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ORIGINAL PAPER

Maple bark beetle (*Scolytus koenigi*) – a new species for Bohemia and its current distribution in the Czech Republic

Petr Martinek[1], Jiří Foit[1], Miloš Knížek[2], Josef Kašák[1]*

[1]*Mendel University in Brno, Department of Forest Protection and Wildlife Management, Zemědělská 1665/1, CZ-61300 Brno, Czech Republic*

[2]*Forestry and Game Management Research Institute, Department of Forest Protection Service, Strnady 136, CZ-25202 Jíloviště-Strnady, Czech Republic*

Abstract
Bark beetles (Curculionidae: Scolytinae) represent an important insect group including many significant pest species, but in some cases, the distribution and ecology of many bark beetles are still not well known. Maple bark beetle *Scolytus koenigi* Schyverew, 1890 is one of the mentioned group of species. The following study presents i) the first data of the occurrence of *S. koenigi* in Bohemia, ii) the first data of the species occurrence in an urban environment (large cities – Prague and Brno), iii) the distribution of the species in the Czech Republic since its first record (in 2013), and iv) new data about the bionomy of the species (i.e. a new host tree – *Acer pseudoplatanus* L. and refinement of the colonized substrate range diameter).

Key words: *Acer* spp.; forestry; mediterranean species; saproxylic; urban site

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1. Introduction

Bark beetles are one of the most important bark and wood-boring insects mainly due to their importance in forest ecosystems and management. On the one hand, these species represent an important functional group in nutrient cycling and food chains (Stokland et al. 2012; Ulyshen 2018). On the other hand, some species cause significant economic and ecological damage (Lieutier et al. 2004; Biedermann et al. 2019; Gomez et al. 2023). Among the group of special importance are representatives of the genus *Scolytus* Geoffroy, 1762 with some species being vectors of ophiostomatoid fungi and having a major impact on the vitality of certain woody plant populations (Pfeffer 1955; Smith & Hulcr 2015). There are 13 species of the genus *Scolytus* occurring in Central Europe, mostly distributed throughout the whole European region (Pfeffer 1995; Petrov 2021) and their ecology is well-known (e.g., Webber 1990; Smith & Hulcr 2015; Cognato et al. 2021). One exception in the previous statement is the maple bark beetle *Scolytus koenigi*, 1890. This species has a limited Ponto-Mediterranean distribution with separated localities of occurrence in warmer regions of Central Europe (Kašák et al. 2015). The species occurs in forest-steppe formations with a representation of maples (*Acer* L.). The bionomy of *S. koenigi* is relatively poorly known, e.g., the structure of the gallery and the base requirements for dimensions of host tree substrate were characterized only in 2015 (Kašák et al. 2015), and the exact requirements of females for the establishment of a new generation have been less studied (Petrov & Kolganikhina 2020). *S. koenigi* is colonizing different maple species (*Acer* spp.). From Mediterranean and Central Europe *Acer campestre* L., *A. platanoides* L., and *A. obtusatum* Willd. are reported as a host tree (Kašák et al. 2015). In Turkestan, the European part of Russia, and the Caucasus, the development of this species occurs on *A. monspessulanum* L., *A. platanoides*, *A. tataricum* L., and *A. turkestanicum* Pax (Petrov & Kolganikhina 2020).

Information about the distribution of *S. koenigi* in Central Europe is fragmentary, although the issue of bark beetles, in general, has been studied intensively (e.g., Galko et al. 2019; Fiala et al. 2020; Resnerová et al. 2023). The species was first found in the Czech Republic in 2013 in southern Moravia (Kašák et al. 2015). Specifically, several infested trees (*A. platanoides* and *A. campestre*) were found at two closely located sites, i.e. Lednice – Rybniční zámeček and Květné jezero Nature reserve. Due to the remoteness of the nearest known localities

