Hymenoptera (Aculeata) of spruce stands in the air-pollution region of Northern Bohemia

E. KULA[1], P. TYRNER[2]

[1]*Mendel University of Agriculture and Forestry, Faculty of Forestry and Wood Technology, Brno, Czech Republic*
[2]*Litvínov Grammar School, Litvínov, Czech Republic*

ABSTRACT: Using Moericke's yellow dishes we studied the Hymenoptera (Aculeata) fauna (with the exception of Formicoidea) in spruce (*Picea abies*) stands of the colder region of Northern Bohemia. We collected 103 species and the most important species in this spectrum were *Vespula vulgaris* (56.4%), *Vespula rufa* (4.7%), *Dolichovespula norvegica* (3.1%), *Dolichovespula saxonica* (4%), *Nysson spinosus* (1.8%), *Andrena lappona* (1.9%), *Cleptes semiauratus* (5.9%), *Halictus* sp. (6.7%) and *Trypoxylon minus* (2.2%). Comparisons made in 1990–1994 and 1995–1999 indicated a recession of species of the genus *Halictus,* of *Andrena nitida* (Apidae), *Pemphredon lugubris, Trypoxylon clavicerum* and *T. minus* (Sphecidae), and an increased abundance of *Cleptes semiauratus* (Cleptidae), *Nysson spinosus* (Sphecidae), *Vespula vulgaris* and *V. rufa* (Vespidae). Compared to closed stands, open spruce stands had a greater species diversity and lower number of captured specimens.

Keywords: Hymenoptera; Aculeata; *Picea abies;* yellow dishes; Northern Bohemia

Closed spruce monocultures are faunistically very poor ecosystems. Due to reduced light conditions there is no herb layer to provide an adequate feed supply for the imagoes of hymenopterous insects. The abundance of sucking insects (aphids, scale insects) producing honeydew (HOLOPAINEN et al. 1991), which is a sought-after feed source of some hymenopterans, is much higher in spruce stands of air-pollution regions. Spruce stands exposed to air-pollution are prone to premature shedding of needles, which leads to the opening of stands and to weed infestation. Information about the fauna of spruce stands in air-pollution regions of Northern Bohemia where the arachno-entomofauna of birch (*Betula pendula* Roth) stands that are substitute forest communities after the decline of spruce stands, was investigated for a long time can help to deduce changes that occurred after the large-area decline of spruce stands in the Ore Mts. and the Děčín Sandstone Uplands. The species spectrum of syrphid flies collected in Moericke's yellow traps was different in birch and spruce stands (127 and 117 species, respectively); the dominant species in both forest types were *Melangyna quadrimaculata* (VERR.) and *Episyrphus balteatus* DEG.; *Eristalis tenax* L. was dominant in birch stands and *Meliscaeva cinctela* (ZETT.) in spruce stands (KULA 1997; KULA, SCHOLZ 1995; KULA, LÁSKA 1997).

The hymenopterans of Bohemia consist of 838 species (PÁDR 1989) that are very important not only as pollinators but also particularly as components of the spectrum of natural enemies of forest pests and regulators of the equilibrium in forest ecosystems. Spider wasps (Pompilidae), digger wasps (Sphecidae), eumenid wasps (Eumenidae) and wasps (Vespidae) are predators, chrysidids (Chrysididae), Cleptidae, Bethylidae are parasitoids that frequently escape attention although they are important. KULA and TYRNER (2000) discovered 159 species in birch stands.

A majority of the authors focused their research activities on warmer localities of Bohemia that have a richer and more interesting fauna (BALTHASAR 1954, 1972; KOCOUREK 1966), in contrast to localities where the climate is colder and more humid (TYRNER 1988, 1995).

The objective of the present study is to report on the Aculeata fauna in spruce stands and to explain their importance.

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MATERIAL AND METHODS

The hymenopterous (Hymenoptera, Aculeata) fauna was collected in Norway spruce [*Picea abies* (L.) KARST.] stands of the Děčín Sandstone Uplands, Sněžník forest district, using the method of Moericke's yellow dishes (diameter 23 cm, depth 8 cm). The yellow dishes were placed inside the stand in two parallel rows, 50 m apart, alternatively one trap situated low (0.3 m) and one high (1.3 m) above the ground. The medium was 1% formaldehyde, which prevented algae to appear and which reduced the attractiveness of trapped invertebrates for birds, and a wetting agent. The low-placed and high-placed dishes were controlled separately in 7-day intervals from 15 April to 15 October 1990–1999.

