doi: 10.17221/60/2016-PPS

First Record of *Dendroctonus micans* (Kugelann, 1794) on Non-native Spruces in Slovakia – Short Communication

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Abstract

Vakula J., Zúbrik M., Galko J., Gubka A., Kunca A., Pavlík J., Nikolov C. (2016): **First record of** *Dendroctonus micans* (Kugelann, 1794) **on non-native spruces in Slovakia – short communication**. Plant Protect. Sci., 52: 277–282.

In 2015, we recorded the first attack of the great spruce bark beetle, *Dendroctonus micans* (Kugelann) (Coleoptera: Curculionidae, Scolytinae) on non-native *Picea orientalis* (L.) and *Picea pungens* (Engelmann) in Slovakia. To our knowledge, the occurrence of *D. micans* on *P. orientalis* in Central Europe has not been described yet. We found that *D. micans* preferred *P. orientalis* over *P. pungens* and other coniferous trees in urban areas. In laboratory conditions, 352 adults of *D. micans* emerged and only 1 predator, *Rhizophagus grandis* (Gyllenhal) (Coleoptera: Monotomidae), was recorded. *D. micans* has a potential to become a serious pest of *P. orientalis* and *P. pungens* in urban, and in air-polluted areas.

Keywords: great spruce bark beetle; urban forestry; pests; *Picea orientalis; Picea pungens*

The great spruce bark beetle, *Dendroctonus micans* (Kugelann, 1794) (Coleoptera: Curculionidae, Scolytinae), is the only representative of the *Dendroctonus* genus in Europe (Pfeffer 1989), and is also the largest bark beetle occurring in Europe (Zúbrik *et al.* 2013). Originally, this species occurred in the north Palearctic ecozone from northern Europe across Siberia to Japan (Fielding & Evans 1997; Akinci *et al.* 2009). During the last 100 years, it spread over all European regions forested with spruce (Averbeke & Gregoire 1995; Akinci *et al.* 2009; Lukášová & Holuša 2011).

D. micans primarily breeds in spruce (*Picea* spp.), especially in *P. abies*, *P. sitchensis*, and *P. orientalis* (Grégoire 1988). It also develops in other tree species such as *Abies* spp., *Larix* spp., *Pinus* spp., and *Pseudotsuga* spp. (Carle 1975; Grégoire 1988). In western Europe, *P. abies* (L.) and *P. sitchensis* (Bongard) are its most frequent host tree species. In the eastern part of Europe it is *P. orientalis* (Kobakhidze *et al.* 1968). In Central Europe, *D. micans* occurs on *P. abies* (Pfeffer 1955) and on introduced North American *Picea pungens* (Kula *et al.* 2010, 2012; Lukášová *et al.* 2014).

Within most of its natural range, *D. micans* normally occurs at low levels and causes little tree mortality. However, outbreaks do occasionally occur (CABI 2015) which result in widespread tree mortality (Kobakhidze *et al.* 1970; Göktürk *et al.* 2011). In Slovakia, *D. micans* belongs to rare species; we have no information about its outbreaks in the past. Similarly, no outbreak has been recorded in the Czech Republic (Kula *et al.* 2012). Pfeffer (1995) classified *D. micans* as a latent secondary pest. Roubal (1941) described sporadic occurrences of *D. micans* on *P. abies* in Slovakia. In the past, *D. micans* was more frequent on *P. abies* in Slovakia. A few studies on its occurrence and protective measures against this species have been published (Pfeffer 1955; Hendrich 1959; Novák *et al.* 1974). It is often mentioned as a pest that is activated in younger stands damaged by *Lymantria monacha* (L.), thinned thickets, in stands

Supported by the Slovak Research and Development Agency, Projects No. APVV-14-0567 and No. APVV-0707-12.

doi: 10.17221/60/2016-PPS

on originally agricultural land, and in spruce trees standing on forest edges. Outbreaks of *D. micans* are often thought to be linked to weakening of trees by drought (Petersen 1952; Akinci 2009; Forestry Commision 2012). Fiending and Evans (1997) stated that *D. micans* breaks out after two consecutive dry seasons. Periods of drought severely weaken the host trees making them less able to withstand beetle attack (Bejer 1985).

D. micans is considered an economically important pest on *P. sitchensis* in England and Denmark (Petersen 1952; Evans & Fielding 1994). So far the largest calamities caused by this species have been observed on *P. orientalis* in Turkey and Georgia (Kobakhidze *et al.* 1970; Akinci *et al.* 2009; Göktürk *et al.* 2011). In the north-eastern part of Turkey, where *D. micans* was firstly discovered in 1966 (Acatay 1968), 120 000 ha with 22.8 million m^3 of wood on standing trees were damaged and a total of 6.96 million m^3 were cut over 20 years (Akinci *et al.* 2009). In the past, occurrence of *D. micans* on *P. pungens* was confirmed in Finland (Juutinen 1953), Denmark (Petersen 1952), Estonia (Voolma 1980), and also in the Czech Republic in the 60s of the last century (Andrš 2001). Over the last decade, its outbreaks on *P. pungens* in the Czech Republic were observed in stands situated in polluted areas (Kula *et al.* 2010, 2012) and also in town residential areas (Lukášová *et al.* 2014).