*Corresponding author. Josef Kašák, e-mail: Abovic@seznam.cz

of the species in Austria, the origin of the South Moravian population is unknown. The species may have been overlooked in the Czech Republic (Kašák 2018), but it may have also spread similarly to some other Mediterranean species of bark and wood-boring beetles, which are spreading northwards and contribute to the mortality of host trees (Čížek 2017; Jendek et al. 2018). Given the changing climatic conditions and the overall decline of trees in the region (Hlásny et al. 2021), the relevance of *S. koenigi* to forest management or the maples perspective in the non-forest landscape is also unclear. Because of the above, the distribution and bionomy of this species in the Czech Republic deserve to be studied. Therefore, the paper presents i) the first record of *S. koenigi* in the Bohemia, ii) the distribution of the species in the Czech Republic and iii) new data on the bionomy of the species.

2. Methods

The present study compiles current knowledge on the occurrence of *S. koenigi* in the Czech Republic found during the last 11 years, i.e. 2013–2024, using various research activities. The most data were gained by random (no systematic sampling design pre-set) checking of declining and dead maples were checked for characteristic damage (the presence of *S. koenigi* galleries) with the highest survey effort, especially in the area of South Moravia, i.e. the region of the first record of *S. koenigi* in the country. Galleries of *S. koenigi* are practically unmistakable in Central Europe also because no other species of the genus *Scolytus* develops on maple trees. The determination of the species based on galleries was confirmed in most cases by finding dead adults or their remains (determined by authors). Further, on a selected locality with probable occurrence of *S. koenigi* (southern Moravia, near Brno) maple trap trees were tested (2 trap logs *A. platanoides* and 2 *A. pseudoplatanus* in 2019) to investigate the species' occurrence (Holuša O. – own data). Additionally, the dataset was enriched by records of *S. koenigi* gained during surveys of insect diversity using window traps in protected areas (Kašák J., Foit J. – own data). The obtained distribution of the species in the Czech Republic is presented (Fig. 1) using faunistic squares according to the network mapping of the Czech Republic (Zelený 1972).

3. Results

In the present study, *S. koenigi* was recorded at a total of nine localities in five faunistic squares in the Czech

