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Invasive pest - box tree moth *Cydalimaperspectalis* Walker. (1859) - and main biological aspects in Georgia

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ABSTRACT

The paper concerns box tree (*Buxus colchica*), the relic of Georgian flora and endemic of the Caucasian dendroflora and the very dangerous invasive pest, that spread on these trees - *Cydalima perspectalis*, that in 2012 together with the planting material of evergreen box tree (*Buxus sempervirens*), imported from Italy for greening of the Olympic village entered in Sochi; the pest invaded the territory of Sochi, and since 2013 from there the outbreak of the pest began, firstly on the territory of the town and then on plantings of the National park, that caused almost 100% defoliation of box tree. From Sochi the pest spread on box trees of the Black Sea coastland of Georgia and began their aggressive destruction. After that the pest has spread in parks and gardens of the whole Georgia, where box tree grew. The pest feeds on box tree leaves, and when leaves exhaust, they may additionally feed on peel of young shoots. Now the Colchic box tree is in very bad condition. Before the box tree moth, in 2009-2010 the invasive disease box blight *Cylindrocladium buxicola* has spread in Georgia, that destroyed more than a half box trees, and further box tree moth *C. perspectalis* added to it. The paper describes the results of study of the main aspects of biology of box tree moth, promotion of reproduction of resistant species by artificial grafting and pest control measures.

Keywords: Box-trees, *Cydalima perspectalis*, Biology, Flight of imago, laying of eggs, larvae

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Introduction

There are up to 49 species of box tree; from them a relic species *Buxus colchica* Pojark. grows in Georgia. It is mainly spread in the subtropical zone of Western Georgia. Sometimes its distribution is mentioned in this zone on the altitude of 1700 m above sea level.

It is an evergreen bush or a tree, grows very slowly, in favorable environmental conditions its height attains up to 15-18 m and diameter - 40-50 cm. It has a very excellent wood. Sprouts are covered with green bark, and a stem is grayish

yellow with very thin bark [1]. Its flower is rich in nectar, seed contains up to 37% of oil. Boiled wood and leaf give a brown paint; it is also used in medicine.

Wood is yellowish, very heavy (it sinks in water, even dry), dense and hard, when machined and polished it resembles an ivory. It is used in building and lathework (for figure handiworks), for manufacturing of music instruments etc. [2]. 1 cu.m of box tree weighs 1000 kg.

Trees of the Colchic box tree were cut down in large numbers in the XIX and the beginning of the XX century, because it represented the export

material. Its area in the forests of Georgia is 8,443 ha. There are many decorative forms of box tree. It well endures shearing. It is a very valuable species for decorative gardening. Box tree lives 500-600 years, is introduced in the Red Book.

In the end of the XX and in the beginning of the XXI century in Georgia and the neighboring countries (Black Sea region), due to weakening of a quarantine new invasive dangerous pests broke through, in their number - box tree moth *Cydalima perspectalis*.

The native land of the box tree moth is Eastern Asia: China, Japan, Korea, Russian Far East and India. Supposedly the pest occurred in Western Europe from China with sapling material; the first data about finding of box tree moth have been recorded in Germany in 2006, after that the pest has been introduced in the list of the most dangerous pests of Europe. After that up to today, besides Germany, it is spread in: Hungary, Romania, Switzerland and in other countries of Europe, and also in Turkey [3, 4].

In 2012 the pest box tree moth *Cydalima perspectalis* entered to the territory of Sochi with sapling material of the evergreen box tree (*Buxus sempervirens*), used for gardening of the Olympic village in Sochi. Since 2013 the pest outbreak began from there: firstly - on the territory of the town and then on the plantings of the National Park. It caused almost 100% defoliation of box tree and its drying [4]. The scientists S.A. Belokobylskij & Yu.I.Gninenko in the Northern Caucasus developed from pests of the North-Caucasian box tree an endoparasitoid - parasitic wasp (insect that lives in tissues of other organisms) and have demonstrated the parasitic wasp [5], which is an endoparasitoid of the dangerous pest - box tree moth.

