JHR 51: 159–169 (2016)
doi: 10.3897/jhr.51.9219
http://jhr.pensoft.net

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The international Society of Hymenopterists

Allochthonous blue spruce in Central Europe serves as a host for many native species of sawflies (Hymenoptera, Symphyta)

Emanuel Kula[1], Jaroslav Holuša[2], Ladislav Roller[3], Miroslav Úradník[4]

1 *Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, 61300 Brno, Czech Republic* **2** *Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Kamýcká 1176, 165 21 Prague, Czech Republic* **3** *Institute of Zoology, Slovak Academy of Sciences in Bratislava, Dúbravská cesta 9, 845 06 Bratislava, Slovakia* **4** *Andreja Hlinku 2586/20, 960 01 Zvolen, Slovakia*

Corresponding author: *Jaroslav Holuša* (holusaj@seznam.cz)

Academic editor: *M. Prous* | Received 14 May 2016 | Accepted 27 June 2016 | Published 29 August 2016

http://zoobank.org/9CCF2F81-753E-4A20-A79D-D698E8526356

Citation: Kula E, Holuša J, Roller L, Úradník M (2016) Allochthonous blue spruce in Central Europe serves as a host for many native species of sawflies (Hymenoptera, Symphyta). Journal of Hymenoptera Research 51: 159–169. doi: 10.3897/jhr.51.9219

Abstract

In air-polluted mountain areas of the Czech Republic, including the Ore Mountains, pure forest stands of introduced blue spruce (*Picea pungens*) were established in the 1980's. We studied the Symphyta (Hymenoptera) fauna in the canopies of these trees at four sites and in the canopies of adjacent *Picea abies* trees at one of these sites by beating tree branches. For the first time, Nearctic blue spruce is reported as a host for 17 European species of Symphyta (sawflies). Diprionids in the genus *Gilpinia* were the most abundant sawflies on *P. pungens* and were more abundant on *P. pungens* than on the native *Picea abies*. Spruce pamphiliids in the genus *Cephalcia* were also more abundant on *P. pungens* than on *P. abies*, while the abundances of representatives of the tenthredinid genera *Pikonema*, *Pachynematus*, and *Pristiphora* were similar on *P. pungens* and *P. abies*. Our results indicate that many species of European spruce Symphyta are able to use the allochthonous species *P. pungens* as a host.

Keywords

Picea pungens, *Picea abies*, Symphyta, Diprionidae, Tenthredinidae, Pamphiliidae, larvae

Introduction

In Central Europe, *P. abies* (L.) Karst is the only native species of spruce (Schwenke 1978). Many introduced spruce species including of the blue spruce, *Picea pungens* Engelm, are occasionally cultivated in urban areas. Beginning in the 1980s, pure stands of *P. pungens* have been planted in an area of about 100 km^2 in the air-polluted mountain regions of the Czech Republic. *P. pungens* was thought to require only modest soil resources, to have a high tolerance to sulfur oxide air pollution, and to have the ability to resist or avoid ungulate herbivores (Šika 1976, Tesař 1981, Balcar 1986, Jirgle et al. 1983, Kubelka et al. 1992). The assumption about high resistance to air pollution was found to be incorrect, however, because the needles of young *P. pungens* and *P. abies* exhibit the same degree of damage in response to air pollutants (Soukupová et al. 2001).

Many forest pests including many defoliators feed on spruce (Pschorn-Walcher 1982).

At least 34 species belonging to three families of Symphyta (32 species in Central Europe) feed on needles of native spruce in Europe. These feeders include Pamphiliidae with at least nine species of *Cephalcia* (Viitasaari 2002), Diprionidae with four *Gilpinia* species and *Microdiprion fuscipennis* (Forsius, 1911) (Kontuniemi 1960, Viitasaari and Varama 1987), and Tenthredinidae with 15 *Pristiphora* s.l. (Beneš and Křístek 1979, Kajmuk 1988), two *Pikonema* and three *Pachynematus* s.l. (Taeger et al. 1998). *Pristiphora tenuiserra* (Lindqvist, 1959), for which the host plant is unknown, may also be a spruce feeder (Holuša and Roller 2000). New generic nomenclature of Nematinae (Prous et al. 2014) has been omitted (*Pikonema* and *Pachynematus* are currently treated as members of a vast genus *Euura*) with respect to applied entomology.

Although the blue spruce *P. pungens* is planted in the extensive, air-polluted areas of the Czech Republic, the Symphyta fauna developing on this allochthonous plant have not been thoroughly studied. One reason is that serious outbreaks of pests have not occurred during the 25- to 30-year period following the establishment of pure stands of *P. pungens* in the Ore Mountains (Holuša and Holuša 2003).

