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The invasive ambrosia beetle, *Gnathotrichus materiarius* (Coleoptera: Curculionidae), in Central Europe

Tomáš Fiala[1], Jaroslav Holuša[1,*], Karolina Resnerová[1], Jiří Foit[2], Ferenc Lakatos[3], Andrzej Mazur[4], Jiří Procházka[5,6], Radoslaw Witkowski[4], Petr Pyszko[7], Carolus Holzschuh[8]

[1]Faculty of Forestry and Wood Sciences, Czech University of Life Sciences, Kamýcká 129, 16500 Praha 6, Suchdol, Czech Republic,[2]Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic,[3]Faculty of Forestry, University of Sopron, Bajcsy-Zs. 4, 9400 Sopron, Hungary,[4]Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, Wojska Polskiego 28, 60-637 Poznań, Poland,[5]Silva Tarouca Research Institute, Lidická 25/27, Brno 60200, Czech Republic,[6]Moravian Museum, Zelný Trh 6, Brno 60200, Czech Republic,[7]Department of Biology and Ecology, Faculty of Science, University of Ostrava, 701 03 Ostrava, Czech Republic[8]Spitzeckweeg 11, 9500 Villach, Austria [*]Corresponding author, mail: holusa@fld.czu.cz

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Gnathotrichus materiarius Fitch, 1858 is an invasive bark beetle that colonizes conifers and has spread widely in Europe. The beetle was introduced from North America to Western Europe, where it was first detected in France in 1933. In countries of Western and Northern Europe, the first detections were found at ports or airports, which probably served as sources of further spread. *Gnathotrichus materiarius* spread eastward to the Czech Republic and other countries in Central Europe from Germany and Poland and spread northward from Italy to Slovenia. The presence of wilting spruces, outbreaks dominated by *Ips typographus* Linnaeus, 1758, and the subsequent transport of timber have probably accelerated the spread of *G. materiarius*. It is possible that *G. materiarius* was imported with timber to Austria, the Czech Republic, and Poland. Although *G. materiarius* has been present in Europe for almost 100 yr, and even though its host trees include *Picea* and *Pinus* spp., which are abundant in Central European forests, no significant damage caused by this beetle has been detected or reported. *Gnathotrichus materiarius* is a typical secondary pest in that it multiplies on decaying trees or trees already infested and killed by other bark beetle species. It has 2 generations a year in Central Europe. The beetles of *G. materiarius* occur the whole year, but the flight of adults starts in early May and the offspring beetles emerge in mid-July. The adults of F2 generation overwinter in wood. The best method for monitoring and detecting the presence of *G. materiarius* is the use of ethanol-baited traps.

Key words: damage, ethanol, lure, spreading, traps

Bark beetles are among the most abundant and ecologically one of the most important forest arthropods (Martikainen et al. 1999). Invasive bark beetles are of considerable importance in forests (Kirkendall and Faccoli 2010). Invasive bark beetles (Coleoptera: Curculionidae) can pose a threat not only to native biodiversity, ecosystem functions, and the economic productivity of forests (Brockerhoff et al. 2006, Aukema et al. 2011) but can also threaten parks and orchards (Francardi et al. 2017, Fiala et al. 2022). Some invasive bark beetles can be important vectors of fungal diseases that cause massive tree death (Montecchio and Faccoli 2014).

There are 29 known invasive bark beetle species in Europe (Alonso-Zarazaga et al. 2022), and many have been in Europe for decades without causing significant damage. One of the invasive bark beetles, *Gnathotrichus materiarius* Fitch, 1858, is currently spreading from Western Europe to the East, since its first detection in 1933. Many authors have assumed that *G. materiarius* would cause economic damage (Table 1) because its host trees include *Picea* and *Pinus*, which represent high percentages of trees in Central European forests (Table 2). Although *G. materiarius* has had relatively little economic importance in America and Europe, its status might change influencing its future economic impacts. Some species of marginal economic importance, after being introduced, began to play a significant role in the process of dying trees and forest stands (Kirkendall and Faccoli 2010, Ploetz et al. 2013, Valenta et al. 2017).

In this article, we summarize the knowledge on the bionomics, distribution, and abundance of this species in Central Europe,

Table 1. Authors who suggested that *Gnathotrichus materiarius* could (or could not) potentially cause substantial damage to forest trees in Europe

Reference	Comments
Doom (1967)	Isolated damage to Douglas fir.
Gauss (1970)	It could cause great damage.
Gladitsch (1969)	It could be the most important wood pest.
Harde (1967)	It could be the most important wood pest.
Hirschheydt (1992)	There was damage higher than *Trypodendron lineatum* in the Rottenburg/neckar area estimated, but no damage was reported in Switzerland.
Kamp (1979)	There is no damage in Germany.
Knížek et al. (2020)	It could be a major wood pest.
Mazur et al. (2018)	In Poland, no important damage is known, but it could be a major pest of woody plants.
Moucheron and Warzée (2006)	It can cause damage.
Schedl (1966)	It could be a primary pest.

Table 2. Percentage of tree species in forests of Austria, Czech Republic, Hungary, and Poland

Country	Percentage of all forest trees represented by Scotch pine and Norway spruce		
	Scotch pine	Norway spruce	Source
Austria	6.2	59.8	Fao.org
Czech Republic	9.8	43.0	Fao.org
Hungary	9.0	1.0	Fao.org
Poland	58.5	6.0	Fao.org

incorporating observations and learnings of entomologists. The pest status, routes of spread, potential risk, and monitoring possibilities are discussed.

Life History

The species was discovered under the bark of *Pinus sylvestris* and was described as *Xyleborus duprezi* Hoffmann, 1936. This taxonomic designation was subsequently revised to *Paraxyleborus duprezi* Hoffmann, 1942; then to *Gnathotrichus duprezi* Hoffmann, 1947; and finally, to the synonymization of *G. materiarius* (Balachowsky 1948).

Gnathotrichus materiarius (Fig. 1) is one of the fungus-farming weevils. This group of commonly called ambrosia beetles evolved a nutritional mutualism with fungi (Hulcr et al. 2007). All ambrosia beetles are dependent on the presence of woody plants, which are typically unhealthy or recently dead and in which the beetles form their tunnel systems ("galleries"). In those galleries, ambrosia beetles actively farm one or several fungal mutualists, which serve as their essential food source (Hulcr et al. 2007). *Gnathotrichus materiarius* belongs to bark beetles of the tribe Corthylini, whose members may be paraphyletic or polyphyletic and appear to have evolved different symbioses with fungi (Hulcr and Stelinski 2017). *Gnathotrichus materiarius* introduces the fungus *Ambrosiozyma monospora* (Saito) Van der Walt, 1972 into the wood, which is then fed on by the beetle larvae (Batra 1963). The lack of host specificity in terms of tree species contributes to the invasiveness of ambrosia beetles in many forest ecosystems (Kirkendall et al. 2008).

Gnathotrichus materiarius is polyphagous on conifers. Its main host trees include conifers of the genera *Abies*, *Larix*, *Picea*, *Pinus*, *Tsuga*, and *Pseudotsuga* (Blackman 1931, Hirschheydt 1992, Mazur et al. 2018). The beetle seems to prefer pine over spruce and pine with thin rather than rough bark (A. Mazur, R. Witkowski personal observation). The beetle attacks freshly felled or dead wood (Fig. 2a) and stumps (Fig. 2b and c). On the stumps, they dig not only through the bark but also through the cut (Fig. 2d). Standing trees are inhabited mainly in the lower part, up to about 2 m above the ground level, which is covered with thick bark (Ryan et al. 2012), while lying wood is inhabited along its entire length, regardless of the thickness of the bark (A. Mazur, R. Witkowski personal observation). The wood moisture content at the time of settlement and its maintenance throughout the period of beetle development is a key determining feature on the reproductive success of ambrosia beetles (Capecki 1967).