D. micans naturally attacks trees stressed e.g. by drought, snow, icing, wood harvest, red rot or Honey fungus but apparently healthy trees are commonly attacked, too. Trees infested by this species can live for several years; repeatedly attacked trees die in 5–8 years (Pfeffer 1955; Křístek & Urban 2004). Adult beetles move mainly by crawling, but they occasionally fly and so can disperse to more distant trees. Maximum natural dispersal rate is approximately 5–6 km/year (O'Neill & Evans 1999).

Rhizophagus grandis Gyllenhal (Coleoptera, Monotomidae) belongs to significant natural enemies of *D. micans*, and is considered the main factor reducing the gradation of the great spruce bark beetle (Kobakhidze *et al.* 1970). It is successfully used as a biological control agent (Grégoire *et al.* 1985; Fielding *et al.* 1997; Lukášová & Holuša 2011).

The objectives of the present study are: (*i*) to document the first record of *D. micans* on non-native spruce species in Slovakia; (*ii*) to map the natural occurrence of *D. micans* in Slovakia; and (*iii*) to determine the spectrum of insects emerged from logs infested by *D. micans* in laboratory.

MATERIAL AND METHODS

Occurrence of Dendroctonus micans on non-native tree species. In 2015, *D. micans* was recorded on *P. orientalis* and *P. pungens* in the town of Liptovský Hrádok. The town is situated in the central part of Slovakia, in the Liptovská kotlina Basin between the High and the Low Tatra Mountains. The mean elevation is 640 m a.s.l.; the town is located in a moderately cool region with mean annual temperature of 6.3°C and mean annual precipitation totals of 691 mm. In total, 4 sites were identified in the central part of the town (Table 1). The infested *P. orientalis* trees were on the average 41 years old, 14.0 m high, their mean diameter at breast height $d_{1.30}$ was 24.0 cm. The infested *P. pungens* trees were on the average 34 years old, 12.9 m high, their mean diameter at breast height $d_{1.30}$ was 35.2 cm. The beetles were detected on the basis of visible symptoms on damaged stems, such as exit holes (Figure 1), pitch tubes (Figure 2), larval tunnels, and beetles and/or larvae presence in galleries.

Occurrence of D. micans on Norway spruce (P. abies). *D. micans* natural occurrence on *P. abies* was described based both on published (Roubal 1941) or unpublished reports (Forest Protection Service in Banská Štiavnica).

Laboratory experiment. To obtain adults of *D. micans* and to determine the spectrum of natural insect enemies, we took 10 wooden logs from the site of the Forestry school in April 2015. Logs were placed into photoeclectors with a total volume of 0.50 m^3 and bark surface of 6.98 m^2. Logs were taken

Figure 1. Exit holes of *D. micans* on a stem of *P. orientalis* together with holes after woodpecker drilling

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Table 1. Study sites in Liptovský Hrádok and number of observed trees/number of trees infested by *Dendroctonus micans*

Site	GPS coordinates	*Picea orientalis*	*Picea pungens*	*Picea abies*	*Picea sitchensis*	*Picea omorika*	*Picea ngelmannii*	*Picea rubens*	*Pinus silvestris*	*Pinus cembra*	*Abies alba*
Town centre	49°2'21.53"N 19°43'24.24"E	–	52/20	3/0	–	–	–	–	12/0	5/0	2/0
Forestry school	49°2'16.96"N 19°43'29.92"E	5/5	24/11	–	–	2/0	3/0	–	2/0	5/0	2/0
Belanská street	49°2'25.81"N 19°43'17.33"E	–	26/8	5/0	–	1/0	–	–	3/0	7/0	–
Arboretum	49°2'30.44"N 19°43'33.35"E	6/4	18/0	1/0	3/0	11/0	–	1/0	5/0	–	–
Total		11/9	120/39	9/0	3/0	14/0	3/0	1/0	22/0	17/0	4/0

from two *P. orientalis* trees and one *P. pungens* tree. The length of logs was 72–89 cm, and their middle diameter was 26–32 cm. The logs were selected from the infested parts of stems on the basis of the presence of overwintering larvae. Photoeclectors were placed in a room with daylight, air temperature of 20°C, and air humidity of 55% in the Forest Protection Service laboratories. The samples of emerged insects were collected weekly during the period from April 23 to August 13, 2015, and preserved in 75% ethylalcohol. The relative abundance of predators and parasitoids was calculated as follows:

$$\%_{pred+par} = N_{pred+par} \times 100/(N_{pred+par} + N_{xyl})$$

where: $N_{pred+par}$ – number of emerged predators and parasitoids; N_{xyl} – number of emerged xylophagous beetles