The host status of *P. pungens* for European native Symphyta is unknown. The goals of this study were (i) to identify the sawflies that feed on *P. pungens* in the Czech Republic and (ii) to compare the abundances of these sawflies on the native *P. abies* and on the introduced *P. pungens.*

Methods

Sawflies were studied in three localities in the Ore Mountains (NW Czech Republic) (Table 1). Two localities (Jirkov, Dlouhá louka) had pure stands of *P. pungens*, and one locality (Sněžník) had a pure stand of *P. pungens* and a pure stand of *P. abies* that were 100 m apart.

Sawfly larvae and adults were sampled by beating tree branches and collecting the falling insects on a sheet stretched on a 0.5 × 1 m metal frame. On each sampling date, 10 samples were collected at each of the four stands. For each sample, two branches

Table 1. Characteristics of studied stands.

Locality	Tree species	Geographic characteristics	Altitude (m asl)	Stand density [%]	Age of stand [years]	Area/percentage of spruce forest in district	Native forest type	Annual mean temperature and total precipitation
Jirkov	*P. pungens*	50°33'11"N, 13°22'59"E	875	90	25–36	14.43 km²/ 15.4%	*Fageto - Piceetum acidophilum*	4–4.5 °C / 1050–1200 mm
Dlouhá louka	*P. pungens*	50°39'00"N, 13°38'04"E	865	70	34	29.37 km²/ 22%	*Fageto - Piceetum acidophilum*	4–4.5 °C / 1050–1200 mm
Sněžník	*P. pungens*	50°47'28"N, 14°04'33"E	576	70	27–31	4.87 km²/ 4.5%	*Piceeto - Fagetum acidophilum*	4.5–5.5 °C / 900–1050 mm
Sněžník	*P. abies*	50°47'30"N, 14°04'15"E	576	70	19	28.76 km²/ 26.6%	*Piceeto - Fagetum acidophilum*	4.5–5.5 °C / 900–1050 mm

were selected at random in the crowns of 10 trees, the branches were located from 0.7 to 2.5 m above the ground, and the sampled trees were in a line with 10 m between adjacent trees. Trees were sampled on 17 May, 15 June, 14 July, 15 August, 15 September, and 15 October 2007. Thus, one sample consisted of insects collected from one stand (a total of 20 branches on 10 trees) across all six sampling dates.

The collected insects were stored in 75% ethanol. Larvae were identified using the keys of Beneš and Křístek (1979), Battisti and Jiang-hua Sun (1996), Battisti and Zanocco (1994), Martinek (1988), and Zanocco and Battisti (1995). Very young larvae (first and second instars) were identified only to genus (*Cephalcia*, *Gilpinia*, and *Pristiphora*). The current knowledge of larvae allows the identification of some *Pachynematus* s.l. and *Pristiphora* s.l. only to the subgeneric level and are here referred to as the *Epicenematus* and *Sharliphora* species groups, respectively. Adult sawflies were identified using the keys of Beneš and Křístek (1979), Viitasaari (2002), and Zhelokhovtsev (1988). The nomenclature follows Taeger and Blank (2011), and host plants are given according to Taeger et al. (1998) unless stated otherwise.

The data of larvae per locality were not normally distributed. When the abundance of a sawfly species was > 10 on both *P. abies* and *P. pungens* at Sněžník, the values were compared with a Wilcoxon pair test in Statistica 12.0.

Results

In total, 748 larvae and 79 adults of 36 species of sawflies were collected (Table 2). Among the 36 species, 23 have been previously associated with spruce, and the 13 have been previously associated with other plant species (Table 2). Larvae obtained from the branches of *P. abies* (N=127) and *P. pungens* (N=621) belonged to 12 and 18 species of Symphyta, respectively.

Table 2. Total numbers of sawflies (Hymenoptera: Symphyta) collected on *P. abies* and *P. pungens* in the Czech Republic (plus information on known host plants for each species of sawfly). The sawflies were collected from 20 branches per stand (two branches on each of 10 trees) in three *P. pungens* stands (at Jirkov, Dlouhá louka, and Sněžník) and in one *P. abies* stand (at Sněžník) on six sampling dates from spring to fall in of 2007. Sawfly species feeding on spruce are in bold. When the abundance of a sawfly species (larvae + adults) was > 10 on both *P. abies* and *P. pungens* at Sněžník, the values were compared with a Wilcoxon pair test (an asterisk indicates a significant difference, and n.s. indicates a non-significant difference). The information on known host plants is from Taeger et al. (1998) unless indicated otherwise.