P. Tyrner carried out determinations of the collected material; J. Straka determined some species of the family Pompilidae, and for this we render our sincere thanks. The material was preserved in 70% ethanol and is stored in the depositaries of the Faculty of Forestry and Wood Technology at Mendel University of Agriculture and Forestry in Brno, the prepared specimens (300 ex) are stored in P. Tyrner's collection (Litvínov).

A greater part of Sněžník forest district (14°04´E, 50°46´N), a part of the Děčín Sandstone Uplands that is adjacent to the eastern part of the Krušné hory Mts. (Ore Mts., Northern Bohemia), is situated on an upland plateau at an altitude of 450–700 m, mountainous climate, annual temperatures 6–7°C, annual sum of precipitation 700 to 800 mm, vegetation period 110–120 days (with average daily temperatures over 15°C). The area was affected by air-pollution for a long time. One of the main pollutants was SO_2 (annual concentrations exceeded 60 μg/m^3 in 1969–1987) (TŮMA 1988). In 1990–1999 the level of SO_2 continuously decreased until 1998 when it dropped to 10–20 μg/m^3 on 60% of the area of the Ore Mts. (HADAŠ 2000).

Out investigations were carried out in three spruce stands (60–100 years) (Letadlo B, Krmelec, Malý dub). The spruce stands are in different classes of air pollution hazard (B), long-term SO_2 load above 60 μg/m^3, good ecological conditions, spruce longevity 20–40 years; class of air pollution hazard (C), load lower than 60 μg/m^3 per year, spruce longevity 40–60 years; pollution-based damage, tree density, related light conditions and degree of weed infestation.

Malý Dub locality – SW slope (7°), altitude 400–450 m, terrain with boulders (10–20%), zone of air-pollution damage C. Closed spruce monoculture since 1910, herb undergrowth consisting of *Avenella flexuosa* (L.) PIRL. and *Pteridium aquilinum* (L.) KUHN, coverage 20%.

Letadlo B locality – southern slope (7°), altitude 450–500 m, terrain with boulders (15–25%), zone of air-pollution damage B. Mixed open stand of spruce (80%), pine (10%) and larch (10%) planted in 1895. Herb cover of 75%, a dominant species is *A. flexuosa,* and also *Calamagrostis villosa* (CHAIX) GMEL. and *Vaccinium myrtillus* L.

Krmelec locality – southern slope (4°), altitude 460–470 m, terrain with boulders (10%), zone of air-pollution damage B. Open spruce monoculture established in 1930, severely damaged by air-pollution. Herb cover consisting of *A. flexuosa, C. villosa* and *V. myrtillus* L., 60% coverage.

RESULTS

The fauna of spruce stands

The fauna in spruce stands is considerably poorer (103 species) than in birch stands (159 species). *Vespula vulgaris* (56.4%) is a eudominant species and *Cleptes semiauratus* (5.9%) and bees of the genus *Halictus* (6.6%) are dominant species.

The species *Trypoxylon minus* (2.2%), *Vespula rufa* (4.7%), *Dolichovespula norvegica* (3.1%) and *Dolichovespula saxonica* (3.9%) ranked among the sub-dominant species. Four species were receding species (Tables 1 and 2).

In Malý dub locality, characterised as a closed spruce stand, we captured only 44 species (2,984 ex), while in the open stands damaged by air pollution in Letadlo B and Krmelec localities the fauna was more abundant (75 and 79 species, respectively) and the overall number of captured specimens was lower (2,347 and 2,360, respectively).

The fauna diversity in the investigated spruce stands did not change markedly in the periods 1990–1994 and 1995–1999: Malý dub (27 × 32), Letadlo B (58 × 59) and Krmelec (54 × 60). The similarity of the fauna determined by Jaccard's index indicated that the fauna of the closed spruce stand was the least stable (Malý dub – 0.508) while the open stands of Letadlo and Krmelec localities were more stable (0.701 and 0.614, respectively).

The bees *Andrena lapponica, A. nitida,* the genus *Halictus, Cleptes semiauratus* and digger wasps (Sphecidae) in general definitely preferred open and light stands to closed stands with no herb undergrowth where particularly the wasp *Vespula vulgaris* appeared. *Dolichovespula norvegica* did not exhibit a higher dependence on the light conditions of investigated stands (Table 2).

