provinces	Su 1997; Ji et al. 2006
Fagaceae	Chinese chestnut	*Castanea mollissima* Bl.	-	Gao et al. 2019
Juglandaceae	Chinese wingnut	*Pterocarya stenoptera* C. DC.	A pest of Chinese wingnut in Shaanxi province	Liu & Liu 2017
Leguminosae	White clover	*Trifolium repens* L.	-	Wang et al. 2013
Lythraceae	Pomegranate	*Punica granatum* L.	One of the main pest of pomegranate in Yunnan and Henan provinces	Su 1997; Zhou et al. 2000
Malvaceae	Chinese parasol tree	Firmiana simplex (L.) W.Wight	-	Gao et al. 2019
Moraceae	Fig	*Ficus carica* L.	-	Zhang et al. 2019
	Mulberry	-	-	Gao et al. 2019

	Paper mulberry	*Broussonetia papyrifera* (L.)	-	Xu et al. 2017
Myrtaceae	Clove	Syzygium aromaticum (L.) Merr. & L. M. Perry	-	Wang 2015
	Guava	*Psidium guajava* L.	-	Zhou et al. 2000
Oleaceae	Chinese ash	*Fraxinus chinensis* Roxb.	A pest of Chinese ash in Hebei and Jilin provinces	Ji et al. 2006; Geng et al. 2010
	Chinese privet	*Ligustrum lucidum* Ait.	-	Xu et al. 2017
	Wild forsythia	*Forsythia* spp.	-	Wang 2007
Pinaceae	Pine	-	A major pest of pine trees in Taiwan	Kou et al. 1989
Paulowniaceae	Paulownia	*Paulownia* spp.	A major pest of paulownia in Hebei and Henan provinces	Zhang et al. 1993; Su 1997
Platanaceae	Planetree	*Platanus* spp.	A pest of planetree in Hebei province	Ji et al. 2006
Poaceae	Bamboo	-	A pest of bamboo in Henan province	Su 1997
	Sugarcane	*Saccharum officinarum* L.	-	Gao et al. 2019
Proteaceae	Macadamia nut	*Macadamia ternifolia* F. Muell.	A major pest of macadamia nut in Guangxi province	Tan et al. 2017
Rhamnaceae	Chinese jujube	*Ziziphus jujuba* Mill.	A pest of Chinese jujube in Anhui and Henan provinces	Lu et al. 1992; Su 1997
Rosaceae	Apple	*Malus pumila* Mill.	A common pest feed on apple in Hebei, Shandong and Shaanxi provinces	Zhang et al. 1993; Wang & Kang 2000; Yang et al. 2006; Zhang et al. 2006; Zhang et al. 2019
	Apricot	*Prunus armeniaca* L.	A common pest feed on apricot in Hebei, Henan and Shaanxi provinces	Su 1997; Wang & Kang 2000; Yang et al. 2006; Zhang et al. 2006
	Cherry	*Prunus* spp.	A pest of cherry in Henan province	Su 1997
	Chinese flowering crabapple	*Malus* spp.	A pest of Chinese flowering crabapple in Hebei province	Ji et al. 2006

	Chinese pearleaf crabapple	*Malus asiatica* Nakai	-	Gao et al. 2019
	Chinese hawthorn	*Crataegus pinnatifida* Bunge	A pest of Chinese hawthorn in Henan province	Su 1997
	Chinese plum	*Armeniaca mume* Sieb	-	Gao et al. 2019
	Japanese cherry	*Cerasus* spp.	A pest of Japanese cherry in Hebei province	Ji et al. 2006
	Loquat	*Eriobotrya japonica* (Thunb.) Lindl.	-	Zhou et al. 2000
	Peach	*Prunus persica* (L.)	A major pest of peach in Hebei, Henan and Shaanxi provinces	Zhang et al. 1993; Su 1997; Wang & Kang 2000; Wang et al. 2000[3]; Yang et al. 2006; Zhang et al. 2006
	Pear	*Pyrus bretscheider* Rehder *Pyrus bretscheider* Rehder f. Ya-li Yü *Pyrus bretscheider* Rehder f. Hsüeh-hua-li Yü *Pyrus bretscheider* cv.Dangshansu pear	A major pest of pear in Hebei, Henan, Shaanxi and Anhui provinces	Zhang et al. 1993; Su 1997; Xu & Jiang. 1999; Wang & Kang 2000; Yang et al. 2006; Zhang et al. 2006
	Plum	*Prunus* spp.	A pest of plum in Henan province	Su 1997
	Quince	*Cydonia oblonga* Mill.	-	Gao et al. 2019
Rutaceae	Citron	*Citrus medica* L.	-	Xu 2019
	Citrus	-	-	Gao et al. 2019
	Pomelo	Citrus maxima (Burm) Merr.	-	Zhou et al. 2000
Salicaceae	Chinese white poplar	*Populus tomentosa* Carriere	A pest of Chinese white poplar in Shaanxi province	Liu & Liu 2017
	Black poplar	*Populus nigra* L.	A pest of black poplar in Henan province	Yu et al. 2009

	Poplar	*Populus* spp.	A pest of poplar in Hebei and Shaanxi provinces	Zhang et al. 1993; Wang & Kang 2000
	Weeping willow	*Salix babylonica* L.	-	Gao et al. 2019
	Willow	*Salix* spp.	A pest of willow in Hebei, Henan and Shaanxi provinces	Zhang et al. 1993; Su 1997; Wang & Kang 2000
Sapindaceae	Longan	*Dimocarpus longan* Lour.	-	Gao et al. 2019
Sapotaceae	Nato tree	-	A major pest of nato tree in Taiwan	Kou et al. 1989
Simaroubaceae	Tree of heaven	*Ailanthus altissima* (Mill.) Swingle	-	Gao et al. 2019
Solanaceae	Tobacco	-	-	Gao et al. 2019
Ulmaceae	Elm	*Ulmus pumila* L	A major pest of elm in Hebei and Henan provinces	Zhang et al. 1993; Su 1997
Vitaceae	Grape	*Vitis* spp.	A pest of grape in Henan province	Su 1997

[1] Scientific name is not included when it was not clearly mentioned in original paper.
[2] The pest status is only included when YSSB was clearly indicated as a pest of a host plant in the literature.
[3] 201of 208 peach varieties selected were attacked by YSSB in a germplasm nursery.

3.3. Dispersal capacity and behavior

After hatching, first instar YSSB nymphs remain aggregated on the egg mass for 5-10 h before dispersing to seek food in the surrounding area (Zhou et al. 2000). First and second instar nymphs exhibit aggregation behavior and third instar nymphs start to disperse and seek food (Zhou et al. 2000), whereas there were also reports that second instars start dispersing to seek food (Lu et al. 1992; Wang & Kang 2000, Feng 2007). Later instar YSSB is actively dispersing to seek food on the host plant (Lu et al. 1992). YSSB adults respond slightly to light and like to stay on the top kiwifruit vines and young fruits under the sun shine during day time (Wang & Kang 2000; Feng 2007), and move to undersides of leaves (Zhou et al. 2000) or other warmer places (Lu et al. 1992) to reside during night.

YSSB adults disperse from host plants to overwintering sites in the fall and then disperse from overwintering sites in the following spring. Aggregations of YSSB adults are found in overwintering sites, with 10 or dozens of individuals together (Wang & Kang 2000). Although the dispersal behavior of YSSB adults after exiting from overwintering sites are not well known, the movement of adults may be triggered by nutritional need and phenology of host plant (Lu et al. 1992). Field survey showed that YSSB (and BMSB) disperse among different host plants (Zhang et al. 1993). Higher proportions of stink bugs (incl. adults and nymphs of both YSSB and BMSB) were found on *Paulownia* spp. from mid-May through mid-July and thereafter decreased sharply, while proportion of stink bugs increased dramatically on pear, *Pyrus bretscheider* Rehder, since mid-July. Relatively higher proportions of stink bugs were also observed on peach, *Prunus persica* (L.) in mid-May and then decreased sharply from end May to mid-August. However, the relative abundance of stink bugs varied only slightly on apple (*Malus pumila* Mill.) and poplar (*Populus* spp.) over time (Zhang et al. 1993). Although the author did not separate the field population data between YSSB and BMSB (Zhang et al. 1993), it is highly possible that YSSB follows the similar movement pattern as BMSB did among host plants and habitats (Leskey & Nielsen, 2018). Field-based mark-recapture study also showed that overwintering YSSB adults can fly 3 km in five days in early (Zhang et al. 1993). Therefore, the dispersal capacity and behavior of YSSB adults and nymphs would have a profound effect on the distribution and population dynamics of YSSB among crops and landscapes during the growing season.

3.4 Host range

YSSB is a polyphagous pest and considered an arboreal species. Collectively, a total of over 57 host plants in 29 families have been reported in China, with the largest group of species from Rosaceae (Table 3). Its' host range includes some economically important crops such as kiwifruit, pear, apple, peach, pomegranate, cherry, Chinese jujube, etc. It also includes woody ornamentals and wild hosts such as black locust, Chinese plum, pine, paulownia, poplar, willow, tree of heaven, etc. Although it has on a wide range of plants, YSSB is not always considered as a major pest depending on the region, host plants and its occurrence (Table 3). Relative abundance of YSSB on different host plants (Zhang et al. 1993) might indicate that host plants vary in suitability and acceptability for YSSB. However, the development and fitness of YSSB on different host plants were rarely studied.

Liu & Liu (2017) reported that kiwifruit is not the most preferred host plant based on the observation that the numbers of YSSB on kiwifruit were less than other host plants from end June to end September and less eggs were laid on kiwifruit. This deduced conclusion might be biased as YSSB can disperse between host plants and across the landscape (Zhang et al. 1993) and YSSB prefers to inhabit on arboreal hosts during the daytime, e.g. tree of heaven (Liu & Liu 2017). Moreover, Zhang (2018) reported that the numbers of YSSB nymphs and adults were much higher than the numbers of BMSB between June and October in a kiwifruit orchard (15 ha) in Zhouzhi county, Shaanxi province, and suggested that YSSB was a dominant stink bug pest on kiwifruit in Xi'an area.