Sawfly species	Number of larvae		Wilcoxon pair test	Number of adults		Known hosts
	On *P. abies* at Sněžník	On *P. pungens* at all three stands (and at Sněžník in brackets)		On *P. abies* at Sněžník	On *P. pungens* at all three stands	
Arge fuscipes (Fallén, 1808)				1	1	*Salix*, *Betula*
***Cephalcia* sp.**	**5**	**17(4)**				
***Cephalcia abietis* (Linné, 1758)**		**11(1)**			**6**	***P. abies*, *P. obovata*, *P. koraiensis***
***Cephalcia alpina* (Klug, 1808)**	**2**	**16(2)**				***P. abies*, *P. obovata*, *P. koraiensis*, *P. jezoensis***
***Cephalcia arvensis* Panzer, 1805**		**16(7)**		**4**	**11**	***P. abies*, *P. obovata*, *P. koraiensis*, *P. jezoensis***
***Cephalcia erythrogaster* (Hartig, 1837)**		**1(0)**		**1**		***P. abies*, *P. koraiensis***
***Cephalcia fulva* Battisti & Zanocco, 1994**	**1**	**6(2)**				***P. abies*, *P. koraiensis***
Dineura viridiorsata (Retzius, 1783)					1	*Betula*
Dolerus gonager (Fabricius, 1781)					1	Poaceae
Dolerus nigratus (O.F.Müller, 1776)					2	Poaceae
***Gilpinia* sp.**	**17**	**84 (42)**	**2.36***			
***Gilpinia abieticola* (Dalla Torre, 1894)**	**19**	**98 (19)**	**0.00 n.s.**		**2**	***P. abies*, *P. obovata*, *Pinus pumila* (probably missidentification, Karel Beneš pers. comm.)**
***Gilpinia hercyniae* (Hartig, 1837)**	**2**	**134 (4)**	**0.80 n.s.**			***P. abies*, *P. obovata* (In N. America *P. glauca*, *P. sitchensis*, *P. pungens*, *P. mariana*, *P. rubens*, *P. pungens* (Quarantine PEST data Sheet))**
***Gilpinia polytoma* (Hartig, 1834)**	7	**19 (19)**	**1.85 n.s.**			***P. abies*, *P. obovata*, and *P. smithiana* (Viitasaari (1987)**
Macrophya sanguinoleta (Gmelin, 1790)					1	*Veronica*, *Galeopsis*, *Senecio*
Pachynematus lichtwardti Konow, 1903					2	unknown
***Pachynematus* (*Epicenematus*) sp.**	**21**	**95(17)**	**0.65 n.s.**			

Sawfly species	Number of larvae		Wilcoxon pair test	Number of adults		Known hosts
	On *P. abies* at Sněžník	On *P. pungens* at all three stands (and at Sněžník in brackets)		On *P. abies* at Sněžník	On *P. pungens* at all three stands	
Pachynematus montanus **(Zaddach, 1883)**					**1**	***P. abies, and P. obovata*** **(Popov & Kajmuk 2010)**
Pachynematus styx **(Benson, 1958)**					**1**	***P. abies***
Pachyprotasis rapae (Linné, 1767)					7	oligophagous
Pamphilius hortorum (Klug, 1808)					1	*Rubus*
Pikonema insigne **(Hartig, 1840)**		**1(1)**				***P. abies*****, and *****P.obovata*** **(Popov & Kajmuk 2010)**
Pikonema scutellatum **(Hartig, 1840)**	**11**	**11(1)**	**1.94 n.s.**	**1**	**1**	***P. abies, P. obovata***
Pristiphora **sp.**	**17**	**39(12)**	**1.40 n.s.**			
Pristiphora abietina **(Christ, 1791)**	**2**	**6(4)**				***P. abies, P. obovata*** **(Popov & Kajmuk 2010) ,** ***P. obovata*** **and** ***P. sitchensis*** **(Kollar 2007, Austara et al 1984)**
Pristiphora compressa **(Hartig, 1837)**	**8**	**41 (12)**	**0.92 n.s.**		**2**	***P. abies*****, and** ***P. obovata*** **(Popov & Kajmuk 2010)**
Pristiphora decipiens **(Enslin, 1916)**	**4**	**15(6)**			**1**	***P. abies***
Pristiphora gerula **(Konow, 1904)**	**1**	**2(0)**				***P. abies***
Pristiphora leucopodia **(Hartig, 1837)**	**2**	**2(0)**				***P. abies***
Pristiphora pallida **(Konow, 1904)**					**1**	***P. abies***
Pristiphora pseudodecipiens **Beneš & *Křístek, 1976***	**6**	**6(0)**		**1**	**1**	***P. abies***
Pristiphora robusta **(Konow, 1895)**		**1(0)**				***P. abies*****, and *****P.obovata*** **(Popov & Kajmuk 2010)**
Pristiphora saxesenii **(Hartig, 1837)**		**7(0)**				***P. abies***
Pristiphora **(*****Sharliphora*****) sp.**	**2**	**9(2)**				
Pristiphora nigella **(Förster, 1854)**					**2**	***P. abies***
Pristiphora parva **(Hartig, 1837)**				**1**		***P. abies***
Tenthredo atra Linné, 1758					1	oligophagous
Tenthredo mesomela Linné, 1758					3	oligophagous
Tenthredo olivacea Klug, 1817					2	oligophagous
Tenthredopsis ornata (Serville, 1823)					3	*Brachypodium*
Tenthredopsis scutellaris (Fabricius, 1804)				1	15	*Festuca, Poa, Dactylis, Elytrigia*
Total	127	621		10	69	

