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MINI-REVIEW

Biology and natural enemies of *Cydalima perspectalis* in Asia: Is there biological control potential in Europe?

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Abstract

The box tree moth, *Cydalima perspectalis* (Walker) (Lepidoptera: Crambidae), a native pest of box trees (*Buxus* spp.) in Asia, was first detected in Germany and the Netherlands in 2007 and has since rapidly spread throughout Europe causing severe damage to ornamental and native box trees. To date, sustainable control strategies for *C. perspectalis* in Europe are lacking, primarily owing to the inadequate information regarding the biology and the ecology of this recent invader. Several studies conducted in Asia, however, may provide important information for the development of management strategies against *C. perspectalis*, which are urgently needed to preserve the natural box tree forests in Europe. The current literatures on the biological characteristics, host plants, phenology, distribution and control options of the box tree moth in Asia are reviewed, preliminary data on the parasitism of *C. perspectalis* in Europe are provided, and options for sustainable long-term solutions for the management of the invasive pest in Europe are discussed.

Introduction

The box tree moth, *Cydalima perspectalis* (Walker) (Lepidoptera: Crambidae), formerly placed in the genera *Phakellura, Glyphodes, Diaphania* and *Neoglyphodes* (Mally and Nuss 2010), is a native pest of *Buxus* trees in Asia (Wang 1980). Its natural distribution includes China, Japan Korea and India (Hampson 1896; Inoue 1982; Park 2008). The recent observations from the Russian Far East (Kirpichnikova 2005) probably refer to introductions because there is no native *Buxus* species in the region. In Europe, the moth was first detected in 2007 in south-west Germany and the Netherlands, where it was likely introduced with shipments of plant material from East Asia (Krüger 2008; Van der Straten and Muus 2010). *Cydalima perspectalis* has subsequently continued to spread, and it has been identified in Switzerland, France, Austria, Belgium, Czech Republic, England, Hungary, Italy, Liechtenstein, Slovakia, Slovenia, Croatia, Romania and Turkey (Kenis et al. 2013; Nacambo et al. 2013). It has been predicted that the moth will likely continue spreading throughout the rest of Europe, except for Northern Fenno-Scandinavia, Northern Scotland and high mountain regions (Nacambo et al. 2013).

Within the area of invasion in north-western Switzerland, *C. perspectalis* has two distinct generations per year (Nacambo et al. 2013). Damage to box trees is caused by the larvae feeding primarily on leaves and to a lesser extent on bark. Continuous outbreaks of *C. perspectalis* in invaded areas have caused severe damage to box trees in nurseries, private gardens, cemeteries and parks, resulting in the replacement of the commonly planted box tree varieties with other ornamentals. *C. perspectalis* also severely attacks the European native box tree, *Buxus sempervirens* (Kenis et al. 2013), which grows in the understory of European broadleaf forests, with a centre of abundance and frequency in the Pyrenees, Southern France, French Prealps, and all around the French and Swiss Jura Mountains (Di Domenico et al. 2012). In south-western Germany and north-western Switzerland, severe outbreaks of *C. perspectalis* in conjunction with the invasion of the new fungus *Cylindrocladium buxicola* Henricot (box blight) caused the devastation of nearly 100 ha of box tree forest in 2010 (John and Schumacher 2013; Kenis et al. 2013). Populations crashed when food resources became limited, but box trees were not able to recover due to continuous re-colonization of the forest with *C. perspectalis* from surrounding areas. Furthermore, the defoliation and death of box trees has already initiated the change of the ground-covering vegetation due to the increased exposure to sunlight, and it is highly likely that large areas of the box tree forest will be lost forever (John and Schumacher 2013). In 2013, other forests became similarly devastated in Switzerland and France (M. Kenis, unpublished data).

Clearly, the continuous spread of *C. perspectalis* poses a serious threat to existing native populations of *B. sempervirens* in Europe, and novel approaches to control *C. perspectalis* are urgently needed in order to minimize the loss of ornamental and native box trees across Europe. As *C. perspectalis* is a relatively recent invader, the knowledge on this pest in Europe remains limited. However, *C. perspectalis* has been the focus of several studies in Asia, and the information obtained from these studies may provide valuable information for the development of sustainable control strategies for *C. perspectalis* in Europe. The aim of this paper is to (i) review the current knowledge on *C. perspectalis* in Asia with a particular focus on natural enemies and (ii) discuss the potential of biological control for *C. perspectalis* in Europe.