3.5 Feeding damage and impact

YSSB nymphs and adults feed on leaves, flowers, shoots, and fruits of host plants (Wang & Kang 2000). Similar to BMSB and other pentatomids, YSSB insert its' stylet into the plant tissue for feeding meanwhile secretes a thick, gel saliva (Zhang et al. 1993) to break down tissue cells and enable consumption of liquid contents (Miles 1972). YSSB feeding results in discoloring, appearance of yellowish-brown spots, withering and even defoliation of leaves or shoots (Xu 2019). Feeding can result in dry, corky tissue just below the surface of feeding sites on fruits, harden, depress and distort the surface of fruiting structures, and thereby reduce the marketing value of the fruits (Zhang et al. 1993; Xu 2019). In worst case, feeding can also cause fruits to abort prematurely and thus significant yield losses (Song & Wang 1993). In addition to direct damage, YSSB feeding can also cause infestation of pathogenic bacteria or fungus, resulting fruit rot (Zhou et al. 2000; Zhang et al. 2019). However, unlike BMSB (Shiozawa 1986), YSSB could not transmit the phytoplasma responsible for Paulownia witches' broom disease (Jin et al. 1981). The following is a summary of the damage symptom and impact of YSSB feeding injury to some economically important crops in China.

Kiwifruit. Besides BMSB, YSSB is another important stink bug pest on kiwifruit (Wang & Kang 2000; Feng 2007; Zhang 2018; Teulon & Xu 2018). Both adults and nymphs of YSSB feed on leaves, flowers, buds, vines and fruits (Wang & Kang 2000), causing leaf yellowing, flower-, bud- and fruit-drop or fruit deformation, respectively (Feng 2007; Liu & Liu 2017). The injured fruit hardens first, becomes soft in 3-5 d and drops to the ground in 5-7 d after feeding, and by then the feeding site expands to a circular spot (ca. 1 cm diameter) on the fruit surface and the flesh underneath turns from dark green into light green with bitter taste (Wang & Kang 2000). As such, YSSB feeding affects both fruit quality and storage (Wang & Kang

2000; Liu & Liu 2017). Wang & Kang (2000) reported that YSSB caused 10-30% yield losses and economic loss of 100-200 CNY per mu (15 mu equal to 1 ha) in kiwifruit orchards in 1999, Zhouzhi county, Shaanxi province. Liu & Liu (2017) reported that fruit injury levels were not significantly different among early ("Cuixiang"), mid- ("Qinmei"), and late ("Hayward") maturing cultivars in a mixed kiwifruit orchard (25 ha), ranging from 4.1 to 48.1%. The mean fruit injury rate for Cuixiang, Qinmei and Hayward was observed at 28.3%, 23.2% and 30.6%, respectively. The number of feeding spots per damaged fruit was ranging from 34 to 89. Severe fruit injury was occurred more in the edge rows of vines orchard close to village road (planted with tree of heaven) than those in the central of the survey kiwifruit orchard (Liu & Liu 2017). This strong edge effect is likely due to the polyphagous nature of YSSB as it moves between its host plants (i.e. kiwifruit and tree of heaven) to meet its nutritional or other physical requirements.

Timing of damage in kiwifruit orchard in Shaanxi province caused by univoltine YSSB nymphs and adults were mostly occurred in June-July and September, respectively (Wang & Kang 2000). By contrast, damages of bivoltine YSSB adults in Shaanxi province were mostly occurred from end June to mid-August and from early August to mid-October for 1st generation and 2nd generation, respectively, and the fruit damage from 2nd generation of YSSB was more serious (Zhang 2018).

Apple. YSSB, BMSB, and pear stink bug, *Urochela luteovaria* Distant (Hemiptera: Urostylidae) are three major stink bug pests on apple, within which BMSB is the most dominant pest (Zhang et al. 2019). The symptoms of stink bug feeding on maturing apple fruit include yellow or red spots (0.5-1 cm diameter), dimpling or depressions, and internally brown spongy flesh. Stink bug feeding on apple at earlier stage would result in corky depressions on the surface and become cat-faced as fruit develops. Feeding may also cause fruit black rot due to secondary infestation of fungal disease such as *Alternaria* spp. (Zhang et al. 2019). Feeding damage is mostly occurred to the fruits growing on the outside area or the surface of the tree, and shaded part of the damaged fruit. Zhang et al (2019) reported that the fruit damage was more severe in apple orchards neighboring to non-managed woodlands in mountain areas, and the fruit injury rate caused by stink bug pests could be up to 60%. Fruit damage was also more severe in those apple orchards with a later harvest when stink bugs migrating from surrounding orchards completed with harvest.

Pear. Both YSSB and BMSB are regarded as the key pests of pear in Hebei province (Zhang et al. 1993; Ji et al. 2006) as well as *Dolycoris baccarum* (L.) in Anhui province (Xu & Jiang 1999). The damage rate of stink bugs was observed at 5-10% in most pear orchards and up to 20-30% in severely attacked pear orchards (Xu & Jiang 1999), or as higher as 40-60% (Zhang et al. 1993). All the research work in the literature collected did not separate the damage rates between the stink bug species, which is indeed challenging as they mostly occur at same time period during the pear growth season. Xu & Jiang (1999) reported that YSSB adults made the most damage to pear fruits between end June and mi-July.

Other crops. Crop damage by YSSB has been also reported in other economic important crops in China. YSSB attacked pomegranate flowers and fruits, and the injury rates was commonly reaching 12-15% and 15-20%, respectively (Zhou et al. 2000). Fruit injury rate of 10-25% by YSSB was reported on Chinese jujube (Lu et al. 1992). As an introduced plant in China since 1960-1970s, macadamia nut was seriously attacked by several stink bug pests including YSSB and BMSB, and the nut damage rate is over 40% and even up to 90% in those not well managed orchards in Guangxi province (Tan et al. 2017). In the case of macadamia nut, feeding by stink bugs can result in shrinking or rotting nuts with no or significantly reduced marketing value.

Nuisance Problem. As the overwintering adults aggregate and overwinter in large numbers inside or under roofs of human dwellings (Lu et al. 1992; Zhang et al. 1993; Wang & Kang 2000), YSSB would be also an important nuisance pest like BMSB (Leskey & Nielsen 2018).

3.6 Integrated pest management approaches

3.6.1 Sampling and monitoring

Visual observation is the primary sampling method to assess emergence patterns, relative population density, and seasonal phenology of YSSB field populations (Zhang et al. 1993; Su 1997; Wang & Kang 2000; Zhou et al. 2000; Zhang et al. 2006). Zhang (2018) used sweep nets to measure population dynamics of stink bug pests between end June and early October in a kiwifruit orchard at Zhouzhi county, Shaanxi province, and found YSSB captures peaking on 10^{th} July (3.4 stink bugs per 10 sweeps of a net) and 7^{th} September (4.6 stink bugs per 10 sweeps of a net). Zhang (2018) also used four different colored sticky traps (25 cm × 30 cm per piece, 20 pieces per trap) in the same kiwifruit orchard to compare their efficiencies and obtained similar result that YSSB captures reached peaks in mid-July and early September. Maximum mean YSSB catches were recorded in bluish-green sticky trap (0.6 stink bugs per trap) followed by blue and yellow traps, and least numbers of YSSB catches were recorded in green traps (0.3 stink bugs per trap). Due to the lower efficiency and costs of colored sticky traps, sweep net was recommended to be used for sampling and monitoring of YSSB in the field (Zhang 2018).

Moreover, beat sampling would also work because of the dropping behavior of disturbed YSSB, but not yet being reported. Based on our own experiences with BMSB, beat sample is challenging to implement on kiwifruit as the vines are fixed and it is difficult to beat/shake vines and to make stink bugs drop from vines.

3.6.2 Cultural control

Sanitation is one of the most recommended cultural control methods to combat YSSB in China. During winter season, sanitary measures such as clearing ground covering vegetation within or nearby the orchard, fallen leaves and vines, and removal of dry bark have been suggested (Xu & Jiang 1999; Wang & Kang 2000; Zhou et al. 2000; Liu & Liu 2017). Sanitation measures should be also applied to the storage facility, human-made dwellings or other artificial structures within or around the kiwifruit orchard to remove and kill the overwintering YSSB adults (Wang & Kang 2000). Other sanitation measure includes destruction of alternate hosts within or nearby the orchard (Feng 2007). As a common pest control practice for the ornamental trees during plant dominant season, kiwifruit or pomegranate trunks could be also painted with lime water, lime-sulfur solution or Bordeaux mixture to destruct the overwintering sites and suppress YSSB overwintering populations (Zhou et al. 2000; Liu & Liu 2017).

3.6.3 Physical control

According to YSSB's aggregation behavior in the overwintering sites in fall, trapping with a bunch of straw attached to the base of the trunk or branch/vine can be used to catch overwintering adults and kill them by burning or other appropriate means (Song & Wang 1993; Feng 2007; Liu & Liu 2017). Song & Wang (1993) also recommended to apply this trapping method in Chinese jujube orchard with 2-3 trees per mu and 1-2 bunches of straws per tree depending on population density of YSSB during the season.

Some authors have suggested bagging as an effective control method to avoid feeding injury by YSSB (Zhang et al. 2006; Liu & Liu 2017). Liu & Liu (2017) stated that feed injury rate of kiwifruit with bagging was significantly reduced in comparison to those without bagging. Zhang et al (2006) also confirmed a significant control effect of bagging to protect apple/peach/pear/apricot from damages of stink bugs (i.e. YSSB and BMSB), which damage rate reduced from 37.5-62.0% for no-bagging fruit to 5.9-8.6% for bagging fruit. However, stink bugs such as YSSB and BMSB with long stylet can still pierce through the bag and feed on apple, pear or peach inside the bag (Zhang et al. 1993; Zhang et al. 2019). Therefore, it was highly recommended to use a relatively larger bag (size over 21 cm × 19 cm, and 2 cm distance between the fruit and the inner side of the bag) to cover apple (Zhang et al. 2006). Liu & Liu (2017) also suggested to use a relatively larger bag for kiwifruit bagging.

Other physical control methods include mechanical removal of eggs and nymphs from crops (Lu et al. 1992; Su 1997; Xu & Jiang 1999; Feng 2007; Liu & Liu 2017), removal of overwintering adults when they disperse into or from overwintering sites such as human dwellings, agricultural machinery facility room or other artificial shelters (Song & Wang 1993; Zhang et al. 1993; Zhang et al. 2006; Feng 2007), and removal of YSSB by shaking or beating vines in early spring, early morning or evenning because of their dropping behavior (Feng 2007; Liu & Liu 2017; Xu 2019). However, these physical removal methods are time consuming and labor cost, which might be not effective and efficient for growers with large areas of fruit plantations.

Using light trap was only mentioned as a control method but no details explained in the literature (Zhang et al. 2017b), whereas Lu et al (1992) stated that light trap could be used at night nearby Chinese jujube orchard between early May and June. Xu (2019) stated that YSSB nymphs and adults have very weak orientation tendency towards light. Due to these controversy reports, the usefulness of light trap is arguable.