The abundance of *Vespula vulgaris* culminated in 1993 (74%), 1995 (70.6%) and 1998 (77.6%) and only in 1997 it was classified as a dominant (5.3%) and in 1999 as a subdominant species (4.8%).

In 1990–1995 *Cleptes semiauratus* occurred sporadically (0.2–0.3%). It culminated in 1996 (18.6%), 1997 (48%), and in 1999 it was still classified as a eudominant species (11.2%).

Halictus sp. were highly dominant in 1992 (24.4%). *Dolichovespula norvegica* was very important in 1994 (6.9%) and from 1995 (1.7%) its dominance gradually increased until 1999 (5.9%). *Dolichovespula saxonica* culminated in 1994 (10.8%) and its high abundance was repeated in 1996 (7.1%). In the 10-year series the species *Nysson spinosus* gradually increased; after reaching a dominant status in 1997 (5%), it was classified as a eudominant species in 1999 (11.2%). At the beginning

Table 1. Survey of the abundance of Hymenoptera (Apocrita) captured by the method of yellow traps in spruce stands (Sněžník)

Locality	Letadlo B				Malý dub				Krmelec				Total	
	1990–1994		1995–1999		1990–1994		1995–1999		1990–1994		1995–1999		1990–1999	
Species	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Ancistrocerus nigricornis (CURTIS, 1826)	8	0.72			3	0.23			7	0.70			18	0.23
Ancistrocerus trifasciatus (MÜLLER, 1776)			1	0.08									1	0.01
Andrena bicolor FABRICIUS, 1775	8	0.72	6	0.48					4	0.40	1	0.07	19	0.25
Andrena carantonica PÉREZ, 1902									1	0.10			1	0.01
Andrena flavipes PANZER, 1799	1	0.09			1	0.08							2	0.03
Andrena fucata SMITH, 1847	8	0.72	9	0.73	10	0.75	5	0.30	15	1.51	12	0.88	59	0.77
Andrena fulvago (CHRIST, 1791)											1	0.07	1	0.01
Andrena fulvida SCHENCK, 1853							1	0.06					1	0.01
Andrena haemorrhoa (FABRICIUS, 1781)	12	1.08	2	0.16									14	0.18
Andrena helvola (LINNAEUS, 1758)											1	0.07	1	0.01
Andrena humilis IMHOFF, 1832									2	0.20			2	0.03
Andrena lapponica ZETTERSTEDT, 1838	44	3.97	40	3.23	7	0.53			29	2.92	28	2.05	148	1.92
Andrena minutula (KIRBY, 1802)	1	0.09	4	0.32					2	0.20	6	0.44	13	0.17
Andrena minutuloides PERKINS, 1914							3	0.18	1	0.10	1	0.07	5	0.07
Andrena nigroaenea (KIRBY, 1802)			1	0.08			1	0.06	1	0.10			3	0.04
Andrena nitida (MÜLLER, 1776)	17	1.54	10	0.81	8	0.60	1	0.06	19	1.91	11	0.80	66	0.86