Developmental Biology

In China and Japan, the basic biology of *C. perspectalis* has been studied, including but not limited to (i) the developmental characteristics of eggs and larvae, (ii) larval diapause, (iii) fecundity of female adults and (iv) sex pheromones (Maruyama and Shinkaji 1987, 1991, 1993; Maruyama 1992, 1993; Tang 1993; Zhou et al. 2005; Kawazu et al. 2007).

Cheng (2005) observed that *C. perspectalis* adults only mate once in their lifetime, and the mating event would last between 1.5 and 2 h. Average life-time fecundity per female varied with generation, ranging from 482.5 ± 213.2 eggs for the overwintered generation to 199.4 ± 107.6 for the third generation.

In Japan, Maruyama and Shinkaji (1987) found that egg developmental duration of *C. perspectalis* varied at different temperatures, lasting 15.3 ± 0.64, 7.1 ± 0.23, 4.0 ± 0.15 and 3.0 ± 0.10 days at 15, 20, 25 and 30°C, respectively. In China, similar egg developmental times were observed by Tang (1993). When reared on *Buxus microphylla* at 25°C in the laboratory, larvae developed through six instars. Instars 1–5 typically developed within 3 days, and stage 6 developed within 8 days (Maruyama and Shinkaji 1991). In Shandong (North China), *C. perspectalis* larvae of the 2nd and 3rd generations of the same year completed development within 24.9 ± 0.73 days at 27°C (Zhang et al. 2007), whereas in Japan development lasted 24.9 ± 2.89 days at 25°C (Maruyama and Shinkaji 1987). The development of pupae lasted 10.0 ± 0.36 days at a constant temperature of 25°C (Maruyama and Shinkaji 1987) and 8.8 ± 0.32 days at a mean temperature of 26.4 ± 0.68°C (Zhou et al. 2005). Overall, the developmental threshold temperature and effective accumulated temperature of *C. perspectalis* larval stage were 10.1°C and 238.1 degree-days ($y = 0.004x - 0.042$) and 11.7 ± 4.8°C and 100 degree-days for the overwintered generation (i.e. first generation) in Japan and China, respectively (Maruyama and Shinkaji 1987; Tang 1993).

Diapause is mainly induced by short daylength experienced by the 1st to 3rd instar larvae (Maruyama and Shinkaji 1993; Xiao et al. 2011). In Japan, the critical photoperiod varied between 13 h 40 min and 14 h 20 min for different *C. perspectalis* populations and was higher at 15°C than at 25°C (Maruyama and Shinkaji 1993).

Kawazu et al. (2007) analysed the sex pheromone of *C. perspectalis* and concluded that the two aldehyde compounds, (Z)-11-hexadecenal (Z11-16: Ald) and (E)-11-hexadecenal (E11-16: Ald) in a ratio of roughly 4 : 1 provided an attractive sex pheromone blend, which could be used for monitoring *C. perspectalis*. Kim and Park (2013) carried out similar studies in Korea and proposed ratios of 5 : 1 and 7 : 1. In addition, they tested various traps and lure systems and suggested uni-traps over delta and wing traps, and film-type lures over rubber septum lures.

Phenology

While in Central Europe, only two generations per year occur (Nacambo et al. 2013), publications from China report 3–5 generations per year, depending on the climatic conditions of the regions (table 1). In Japan, *C. perspectalis* had three generations a year in the Tokyo-Chiba area, with adult flight periods

Table 1 Number of generations and overwintering larval instars of *Cydalima perspectalis* in different locations in China

Location	Latitude	Longitude	Generation	Overwintering larval insta	References
Langfang City, Hebei Province North China	39°31′15.66″	116°42′23.94″	3	3rd	Sun et al. (2009)
Taian City, Shandong Province East China	36°12′0.91″	117°5′15.41″	3	3rd	Hu et al. (1993)
Tengzhou City, Shandong Province East China	35°5′2.48″	117°9′51.80″	3	2nd and 3rd	Niu et al. (2008)
Xian City, Shannxi Province Northwest China	34°15′53.95″	108°56′39.37″	3	2nd	Fang and Hui (1998)
Xinyang City, Henan Province Central China	32°7′23.64″	114°4′7.94″	3	2nd and 3rd	Shi and Hu (2007)
Ji'an City, Jiangxi Province East China	27°6′46.94″	114°59′34.49″	3	3rd and 4th	Xu and Liang (2001)
Sanming City, Fujian Province East China	26°10′12.62″	118°11′25.68″	4	3rd	Wang (2008)
Shanghai City, East China	31°13′49.41″	121°28′25.33″	4	2nd and 3rd	Tang (1993)
Guilin City, Guangxi Province South China	25°16′24.84″	110°17′24.70″	5	Mature larvae	Huang and Li (2001)
Lishui City, Zhejiang Province East China	28°26′56.88″	119°28′55.30″	5	3rd to 5th	(Chen et al. 2005; She and Feng 2006)
Zigong City, Sichuan Province Southwest China	29°20′20.51″	104°46′42.39″	5	3rd	Zhu (1990)