Fig. 1. Adult *Gnathotrichus materiarius* in a) dorsal view and b) lateral view.

Our observations support the fact that the beetles prefer to occupy fallen wood in autumn, similar to ambrosia beetles of the genus *Trypodendron* (Borden 1988).

In the new invasive range, beetles of *G. materiarius* occur the whole year, but the flight of adults starts in early May (Fiala et al. 2023). The sex ratio in the population is almost equal, and males initiate attacks on host trees because *G. materiarius* is a diploidal species. Flechtmann and Berisford (2003) suggested sulcatol as a potential aggregation pheromone. Unmated males release the sulcatol, for a minimum of 12 days. Males stop producing sulcatol 24 h after mating with females. Independent females are unable to initiate galleries, and no sulcatol was detected in their head space and hindgut

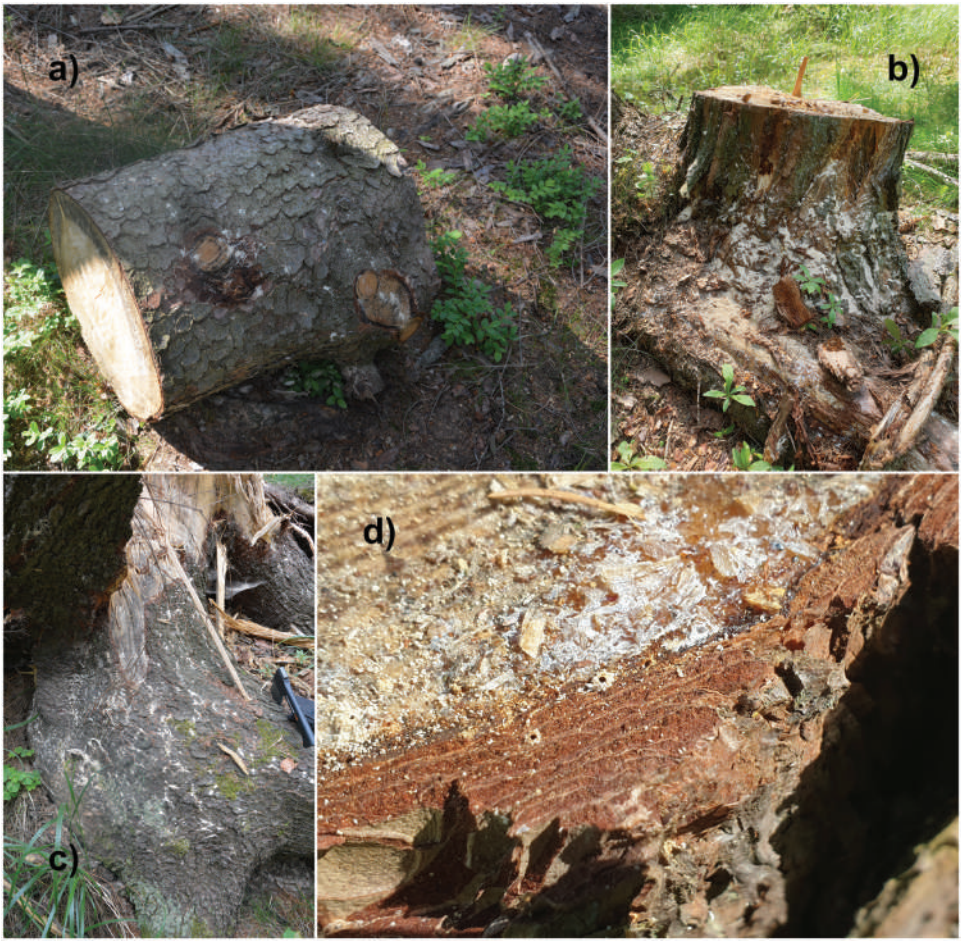

Fig. 2. Log of a) spruce, b) pine stump, c) broken spruce stump, and d) a cut on a pine stump heavily occupied by *Gnathotrichus materiarius* with obvious piles of sawdust indicating that there are entry holes of bark beetles.

(Flechtmann and Berisford 2003). This beetle is a monogamous species, with no sibling mating or asexual reproduction, which distinguishes *G. materiarius* from other species from the Xyleborini tribe (Kirkendall 1983, Flechtmann and Berisford 2003, Jordal and Cognato 2012, Mazur et al. 2018).

The first-instar larvae of *G. materiarius* appear in the second half of May (Fig. 3a). Larval development *Gnathotrichus* sp. takes at minimum 6 wk. A pupal stage lasts 10 days (Liu and McLean 1993) (Fig. 3b). The offspring beetles of *G. materiarius* emerge in mid-July. The beetles of F1 generation swarm in late July and early August (Fiala et al. 2023), and larval development of their offspring probably lasts until the end summer. Adults of F2 generation overwinter in wood (see Kamp 1979, Týr 2021). The sex ratio is 1:1 (Doom 1967), and the system of galleries is like those of *Trypodendron lineatum* Olivier, 1800. The female first creates the radial entrance gallery, which reaches a depth of 0.5–3.0 cm, and then female creates one or more mother galleries; about one-third of those galleries follow the course of annual rings, and the others intersect annual rings in various ways (Doom 1967, Kamp 1979, Mazur et al. 2018).

Global Distribution

Gnathotrichus materiarius originated in North America (Blackman 1931); occurrence in the Antilles has not been confirmed because the original records are based on erroneous determinations (Bright 2019). In Europe, *G. materiarius* was first detected along the English Channel in France in 1933 (Balachowsky 1949). In other countries of Western and Northern Europe, the first detections were at ports (Belgium, Finland, the Netherlands, Spain, Sweden, and the United Kingdom) or airports (Germany, Italy, and Switzerland) (Fig. 4, Table 3), which were probably sources of dissemination in those same countries. As in 2023, the eastern border of its spread runs through Finland, Poland, the Czech Republic, Hungary, Slovenia, and Italy (Fig. 4).

Spread in Central Europe

In Germany, *G. materiarius* has been recorded throughout the country in 2020s. The beetle has been detected in many locations in the Middle Rhine Valley (Baden-Württemberg) and in the north of the country (Mecklenburg) (Bleich et al. 2021). From Germany, *G. materiarius* spread east to the Czech Republic, where it was first detected in 2005 in the western part of Bohemia, near the border with Bavaria (Knížek 2009) (Fig. 4). It is likely that *G. materiarius* spread naturally into the Czech Republic from other directions, i.e., into southern Bohemia from northern Austria or Bavaria and into northern Bohemia from Saxony (Fig. 5). The beetle spread from Saxony to southern Poland where it was first reported from Poland (Witkowski et al. 2016). However, it is possible that it spread to Poland from northern Germany, where *G. materiarius* was detected as early as the 1990s (Esser and Schneider 2002).

