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Occurrence, bionomy and harmfulness of the sawfly *Pachynematus* (*Pikonema*) *scutellatus* in the eastern Czech Republic

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Abstract

From 1998 to 2006 the sawfly *Pachynematus* (*Pikonema*) *scutellatus* (Hartig) was studied at 45 localities in the eastern Czech Republic. A total of 3417 adults and 248 larvae were collected using Malaise traps, yellow sticky boards, emergence traps and sweep-net. The sawfly occurs from 220 m to above 1000 m a.s.l. in the mountains. Numbers of cocoons correlated positively with forest age. A profound decrease occurred in the numbers of *P. scutellatus* in mature forests during the 8-year study period. Less than 10% of the sawflies had a prolonged 2-year diapause. More males than female sawflies were caught in the Malaise traps and by sweeping with nets. Equal numbers of males and females were caught in emergence traps and on yellow sticky boards. The flight period started about April 24 for both males and females and ended around May 27 for males and May 30 for females and was strongly affected by the weather, which sometimes stopped flight activity. The period of flight varied according to year and localities from 9 to 27 days in males and from 27 to 36 days in females. Most likely four instars occur in males and five in females. Larval development lasted about 5 weeks, ending at the beginning of June. Control measures already formulated for use against *Pristiphora abietina* (Christ) are also suitable for *P. scutellatus*, because their phenology is closely similar.

Key words: *Pikonema scutellatus*, bionomy, emergence, flight activity, prolonged diapause, sex ratio, Czech Republic.

Introduction

Spruce tenthredinids seriously damaged several thousands spruce forests during the second half of 20th century in the Czech Republic (Holuša and Holuša, 2003). Although *Pristiphora abietina* (Christ) is the most economically important species, mainly in young forests, the sawfly *Pachynematus* (*Pikonema*) *scutellatus* (Hartig) is one of the most abundant spruce tenthredinids in the country (Holuša, 1999; Holuša, 2002). Apart from this, it could be an important predisposing stressed factor even at lower densities in spruce forests originated from reforestation and suffering from drought, and the honey fungus (Holuša and Liška, 2002). Historically, this sawfly is already known to cause important economic damage (Pschorn-Walcher, 1982), which has prompted several studies on the insect (see Pschorn-Walcher, 1982). Subsequent to these early studies *P. scutellatus* has not been studied again in detail. Although the above-mentioned authors conducted precise studies some facts like a population densities and sex ratio of adults were not reported or the numbers of instars reported are high.

Because of its great abundance and economic importance, the purpose of the present studies was to determine the insect's occurrence, period of flight activity, correlation with bud break of trees, length of larval development, population densities and proportion of specimens with prolonged diapause and to implement this knowledge in integrated pest management (IPM) against *P. abietina*.

Materials and methods

Study sites

The studies were made at 45 sites in the eastern Czech Republic over an 8-year period from 1998 to 2006 (tables 1-2). Most of the plots were located in intensively managed forests (Ostravská pánev plateau, Podbeskydská pahorkatina Hills) with 9 to 20% forest cover consisting of 30 to 50% Norway spruce in the Nízký Jeseník Hills (70% forest cover) with a predominance of Norway spruce (68%) and in the Moravskoslezské Beskydy Mountains which are 90% covered with forests, 76% of which is Norway spruce (Culek, 1996). Two other study sites were in the Javorníky highlands, which are 55% covered by forests consisting of 67% Norway spruce. Eight other study sites were located elsewhere in the country (table 1). Observations in the main study area at Paskovský les Wood (table 1) were cut short as the result of intensive logging done to manage a severe outbreak of the honey fungus [*Armillaria ostoyae* (Herink.) Schaffer] (Holuša and Liška, 2002).

Traps and trapping periods

The insects were collected using Malaise traps (Townes, 1972). The traps were installed in the Norway spruce stands from March/April to October and were emptied every 2 to 4 weeks. In 1998, most of the traps were operated only from March to June and emptied every 3 days. Additionally, insects were caught by using sweep nets with 100 sweeps being made on a permanent, 25 m long sample transect along the young forest border (one sweep per each step of the operator). The diameter of sweep net was 40 cm and the length of the

Table 1. Numbers of *P. scutellatus* caught at each study site. (Y = young forest-thicket, pole timber; M = mature, high forest; number of specimens: male/female).