RESULTS AND DISCUSSION

Occurrence of D. micans on non-native tree species. In February 2015, totally 204 trees of 10 species were observed in order to determine the infestations of *D. micans*. Infestations of *D. micans* were recorded on *P. orientalis* and *P. pungens*. To our knowledge this is the first published infestation of *D. micans* on non-native spruce species in Slovakia and the first attack of *P. orientalis* in Central Europe. During the inspection we found that from 67% (Arboretum) to 100% (Forestry school) of *P. orientalis* and from 0% (Arboretum) to 46% (Forestry school) of *P. pungens* trees were infested at each site (Table 1). The entrance holes with pitch tubes were concentrated on the basal parts of stems, usually below the height of 2 m. Some of the *P. pungens* trees were also attacked in the crown up to the height of 6.5 m. The entrance holes were often placed around the wounds from de-branching. The infested trees were difficult to identify from a distance, because there were no visible symptoms like defoliation and discolouration. *P. abies* trees growing in the surroundings of infested *P. orientalis* and *P. pungens* were not attacked. Similarly, *P. sitchensis* (Bongard), *P. omorika* (Pančić), *P. engelmannii* (Parry ex Engelmann), *P. rubens* (Sargent), *Pinus silvestris* (L.), *P. cembra* (L.), and *Abies alba* (Miller) occurring near the infested trees were not attacked.

Figure 2. Pitch tubes of *D. micans* on *P. pungens*

P. orientalis is a native species of South Europe (Caucasus), and in Slovakia it is rarely planted in urban and park areas. Therefore we have no specific data on its distribution in Slovakia. *P. pungens* is a native species of North America, and in Slovakia it belongs to the most common tree species used in urban and park areas. It is also planted in forests of air-polluted areas. According to the inventory data of the National Forest Centre, the area of *P. pungens* forest cover is 98.20 ha, most of which is situated in the regions of Košice (38.70 ha) and Banská Bystrica (32.10 ha).

From the spatial point of view, the closest information about the infestation of *P. pungens* by *D. micans* is from the Czech Republic from 2011–2012 (Lukášová *et al.* 2014). In Poland, it has been

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recorded only on *P. abies* (Grodzki 1995), no attacks were recorded on *P. pungens (*Grodzki, pers. com.). In the 60s of the last century, Andrš (2001) found that *D. micans* prefers *P. pungens* over *P. abies*. This author did not find any infested trees of *P. abies* in the surroundings of infested *P. pungens* trees. This is in accordance with our results. In our study we found that *D. micans* highly prefers *P. orientalis* and *P. pungens* to other tree species, and based on the infestation rate we assume that from the two mentioned it prefers *P. orientalis* more. The successfulness of infestation of several *Picea* spp. by *D. micans* was compared in Denmark where the following order was determined: *P. pungens* = *P. orientalis* > *P. sitchensis* = *P. alba* > *P. abies* > *P. omorika* (Bejer 1985; Fielding & Evans 1997). This finding is partly in accordance with our results.

Occurrence of D. micans on Norway spruce (P. abies). Norway spruce (*P. abies*) is the second most abundant tree species in Slovakia and covers 25.7% of total forest area. Roubal (1941) described 13 sites with confirmed occurrence of *D. micans* on *P. abies*. In the period 1990–2015, inspectors of the Forest Protection Service in Banská Štiavnica recorded beetles of *D. micans* on *P. abies* at 9 sites. Species were found on infested Norway spruce trees or were unintentionally captured in pheromone traps baited for *Ips typographus*. Sites of *D. micans* occurrence in Slovakia are shown in Figure 3. Natural occurrence of *D. micans* on *P. abies* is concentrated in spruce stands at higher elevations.

Laboratory experiment. In laboratory, we determined Coleoptera, Raphidioptera, and Hymenoptera emerged from infested logs (Table 2). A total of 352 adults of *D. micans* were collected. The mean density of *D. micans* per 1 dm^2 was 0.50 specimens. In total, 22 adults of *Tetropium fuscum* (F.) emerged. Entomofauna on *P. pungens* in Slovakia was thoroughly studied by Kršiak *et al.* (2009), who described a total of 12 species of bark beetles (Curculionidae, Scolytinae). *D. micans* was not listed among them. *T. fuscum* (F.) and *T. castaneum* (L.) belong to less important secondary spruce pests in Slovakia (Hendrych 1959; Vakula *et al.* 2015) and in BAWBILT countries (Evans *et al.* 2004). Trees infested by *D. micans* are in the second year usually infested by *T. fuscum*, which fastens mortality of infested trees (Pfeffer 1955; Grodzki 1995; Křístek & Urban 2004).