3.6.4 Host plant resistance

The crop itself is the starting point for any IPM system, and thus host plant resistance would play a fundamental role for IPM (Xu 2019). Liu & Liu (2017) found that YSSB did not have any feeding preference and cause similar feeding injury among three kiwifruit cultivars, namely Cuixiang, Qinmei and Hayward. But feeding preferences of YSSB on peaches and Chinese jujubes were reported (Song & Wang 1993; Wang 1998; Wang et al. 2000). In a germplasm nursey in Henan province, varieties of nectarines (*Prunus persica var. nectarina*), flat peaches (*Amygdalus persica* L.‘Compressa’) and yellow-fleshed peaches (*Amygdalus persica* L.) were highly susceptible to YSSB, while varieties of white peaches and ornamental flower peaches were medium susceptible, and varieties of dwarf peaches (*Amygdalus persica* L. *var. densa* Makino) were resistant with no fruit injury by YSSB (Wang 1998; Wang et al. 2000). The pest resistance level was also different among the peach varieties in a same group, and the pest resistance level of a peach variety might be link with presence of fuzz on the fruit skin or not. For example, those varieties without fuzz in nectarine groups were heavily attacked by YSSB, whereas those varieties with fuzz in ornamental flower peach groups were much less attacked (Wang 1998; Wang et al. 2000). In a field cage study on different Chinese jujube varieties, Song & Wang (1993) found that YSSB preferred to feed on “*Hui-zao*” than “*Ji-xin-zao*” and “*Jiu-yue-qin*”, and the mortality of YSSB nymphs or adults was very higher in the later two resistant varieties.

3.6.5 Biological control

Biological control can be a cost-effective, sustainable and environmentally safe approach for the management of arthropod pests in long term. There are only a few literature reported on potential biological control agents of YSSB in China, including the parasitoids, predators and entomopathogens (Table 4). Hymenopteran egg parasitoids are the primary natural enemy of YSSB, but parasitism rates are highly variable among different habitats and studies (Zhang et al. 1993; Su 1997; Wang & Qiu 1998; Liu & Liu 2017). Liu & Liu (2017) mentioned that the parasitism rate of YSSB in pear and apple orchards could be reached up to 70-80%, and thus stated that biological control with mass release of egg parasitoids would effectively control YSSB in kiwifruit orchard even though there was no field release data to support such an optimistic assumption. A field study in Hebei province showed that *Trissolcus flavipes* Thomon (Hymenoptera: Scelionidae) was a dominant parasitoid of YSSB eggs in pear and peach orchards, and the mean and maximum parasitism rate between May and August was 30.6% and 43.5%, respectively (Zhang et al. 1993). Wang & Qiu (1998) reported that *Anastatus fulloi* Sheng et Wang (Hymenoptera: Eupelmidae) and *Telenomus* sp. (Hymenoptera: Scelionidae) were the two dominant parasitoids attacking 1st generation YSSB eggs in the field with a parasitism rate of 28.9% and 27.1%, respectively. As for the 2nd generation YSSB eggs, *Ootetrastichus* sp. (Hymenoptera: Eulophidae) was the most dominant parasitoid with a mean parasitism rate of 42.5%, followed by *A. fulloi* (21.2%), *Telenomus* sp. (10.8%) and *Mesopolobus tabatae* (Ishii) (Hymenoptera: Pteromalidae) (3.8%). By contrast to above studies, Su (1997) reported only 2% parasitism rate of YSSB eggs in the field from a 3-year study in Xi county, Henan province. Anyhow, as mass rearing techniques of *Anastatus* species have been well established in China (Li et al. 2014), there is higher potential to use *A. fulloi* with augmentative biological control approach to attack YSSB eggs, and thereby suppress YSSB nymphal populations in the field.

The literature information on predators and entomopathogens of YSSB were very limited. Su (1997) made a very general statement that birds such as black drongo, great tit and magpie could play an important role in suppressing YSSB nymphs in fruit orchards. Interestingly, Lu et al (1992) found that *Beauveria bassiana* (Bals.) Vuill. infested YSSB adults and the infestation rate was 20-30% in Chinese jujube orchard during the raining season in June in Anhui province. Considering improved technology development and increased application of micro-biopesticides nowadays, *B. bassiana* would be a promising biological control agent against YSSB for further research in the future.

As far as biological control is concerned, we should be also aware of defense behavior of stink bugs. When they are disturbed, YSSB would release defensive chemicals which would be also used against natural enemies (Xu 2019). Laboratory behavioral bioassays showed that the odor of YSSB male metathoracic scent gland elicited an alarm response, making the conspecific male individuals alert and disperse (Kou et al. 1989). Kou et al (1989) also identified nine compounds from the glandular secretion of both YSSB males and females, including (*E*)-2-hexenal, (*E*)-4-keto-2-hexenal, (*E*)-2-hexenyl acetate, *n*-undecane, *n*-dodecane, (*E*)-2-decenal, *n*-tridecane, (*E*)-2-decenyl acetate, and *n*-pentadecane, among which *n*-tridecane and (*E*)-4-keto-2-hexenal comprised nearly 70% of the total secretion. Although the biological functions of these compounds is to be further clarified, understanding of such behavioral and chemical ecology of YSSB and their interactions with parasitoids or predators would help develop novel methods to enhance our biological control attempts.

Table 4 List of potential biological control agents against *Erthesina fullo* identified in China

Agent	Family	Host stage affected	% parasitism[1]	Reference
Parasitoid				
Anastatus fulloi Sheng et Wang	Eupelmidae	Egg	28.9%	Wang & Qiu 1998
Mesopolobus tabatae (Ishii)	Pteromalidae	Egg	3.8%	Wang & Qiu 1998
Ootetrastichus sp.	Eulophidae	Egg	42.5%	Wang & Qiu 1998
Telenomus gifuensis Ashmead	Scelionidae	Egg	2%	Su 1997
Telenomus sp.	Scelionidae	Egg	27.1%	Wang & Qiu 1998
Trissolcus flavipes Thomon (syn. *Trissolcus cultratus* Mayr)	Scelionidae	Egg	43.5%	Zhang et al. 1993
Trissolcus japonicus (Ashmead) (syn. *Trissolcus halyomorphae* Yang)	Scelionidae	Egg	-	Zhang et al. 2017a
Trissolcus sp.	Scelionidae	Egg	2%	Su 1997
Predator				
Birds	-	Nymph and adult	-	Xu 2019; Zhou et al. 2000
Black drongo (*Dicrurus macrocercus* Vieillot)	Dicruridae	Nymph and adult	-	Su 1997
Great tit (*Parus major* L.)	Paridae	Nymph and adult	-	Su 1997
Magpie (*Pica pica* L.)	Corvidae	Nymph and adult	-	Su 1997
Chickens	Phasianidae	Nymph and adult	-	Zhou et al. 2000
Mantis	-	Nymph	-	Xu 2019
Spider	-	Nymph and adult	-	Xu 2019
Entomopathogen				
Beauveria bassiana (Bals.) Vuill.	Cordycipitaceae	Adult	30%	Lu et al. 1992

[1] % parasitism (either maximum or mean) in the field is included when it was clearly mentioned in original paper.

3.6.6 Chemical control

Chemical control is currently the most adopted method against YSSB in China (Xu 2019). A list of insecticides recommended against YSSB is summarized in Table 5, including mainly organophosphates and pyrethroids. The efficacy of some insecticides against YSSB was tested either in the laboratory or in the field, which showed satisfactory control results. The mortality rate of YSSB nymphs reached 100% in 24 or 48 h after their exposure to some of the insecticides in the laboratory, e.g. malathion, omethoate, deltamethrin, fenpropathrin and lambda-cyhalothrin (Su 1997). Field cage test on Chinese jujube showed that isocarbophos and omethoate provided nearly 100% and over 95% control of YSSB in 48 h after spraying, respectively (Song & Wang 1993). Zhang et al (2006) reported that insect growth regulators such as chlorbenzuron and triflumuron provided over 90% and 80% control of YSSB nymphs and adults, respectively. In a 100-ha pomegranate orchard, the damage rate of flower/bud and fruit from YSSB was reduced to 5-7% and 3-5%, respectively, after spraying of fenvalerate, lambda-cyhalothrin, omethoate, dichlorvos and methidathion (Zhou et al. 2000). Besides pesticide spray to control YSSB, Feng (2007) suggested to use smoke smoking fumigation with a combination of sawdust, ammonium nitrate, diesel, and dichlorvos in the centre of kiwifruit orchard in late evening or early morning of a cloudy day. Fumigation could be also applied for YSSB overwintering adults in the artificial buildings (not for human living) surrounding fruit orchards (Zhang et al. 2006). Moreover, a repellent (‘Quchunwang’) of stink bugs on vines could be applied in early June at the ratio of 40-60 pieces per mu, which would last for 46-87 day with repellent effect of approximately 70-96.4% (Wei et al. 2000).

Timing of insecticide spray is an important factor affecting its’ efficacy against YSSB. Wang & Kang (2000) suggested to spray insecticides at different crucial time periods in kiwifruit orchard, attacking overwintering YSSB adults, eggs and 1-2 instar nymphs, respectively. Others also suggested targeting insecticide treatments against YSSB nymphal populations (Song & Wang 1993; Su 1997; Feng 2007). These recommendations are all very useful against YSSB, however, the recommended chemical insecticides except insect growth regulators are highly toxic to bees (Table 5) and most probably other natural enemies in the field. Therefore, to protect natural enemies in the field, Zhang et al (2006) suggested to apply insect growth regulators rather than those broad-spectrum insecticides during the peak time of YSSB occurrence. Furthermore, it is very important to apply any insecticide following technical recommendations on the label of the commercial product, e.g. dosage calibration, timing of application, pre-harvest interval, etc. Although no resistance of YSSB to insecticides has been reported, it is highly recommended to rotate between insecticides with different modes-of-action, and only use one insecticide but no pesticide cocktails at a time.