Five species in the genus *Cephalcia* were only found in small numbers and on several specimens of *P. pungens*, and two of these five species were found on *P. abies* (Table 2). The abundance of larvae belonging to *Cephalcia* species did not differ between samples from *P. abies* and *P. pungens* (Table 2).

Diprionids of the genus *Gilpinia* were the most abundant sawflies in the samples and represented 51.8% and 35.4% of the specimens collected from *P. pungens* and *P. abies*, respectively. *Gilpinia abieticola* and *G. hercyniae* were the most numerous species, while *G. polytoma* was recorded exclusively in the *P. abies* and *P. pungens* stands at Sněžník. Although the *Gilpinia* abundancy did not differ between *P. abies* and *P. pungens* stands, more first and second instar larvae of *Gilpinia* were found on *P. pungens* than on *P. abies* at Sněžník (Table 2).

Almost identical species (both larvae and adults) of spruce tenthredinids (*Pristiphora*, *Pachynematus*, and *Pikonema*) were found in the *P. abies* and the *P. pungens* samples, and the abundance of larvae of each species did not differ on *P. abies* vs. *P. pungens*. Based on larvae, *Pachynematus* (*Epicenematus*) sp. followed by *Pristiphora compressa* were the most abundant species in *P. pungens* samples (Table 2).

Across all species, sawfly abundance did not statistically differ on *P. abies* vs. *P. pungens* at Sněžník ($z=0.59$, $p>0.05$).

Discussion

In the current study, a total of 18 sawfly species were collected from *P. pungens* in the Ore Mountains of the Czech Republic. This represents 56% of the species of needle-feeding spruce sawflies in Central Europe (N=32) (Beneš and Křístek 1979, Holuša 2005, Jachym et al. 2005). *P. pungens* was recorded as a new host for 17 of these Palaearctic species. The 13 additional species have not been associated with spruce as a host, and their occurrence in the samples was accidental (Table 2).

In Central Europe, eight species of Pamphiliidae are associated with *P. abies* (Holuša et al. 2007). We confirmed that *P. pungens* is a host for *C. abietis*, *C. arvensis*, *C. alpina*, *C. fulva*, and *C. erythrogaster*. In Europe, the most abundant sawfly has been *C. abietis* followed by *C. arvensis*, and mass outbreaks of *C. abietis* (Escherich 1942, Pschorn-Walcher 1982, Kula 1987, Liška et al. 1991) and local outbreaks of *C. arvensis* and *C. alpina* have been repeatedly reported (Křístek and Švestka 1986, Martinek 1991, 1992, Liška 1999, Zanocco and Battisti 1995).

The most abundant larvae collected from *P. pungens* were species of *Gilpinia*. All three spruce diprionids (*G. abieticola*, *G. hercyniae*, and *G. polytoma*) are common in spruce stands in Central Europe (Úradník and Kulfan 2002, Holuša and Roller 2004), but the three species can differ in abundance, dominance, and frequency (Martinek 1960, Úradník and Kulfan 2002, Holuša and Roller 2004). Untill this study, *G. hercyniae* has been the only European diprionid known to feed on *P. pungens* (Balch 1939).