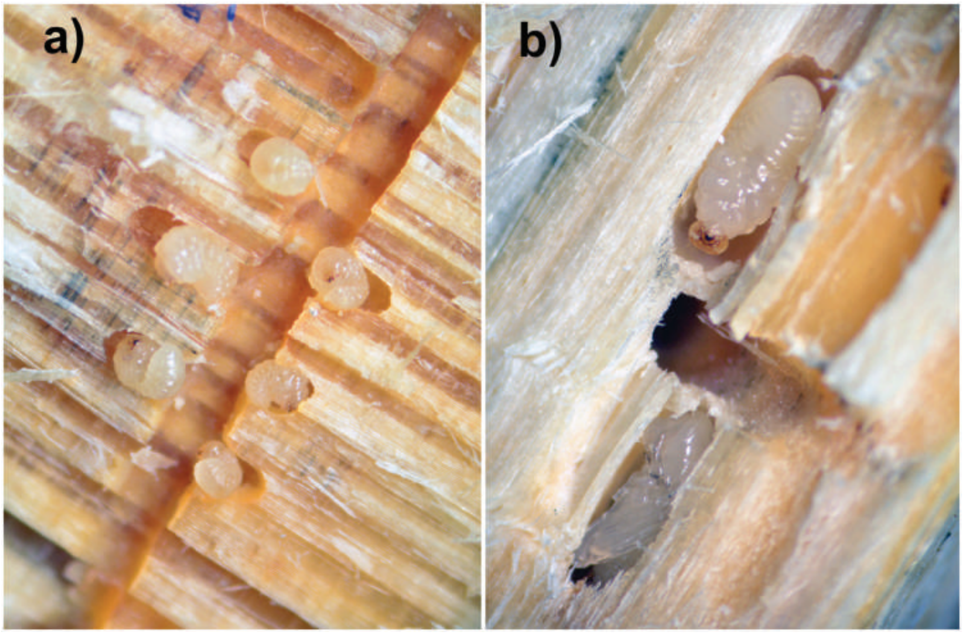

Fig. 3. a) Young larvae in larval galleries, which emerge from the maternal gallery, pass diagonally through the image and b) larva before pupation (top) and pupae (bottom) of *Gnathotrichus materiarius*.

Once introduced into Poland, *G. materiarius* spread widely in that country from 2015 to 2019; at present, the 37 known localities in Poland (Supplementary S1) are mainly located in the southwestern part of the country (Fig. 5). The beetle is now spreading eastwards (Mazur et al. 2018), and it is possible that it spread from southern Poland to the eastern Czech Republic (Fig. 4). However, it could also have spread into the eastern Czech Republic from Bohemia in the western Czech Republic (Fig. 4). Spread from southern Moravia is unlikely because, despite a number of entomological surveys, *G. materiarius* has not yet been found in central Moravia and further spread through southern Moravia was not confirmed despite several surveys using mainly flight interception traps or hand collecting (Unar et al. 2021, J. Procházka, unpublished survey). In 16 yr, the beetle spread throughout the Czech Republic, and a total of 35 localities have reported its presence (up to November 2021) (Supplementary S1, Fig. 5). Only 2 localities are known in Moravia, of which the oldest record is from 2015 in South Moravia. Before 2015, the species probably did not occur there, despite extensive passive capture of beetles (including bark beetles) in flight interception traps (Schlaghamerský 2000, Procházka et al. 2018). *Gnathotrichus materiarius* was also not detected in the Bílé Karpaty Mts. (eastern Moravia) in 2015 despite substantial monitoring (Račanský 2019). Given the year of its detection, *G. materiarius* probably spread to south Moravia from the south of Austria.

Gnathotrichus materiarius probably spread from northern Italy into Slovenia, and into Carinthia, where it was first reported beyond the Alps in 2012 (Aurenhammer et al. 2015). Because the spread of invasive insects is often blocked by geographical barriers (Liebhold and Tobin 2008, Wan and Yang 2016), *G. materiarius* could have been artificially introduced to the Alps. Across Austria, only 4 localities are known to have this beetle (Supplementary S1, Fig. 5), which are distributed along the foothills of the Alps toward the Pannonia, where it penetrated western Hungary. The beetle has been known around Sopron since 2016 (Lakatos 2019) (Fig. 5). *Gnathotrichus materiarius* does not seem to be spreading further into Hungary because it has not been detected in central Hungary (F. Lakatos, personal observation). It is possible that it spreads to South Moravia from western Hungary, where it was found in 2015. This beetle probably already occurs in western Slovakia, where it could spread to South Moravia (Fig. 5).

Factors Favoring the Spread

In several places, the abundance of *G. materiarius* has sharply increased recently. In 2017, numerous beetles were found inhabiting raw wood material harvested from western and southern Poland (Mazur et al. 2018). In 2018, *G. materiarius* was found on only 3% of experimental stumps in the National Park Bohemian Switzerland (Northern Bohemia) (K. Resnerová, unpublished data, see Supplementary S1), while in 2020 and only 50 km to the south, the beetle infested more than 70% of experimental logs (K. Resnerová, unpublished data). Similarly, in the area surrounding Sopron in Hungary laying on the edge of *G. materiarius* recent range in Central Europe, the number of *G. materiarius* captured in pheromone traps increased significantly from 2016 to 2019 (Fig. 6).

The spread of *G. materiarius* can also be supported by the wilting of spruce due to drought and subsequent infestation by honey fungus (*Armillaria* ssp.) and bark beetles (Holuša et al. 2018). The presence of withering trees, an outbreak dominated by *Ips typographus* Linnaeus, 1758 (Hlásny et al. 2021), and the subsequent transport of wood could accelerate the spread of the beetle. This corresponds to the rapid spread of the beetle in Poland following the *I. typographus* outbreak that began in 2015. Whereas the beetle required only 5 yr to spread widely in Poland, it required 20 yr to spread widely in the Czech Republic.

It is possible that *G. materiarius* was imported with timber to Austria, the Czech Republic, and Poland. One of the materials used by bark beetles is wood packaging material (Meurisse et al. 2019), the treatment of which in international trade is based on phytosanitary measure according to International Phytosanitary Measures 15 (ISPM 15). According to this measure, all wood imported from

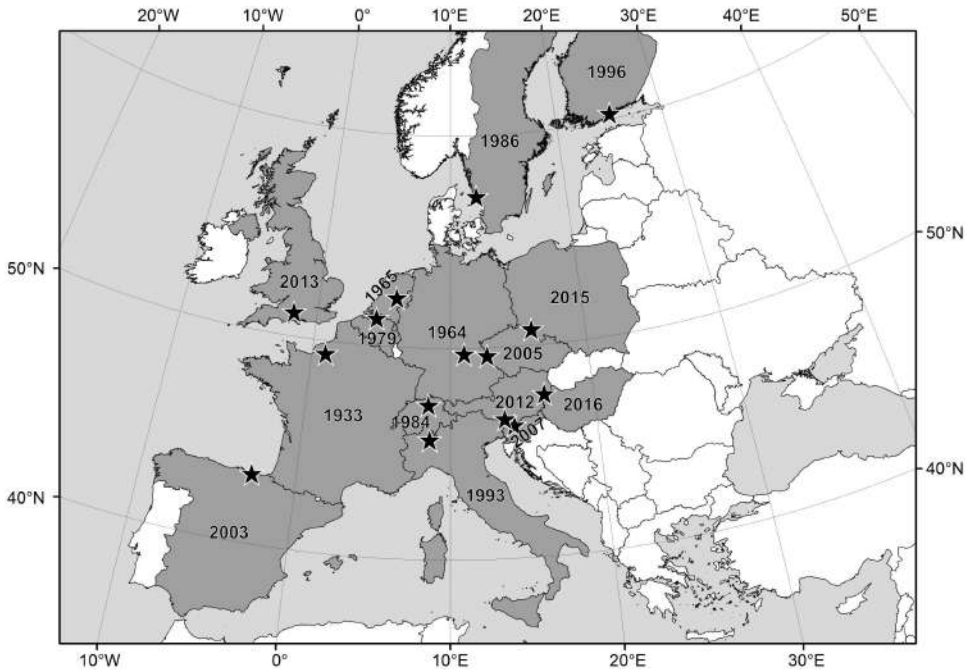

Fig. 4. Distribution of *Gnathotrichus materiarius* throughout Europe with the years and locations (stars) of its discovery.

