



The box tree moth, *Cydalima perspectalis*, in Europe: horticultural pest or environmental disaster?

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The box tree moth, *Cydalima perspectalis*, was accidentally introduced in Europe some years ago, most likely through the trade of live plants. Within a few years it has already invaded at least 16 countries, in which it has become a serious pest of ornamental box trees (*Buxus* spp.). However, it is its impact on natural box tree stands that causes the most concern. It has already severely damaged isolated box populations in Germany and Switzerland, up to their local extirpation. Its spread and establishment in other parts of the natural distribution areas of the two European box trees species will undoubtedly have negative consequences on unique forest ecosystems, especially if nothing is done to control the pest. Populations in Southern Europe, which are naturally severely reduced, are particularly at risk.



Fig. 1. Larva of *Cydalima perspectalis*. Photo: Tim Haye



Fig. 2. Adult of *Cydalima perspectalis*. Photo: Tim Haye

Introduction

The live plants trade is the main pathway of introduction of exotic plant pests. Some of them can become serious threats to indigenous plants and, by cascading effects, to the ecosystem in which they live. A recent example in Europe is the arrival of the box tree moth, *Cydalima perspectalis* (Walker) (Lep: Crambidae). This insect originates from East Asia (China, Japan and Korea) and was first discovered in South-western Germany and the Netherlands in 2007. *Cydalima perspectalis* most likely arrived via the trade of box plants (*Buxus* spp.) from Asia and within a few years, has become a serious pest of one of Europe's most popular ornamental shrubs. The moth has also invaded several natural *Buxus* populations in Central Europe.

Biology and Ecology

Eggs are laid in patches on the abaxial surface of box leaves. Young larvae overwinter in diapause in a cocoon built between leaves. Diapause is induced by day length and temperature experienced by young larvae (Maruyama and Shinkaji 1993). Larval feeding (Fig. 1) continues in spring and pupation also occurs in the foliage. In northern Switzerland, *C. perspectalis* completes two generations per year, with adults (Fig. 2) flying in June and August-September (Nacambo et al. 2013). In warmer areas, three and even four generations per year may occur. Although other plant genera (e.g. *Ilex* and *Euonymus*) are reported as hosts in Asia, *C. perspectalis* has been recorded in Europe exclusively on *Buxus*. On the other hand, it feeds on all of the widely used box species and cultivars in Europe (Leuthardt and Baur 2013).