occurring from mid-May to late June, from late July to late August and from late August to mid-September (Maruyama and Shinkaji 1987). Based on studies on the photoperiodic induction of larval diapause, Maruyama and Shinkaji (1993) suggested the occurrence of two to four generations per year in Japan.

In China, most publications mention that larvae overwinter as 3rd instars, as in Central Europe (Nacambo et al. 2013) but some also mention later instar as overwintering stage (table 1). In Japan, according to Maruyama and Shinkaji (1991), larvae enter diapause in the 4th or 5th instar.

Host Plants

Table 2 lists the host plants of *C. perspectalis* in Asia. Ten species of *Buxus* have been reported as hosts. In Japan, injury levels on four different *Buxus* species and varieties (i.e. *Buxus microphylla*, *B. sempervirens*, *B. microphylla var. insularis* and *B. microphylla var.*

Table 2 Host plants of *Cydalima perspectalis* in Asia

Country	Family	Species and varieties	References
China	Aquifoliaceae	*Ilex purpurea* Hasskarl	Shi and Hu (2007)
	Buxaceae	*Buxus. bodinieri* Léveillé	Shen and Liu (1988)
		Buxus. harlandii Hance	Shi and Hu (2007)
		Buxus. megistophylla Léveillé	Shi and Hu (2007)
		Buxus. microphylla Siebold & Zuccarini	Shi and Hu (2007)
		Buxus. microphylla Siebold &Zuccarini var. *insularis* Nakai	Peng and Tian (1994)
		Buxus. microphylla Siebold&Zuccarini. var. *japonica* (Müll. Arg. ex Miq.) Rehder & E.H. Wilson	Yi et al. (2003)
		Buxus rugulosa Hatusima [syn. *Buxus sinica* (Rehder & E.H. Wilson) M. Cheng ssp. *sinica* var. *parvifolia* M. Cheng]	Chen et al. (2005)
		Buxus. sempervirens L.	Tang (1993)
		Buxus. sinica (Rehder & E.H. Wilson) M. Cheng	Chen et al. (2005)
		Buxus. sinica (Rehder & E.H. Wilson) M. Cheng var. *aemulans* (Rehder & E.H. Wilson) Brückner & Ming [basionym: *Buxus sinica* (Rehder & E.H. Wilson) M. Cheng ex M. Cheng subsp. *aemulans* (Rehder & E.H. Wilson) M. Cheng]	Chen et al. (2005)
	Celastraceae	*Euonymus alatus* (Thunberg) Siebold	Shi and Hu (2007)
Japan	Aquifoliaceae	*Ilex purpurea* Hasskarl	Uezumi (1975)
	Buxaceae	*Buxus. microphylla* Siebold & Zuccarini	Uezumi (1975)
		Buxus. microphylla Siebold &Zuccarini var. *insularis* Nakai	Maruyama and Shinkaji (1987)
		Buxus. sempervirens L.	Maruyama (1992)
		Buxus. sinica (Rehder & E.H. Wilson) M. Cheng	Maruyama (1993)
	Celastraceae	*Euonymus japonicus* Thunberg	Uezumi (1975)

japonica) were investigated by Maruyama (1992), who concluded that *B. microphylla* was the preferred host plant. Other host plants reported from China and Japan include *Euonymus alatus* (Thunberg) Siebold, *Ilex purpurea* Hasskarl (Aquifoliaceae) and *Euonymus japonicus* Thunberg (Celastraceae) (Uezumi 1975; Shi and Hu 2007). However, Van der Straten and Muus (2010) questioned the latter two records, based on unpublished negative tests by the Plant Protection Service in the Netherlands, reproducing these data with European populations of *C. perspectalis*. In Europe, damage has only been reported on *Buxus* spp., mainly *B. sempervirens* and its cultivars but also the commonly planted Asian *B. microphylla* (Leuthardt and Baur 2013).