Locality	Longitude; Latitude	Altitude	Forest	Year of investigation	Malaise trap	Yellow Sticky boards	Sweeping	Emergence traps	Larvae
Albrechtice	18°35'; 49°47'	230	Y	1998	0		0/1		
Brná	16°20'; 50°04'	440	Y	2002		5/1			
Bystřice nad Olší	18°41'; 49°38'	390	M	2000-2003	20/19	0/2			
Čeladná	18°19'; 49°27'	830	M	2001-2002	3/0				
Čeladná	18°22'; 49°29'	900	M	2001-2002	82/8				
Čeladná	18°22'; 49°29'	920	M	2001-2002	0				
Čeladná	18°19'; 49°30'	1120	Y	2003	16/2				
Čeladná	18°19'; 49°31'	1000	Y	1999	0				2
Čeladná	18°21'; 49°29'	850	M	2001-2002	0				
Chlebovice	18°16'; 49°39'	550	Y/M	1998	67/6	1/0	0		
Dobrá	18°16'; 49°41'	340	Y	2001	0/1				
Fryčovice	18°15'; 49°40'	315	Y/M	1998	4/4				
Hodoňovice	18°20;' 49°37'	480	Y	2001		6			
Hradiště	18°19'; 49°44'	300	M	2003		1/0			
Janovice	15°15' ; 49°19'	640	Y	2002		0/1			
Karolínka	18°16'; 49°20'	540	Y	1999	2/2				
Kněžpole	17°19'; 49°51'	590	Y	2005		3/1			
Krásná	18°27'; 49°36'	750	Y	2001	1/0		3		
Krásná	18°27'; 49°32'	1170	Y	2002	35/4				
Krásná	18°31'; 49°34'	1150	Y/M	2003	20/4				
Kyjovice	18°03'; 49°49'	385	Y/M	2005-2006	46/29	22/5			
Lhotka	18°19'; 49°36'	700	Y/M	1998, 2001, 2002	14/7	3/1	8/2		
Morávka	18°36'; 49°33'	900	Y/M	2003	33/15				
Morávka	18°33'; 49°35'	590	Y	2001, 2003		2/8			4
Nýdek	18°44'; 49°39'	530	Y	2002, 2003, 2005		9/19			
Oprechtice	18°16'; 49°44'	260	Y	1998	40/3	1/0	1/0		
Ostravice	18°25'; 49°31'	1060	Y/M	2003	56/4				
Palkovice	18°17'; 49°38'	560	Y/M	2002		0/3			
Paskov	18°17'; 49°43'	275	Y/M	1998-2006	1272/386	13/3	16/4	169/193	222
Peklo	16°20'; 50°08'	420	Y	2002-2003		7/3			
Pražmo	18°29'; 49°36'	540	Y	2000-2001	1/16				
Přibyslav	15°22'; 16°09'	450	Y	2002		2/1			
Prostřední Bečva	18°15'; 49°29'	880	M	2001	3/0				
Pustá Polom	17°59'; 49°39'	463	Y/M	2001-2003, 2005-2006	14/28	18/11			15
Pustá Polom	18°00'; 49°52'	430	Y/M	2001-2003, 2005-2006	82/74	41/34			
Sedliště	18°21'; 49°44'	310	Y	1998	13/7		3/2		3
Šilheřovice	18°16'; 49°54'	220	Y	1999				1/0	
Skřipov	17°55'; 49°48'	490	Y/M	1999-2000, 2005	98/101	27/10			
Spy	16°07'; 50°20'	300	Y	2001-2002, 2003	24/9	2/7			
Stará Bělá	18°14'; 49°45'	260	Y	1998	29/0	4/0	3/1		
Stožec	13°49'; 48°47'	1230	M	2003	6/0				
Trojanovice	18°15'; 49°31'	580	Y	2000	15/22				
Velké Karlovice	18°19'; 49°20'	670	Y	2003	9/1				
Železná Ruda	13°12; 49°11′	1180	M	2003	8/0				
Total					2003/757	149/104	31/10	170/193	248

Table 2. Population density of *P. scutellatus* at the Paskov site from 1998 to 2003 (from 2004 to 2006 no specimen was found).

Year of installation/ emergence	Number of traps	Average ± SD (ex/0.25 m^2)	Percentage of cohorts from the same place beginning of the year of installation					Proportion of male (males/females)	Deviation from equality
			1998	2000	2001	2002	2003		
1998	10	9.9 ± 4.7	86.7					0.38	z = 2.37 p < 0.01
1998/1999	10	1.2 ± 0.0	10.6					0.17	z = 2.53 p < 0.01
1998/2000	10	0.3 ± 0.7	2.7					0	p < 0.01
2000	20	4.3 ± 3.4		95.4				0.57	z = 2.39 p > 0.01
1998/2001	10	0							
2000/2001	8	0.5 ± 0.8		4.6				1	z = 1.88 p > 0.01
2001	11	0.9 ± 0.8			91.0			0.70	z = 1.38 p > 0.01
1998/2002	10	0							
2000/2002	8	0							
2001/2002	10	0.1 ± 0.3			9.0				
2002	11	0.4 ± 0.7				100		0.5	p > 0.01
2001/2003	7	0							
2002/2003	5	0							
2003	9	0.3 ± 0.5					100	0.5	p > 0.01
Total			100	100	100	100	100		

handle was 50 cm. The lower branches on trees along the open, woodland borders (height of trees about 10m) were swept every 3 days from the ground upward for approximately 2.5 m in eight localities in 1998 (table 1).