The numbers of spruce tenthredinids in the genera *Pikonema*, *Pristiphora*, and *Pachynematus* were similar on *P. pungens* vs. *P. abies*. We suspect that the L1 and L2 larvae identified as *Pachynematus* (*Epicenematus*) sp. are *P. montanus*, although *Pachynematus* (*Epicenematus*) *pallescens* (Hartig, 1837) and the extremely rare *P. styx* may also be present in the studied stands. The former species has the ability to rapidly increase (Kolubajiv 1939, Martinek 1994, Reisenberger and Krehan 1993) and is widespread not only in *P. abies* stands (Holuša 2002) but also in *P. pungens* stands (this study). Another species that can rapidly increase, *Pikonema scutellatum*, was rarely collected in the study area, although it is common in Central Europe (summarised by Holuša and Lubojacký 2008). Because one adult of the very rare species *Pikonema insigne* was found in the *P. pungens* stand at Sněžník, we suspect that *P. pungens* is a host for this species.

The larvae of eight *Pristiphora* species plus adults of *P.* (*Sharliphora*) *pallida* and *P.* (*Sharliphora*) *parva* were collected on *P. pungens*, but it is very probable that larvae of *Pristiphora* (*Sharliphora*) sp. were represented mainly by the larvae of *Pristiphora nigella. P. abietina* is a pest of Norway spruce in Central Europe (Pschorn-Walcher 1982) and often occurs in high numbers with *Pikonema scutellatum* and *Pachynematus montanus* (Kolubajiv 1939, 1958). However, *P. abietina* prefers lower altitudes where it can rapidly increases (Martinek 1960, Holuša 2002). Thus, the low abundance of this species in the studied stands is in accordance with the aforementioned studies. *P. compressa*, the most common *Pristiphora* in *P. pungens* stands, could be even more abundant than *P. abietina* in mountain stands of *P. abies* (Úradník and Kulfan 2002). We also found *P. pallida* and *P. robusta*, that have been very seldom recorded in spruce stands (Forsius 1911, Křístek 1973).

In the investigated air-polluted areas the native *P. abies* stands are almost completely absent because this tree was not used for forest regeneration in the 1980's (Kubelka et al. 1992). Our study indicates that a range of *P. abies* defoliators use *P. pungens* as a substitute host plant. This phenomenon has also been documented for herbivorous moths. Of the 50 moth species that feed on *P. abies* in Europe, 31 have been found to develop on the needles and buds of *P. pungens* (Kulfan et al. 2010).

The spruce-feeding sawflies in Central Europe are not strictly monophagous on *P. abies*. Most of these species have been observed to feed on other Palaearctic spruces like *Picea obovata* (Ledeb.), *Picea koraiensis* Nakai, and *Picea jezoensis* (Sieb. & Zucc.) (Taeger et al. 1998). Before the current study, however, Nearctic spruces had not been reported as hosts for European Symphyta other than for *G. hercyniae* (Balch 1939).

Because the abundance of sawfly larvae and adults was low in the current study (compare with Holuša 1999, Holuša and Lubojacký 2008), we did not observe substantial defoliation of trees in the *P. pungens* stands in 2007. Severe defoliation of *P. pungens* was reported in the 1970s and early 1980s even at altitudes of 900 m (Holuša and Holuša 2003). Many sawfly outbreaks occurred throughout the Czech Republic in the early 1980s. The most recent instance of severe defoliation and subsequent chemical treatment was in 1982 (Holuša and Holuša 2003). The regeneration of *P. abies* stands has recently increased in the Ore Mountains (Šrámek et al. 2008), and thus populations of sawflies living on *P. pungens* may recolonize the *P. abies* stands in the future. Although sawflies have not recently caused extensive damage to spruce in Central Europe, the spruce sawflies are in a latency period in this region (Holuša et al. in prep.), and local outbreaks have occasionally occurred (Egginger et al. 2014).

Conclusions

Our results demonstrate that European spruce sawflies are able to use the diverse allochtonous spruce species as hosts and may show stronger preferences for the new host, here especially *P. pungens*, than for the native host, *P. abies*.

Acknowledgements

This study was supported by grants VZ MSM 6215648902 "Forest and Wood: the support of functionally integrated forest management and use of wood as a renewable raw material", and EHP-CZ02-OV-1-044-01-2014 "Frameworks and possibilities of forest adaptation measures and strategies connected with climate change". The study was also sponsored by the following companies and organizations: Netex Co. (Děčín), Nadace ČEZ Co. (Prague), Lafarge cement (Čížkovice). The authors thank Dr. Bruce Jaffee (USA) for critically reading the manuscript.

References

Austara Q, Annila E, Bejer B, Ehnstrom B (1984) Insect pests in forests of the Nordic countries 1977–1981. Fauna Norvegica, Series B: Norwegian Journal of Entomology 31: 8–15.

