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The bark beetles *Orthotomicus laricis* and *Orthotomicus longicollis* are not pests in Central Europe: a case study from the Czech Republic

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Abstract

The bark beetle *Orthotomicus laricis* (F.) (Coleoptera Curculionidae Scolytinae) occurs on conifers in coniferous forests and even on confers in areas with few forests at a wide range of altitudes throughout the Czech Republic. Although *O. laricis* is a common species, its population densities are low. The bark beetle *Orthotomicus longicollis* (Gyllenhal) was recorded for the first time on pines in the Czech Republic in the 1990s and in Bohemia in 2017. *O. longicollis* is known only from several localities in the eastern Czech Republic at 200-400 m elevation. Several weakened trees with *O. longicollis* infestations along the lower parts of their trunks were found in 2017. There is no evidence that either *O. laricis* or *O. longicollis* is able to kill healthy trees, and records from the Czech Republic include no data about damage caused to timber by the two species. Neither species should be considered a primary or even a secondary pest, i.e. subeconomic pest.

Key words: pine, spruce, *Orthotomicus*, pest status.

Introduction

Bark beetles (Coleoptera Curculionidae Scolytinae) are a diverse group with a worldwide distribution. The overwhelming majority of bark beetle species breed only in dead trees and tree parts, and play a valuable role in nutrient cycling and as food for other animals. In temperate and boreal forests, however, some species of scolytid bark beetles are the most serious pests of economically important trees (Lieutier *et al*., 2004). Although a large number of scolytid species infest only stressed or dying trees (Paine *et al*., 1997; Wood, 1982) and have no effect on trees, one-third of the 120 scolytid species occurring in Central Europe are classified as pests in at least one European country (Lieutier *et al*., 2004) where they feed on, kill, and damage economically important tree species.

The term "pest" identifies an organism that interferes with human management objectives. Bark beetles are often considered pests when, for example, they kill large numbers of trees in commercial plantations or natural forests. Although they are not generally considered to be pests if they kill trees in a wilderness area, they are regarded as pests with regard to some human values but not others if they kill trees in a national forest that is managed for multiple uses (Raffa *et al*., 2009). Although bark beetle outbreaks significantly affect forest stands, they are unlikely to be detrimental in the long term (Hart *et al*., 2015).

Nine species of bark beetles belong to the genus *Orthotomicus* in Europe: *O. erosus* (Wollaston), *O. laricis* (F.), *O. longicollis* (Gyllenhal), *O. mannsfeldi* (Wachtl), *O. proximus* (Eichhoff), *O. robustus* (Knotek), *O. starki* Spessivtsev, *O. suturalis* (Gyllenhal), and *O. tridentatus* Eggers (Knizek, 2011). *O. erosus* has been mentioned as a forest pest in only one European country (the name was not recorded) (Gregoire and Evans, 2004). *O. erosus* commonly infests and reproduces on stressed or damaged trees, although a large number of newly emerging adults can lead to the colonization of nearby healthy trees (Gil and Pajares 1986; Pernek *et al*., 2019). However, the extent of the damage caused by *O. erosus* has been quantified only occasionally. Winglefield and Swart (1994) reported that together with the weevil *Pissodes nemorensis* Germar, *O. erosus* further damaged pine trees that were infected with the fungus *Sphaeropsis sapinea* (Fr.) Dyko et B. Sutton in South Africa. In Croatia, 446 ha and about 9,000 m^3 of wood mass have been reported to be infested in 2018 (Pernek *et al*., 2019). *O. tridentatus* was reported to damage the cedar (*Cedrus* sp.) forests in the Taurus Mountains (Avci and Sarikaya, 2009).