In many localities yellow sticky board traps were used for several years (table 1). These were made of 14.8 x 21 cm, yellow plastic boards, coated on both sides with entomological glue (Temoocid®) suspended (from a tree branch) about 2 m above the ground. They were laid out in lines of 20 boards on every other tree on the southeastern side of trees. All the traps were in place from mid April to the mid June.

In 1998, 30 emergence traps (50 x 50 cm) were installed in a: (i) 6-year-old thicket (five traps), (ii) 12-year-old, small, pole size stand (five traps), (iii) 27-year-old, pole-size stand (10 traps) and (iv) 61-year-old spruce stand (10 traps) at Paskovský les (the main study site). In 1999, all emergence traps were set out again at these same places to determine how many individuals underwent prolonged diapause. Following years some traps were set out at the same place in the oldest forest (61 years). The traps were in operation during the full period of larval development when the present year larvae were active above ground as well as when they entered the ground to form cocoons. Ground was not cleared from cocoons before installation of the traps. The study sites and traps were often affected by logging, which resulted in fewer traps (table 2).

In 1998 and 1999, larvae were beaten from 10 young, spruce trees every 3 days. After strong storms many larvae were collected which had fallen from the tree crowns and climbed back onto the tree stems in the oldest forest (61 years) at Paskovský les. In 1999, all emergence traps were covered with sticky transparent plastic to catch falling larvae. Mature larvae, which fell from the trees, were again collected and the widths of their head capsules were measured.

During 2005-2006, correlation between swarming of *P. scutellatus* and bud breake of spruces was studied in five localities (Kyjovice, two at Pustá Polom, two at Skřipov) in very young spruce forests (ca. 10-year-old) in the Nizký Jeseník highlands. Five yellow sticky boards and one Malaise trap were used in each locality. They were exposed from the beginning of April to the end of June and were emptied every 2 or 3 days. Parallel to this, twenty spruces were observed and photographed of them were taken to establish the percentage of trees undergoing bud break.

The numbers of emerged adults, which had emerged in the emergence traps and correlations were tested with ANOVA and equality of sex ratio was tested by comparing two proportions using the Statistica 7.0 program ($\alpha = 0.05$).

Results and discussion

Distribution

Three thousand, four hundred and seventeen specimens were collected using all the sampling methods. *P. scutellatus* is a very common species found in all localities. Malaise traps were the most effective method (table 1). The results showed that *P. scutellatus* occurs over a wide range of altitudes, from 220 m to 1000 m a.s.l. in the mountains. These observations confirmed the results of Křístek (1973; 1980). The number of sawflies varied from several to more than 100 specimens depending on installation position of the Malaise traps, locality and year. The position of the trap strongly influenced the number of sawflies caught as few sawflies were caught in traps placed in young forests. The sawfly prefers middle age forests, but it can live in older 60 to 80 year-old forests or even thickets (Kolubajiv, 1952). Malaise traps are more effective for catching sawflies that migrate than are yellow sticky boards hung from trees. Frequently no sawflies were caught in Malaise traps placed in mature forests (table 1), probably because after emergence females and some males fly directly to the upper forest canopy (Křístek, 1657).

Population density and prolonged diapause

In 1998, 121 specimens were caught in all the emergence traps compared to only 15 specimens caught in these same traps at the same position in 1999. In both years most of the insects were trapped in the oldest forest (61 years). In 1998, numbers increased significantly ($F = 9.25$; $p < 0.01$) and were positively correlated with the age of the forests ($r = 0.9723^{**}$) with fewer adults being caught in the youngest forest (6 year-old forest; 0.2 ± 0.44 specimens/0.25 m^2). The corresponding values for 12 and 27 year-old forests were 1.2 ± 1.13 and 1.8 ± 1.79, respectively and in the oldest (61 years) 9.9 ± 4.7 specimens/0.25 m^2. In subsequent years there was a considerable decrease in adult numbers in mature forests and none were caught in the emergence traps from 2002 to 2006 (table 2). The decrease in numbers of adults at Paskovský les is obvious even in male material from Malaise traps although the position of the traps was changed from 1998 to 2002 as a result of growth of trees (figure 1).

In 2001, no adults were caught in the emergence traps, which had been set out in the same positions as in 1998. Only a few individuals emerged in 1999 and even fewer in 2000 (table 2). A 1-year prolonged, diapause occurred in 4.6% of the specimens in 2001 and 9.0% in 2002. No specimens with prolonged diapause were collected in 2002 and 2003 (later no specimen was sampled), probably because of the low populations of sawflies in those years. The percentage of specimens with prolonged diapause is not high, although the percentage of specimens emerging in the current year could have been overestimated, because the ground was not cleaned from cocoons before experiments. Specimens with diapause prolonged for more than one year could therefore have been sampled during the first year of study.

Maximum of specimens with prolonged diapause could be represented by 13.3% (10.6 + 2.7% emerged in 1999 and 2000, entered in 1997 or early), which correspondents with the results of 13% in northern Germany (Thalenhorst, 1954). These numbers are lower than those reported by others, i.e. 27% reported from the Styria (Nigitz, 1974) and up to 72% in Saxony (Gäbler, 1952).