From Sochi the pest has spread on Colchic box trees of the Black Sea coast of Georgia and aggressively destructed it. After that the pest has spread in parks and gardens of the whole Georgia, where box tree grew. The pest feeds on box tree leaves, and when leaves exhaust, they may additionally feed on peel of young shoots [6]. Now the Colchic box tree is in very bad condition. Before the box tree moth, in 2009-2010 the invasive disease box blight *Cylindrocladium buxicola* spread in Georgia, that destroyed more than a half of box trees [7], and further (since 2013) box tree moth *C. perspectalis* added to it.

It should be noted, that at present the Colchic box tree is in very bad situation, because 2-3 years ago box blight *Cylindrocladium buxicola* spread, that began destroying of box tree and, unfortunately, in Georgia and in other countries a control of this fungal disease is hampered; there is no point in spraying the 15-20 m length trees by above ground equipment (that is - by bio preparation). It is impossible to spray all leaves diseased by fungi (they must get wet). As we know from various scientists in literature [8], a spore of this fungus lives in soil 5 years; imagine how difficult a complete elimination of this disease is. In addition, as we know a majority of box tree copses grow under the crowns of other trees and contact of the bio preparation with these trees is a problem.

To the spread of this fungal disease and strong damage, or defoliation of box tree a very dangerous and aggressive pest - box tree moth *C. perspectalis* was added; this became a reason of study of its main biological aspects (mode of life) and research.

Objectives and methods

We identified Box tree moth for the first time in Georgia on 6th of August 2014 in the resort Grigoleti of Lanchkhuti municipality, in the private yard of an inhabitant, on the bushes of the Colchic box tree *Buxus colchica* Pojark. After that we carried out observations in the forest massifs of box tree in Adjara: in Kintrishi protected area, Mtirala national park, Machakhela national park, Khelvachauri, in general in the whole Georgia, where box tree is distributed. We carried out all kinds of observations: on distribution, biology and a mode of life, in general.

Actively feeding larvae of the final age of the pest box tree moth *Cydalima* (= *Diaphania*) *perspectalis* (Lepidoptera: Pyralidae) were placed in small bags of black fabric and delivered to the laboratory of Vasil Gulisashvili Forest Institute of Agricultural University of Georgia, there were placed in big insect rearing chamber and a feed - box tree shoots with leaves - has been given to them. Larvae pupated on 14.08.2014 and after 12 days, on 26.08.2014 moths (imago) fled out, they were straightened on the insect straightening board, moths were identified and material was placed in the entomological box that is kept in the laboratory.

Since 2014 Box tree moth that broke through the

Black Sea region, spread in the whole Georgia and also in Turkey.

The intensity of pest spread was determined according to a percentage of damage (with destruction) of tree crown - leaves - in this way:

- if tree leaves were not damaged or eaten - 0 number;
- if tree leaf damage was one tenth of a crown, or 10% - weak damage;
- if tree leaf damage was one fourth of a crown, or 25% - moderate damage;
- if tree leaf damage was a half, or 50% - strong damage;
- if tree leaf damage was from 50% up to 75% - very strong damage;
- if tree leaf damage was 75% or more - the tree already dies (defoliation occurred).

We researched and studied various aspects of biology of the pest: different phases of development of the pest, quantity, density of settling, degree of damage etc., we also measured phases by 8x ocular

microscope MBC-1 with diopter scale, sizes of various phases of box tree moth (50 specimens from each phase).

Results and discussion

We have found box tree moth for the first time in Georgia in the town let Grigoleti, Lanchkhuti district on 6th of August 2014; it migrated from Sochi to Abkhazia [3], and from there it very quickly spread in big numbers in Adjara box tree plantations, and in 3 years it spread basically in Western Georgia and then in Kartli and Eastern Georgia.