Orthotomicus bark beetles are frequently detected in international ports and in plant quarantine inspections (Brockerhoff *et al*., 2003; 2006a; Rassati *et al*., 2015; 2017). They are often found in timber, wood products, and woody packaging materials (Wood and Bright, 1992; Haack, 2001, Brockerhoff *et al*., 2006b; Kirkendall, 2018). The potential for damage caused by introduced *Orthotomicus* spp. in non-native regions has led to intensive efforts to develop pheromone lures for *O. erosus* (Giesen *et al*., 1984; Klimetzek and Vite, 1986; Mendel, 1988; Paiva *et al*., 1988; Seybold *et al*., 2006) and *Orthotomicus latidens* (LeConte) (Miller *et al*., 2005; Steed and Wagner, 2008). In contrast, *Orthotomicus* species native to Central Europe have not been considered pests (Pfeffer, 1955; Schwenke, 1972) with some exceptions (Judeich and Nitsche, 1895; Escherich, 1923; Pfeffer, 1961; Forst *et al*., 1970; Kudela, 1970; Svestka *et al*., 1996).

Those phytophagous insects and pathogens that cause substantial damage to forests are particularly vulnerable to disruption by climate change. Current data and models suggest that global warming will result in the redistribution of insect pests, resulting in the invasion of new habitats and forest types (Logan *et al*., 2003).

Effects of climate change on forest insects have been demonstrated for a number of species and guilds, although generalizations are difficult because the responses to climate change are often species specific. There is evidence that recent warmer temperatures have permitted the expansion of bark beetles to higher latitudes and elevations (Pureswaran *et al*., 2018). Climate and weather can have direct effects on trees, because drought and storms can weaken trees and predispose them to attack by bark beetles and pathogens. There are some examples of shifts in the status of bark beetles from non-pest to pest in some countries. Damage caused by *Ips acuminatus* (Gyllenhal) has recently occurred in previously undamaged areas in Europe and has been attributed to rising summer temperatures and drought (Siitonen, 2014). Many authors predict that climate change will increase insect herbivory rates, alter the distribution and outbreak frequency of key insect pests, alter relationships with natural enemies in an unpredictable manner, and decrease biodiversity (Williams and Liebhold, 1995; Fleming, 1996; Coley, 1998).

The aim of the current research was to document the distribution and pest status of *O. laricis* and *O. longicollis* in the Czech Republic, which is part of the native distribution ranges of the two species in Central Europe. *O. laricis* is known to be very common in the Czech Republic (Pfeffer, 1995), lays clusters of eggs in the mother gallery, and feeds on multiple hosts (spruce, pines, fir, and larch) (Schwenke, 1972; Schwerdtfeger, 1981; Nunberg, 1982; Knizek, 2006; Roganović, 2013; Burakowski *et al*., 1992; Vojtech *et al*., 2013; Foit, 2010; Holuša *et al*., 2017b). *O. longicollis*, in contrast, is considered to be a rare and threatened species (Farkac *et al*., 2005; Lastuvka *et al*., 2016) that lays eggs individually in egg-niches along the mother gallery, and that feeds only on pines (Schwenke, 1972; Markalas, 1997). At the outset of this study, we assumed that *O. laricis*, being more abundant and polyphagous, is more likely to be a potential pest than *O. longicollis*.

Materials and methods

Distribution of *O. laricis*

Data concerning the distribution of *O. laricis* in the Czech Republic were obtained from amateur entomologists, who have been collecting data on the occurrence of these beetles in the country throughout the 20th and 21st centuries. Although the data were collected without any apparent design, data are lacking for only a few areas in the country (figure 1). Additional data on *O. laricis* occurrence on Norway spruce - *Picea abies* (L.) Karst. - and pine (*Pinus sylvestris* L.) stumps and broken trees in 2012-2018 (see also Foit, 2010; Holuša *et al*., 2017b) were also collected by one of the authors (M. Knížek) (supplemental material table S1).

Additional data (and the sources of the data) concerning *O. laricis* frequency were also obtained by observation of Norway spruce trap trees, Norway spruce trees infested by bark beetles, Norway spruce trees struck by lightning, Norway spruce stumps, and girdled Blue spruce trees (*Picea pungens* Engelmann) as described in the following sections.