Sex ratio

At Paskovský les, the secondary sex ratio was female biased in 1998 (portion of males was 0.38) but in 2000 it was equal (0.57) and in 2001 male biased (0.70) (table 2). Craig and Mopper (1993) found female-biased sex ratios to be most common. They (Craig and Mopper, 1993) gave the sex ratios for 43 sawfly species, of which a male biased sex ratio was reported for only four species. Theoretically a higher proportion of males may influence sawfly extinction probability (Craig and Mopper, 1993). The numbers of emerging adults decreased considerably from 1998 to 2001 for both males ($F = 12.10$; $p < 0.01$) and females ($F = 19.11$; $p < 0.01$), plus the number of males caught using the Malaise traps also decreased during the study period (figure 1).

Although males dominated in the Malaise traps ($z = 26.04$; $p < 0.01$) and swept material ($z = 3.44$; $p < 0.01$), the sex ratio was equal for total number of specimens caught in the emergence traps at total ($z = 1.20$; $p > 0.01$) and yellow sticky boards ($z = 1.75$; $p > 0.01$). Perhaps this resulted from the fact that females run mostly along twigs and are glued more often on boards. The sex ratio of *P. scutellatus* has been studied by a few authors and is based mainly on investigations of cocoons. In Saxony the proportion of females was 68% (Gäbler, 1952), in the Czech Republic 67 to 76% and 52 to 54% in northern Germany (based on fallen larvae) (Thalenhorst, 1966). The female-biased sex ratio can probably be interpreted as the result of the outbreak levels of *P. scutellatus* in those areas.

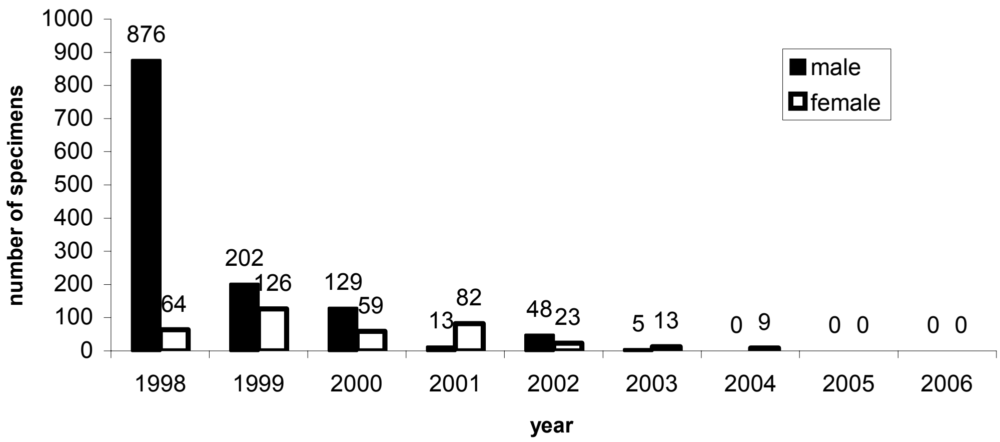

Figure 1. Numbers of sawflies caught in Malaise traps near Paskovský les.

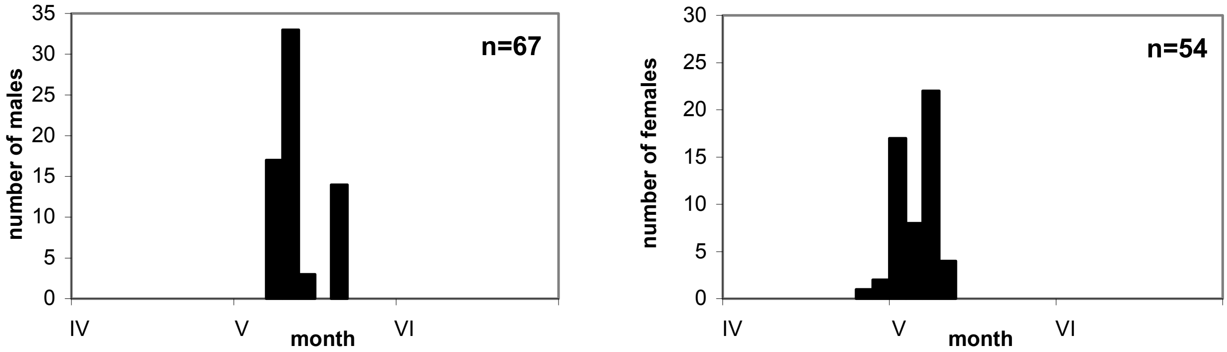

Figure 2. Emergence of *P. scutellatus* near Paskovský les in 1998.