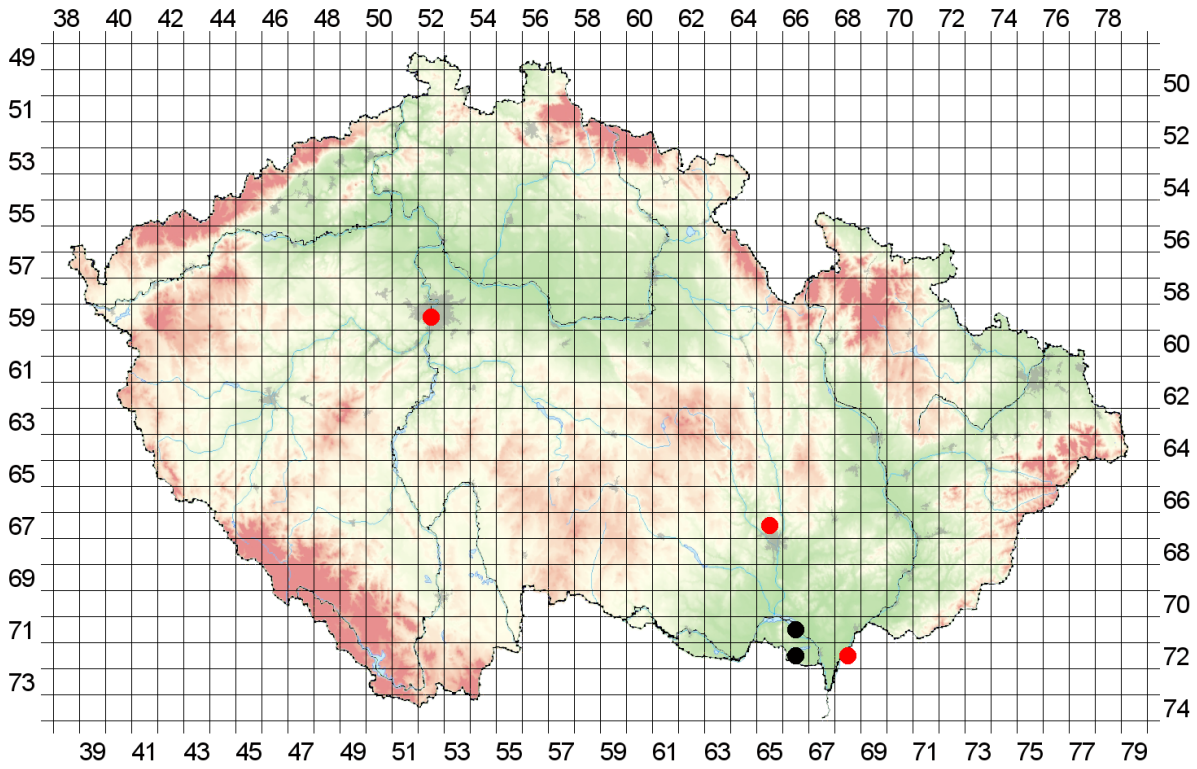

Fig. 1. Known occurrence of maple bark beetle *Scolytus koenigi* in the Czech Republic. Black circle = known occurrence in the year 2013 published in Kašák et al. (2015); red circle = new records outside the published squares. The map has been created by the utility of www.biolib.cz (accessed October 2023).

Republic between 2013 and 2024 (Fig. 1, Table 1). Between the years 2014–2020, *S. koenigi* was recorded in four new localities in the proximity of its first detection in southern Moravia (the two localities found in 2013). In 2022 and 2024, it was recorded in Bohemia for the first time, specifically in the capital city – Prague (city parks in Břevnov and Smíchov, Fig. 2, 3 respectively). Afterwards in 2023, *S. koenigi* was recorded in Brno (city park in Lužánky), the second largest city in the country. Thus, the occurrence of *S. koenigi* was newly evidenced in seven localities and three faunistic squares and was also reconfirmed in one of the two localities of the species' first finding in 2013 (the second locality was not visited). All localities are situated in lowlands in the warmest regions. Moravian localities, except Brno – Lužánky, are located in the wider area of the confluence of the Thaya and the Morava rivers (most of them covering several km^2). *S. koenigi* localities in Prague – Břevnov and Smíchov situated in Bohemia are exceptional mainly for its northern location and remoteness (the distance is approximately 200 km from the Moravian localities). Together with Brno – Lužánky it is the first evidence of the species occurrence in an urban habitat ever – park inside a large city (Fig. 3). In addition, during the present study, new information on the bionomy of *S. koenigi* was obtained (Table 1). Overall, most of the trees found to be colonised by *S. koenigi* were partly to full sun-exposed trees in lowland oak zone forests, i.e. forest-steppe, sparse floodplain forests and city parks. A new host tree *A. pseudoplatanus* was identified. For the first time in the Czech Republic, high numbers of galleries were recorded not only on the branches of the host tree but also on the trunks (hundreds per tree). Furthermore, the known range of colonized host substrate size that the species colonizes was broadened, with successfully completed galleries found on wood segments up to 65 cm in diameter (Fig. 4). Galleries of *S. koenigi* exhibited the same features in localities situated around the Thaya and Morava rivers, according to Kašák et al. (2015). Therefore, only basic data are presented in Table 1.

4. Discussion

The present study summarizes current knowledge on *S. koenigi* occurrence in the Czech Republic, up to date the species was recorded in nine localities in the country during 2013–2024 (Fig. 1, Table 1). Additionally, the two known localities of the species' first records in 2013, the study reports seven new localities, including first locality in Bohemia (capital city Prague). Moreover, the new records of *S. koenigi* from Prague and Brno city parks represent the first evidence of the species' occurrence in urban habitats ever (Fig. 3). Furthermore, the present study obtained new facts regarding the species' biology and utilization of a new tree host species (Fig. 4, Table 1).