Table 5 List of insecticides against *Erthesina fullo* reported in in China

Insecticide class	Active ingredient	Host stage affected	Preharvest interval (days) [1]	Toxicity to bees[2]	Reference
Carbamates	Metolcarb	Adult	25	Highly toxic	Wang & Kang 2000
Insect growth regulator (Benzoylureas)	Chlorbenzuron	Nymph	7	Relatively non-toxic	Zhang et al. 2006
	Triflumuron	Nymph	21	Relatively non-toxic	Zhang et al. 2006
Organophosphates	Acephate[3]	Egg	45	Highly toxic	Wang & Kang 2000
	Chlorpyrifos[3]	Nymph	28	Highly toxic	Zhang et al. 2006
	Dichlorvos	Nymph, adult	7	Highly toxic	Wang & Kang 2000
	Fenitrothion	Nymph	15	Highly toxic	Wang & Kang 2000
	Isocarbophos[3]	Egg, nymph, adult	28	Highly toxic	Song & Wang 1993; Wang & Kang 2000
	Malathion	Nymph, adult	10	Highly toxic	Su 1997; Wang & Kang 2000
	Methidathion	Adult	30	Highly toxic	Wang & Kang 2000
	Omethoate[3]	Nymph, adult	21	Highly toxic	Su 1997; Wang & Kang 2000
Pyrethroids	Alpha-cypermethrin	Nymph	14	Highly toxic	Xu 2019
	Beta-cypermethrin	Nymph	40	Highly toxic	Xu 2019
	Bifenthrin	Nymph	10	Highly toxic	Zhang et al. 1993
	Deltamethrin	Nymph	14	Highly toxic	Su 1997; Wang & Kang 2000
	Fenpropathrin	Nymph, adult	14	Highly toxic	Zhang et al. 1993; Su 1997; Wang &

	Fenvalerate	Nymph, adult	20	Highly toxic	Kang 2000; Song & Wang 1993; Wang & Kang 2000
	Lambda-halothrin	Nymph	7	Highly toxic	Su 1997; Xu 2019
Repellent	Quchunwang[4]	Adult	Unknown	Unknown	Wei et al. 2000

[1] Maximum preharvest day is used if it is different days between different host crops.
[2] Toxicity to bees: Highly toxic (LD_{50}<2μg a.i./bee); Moderately toxic (LD_{50} 2-11 μg a.i./bee); Relatively non-toxic (LD_{50}>11μg a.i./bee), according to the information from North Carolina Agricultural Chemicals Manual (2016), College of Agriculture and Life Sciences, NC State University, USA.
[3] Chemicals currently in phase-out process and not permitted to apply on vegetables, oranges, and/or other fruit plants in China.
[4] Product name only reported in literature but not available in the registered data of China Pesticide Information Network.

3.6.7 Area-wide control approach

As mentioned above, YSSB adults can disperse between host plants and across the landscape. Through field surveys, Song & Wang (1993) confirmed that the occurrence of YSSB is much more severe in mixed fruit orchards of Chinese jujube and persimmon/pear/apricot than pure Chinse jujube orchards. Higher densities of YSSB were observed on plants in edge rows than those in central area of the orchards (Song & Wang 1993). Such a strong edge effect also occurs in kiwifruit orchard, and the association of YSSB with adjacent forested areas and preferred host plants may drive this border effect (Liu & Liu 2017). Based on the phenological information of YSSB, Zhang et al (1993) suggested to take area-wide approach to improve control effects, applying chemical control mainly on paulownia and peach in June-July and then on pear in July-August. Therefore, area-wide control approach should be deployed to manage YSSB not only on target crops (e.g. Chinese jujube, pear, kiwifruit) but also on host plants in surrounding areas (Song & Wang 1993; Zhang et al. 2006; Liu & Liu 2017).

3.7 Conclusions

YSSB is an important stink bug species in China, causing economic damage in many horticultural crops such as kiwifruit, apple, pear, peach, pomegranate and Chinese jujube although actual economic losses in those crops are not well documented in the published literature. Although its' reproductive output is less than BMSB, YSSB still shares many other biological characteristics with BMSB, e.g. polyphagous, a primarily *r*-selected life history, reproductive diapause, high dispersal capacity, aggregation behavior, and association with human-modified ecosystems, which make the latter a successful global invader (Leskey & Nielsen 2018). As suggested by David & Xu (2018), we could deduce that YSSB is a potential invasive species with significant biosecurity threats to other countries outside its native range, including New Zealand. If YSSB arrives in New Zealand, it could potentially infect species of economic importance to New Zealand, such as stone fruit, apples and kiwifruit.

Current control programmes for YSSB in cultivated crops in China rely primarily on chemical insecticides, which are mostly conventional broad-spectrum products and not always compatible with IPM programmes. The control effects of insecticide spray may be deteriorated because abundant wild host plants can serve as a reservoir for this highly polyphagous and mobile pest to reinvade managed crops. Moreover, extensive and indiscriminate usage of these broad-spectrum insecticides would result in environmental degradation, adverse effects on human health and other organisms, residue problems in the agricultural produce, eradication or reduction of pollinators and natural enemies and the development of resurgence and resistant to pesticides in insect pests. It is therefore very important to explore more specific and environmentally friendly insecticides and apply a biologically-based area-wide IPM strategy against YSSB and other stink bugs such as BMSB. Biological control agents such as *A. fulloi* and *B. bassiana* shall be further investigated to explore augmentative biological control approach, which would play a more important role in the IPM strategy for sustainable management of YSSB.

3.8 Research gaps identified from the literature review

While we have elaborated much about the biology, ecology, and management of YSSB as described above, additional key research questions remain, including:

(a) Early- and late season biology and ecology of YSSB: Biology and ecology of YSSB adults emerging from overwintering site in the early season and aggregating from host plants to overwintering sites in the fall are not well characterized. There might be a gap between the time period in which YSSB disperses from overwintering sites and when it appears in agricultural crops, specifically tree fruits. Where emerged overwintering adults go and what they do immediately following their exit from overwintering sites are unknown. Which factors drive YSSB adults enter into or exit from overwintering diapause? With a clear understanding of these important life history strategies, we might develop a novel control tactics to target these crucial periods before their invasion into target crops and thereby protect the target crop from feeding injury by YSSB.

(b) Dispersal behavior and landscape ecology of YSSB: although several studies have tried to assess adult dispersal between and among host and showed the edge effect of YSSB population densities, a more systematic and standardized study throughout the growing season of crops with adjacent wooded habitats is still required to assess dispersal behavior, distribution pattern and population dynamics of YSSB across landscape as well as the influence of landscape features on YSSB abundance in various habitats. Laboratory bioassay study with flight mills will also provide useful information on dispersal capacity of YSSB adults and nymphs. The knowledge gained here will help us better understand the potential of YSSB migrating into and among crops and spreading across landscapes, and thereby developing an area-wide IPM strategy to control YSSB.

(c) Semiochemicals and trap-based monitoring: The existing sampling methods with visual observation, sweep net or beating are time consuming and inefficient. The pheromone-based lures and traps have been successfully developed and applied for monitoring of BMSB (Weber et al. 2017; Leskey & Nielsen 2018). It is also possible to carry out chemical ecology research on YSSB, particularly identification of aggregation pheromone utilized by YSSB, and develop pheromone-based sampling and monitoring tools. This would be very useful not only for proper field research on phenology and dynamics of YSSB on target crops but also to lay a foundation for development of a surveillance or IPM programme for YSSB. More thorough understanding of phenology and dynamics of YSSB on target crops serves as baseline knowledge for development of sound monitoring and management programmes for YSSB.

(d) Last but not least, screening of much safer and environmentally friendly insecticides with no or less negative impact on pollinators and natural enemies is desirable for any IPM programme against YSSB, as well as development of economic thresholds if possible.

3.9 The key Chinese articles to be fully translated into English (recommendation only)

Even though our current literature review covers the most key knowledge of YSSB in China, considering the business sector and concerns of Zespri as well as the quality of the publication, we would like to recommend the following four key Chinese literatures related to both YSSB and kiwifruit to be fully translated into English if necessary.

1) Feng, H. 2007. The occurrence and control of pests in kiwifruit orchards. *Northwest Horticulture* (12): 22.

2) Liu, B., Liu, G.P. 2017. The damage and control measures of yellow spotted stink bug in kiwifruit orchard. *Shananxi Journal of Agricultural Sciences* 63(12): 63-64.

3) Wang, H.Z., Kang,Y.X. 2000. Control of yellow spotted stink bug on kiwifruit. *Northwest Horticulture* (2): 38-39.

4) Zhang, Y. 2018. The occurrence of stink bugs on kiwifruits. *Shananxi Journal of Agricultural Sciences*. 64(10): 27-28, 52.

Moreover, there are another three key Chinese literatures with more detailed knowledge on YSSB biology on mixed fruit trees, Chinese jujube and pomegranate in Hebei, Henan and Yunnan provinces, respectively.

5) Zhang, C.T., Li, D.L., Su, H.F., Xu, G.L. 1993. A study on the biological characteristics of *Halyomorpha picus* and *Erthesina fullo*. *Forest Research* 6(3): 271-275.

6) Song, H.W., Wang, C.M. 1993. Damage by *Halyomorpha halys* (Stal) and *Erthesina fullo* (Thunberg) to jujube trees and their control. *Entomological Knowledge* 30(4): 225-228.

7) Zhou, Y,S., Yin, Z.H., Luo, G.L., Wang, S.L., Lu, J., Zhu, T.G., Fan, J., Li, Z.X. 2000. Occurrence of *Erthesina fullo* Thunberg and its control. *Journal of Southwest Agricultural University* (22):3

Funding

This research was supported by Zespri Group Ltd (project number BS20093).

Acknowledgements

CABI is an international intergovernmental organization and we gratefully acknowledge the core financial support from our member countries (and lead agencies) including the United Kingdom (Department for International Development), China (Chinese Ministry of Agriculture and Rural Affairs), Australia (Australian Centre for International Agricultural Research), Canada (Agriculture and Agri-Food Canada), Netherlands (Directorate-General for International Cooperation), and Switzerland (Swiss Agency for Development and Cooperation). See https://www.cabi.org/about-cabi/who-we-work-with/key-donors/ for full details. We thank Elaine Gould and Zhitan Sun (Zespri) for their constructive comments on an earlier draft of the report. We also thank Zhande Liu and Jianjun Li (Northwest Agriculture and Forestry University, China) and Lu Yan (Haisheng Kiwifruit Orchard, China) for taking insect pictures in their kiwifruit orchards.

References

Ahmad I, Memon N, Kamaludin S 2004. A revision of hayline stink bug genus *Erthesina* Spinola (Hemiptera: Pentatomidae: Pentatominae) and their clasdistics. *Pakistan Journal of Zoology* 36(4): 285-293.

Anon. 2014. Yellow spotted stink bug. Ministry for Primary Industries. Wellington, New Zealand. http://www.kvh.org.nz/vdb/document/100435 (accessed October 2019).

CABI ISC 2019. Datasheet report for *Erthesina fullo*. https://www.cabi.org/ISC/datasheetreport/21901 (accessed October 2019).