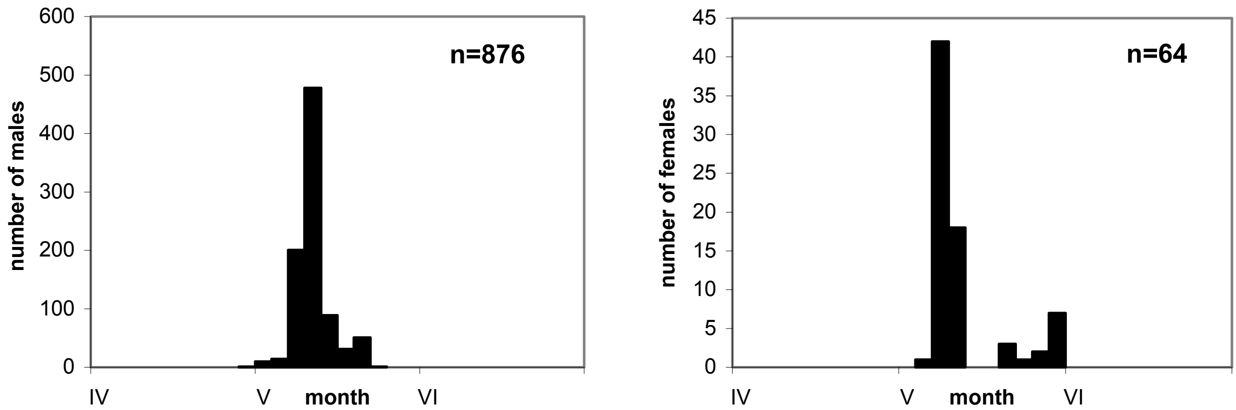

Figure 3. Flight activity of *P. scutellatus* near Paskovský les in 1998.

Emergence from the soil and flight activity

In 1998, adults first emerged from the soil at the end of April and this continued until mid- May (figure 2). Males started to fly during the peak of emergence from the soil (figure 3). For females the time and duration of emergence was less concise as flight ceased during cool weather (figure 3). There is a weak proterandry; males leave their cocoons about 3 days sooner, as Křistek (1657) recorded.

The flight period lasted from April 24 to May 27 for male sawflies and from April 24 to May 30 for females from 1998 to 2006. The flight period varied both according to year and sampling locality, i.e., from 9 to 27 days for males and from 27 to 36 days for females and was strongly influenced by rainy, cold weather that sometimes caused flight activity to cease (figure 3). These results agree with those reported (Gäbler, 1952; Kolubajiv, 1958; Kolubajiv and Kalandra, 1952; Křístek, 1657; 1980; Nägeli, 1936). During the present study the weather was ideal for emergence and flight activity with April and May mean day temperatures about double average and the total monthly precipitation was slightly below normal (Zahradník, 1999; 2000; 2001).

Because of the fact that flight activity coincides with the spruce bud break of spruce (Pschorn-Walcher, 1982) good correlation between swarming of sawflies and bud break of the majority of trees could be one reason why the outbreaks of sawflies are permanent and common in lower altitudes in northern Moravia, Silesia and eastern Bohemia (Holuša and Holuša, 2003). Statistically significant correlation between percentage of total sawflies sampled and percentage of flushing spruces was found in 2005 (yellow sticky boards r = 0.9492**, Malaise trap r = 8583**, all r = 0.8218**) as well in 2006 (yellow sticky boards r = 0.9386**). Curves are not identical but peaks are very similar to those for bud break of trees (figure 4) although these coincided less closely in 2006 (figure 5).

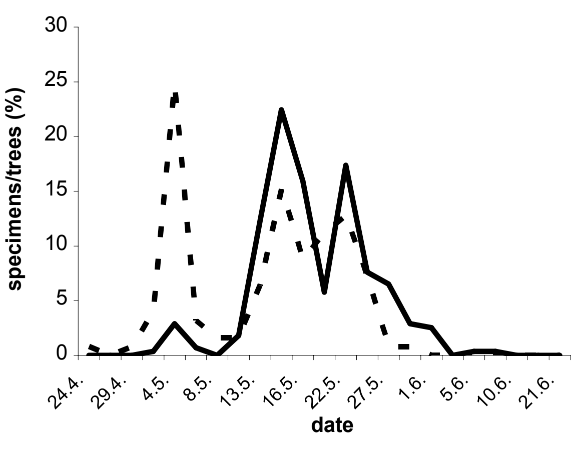

Figure 4. Percentage of sampled sawflies *P. scutellatus* (full line) and percentage of bud break (dotted line) spruces in 2005.

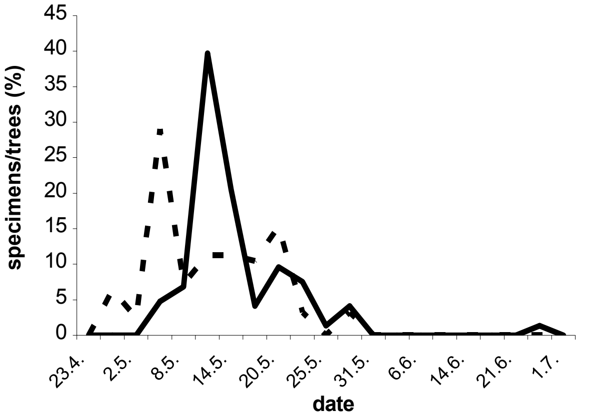

Figure 5. Percentage of sampled sawflies *P. scutellatus* (full line) and percentage of bud break (dotted line) spruces in 2006.