Andrena nycthemera IMHOFF, 1868							1	0.06					1	0.01
Andrena ovatula (KIRBY, 1802)	2	0.18							1	0.10			3	0.04
Andrena subopaca NYLANDER, 1848			2	0.16	1	0.08			9	0.91	1	0.07	13	0.17
Anoplius infuscatus (VAN DER LINDEN, 1827)					1	0.08							1	0.01
Anoplius nigerrimus (SCOPOLI, 1763)	2	0.18	1	0.08									3	0.04
Anoplius tenuicornis (TOURNIER, 1889)	1	0.09			2	0.15			3	0.30			6	0.08
Anthophora furcata (PANZER, 1798)											1	0.07	1	0.01
Apis mellifera LINNAEUS, 1758			1	0.08							1	0.07	2	0.03
Arachnospila sp.									1	0.10			1	0.01
Arachnospila spissa (SCHIOEDTE, 1837)											1	0.07	1	0.01
Argogorytes mystaceus (LINNAEUS, 1761)			2	0.16							1	0.07	3	0.04
Cleptes semiauratus (LINNAEUS, 1761)	2	0.18	139	11.21			100	6.05			214	15.65	455	5.92
Crossocerus annulipes (LEPELETIER & BRULLÉ, 1834)								1	0.10				1	0.01
Crossocerus assimilis (F. SMITH, 1856)	1	0.09	1	0.08							1	0.07	3	0.04
Crossocerus barbipes (DAHLBOM, 1854)	11	0.99	4	0.32					2	0.20	2	0.15	19	0.25
Crossocerus binotatus (LEPELETIER & BRULLÉ, 1834)	2	0.18	1	0.08			1	0.06					4	0.05
Crossocerus capitosus (SHUCKARD, 1837)											7	0.51	7	0.09
Crossocerus cetratus (SHUCKARD, 1837)	1	0.09	1	0.08			1	0.06	1	0.10	1	0.07	5	0.07
Crossocerus congener (DAHLBOM, 1845)											1	0.07	1	0.01
Crossocerus dimidiatus (FABRICIUS, 1781)	3	0.27	2	0.16	1	0.08	2	0.12	7	0.70	2	0.15	17	0.22
Crossocerus heydeni KOHL, 1880											1	0.07	1	0.01
Crossocerus leucostomus (LINNAEUS, 1758)	4	0.36	5	0.40			2	0.12	4	0.40	8	0.59	23	0.30
Crossocerus megacephalus (ROSSI, 1790)	3	0.27	2	0.16					4	0.40	6	0.44	15	0.20
Crossocerus pusillus LEPELETIER & BRULLÉ, 1834	13	1.17	2	0.16					4	0.40	3	0.22	22	0.29
Crossocerus styrius (KOHL, 1892)							1	0.06			1	0.07	2	0.03
Dipogon subintermedius (MAGRETTI, 1866)	9	0.81	9	0.73	8	0.60	5	0.30	7	0.70	12	0.88	50	0.65
Dolichovespula adulterina (BUYSSON, 1905)	1	0.09	3	0.24	3	0.23	1	0.06	3	0.30			11	0.14
Dolichovespula media (RETZIUS, 1783)	2	0.18	6	0.48	1	0.08	2	0.12	2	0.20	3	0.22	16	0.21
Dolichovespula norvegica (FABRICIUS, 1793)	24	2.17	23	1.85	41	3.08	95	5.75	26	2.62	27	1.98	236	3.07
Dolichovespula saxonica (FABRICIUS, 1793)	63	5.69	63	5.08	53	3.98	55	3.33	39	3.93	31	2.27	304	3.95
Dolichovespula sylvestris (SCOPOLI, 1763)	1	0.09	2	0.16	3	0.23			1	0.10			7	0.09