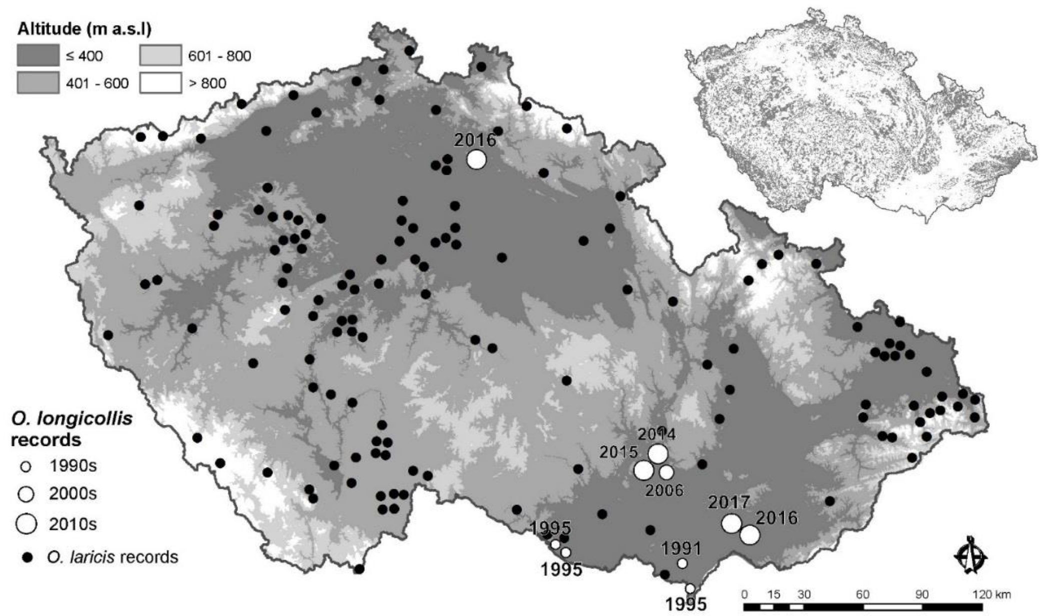

Figure 1. Distribution of *O. laricis* (small black circles) and *O. longicollis* (white circles) in the Czech Republic. The smaller map indicates the distribution of coniferous forests.

Norway spruce trap trees

Spruce trap trees (i.e., spruce trees that were cut and left on the soil surface at the site) were used in four study areas in the Czech Republic: Havířov (49.8166667°N 18.3666667°E), the area surrounding the town of Libavá (49.667°N 17.63°E), Smrk Mt. (49.50°N 18.37°E), and Psáře (49.77°N 14.93°E). A total of 492 trap trees were studied between 2005 and 2010. Bark beetles were counted and identified to species on four sections of the stem (sections were identified but the tree was left intact, i.e., it was not cut into sections) (the methods were previously described by Holuša *et al.*, 2012; 2017a).

Standing Norway spruce trees infested by bark beetles

From 2006-2009, logged spruce trees were studied at 34 localities in the eastern part of Czech Republic (from 50.23°N 17.43°E to 49.51°N 18.80°E at elevations of 300-450 and 500-700 m). Studied trees were between 60 and 120 years old and had been logged because they were suffering from drought, attack by *Armillaria* sp., and recent invasion by large numbers of bark beetles. The localities were visited twice yearly (May-June and August-September), and more than 10 trees were studied on each visit to each locality. The bark beetles were counted and identified to species for three 1-m by 10-cm areas per tree. A total of 636 spruce trees were studied from 2006-2009 (the methods were previously described by Holuša *et al.*, 2012). In 2011 and 2012, 30 standing spruces infested by bark beetles were studied in the Šumava Mts. (49.05°N 13.45°E) (the methods were previously described by Lukášová *et al.*, 2012; Holuša and Lukášová, 2017). The sample area width (along the longitudinal axis of the tree) was ca. 0.5 m, and the length was equal to one-half the circumference of the trunk. Each tree was sampled in four positions or sections.

Norway spruce struck by lightning

A total of 194 Norway spruce trees damaged by lightening were studied in the basin of the Šance dam (centre of dam 49.4890125°N 18.4251214°E; area 14.4 km^2) in 1997-1999. The trees were debarked along their whole length, and each 1-m-long section on each tree was examined such that a total of 6751 1-m-long sections were examined. The bark beetles in each section were counted and identified to species (the methods were previously described by Kula and Zabecki, 1999).