On the other hand, the bud break of trees occupies a longer period in mountains (Holuša personal observation). Damaged forests at higher altitudes are a result of long-term outbreak. Even in the Czech Republic, spruce tenthredinids have broken out in altitudes above 700 m in Moravskoslezské Beskydy Mts and Krušné hory Mts (Holuša and Holuša, 2003).

Larval development

Most larvae (198 specimens) were collected in the older forest at Paskovský les during descent of mature larvae to the ground. In younger spruce forests the number of larvae was very low with only a few larvae being collected by beating the foliage (table 1). The frequency curve for head capsule width of larvae has several peaks (figure 6). Most likely the youngest larvae were probably not collected because young spruce tenthredinid larvae can be firmly attached to the needles (Holuša, 1999). The width of head capsules for the first instar larvae mentioned by Křístek (1958) (0.450-0.540 mm) is smaller than all recent data. The peaks placed on left side probably represent the second (head capsule width 0.75-0.90 mm) and third instar larvae (0.95-1.35 mm). The two close peaks are probably for the fourth instar male and female larvae (1.35-1.75 mm). The high numbers of third and the fourth instar larvae resulted from larvae being washed off by rain from May 21 to June 10 with peaks on May 23 and June 2 1998 (n = 137) and cessation of larval feeding from May 27 to June 11 1999 (n = 45). The tail of the curve probably represents the fifth instar (1.75-2.05 mm), female larvae, because sawfly males have usually one instar less than females (Craig and Mopper, 1993). These findings do not agree with those of Křístek (1958) who recorded five instars for males and six to seven instars for females (head case width of 2nd 0.720-0.900 mm; 3rd 0.945-1.260 mm; 4th 1.305-1.620 mm; 5th 1.530-1.890 mm; 6th 1.710-2.070 mm, 7th 1.845-2.070 mm). He suggested that the increased number of instars was the result of lower temperatures during development, but his results are based on a very small number of reared larvae (38), a possible reason for the difference in the presented data. In contrast, Thalenhorst (1973) reported six instars at temperatures below 30 °C. Pschorn-Walcher (1982) reported five or six instars in Denmark. Based on the present study it seems that four instars occur for males and five for females in the study area, as occurs for *P. abietina* (Holuša, 1999), however, more instars might occur.

Larval development was completed by the beginning of June and in 1998 the last larvae were found on June 11 (maximum of dropped larvae was found on June 5). Provided that the adults fly in the first 10 days of May and the embryonic development takes 5 days (Křístek, 1657), larval development lasted about 5 weeks. No larvae had eggs of parasitoids on the body.

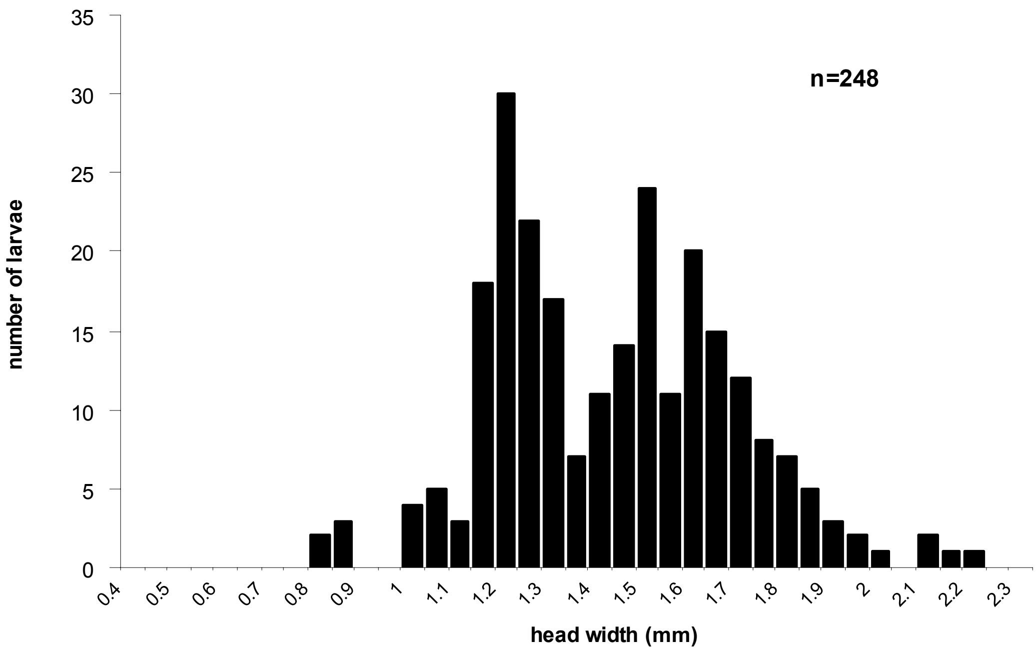

Figure 6. Head capsule widths of *P. scutellatus* larvae.