Natural Enemies in Asia

Natural enemies of *C. perspectalis,* including predators and parasitoids, have been reported from various regions in China, Japan and the Republic of Korea (Choo et al. 1991; Lee et al. 1997; Chen et al. 2005) and are summarized in table 3.

Three tachinid flies are known to parasitize larvae of *C. perspectalis* in Asia, including *Exorista* sp., *Pseudoperichaeta nigrolineata* (Walker) and *Compsilura concinnata* (Meigen) (Diptera: Tachinidae) (Shima 1973; Shi and Hu 2007). In the region of Xinyang (Henan province, China), the mortality of *C. perspectalis* larvae and pupae caused by *Exorista* sp. was 32.6% and 47.5%, respectively (Shi and Hu 2007). *Pseudoperichaeta nigrolineata* was reported as a parasitoid of *C. perspectalis* in Japan (Shima 1973). It is a highly polyphagous parasitoid of at least 9 Lepidoptera families, primarily Crambidae, Pyralidae and Tortricidae (Martinez and Reymonet 1991) and occurs throughout Europe, Siberia, China and Japan. *Compsilura concinnata,* attacking *C. perspectalis* in Japan, is another tachinid with a very broad host range that has now been recovered from at least 180 species of Lepidoptera and Symphyta worldwide (Boettner et al. 2000).

Chelonus tabonus (Sonan) (Hymenoptera: Braconidae) is considered to be the most abundant parasitoid of *C. perspectalis* in China, causing parasitism levels of up to 50% in some areas (She and Feng 2006). It is a solitary egg–larval parasitoid which oviposits in the eggs of *C. perspectalis*. The parasitoid larva subsequently develops in the host larva and does not emerge until the host larva reaches the 5th instar. Then, the parasitoid larva builds a cocoon and pupates beside the dead body of the host larva, and the adult emerges within 10–20 days (Chen et al. 2005). *Chelonus tabonus* is widely distributed across East Asia including Japan, Korea and the Chinese Provinces of Zhejiang, Jiangsu, Fujian, Shandong, Sichuan, Guizhou, Yunnan and Taiwan, as well as Indonesia, Southeast Asia (Papp 2003; She and Feng 2006; Zhang 2008). Host records from the literatures suggest that *C. tabonus* has a rather broad ecological host range, capable of parasitizing several Lepidopteran hosts including: *Diaphania pyloalis* (Crambidae), *Maruca testulalis* (Crambidae), *Eucosma aemulana* (Tortricidae), *Haritalodes* (=*Sylepta*) *derogate* (Crambidae) and

Table 3 Natural enemies of *Cydalima perspectalis* in Asia and Europe

Order	Family	Species	Host stage attacked	Country	References
Parasitoids					
Diptera	Tachinidae	*Compsilura concinnata* (Meigen)	Larva	Japan	Shima (1973)
	Tachinidae	*Exorista* sp.	Larva	China	Shi and Hu (2007)
	Tachinidae	*Pseudoperichaeta nigrolineata* (Walker)	Larva	Japan, Switzerland	(Shima 1973; Nacambo 2012)
Hymenoptera	Braconidae	*Chelonus tabonus* (Sonan)	Egg	China	She and Feng (2006)
	Braconidae	*Chelonus* sp.[1]	Egg	China	Chen et al. (2005)
	Braconidae	*Dolichogenidea stantoni* (Ashmead)	Larva	China	She and Feng (2006)
	Chalcidae	*Brachymeria lasus* (Walker)	Pupa	China	Chen et al. (2005)
	Encyrtidae	*Tyndarichus* sp.	Egg	China	Zhao et al. (2004);
	Ichneumonidae	*Apechthis compunctator* (L.)	Pupa	Switzerland	Nacambo (unpublished data)
	Ichneumonidae	*Casinaria* sp.	Larva	China	Zhao et al. (2004)
Predators					
Thysanoptera	Aeolothripidae	*Aeolothrips* sp.	Egg	China	Chen et al. (2005)
		Undescribed spiders	Larva	China	Chen et al. (2005)

[1]Most likely the species found by Chen et al. (2005) was also *C. tabonus*.

