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On the occurrence of web-spinning sawflies of the genus *Cephalcia* (Hymenoptera, Pamphiliidae) in the Czech Republic

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ABSTRACT: In total, 55,862 specimens of seven species of the genus *Cephalcia* (*C. abietis, C. arvensis*, *C. alashanica*, *C. alpina, C. annulicornis, C. erythrogaster*, *C. masuttii*) were collected using Malaise traps in spruce mountain forests from 2001 to 2006. Sex ratio was male biased as a result of used methods; males are more active and quicker. The flight activity started in the studied localities at the beginning of May or the beginning of June depending on the actual weather. *C. alpina* flew first, followed by *C. erythrogaster* and *C. arvensis*, the last flying species were *C. alashanica* and *C. abietis*. *C. abietis* was the most abundant in all localities within all years (total dominance of 93%). *C. arvensis*, *C. alashanica* and *C. alpina* were collected in more than hundred of specimens while *C. annulicornis*, *C. erythrogaster* and *C. masuttii* were collected only occasionally. Environmental variables were tested with the RDA model which proved several of them (years of 2001–2003, 2006, Český les and Slavkovský les) as significant. This is probably a result of following facts: (*i*) web-spinning sawflies occur throughout the whole range of spruce in Central Europe (therefore only two mountain regions were significant, but no species is positively correlated with them); (*ii*) *C. abietis* expanded in the Krkonoše Mts. in 2003 and 2006; (*iii*) *C. alashanica, C. alpina, C. annulicornis, C. erythrogaster* were more abundant in 2002; (*iv*) abundances of all species were very low in 2000. The factor of management was not significant, although samples from cultural forests prevailed and *C. abietis* was the most abundant in the cultural forests. *Cephalcia* species occur in a wide range of altitudes without any clear preference therefore this variable was not significant neither.

Keywords: *Cephalcia*; faunistics; Norway spruce; mountains; Czech Republic

The web-spinning sawfly *Cephalcia abietis* is one of the most serious forest pests therefore its bionomy, ecology and outbreak reasons of this species were studied in Germany, Poland and in the Czech Republic as well (Pschorn-Walcher 1982). On the other hand, only a little attention was paid to other species of the genus *Cephalcia* Panzer, 1805, especially those living on spruce.

Ten *Cephalcia* species were recorded in the Czech Republic, although occurrences of only seven species were recently confirmed (Gregor, Baťa 1940; Beneš 1976; Šedivý 1989). The higher number of species is a consequence of intensive studies using modern taxonomical methods which resulted in distinguishing of other species that escaped a previous detection. The study of different types of so far known web-spinning sawflies resulted in series of nomenclature changes concerning also species occurring in our territory (cf. Blank et al. 1998). Moreover, new *Cephalcia* species were recently recognized as a result of studies using modern taxonomical methods (cf. Battisti, Zanocco 1994; Battisti, Boato 1998; Battisti et al. 1998).

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Because of the lack of a recent survey of *Cephalcia* species in the Czech Republic, the goals of this study were (*i*) to monitor web-spinning sawflies living on spruce in mountainous regions and (*ii*) to compare species composition and abundances of these species in cultural and near-natural spruce forests.

MATERIAL AND METHODS

The web-spinning sawflies were studied by Malaise traps of Townes type (Townes 1972). Traps were placed in closed older spruce (*Picea abies* [L.] Karst.) forests, 80–110-years-old, at the distance of 50 m from the forest edge. The habitat belongs to the association *Athyrio alpestris-Piceetum, Calmagrostio villosae-Piceetum* and localities lay in mountainous regions of the Czech Republic; (*i*) *Euhercynicum* (the Šumava Mts., Slavkovský les, Český les, Brdy Upland and Žďárské vrchy Upland), (*ii*) Sudeten (the Krkonoše Mts. and the Krušné hory Mts.) and (*iii*) Carpathians (the Moravskoslezské Beskydy Mts.). Only one trap was placed on each locality because there was no difference in numbers of sampled sawflies among five traps placed in line (Holuša et al. 2007). In three areas (localities Trojmezná Mt., Medvědín Mt. and Klínovec Mt.), pairs of "near-natural forest" and "cultural forest" (according to Vrška, Hort 2004) were found and traps were operated in both forest types in parallel (Table 1).