Balch RE (1939) The Outbreak of the European Spruce Sawfly in Canada and some important Features of its Bionomics. Journal of Economic Entomology 32: 412–418. doi: 10.1093/jee/32.3.412

Balcar V (1986) Tolerance dřevin v juvenilním stádiu k průmyslovým imisím (Tolerance of species of trees in the juvenile stage to industrial air pollution). Práce VÚLHM, Jíloviště-Strnady 69: 137–165.

Battisti A, Jiang–hua Sun (1996) A survey of spruce web-spinning sawflies of the genus Cephalcia Panzer in north-eastern China, with a guide to the identification of prepupae (Hym., Pamphiliidae). Journal of Applied Entomology 120: 275–280. doi: 10.1111/j.1439-0418.1996.tb01606.x

Battisti A, Zanocco D (1994) Biosystematics of Cephalcia arvensis Panzer Group I. Description of Cephalcia fulva n.sp. (Hymenoptera Pamphiliidae). Redia 77: 297–311.

Beneš K, Křístek J (1979) Současný stav taxonomie evropských druhů čeledí Pamphiliidae, Diprionidae a Tenthredinidae (Hymenoptera, Symphyta) žijících na smrku [Present state of taxonomic knowledge on European species of the families Pamphiliidae, Diprionidae and Tenthredinidae feeding on spruce (Hymenoptera, Symphyta)]. Acta Universitatis Agriculturae Brno C 48: 77–118.

Egginger M, Schopf A, Schafellner C (2014) Unprecedented outbreak of the spruce sawfly Pachynematus montanus (Zaddach 1883) in the northern part of the Flachgau. Mitteilungen der Deutschen Gesellschaft für allgemeine und angewandte Entomologie 19: 63–67.

Escherich K (1942) Die Forstinsekten Mitteleuropas. Bd. 5. Paul Parey, Berlin.

Forsius R (1911) Zur Kenntnis einiger Blattwespen und Blattwespenlarven. Meddelanden af Societas pro Fauna et Flora Fennica, Helsingfors 37: 77–88.

Gregor F, Baťa L (1942) Prodromus Hymenopterum patriae nostrae VI. Sborník entomologického oddělení Zemského Musea Praha 20: 257–344.

Holuša J (1999) Bionomie pilatky smrkové (Hymenoptera:Tenthredinidae) na severní Moravě a ve Slezsku v letech 1998-1999. Bionomy of little spruce saw-fly (Hymenoptera: Tenthredinidae) in north Moravia and Silesia. Zprávy lesnického výzkumu 44: 19–27.

Holuša J (2002) Species composition of spruce tenthredinids (Hymenoptera: Tenthredinidae) in the eastern part of the Czech Republic. Biologia, Bratislava 57: 213–222.

Holuša J (2005) First records of sawfly Pachynematus styx (Benson, 1958) (Hymenoptera: Tenthredinidae) in Bohemia (Czech Republic). Silva Gabreta 11: 25–26.

Holuša J, Holuša O (2003) Historický průběh přemnožení pilatky smrkové (Hymenoptera: Tenthredinidae) v České republice. The outbreak history of little spruce sawfly (Hymenoptera:Tenthredinidae) in the Czech Republic. Zprávy Lesnického Výzkumu 48: 186–194.

Holuša J, Horák J, Lukášová K (in prep.) What can a time series tell us about the potential risk posed by defoliators of Norway spruce?

Holuša J, Liška J, Modlinger R, Véle A (2007) On occurrence of web-spinning sawflies of the genus Cephalcia (Hymenoptera, Pamphiliidae) in the Czech Republic. Journal of Forest Science 53 (Special Issue): 57–62.

Holuša J, Lubojacký J (2008) Occurrence, bionomy and harmfulness of the sawfly Pachynematus (Pikonema) scuttelatus in the eastern Czech Republic. Bulletin of Insectology 61: 59–66.

Holuša J, Roller L (2000) The records of rarely collected sawflies of genus Pristiphora subg. Lygaeonematus (Hymenoptera, Tenthredinidae) in the Czech Republic. Acta Universitatis Agriculturae et Silvicultarae Brno 48: 7–11.

Holuša J, Roller L (2004) Notes to distribution and seasonal activity of spruce diprionids (Hymenoptera: Diprionidae) in the eastern part of the Czech Republic. Journal of Forest Science 50: 579–585.

Jachym M, Liška J, Holuša J (2005) First record of Cephalcia masuttii (Hymenoptera: Pamphiliidae) in Poland and the Czech Republic. Entomological Problems 35: 113–114.