Table 1 to be continued

Locality	Letadlo B				Malý dub				Krmelec				Total	
	1990–1994		1995–1999		1990–1994		1995–1999		1990–1994		1995–1999		1990–1999	
Species	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Ectemnius borealis (ZETTERSTEDT, 1838)			1	0.08							1	0.07	2	0.03
Ectemnius cavifrons (THOMSON, 1870)					2	0.15			9	0.90	3	0.22	14	0.18
Ectemnius cephalotes (OLIVIER, 1791) n. 1811?							1	0.06					1	0.01
Ectemnius continuus (FABRICIUS, 1804)									1	0.10			1	0.01
Ectemnius ruficornis (ZETTERSTEDT, 1838)	10	0.90	8	0.65	2	0.15	1	0.06	13	1.31	4	0.29	38	0.49
Halictus rubicundus (CHRIST, 1791)	3	0.27	1	0.08							4	0.29	8	0.10
Halictus sp.	138	12.47	78	6.29	12	0.90	23	1.39	187	18.83	74	5.41	512	6.66
Hylaeus communis NYLANDER, 1852			1	0.08					2	0.20			3	0.04
Hylaeus confusus NYLANDER, 1852	3	0.27	2	0.16	1	0.08			2	0.20	1	0.07	9	0.12
Hylaeus sp.			1	0.08									1	0.01
Chelostoma florisomne (LINNAEUS, 1758)	1	0.09							1	0.10	1	0.07	3	0.04
Chelostoma rapunculi (LEPELETIER, 1841)							1	0.06					1	0.01
Chrysis ignita LINNAEUS, 1761			1	0.08							2	0.15	3	0.04
Lindenius albilabris (FABRICIUS, 1793)							1	0.06					1	0.01
Megachile ligniseca (KIRBY, 1802)											1	0.07	1	0.01
Mellinus arvensis (LINNAEUS, 1758)							1	0.06			1	0.07	2	0.03
Mimumesa dahlbomi (WESMAEL, 1852)	2	0.18	11	0.89					2	0.20	10	0.73	25	0.33
Nomada flavoguttata (KIRBY, 1802)			1	0.08					1	0.10			2	0.03
Nomada fucata PANZER, 1798	2	0.18											2	0.03
Nomada goodeniana (KIRBY, 1802)			2	0.16					1	0.10			3	0.04
Nomada leucophtalma (KIRBY, 1802)									1	0.10			1	0.01
Nomada panzeri LEPELETIER, 1841			1	0.08									1	0.01
Nysson spinosus (FOERSTER, 1771)	11	0.99	28	2.26			2	0.12	7	0.70	92	6.73	140	1.82
Omalus aeneus (FABRICIUS, 1787)			12	0.97			5	0.30			18	1.32	35	0.46
Osmia leaiana KIRBY, 1802											1	0.07	1	0.01
Osmia rufa (LINNAEUS, 1758)	1	0.09											1	0.01
Passaloecus borealis DAHLBOM, 1845	1	0.09							1	0.10	1	0.07	3	0.04
Passaloecus brevilabris WOLF, 1958	4	0.36	2	0.16	1	0.08		0.00	1	0.10			8	0.10
Passaloecus corniger SHUCKARD, 1837	1	0.09	3	0.24	1	0.08			2	0.20	1	0.07	8	0.10
Passaloecus eremita KOHL, 1893	1	0.09	1	0.08							2	0.15	4	0.05
Passaloecus gracilis (CURTIS, 1834)			1	0.08							1	0.07	2	0.03
Passaloecus insignis (VAN DER LINDEN, 1829)	22	1.99	17	1.37	6	0.45	12	0.73	22	2.22	26	1.90	105	1.37
Passaloecus monilicornis DAHLBOM, 1844	11	0.99	7	0.56					5	0.50	3	0.22	26	0.34
Passaloecus singularis DAHLBOM, 1844	3	0.27		0.00					3	0.30	2	0.15	8	0.10
Pemphredon inornata SAY, 1824	2	0.18							17	1.71			19	0.25
Pemphredon lugens DAHLBOM, 1842	2	0.18											2	0.03
Pemphredon lugubris (FABRICIUS, 1793)	30	2.71	9	0.73	12	0.90	1	0.06	15	1.51	1	0.07	68	0.88
Pemphredon montana DAHLBOM, 1845	1	0.09	2	0.16					3	0.30			6	0.08
Pemphredon morio VAN DER LINDEN, 1829	1	0.09	1	0.08					1	0.10	1	0.07	4	0.05
Pemphredon rugifer DAHLBOM, 1843	1	0.09	3	0.24							2	0.15	6	0.08
Priocnemis exaltata (FABRICIUS, 1776)			9	0.73			2	0.12			8	0.59	19	0.25
Psenulus pallipes (PANZER, 1797)	1	0.09	1	0.08									2	0.03
Pseudomalus violaceus (SCOPOLI, 1763)											1	0.07	1	0.01
Rhopalum clavipes (LINNAEUS, 1758)			1	0.08	1	0.08			1	0.10	2	0.15	5	0.07
Rhopalum coarctatum (SCOPOLI, 1763)	1	0.09											1	0.01
Sphecodes crassus THOMSON, 1870									1	0.10			1	0.01
Sphecodes miniatus HAGENS, 1882	1	0.09											1	0.01