CABI 2020. CAB Abstracts (https://www.cabi.org/publishing-products/cab-abstracts/) and CAB Abstracts Archive (https://www.cabi.org/publishing-products/cab-abstracts-archive/) (accessed January 2020).

CNKI 2019. WKBD discipline and publishing resources distribution. CNKI Guide. 2019.12.28, No. 37. In Chinese.

Feng H 2007. The occurrence and control of pests in kiwifruit orchards. *Northwest Horticulture* (12): 22. In Chinese.

Fraser D, Kumar S, Aguilar G 2017. Mapping the potential global range of the brown marmorated stink bug, *Halyomorpha halys*, with particular reference to New Zealand. *Climate* 5: 75, doi:10.3390/cli5030075.

Gao CQ, Wang MN, Wang Y, Zhang YF, Hao DJ 2019. Investigation of forest true bugs (Hemiptera: Heteroptera) from Shanghai area. *Journal of Nanjing Forestry University* 43(1):167-174. In Chinese.

Geng HL, Yang HY, Li JR, Wang SL, Zhang QZ 2010. Damage of yellow spotted stink bug to *Fraxinus chinensis* Roxb and its' control techniques. *Jilin Agriculture* (12): 127. In Chinese.

Ji SL, Li J, Mu XH, Zhang YQ, Bian XR 2006. Integrated control of yellow spotted stink bug and brown marmorated stink bug BMSB. *Northern Fruits* (5): 25-26. In Chinese.

Jin KX, Liang CJ, Deng DL 1981. A study on insect vectors of *Paulownia* witches' broom disease. *Forestry Science and Technology Newsletter* (12): 23-24. In Chinese.

Kou R, Tang DS, Chow YS 1989. Alarm pheromone of pentatomid bug, *Erthesina fullo* Thunberg (Hemiptera:Pentatomidae). *Journal of Chemical Ecology* 15(12): 2695-2702.

Landcare Research 2019. Yellow spotted stink bug - *Erthesina fullo* (Thunberg, 1783). https://www.landcareresearch.co.nz/resources/identification/animals/pentatomidae/factsheets/erthesina-fullo (accessed June 2019)

Leskey TC, Nielsen AL 2018. Impact of the invasion brown marmorated stink bug in North America and Europe: history, biology, ecology, and management. Annual Review of Entomology 63: 599-618.

Li DS, Liao C, Zhang BX, Song ZW 2014. Biological control of insect pests in litchi orchards in China. *Biological Control* 68: 23-36.

Li Q, Cheng A, Wang H, Zhang W 1998. The prevention and control of the brown marmorated sting bug and yellow marmorated sting bug. *Plant Doctor* 11(1): 17–18. In Chinese.

Liu B, Liu GP 2017. The damage and control measures of yellow spotted stink bug in kiwifruit orchard. *Shananxi Journal of Agricultural Sciences* 63(12): 63-64. In Chinese.

Liu Y, Wu H, Xie Q, Bu W 2015. Novel detection of insecticide resistance related P450 genes and transcriptome analysis of the Hemimetabolous pest *Erhtesina fullo* (Thunberg) (Hemiptera: Heteroptera). PLOS One 10(5), e0125970. doi:10.1371/journal.pone.0125970.

Lu XX, Wu XC, Wang L 1992. Bionomics and control techniques of *Erthesina fullo* (*Thunberg*) on jujube trees. *Plant Protection* 18(4):30-32. In Chinese with English abstract.

Miles PW 1972. The saliva of Hemiptera. *Advances in Insect Physiology* 9: 183–255.

Mitchell C 2014. Yellow spotted stink bug found in NZ. The Timaru Herald, Nov 13 2014, https://www.stuff.co.nz/business/farming/cropping/63163690/ (accessed June 2019)

Ovid 2020. About Ovid. https://www.ovid.com/about-ovid.html (accessed January 2020)

Shiozawa, H. 1986. Transmission of *Paulownia* witches' broom by stink bugs, *Halyomorpha mista* Uhler. *Bull. Res. Lab. Jpn. Plant Prot. Assoc.* 4: 45-50.

Song HW, Wang CM 1993. Damage by *Halyomorpha halys* (Stal) and *Erthesina fullo* (Thunberg) to jujube trees and their control. *Entomological Knowledge* 30(4): 225-228. In Chinese.

Su YY 1997. Biology characteristics and control technique of yellow spotted stink bug. *Forest Science and Technology Development* (5): 44-45. In Chinese.

Tan DJ, Wang WL, Chen HS, Tan QJ, Tang XH, Zheng SF, Huang XY, Liang F 2017. The stink bugs that damage the *Macadamia ternifolia* F. Muell and control measu res.Agricultural Research and Application (1): 74-78. In Chinese.

Teulon DAJ, Xu B 2018. Biosecurity risks from stink bugs to New Zealand kiwifruit identified in Chinese language literature. *New Zealand Plant Protection 71: 140-150*.

VIP 2020. China Science and Technology Journal Database. http://www.cqvip.com/productor/pro_zk.shtml (accessed January 2020)

Walker K 2005. Yellow-spotted stink bug *(Erthesina fullo)* Updated on 11/25/2011 10:33:21 AM Available online: PaDIL - http://www.padil.gov.au. (accessed October 2019)

Wanfang Data 2020. Wanfang Data resources. http://www.wanfangdata.com.cn/resource_nav/index.do (accessed January 2020)

Wang GH, Qiu XL 1998. Preliminary survey report of egg parasitoids of yellow spotted stink bug. *Jiangxi Plant Protection* (21): 4. In Chinese.

Wang HZ, Kang YX 2000. Control of yellow spotted stink bug on kiwifruit. *Northwest Horticulture* (2): 38-39. In Chinese.

Wang, K. 2007. The research on investigation of pest occurrence and control of wild fprsythia in Shaanxi. *Northwest Agricultural and Forestry University, MSc Thesis*, pp. 36. In Chinese with English abstract.

Wang LH, Guo LL, Yu H, Mao XR, Wang YB 2013. Investigation of insect community of *Trifolium repens* lawn in east of Henan province. *Journal of Henan Agricultural Sciences* 42(3): 87-91. In Chinese with English abstract.

Wang LR, Zhu GR, Fang WC, Wang YH 2000. Resistance of peach varieties to *Erthesina fullo* Thunb. *Journal of Fruit Science* 17 (Supplement issue): 22-25. In Chinese with English abstract.

Wang QY 2015. *Erthesina fullo*. In: Institute of Plant Protection, Chinese Academy of Agricultural Sciences, China Society of Plant Protection, ed. Crop Disease and Insect Pests in China. Third Edition, Vol. II. China Agriculture Press, Beijing, China. pp.965-967. In Chinese.

Weber DC, Morrison WR, Khrimian A, Rice KB, Leskey TC, Rodriguez-Saona C, Nielsen AL, Blaauw BR 2017. Chemical ecology of *Halyomorpha halys*: discoveries and applications. *Journal of Pest Science* 90: 989–1008. doi: 10.1007/s10340-017-0876-6.

Wei YP, Zhang X, Liu YN 2000. Repellent effect of 'Quchunwang' to stink bugs in orchards. *Shaanxi Journal of Agricultural Sciences* (5): 16-17.

WoS Group. 2020. Web of Science. https://clarivate.com/webofsciencegroup/solutions/web-of-science/ (accessed January 2020)

Xu HJ, Wang F, Guo TB, Zhang RF, Song MH, Zhou XY, Qian GZ, Gao SF 2017. Investigation on species and damage of insects in Hemiptera: Heteroptera in Xuzhou urban and suburb area. *Journal of Jiangsu Forestry Science & Technology* 44(3): 9-14. In Chinese with English abstract.

Xu MW, Jiang YC 1999. Three stink bugs damaging Dangshan pear in ancient Yellow River areas. *Shanxi Fruits* (2): 29. In Chinese.

Xu ZH 2019. How to control the *Erthesina fullo* that can use chemical weapons. *Bonsai Flowers and Trees* (4): 36-37. In Chinese.

Yang SY, Wang DY, Chen GM, Li H, Bian XR 2006. The occurrence and integrated control techniques of the yellow spotted sting bug and brown marmorated sting bug. *Shanxi Fruits* (3): 10-11. In Chinese.

Yang WY 1962. Economic Insect Fauna of China. Fasc. 2, Hemiptera: Pentatomidae. China Science Press, Beijing. pp. 138. In Chinese.

Yu MF, Zhu Y, Zhao HQ 2009. Population quantity of *Erthesina fullo Thunberg* and the community analysis of *Populus nigra* in SUYA Lake Wetland. *Guangdong Agricultural Sciences* (8): 208-210. In Chinese with English abstract.

Zhang CT, Li DL, Su HF, Xu GL 1993. A study on the biological characteristics of *Halyomorpha picus* and *Erthesina fullo*. *Forest Research* 6(3): 271-275. In Chinese with English abstract.

Zhang JP, Zhang F, Gariepy T, Mason P, Gillespie D, Talamas E, Haye T 2017a. Seasonal parasitism and host specificity of *Trissolcus japonicus* in northern China. *Journal of Pest Science* 90: 1127-1141. http;//doi.org/10.1007/s10340-017-0863-y.

Zhang TX, Jiang JF, Chang R 2017b. The occurrence and control of major fruit pests on jujube trees. *Modern Rural Technology* (8): 34. In Chinese.

Zhang Y 2018. The occurrence of stink bugs on kiwifruits. *Shananxi Journal of Agricultural Sciences* 64(10): 27-28, 52. In Chinese.

Zhang YQ, Mu XH, Ji SL, Li J, Bian XR 2006. Biology and control of the yellow spotted sting bug and brown marmorated sting bug. *Deciduous Fruits* (3): 42-44. In Chinese.

Zhang ZF, Dong XL, Lian S, Wang CX, Li BH. 2019. The damage sumptoms and control of stink bugs on apple. *Fruit Growers' Friends* (1): 31, 52. In Chinese.

Zhou YS, Yin ZH, Luo GL, Wang SL, Lu J, Zhu TG, Fan J, Li ZX 2000. Occurrence of *Erthesina fullo Thunberg* and its control. *Journal of Southwest Agricultural University* 22(3): 234-236. In Chinese with English abstract.

Appendix 1.

A Full List of Literature Related to YSSB under Different Target Crops or Research Subjects

Kiwifruit (6)

1. Feng, H. 2007. The occurrence and control of pests in kiwifruit orchards. *Northwest Horticulture*. (12): 22. (In Chinese) [冯华. 猕猴桃园蝽象的发生与综合防治. 西北园艺, 2007, (12): 22.]