Table 1. Records of *Scolytus koenigi* in the Czech Republic. [1]Faunistic squares according to Zelený et al. (1972). [2]Date of record or collection (ordered chronologically). All adults and galleries of *S. koenigi* were identified by authors. [3]Sources include published documents (cited as author and year of publication), unpublished documents that were not peer-reviewed such as reports of saproxylic beetle surveys (only the name of author is mentioned). [4]Colonised species = a number of individuals of species of maples (*Acer* spp.) occupied by *S. koenigi*: ACA = *A. campestre*, APL = *A. platanoides*, APS = *A. pseudoplatanus*. [5]Diameter = diameter (or range) of colonised part of a tree. [6]Number of galleries = recorded number of maternal galleries of *S. koenigi*, AG = abandoned galleries.

Locality	Faunistic square[1]	Date[2]	Source[3]	Colonised species[4]			Colonised substrate	Diameter[5] (cm)	Number of galleries[6]
				ACA	APL	APS			
Lednice – Rybniční zámeček	7266	XI. 2013	Kašák et al. 2015	4	1	—	ACA: dead trees, dead branches on live trees APL: dead branches (fallen)	3–39	tens
Lednice – Květné Jezero	7266	XI. 2013	Kašák et al. 2015	2	—	—	dead trees	5–10	tens
Lednice – Thaya river near Minaret	7166	XII. 2015	Kašák J.	—	1	—	dead branch (fallen)	3–5	ca. 10 AG
Tvrdonice – natural monument Stibůrkovská jezera	7268	VI. 2016	Foit J.	1	—	—	dead tree	20	ca. 10 AG
Lednice – former Hubertova šopa barn	7166	VI. 2017	Kašák J.	—	1	—	dead branch on live tree	8	ca. 15 AG
Lednice – Rybniční zámeček chateau	7266	II. 2017	Kašák J.	1	3	—	ACA: dead tree APL: dead branches on live trees	ACA: ca. 20 APL: 3–10	several AG / tree
Lednice – Hraniční zámeček chateau	7266	XI. 2020	Kašák J.	—	3	1	APL: dead trees APS: dying trees and branches	APL: 2–65 APS: 10–30	APL: hundreds of AG APS: few AG
Prague – Břevnov	5952	III. 2022	Martinek P., Kašák J.	—	1	—	dead tree	20	11 AG
Brno – Lužánky	6765	VI. 2023	Martinek P., Kašák J.	—	—	1	dead branch (fallen)	4	3 AG
Prague – Smíchov	5952	I. 2024	Kočvara R., Knížek M.	—	1	—	dead tree	2–31	hundreds of AG

Fig. 2. Galleries of maple bark beetle *Scolytus koenigi* on *Acer platanoides* found at the locality Prague-Břevnov (Bohemia, Czech Republic) – the first record of the species in Bohemia (March 23, 2022).

Fig. 3. Spring view on *Acer platanoides* tree colonised by maple bark beetle *Scolytus koenigi* in park of Břevnov (Prague, Bohemia, Czech Republic) – the first record of the species in urban habitat (March 23, 2022).

Fig. 4. Trunk of fallen *Acer platanoides* tree near Hraniční zámeček chateau (southern Moravia, Czech Republic) (December 14, 2020) – trunk was densely colonised by maple bark beetle *Scolytus koenigi* up to the diameter 65 cm.