Girdling of blue spruce trees

In April of 2014 and 2015, a total of 122 trees in the localities of Dlouhá louka (50.6485611°N 13.6280278°E; 47 trees) and Sněžník (50.7954722°N 14.0695250°E; 75 trees) in the Krušné hory Mts were girdled with a chainsaw to the depth of 10 cm and a height of 20 cm. The trees were debarked along their whole length in July of each year, and the number and identity of bark beetles were determined for each 1-m section.

Norway spruce stumps

In July 2018, a total of 61 stumps (height 70-210 cm) from broken or uprooted spruce trees were prepared at five localities in the National Park České Švýcarsko: two localities were at Doubice (50.8633°N 14.3309 °E; 50.8895°N 14.4355°E), two were at Hřensko (50.8707°N 14.3157°E; 50.8832°N 14.2484°E), and one was at Dolní Chřibská (50.8670°N 14.4456°E). The stumps were debarked, and beetles were counted and identified to species and their areas were measured.

Distribution of *O. longicollis*

All literature data concerning *O. longicollis* occurrence in the Czech Republic were summarised. A few data were also obtained while the authors studied trees infested by bark beetles in the Czech Republic (table 1, identified by J. Foit); some of these data were collected in cross-vane traps deployed for detection of *Monochamus galloprovincialis* (Olivier) (Foit *et al.*, 2019). The study of Foit *et al.* (2019) was carried out in four localities in the Czech Republic: Sobotka (50.504284°N 15.127323°E, 320 m a.s.l.), Bělá pod Bezdězem (50.508427°N 14.827407°E, 300 m a.s.l), Soběšice (49.260033°N 16.607733°E, 350 m a.s.l.), and Bzenec (48.941067°N 17.285050°E, 200 m a.s.l.). At each locality, 6 cross-vane traps (Crosstrap®, Econex, Murcia, Spain) were installed in three pairs, with each pair consisting of one trap positioned next to the ground (approximately 2 m above the ground) and another trap positioned in the tree crown (18-24 m above the ground). At each locality, one pair of traps was not lured, one pair was baited with pheromone-kairomone Gallopro Pinowit® (WITASEK Pflanzenschutz GmbH, Feldkirchen in Kärnten, Austria), and one pair was baited with pheromone-kairomone Galloprotect Pack® (SEDQ, Barcelona, Spain). The lures were renewed every 30-45 days (Foit *et al.*, 2019).

Reports on the occurrence and damage of both species were obtained by searching the Web of Science, Scopus, Google Scholar, regional journals, and Czech and Slovak pest reports (www.vulhm.cz; www.los.sk/elaborat.html).

Data concerning distribution of coniferous forests were obtained from Brus *et al.* (2011) and then corrected using the Corine Land Cover inventory. The program ArcMap 10.0 (ESRI, Redlands, CA, USA) was used to create maps showing the distribution of *O. laricis*, *O. longicollis*, and coniferous forests in the Czech Republic (figure 1).

Results

O. laricis has been documented from 152 localities throughout the whole territory of the Czech Republic (figure 1). The species occurs at altitudes ranging from 100 to 1,100 m a.s.l., although the number of records is highest between 300 and 400 m a.s.l. (figure 2). *O. laricis* occurs in all coniferous forests in the country, even at low altitude areas where coniferous forests are scarce (figure 1, supplemental table S1). No standing Norway spruce infested by spruce bark beetles (*Ips* spp.) was also infested with *O. laricis* (656 trees were examined). We also failed to find *O. laricis* on any Norway spruce trap trees (492 trap trees were examined) or on any Norway spruce trees that had been struck by lightning (194 trees

Table 1. Background information on localities in the Czech Republic where *O. longicollis* has been detected.