Table 1 to be continued

Locality	Letadlo B				Malý dub				Krmelec				Total	
	1990–1994		1995–1999		1990–1994		1995–1999		1990–1994		1995–1999		1990–1999	
Species	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Symmorphus gracilis (BRULLÉ, 1832)	1	0.09											1	0.01
Tachysphex unicolor (PANZER, 1809)											1	0.07	1	0.01
Trichrysis cyanea (LINNAEUS, 1761)	1	0.09	3	0.24									4	0.05
Trypoxylon clavicerum LEPELETIER & SERVILLE, 1825	41	3.70	9	0.73	23	1.73	4	0.24	23	2.32	9	0.66	109	1.42
Trypoxylon figulus (LINNAEUS, 1758)	1	0.09											1	0.01
Trypoxylon minus DE BEAUMONT, 1945	56	5.06	20	1.61			1	0.06	62	6.24	30	2.19	169	2.20
Vespula austriaca (PANZER, 1799)	1	0.09	2	0.16	1	0.08	1	0.06					5	0.07
Vespula germanica (FABRICIUS, 1793)			2	0.16					1	0.10			3	0.04
Vespula rufa (LINNAEUS, 1758)	25	2.26	93	7.50	66	4.95	72	4.36	31	3.12	73	5.34	360	4.68
Vespula vulgaris (LINNAEUS, 1758)	483	43.63	564	45.48	1,061	79.65	1,247	75.48	381	38.37	604	44.18	4,340	56.43
Total	1,107	100	1,240	100	1,332	100	1,652	100	993	100	1,367	100	7,691	100

of the investigated period the species *Passaloecus insignis* virtually reached a dominant status (3.8–5.1%), but after its recession in 1992–1995, it was classified as eudominant in 1999 (10.1%).

Trypoxylon clavicerum culminated in 1991 and then continuously receded from these ecosystems. *Trypoxylon minus,* which had a dominant status in 1990 (18.9%), can be evaluated in the same way. *Vespula rufa* culminated in 1994–1995 (7–8.1%), in 1996–1999 the level of dominance was balanced (4.7–4.3%).

Anoplius tenuicornis, Passaloecus brevilabris, Pemphredon inornata were among the species that receded during the 10-year period due to the changing conditions of the site, and the species *Cleptes semiauratus* and *Omalus aeneus* entered the spruce ecosystems.

Similarity of the fauna of birch and spruce stands in the localities

The six localities that were investigated using the method of Moericke's traps differed considerably in the number of trapped specimens; more specimens were captured in birch (Letadlo A – 145, Tisá – 90, Vlčák – 68) (KULA, TYRNER 2000) than in spruce stands (Krmelec – 79, Letadlo B – 75, Malý dub – 44).

It was evident from Jaccard's index that the species spectra of the localities Tisá (birch) and Malý dub (spruce) were very much alike (66.7). Both stands can be classified as shaded, closed, with poorer light conditions and reduced supply of feed for the imagoes of predatory and parasitic Aculeata species.

A high level of similarity (53.2) was characteristic of the birch (Vlčák) and spruce (Letadlo B) stands. The spruce stand is partly open and there are gaps in the birch stand.

The similarity of most localities ranged between 39 and 47. The level of similarity was lowest (i.e. 31.4) between Vlčák (birch) and Malý dub (spruce) localities, and between Letadlo A (birch) and Malý Dub (spruce), i.e. 21.8. A generally poor species spectrum is characteristic of Malý Dub locality while the highest species diversity was discovered in Letadlo A locality. The fauna diversity of the

Table 2. Dominance of the most important Apocrita species in spruce stands in 1990–1999 (Sněžník, Moericke's yellow dishes)

Species	Letadlo B	Malý dub	Krmelec	Total
Andrena lapponica	3.58	0.23	2.41	1.92
Andrena nitida	1.15	0.30	1.27	0.86
Halictus sp.	9.20	1.17	11.06	6.66
Cleptes semiauratus	6.0	3.35	9.07	5.92
Nysson spinosus	1.66	0.06	4.19	1.82
Passaloecus insignis	1.66	0.60	2.03	1.37
Pemphredon lugubris	1.66	0.43	0.68	0.88
Trypoxylon clavicerum	2.13	0.90	1.35	1.42
Trypoxylon minus	3.24	0.03	3.90	2.20
Dolichovespula norvegica	2.0	4.56	2.24	3.07
Dolichovespula saxonica	5.37	3.62	2.97	3.95
Vespula vulgaris	44.61	77.34	41.74	56.43
Vespula rufa	5.03	4.62	4.41	4.68

Table 3. The level of similarity between the birch and spruce localities (Jaccard's index of similarity) (T – Tisá, V – Vlčák, A – Letadlo A, D – Malý dub, B – Letadlo B, K – Krmelec)

	T	V	A	D	B	K
T	×					
V	39.8	×				
A	46.9	42.0	×			
D	66.7	31,4	21.8	×		
B	44.3	53,2	40.8	39.1	×	
K	45.2	45.0	40.5	40.2	39.1	×

localities Vlčák and Malý dub did not differ markedly, but the species spectrum was differentiated (Table 3).