Table 3. First year and locality of *Gnathotrichus materiarius* detection in European countries

Country	Year	Locality	Latitude	Longitude	Comments	References
Austria	2012	Rote Wand	46.5865N	13.7391E	60 km from the discovery place in Slovenia	Aurenhammer et al. (2015)
Belgium	1979	Brasschaat	51.2830N	4.4902E	Port	Boosten (1982)
Czech Republic	2005	Bělá nad Radbuzou	49.5985N	12.6882E	Near boundary with Bavaria	Knížek (2009)
Finland	1996	Vantaa	60.2421N	25.1701E	Port	Valkama et al. (1998)
France	1933	Rouen	49.3866N	0.9904E	Port	Balachowsky (1949)
Germany	1964	Forchheim	49.7155N	11.0272E	Near international airport at Nurnberg	Gladitsch (1969)
Hungary	2016	Sopron	47.6682N	16.5767E	Near boundary with Austria	Lakatos (2019)
Italy	1993	Pombia	45.6461N	8.6293E	International airport	Bernabò (2000)
Netherlands[a]	1965	Vaassen	52.2925N	5.9257E	Near port	Schedl (1966)
Poland	2015	Krzeszów	50.7304N	16.0338E	Near boundary with the Czech Republic	Witkowski et al. (2016)
Switzerland	1984	Buchenegg	47.2941N	8.5096E	Near international airport at Zurich	Hirschheydt (1992)
Slovenia	2007	Brdo Pri Kranju	46.2754N	14.3821E	80 km far from port of Terst and Italian discovery	Jurc et al.(2012)
Spain	2003	Inama	43.2882N	2.6912W	Near port and international airport, near France	López et al. (2007)
Sweden	1986	Varberg	57.1057N	12.2502E	Port, probably imported from France or Spain	Gillerfors (1988)
United Kingdom	2013	Ringwood Forest	50.8800N	1.8300W	Near port	Inward (2020)

[a]Based on the presence of galleries, researchers assumed that the species occurred in the Netherlands as of 1954, but adults were not caught until 1965 (Doom 1967).

outside of Europe must be debarked and then heated or fumigated. However, about 0.1%–0.5% of wood treated according to the ISPM 15 standard was found to contain live quarantine insects under the bark (Haack and Petrice 2009, Haack and Brockerhoff 2011). Thus, even the ISPM 15 standard will not protect the importing country from the spread of invasive species (Evans 2007). As evidence of that problem, *G. materiarius* was found in Sweden in debarked wood that was imported from France (Gillerfors 1988, Schroeder 1990).

Precipitation of the driest quarter of the year is the most important predictor of *G. materiarius* distributions. In Europe, highly suitable areas are concentrated in the Balkans, the Black Sea and Caucasus region, the Baltic countries, the Scandinavian Peninsula, and Ukraine. The model indicated that *G. materiarius* can find suitable climate conditions for its occurrence across 13.1% of Europe recently. The less suitable predictions suggest that as the climate changes, the species' range will expand mainly eastwards to the Ural Mountains and northwards almost to the Arctic Circle on

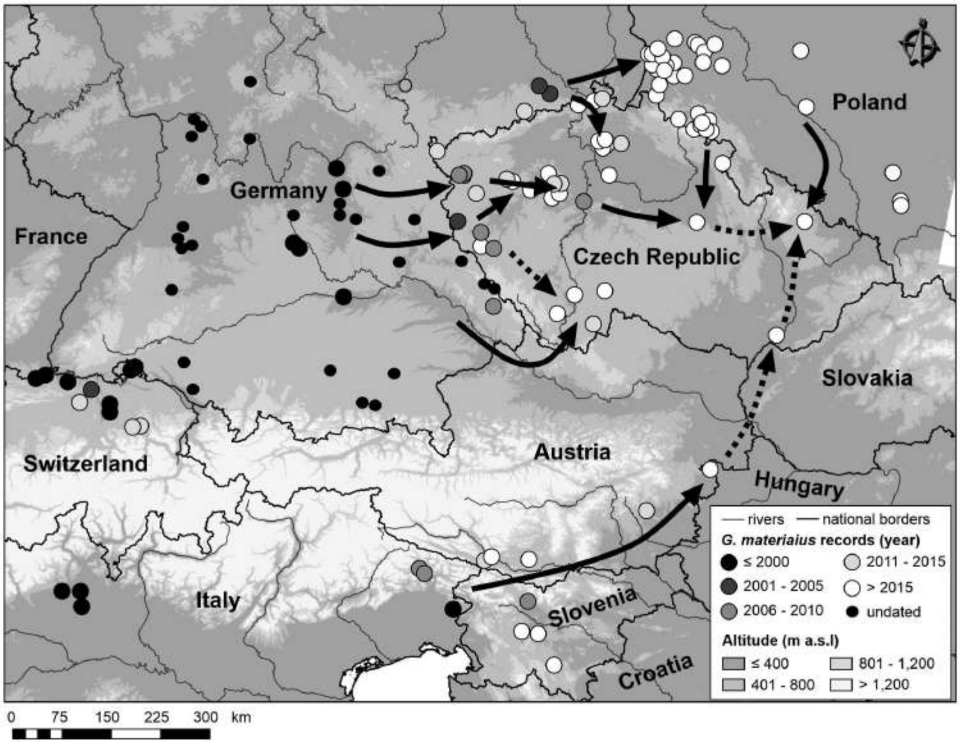

Fig. 5. Distribution of *Gnathotrichus materiarius* in Austria, Germany, Hungary, northern Italy, Poland, Slovenia, and Switzerland with directions of expected spread (full arrows are very likely directions of spread, and dashed arrows are hypothetical directions of spread).

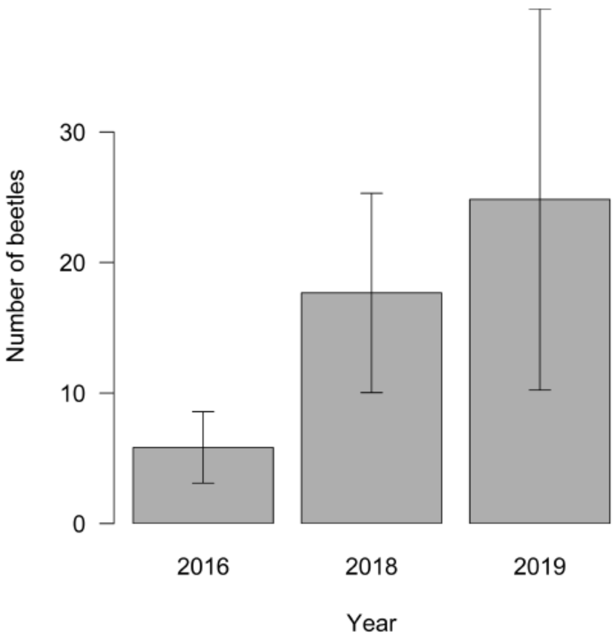

Fig. 6. Numbers (means ± SE) of *Gnathotrichus materiarius* beetles caught per trap near Sopron (western Hungary). The abundance of beetles over the years was tested by general linear model with a negative binomial distribution (logarithmic link) and with individual sampling plots as a covariate. The number of beetles differed among years (df = 11, $F = 5.76$, $P = 0.016$) (6 Econex crosstrap mini pheromone traps were lured with ethanol, alpha pinene, and ipsdienol).

the Scandinavian Peninsula. Only slight shifts in the western and southern parts of the species' range are predicted (Witkowski et al. 2022).