Locality	Coordinates	Altitude (m a.s.l.)	Age and dominance of Scotch pine (*Pinus sylvestris*) in forests	Area of pine wood infested by bark beetles per forest area (m^3/ha)	Date	Method	Numbers of *O. longicollis* specimens collected or enter holes observed	Reference or collector
Brno	49.2388333N 16.6233333E	330	60-80, open forest 100%	0.0051-0.02	V.2006	Revision and debarking of 80 dying pines	3	J. Foit lgt., det. et coll (Foit 2010)
Bzenec	48.9410000N 17.2850000E	201	80-120, even aged stand, >70%	0.0051-0.02	VI.-X.2015	6 cross-vane traps: 2 unbaited 2 Gallopro Pinowit® 2 Galloprotect Pack®	14	V. Čermák and A. Havlíčková lgt., J. Foit, det. et coll.
Bzenec	48.9410000N 17.2850000E	201	80-120, even aged stand, >70%	0.0051-0.02	V.-IX.2016	6 cross-vane traps: 2 unbaited 2 Gallopro Pinowit® 2 Galloprotect Pack®	50	V. Čermák and A. Havlíčková lgt., J. Foit, det. et coll.
Bzenec	48.9580775N 17.2223633E	211	47, close canopy, 100%	0.0051-0.02	2017	Group of 15 weakened pines infested by *O. longicollis*	>1 entry hole per dm^2	E. Kula lgt., J. Foit det. et coll.
Bzenec	48.9580775N 17.2223633E	211	47, close canopy, 100%	<0.005	20.V.2018	Two dying pines infested by *O. longicollis*	>1 entry hole per dm^2	E. Kula lgt., J. Foit det. et coll.
Havraníky	48.8157325N 16.0049553E	320	60-80, open forest 100%	0.20-0.25	14.III.1995	Ocular inspection of 20 pines	2	Knížek, Liška 1996
Hnanice	48.8022900N 15.9689386E	330	60-80, open forest 100%	0.20-0.25	14.II.1995	Ocular inspection of 20 pines	12	Knížek, Liška 1996
Ladná	48.8001986N 16.8618678E	160	60-80, open forest 100%	<0.05	23.II.1991	Ocular inspection of 15 pines	4	Knížek, Liška 1996
Lanžhot	48.6902600N 16.9354906E	150	60-80, open forest 100%	<0.005	23.VIII. 1995	Ocular inspection of 10 pines	14	Knížek, Liška 1996
Soběšice	49.2608333N 16.6055000E	340	ca 90, a mosaic of even aged pine and oak stands of 10-140 years, >70%	0.021-0.03	VII.2014	Girdling of 16 pines by removing 7-10-cm-wide bands of bark	>100	J. Foit lgt., det. et coll
Soběšice	49.2600000N 16.6076667E	350	80-120, even aged stand, >70%	0.021-0.03	VI.-IX.2015	6 cross-vane traps: 2 unbaited 2 Gallopro Pinowit® 2 Galloprotect Pack®	12	V. Čermák and A. Havlíčková lgt., J. Foit, det. et coll.
Soběšice	49.2600000N 16.6076667E	351	80-120, even aged stand, >70%	>0.05	V.-IX.2016	6 cross-vane traps: 2 unbaited 2 Gallopro Pinowit® 2 Galloprotect Pack®	12	V. Čermák and A. Havlíčková lgt., J. Foit, det. et coll.
Sobotka	50.5043333N 15.1273333E	320	80-120, even aged stand, >70%	>0.05	27.IX.2016	6 cross-vane traps: 2 unbaited 2 Gallopro Pinowit® 2 Galloprotect Pack®	1	K. Hradil lgt., J. Foit det. et coll.

were examined). *O. laricis* was found only on broken trunks (localities Bystřice nad Olší, Stonařov, Pežgov) and fresh pine stumps (locality Kostelec nad Černými Lesy) (supplemental table S1), Norway spruce tree stumps, and on girdled blue spruce trees. In the České Švýcarsko National Park, 29.5% of the Norway spruce stumps were infested with *O. laricis*, with a maximal density of 38.9 galleries per m^2. Among all girdled blue spruce trees examined, 4.9% were infested with *O. laricis* (only 0.3% of the 1-m sections were infested with *O. laricis*).