Notes on harmfulness and IPM against *P. scutellatus*

P. scutellatus is an abundant and common species in the eastern Czech Republic but its economic importance is rather limited. No total defoliation and death of trees were observed in any of the studied localities. Although *P. scutellatus* prefers older forests, *P. abietina* was more important in these. The density of emerged adults of *P. abietina* (6.0 ± 8.5 specimens/0.25 m2) (Holuša, 1999) was the similar to the 9.9 ± 4.7 specimens/0.25 m^2 (see above) of *P. scutellatus* in older forest in Paskovský les in 1998 [no statistically significant difference ($p > 0.01$)]. The abundance of dropped larvae was higher in *P. abietina* (72 larvae per 2.5 m^2) than in *P. scutellatus* (45 larvae).

Recently, population densities of both species have decreased in the studied area (tables 1-2) and damage caused by spruce tenthredinids has decreased rapidly not only in the eastern Czech Republic but in the whole country (Liška and Holuša, 2006). Therefore continued detailed study of the impact of *P. scutellatus* on forest stands could not be undertaken.

Recommendations for the integrated pest management (IPM) of *P. abietina* have been worked out by Holuša and Drápela (2003). Heavy feeding on spruce is followed by increased of height increment of trees (Pschorn-Walcher, 1982). Using a very simple method for evaluation of damage, the abundance of sawfly larvae can be estimated. This method, which can be used in forest practise, is based on the assessment of the percentage of defoliation of each whorl beginning from the top of about 100 trees using four classes of defoliation (Holuša and Holuša, 2002). The critical value influencing the height of current increment of trees by *P. abietina* in younger forest was established (Holuša and Drápela, 2003). Yellow sticky boards are used to establish the economic threshold of adults. Neither, assessment of defoliation in older forests (evaluation is difficult here without cutting) nor use of yellow sticky boards (in older forests only emergence traps can be used) is useful in *P. scutellatus*. Because of close proximity of damaged older spruce forests and high proportion of *P. abietina*, older forest was taken as the areas of measurements in 1998.

Bionomics of *P. scutellatus* are very similar to *P. abietina*. Therefore it is possible to follow IPM for both species. The small number of *P. scutellatus* individuals with more than one – year diapause does not complicate the control measures; a repetition of spraying in the following year is not necessary. Timing of control is the same because of identical development of both species.

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References

CRAIG T. P., MOPPER S., 1993.- Sex ratio variation in sawflies, pp. 61-92. In: *Sawfly life history adaptations to woody plants* (WAGNER M. R., RAFFA K. F., Eds).- Academic Press Inc., San Diego, USA.

CULEK M., 1996.- *Biogeografické členění České republiky* [Biogeographical structure of the Czech Republic].- Enigma, Praha, Czech Republic.

GÄBLER H., 1952.- Die beiden wichtigsten kleinen Fichtenblattwespen (*Lygaeonematus pini* und *Pachynematus scutellatus*).- *Archiv für Forstwesen*, 1: 88-94.

HOLUŠA J., 1999.- Bionomie pilatky smrkové (Hymenoptera: Tenthredinidae) na severní Moravě a ve Slezsku v letech 1998-1999 [Bionomics of *Pristiphora abietina* (Hymenoptera: Tenthredinidae) in northern Moravia and Silesia in 1998-1999].- *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., DRÁPELA K., 2003.- Integrated management of little spruce sawfly (*Pristiphora abietina*): designed pattern, pp. 16-24. In: *Proceedings: ecology, survey, and management of forest insects* (MCMANUS M. L., LIEBHOLD A. M., Eds), Krakow, Poland, September 1-5, 2002. U.S. Department of Agriculture, Forest Service, Northeastern Research Station.

HOLUŠA J., HOLUŠA O., 2002.- Monitoring of sawfly (Hymenoptera: Tenthredinidae) infestation on spruce.- *Journal of Forest Science*, 48: 219-224.

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., LIŠKA J., 2002.- Hypotéza hynutí smrkových porostů ve Slezsku (Česká republika) [Hypothesis of spruce forest decline in Silesia (the Czech Republic)].- *Zprávy lesnického výzkumu*, 47: 9-15.

KOLUBAJIV S., 1952.- *Naše nejškodlivější smrkové pilatky a boj proti nim* [Our most harmful sawflies and protection against them].- Brázda, Praha, Czech Republic.

KOLUBAJIV S., 1958.- Příspěvek k bionomii, ekologii a gradologii smrkových pilatek skupiny Nematini [Contribution to bionomics, ecology and gradology of spruce tenthredinids of the Nematini group].- *Sborník Československé Akademie zemědělských věd* (*Lesnictví*), 4: 123-150.