Jirgle J, Kučera J, Tichý J, Materna J (1983) Poškození lesů v Jizerských horách imisemi (Injury of forests by pollution in Jizerske hory Mts.). Zprávy lesnického výzkumu 28: 16–24.

Kajmuk EL (1988) Khvoyegryzushchie pililshchiki podsemeystva Nematinae centralnoy Jakutii. In: Nasekomye lugovo-taezhnykh biocenozov Jakutii. Dalnauka, Jakutsk, 81–87.

Kollár J (2007) The harmful entomofauna of woody plants in Slovakia. Acta Entomologica Serbica 12: 67–79.

Kolubajiv S (1939) Příspěvek k bionomii pilatek smrkových Lygeonematus pini Retz. (=Nematus abietinus Christ.) a Pachynematus montanus Zadd. [A contribution to the biology of the spruce saw-flies Lygaeonematus pini Retz. and Pachynematus montanus Zadd.]. Lesnická práce 18: 317–338.

Kolubajiv S (1958) Příspěvek k bionomii, ekologii a gradologii smrkových pilatek skupiny Nematini [A contribution to the biology, ecology and gradology of the spruce saw-flies Nematini]. Sborník ČSAZV (Lesnictví.) 4: 123–150.

Konow FW (1895) Neue oder wenig bekannte Tenthrediniden und eine analytische Übersicht der Gattung Holocneme Knw. Természetrajzi Füzetek 18: 50–57.

Kontuniemi T (1960) Suomen sahapistiäistoukkien ravintokasvit. Die Futterpflanzen der Sägewespenlarven (Hymenoptera, Symphyta) Finnlands. Animalia Fennica 9: 1–104.

Křístek J (1973) Příspěvek k rozšíření smrkových pilatek a hřebenulí na Moravě [Contribution to occurence of spruce sawflies (Nematinae and Diprionidae) in Moravia]. Sborník VŠZ Brno C 42: 47–60.

Křístek J, Švestka M (1986) Gradace ploskohřbetky severské (Cephalcia arvensis Pz.) na severní Moravě [Outbreak of webspinning sawfly Cephalcia arvensis Pz. in Northern Moravia]. In: Sb. ref. z konf. „Uplatňovanie výsledkov výskumu v ochrane lesov, Zvolen, 11–12 Jún, 1986, 103–108.

Kubelka L, Karásek A, Rybář V, Badalík V, Slodičák M (1992) Obnova lesa v imisemi poškozené oblasti severovýchodního Krušnohoří (Forest regeneration in area damage by pollution in NE Krušne hory Mts.), Ministry of Agriculture of the Czech Republic, Prague.

Kula E (1987) A more exact process in the control of false spruce webworm larvae (Cephalcia abietis L.). Acta Universitatis Agriculturae Brno C 56: 127–139.

Kulfan J, Kula E, Zach P, Dvořáčková K, Patočka J, Kršiak B (2010) Caterpillar assemblages on introduced blue spruce: differences from native Norway spruce. Allgemeine Forst und Jagdzeitung 181: 188–194.

Liška J (1999) Ploskohřbetky rodu Cephalcia (Hymenoptera, Pamphiliidae) žijící na smrku [Sawflies of the genus Cephalcia (Hymenoptera, Pamphiliidae) living on Norway spruce]. Zpravodaj ochrany lesa 5: 21–23.

Liška J, Píchová V, Knížek M, Hochmut R (1991) Přehled výskytu lesních hmyzích škůdců v českých zemích [A surway of occurrence of forest insect pests in the Czech Republic]. Lesnický průvodce 3: 1–67.

Martinek V (1960) Insecta, Arachnoidea a Diplopoda smrkových kultur střední Evropy. Rozpravy ČSAV (řada MPV) 70: 1–143.

Martinek V (1988) Rozlišování eonymf a pronymf ploskohřbetek. Lesnická práce 67: 415–418.

Martinek V (1991) Přemnožení ploskohřbetky severské (Cephalcia arvensis Panz.) (Hym., Pamphiliidae) ve východních Čechách [An outbreak of the web-spinning sawfly Cephalcia arvensis Panz. (Hym., Pamphiliidae) in Eastern Bohemia]. Lesnictví 37: 543–570.

Martinek V (1992) Nový škůdce smrku, ploskohřbetka černá (Cephalcia falleni (Dalm.)) (Hym., Pamphiliidae) v Orlických horách [The sawfly Cephalcia falleni (Dalm.) as a new pest on spruce in the Orlické hory Mts.]. Lesnictví-Forestry 38: 205–220.