The Sobotka locality is the first record of *O. longicollis* in Bohemia (one beetle per 6 cross-vane traps). *O. longicollis* was recorded for the first time in the Czech Republic in 1990s; it was observed in a single locality in the 2000s, and in five localities in the 2010s (table 1, figure 1), all of which are in the eastern Czech Republic (the historical country of Moravia) at 200-400 m elevation. The volume of pine infested by bark beetles was very low in the surroundings of all localities (table 1).

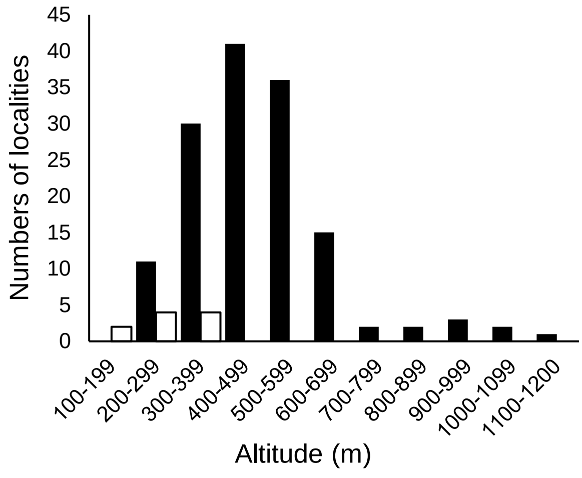

Figure 2. Altitudinal distribution of *O. laricis* (black columns) and *O. longicollis* (white columns) in the Czech Republic.

O. longicollis was trapped in only three localities with traps lured for *M. galloprovincialis* (<10 beetles per trap) (table 1).

O. longicollis has been detected in middle-aged to mature pine forests on weakened or dying trees (table 1). In 1990s, only several beetles were found, but more specimens of the species were detected in subsequent years. In 2017 in the town of Vracov, *O. longicollis* was detected in the lower parts of the trunks of 15 pine trees (table 1). On the two trap trees that were deployed, one was not infested with bark beetles and the other was infested with *Tomicus piniperda* (L.), *Tomicus minor* (Hartig), and *Pityogenes chalcographus* (L.) but not with *O. longicollis.* On 20 May 2018, two dying pine trees were examined at the same location: *O. longicollis* was found up to 6 m height on both trees; there were <1 entry hole per dm^2 in one tree (dbh = 23.1 cm and height = 24.5 m), and >1 entry hole per dm^2 in the other tree (dbh = 24.5 cm and height = 24.5 m) (table 1).

The records from the Czech Republic and the Slovak Republic contain no data indicating that *Orthotomicus* spp. damage timber (www.vulhm.cz; www.los.sk/elaborat.html).

Discussion

O. laricis is more common than *O. longicollis* in the Czech Republic. During the last 100 years, *O. laricis* has been found at more than 150 localities but *O. longicollis* at only eight localities. *O. laricis* is a common native species in coniferous forests throughout the whole territory of the Czech Republic, because the country is located in the centre of its extensive range (Schwenke, 1972; Lekander *et al*., 1977; Nunberg, 1982; Burakowski *et al*., 1992; Knížek, 2011). In contrast, *O. longicollis* was recorded for the first time in the Czech Republic in the 1990s (current study, Knížek and Liska, 1996). We suspect that *O. longicollis* has recently been spreading in the Czech Republic but remains localized and relatively rare, as it is in neighbouring Poland (Mokrzycki, 1995; 2004), southwestern Slovakia (Vakula *et al*., 2013), and Hungary (Gyorgy and Podlussany, 2005).

We have confirmed that *O. laricis* occurs at altitudes ranging from 100 to 1,100 m a.s.l (Burakowski *et al*., 1992; Pfeffer and Knížek, 1996; Galko *et al*., 2010; Vojtech *et al*., 2013). *O. longicollis* occurs mainly in the southwestern part of the Czech Republic at localities below 400 m a.s.l.