Monitoring Options

We have summarized the results of many local surveys (peer-review published as well as unpublished) and found data from 78 localities in Central Europe (Austria, the Czech Republic, Hungary, and Poland). For almost 95% of the detections, we know the method of detection (Supplementary S1). Of the detected beetles, almost 40% were captured in pheromone traps and >30% were captured with artificially produced pheromone evaporators (Table 4).

Half of the data were obtained by systematic and targeted searches of stumps or experimental logs (Supplementary S1). However, this method is time and technically demanding. The stumps or logs must be debarked. If boreholes are detected in the wood, smaller sections of wood must be cut with a chainsaw and stored in the laboratory in emergence traps. Only a small portion of the data (6%) represents accidental findings or hobby-collecting activities of amateur entomologists (captured in flight, sweeping, or debarking, or found on firewood or in a pool) (Table 4).

Most of the published data concerning *G. materiarius* detection in Europe come from pheromone traps lured for bark beetles of the genus *Ips* (Schneider 1985, Valkama et al. 1998, Knížek 2009, Mazur et al. 2018). Similarly, our data were obtained by trapping beetles on artificial lures containing ethanol or ethanol combined with other substances were used (Supplementary S1). The attraction of ambrosia beetles to ethanol is related to their preference for woody material that has sufficiently aged to allow anaerobic respiration to generate ethanol (Moeck 1970).

The numbers of captured *G. materiarius* beetles on Wood Stainers Lure containing the pheromone sulcatol (Flechtmann and Berisford 2003) were compared with other lure treatments. No beetles were captured with α-pinene (Fiala et al. 2023). Fewer beetles were captured with Cembräwit (compounds are ipsenol, ipsdienol, methylbutenol, and amitinol) (Fiala et al. 2023) since *G. materiarius*

Table 4. Numbers of localities in Central Europe (Austria, Czechia, Germany, Hungary, Poland on based by publicated findings) where *G. materiarius* was detected by the indicated method

Method of detection	Numbers of localities
Artificial pheromone (IT-Ecolure, ID-Ecolure, Cembräwit, and Amitinuswit)	23
Blended volatile (ethanol, α-pinene, and ipsdienol)	5
From tree/log/stump	39
Window traps	1
In flight/taping	5
Unspecified	5

has shown a positive response to this lure (Schneider 1985), but more beetles were captured with ethanol (Fiala et al. 2023). The attractiveness of sulcatol in a mixture of α-pinene and ethanol as a major aggregation pheromone was therefore not confirmed and the universal bait for the detection of this species remains ethanol (Fiala et al. 2023).

Pest's Impact

Whether an invasive species becomes a pest depends on ecological variables, the number of introductions, and the origin of the species. Only about 10% of invasive species become significant pests in the new territory (Williamson and Fitter 1996, Smith et al. 1999). Similar to the previous trend, a small percentage of ambrosia beetle species introduced into non-native habitats cause significant damage to living trees (e.g., Francardi et al. 2017). Most cases of newly established ambrosia beetles have been assumed to be nondamaging. The most common factor in bark beetle damage is the host's physiological stress (Netherer et al. 2021). Some introduced ambrosia beetles are not considered pests in Europe, they can easily detect the ethanol emitted by stressed trees and can thereby locate and colonize those affected trees (Ranger et al. 2015). Another factor that could affect the impact of invasive species is the evolutionary relationships of new hosts to the pest's original host (Mech et al. 2019).

Most of the major damage, e.g., the killing of healthy trees or the infestation of stressed trees, that are consequently killed, caused by invasive bark beetles is reported from southern Europe (Pennacchio et al. 2012, Montecchio and Faccoli 2014, Daubree 2016, Faccoli et al. 2016, Francardi et al. 2017, Leza et al. 2020). Only trees infested by invasive bark beetles have been reported from Central Europe, and this includes only colonizing downed wood by the ambrosia bark beetle, *Xylosandrus germanus*, in Switzerland and Slovakia (Maksymov 1987, Galko et al. 2019). On the other hand, no trees killed by *X. germanus* has been reported in the Czech Republic (Fiala et al. 2020).

Many authors have warned that *G. materiarius* could potentially cause damage (Table 1). However, this species has been present in Europe for almost 100 yr, and no killed trees has been identified or reported, even though spruce and pine, its preferred host trees, and the most numerous tree species in the commercial forests of Central Europe (Table 2). In Switzerland, *G. materiarius* was first found in the northern part of the country in the 1980s. Bovey (1987) warned of the serious damage that *G. materiarius* could cause to Swiss forests, but so far (i.e., after >35 yr), no major problems caused by this species have been reported (Sanchez et al. 2020).

In Poland, *G. materiarius* infestation was recently observed for the first time in Scots pine wood in managed forests in southwest Poland. The scale of the infestation was not economically important (Mazur et al. 2018). *Gnathotrichus materiarius* infestation of standing trees was found in southern Bohemia, but the infestation was not quantified (Knížek et al. 2020). In locations where we conducted more intensive surveys, the surrounding trees were not attacked; no signs of tree infestation by *G. materiarius* were observed in the Bohemian Switzerland National Park (K. Resnerová, unpublished data), in the landscape-protected area Kokořínsko–Máchův kraj (K. Resnerová, unpublished data), or in the area around Sopron (Fig. 6).

Gnathotrichus materiarius may be a typical secondary pest when propagated on withering trees or trees infested and killed by other bark beetle species. Even though *G. materiarius* inhabits dead and weakened trees, there is no information about cases of attacks on healthy trees. It most often inhabits the butt of standing trees and the bedding, both with and without bark (Bussler and Immler 2007), but in the case of logs without bark, the beetles dig only in the parts with the bark. *Gnathotrichus materiarius* seems to prefer thick-barked fragments (Knížek et al. 2020, Fiala et al. 2022).

Gnathotrichus materiarius is a pest that causes damage to the sapwood of coniferous wood trees. Despite the small diameter of the holes and sidewalks, measuring approximately 1 mm, inhabited wood is a much less valuable raw material (Lindgren and Fraser 1994, Faccoli 1998). Galleries of *G. materiarius* reach quite deep, which reduces the size of valuable assortments and causes financial losses. The fungal mycelium can cause wood staining, which is considered an aesthetic defect (Mazur et al. 2018). The mechanical properties of the wood are not impaired by the fungal infestation, as has been found in *I. typographus* (Hýsek et al. 2021).

Conclusions

Gnathotrichus materiarius is an invasive species that has been repeatedly introduced into Europe with the transport of wood and wood packaging materials. Once in Europe, it has probably spread naturally, with the transport of wood, to the east and currently occurs throughout Western and Central Europe. Considering the biology and ecology, as well as the dynamic spread of the species, *G. materiarius* can become one of the most important technical pests of conifer trees in the future.