The traps were installed from the end of April to the end of October and emptied in two-week or one month intervals during the period 2001–2006. The sawflies were determined according to the key of Viitasaari (2002) and the voucher specimens are preserved in Forestry and Game Management Research Institute Jíloviště-Strnady.

Data were processed by multivariate analysis (redundancy analysis) using software pack CANOCO for Windows 4.5© (Ter Braak, Šmilauer 1998). Furthermore, the Monte-Carlo permutation test (499 permutations) was used for a significance assessment of environmental variables.

RESULTS AND DISCUSSION

Faunistics

In total, 55,862 specimens of seven species of the genus *Cephalcia* (*C. abietis* – 52,127 ex, *C. arvensis* – 2,933 ex, *C. alashanica* – 476 ex, *C. alpina* + *C. annulicornis* – 227 + 21 ex; *C. erythrogaster* – 77 ex; *C. masuttii* – 1 ex) were collected from 2001 to 2006 (Table 1). Sex ratios were male biased (95% of males) as a result of used methods since males are more active flyers. In *Cephalcia* species, ratios of emerged males and females are known to be equal (Pschorn-Walcher 1982).

C. abietis was the most abundant species followed by *C. arvensis*, *C. alashanica* and *C. alpina* (Table 1). All these species are common and abundant in Central Europe (cf. Beneš 1976; Pschorn-Walcher 1982). *C. abietis* is a very serious pest in forestry. Several serious outbreaks are known in Central Europe from the end of 19th century and the beginning of the 20th century (Escherich 1942; Pschorn-Walcher 1982). In the Czech Republic, many severe outbreaks occurred with the heaviest one in the 1980s (cf. Liška et al. 1991). Local outbreaks of *C. arvensis* and *C. alpina* were reported by several authors (cf. Křístek, Švestka 1986; Martinek 1988, 1991; Liška 1998, 1999). *C. alashanica* was a common species in the Moravskoslezské Beskydy Mts.; elsewhere it was rare. Two specimens caught in the Šumava Mts. represent the first record from this area.

The record of *C. masuttii* is the most interesting from the faunistic point of view. It is the first record in the Czech Republic (already published in Jachym et al. 2005) and its description, as web-spinning sawfly, was also based on materials from the Bavarian Forest Mts. (Battisti, Boato 1998). Our locality is placed 10 km apart from the locality of Bodenmais in Bavaria, listed in the species description study 3 prepupae (Battisti, Boato 1998). Only a single above mentioned specimen was found in the Czech Republic even by using the very effective methods of collecting sawflies with Malaise traps and a collar tree trap (see also Jachym et al. 2005).

Apart from *C. annulicornis* and *C. masuttii*, *C. erythrogaster* was the rarest species but it occurred in all studied mountains nevertheless. All spruce *Cephalcia* species probably occur in the whole range of spruce in Central Europe, but some of them in very low densities.

Notes to taxonomical problems

Recently, *C. annulicornis* was repeatedly validated as a separate species distinguished from *C. alpina* (cf. Battisti et al. 1998; as *C. falleni* and *C. annulicornis*). Using identification features given by Battisti et al. (1998), *C. annulicornis* could be recognized in 10% of the *C. alpina* material, but the determination using diagnostic external characters is very problematic. There is a continuous transi-

Table 1. Survey of studied web-spinning sawflies of the genus *Cephalcia* in the Czech Republic