KOLUBAJIV S., KALANDRA A., 1952.- Další kalamitní rozvoj pilatek (*Pachynematus scutellatus* Htg. a *P. montanus* Zadd.) na smrku v Československu v roce 1950 a boj leteckým a pozemním poprašováním proti nim [Further increasing of outbreak of sawflies (*Pachynematus scutellatus* Htg. a *P. montanus* Zadd.) on spruce in the Czechoslovakia in 1950 and aerial and terrestrial protection against them].- *Práce výzkumného ústavu lesnického*, 1: 88-124.

KŘÍSTEK J., 1957.- Poznámky k bionomii a ke kontrole pilatky proužkované (*Pachynematus scutellatus* (Htg.)) [Notes to bionomics and monitoring of *Pachynematus scutellatus* (Htg.)].- *Sborník Vysoké školy zemědělské lesnické fakulty* (*Brno*) *C*, 26: 273-291.

KŘÍSTEK J., 1958.- Poznámky k bionomii a ke kontrole pilatky proužkované (*Pachynematus scutellatus* (Htg.)) [Notes to bionomics and monitoring of *Pachynematus scutellatus* (Htg.)] II. part.- *Sborník Vysoké školy zemědělské lesnické fakulty* (*Brno*) *C*, 27: 57-74.

KŘÍSTEK J., 1973.- Příspěvek k rozšíření smrkových pilatek a hřebenulí na Moravě [Contribution to distribution of spruce tenthredinids and dipriodinids in Moravia].- *Sborník Vysoké školy zemědělské* (*Brno*) *C*, 42: 47-60.

KŘÍSTEK J., 1980.- Populační dynamika hmyzích lesních škůdců jako základ integrované ochrany lesů proti nim [Population dynamics of forest pests as a basis of integrated pest management]. *Ms Dissertation*, Vysoká škola zemědělská, Brno, Czech Republic.

LIŠKA J., HOLUŠA J., 2006.- Listožravý a savý hmyz [Leaf eating insects], pp. 32-37. In: *Výskyt lesních škodlivých činitelů v roce 2005 a jejich očekávaný stav v roce 2006* [Occurrence of forest damaging agents in 2005 and forecast for 2006] (KAPITOLA P., Ed.).- *Zpravodaj ochrany lesa* [Reports of Forest Protection], Supplementum 2006: 1-76.

NÄGELI W., 1936.- Die kleine Fichtenblattwespe (*Lygaeonematus pini* Retz. = *Nematus abietinus* Christ).- *Mitteilungen der Schweizerischen Anstalt fur das forstliche Versuchswesen*, 9: 213-381.

NIGITZ H. P., 1974.- Über die fichten - Nematinen (Hym., Tenthredinidae) der Steiermark.- *Zetschrift fur Angewandte Entomologie*, 75: 264-284.

PSCHORN-WALCHER H., 1982.- Unterordnung Symphyta, Pflanzenwespen, pp. 4-234. In: *Die Forstschädlinge Europas. 4 Hautflügler und Zweiflügler* (SCHWENKE W., Ed.).- Parey, Hamburg, Germany.

THALENHORST W., 1954.- Zur Kenntnis der Fichtenblattwespen II. Die Apparenzen der Nematini.- *Zeitschrift für Pflanzenkrankheiten, Pflanzenpathologie und Pflanzenschutz*, 61: 196-202.

THALENHORST W., 1966.- Zur Kenntnis der Fichtenblattwespen VII. Das geschlechterverhaltnis.- *Zeitschrift für Pflanzenkrankheiten, Pflanzenpathologie und Pflanzenschutz*, 73: 57-69.

THALENHORST W., 1973.- Zur Kenntnis der Fichtenblattwespen IX. Die temperature-Entwiclunks-Function von ei und larve.- *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz*, 80:134-147

TOWNES H., 1972.- A light-weight Malaise trap.- *Entomological News*, 83: 239-247.

ZAHRADNÍK P., 1999.- Povětrnostní podmínky [Weather conditions], pp. 4-9. In: Výskyt lesních škodlivých činitelů v roce 1998 a jejich očekávaný stav v roce 1999 [Occurrence of forest damaging agents in 1998 and forecast for 1999].- *Zpravodaj ochrany lesa* [Reports of Forest Protection], Supplementum 1999: 1-65.

ZAHRADNÍK P., 2000.- Povětrnostní podmínky [Weather conditions], pp. 4-10. In: Výskyt lesních škodlivých činitelů v roce 1999 a jejich očekávaný stav v roce 2000 [Occurrence of forest damaging agents in 1999 and forecast for 2000] (KNÍŽEK M., KAPITOLA P., Eds).- *Zpravodaj ochrany lesa* [Reports of Forest Protection], Supplementum 2000: 1-62.

ZAHRADNÍK P., 2001.- Povětrnostní podmínky [Weather conditions], pp. 4-11. In: Výskyt lesních škodlivých činitelů v roce 2000 a jejich očekávaný stav v roce 2001 [Occurrence of forest damaging agents in 2000 and forecast for 2001] (KNÍŽEK M., KAPITOLA P., Eds).- *Zpravodaj ochrany lesa* [Reports of Forest Protection], Supplementum 2001: 1-76.

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