Intensive spread of the pest in 2-3 years has severely damaged and defoliated box trees [4], drying of trees began, mainly in Western Georgia and Adjara, where there was the most box trees; a period of their destruction began; the 400- 500 years old box trees dried in Tkibuli, Martvili, on Kolkheti lowland, in Kintrishi, Mtirala, Machakhela, Khelvachauri etc. (Fig. 1, 2).

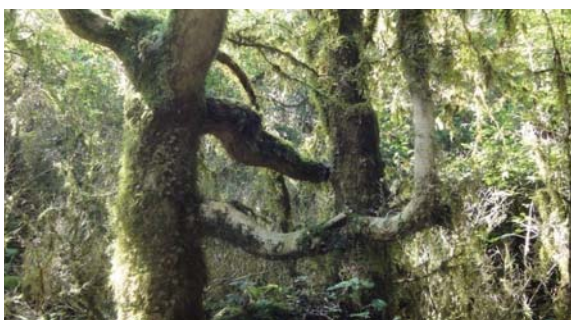


Fig.1. Old dried box trees in Kintrishi



Fig.2. Small dried box tree in Mtirala

#	Location	damage of box tree leaves (eating) in %					
		healthy 0 -%	weak 10%	moderate 25%	strong 50%	very strong 50-75%	defoliated 75% and >
1	Tkibuli (Mukhuri)	1-2	+	+	+	+	-
2	Martvili (Gachedili - Salkhino)	-	-	-	+	+	+
3	Kolkheti lowland	-	+	+	+	+	+
4	Kintrishi	-	+	+	+	+	+
5	Mtirala	-	+	+	+	+	+
6	Machakhela	-	+	-	+	-	-
7	Khelvachauri (Kirnati)	-	+	+	+	+	+

Table. Box tree moth spread in Western Georgia and coastland of Black Sea and damage caused by it in % in 2016-2017

We recorded a damage of tree by box tree moths - Table (% of damage - defoliation of leaves). As we see from the Table, box trees are almost destroyed, due to high density of the pest and its aggressiveness that caused almost total devastation of box trees in the entire Georgia.

We have delivered young larvae of box tree moth, found in the field conditions (in Western Georgia and also in Eastern Georgia) to Tbilisi and began in the laboratory of the Forestry Institute of the Agricultural University of Georgia their study and observation on their biological aspects - mode of life etc.

Egg. The female moth lays egg clusters on the underside of a leaf, winters in the egg phase. Egg is yellowish in color, 1 mm on average. On Spring 2017 larvae hatched from wintered eggs (Fig.3)



Fig.3. larvae of I age, hatched from egg clusters laid by moth



Fig.4. Mesophyll of underside of leaf eaten by larvae of moth of I-II age

Larva. Larvae of moth of the first age hatched, began active eating of mesophyll of underside of

box tree leaf (Fig.4). We have measured the newly hatched I age larvae: they were 1.1-1.2 mm; the II age larvae were 2.3-2.4 mm; these newly hatched larvae are white or yellowish-green in color, heads are black. The larvae of 3-4 ages became green, again with black head. Larvae have black stripes on the both sides. The size of larvae of the last age is up to 2.5 cm (Fig.5). They actively feed and are insatiable - they eat leaves completely (they change skin 4 times). When feed is in short supply, they also eat skin of young shoots; at last on the 25th-27th day of their development larvae make a gossamer, wrap up in it and pupate.



Fig.5. larva of box tree moth of the last age

Pupae. The larvae of the last age of the I generation pupated on 14-15 May, when the temperature was 20-23°. The first moth of the I generation flew out on 28-29 May, i.e. the phase of chrysalis lasted for 14 days (Fig. 6, 7).



Fig.6. The largest chrysalis 1.95 cm



Fig.7. The smallest chrysalis 1.65 cm

Imago. Moths that fled out from one and the same population of box tree moth - 12-15% are brown, and the remaining 85-88% - of ordinary white color, with brown edging around wings (Fig.8, 9).