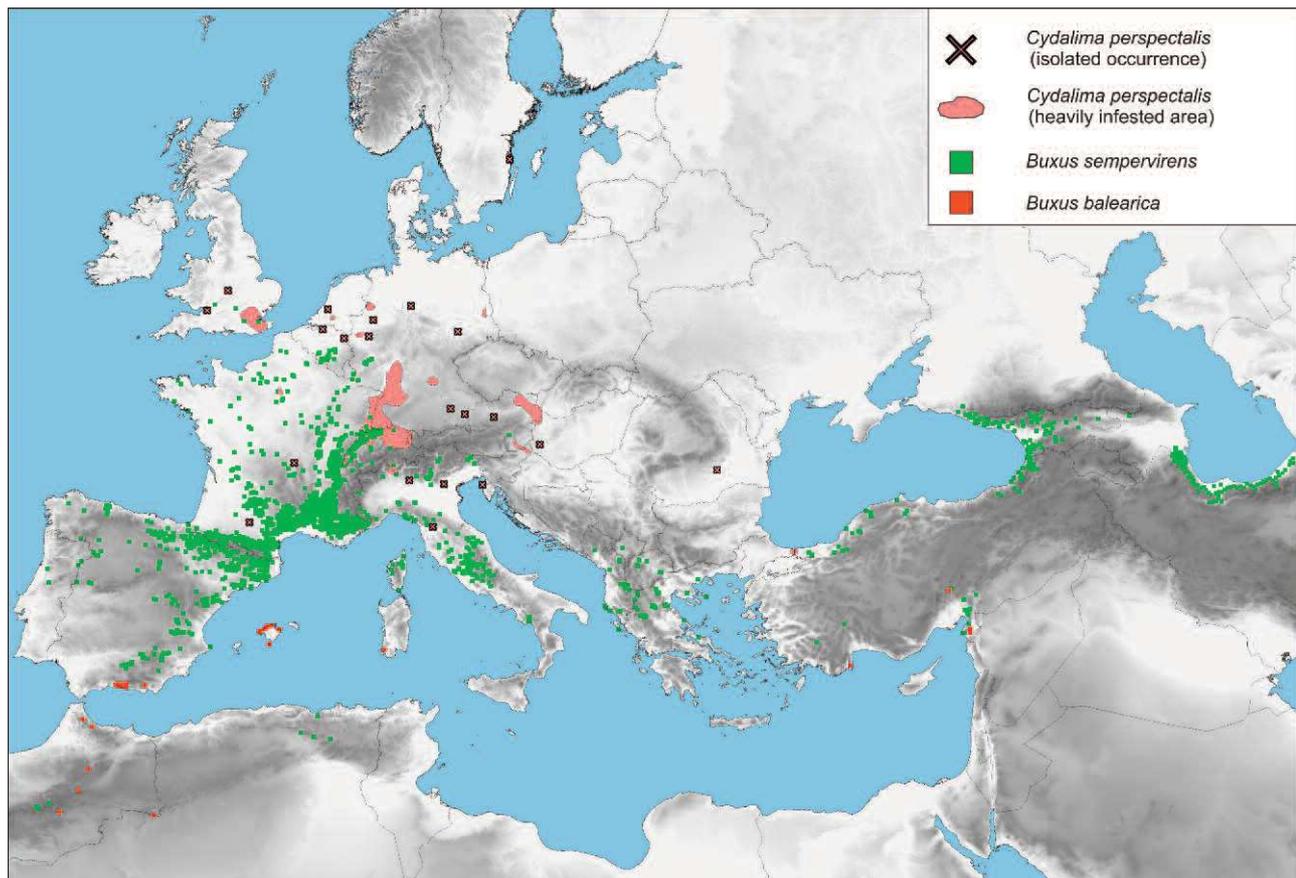


Fig. 3. Natural distribution of the two *Buxus* spp. (modified from Di Domenico et al. 2012) and known distribution of *Cydalima perspectalis* in Europe in December 2012 (references in Nacambo et al. 2013)

Actual and potential spread in Europe

At the end of 2012, i.e. five years after the first record in Germany and the Netherlands, *C. perspectalis* was officially present in 16 countries (Fig. 3). Although adults are good flyers, the rapid spread of the moth in Europe is mainly due to the trade of ornamental box trees. Eggs and young larvae can travel inconspicuously on their evergreen host plants. Moreover, the European Union is a free market for live plants and *C. perspectalis* is not listed in the EC Plant Health Directive or classified as a quarantine pest by the European and Mediterranean Plant Protection Organisation (EPPO)

A climate model (Nacambo et al. 2013) showed that the moth is able to spread and establish successfully in most of Europe, except in most of Fennoscandia and Scotland. It is likely, however, that populations and damage will be higher in the Southern half of Europe, where *C. perspectalis* is able to develop two or more generations per year.

Impact

Larvae feed mainly on leaves but may also attack the bark. Total defoliation is common (Fig. 4) and usually results in the death of the trees. The effect of the moth is often aggravated by the occurrence of the box blight, caused by the fungal pa-

thogen *Cylindrocladium buxicola* Henricot, another invasive species that arrived in Europe a few years before *C. perspectalis*. In infested areas, it has become impossible to maintain healthy box trees without chemical treatment or laborious mechanical removal of larvae. Box trees have played a central role through the centuries in the landscape of European gardens, including historical villas, parks and cemeteries but, since the arrival of the pest, it has become common practice to replace *Buxus* with other plant species.

Besides cultural and economic effects, the most serious threat from *C. perspectalis* is likely to be on the natural *Buxus* populations. Two box tree species naturally occur in Europe. The common box (*B. sempervirens*) is widely present across Central and southern Europe, whereas the Balearic box (*B. balearica*) occurs in southern Spain, Balearic Islands and Sardinia (Fig 3). Populations of *B. sempervirens* in the temperate regions of Western Europe are rather abundant and continuous. In contrast, in Southern Europe both *B. sempervirens* and *B. balearica* are characterized by fragmented and locally scarce populations. The two species are also found in North-West Africa and Turkey, and *B. sempervirens* extends eastwards to Georgia, Russia, Kazakhstan and Iran (Fig 3). *Buxus* spp. populations located in southern Europe underwent severe reduction in the last few millennia and are still undergoing a process of fragmentation and local isolation (Di Domenico et al. 2012).

The distribution of the moth and that of the natural box tree populations do not yet overlap, with the exception of the Nor-





Fig. 4. Ornamental box tree killed by *Cydalima perspectalis* in Switzerland. Photo: Tim Hays

