

Damage Level of *Cydalima perspectalis* (Lepidoptera: Crambidae) on Naturally Growing and Ornamental Box Populations in Artvin, Turkey

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Abstract

Aim of study: The box tree moth, *Cydalima perspectalis* (Lepidoptera: Crambidae), is an important alien invasive species on box, *Buxus sempervirens*, in Turkey. It was first detected in 2011 in Istanbul. It is a native pest of box plants in Asia. Its first discovery in Europe has been made in 2007 in Germany. Since then it has been successfully established in various ecosystems in Europe. Caterpillars feed on box leaves and cause severe defoliation and tree deaths. In this study, damage level and defoliation percentage were investigated on ornamental and naturally growing box plants.

Area of study: Box plants were sampled in Artvin in the Eastern Black Sea Region of Turkey.

Material and Method: A total of 90 box plants that were either naturally growing or ornamental box plants were sampled

Main results: Majority of the naturally growing box plants (63.4%) had strong and very strong damages, and 71.4% of the ornamental box plants had middle and strong damage levels.

Research highlights: Of the all observed plants, 53.4% had 40-100% defoliation and 25% of these plants did not recover.

Keywords: Box Tree Moth, *Buxus sempervirens*, Defoliation, Alien Species

Cydalima perspectalis (Lepidoptera: Crambidae)'in Artvin, Türkiye'deki Doğal Olarak Yetişen ve Süs Bitkisi Olarak Yetiştirilen Şimşir Populasyonlarındaki Zarar Seviyesi

Öz

Çalışmanın Amacı: Şimşir kelebeği, *Cydalima perspectalis* (Lepidoptera: Crambidae), Türkiye'de, şimşirin, *Buxus sempervirens*, önemli bir yabancı istilacı türüdür. İlk olarak 2011'de İstanbul'da tespit edilmiştir. Asya'daki şimşirlerin doğal bir türüdür. Avrupa'da ilk olarak 2007 yılında Almanya'da tespit edilmiştir. Tespit edildiği günden buyana Avrupa'da çeşitli ekosistemlere başarılı bir şekilde yerleşmiştir. Tırtıllar şimşir yapraklarıyla beslenir ve şiddetli yaprak kaybına ve ağaç ölümlerine neden olur. Bu çalışmada, süs bitkisi olarak yetiştirilen ve doğal olarak yetişen şimşirlerdeki zarar seviyesi ve yaprak kaybı oranı araştırılmıştır.

Çalışma Alanı: Türkiye'nin Doğu Karadeniz Bölgesindeki Artvin'de şimşir bitkileri örneklenmiştir.

Materyal ve Yöntem: Doğal olarak yetişen ya da süs bitkisi olarak yetiştirilen toplam 90 şimşir örneklenmiştir.

Temel Sonuçlar: Doğal olarak yetişen şimşirlerin çoğunluğu (%63,4) kuvvetli ve çok kuvvetli zarar görmüştür, süs bitkisi olarak yetiştirilen şimşirlerin %71,4'ü ise orta düzeyde ve kuvvetli zarar görmüştür.

Araştırma vurguları: İncelenen tüm bitkilerin %53,4'ünde %40-%100 yaprak kaybı yaşanmış ve bunların %25'i zararı atlatamamıştır.

Anahtar Kelimeler: Şimşir Kelebeği, *Buxus sempervirens*, Yaprak Kaybı, Yabancı Tür



Introduction

The box tree moth (BTM) *Cydalima perspectalis* (Walker, 1859) (Lepidoptera: Crambidae) is an alien invasive species in Europe including Turkey, and causes severe damages to box trees (*Buxus* spp.) in gardens, natural and semi-natural box tree forests (Krüger, 2008; Feldtrauer, Feldtrauer & Brua, 2009; Leuthardt, Billen & Baur, 2010; Straten and Muus, 2010; Hizal, Köse, Yesil & Kaynar, 2012; Kenis, Nacambo, Leuthardt, Di Domenico & Haye, 2013). BTM is a native species of East Asia (Inoue, Sugi, Kuroko, Moriuti & Kawabe, 1982). In Europe, the species was first recorded in 2007 from southwest Germany and the Netherlands (Krüger, 2008, Straten & Muus, 2010). Since then it has spread throughout in various ecosystems in Europe (Feldtrauer et al., 2009; Leuthardt et al., 2010; Straten & Muus, 2010; Sáfián and Horváth, 2011; Seljak, 2012; Kenis et al., 2013; Fora and Pořta, 2015). In Turkey, BTM was first reported from İstanbul (Hizal et al., 2012), then found in Düzce (Öztürk, Akbulut & Yüksel, 2016), Artvin and Bartın (Anonymous, 2018; Toper-Kaygın and Taşdeler, 2018).