4.1. Maple bark beetle in Prague

The occurrence of *S. koenigi* as a Ponto-Mediterranean species in Prague is exceptional, mainly due to the remoteness of the locality in the northern direction from the species range and the isolation from the nearest known localities in South Moravia (approximately 200 km, Fig. 1). The wider area of Prague is characterized by the warm climate and the presence of rich natural habitats, e.g., for saproxylic beetles. These natural habitats are old deciduous forests and forest steppes, parks, game reserves, and alleys with great woody species biodiversity (Veselý 2002; Bílý 2017). The distribution pattern of *S. koenigi* is similar to that of another thermophilic insects present in the Czech Republic. These species are primarily found in the warmest regions of southern Moravia and central Bohemia (Sláma 1998; Beneš et al. 2002). Another explanation for the occurrence of *S. koenigi* in such isolated location is its potential to be introduced through wood products and materials. Intensive transport of plants and plant products is the point of entry for the numerous species of invasive insect species into urban areas (Gaertner et al. 2017). This is further substantiated by recent findings of expansive and invasive bark and wood-boring beetles within these localities, e.g., bark beetle *Dryocoetes himalayensis* Strohmeyer, 1908 (Kašák et al. 2023) and *Semanotus russicus* (March 2022, galleries observed by J. Kašák, photo determined by M. Hoskovec) in the case of Prague (Břevnov), as well as the jewel beetle *Lamprodila festiva* (June 2019, galleries observed by P. Martinek) in the case of Brno.

4.2. Maple bark beetle in urban habitat

S. koenigi has been previously reported only from rural sites of forest-steppe and the zone of lowland oak forests (Kašák et al. 2015; Petrov & Kolganikhina 2020). The documented occurrence of *S. koenigi* in the urban sites of large cities such as Prague and Brno is interesting. *S. koenigi* is a thermophilic Ponto-Mediterranean species of bark and wood-boring beetle, which corresponds to its occurrence in the forest-steppe localities of the warmest parts of the Czech Republic (Kašák et al. 2015 and Fig. 1). The occurrence of thermophilic southern European species in large cities of Central Europe has been recorded several times, e.g., during the spread of the already mentioned *L. festiva* and *S. russicus* (Čížek 2017; Jendek et al. 2018, Królik et al. 2023). This might be partly due to the species introduction (see above) but the species' occurrence might be also supported by significantly higher temperatures in cities (Tzavali et al. 2015; Venter et al. 2021), the specific management of city habitats, and the worsened condition of trees in the urban greenery (Carpaneto et al. 2010; Horák 2018; Czaja et al. 2020). Temperature conditions in large cities reach up to around 5 °C higher average temperatures (Tzavali et al. 2015) than in rural conditions. It means that cities are warmer by up to a climate zone. This can decrease the mortality pressure on larval individuals (through a reduction in the number of frost days) and increase the reproduction of insect imagoes (due to a more stable climate during the active period) (Meineke et al. 2013; Dale & Frank 2017; Karthik et al. 2022). The specific management of urban greenery mainly includes: a) the presence of varied tree

species composition on a small area (i.e. the probable occurrence of the host tree), b) care for trees in the form of cuttings (these cuttings support the presence of materials suitable for bark and wood-boring beetles, e.g., cut wounds, stumps of branches etc.), c) often unsuitable conditions for trees in particular – high temperatures, and drying of the soil substrate leads to the weakening of woody plants (Czaja et al. 2020). Or, more precisely to the creation of trees potentially suitable for colonization by the bark and wood-boring beetle (Horák 2018).

4.3. Notes on maple bark beetle ecology

At the northern border of the species' range in Central Europe, *S. koenigi* was found on dead branches and thinner trunks (presence of *S. koenigi* galleries). Kašák et al. (2015) specified galleries densities as low (52 galleries were found in 10 approximately 0.5 m long sections with 3–12 cm in diameter, and the average number of larval galleries per one gallery system was approximately 55). Despite the intensive search for characteristic galleries of *S. koenigi* during sampling at the sites, only units of infested trees with a few galleries on stems and branches with similar parameters (please see Results and Tab. 1) were mostly found regardless many potential host trees for *S. koenigi* development were present. At some localities, such as the area surrounding (radius of about 300–500 m) the infested tree in Prague – Břevnov and Brno – Lužánky, several dozen maples (mostly *A. platanoides* and *A. campestre*, and a few *A. pseudoplatanus*) were surveyed. These trees were found to be often weakened, variously damaged, with dead or dying branches that are potentially suitable for the species' development. Although the trees were favourable for the development of other bark and wood-boring beetles, *S. koenigi* galleries were not observed. The trees were frequently colonised by the longhorned beetles *Leiopus nebulosus* (Linnaeus 1758) and the threatened *Leioderes kollari* (Redtenbacher 1849) – galleries observed by the authors.