2. Liu, B., Liu, G.P. 2017. The damage and control measures of yellow spotted stink bug in kiwifruit orchard. *Shananxi Journal of Agricultural Sciences* 63(12): 63-64. (In Chinese) [刘博, 刘国鹏. 麻皮蝽在猕猴桃园的危害及防治措施. 陕西农业科学, 2017, 63(12): 63-64.]

3. Wang, H.Z., Kang,Y.X. 2000. Control of yellow spotted stink bug on kiwifruit. *Northwest Horticulture* (2): 38-39. (In Chinese) [王鸿哲, 康云霞. 猕猴桃麻皮蝽的防治. 西北园艺, 2000, (2): 38-39.]

4. Zhao, Y.J., Qu, X.N. 2008. The control of pests and diseases during the kiwifruit dormant period. *Fruit Growers' Friend* (12): 31, 40. (In Chinese) [赵英杰, 屈学农. 猕猴桃休眠期病虫害防治方法. 果农之友, 2008, (12): 31, 40.]

5. Zhang, Y. 2018. The occurrence of stink bugs on kiwifruits. *Shananxi Journal of Agricultural Sciences* 64(10): 27-28, 52. (In Chinese) [张毅. 蝽象在猕猴桃上的发生规律研究. 陕西农业科学, 2018, 64(10): 27-28,52.]

6. Teulon, D.A.J., Xu, B.Q. 2018. Biosecurity risks from stink bugs to New Zealand kiwifruit identified in Chinese language literature. *New Zealand Plant Protection* 71: 140-150.

Mixed fruit tress** (incl. peach, pear, apple, etc. and paulownia)* ***(14)

7. Bian, X.R., Nan, S.Y. 2002. Integrated control technology of *Erthesina fullo* and *Halyomorpha halys*. *Fruit Trees Applied Technology and Information* (9): 18-19. (In Chinese) [边秀然，南淑英. 黄斑蝽 茶翅蝽综合防治技术.果树实用技术与信息, 2002, (9): 18-19.]

8. Chen, D.Y., Chen, H.J., Zhang, J.Y. 2004. Occurrence and control of YSSB and BMSB in orchard. *Fruit Growers' Friend*. (2): 52. (In Chinese) [陈冬亚，陈汉杰，张金勇. 果园黄斑蝽象和茶翅蝽的发生和防治技术. 果农之友, 2004, (2): 52.]

9. Ji, S.L., Li, J., Mu, X.H., Zhang, Y.Q., Bian, X.R. 2006. Integrated control of YSSB and BMSB. *Northern Fruits* (5): 25-26. (In Chinese) [姬松龄，李军，慕晓华，张永强，边秀然. 黄斑蝽、茶翅蝽综合防治技术研究.北方果树, 2006, (5): 25-26.]

10. Li, D.L., Zhang, C.T., Su, H.F., Xu, G.L. 1991. The control technology of the *Halyomorpha halys* and *Erthesina fullo*. *Hebei Agricultural Sciences and Technology* (03): 18. (In Chinese) [李大乱, 张翠疃, 苏海峰, 徐国良. 茶翅蝽象和黄斑蝽象的防治技术. 河北农业科技, 1991, (03): 18.]

11. Li, Q., Cheng, A., Wang, H., Zhang, W. 1998. The prevention and control of the brown marmorated sting bug and yellow spotted sting bug. *Plant Doctor* 11(1): 17–18. (In Chinese) [李钦存, 程爱英, 王红森, 张卫勇. 茶翅蝽和麻皮蝽的防治技术.对症处方. 植物医生, 1998, 11(1): 17-18.]

12. Qiu, L.F. 2007. Studies on biology of the brown marmorated stink bug *Halyomorpha halys* (Stål) (Hemiptera:Pentatomidae), an important pest for pome trees in China and its biological control. *Chinese Academy of Forestry*. (PhD thesis in Chinese with English abstract) [仇兰芬. 危害果树的重要害虫-茶翅蝽生物学及其生物防治研究. 博士学位论文.中国林业科学研究院. 2007]

13. Su, Y.Y. 1997. Biology characteristics and control technique of yellow spotted stink bug. *Forest Science and Technology Development* (5): 44-45. (In Chinese) [苏延英. 黄斑蝽生物学特性及防治技术研究. 林业科技开发,1997, (5): 44-45.].

14. Wang, Y.S., Xu, H., Hu, M.R. 2019.The control measures of three different stink bugs. *Northwest Horticulture* (6): 29-31. (In Chinese) [王一珊, 徐欢, 胡美绒. 果园三种主要蝽象的防治. 西北园艺, 2019, (6): 29-31.]

15. Yang, S.Y., Wang, D.Y., Chen, G.M., Li, H., Bian, X.R. 2006. The occurrence and integrated control techniques of YSSB and BMSB. *Shanxi Fruits* (3): 10-11. (In Chinese) [杨素英, 王冬毅, 陈桂敏, 李华, 边秀然. 黄斑蝽、茶翅蝽发生规律及综合防治技术研究.山西果树, 2006, (3): 10-11.]

16. Zhang, C.T., Li, D.L., Su, H.F., Xu, G.L. 1993. A study on the biological characteristics of *Halyomorpha picus* and *Erthesina fullo*. *Forest Research* 6(3): 271-275. (Chinese with English abstract) [张翠疃, 李大乱, 苏海峰, 徐国良. 茶翅蝽和黄斑蝽生物学特性研究. 林业科学研究, 1993, 6(3): 271-275.]

17. Zhang, R., Wang, E.Y., Yang, S.Y., Chen, G.M., Bian, X.R. 2006. New techniques to control YSSB and BMSB. *China Forests* (3): 41. (In Chinese) [张锐, 王冬毅, 杨素英, 陈桂敏, 边秀然. 黄斑蝽、茶翅蝽的综合防治新技术.中国林业, 2006, (3): 41.]

18. Zhang, Y., Zhao, D., Liu, W., Wang, K. 2010. The occurrence and control of major true bugs pests in orchard. *Modern Rural Technology* (13): 23–24. (In Chinese) [张艳霞, 赵丹, 刘文献, 王坤宇. 果园主要蝽类害虫发生规律与防治要点. 现代农村科技, 2010, (13): 23–24.]

19. Zhang, Y.Q., Mu, X.H., Ji, S.L., Li, J., Bian, X.R. 2006. Biology and control of the yellow spotted sting bug and brown marmorated sting bug. *Deciduous Fruits* (3): 42-44. (In Chinese) [张永强, 慕晓华, 姬松龄, 李军, 边秀然. 黄斑蝽和茶翅蝽的生物学特性及防治技术. 落叶果树, 2006, (3): 42-44.]

20. Hameed, S.F. 1978. New insect-pests of pome and stone fruit plants of Kulu valley, Himachal Pradesh. *Indian Journal of Entomology* 40(4): 454-45.

***Macadimia nut* (1)**

21. Tan, D.J., Wang, W.L., Chen, H.S., Tan, Q.J., Tang, X.H., Zheng, S.F., Huang, X.Y., Liang, F. 2017. The stink bugs that damage the *Macadamia ternifolia* F. Muell and control measures. Agricultural Research and Application (1): 74-78. (In Chinese) [谭德锦, 王文林, 陈海生, 潭秋锦, 汤秀华, 郑树芳, 黄锡云, 梁锋.为害澳洲坚果的蝽象类害虫及防治方法. 农业研究与应用, 2017, (1): 74-78.]

Apple (1)

22. Zhang, Z.F., Dong, X.L., Lian, S., Wang, C.X., Li, B.H.. 2019. The damage sumptoms and control of stink bugs on apple. *Fruit Growers' Friends* (1): 31,52. (In Chinese) [张振芳,

董向丽, 练森, 王彩霞, 李保华. 蝽类害虫在苹果果实上的危害状及其防控. 果农之友, 2019, (1): 31, 52.]

Chinese jujube (8)

23. Li, F., Deng,Y.H. 2004. Major jujube pests and control techniques in Jiangxi province. *Jiangxi Horticulture* (6): 41-43. (In Chinese) [李凡, 邓毓华. 江西枣树主要病虫害及其综合防治技术. 江西园艺, 2004, (6): 41-43.]

24. Li,Y., Miao,J.W. 2006. Control techniques for jujube pests. *Yantai Fruits* (3): 40. (In Chinese) [李扬, 缪金伟. 冬枣的病虫害防治技术.烟台果树, 2006, (3): 40.]

25. Lu, X.X., Wu, X.C., Wang, L. 1992. On the bionomics and control techniques of *Erthesina fullo* (*Thunberg*) on jujube trees. *Plant Protection* 18(4):30-32. (In Chinese with English abstract) [鲁绪祥, 吴献春, 王林. 枣树黄斑蝽象生物学特性及防治技术.植物保护.1992,18(4): 30-32]

26. Lv, Q. 2014. Non-pollution control measures for diseases and insect pests of winter jujube. Nongjia Keji (7): 53. (In Chinese) [吕倩. 冬枣病虫害无公害控制措施. 农家科技(下旬刊), 2014, (7): 53.]

27. Song, H.W., Wang, C.M. 1993. Damage by *Halyomorpha halys* (Stal) and *Erthesina fullo* (Thunberg) to jujube trees and their control. *Entomological Knowledge* 30(4): 225-228. (In Chinese with English abstract) [宋宏伟, 王彩敏. 麻皮蝽和茶翅蝽对枣树的危害及防治研究.昆虫知识, 1993, 30(4): 225-228.]

28. Wang, M.J., Bian, J.T., Mu, X.M., Guo, J.H. 2003. Non-pollution control measures for diseases and insect pests of winter jujube. *Bulletin of Agricultural Science and Technology* (03): 32-33. (In Chinese) [王美健, 边金田, 穆香明, 郭俊华. 冬枣病虫害无公害控制措施. 农业科技通讯, 2003, (03): 32-33.]

29. Yu, X.B., Zhou, X.Z., Zhou, Y.D., Bi, S.D., Wang, X.C., Zhao, X.J. 2009. Dynamics and difference of winter jujube and snow jujube pest population. *Anhui Agri Sci Bulletin* 15(21): 108, 159. (In Chinese with English abstract) [郁晓蓓，周夏芝，邹运鼎，毕守东，王晓翠，赵学娟. 冬枣和雪枣害虫种群动态及其差异. 安徽农学通报, 2009, 15(21): 108, 159.]