BTM feeds on *Buxus sempervirens* L. and *B. microphylla* Sieb. & Zucc. in Europe (Leuthardt and Baur, 2013). It is reported to feed on *B. sinica* (Rehder & E.H.Wilson) M.Cheng and feed on other *Buxus* spp. in China and Japan (Wan et al., 2014). *Euonymus japonicus* Thunb. and *Ilex purpurea* Hassk. are also mentioned as host plants in Asia (Straten & Muus, 2010). In Turkey, the species has been reported only on *B. sempervirens* to date (Anonymous, 2018; Toper Kaygın & Taşdeler, 2018).

Formerly, natural *B. sempervirens* populations in the region have been devastated by boxwood blight *Cylindrocladium buxicola* Henricot (Henricot & Culham 2002) disease. This fungal pathogen was first noted in the end of 2011, in Trabzon and Artvin provinces. Devastating effects were reported in affected areas. Approximately 90% of the boxwood plants have been completely defoliated by this disease (Lehtijärvi, Dođmuş-Lehtijärvi & Oskay, 2014; 2017).

Buxus sempervirens has ecological, economic and cultural value for the region.

There are remarkable stands or wild populations in or close to protected areas. Box plants are used in gardens and parks as design plants. In addition, its hardwood is used in handcrafting industry, and fresh branches in floristry.

Foresters and the local community have concerns about the BTM's potential threat on natural *B. sempervirens* populations. Today distribution range of the *B. sempervirens* and BTM overlaps in Turkey. BTM has been recorded to devastate large areas that are larger than 100 ha of natural box forests during one single summer generation in Switzerland (Leuthardt and Ramin, 2011). Similar records have been notified from Russian Caucasus (Gninenko, Shiryaeva & Shurov, 2014). Caterpillars feed on the leaves of box trees and cause severe defoliation and eventually the death of trees. Defoliation and rapid death of the box trees increase exposure to sunlight in these destroyed ecosystems and cause a change of the ground covering vegetation (John and Schumacher, 2013). In Turkey, the effects of the moth on the survival of natural box populations and functions of forest ecosystems in the devastated large areas are of great concern. In this study, we aimed to evaluate the damage of BTM on sampled box plants and discuss damage level and the survival of natural box plants after attack.

Materials and Methods

The study was conducted from March to October in 2018, in Artvin in the Eastern Black Sea region of Turkey. A total of 90 box plants that were either naturally growing or ornamental box plants were sampled.

Buxus sempervirens L.

Buxus sempervirens L. has a wide distribution range in Euro-Siberian flora region. It basically grows in the understory of broad leaved forests along river valleys. In the distribution range, there are *Picea orientalis* (L.) Link. and *Alnus glutinosa* subsp. *barbata* (C. A. Mey.) Yalt. few in number at the canopy, and *Sambucus nigra* L. and *Ilex colchica* Poj. at the understory layer, and *Dryopteris* Adans., *Pteridium* Gled. ex Scop., *Galium* L. at the herbaceous layer together with box plants (Aksoy, 1998). *B. sempervirens* establishes pure forest stands at

900 m a.s.l. and 1500 m a.s.l at Firtına Valley (Figure 1a) in the Eastern Black Sea region (Aksoy, 1998). These distribution areas are located in Kaçkar Mountains National Park. In addition to these stands, natural populations of wild *B. sempervirens* in Hatıla Valley National Park, Klaskür Valley, Kamilet Valley,

Boxwood Gene Protection Forest and Galyan Valley in the Eastern Black Sea region are remarkable. Diameter and height of the box plants can reach 8-35 cm and 2-10 m, respectively (Aksoy, 1998). All the mentioned sites have faced BTM damage in the region (Figure 1b).

In Turkey, *B. sempervirens* and *B. balearica* Lam. are the native box species (Yaltrık and Efe, 2000).