It seems that *O. laricis* cannot compete with the more abundant spruce bark beetles. It was not found on Norway spruce trap trees, spruce trees infested by bark beetles, or spruce trees struck by lightning; all of these were mainly infested by *Ips* spp. (Holuša *et al*., 2010; 2012; 2017b; Lukášová *et al*., 2012; Holuša and Lukášová, 2017; Kula and Zabecki, 1999). In a Polish study, less than 5% of trees weakened by drought and the honey fungus (*Armillaria* spp.) were infested by *O. laricis* (Grodzki, 1997). According to the latter study, the occurrence of *O. laricis* was secondary to that of the main and more aggressive species, *P. chalcographus*, *Ips typographus* L., and *Ips amitinus* (Eichhoff).

We have found *O. laricis* only on girdled blue spruce trees, which are not very attractive to *Ips* spp. (Kula *et al*., 2009), and on the stumps of Norway spruce and pine trees (see also Foit, 2010), <30% of which were infested by *Ips* spp. *O. laricis* beetles can overwinter in the bark of pine stumps (Holuša *et al*., 2017b). Overall, the data indicate that *O. laricis* mainly infests remnants of pine trees damaged by fire or freshly broken trunks, fresh stumps, or undebarked trunks of pine trees (Karpinski, 1931; Pfeffer, 1955; Schwenke, 1972; Meier *et al*., 2002; Toivanen *et al*., 2010; Foit, 2010).

We did not find any locality with an abundant population of *O. laricis.* This agrees with the finding that bark beetle abundances are usually low in Central Europe (Grodzki, 1997; 2009; Starzyk *et al*., 2006; Grodzki *et al*., 2007; Grodzki and Plata, 2008, Holuša *et al*., 2017b). If the amount of available food is sufficiently large (e.g., if pine stumps are abundant), however, the population density of *O. laricis* can increase (Wermelinger *et al*., 2002; Starzyk *et al*., 2008).

O. longicollis infested the lower parts of pine trunks where the bark is thicker because this species only occasionally infests parts of the tree with thin bark (Markalas, 1997; Voolma *et al*., 1998; Mokrzycki, 2004; Kunca, 2017).

High population densities of *O. longicollis* in the Czech Republic occur in trees dying from drought, which has also been observed in Slovakia (Wermelinger *et al*., 2008; Vakula *et al*., 2013), or in burnt trees (Markalas, 1997), that remain in the forest. Infestations of *O. longicollis* are often associated with infestations of other bark beetles, e.g., *Ips sexdentatus* (Borner) (own observation of Knížek). In contrast to *O. laricis*, the abundance of *O. longicollis* is increasing on weakened trees in southeastern Czech Republic (current study) as well as in the neighbouring southwestern Slovakia (Pastircakova *et al*., 2018).

Bussler *et al*. (2011) found that the population dynamics of most scolytid species in Central European forests are driven by resource availability and related traits, such as host range. For pest species, in contrast, the latter authors found that breeding performance and aggressiveness are driven by body size and number of generations per year.

Nevertheless, abundant species, such as *O. laricis*, have the potential to become pests because the stressing of host plants by climate change in Central Europe (Holuša *et al*., 2018) may result in new interactions between the beetle and its hosts (Cudmore *et al*., 2010) and may affect interactions between the beetle, mites, and fungi (Paine *et al*., 1997; Hofstetter *et al*., 2007). *O. laricis*, however, has not proven to be an important pine pest even in areas outside of its native range where it was introduced, e.g., Chile and Argentina (Tiranti, 2010). The beetle is common in Chile's extensive monocultures of Monterrey pine - *Pinus radiata* (D. Don) -, and is currently common in freshly cut logs, stumps, and slashes but does not appear to infest standing trees, and does not appear to damage trees in either Chile or Argentina (Kirkendall, 2018). *O. laricis*, however, is a vector of blue stain fungi, which include primary tree pathogens (de Errasti *et al*., 2018).

Conclusions

There is no evidence that *O. laricis* or *O. longicollis* infest and multiply on healthy trees in Central Europe. Therefore, they should not be considered as primary pests or even as secondary pests, i.e. subeconomic pest.

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