Detection of the species can be expected in other countries to the east of its current known distribution. *Gnathotrichus materiarius* adults can be found in traps deployed for the capture of bark beetles in the genus *Ips*. Because trap deployment is a common method of monitoring economically important species in many countries, we recommend that, in those countries to the east of the current known occurrence of *G. materiarius*, the insects caught in these traps be examined for the presence *G. materiarius* and other nontarget species. In the case of targeted monitoring, it is best to use ethanol in traps for the detection of this species.

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Author Contributions

Tomas Fiala (Data curation [Equal], Formal analysis [Equal], Methodology [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Jaroslav Holusa (Data curation [Equal], Methodology [Equal], Supervision [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Karolina Resnerova (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Jiří Foit (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Ferenc Lakatos (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Andrzej Mazur (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Jiří Procházka (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Radosław Witkowski (Data curation [Equal], Visualization [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Petr Pyszko (Methodology [Equal], Validation [Equal]), and Carolus Holzschuh (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal])

Data Availability

The data on the occurrence of species are included in Supplementary Material. Small datasets dealing with numbers of beetles sampled at Sopron and sharing of 2 bark beetle species logs are available from the corresponding author on reasonable request.

References

Alonso-Zarazaga MA, Barrios H, Borovec R, Caldara R, Colonnelli E, Gültekin L, Hlaváč P, Korotyaev B, Lyal CHC, Machado A, et al. Cooperative catalogue of Palaearctic Coleoptera Curculionoidea. 2022 [accessed 2022 Feb 14]. http://weevil.info/content/palaearctic-catalogue.

Aukema JE, Leung B, Kovacs K, Chivers C, Britton KO, Englin J, Frankel SJ, Haight RG, Holmes TP, Liebhold AM, et al. Economic impacts of non-native forest insects in the continental United States. PLoS One. 2011:6(9):e24587.

Aurenhammer S, Komposch C, Holzer E, Holzschuh C, Holzinger WE. Xylobionte Käfergemeinschaften (Insecta: Coleoptera) im Bergsturzgebiet des Dobratsch (Schütt, Kärnten) (Saproxylic beetles (Insecta: Coleoptera) in the rockslide area of the Dobratschmountain (Carinthia, Austria)). Carinthia II. 2015:205/125:439–502.

Balachowsky A. Faune de France 50. Coléoptéres Scolytides [Coleoptera Scolytidae]. Paris (France): Librairie de la Faculte des Sciences; 1949.

Batra LR. Contributions to our knowledge of ambrosia fungi. II. *Endomycopsis fasciculata* nom. nov. (Ascomycetes). Am J Bot. 1963:50(5):481–487. https://doi.org/10.1002/j.1537-2197.1963.tb07218.x

Bernabò E. Osservazioni sulla presenza in Italia di *Xylosandrus germanus* (Blandford, 1894) e *Gnathotrichus materiarius* (Fitch, 1858) (Coleoptera: Scolytidae). Riv Piem St Nat. 2000:21:255–262.

Blackman MW. A revisional study of the genus *Gnathotrichus* Eichhoff in North America. J Wash Acad Sci. 1931:21(12):264–276.

Bleich O, Gürlich S, Köhler F. Online Verzeichnis der Käfer Deutschlands [Online directory of Germany's beetles]. 2021 [accessed 2021 Oct 10]. www.colkat.de.

Boosten G. Coléoptères de Belgique. X. Bull Ann Soc r belge Ent. 1982:118:212–215.

Borden JH. The striped ambrosia beetle. In: Berryman AA, editor. Dynamics of forest insect populations—patterns, causes, implications. New York (NY): Plenum Press; 1988. p. 579–596.

Bovey P. Coleoptera Scolytidae, Platypodidae. Insecta Helvetica, Catalogus. Zürich (Switzerland): Fotorotar; 1987.

Bright DE. A taxonomic monograph of the bark and ambrosia beetles of the West Indies (Coleoptera: Curculionoidea: Scolytidae). Occas Pap Fla State Collect Arthropods. 2019:12:1–491.

Brockerhoff EG, Bain J, Kimberley M, Knížek M. Interception frequency of exotic bark and ambrosia beetles (Coleoptera: Scolytinae) and relationship with establishment in New Zealand and worldwide. Can J For Res. 2006:36(2):289–298. https://doi.org/10.1139/x05-250

Bussler H, Immler T. Neue Borkenkäferarten in Bayern. Forstsch Aktuell. 2007:38:5–8.

Capecki Z. Drwalnik paskowany—*Trypodendron lineatum* Ol. (Scolytidae, Coleoptera) na terenie Polski. Prace Inst Badawczego Leśnictwa. 1967:314:3–80.

Daubree J-B. Le scolyte *Xylosandrus crassiusculus* (Coleoptera: Curculionidae) en France: de la detection a la lutte (The bark beetle *Xylosandrus crassiusculus* (Coleoptera: Curculionidae) in France: from detection to control). In: Annales de l'AFPP, 4e Conférence sur l'entretien des Jardins, Espaces Végétalisés et Infrastructures, 19 et 20 Octobre 2016. Toulouse (France): ENSAT; 2016. p. 35–44.

Doom D. Notes on *Gnathotrichus materiarius* (Col. Scolytidae), a timber beetle new to the Netherlands. Entomol Berichten. 1967:27(8):143–148.

Esser J, Schneider M. Käferfunde aus der Mark Brandenburg—faunistisch bemerkenswerte Arten (Beetle finds from the Mark Brandenburg—faunistically remarkable species). Märkische Entomol Nachrichten. 2002:4(2):39–44.

Evans HF. ISPM15 treatments and residual bark: how much bark matters in relation to founder populations of bark and wood boring beetles? In: Evans HF, Oszako T, editors. Alien invasive species and international trade. Warsaw (Poland): Forest Research Institute; 2007. p. 149–155.

Faccoli M. The North American *Gnathotricus materiarius* (Fitch) (Coleoptera Scolytidae): an ambrosia beetle new to Italy. Redia. 1998:81:151–154.

Faccoli M, Campo G, Perrotta G, Rassati D. Two newly introduced tropical bark and ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) damaging figs (*Ficus carica*) in southern Italy. Zootaxa. 2016:4138(1):189–194. https://doi.org/10.11646/zootaxa.4138.1.10

Fiala T, Holuša J, Procházka J, Čížek L, Dzurenko M, Foit J, Galko J, Kašák J, Kulfan J, Lakatos F, et al. *Xylosandrus germanus* in central Europe: spread into and within the Czech Republic. J Appl Entomol. 2020:144(6):423–433. https://doi.org/10.1111/jen.12759

Fiala T, Holuša J, Véle A. Both native and invasive bark beetles threaten exotic conifers within the spa towns in the Czech part of "The Great Spas of Europe". Urban For Urban Green. 2022:67:127417.

Fiala T, Pyszko P, Holuša J. Using ethanol and other lures to monitor invasive ambrosia beetles in endemic populations: case study from the Czech Republic. Front For Glob Change. 2023:6:1258729. https://doi.org/10.3389/ffgc.2023.1258729

Flechtmann CAH, Berisford CW. Identification of sulcatol, a potential pheromone of the ambrosia beetle *Gnathotrichus materiarius* (Col., Scolytidae). J Appl Entomol. 2003:127(4):189–194. https://doi.org/10.1046/j.1439-0418.2003.00743.x

Francardi V, Noal A, Francescato S, Pinto R, Bruni A, Loffredi L, Bucini D, Guarnieri D, Bellantuono M, Esposito N, et al. Coexistence of *Xylosandrus crassiusculus* (Motschulsky) and *X. compactus* (Eichhoff) (Coleoptera: Curculionidae: Scolytinae) in the National Park of Circeo (Lazio, Italy). Redia. 2017:100:149–155.