Only in two cases, three trees were found to be completely occupied with hundreds of *S. koenigi* galleries (Fig. 4; locality Hraniční Zámeček and Prague-Smíchov). In contrast, in the areas of the species' distribution range with a more continental climate, larger numbers of trees are frequently heavily colonized by *S. koenigi* (Petrov & Kolganikhina 2020).

Interesting findings on *S. koenigi* bionomy are provided by the research from the southern pre-Ural part of Russia, where fire-affected forest stands were studied (Petrov & Kolganikhina 2020). Branches and stem parts of *A. platanoides* were very sporadically colonized by *S. koenigi* (this was similar like in our sides without exceptions) before the fire. In these cases the gallery densities of *S. koenigi* were similar to those of the Czech Republic (see Results and Tab. 1; Kašák et al. 2015). However, 4 years after the fire, significantly higher densities and fecundity of *S. koenigi* were recorded. On stems (25–27 m long), there was an increasing average number of galleries from 4 (pre-fire) to 360 and fecundity from 50 larval galleries per one gallery system to 81 (Petrov & Kolganikhina 2020). *S. koenigi* is a species of xerothermic habitat and was documented to increase its abundance in forests affected by fires (Petrov & Kolganikhina 2020). Trees damaged by fire (weakened or dying) present a very specific substrate for the development of bark and wood-boring beetles and host a unique pyrophilic fauna of beetles that show specific adaptations (Škorpík et al. 2011; Stokland et al. 2012; Hjältén et al. 2018). *S. koenigi* may prefer dry pyrogenically formed wood substrates, where it might be very numerous, and in other circumstances, the *S. koenigi* population survives singly in suboptimal conditions on dry branches. This corresponds to findings in the southern parts of Russia, where *S. koenigi* showed a significantly lower success rate of development in the relatively wetter lower parts of trees with the activity of wood fungi (Petrov & Kolganikhina 2020). In the relatively wetter climate of the Czech Republic (compared to continental Eurasia), *S. koenigi* could prefer drier branches. This is also in line with our observations of the species' preference for partly to fully sun-exposed trees. Largely unsuccessful larval development was recorded in branches lying on the ground in floodplain forests (locality Lednice, Thaya near Minaret). Here, we offer a possible explanation of the observed activity patterns of the bionomy of *S. koenigi* in the Czech Republic, i.e. the species' low abundance and the low number of colonized trees. The species might be limited by a combination of factors: a) the specific requirements of *S. koenigi* for the characteristics of the host tree, and b) the higher climatic demands of this Ponto-Mediterranean species.

5. Conclusions

Ten years after the first observation of *S. koenigi* in the Czech Republic, it can be concluded: i) the species does not spread significantly over the Central European region, although there is a large number of trees potentially suitable for *S. koenigi* development in the landscape, ii), *S. koenigi* can participate in the declining of individual trees, however, under the specific conditions, iii) at the moment, *S. koenigi* does not appear to be a potentially dangerous pest for maples in the conditions of the Czech Republic and the species can be characterised as a facultative parasite (Petrov & Kolganikhina 2020) sensu (Raffa et al. 1993), and iv) further research on this bark beetle is desirable, especially in the area of distribution, population genetics, conditions for development, bionomy (length of development, numbers of generations, phenology of occurrence of adults, etc.), fungal associates (their pathogenicity, transmission, etc.).

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