Fig.8. Moths of box tree moth, white and brown



Fig.9. Moth of box tree moth with open wings



Fig.10. Imago of box tree moth

The moth (imago) of the pest with open wings is 4.0-4.5 cm (Fig.10). On a head it has big embossed eyes of dark color and thread-like whiskers (Fig.6). Males have white wings with dark brown edging, females - light brown with white spot and with bluish violet nacreous shine. In the ends of wings - short thin hairs in a form of fringe. It gives yearly 3 or 4 generations.

Ovaries of moths. We cut the newly fled out female moths; eggs of yellowish color were discovered in ovaries - on aver. 1mm, 59-61 pcs (Fig. 11, 12).



Fig.11. Cross section of ovary of female moth

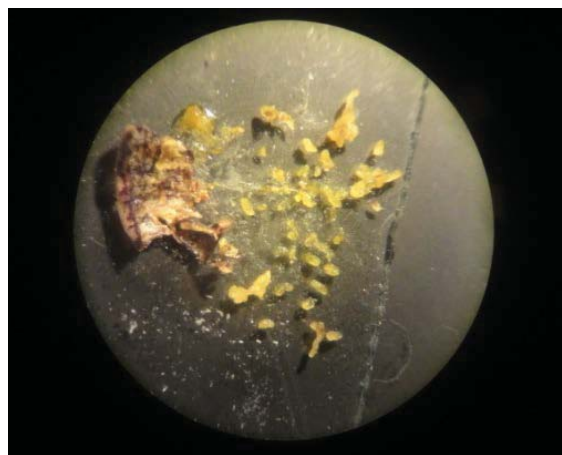


Fig.12. Average number of eggs in ovary 59-61 pcs

1. Mechanical control measures may be carried out against box tree moths, when larvae and eggs of box tree moths are collected by hand and burnt.

2. Biological by means of useful insects and **insect traps with pheromones**. From bio preparations there recommended the bacterial preparation - lepidocide, that is produced on the basis of the bacteria *Bacillus thuringiensis var. kurstaki*, only by the Russian company “Sibbiopharm” from Berdsk, which has wide experience in producing of bio preparations, is characterized by good results on the larvae of first - second- third ages, or on young larvae [9, 10], when a larva eats leaves processed with this bacteria.

3. In a deadlock the pyrethroids are used from the chemical pesticides against box tree

moth: the preparations “Decis”, “Fastac”, “Karate”, as well as drastic systematic preparations - “Bi-58” or Carbophos; however at use of chemical preparations we must be very careful, avoid from children and animals. In general use of chemicals in forest in Georgia is prohibited.

A network of nurseries should be established, where the box tree moth-resistant forms will be grown; then they will be artificially reproduced in box tree lost massifs, when box tree moth will begin reducing its outbreak. Rescuing of unique plants from total destruction must be helped by the organization of special reserves, where selectionists will can to select the box tree forms.

Conclusion

1. In 2009- 2010 in Georgia the invasive disease - box blight *Cylindrocladium buxicola* spread in Georgia, that destroyed more than half of Colchic box tree, and then (since 2013) the pest box tree moth *Cydalima perspectalis* added to it.
2. In 2012 the pest box tree moth *Cydalima perspectalis* entered to the territory of Sochi with sapling material of the evergreen box tree (*Buxus sempervirens*), used for gardening of Olympic village in Sochi. Since 2013 the pest outbreak began from there: in Abkhazia and in the entire Georgia, also in Turkey. It caused almost 100% defoliation of box tree and its drying.
3. The pest turned out to be very aggressive; in a season it gives 3 or 4 generations, that is destructive for trees and plants.
4. In 2013 – 2014 the pest has spread in the entire Adjara, and then in the whole Georgia.
5. By route walking we have researched and determined a damage caused by pests and diseases, massive spread of the pest. Before the means for their control have been determined, the pest has brought box trees to the brink of extinction.
6. After spread of a box tree moth, a part of box trees turned out to be resistant in respect of the pest disease, so we should take scions from these box trees and to plant box tree nurseries by grafting and then replant them in the areas with lost box tree, where the climate was favorable for box trees. Acknowledgments
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