Omiodes (=*Hedylepta*) *indicate* (Crambidae) (Watanabe 1935; Chien et al. 1984).

Dolichogenidea stantoni (Ashmead) (Hymneoptera: Braconidae) (syn. *Urogaster stantoni*, *Apanteles stantoni*) is a gregarious larval endoparasitoid of *C. perspecatlis* in China (Chen et al. 2005), which has also been reported in the Philippines, India, Malaysia, Fiji and Papua New Guinea from other hosts (Chou 1999). Its host range comprises several other Lepidoptera. In India, it was recorded from larvae of the closely related pumpkin caterpillar *Diaphania indica* (Lepidoptera: Pyralidae) (Krishnamoorthy et al. 2004; Visalakshy 2005), from larvae of the Muga Silkworm, *Antheraea assamensis* (Helfer) (Lepidoptera: Saturnidae) (Das 2012) and from pupae of the mustard leaf webber, *Crocidolomia pavonana* Fabricius (Lepidoptera: Pyralidae) (Men and Kandalkar 2000). In China, *D. stantoni* was reared from *Parotis marginata* (Lepidoptera: Crambidae), Taiwan (Chou 1999). Parasitism of *D. indica* caused by *D. stantoni*, in India, was on average 37.3% (Krishnamoorthy et al. 2004).

Brachymeria lasus (Walker) (Hymenoptera: Chalcididae) is the only parasitic wasp that was found to attack pupae of *C. perspectalis* in China (Chen et al. 2005). The host range of this highly polyphagous pupal parasitoid comprises more than 100 species of Lepidoptera, Hymenoptera and Diptera (Universal Chalcidoidea Database Taxon Record). It is widely distributed among Asia and Oceania (Husain and Agarwal 1982) as well as North America, where it was introduced for the biological control of gypsy moth, *Lymantria dispar* L. (Weseloh and Anderson 1982).

Zhao et al. (2004) reared *Casinaria* sp. (Hymneoptera: Ichneumonidae) from *C. perspectalis* larvae, but the species was not further identified. *Casinaria* species are koinobiont endoparasitoids of mostly Lepidoptera larvae, but also Diptera and Hymenoptera. In the same study, eggs were found to be attacked by an unknown *Tyndarichus* species (Hymenoptera: Encyrtidae), but no further information was given on its abundance or impact.

The impact of predators on *C. perspectalis* populations in Asia is mostly unknown. Chen et al. (2005) reported that, in China, *Aeolothrips* sp. would feed on eggs and unidentified spiders on larvae of *C. perspectalis*.

Control Measures in Asia

Control of *C. perspectalis* in parks, green belts or nurseries in Japan and China is achieved mainly through application of broad-spectrum chemical insecticides, for example the pyrethoids deltamethrin and cypermethrin (Maruyama and Shinkaji 1987; Zhang et al. 2005; Zhou et al. 2005; She and Feng 2006; Ma et al. 2006; Xi et al. 2009). Due to the continuous use of chlorfluazuron in Shandong province, *C. perspectalis* has already developed some level of resistance, and thus, the use of spinosad and fipronil was recommended and has since proved to be more efficient (Zhang et al. 2007). Bioinsecticides based on Neem oil and *Bacillus thuringiensis* (Bt) var. *kurstaki* also showed some success in controlling *C. perspectalis* in China (Li et al. 2004).

Two nematode species, *Steinernema carpocapsae* (Rhabditida: Steinernematidae) and *Heterorhabditis bacteriophora* (Rhabditida: Heterorhabditidae), collected from forest soils in the Republic of Korea, were evaluated in the laboratory for their effectiveness against *C. perspectalis* (Choo et al. 1991). The exposure of *C. perspectalis* larvae to 20, 40 or 80 *S. carpocapsae* or 10, 20 or 40 *H. bacteriophora* resulted in 97.8–100% and 92–98.9% mortality, respectively.

Isolates of the entomopathogenic fungus, *Beauveria bassiana* (Bals.-Criv) Vuill. (Hypocreales: Cordycipitaceae), were tested against *C. perspectalis* in Korea, but larvae were not affected (Lee et al. 1997).

Prospects for Control in Europe

Control methods advised against *C. perspectalis* on ornamental box trees in Europe include the use of insecticides, preferably biopesticides such as Bt. and mechanical removal of larvae by hand or by shacking or water-spraying the infested trees (Kenis et al. 2013). However, these methods are not applicable in forests, even if, for example, the application of Bt. may be considered as a temporary solution to protect high-value natural stands. There is thus an urgent need to develop new environmentally friendly management strategies to preserve the unique natural box tree forests in Europe.