Galko J, Dzurenko M, Ranger CM, Kulfan J, Kula E, Nikolov C, Zúbrik M, Zach P. Distribution habitat preference, and management of the invasive ambrosia beetle *Xylosandrus germanus* (Coleoptera: Curculionidae, Scolytinae) in European forests with an emphasis on the West Carpathians. Forests. 2019:10(1):10.

Gauss R. Möglichkeiten der Ein- und Verschleppung von Insekten. Mitt Ent Ver Stutt. 1970:5:41–44.

Gillerfors G. Skalbaggar införda till Sverige med importerad massaved [Beetles introduced to Sweden with imported pulpwood]. Entomol Tidskr. 1988:109:42–45.

Gladitsch S. Neue Beobachtungen über den eingeschleppten Scolytiden *Gnathotrichus materiarius* Fitch. Mitt Ent Ver Stutt. 1969:4:76–78.

Haack RA, Brockerhoff EG. ISPM No. 15 and the incidence of wood pests: recent findings, policy changes, and current knowledge gaps. In: The International Research Group on Wood Protection, 42nd Annual Meeting, Queenstown, New Zealand; 2011. p. 2–12.

Haack RA, Petrice TR. Bark- and wood-borer colonization of logs and lumber after heat treatment to ISPM 15 specifications: the role of residual bark. J Econ Entomol. 2009:102(3):1075–1084. https://doi.org/10.1603/029.102.0328

Harde K.W. Über den für Deutschland neuen Borkenkäfer *Gnathotrichus materiarius* Fitch. Mitt Ent Ver Stutt. 1967:2:66–67.

Hirschheydt JV. Der Amerikanische Nutzholzborkenkäfer *Gnathotrichus materiarius* (Fitch) hat die Schweiz erreicht (The ambrosian beetle *Gnathotrichus materiarius* (Fitch) has reached Switzerland). Mitt Schweiz Entomol Ges. 1992:65:33–37.

Hlásny T, Zimová S, Merganičová K, Štěpánek P, Modlinger R, Turčáni M. Devastating outbreak of bark beetles in the Czech Republic: drivers, impacts, and management implications. Forest Ecol Manag. 2021:490:119075.

Holuša J, Lubojacký J, Čurn V, Tonka T, Lukášová K, Horák J. Combined effects of drought stress and *Armillaria* infection on tree mortality in Norway spruce plantations. Forest Ecol Manag. 2018:427:434–445. https://doi.org/10.1016/j.foreco.2018.01.031

Hulcr J, Mogia M, Isua B, Novotný V. Host specificity of ambrosia and bark beetles (Col., Curculionidae: Scolytinae and Platypodinae) in a New Guinea rainforest. Ecol Entomol. 2007:32(6):762–772.

Hulcr J, Stelinski LL. The ambrosia symbiosis: From evolutionary ecology to practical management. Annu Rev Entomol. 2017:62:285–303. https://doi.org/10.1146/annurev-ento-031616-035105

Hýsek S, Löwe R, Turčáni M. What happens to wood after a tree is attacked by a bark beetle? Forests. 2021:12(9):1163.

Inward DJG. Three new species of ambrosia beetles established in Great Britain illustrate unresolved risks from imported wood. J Pest Sci. 2020:93(1):117–126.

Jordal BH, Cognato AI. Molecular phylogeny of bark and ambrosia beetles reveals multiple origins of fungus farming during periods of global warming. BMC Evol Biol. 2012:12:133. https://doi.org/10.1186/1471-2148-12-133

Jurc M, Bojovic S, Fernández MF, Jurc D. The attraction of cerambycids and other xylophagous beetles, potential vectors of *Bursaphelenchus xylophilus*, to semio-chemicals in Slovenia. Phytoparasitica. 2012:40:337–349.

Kamp HJ. Ein beitrag zur kenntnis von *Gnathotrichus materiarius* Fitch, der Adventivart aus Nordamerika (Col. Scolytidae) [A contribution to the knowledge of Gnathotrichus materiarius Fitch, the adventitious species from North America (Col. Scolytidae)]. Mitteilungen Entomol Verein Stuttgart 1869 E.V. 1979:14:57–87.

Kirkendall LR. The evolution of mating systems in bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae). Zool J Linn Soc. 1983:77(4):293–352. https://doi.org/10.1111/j.1096-3642.1983.tb00858.x

Kirkendall LR, Cortivo MD, Gatti E. First record of the ambrosia beetle, *Monarthrum mali* (Curculionidae, Scolytinae) in Europe. J Pest Sci. 2008:81:175–178.

Kirkendall LR, Faccoli M. Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe. ZooKeys. 2010:56:227–251. https://doi.org/10.3897/zookeys.56.529

Knížek M. Faunistic records from the Czech Republic—272. Coleoptera: Curculionidae: Scolytinae. Klapalekiana. 2009:45(1):22.

Knížek M, Liška J, Lorenc F, Lubojacký J, Véle A, Zahradník P. Význam biotických škodlivých činitelů borovice lesní [Importance of biotic harmful agents of Scots pine]. Zpravodaj Ochrany Lesa. 2020:23:62–71.

Lakatos F. Honos, behurcolt és várható, a fatestben fejlödö szúfajok magyarországon [Native, introduced and expected wood species in Hungary]. Növényvédelem. 2019:55(12):523–535.

Leza M, Nuñez L, Riba JM, Comparini C, Roca A, Gallego D. First record of the black twig borer, *Xylosandrus compactus* (Coleoptera: Curculionida, Scolytinae) in Spain. Zootaxa. 2020:4767(2):345–350.

Liebhold AM, Tobin PC. Population ecology of insects invasions and their management. Annu Rev Entomol. 2008:53:387–408. https://doi.org/10.1146/annurev.ento.52.110405.091401

Lindgren BS, Fraser RG. Control of ambrosia beetle damage by mass trapping at a dryland log sorting area in British Columbia. For Chron. 1994:70(2):159–163. https://doi.org/10.5558/tfc70159-2

Liu Y-B, McLean JA. Observations on the biology of the ambrosia beetle *Gnathotrichus retusus* (LeConte) (Coleoptera: Scolytidae). Can Entomol. 1993:125(1):73–83. https://doi.org/10.4039/ent12573-1

López S, Iturrondobeitia JC, Goldarazena A. Primera cita de la Península Ibérica de *Gnathotrichus materiarius* (Fitch, 1858) y *Xylosandrus germanus* (Blandford, 1894) (Coleoptera: Scolytinae). Bol Soc Entomol Arag. 2007:40:527–532.

Maksymov JK. Erstmaliger Massenbefall des schwarzen Nutzholzborkenkäfers, *Xylosandrus germanus* Blandf., in der Schweiz [First mass infestation of the black timber bark beetle, *Xylosandrus germanus* Blandf., in Switzerland]. Schweiz Z Forstwesen. 1987:138:215–227.