Martinek V (1994) Pilatka horská (Pikonema montana (Zadd.), Hymenoptera, Tenthredinidae), významný škůdce smrku v pahorkatině severovýchodních Čech [The sawfly Pikonema montana (Zadd.) (Hym., Tenthredinidae) an important pest on spruce in the hills of North-East Bohemia]. Lesnictví-Forestry 40: 139–149.

Popov AA, Kajmuk EL (2010) Pilil'shchiki semejstva Tenthredinidae (Hymenoptera, Symphyta) Jakutii. Proceedings of the Russian Entomological Society, St. Peterburg 81: 67–73.

Prous M, Blank SM, Goulet H, Heibo E, Liston A, Malm T, Nyman T, Schmidt S, Smith DR, Vardal H, Viitasaari M, Vikberg V, Taeger A (2014) The genera of Nematinae

(Hymenoptera,Tenthredinidae). Journal of Hymenoptera Research 40: 1–69. doi: 10.3897/JHR.40.7442

Pschorn-Walcher H (1982) Unterordnung Symphyta, Pflanzenwespen. In: Schwenke W (Ed.) Die Forstschädlinge Europas 4. Hautflűgler und Zweiflűgler. W. Parey, Hamburg, Berlin, 1–234.

Reisenberger H, Krehan H (1993) Praxisorientiere Bekämpfungsversuch gegen die Fichtengebirgblattwespe Pachynematus montanus. Forschutz Aktuel 18: 13–15.

Schwenke W (Ed.) (1978) Die Forstschädlinge Europas 3. Ein Handbuch in fünf Bänden. Parey, Hamburg, Berlin, 1–467.

Soukupová J, Rock BN, Albrechtová J (2001) Comparative study of two spruce species in a polluted mountainous region. New Phytologist 150: 133–145. doi: 10.1046/j.1469-8137.2001.00066.x

Šika A (1976) Růst smrku pichlavého v lesních porostech (The growing of Picea pungens in the forest stands). Zprávy lesnického výzkumu 22: 8–12.

Šrámek V, Lomský B, Slodičák M, Balcar V, KuIhavý J, Hadaš P, Pulkráb K, Šišák L (2008) The Ore Mountains: Will Successive Recovery of Forests from Lethal Disease be Successful. Mountain Research and Development 28: 16–221. doi: 10.1659/mrd.1040

Taeger A, Altenhofer E, Blank SM, Jansen E, Kraus M, Pschorn-Walcher H, Ritzau C (1998) Kommentare zur Biologie, Verbreitung und Gefährdung der Pflanzenwespen Deutschland (Hymenoptera, Symphyta). In: Taeger A, Blank SM (Eds) Pflanzenwespen Deutschland (Hymenoptera, Symphyta) Kommentierte Bestandsaunahme. Verlag Goecke und Evers, Keltern, 49–136.

Taeger A, Blank SM (2011) ECatSym – Electronic World Catalog of Symphyta (Insecta, Hymenoptera). Program version 3.10, data version 38 (cit. 07.12.2011) – Digital Entomological Information, Müncheberg. http//www.zalf.de/home_zalf/institute/dei/php_ecatsym/ecatsym.php

Tesař V (1981) Růst dřevin v obnovním cíli při silném ohrožení imisemi na Trutnovsku (Growth of tree species in forest restoration under heavy threat pollution at Trutnov region). Zprávy lesnického výzkumu 26: 16–20.

Úradník M, Kulfan J (2002) Structure of sawfly pseudocaterpillar (Hymenoptera: Symphyta) assemblages feeding on Norway spruce and their seasonal changes. Acta Zoologica Universitatis Comenianae 44: 57–62.

Viitasaari M (Ed.) (2002) Sawflies I. Tremex Press Ltd., Helsinki.

Viitasaari M, Varama M (1987) Sahapistiäiset 4. Havupistiäiset (Diprionidae). Reports, University of Helsinki, Department of Agricultural and Forest Zoology, Helsinki 10: 1–79.

Zanocco D, Battisti A (1995) Infestazioni di Cephalcia arvensis in peccete delle Prealpi Venete. III. Note su altre specie di Cephalcia della picea e guida al riconoscimento pratico. Monti e Boschi 2: 23–30.

Zhelokhovtsev AN (1988) Otryad Hymenoptera – Pereponchatokrylye, Potryad Symphyta – Sidyachebryukhie. In: Medvedev KH, Opredyeliteľ nasekomykh evropeiskoi tschasti SSSR. Tom III. Pereponchatokrylyje. Schestaja chasť. Nauka, Leningrad, 7–234.