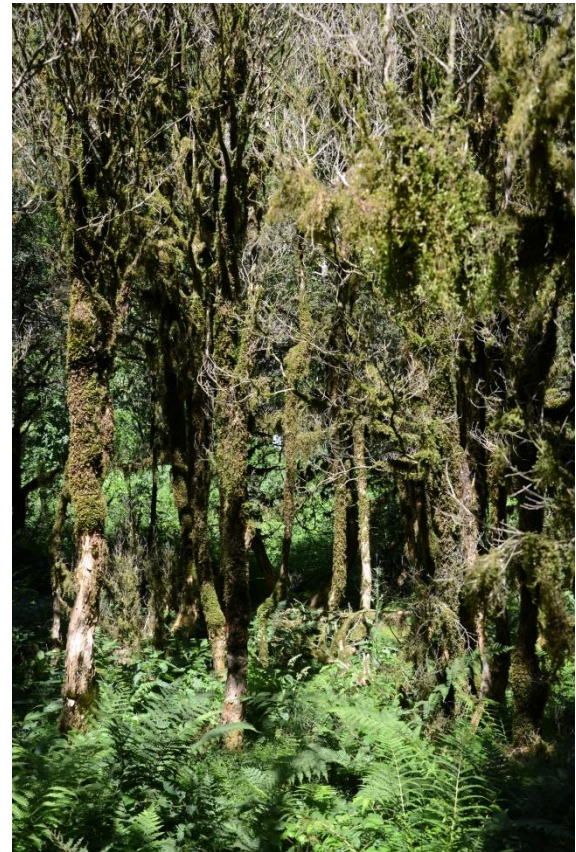
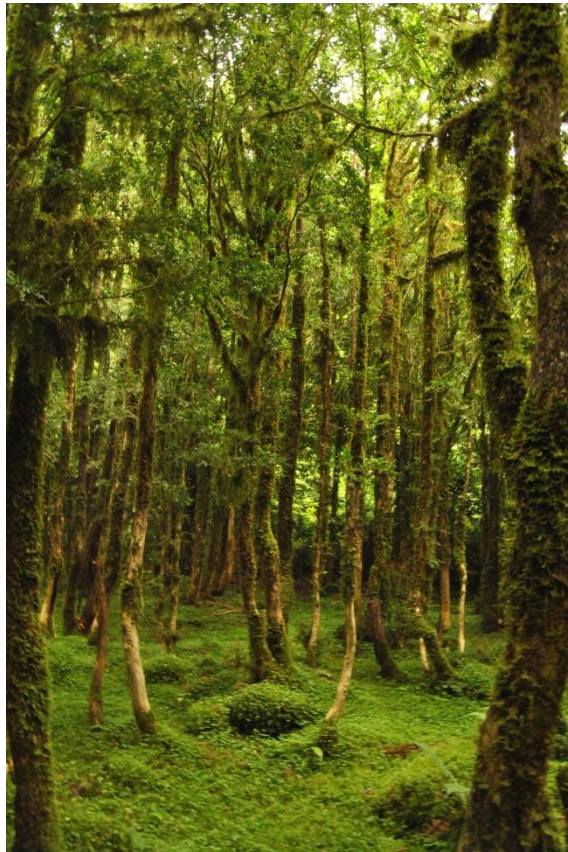


Figure 1. Natural *Buxus sempervirens* stand at Firtına Valley located in Kaçkar Mountains National Park, a. stand scene before *Cydalima perspectalis* damage, b. stand scene after the damage (Photos by Ođuz Kurdođlu)

Field Survey

Naturally growing and ornamental box plants were sampled at wild habitats along Çoruh River from Artvin to Borçka at dispersed habitat and at the campus of Artvin Çoruh University, respectively. There were 41 naturally growing and 49 ornamental box plants. BTM larval feeding activity was first recorded at 20 March 2018 in Artvin Çoruh University Campus. After this date, naturally growing box plants and ornamental box plants

have been observed every 10 days and 3-5 days until late October, respectively.

Observations on the Damage Level

Defoliation percentage and damage level on the sampled box plants were made by visual assessments following the work of Fora & Pořta (2015). There were 5 classes both for defoliation percentage and damage level. Defoliation percentages (%) were classified as 0, 1-20, 21-40, 41-60 and >60, and

corresponding damage levels were 0, 1, 2, 3 and 4, respectively. The significance of damage was categorized as follows: undamaged, weak, middle, strong and very strong (Fora & Pošta, 2015).

Defoliation percentage for every attacked box plant was recorded on every observation date. There were more or less recovery of the leaves on the damaged box plants until the next generation's caterpillars were observed. By the end of the October, total recovery of the leaves were recorded based on visual assessments as done for defoliation percentages before.

Results and Discussion

The first larval feeding activity was recorded on ornamental plants on March 20, 2018. Caterpillars either massively ate or skeletonized the leaves. Caterpillars were protected by loose webbing (Figure 2a, b, c).

Pupation occurred in the foliage and BTM pupae were well hidden between leaves and hard to see (Figure 2d). As for the adults, the most common variant of the species that has mostly white wings with a dark brown band at the outer margin were observed (Figure 2e). Newly hatched young caterpillars fed only at the underside of the leaves (Figure 2f).

The damage of BTM was observed 95.6% of the box plants examined. Defoliation percentages ranged between 10% and 100%. Of the 90 plants, 4.4% were undamaged, and 13.3%, 28.9%, 34.4% and 19.0% of the rest had weak, middle, strong and very strong damages, respectively. According to the defoliation percentages, majority of the naturally growing box plants (63.4%) had strong and very strong damages, and 71.4% of the ornamental box plants had middle and strong damages (Table 1).