From predators, 17 adults of *Thanasimus formicarius* L. (Cleridae), 1 adult of *Rhizophagus grandis* Gyllenhal (Monotomidae), and 9 adults of *Phaeostigma notata* F. (Raphidiidae) were recorded. *T. formicarius* is predator to more than 20 species of bark beetles, including *D. micans* (Kenis *et al.* 2004). *Tetropium* spp. are also attacked by this predator (Kenis & Hilszczanski 2004). Only one specific predator, *R. grandis,* emerged from the samples, which is the most significant predator of *D. micans* (Grégoire *et al.* 1985; Fielding & Evans 1997). In the Czech Republic, *R. grandis* was also found on *P. pungens* (Lukášová *et al.* 2014). Adults and larvae of *R. grandis* feed on the eggs, larvae, pupae, and callow adults of the prey. During larval life, each individual consumes the equivalent of one fully grown larva (Merlin *et al.* 1984). *P. notata* is polyphagous predator of various bark and wood boring insect including *Tetropium* spp. (Kenis & Hilszczanski 2004). From parasitoids, 20 adults of Ichneumonoidea and 21 adults of Chalcidoidea were recorded. The results showed that natural enemies were less abundant in these populations; the relative abundance of predators and parasitoids was low (ca. 15.4%). The locality of Liptovský Hrádok, like other urban areas, is characterised by an isolated population of *D. micans*. A low incidence and abundance of polyphagous natural enemies is a common phenomenon in simple bark beetle populations that have limited access to other bark beetle populations and that live in separated biotopes (Wegensteiner & Weiser 1996; Lukášová *et al.* 2014).

Considering the ongoing climate change and higher occurrence of dry years and low abundance of

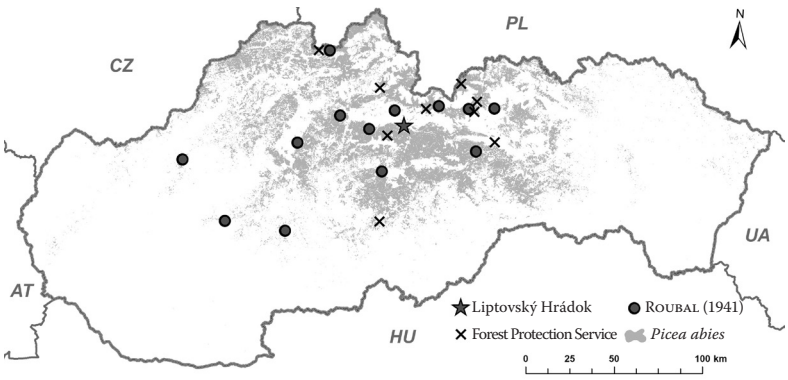

Figure 3. Occurrence of *Dendroctonus micans* attacks on *Picea abies* (Roubal 1941, unpublished data of Forest Protection Service) in Slovakia. Attacks on *Picea orientalis* and *Picea pungens* were recorded in Liptovský Hrádok (star symbol)

doi: 10.17221/60/2016-PPS

Table 2. Number of insects emerged from infested logs which were placed in photoeclectors

Log	Host tree										Total
	Picea orientalis 1				*Picea orientalis* 2			*Picea pungens* 1			
	2A	2B	2C	2D	3A	3B	3C	4A	4B	4C	
Area of log (dm^2)	79.8	75.5	60.6	67.4	69.2	65.1	71.3	76.4	67.7	64.9	697.8
Coleoptera											
Dendroctonus micans	17	3	14	58	–	–	195	6	56	3	352
Tetropium fuscum	15	1	2	2	–	1	–	1	–	–	22
Thanasimus formicarius	7	3	1	1	3	1	–	–	–	1	17
Rhizophagus grandis	–	–	–	–	1	–	–	–	–	–	1
Raphidioptera											
Phaeostigma notata	3	–	1	–	1	–	–	3	–	1	9
Hymenoptera											
Ichneumonoidea	6	–	–	–	12	2	–	–	–	–	20
Chalcidoidea	–	–	–	–	–	–	–	11	–	10	21

the bio-control complex, we assume that *D. micans* outbreaks will likely become more frequent. This pest may in future severely threaten cultivation of *P. pungens* and *P. orientalis* in urban areas, as well as forest stands of *P. pungens* in air-polluted areas.

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Received: 2016–01–20
Accepted after corrections: 2016–06–28
Published online: 2016–08–12

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