In the spruce stand of **Malý dub** the spectrum of Aculeata specimens was the poorest (44); 33 species (1,853 ex) flew into the traps placed low above the ground and only 25 species (1,131 ex) into traps placed higher.

Vespula vulgaris made up 77.3% of the Aculeata spectrum and proves the strong fixation of this species to spruce stands, as a rule for the honeydew-producing aphids. *Cleptes semiauratus* (3.35%) is a sub-dominant species that culminated in 1996–1997. The culmination deviations of the wasps *Dolichovespula norvegica* (4.56%), *D. saxonica* (3.62%) and *Vespula rufa* (4.62%) were less marked (Table 2).

Wasps affected the overall increased abundance of Aculeata (1993, 1995, 1998). *Cleptes semiauratus* (1.2%) did not appear until 1996–1999. *Trypoxylon clavicerum* disappeared from the stand after 1994. *Pemphredon lugubris* and *Andrena lapponica* appeared only at the outset of the studied period.

Letadlo B spruce stand – the abundance is 75 species of Apocrita; 65 species were captured in traps placed near the ground (1,249 ex) and 49 species (1,098 ex) in traps placed higher.

A major part of the specimens was the eudominant species *Vespula vulgaris* (44.61%), accompanied by members of the genus *Halictus* (9.2%), *Cleptes semiauratus* (6.0%), *Trypoxylon minus* (3.2%) and *Andrena lapponica* (3.75%), wasps *Dolichovespula norvegica* (2.0%), *D. saxonica* (5.37%), *Vespula rufa* (5.02%) and digger wasps *Nysson spinosus* (1.66%) and *Trypoxylon clavicerum* (2.1%) (Table 2).

An overall increasing tendency in the numbers of trapped specimens until 1993 was characteristic of the studied period. The following culmination period (1997, 1998) reached the level of 1993. The culmination of *V. vulgaris* was very marked (1993, 1995, 1997). The abundance of wasps *Dolichovespula norvegica* and *D. saxonica*, and the bee *Andrena lapponica* was balanced in spite of an increase in 1994 while the abundance of *Trypoxylon minus* was higher in 1990–1994. The abundance of *Cleptes semiauratus* was not very high until 1996 while the abundance of the species *Trypoxylon minus, T. clavicerum* and *Crossocerus barbipes* was higher in the first half of the studied period.

Krmelec locality – the spruce stand with the same spectrum of Aculeata fauna (79 species) as Letadlo B locality; 62 species were captured in the low traps (145 ex) and 53 species (907 ex) in the higher traps.

The Aculeata fauna consisted of two eudominant species – *Vespula vulgaris* (41.73%) and *Halictus* sp. (11.1%), dominant *Cleptes semiauratus* (9.7%) and seven sub-dominant species *Trypoxylon minus* (3.9%) and *Nysson spinosus* (4.2%), *Dolichovespula norvegica* (2.2%), *D. saxonica* (3.0%), *Vespula rufa* (4.4%) and *Andrena lapponica* (2.4%).

V. vulgaris culminated twice, i.e. in 1993 and 1998. In 1997 there was a mass incidence of *Cleptes semiauratus,* which was trapped only in the second half of the studied period. *Nysson spinosus* and *Priocnemis exaltata* appeared in parallel while *Pemphredon inornata* and *P. lugubris* appeared in the first half of the 1990s.