30. Zhang, T.X., Jiang, J.F, Chang, R. 2007. The occurrence and control of major fruit pests on jujube trees. *Modern Rural Technology* (8): 34. (in Chinese) [张同新, 蒋俊芳. 常如.枣树主要驻果害虫的发生及防治. 现代农村科技, 2007, (8): 34.]

Peach (4)

31. Wang, L.R., Zhu, G.R., Fang, W.C., Wang, Y.H. 2000. Resistance of peach varieties to *Erthesina fullo* Thunb. *Journal of Fruit Science* 17(Supplement issue): 22-25 (In Chinese with English abstract) [王力荣, 朱更瑞, 方伟超, 王玉华. 桃对黄斑蝽象的抗性. 果树科学, 2000,17(增刊): 22-25.]

32. Wang, Y.H. 1998. Resistance of peach varieties to yellow spotted stink bug. *Deciduous Fruits* (4):18-19. (In Chinese) [王玉华. 不同类群的桃对黄斑蝽象的抗性调查. 落叶果树, 1998, (4): 18-19.]

33. Yan, J.Y., Liu, S.Y. 2010. Pest control techniques of flat peach. *Shanxi Fruits* (3):53-54. (In Chinese) [闫加印, 刘士勇. 扁桃病虫害防治技术. 山西果树, 2010, (3):53-54.]

34. Xie, F.G., Ye, J.F., Zhang, Y.B. 2008. Non-polution control measures for diseases and insect pests of nectarine. *Forest By-products of China* (6): 49-51. (In Chinese) [谢发根, 叶金发, 张跃波. 油桃主要虫害的无害化综合治理. 中国林副特产, 2008, (6): 49-51.]

Pears (6)

35. Han, X.J. 2002. Damage of Stink bugs and its' control technology. *Plant Doctor* (02): 28. (In Chinese) [韩学俭. 梨蝽象危害及其防治技术. 植物医生, 2002, (02): 28.]

36. Liu, W.G. 2003. Investigation of insect community of *Trifolium repens* Lawn in east of Henan Province. *Journal of Henan Agricultural Sciences* 42(3):87-91. (Chinese with English abstract) [刘卫国. 豫东梨区蝽象优势种的发生及防治技术. 病虫害防治.2003. 42(3):87-91.]

37. Li, Z.H. 2017. Methods of pest control during pear planting. *Seed Science and Technology* 35(05): 104, 108. (In Chinese) [李志辉. 梨树种植过程中虫害的防治方法. 种子科技, 2017, 35(05): 104, 108.]

38. Peng, G., Yan, C.G., Wu, C.S. 2010. Discussion on the key technical measures of disease and insect control on early ripening pear in South China. *China Fruits and Vegetable* (07): 29. (In Chinese) [彭岗, 晏才刚, 吴成生. 谈谈南方早熟梨病虫害防治的关键技术措施. 中国果菜, 2010, (07): 29.]

39. Xu, M.W., Jiang, Y.C. 1999. Three stink bugs damaging Dangshan pear in ancient Yellow River areas. *Shanxi Fruits* (2): 29. (In Chinese) [许明伟, 蒋玉超. 黄河故道地区危害砀山酥梨的三种蝽象. 山西果树, 1999, (2): 29.]

40. Zhang, Q.M. 2013. Pear cultivation with high quality and yield of fresh fruit. *Hunan Agriculture* (6): 11. (In Chinese) [张秋明. 时鲜水果优质高产栽培梨(六). 湖南农业, 2013, (6):11.]

Pomegranate (1)

41. Zhou, Y.S., Yin, Z.H., Luo, G.L., Wang, S.L., Lu, J., Zhu, T.G., Fan, J., Li, Z.X. 2000. Occurrence of *Erthesina fullo Thunberg* and its control. *Journal of Southwest Agricultural University* 22(3): 234-236. (In Chinese with English abstract) [周又生, 尹忠华, 罗贵林, 王世龙, 陆进, 朱天贵, 番俊, 李正旭. 石榴麻皮蝽象发生归律及其防治研究. 西南农业大学学报, 2000, 22(3): 234-236.]

Longan (1)

42. Hu, Q.Y., Chen, Y.H., Huang, Y.Q., Zhan, Z.X., Zhang, X.J. 2000. Stink bugs damaging longan and their control. *Entomology in 21st Century, Annual Meeting of China Entomology Society* pp. 697-698. (In Chinese) [胡奇勇，陈元洪，黄玉清，占志雄，张晓俊. 危害龙眼的蝽类昆虫及防治. 中国昆虫学会年会-走向 21 世纪的昆虫学, pp. 697-698.]

Orange (1)

43. Wang, P.J. 2012. The occurrence and control of major insect pests and diseases on orange plants in Hanjiang valley. *Fruit Tree Hospital* (2): 30-32. (In Chinese) [王平杰. 汉江河谷地区几个柑橘重大病虫害发生特点及防治技术.果树医院, 2012, (2): 30-32.]

Biological control agents (5)

44. Wang, G.H. Qiu, X.L. 1998. Preliminary survey report of egg parasitoids of yellow spotted stink bug. *Jiangxi Plant Protection* (21): 4. (In Chinese) [王国红, 邱新兰. 麻皮蝽卵寄生蜂调查初报. 江西植保, 1998, (21): 4]

45. Zhan, H.X. 2017. Reproductive biology of *Halyomorpha halys* (Stal) and its egg parasitoid *Trisslocus japonicus* (Ashmead). Anhui Normal University. MSc Thesis. (In Chinese with English abstract) [詹海霞. 茶翅蝽及其寄生性天敌茶翅蝽沟卵蜂的生殖生物学研究. 安徽师范大学硕士学位论文, 2017.]

46. Misra, R.M., Misra, B.N., Misra, R.K. 2001. *Beauveria bassiana* (Balsamao) Vuillemein- a fungal pathogen of *Erthesina fullo* Thunb (Heteroptera: Pentatomidae). *Indian Journal of Forestry* 24(2):253-255]

47. Okumura, E.,Tanaka, R., Yoshiga, T. 2013. Species-specific recognition of the carrier insect by dauer larvae of the nematode *Caenorhabditis japonica*. *The Journal of Experimental Biology* 216: 568-572.

48. Zhang, J.P. Zhang, F. Gariepy, T., Mason, P. Gillespie, D., Talamas, E., Haye, T. 2017. Seasonal parasitism and host specificity of *Trissolcus japonicus* in north China. *Journal of Pest Science* 90(4):1127-1141

Chemical control (2)

49. Wei, Y.P., Zhang, X., Liu, Y.N. 2000. Repellent effect of 'Quchunwang' to stink bugs in orchards. *Shaanxi Journal of Agricultural Sciences* (5): 16-17. (In Chinese) [魏永平, 张兴，刘永宁. 驱蝽王驱除果园蝽象的实验效果. 陕西农业科学, 2000, (5): 16-17.]

50. Xu, Z.H. 2019.How to control the *Erthesina fullo* that can use the chemical weapon. *Bonsai Flowers and Trees* (4): 36-37. (In Chinese) [徐志鸿. 如何防治会使用"化学武器"的麻皮蝽.花木盆景, 2019, (4): 36-37.]

Chemical ecology (1)

51. Kou, R, Tang, D.S, Chow, Y.S. 1989. Alarm pheromone of pentatomid bug, *Erthesina fullo* Thunberg (Hemiptera:Pentatomidae). *Journal of Chemical Ecology* 15(12): 2695-2702.

Other host plants (17)

52. Dou, J.H. 2016. Investigation of insect pests on *Fraxinus chinensis* Roxb and occurrence and control of several new insect pests. Shandong Agricultural University, MSc Thesis. (In Chinese with English abstract) [窦京海. 白蜡树害虫调查与几种新白蜡害虫的发生规律及防治. 山东农业大学硕士学位论文, 2016]

53. Geng, H.L., Yang, H.Y., Li J.R., Wang, S.L., Zhang Q.Z. 2010. Damage of yellow spotted stink bug to *Fraxinus chinensis* Roxb and its' control techniques. *Jilin Agriculture* (12): 127. (In Chinese) [耿洪亮, 杨合延, 李洁茹, 王淑利, 张清珍. 黄斑蝽象对金叶白蜡的为害及综合防治技术. 吉林农业, 2010, (12): 127]

54. Gao, C.Q., Wang, M,N., Wang, Y., Zhang, Y.F., Hao, D.J. 2019. Investigation of forest true bugs (Hemiptera: Heteroptera) from Shanghai area. *Journal of Nanjing Forestry University (Natural Sciences Edition)* 43(1): 167-174. (In Chinese with English abstract) [高翠青, 王美娜, 王焱, 张岳峰, 郝德君. 上海地区林地蝽类昆虫种类调查. 南京林业大学学报(自然科学版), 2019, 43(1): 167-174.]

55. Huang, W.X. 2019. Investigation and analysis on the major insect pests of garden plants in Xishui County. *Guizhou Forestry Science and Technology* 47(2): 42-47, 64. (Chinese with English abstract) [黄文学. 习水县园林植物主要害虫调查分析研究.贵林林业科技.2019, 47(2): 42-47, 64.]

56. Wang, K. 2007.The research on investigation of pest occurrence and control of wild fprsythia in Shaanxi. *Northwest Agricultural and Forestry University*. (Chinese with English abstract) [王珂. 陕西省野生连翘害虫调查及防治方法初探. 西北农林科技大学(硕士学位论文), 2007.]

57. Wang, L.H., Guo, L.L., Yu, H., Mao, X.R., Wang, Y.B. 2013. Investigation of insect community of *Trifolium repens* lawn in east of Henan province. *Journal of Henan Agricultural Sciences* 42(3): 87-91. (In Chinese with English abstract) [王刘豪, 郭莉莉, 余昊, 毛晓瑞, 王运兵. 豫东地区白三叶草坪昆虫群落调查及分析. 河南农业科学, 2013, 42(3): 87-91.]

58. Xu, H.J., Wang, F., Guo, T.B., Zhang, R.F., Song, M.H., Zhou, X.Y., Qian, G.Z., Gao, S.F. 2017. Investigation on species and damage of insects in Hemiptera: Heteroptera in Xuzhou urban and suburb area. *Journal of Jiangsu Forestry Science & Technology* 44(3): 9-14. (In Chinese with English abstract) [徐辉筠, 王菲, 郭同斌, 张瑞芳, 宋明辉, 周晓宇, 钱桂芝, 高世虎. 徐州半翅亚目昆虫种类及危害调查. 江苏林业科技, 2017, 44(3): 9-14.]