Martikainen P, Siitonen J, Kaila L, Punttila P, Rauh J. Bark beetles (Coleoptera, Scolytidae) and associated beetle species in mature managed and old-growth boreal forests in southern Finland. Forest Ecol Manag. 1999:116(1–3):233–245. https://doi.org/10.1016/s0378-1127(98)00462-9

Mazur A, Witkowski R, Góral J, Rogowski G. Occurrence of *Gnathotrichus materiarius* (Fitch, 1858) (Coleoptera, Curculionidae, Scolytinae) in South-Western Poland. Folia For Pol. 2018:60(3):154–160. https://doi.org/10.2478/ffp-2018-0015

Mech AM, Thomas KA, Marsico TD, Travis D, Herms DA, Allen CR, Ayres MP, Gandhi KJK, Gurevitch J, Havill NP, et al. Evolutionary history predicts high-impact invasions by herbivorous insects. Ecol Evol. 2019:9(2):12216–12230.

Meurisse N, Rassati D, Hurley BP, Brockerhoff EG, Haack RA. Common pathways by which non-native forest insects move internationally and domestically. J Pest Sci. 2019:92(1):13–27. https://doi.org/10.1007/s10340-018-0990-0

Moeck HA. Ethanol as the primary attractant for the ambrosia beetle *Trypodendron lineatum* (Coleoptera: Scolytidae). Can Entomol. 1970:102(8):985–995. https://doi.org/10.4039/ent102985-8

Montecchio L, Faccoli M. First record of thousand cankers disease *Geosmithia morbida* and walnut twig beetle *Pityophthorus juglandis* on *Juglans nigra* in Europe. Plant Dis. 2014:98(5):696. https://doi.org/10.1094/PDIS-10-13-1027-PDN

Moucheron B, Warzée N. *Gnathotrichus materiarius* (Fitch, 1858): un scolyte nord-americain a surveiller nouveau pour la faune Belge (Coleoptera, Scolytidae). Lambillionea. 2006:106(4):610–612.

Netherer S, Kandasamy D, Jirosová A, Kalinová B, Schebeck M, Schlyter F. Interactions among Norway spruce, the bark beetle *Ips typographus* and its fungal symbionts in times of drought. J Pest Sci. 2021:94(3):591–614. https://doi.org/10.1007/s10340-021-01341-y

Pennacchio F, Santini L, Francardi V. Bioecological notes on *Xylosandrus compactus* (Eicchoff) (Coleoptera: Curculionida: Scolytinae), a species recently recorded into Italy. Redia. 2012:95:67–77.

Ploetz RC, Hulcr J, Wingfield MJ, de Beer ZW. Destructive tree diseases associated with ambrosia and bark beetles: black swan events in tree pathology? Plant Dis. 2013:97(7):856–872.

Procházka J, Stejskal R, Čížek L, Hauck D, Knížek M. *Dryocoetes himalayensis* (Coleoptera: Curculionidae: Scolytinae), a new bark beetle species for Slovakia and Austria, and its occurrence in the Czech Republic. Klapalekiana. 2018:54:117–121.

Račanský Z. Vliv obnovy výmladkového hospodářství v NPR Zahrady pod Hájem na vybrané čeledi saproxylických brouků [The effect of the restoration of sapling management in the NPR Zahrady pod Hájem on selected families of saproxylic beetles] [MSc thesis]. [Brno (Czech Republic)]: Masarykova univerzita; 2019.

Ranger CM, Schultz PB, Frank SD, Chong JH, Reding ME. Non-native ambrosia beetles as opportunistic exploiters of living but weakened trees. PLoS One. 2015:10(7):e0131496. https://doi.org/10.1371/journal.pone.0131496

Ryan K, Groot P. de, Smith SM. Evidence of interaction between *Sirex noctilio* and other species inhabiting the bole of *Pinus*. Agric For Entomol. 2012:14(2):187–195.

Sanchez A, Chittaro Y, Germann C, Knížek M. Annotated checklist of Scolytinae and Platypodinae (Coleoptera, Curculionidae) of Switzerland. Alp Entomol. 2020:4:81–97. https://doi.org/10.3897/alpento.4.50440

Schedl KE. Ein für Deutschland und Holland neuer Borkenkäfer. Anz Schädlingskd. 1966:39:118–120.

Schlaghamerský J. The saproxylic beetles (Coleoptera) and ants (Formicidae) of Central European Hardwood Floodplain Forests. Folia Facultatis Scientiarium Naturalium Universitatis Masarykianae Brunensis. Biologia. 2000:103:1–168.

Schneider I. *Gnathotrichus materiarius* Fitch (Col., Scolytidae) in Pheromonfallen von *Ips cembrae* (Heer) (Col., Scolytidae), ein neuer Fundort für NW-Deutschland (Gnathotricfius materiarius Fitch (Col., Scolytidae) in pheromone traps of the European Larch Bark Beetle, *Ips cembrae* (Heer) (Col., Scolytidae), a new location for Europe in North West Germany). Anz Schädlingskd PFL. 1985:58(3):50–51.

Schroeder LM. Occurrence of insects in coniferous roundwood imported to Sweden from France and Chile. EPPO Bull. 1990:20(4):591–596. https://doi.org/10.1111/j.1365-2338.1990.tb00181.x

Smith CS, Lonsdale WM, Fortune J. When to ignore advice: invasion predictions and decision theory. Biol Invasions. 1999:1:89–96.

Týr V. Brouci (Coleoptera) Žihle a okolí. 14. část. Nemonychidae, Anthribidae, Attelabidae, Brentidae, Curculionidae (Platypodinae, Scolytinae) (Beetles (Coleoptera) in the surroundings of Žihle. Part 14. Nemonychidae, Anthribidae, Attelabidae, Brentidae, Curculionidae (Platypodinae, Scolytinae)). Západočeské Entomol Listy. 2021:12:1–15.

Unar P, Janík D, Běťák J, Procházka J. Následky ledovky v lesích NP Podyjí a jejich odraz ve vývoji druhové rozmanitosti porostů 5 let po disturbance (Consequences of the glaze in the forests of Podyjí National Park and their reflection in the development of species diversity of stands 5 years after disturbance). Thayensia. 2021:18:47–102.

Valenta V, Moser D, Kapeller S, Essl F. A new forest pest in Europe: a review of Emerald ash borer (*Agrilus planipennis*) invasion. J Appl Entomol. 2017:141(7):507–526. https://doi.org/10.1111/jen.12369

Valkama H, Martikainen P, Räty M. First record of North American ambrosia beetle *Gnathotrichus materiarius* (Fitch) (Coleoptera, Scolytidae) in Finland—a new potential forest pest? Entomol Fenn. 1998:8(4):193–195.

Wan F-H, Yang N-W. Invasion and management of agricultural alien insects in China. Annu Rev Entomol. 2016:61:77–98. https://doi.org/10.1146/annurev-ento-010715-023916

Williamson M, Fitter A. The varying success of invaders. Ecology. 1996:77(6):1661–1666. https://doi.org/10.2307/2265769

Witkowski R, Dyderski MK, Bełka M, Mazur A. Potential European geographical distribution of *Gnathotrichus materiarius* (Fitch, 1858) (Coleoptera: Scolytinae) under current and future climate conditions. Forests. 2022:13(7):1097. https://doi.org/10.3390/f13071097

Witkowski R, Góral J, Nowik K, Rogowski G, Skałecka K, Mazur A. *Gnathotrichus materiarius* (Fitch, 1858) (Coleoptera: Curculionidae, Scolytinae)—new species of beetle in the polish fauna. Acta Sci Pol Silv Colendar Ratio Ind Lignar. 2016:15(1):43–47.