Mountains	Šumava Mts.						Krkonoše Mts.						Brdy Upland		Krušné hory Mts.		Český les		Slavkovský les		Žďárské vrchy Upland	Beskydy Mts.									Total	Dominance (%)
Species/ locality	Trojmezná Mt. (commercial forest)			Jezerní hora Mt. (near-natural forest)			Medvědín Mt. (near-natural forest)			Medvědín Mt. (commercial forest)			Velký Tok		Hill Praha	Klínovec Mt. (near-natural forest)	Klínovec Mt. (commercial forest)	Dyleň (Horní)	Dyleň (Dolní)	Kladská (Kynžvart)	Kladská (Kynžvart)	Kladská (Ztracená)	Šindelní vrch Mt.	Smrk Mt. (Podolánky)		Smrk Mt. (Daličany)		Smrk Mt. (Daličany)		Radhošť Mt.	Blato Mt. (Bařiny)		
Year	2003	2004	2006	2003	2005	2006	2003	2004	2006	2003	2004	2006	2005	2006	2001	2004	2004	2002	2002	2001	2002	2002	2006	2001	2002	2001	2002	2001	2002	2001	2001		
Longitude; latitude	48°46'N, 13°49'E			49°10'N, 13°11'E			50°44'N, 15°35'E			50°45'N, 15°35'E			49°42'N, 13°52'E		49°41'N, 13°51'E	50°23'39"N, 12°58'30"E	50°23'32"N, 12°58'42"E	12°31'E, 49°58'N	12°31'E, 49°57'N	12°39'E, 50°06'N		12° 40'E, 50°06'N	49°39'N, 15°56'E	18°22'E, 49°29'N		18°21'E, 49°29'N		18°22'E, 49°29'N		18°14'E; 49°28'N	18°19'E, 49°28'N		
Altitude (m a.s.l.)	1,230			1,180			1,150			1,100			840		820	1,150		820	790	800		820	770	820		940		920		850	830		
C. abietis (Linnaeus, 1758)	1	0	27	107	12	82	17	0	146	969	9	3,126	0	275	8	1	3	5,541	3,574	10	1,749	474	10,058	24	6,440	50	4,399	6	15,016	2	2	52,127	93.311
C. annulicornis (Hartig, 1837)	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	14	0	0	0	0	21	0.015
C. alashanica Gussakovskij, 1935	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	12	0	0	8	1	6	0	195	0	51	0	201	0	0	476	0.852
C. alpina (Klug, 1808)	13	89	0	11	4	7	2	0	1	2	1	3	6	15	0	2	1	1	2	0	1	1	7	0	21	0	22	0	28	0	0	227	0.406
C. arvensis Panzer, 1805	31	49	36	111	35	46	19	2	291	42	6	286	28	354	5	26	52	42	20	0	1	13	152	11	239	57	220	13	775	1	1	2,933	5.250
C. erythrogaster (Hartig, 1837)	0	2	0	2	3	6	1	0	0	0	2	0	1	19	0	0	0	0	1	0	1	1	4	0	12	0	12	0	10	0	0	77	0.138
C. masuttii Battisti & Boato, 1998	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.002
C. sp.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.015
Total	45	140	64	233	55	142	39	2	438	1,013	18	3,415	37	663	13	29	56	5,596	3,597	10	1,760	490	10,227	35	6,912	107	4,718	19	16,030	3	3	55,864	100

Table 2. Summary of variability explained by the main axes in the RDA model

	Axes			
	1	2	2	4
Eigenvalues	0.39	0.14	0.08	0.04
Species-environment correlations	0.91	0.69	0.8	0.8
Cumulative percentage variance of species data	38.8	52.4	60.3	64.5
Cumulative percentage variance of species-environment relation	59	79.6	91.5	97.9

tion in diagnostic features between both species in our material.

C. arvensis is morphologically as well as bionomically a very variable species. The pale specimens significantly varied in size in the collected material. There were also found big dark specimens mainly with dark dorsal side of abdomen. Similar specimens were described as f. *irrorata* Dahl., which is very similar to *C. intermedia* Helén known from Northern Europe. It is supposed that this species does not occur in Central Europe, but two of our specimens resemble this species (listed as *C.* sp. in Table 1).