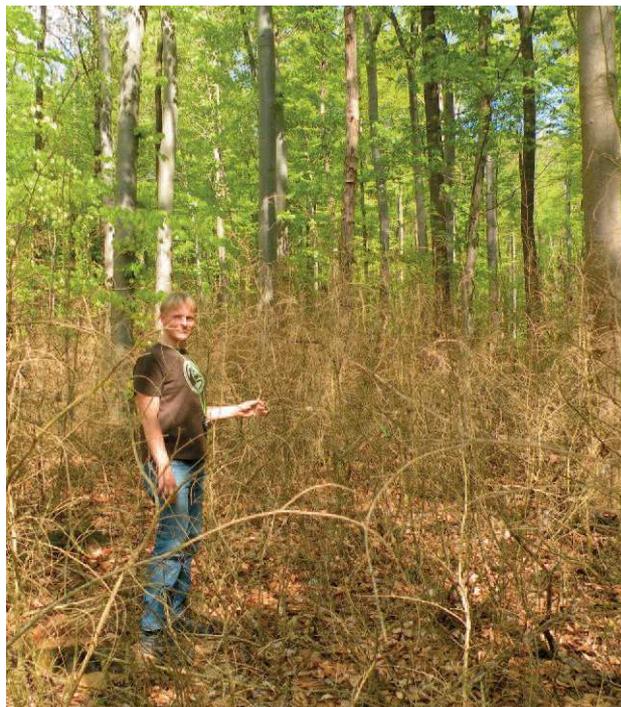


Fig. 5. Natural stand of *Buxus sempervirens* defoliated by *Cydalima perspectalis* in Grenzach-Whylen (Germany). Photo: Tim Hays

thern Jura Mountains in north-western Switzerland and south-western Germany, where a few isolated but dense stands of *B. sempervirens* are found. Between 2009 and 2010, some of the populations located near the city of Basle have been destroyed by the moth (John and Schumacher 2013). In the Nature Reserve of Grenzach-Whylen, which hosts the largest box tree forest in Germany, all shrubs lost more than 90% of their foliage and 27% of them lost all their leaves (Fig. 5). More alarmingly, and despite a strong decrease in moth population levels in 2011, a tree-marking experiment revealed that box trees had not recovered in 2012 and that all the plants that had been completely defoliated in 2010 died (Nacambo 2012). This suggests that *B. sempervirens* is not able to survive total defoliation. A change of the ground covering vegetation due to increased exposure to sunlight has already been observed (John and Schumacher 2013). New stands were defoliated in late 2012, causing serious concerns for the survival of *B. sempervirens* in the region. The imminent arrival of *C. perspectalis* in the main distribution areas of *B. sempervirens* in the French Massif Central and the Pyrenees will undoubtedly have severe consequences, not only on the plant species itself, but also on the functioning of unique forest ecosystems as a whole. Furthermore, the invasive moth may also threaten the survival of *B. sempervirens* and the rare *B. balearica* in southern Europe, where they already experience a historical decline.

Recommendations for management

Cultivated box trees can be protected by chemical insecticides or, preferably, biopesticides based on *Bacillus thuringiensis* (Bt). In private gardens with few trees, the moth may be controlled by hand picking caterpillars, by shaking trees or by spraying water. In forests, however, these methods are not adequate. Given the urgency of the situation, a classical biological control program based on the introduction of a specific natural enemy from the region of origin probably provides the only sustainable solution. Surveys in Switzerland showed that the natural enemy complex in Europe is very poor. Larval parasitism was less than 1% and represented by a single tachinid parasitoid, *Pseudoperichaeta nigrolineata* (Walker) while no egg or pupal parasitoids were found (Nacambo 2012). Predators were not commonly observed either, possibly due to the sequestration of toxic alkaloids from their host-plant (Leuthardt et al. 2013). A few parasitoids are mentioned in the Asian literature but little is known on their efficiency and specificity. Furthermore, these records are restricted to ornamental plants in urban areas while surveys for natural enemies in the area of origin should be made primarily in the native habitats of *Buxus* spp.

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References

- Di Domenico F, Lucchese F, Magri D (2012) *Buxus* in Europe: Late Quaternary dynamics and modern vulnerability. *Perspect. Plant Ecol Evol Syst* 14:354-362.
- John R, Schumacher J (2013) Der Buchsbaum-Zünsler (*Cydalima perspectalis*) im Grenzach-Wyhlener Buchswald – Invasionsschronik und Monitoringergebnisse. *Gesunde Pflanzen* 65:1–6.
- Leuthardt FLG, Baur B (2013) Oviposition preference and larval development of the invasive moth *Cydalima perspectalis* on five European box-tree varieties. *J Appl Entomol* DOI: 10.1111/jen.12013.
- Leuthardt FLG, Glauser G, Baur B (2013) Composition of alkaloids in different box-tree varieties and their uptake by the box-tree moth *Cydalima perspectalis*. *Chemoecology* DOI: 10.1007/s00049-013-0134-1.
- Maruyama T, Shinkaji N (1993) The life cycle of the box-tree pyralid, *Glyphodes perspectalis* (Walker) (Lepidoptera: Pyralidae). III. Photoperiodic induction of larval diapause. *Jpn. J Appl Entomol Zool* 37:45-51. (In Japanese with English abstract).
- Nacambo S (2012) Parasitisme, développement, modèle climatique et impact de *Cydalima perspectalis* en Europe. MSc thesis, University of Neuchâtel, Switzerland.
- Nacambo S, Leuthardt FLG, Wan H, Li, H, Haye T, Baur B, Weiss RM, Kenis M (2013) Development characteristics of the box-tree moth *Cydalima perspectalis* and its potential distribution in Europe. *J Appl Entomol* (in press).

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