59. Yu, M.F., Zhu, Y., Zhao, H.Q. 2009. Population quantity of *Erthesina fullo Thunberg* and the community analysis of *Populus nigra* in SUYA Lake Wetland. Guangdong Agricultural Sciences. (8): 208-210. (In Chinese with English abstract) [禹明甫, 朱玉, 赵红启. 宿鸭湖湿地麻皮蝽种群数量与黑杨群落分析. 广东农业科学, 2009, (8): 208-210.]

60. Zhao, M.A. 2013. Living habits and control techniques of common stink bug pests on flowers. Kexue Zhongyang. 1. (In Chinese) [赵明安. 花卉常见蝽类害虫的生活习性与防治技巧. 科学种养. 2013. 1]

61. Dhiman, S.C., Yadav, Y.K., Deepti, S. 2004. Occurrence of two pentatomid bugs, *Halys dentatus* Fabr. and *Erthesina fullo* Thunb., together on some economic forest trees and their seasonal occurrence. *Indian Forester* 130(7): 821-824.

62. Hoffmann, W.E. 1930. The food habits of *Erthestina fullo* (Thunb.). *Lingnan Science Journal* 9(1-2): 139-142.

63. Joshi, K.C., Gurung, D., Sarma, P.C. 1984. Insect pests of poplars in north-eastern region. *Indian Farming* 34(4): 21-22.

64. Kumar, M., Ahmad, M. 2003. First record of pentatomid infestation on *Paulownia fortune*. *Indian Journal of Entomology* (3): 303-307.

65. Maki, M. 1916. Report on injurious insects of the mulberry tree in Formosa. (Formosan Government Agricultural Experiment Station Publication No.90). Report on Injurious Insects of the Mulberry Tree in Formosa. pp. 265.

66. Roychoudhury, N., Joshi, K.C. 2011. New record of pentatomid bug, *Erthesina fullo* Thunbery and *Halys dentatus* Fabricius (Heteroptrra:Pentatomidae), feeding on teak in Madhya Pradesh. *Indian Journal of Forestry* 34(1):117-120.

67. Sen, A.C. 1966. A survey of the Pentatomid bugs on the economic plants in the Hanchi district. *Indian Journal of Entomology (missing vol. pages).*

Taxonomy (8)

68. Cui, X.Y., Li, N., Li, X.Y., Hu, Q., Bu, W.J. 2017. Recognition of late instars of nymphs among nine stinkbug species injuring crops and trees. *Plant Protection* 43(1): 83-88. (In Chinese with English abstract) [崔新仪, 李宁, 李向东, 胡奇, 卜文俊. 9 种农林有害蝽类昆虫高龄若虫龄期的区分. 植物保护. 2017, 43(1): 83-88.]

69. Long, J. 2000. A preliminary study on phylogeny of the subfamily Pentatomidae in China. *Jiangxi Agricultural University, MSc thesis*. (In Chinese with English abstract) [龙骏. 中国蝽亚科昆虫族间系统发育支序分析初探. 江西农业大学图书馆硕士学位论文, 2000.]

70. Sun, Q.X. 2004. Molecular Systematics of Hemiptera: Pentatomidae: Pentatominae. MSc Thesis, Northwest Agriculture and Forestry University. (In Chinese with English abstract) [孙钦霞. 蝽亚科部分族的分子系统学研究（半翅目：蝽科）.西北农林科技大学.硕士学位论文, 2004.]

71. Xu, Z.Q., Zheng, L.Y. 1993. Phylogenetic analysis of the genus dalpada of Pentatomidae (Hemiptera). *Entomotaxonomia* 15(1):17-28. (In Chinese) [徐志强, 郑乐怡. 蝽科 Dalpada 属群的系统发育分析(半翅目). 昆虫分类学报, 1993, 15(01):17-28.]

72. Zhao, Q. 2013. A revision of the Asopinae from China and the study of DNA taxonomy of Arma, Carbula and Eysarcoris (Hemioetra: Pentatomidae). Nankai Univeraity. (In Chinese with English abstract) [赵清. 中国益蝽亚科修订及蠋蝽属、辉蝽属和二星蝽属的 DNA 分类学研究 (半翅目: 蝽科). 南开大学图书馆(博士学位论文). 2013.]

73. Ahmad, I., Memon, N., Kamaludin, S. 2004. A revision of hayline stink bug genus *Erthesina* Spinola (Hemiptera: Pentatomidae: Pentatominae) and their clasdistics. *Pakistan Journal of Zoology* 36(4): 285-293.

74. Iba, F. 1936. On *Erthesina fullo* Thunberg, especially the colour variation of the nymphs. *Nojikairyo-shiryo* (106): 54-59.

75. Ward, N, Burnip, G, Hill, R. 2013. Plants and environment investigation report: October to December 2013. *Surveillance* 41(1): 51-52.

Molecular biology (8)

76. Dai, J.X., Zheng, Z.M. 2005. Phylogenetic relationships of eleven species of Pentatomidae based on sequences of cytochrome by gene. *Entomological Knowledge* 42(4): 395-399. (In Chinese with English abstract) [代金霞, 郑哲民. 基于 Cyt *b* 基因序列探讨蝽亚科 11 种昆虫的系统发育关系. 昆虫知识, 2005, 42(4): 395-399.]

77. Gao, S., Ren, Y., Sun, Y., Wu, Z., Ruan, J., He, B., Zhang, T., Yu, X., Tian, X., Bu, W. 2016. PacBio full-length transcriptome profiling of insect mitochondrial gene expression. *RNA Biology* 13(9): 820-825.

78. Ji, H., Xu, X., Jin, X., Yin, H., Luo, J. 2019. Using high-resolution annotation of insect mitochondrial DNA to decipher tandem repeats in the control region. *RNA Biology* 16(6): 830-837.

79. Li, H. M., Deng, R. Q., Wang, X. Z. 2006. Phylogenetic relationships of the Pentatomomorpha (Hemiptera: Heteroptera) inferred from nuclear 18S rDNA sequences. *Zoological Research* 27(3): 307-316.

80. Liu, Y., Wu, H., Xie, Q., Bu, W. 2015. Novel detection of insecticide resistance related P450 genes and transcriptome analysis of the Hemimetabolous pest *Erhtesina fullo* (Thunberg) (Hemiptera: Heteroptera). *PLOS One* 10(5), e0125970. doi:10.1371/journal.pone.0125970

81. Ma, C.Y., Zheng, Z.M. 2005. Comparative study on esterase isozymes in two species of Pentatomidae. *Ningxia Engineering Technology* 4(1): 68-69, 73. (In Chinese with English abstract) [马春燕, 郑哲民. 两种蝽科昆虫酯酶同工酶的比较研究. 宁夏工程技术, 2005, 4(1): 68-69, 73.]

82. Ren, Y.P., Zhang, J.Q., Sun, Y., Wu, Z.F., Yuan J.S., He, B.J., Liu, G.Q., Gao, S., Bu, W. 2016. Full-length transcriptome sequencing on PacBio platform. *Chinese Science Bulletin* 61(11): 1250-1254. (In Chinese with English abstract) [任毅鹏, 张佳庆, 孙瑜, 吴振峰, 阮吉寿, 贺秉军, 刘国卿, 高山, 卜文俊. 基于 PaBio 平台的全场转录组测序. 中国科学, 2016, 61(11): 1250-1254.]

83. Zhang, H.F, Zheng, L.Y. 2001. Study on the chromosomes in six species of pentatomid bugs (Hemiptera:Pentatomidae). *Acta Entomological Sinica* 44(2): 129-134. (In Chinese with English abstract) [张虎芳, 郑乐怡. 六种蝽象的染色体研究(半翅目: 蝽科). 昆虫学报, 2001, 44(2): 129-134.]

Others (3)

84. Jin, K.X., Liang, C.J., Deng, D.L. 1981. A study on insect vectors of *Paulownia* witches' broom disease. *Forestry Science and Technology Newsletter* (12): 23-24. (In Chinese) [金开璇, 梁成杰, 邓丹荔. 泡桐丛枝病传毒昆虫研究. 林业科技通讯, 1981, (12): 23-24.]

85. Mou, J.Y. 1963. The research on the mycanfium of *Erthesina fullo* Thunberg. *Journal of Shandong Agriculture University* (8): 79-82. (In Chinese) [牟吉元. 黄斑蝽象贮菌器发育的研究. 山东农学院学报, 1963, (8): 79-82.]

86. Esaki, T. 1926. List of the Heteroptera of Formosa. Ann. Hist. Nat. Mus. Natnl. Hung. *(missing vol. pages).*

Patent (1)

87. Luo, C. Bristow, J.T., Bristol, J.T. Insecticidal composition useful for e.g. controlling agricultural pests in invasive plant or plant propagation material and pest causing health hazard, and protecting plant from agricultural pests, comprises bifenthrin and indoxacarb. [Patent] Jiangsu Rotam Chem Co Ltd. *(missing patent number and year)*

contact CABI

europe

CABI Head Office
Nosworthy Way, Wallingford, Oxfordshire, OX10 8DE, UK
T: +44 (0)1491 832111

CABI Europe – UK
Bakeham Lane, Egham, Surrey, TW20 9TY, UK
T: +44 (0)1491 829080

CABI Europe – Switzerland
Rue des Grillons 1, CH-2800 Delémont, Switzerland
T: +41 (0)32 4214870

asia

CABI South Asia
Opposite 1-A, Data Gunj Baksh Road, Satellite Town, Rawalpindi-Pakistan
T: +92 (0)51 9290132

CABI Southeast Asia
PO Box 210, 43400 UPM Serdang, Selangor, Malaysia
T: +60 (0)3 89432921

CABI South Asia
2nd Floor, CG Block, NASC Complex, DP Shastri Marg, Opp. Todapur Village,
PUSA, New Delhi – 110012, India
T: +91 (0)11 25841906

CABI East Asia
C/o Internal Post Box 85, Chinese Academy of Agricultural Sciences,
12 Zhongguancun Nandajie, Beijing 100081, China
T: +86 (0)10 82105692

africa

CABI Africa
Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya
T: +254 (0)20 7224450/62

americas

CABI North America
875 Massachusetts Avenue, 7th Floor, Cambridge, MA 02139, USA
T: +1 617 3954051

CABI Caribbean & Latin America
Gordon Street, Curepe, Trinidad and Tobago
T: +1 868 6457628

CABI Caribbean & Latin America – Brazil
UNESP- FEPAF- Fazenda Experimental Lageado
Rua José Barbosa de Barros, 1780, Botucatu – SP, CEP: 18610-307, Brazil
T: +14 3880 - 7670 / 3880 - 7680

www.cabi.org

KNOWLEDGE FOR LIFE