Fora & Pošta (2015) studied at parks and gardens located in both urban and rural places. They reported that 19.35% of the individuals did not defoliate, 50.00%, 8.06%, 6.45%, 16.14% had weak, middle, strong and very

strong damages, respectively. The percentage of middle, strong and very strong damaged plants in our study are higher than Fora & Pošta (2015)'s results. When we compare our results that are related to naturally growing box plants at wild habitats, our damage results are again higher than Fora & Pošta (2015)'s results at the formerly mentioned damage levels. For the ornamental box plants in our study, our results are higher at middle and strong damage levels than Fora & Pošta (2015)'s results. Apparently BTM has well established in *B. sempervirens* growing areas both in gardens and wild habitats and damage box plants seriously in the Eastern Black Sea Region of Turkey. And their damage to box plants could be higher than some invaded countries in Europe.

Box plants that had weak and middle damage and lost their foliage up to 40% fully recovered after the BTM larval feeding. Plants with 41-60% defoliation recovered 50 to 75% of the defoliated leaves. There was 25% recovery of the leaves in 5 of the box plants that had very strong damage and faced more than 60% defoliation during larval feeding. No recoveries were observed in fully defoliated 12 box plants (Table 2, Figure 3).

The overlapping distribution of BTM and naturally growing box tree populations have also been reported from north-western Switzerland and south-western Germany (John & Schumacher, 2013). BTM caused more than 90% defoliation of all box trees in the Nature Reserve of Grenzach-Whylen where there is largest box tree forest in Germany. And 27% of the box plants could not recover (Kenis et al., 2013). In the current study, 95.6% of examined box plants were defoliated in different degrees by BTM. 53.4% of the all observed plants had strong and very strong damage and lost more than 40% of their foliage. Of these that had strong and very strong damages, 25% could not recover.



Figure 2. a. skeletonized leaves, b. late instar larva feeding on leaves, c. loose webbing around larva, d. pupa in the foliage, e. adult, f. young caterpillars feeding at the underside of the leaves (Photos by Hazan Alkan Akıncı)

Table 1. Defoliation percentage and damage level of BTM at the studied sites

Defoliation (%)	Damage level	Damage significance	Number of box plants	Number of box plants	
				naturally growing	ornamental
0	0	undamaged	4 (4.4)*	2 (4.9)	2 (4.1)
1-20	1	weak	12 (13.3)	7 (17.1)	5 (10.2)
21-40	2	middle	26 (28.9)	6 (14.6)	20 (40.8)
41-60	3	strong	31 (34.4)	16 (39.0)	15 (30.6)
> 60	4	very strong	17 (19.0)	10 (24.4)	7 (14.3)
Total number of box plants			90	41	49

* Numbers in brackets show the percentage (%) of box plants

Table 2. Recovery status of the leaves after BTM damage

Defoliation (%)	Damage level	Damage significance	Number of box plants	Recovery of the leaves after BTM damage	
				recovered leaves	no recovery
0	0	undamaged	4 (4.4)*		
1-20	1	weak	12 (13.3)	fully recovered	
21-40	2	middle	26 (28.9)	fully recovered	
41-60	3	strong	31 (34.4)	½ and ¾ of the leaves recovered	
> 60	4	very strong	17 (19.0)	¼ of the leaves recovered in 5 plants	no recovery in 12 plants

* Numbers in brackets show the percentage (%) of box plants

In conclusion, only 4.4% of studied box trees were undamaged, 42.2 % had weak or middle damages. These results suggest that BTM has a quite strong harmful effect on box trees in the study site. Tree deaths at the understory of forests in BTM's distribution range will inevitably affect functioning of forest ecosystems. John & Schumacher (2013) already report the change of the ground covering vegetation due to increased exposure to sunlight after tree deaths. Repeated attacks of BTM threaten the survival of *B. sempervirens* in the region. So far, there is no invasion report on *B. balearica* in Turkey. But possible arrival of the moth to the distribution area of

B. balearica areas may have severe consequences and destroy this rare species.

Manual removal of the caterpillars every 2 days in parks and gardens (Artvin Çoruh University campus in our case) may be effective against BTM. But in forests additional control measures are needed. As the existing prevention and control measures are not enough to overcome the dispersal and damage of BTM, further studies should focus on the biological control of the moth for sustainable solution such achieved in other important pests (Clausen, 1978; Grégoire, 1988; Alkan-Akıncı, Eroğlu & Özcan, 2010; Fischbein and Corley, 2015).



Figure 3. Naturally growing box plants that were fully defoliated and could not recover (Photos by Hazan Alkan Akıncı)

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