Control will probably not be provided by indigenous natural enemies at least in the short or medium term. In a recent study on natural enemies of *C. perspectalis* in north-western Switzerland (Nacambo 2012), 12 022 freshly laid eggs were exposed in three forest areas at various dates in 2011 and 2012, and not a single egg parasitoid was reared. No obvious sign of egg predation was observed either. From 5144 larvae collected at 19 sites and at various dates between 28 March 2011 and 06 August 2012, 34 specimens of the tachinid *Pseudoperichaeta nigrolineata* (Walker) emerged from late larval instars. The tachinid attacked both the first generation in April–May and the second generation in July–August. In total, it was found at six different sites, three private gardens and three natural forest stands, all located in the Swiss Cantons Basel-Landschaft and Basel-Stadt and the bordering district of Lörrach in Baden-Württemberg, Germany. Additionally, 194 pupae were collected during the surveys, and 44 were exposed at one site during the pupation period, but none was parasitized (Nacambo 2012). However, from a small sample of eight pupae collected in late October 2013, two females of *Apechthis compunctor* (L.) (Hymenoptera: Ichneumonidae) were reared (Nacambo 2012). This solitary idiobiont endoparasitoid is known to attack pupae from a wide range of lepidopteran families, including Tortricidae, Pyralidae, Pieridae, Lycaenidae and Noctudiae (Fitton et al. 1988).

Zimmermann and Wührer (2010) investigated the potential of the polyphagous European Lepidopteran parasitoid *Bracon brevicornis* Wesmael (Hymenoptera: Bracondiae), and they showed that the wasp was unable to develop on *C. perspectalis*, despite frequently observed oviposition events. Albert and Lehneis (2010) reported that laboratory trials with the egg parasitoids *Trichogramma brassicae* (Hymenoptera: Trichogrammatidae) resulted in high parasitism, but additional laboratory tests with *T. brassicae* and *Trichogramma dendrolimi* Matsumura showed that the latter species is more efficient, causing 44.15% parasitism (Göttig 2012). However, parasitism rates by *T. dendrolimi* and *T. brassicae* when released onto infested plants inside cages were only 11.04% and 0.44%, respectively, indicating a low searching capacity of the wasps (Göttig 2012). The efficacy of *Trichogramma* spp. under field conditions remains unknown. Field trials in Germany using the entomopathogenic nematode *S. carpocapsae* against larvae resulted in some level of control, but further investigations are needed to improve application techniques and reduce applications rates (Göttig 2012).

All parasitoids of *C. perspectalis* known from the Asian literatures are reported as being polyphagous. However, as often with host–parasitoid records, some of these records are likely to be erroneous. Among the parasitoids reported, the existence of undetected sibling species specific to *C. perspectalis* cannot be ruled out. Therefore, the taxonomy and the host range of some of these parasitoids should be reinvestigated. Given that the knowledge on natural enemies of *C. perspectalis* in Asia is fairly limited and restricted to a few urban areas, additional surveys for natural enemies should focus primarily on natural box tree stands in China, Korea or Japan, where new, possibly more host specific parasitoids may be found. These surveys would also provide knowledge on the role of natural enemies on population dynamics in natural box tree stands. To our current knowledge, *C. tabonus* is the most promising candidate for classical biological control of *C. perspectalis* in Europe due to high parasitism levels observed in China. Furthermore, Braconidae of the subfamily Cheloninae are known to be usually rather host specific (Shaw and Huddleston 1991). However, prior to importation *of C. tabonus*, its host specificity has to be investigated to exclude any potential negative effects on non-target species native to Europe. Host range testing in Europe should focus on species, which are ecological similar, closely related, for example European Crambidae, or considered as beneficial (Kuhlmann et al. 2006). Ideally, the parasitoid strains to be tested should originate from regions in Asia climatically similar to Europe to increase chances of establishment if considered for subsequent releases. If *C. tabonus* turns out to be specific to *C. perspectalis*, it could provide an environmentally friendly and sustainable solution for controlling the box tree moth in Europe, saving not only one of Europe’s most popular ornamental shrubs, but also protecting the unique natural populations of *B. sempervirens* and *B. balearica* in Central and Southern Europe.

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