Phenology

This study confirmed previously known periods of the *Cephalcia* species flight activities (cf. Martinek 1988). The flight activity started in the studied localities at the end of May or at the beginning of June depending on the actual weather. *C. alpina* flew first, followed by *C. erythrogaster* and *C. arvensis*, the last flying species were *C. alashanica* and *C. bietis*. All species flew until the beginning or the end of July with exception of *C. arvensis* which was sampled even in August.

Not recorded species of *Cephalcia*

Three species of the genus *Cephalcia* known from the territory of the Czech Republic were not found (*C. fulva*, *C. hartigi* and *C. lariciphila*). The host plant of *C. fulva* is also spruce (cf. Viitasaari 2002), but this species is known only from eastern part of the country (cf. Battisti, Zanocco 1994). *C. hartigi* is associated with *Abies* (cf. Viitasaari 2002) and it was reported by Beneš (1976) from several localities only. *C. lariciphila* feeds on *Larix* (cf. Viitasaari 2002) and it is common in the Czech Republic (Beneš 1976). A recent outbreak of *C. lariciphila* was reported from Větrný Jeníkov (Vejpustková, Holuša 2006). This species was not found in surroundings of the studied localities since larch lacks.

Model

The importance of all explanatory variables, their significance and correlations with axes are presented in Fig. 1 and Table 3. The first canonical axis explains 38.8% of variability, both canonical axes explain 53% of variability (Table 2). All axes explain 100% of variability. The whole model was statistically significant ($F = 2.2$, $P < 0.05$) though only several environmental variables (years of 2001–2003, 2006, Český les and Slavkovský les) were significant (Table 3).

This is probably a result of several facts: (*i*) web-spinning sawflies occur throughout the whole range of spruce (therefore only two mountain regions were significant, but no species is positively correlated with them); (*ii*) *C. abietis* expanded in the Krkonoše Mts. in 2003 and 2006 (Liška 2006) what explains the positive correlation with *C. abie-*

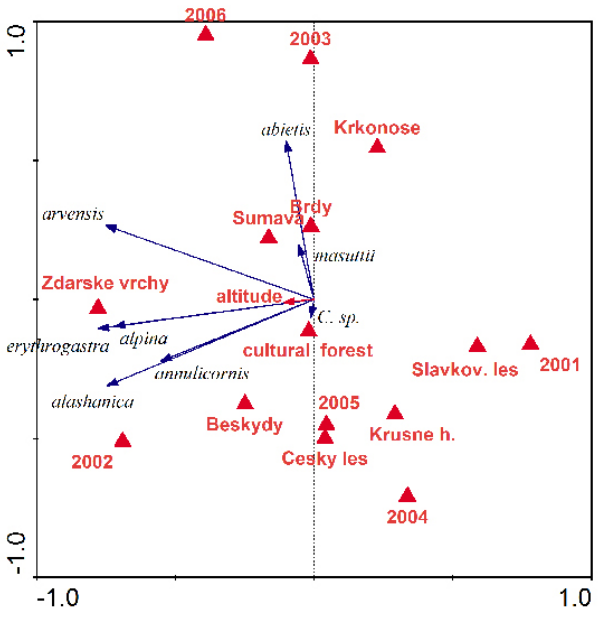

Fig. 1. Ordination diagram (RDA) showing an influence of years, localities, altitudes and forest management on *Cephalcia* species occurrence. Canonical axes explain 65.8% of variability

Table 3. Results of the redundancy analysis of explanatory variables, their significance and correlations with the axes

Explanatory variable	AX1	AX2	AX3	AX4	*P*	*F*	I. F.
2002	–0.4737	–0.2585	–0.4476	–0.0278	0.004	5.14	11.5050
2006	–0.2433	0.4357	0.1247	0.1315	0.008	4.41	0
Slavkovský les	0.2446	–0.0520	–0.4420	–0.3962	0.010	4.34	1.3435
Český les	0.0132	–0.1227	–0.0417	0.2208	0.012	4.27	1.4660
2003	–0.0063	0.3115	0.1018	–0.2295	0.028	3.39	2.3663
2001	0.535	–0.0819	–0.2736	0.0148	0.076	2.15	9.3966
Krkonoše Mts.	0.1417	0.2498	0.0327	0.1368	0.182	1.65	11.8677
Beskydy Mts.	–0.1868	–0.2079	–0.3323	0.1258	0.258	1.36	0
Krušné hory Mts.	0.0972	–0.1014	0.2218	0.3344	0.402	0.91	6.0395
Altitude	–0.0992	–0.0073	–0.4905	0.1513	0.574	0.66	3.8616
2004	0.1875	–0.2911	0.3956	0.0943	0.640	0.59	3.3560
Žďárské vrchy Upland	–0.1806	–0.0055	0.0345	0.0608	0.618	0.56	2.8519
2005	0.0149	–0.1107	0.2957	–0.0173	0.728	0.49	1.7149
Šumava Mts.	–0.1020	0.1011	0.3764	–0.2544	0.700	0.48	11.0601
Cultural forest	–0.0456	–0.1987	–0.1588	0.0657	0.810	0.35	1.6895
Brdy Upland	–0.0049	0.0803	0.2167	–0.1305	0.970	0.07	3.2033

tis; (*iii*) *C. alashanica, C. alpina, C. annulicornis, C. erythrogaster* were more abundant in 2002 (Table 1); (*iv*) abundances of all species were very low in 2000 (Table 1).

Although samples from cultural forests prevailed and *C. abietis* was the most abundant species in the cultural forests at first appearance (Table 1), the variable of management was not significant. The collected material is probably insufficient to decide this aspect definitely. *Cephalcia* species occur in a wide range of altitudes without any clear preference therefore the altitude was not significant in our analysis neither.

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K výskytu ploskohřbetek rodu *Cephalcia* (Hymenoptera, Pamphiliidae) v České republice

ABSTRAKT: V letech 2001–2006 bylo pomocí Malaiseho lapačů odchyceno v horských smrčinách České republiky celkem 55 862 jedinců rodu *Cephalcia* (*C. abietis*, *C. arvensis*, *C. alashanica*, *C. alpina*, *C. annulicornis*, *C. erythrogaster*, *C. masuttii*). V materiálu výrazně převažovali samci, což je způsobeno tím, že samci jsou aktivnější a rychlejší letci. Letová aktivita začínala na studovaných lokalitách na konci května nebo na počátku června v závislosti na počasí. *C. alpina* létala první, následována *C. erythrogaster* a *C. arvensis*, poslední poletovala *C. alashanica* a *C. abietis*. *C. abietis* byla nejpočetnější ve všech letech a na všech lokalitách (93 %). Celkem bylo odchyceno několik stovek jedinců *C. arvensis*, *C. alashanica* a *C. alpina*, zatímco druhy *C. annulicornis*, *C. erythrogaster* a *C. masuttii* byly sbírány jen výjimečně. V modelu RDA byly statisticky signifikantní jen některé environmentální proměnné (roky 2001–2003, 2006, pohoří Český les a Slavkovský les). To je pravděpodobně důsledkem několika faktorů: (*i*) pilatky se vyskytují v celém areálu smrku, proto byly statisticky signifikantní pouze dva regiony; (*ii*) *C. abietis* gradovala v roce 2003 a 2006 v Krkonoších; (*iii*) *C. alashanica*, *C. alpina*, *C. annulicornis* a *C. erythrogaster* byly početnější v roce 2002; (*iv*) početnost všech druhů byla v roce 2000 nízká. Faktor managementu nebyl signifikantní, i když početnost kusů ve vzorcích z hospodářských lesů převládala a *C. abietis* v nich byla početnější. Ploskohřbetky se vyskytují ve vyšších polohách bez zjevné závislosti na nadmořské výšce.

Klíčová slova: *Cephalcia;* faunistika; smrk; hory; Česká republika

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