DISCUSSION

Altogether 103 species of Hymenoptera (Aculeata) were discovered in spruce stands, less than in birch stands where 159 species were collected using the same method (KULA, TYRNER 2000), representing 12.3% of the total number of 838 species occurring in Bohemia and quoted by PÁDR (1989). Euro-Siberian and Central European species not very particular in terms of temperature were absolutely prevalent, similarly like the sub-montane and mountain species. The families Sphecidae and Apidae, in particular, were very dependent on solar radiation. Comparisons of stands opened due to air-pollution damage with closed stands showed that the number of species was higher in the former type. The significant abundance of species of the family Vespidae in spruce stands can be attributed to their feeding fixation to the high numbers of aphids and scale insects (especially in the air-polluted stands) producing honeydew (HOLOPAINEN et al. 1999). *Vespula vulgaris,* in particular, is a eurytopic species which is also dominant in other types of forest biotopes (SKIBIŃSKA 1989). The high abundance of bees *Andrena lapponica* is due to the incidence of the main nutrient plant (*Vaccinium myrtillus* – KOCOUREK 1966) and *Andrena nitida* is a widely distributed polyectic species with no clear-cut preferences in terms of temperature. The highest abundance of the Aculeata in Letadlo B locality can be attributed to the favourable southern exposure (Letadlo B), highest degree of undergrowth coverage and lower density of the crown canopy. The high dominance of species of the genus *Halictus* in 1992 (24.4%) is associated with field formation using a bulldozer and denudation of the mineral substrate where the species have their nests. In the conditions of spruce forest the species *Cleptes semiauratus* parasitises in the cocoons of the sawfly *Pachynematus scutellatus* (Htg.) which the females hunt on the ground (MARTINEK 1951). This parasitoid considerably reduces the abundance of sawflies that damage spruce trees, and the population peaks of *Cleptes semiauratus* are a response to the increased abundance of its host. The average increasing density of the crown canopy in the succession of spruce stands, and hence decreased solar radiation can explain the reduction of the dominance of digger wasps *Pemphredon lugubris, Trypoxylon clavicerum* and *T. minus*. We cannot explain the high abundance of *Nysson spinosus* because the potential hosts (*Gorytes* sp.) were either not represented at all or their abundance was very low (*Argogorytes mystaceus*).

CONCLUSION

The Aculeata (Hymenoptera) fauna in spruce stands (*Picea abies)* consisted of 103 species that belong to 8 families, the most important of which is *Vespula vulgaris* (56.4%), *Vespula rufa* (4.7%), *Dolichovespula norvegica* (3.1%), *Dolichovespula saxonica* (4%), *Nysson spinosus* (1.8%), *Andrena lapponica* (1.9%), *Cleptes semiauratus* (5.9%), *Halictus* sp. (6.7%) and *Trypoxylon minus* (2.2%). The development of the Aculeata community was characterised by the withdrawal of representatives of the genus *Halictus, Andrena nitida* (Apidae), *Pemphredon lugubris, Trypoxylon clavicerum* and *T. minus* (Sphecidae), and increase of *Cleptes semiauratus* (Cleptidae), *Nysson spinosus* (Sphecidae), *Vespula vulgaris* and *V. rufa* (Vespidae). The opened spruce stands had a higher species diversity, but a lower number of trapped specimens at the same time.

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Hymenoptera (Aculeata) porostů smrku imisní oblasti severních Čech

E. Kula[1], P. Tyrner[2]

[1]*Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Brno, Česká republika*

[2]*Gymnázium Litvínov, Litvínov, Česká republika*

ABSTRAKT: Fauna Hymenoptera (Aculeata) (s výjimkou Formicoidea) byla studována v chladnější oblasti severních Čech v porostech smrku *Picea abies* metodou Moerickeho žlutých misek. Ve spektru 103 druhů měly nejvýznamnější postavení *Vespula vulgaris* (56,4 %), *Vespula rufa* (4,7 %), *Dolichovespula norvegica* (3,1 %), *Dolichovespula saxonica* (4 %), *Nysson spinosus* (1,8 %), *Andrena lappona* (1,9 %), *Cleptes semiauratus* (5,9 %), *Halictus* sp. (6,7 %), *Trypoxylon minus* (2,2 %). Ze srovnání výskytu v letech 1990–1994 a 1995–1999 vyplývá ústup zástupců rodů *Halictus, Andrena nitida* (Apidae), *Pemphredon* *lugubris, Trypoxylon clavicerum* a *T. minus* (Sphecidae) a vzestup výskytu *Cleptes semiauratus* (Cleptidae), *Nysson spinosus* (Sphecidae), dále *Vespula vulgaris, V. rufa* (Vespidae). Uvolněné smrkové porosty se vyznačovaly vyšší druhovou diverzitou při nižším počtu zachycených jedinců než porosty s vyšším zápojem korun.

Klíčová slova: Hymenoptera; Aculeata; *Picea abies*; Moerickeho žluté misky; severní Čechy

Zapojené smrkové monokultury představují faunisticky velmi chudé ekosystémy. Smrk se zvláště v imisních oblastech vyznačuje zvýšeným zastoupením savého hmyzu (mšice, puklice) produkujícího medovici (HOLOPAINEN et al. 1991), která je vyhledávaným zdrojem potravy některých blanokřídlých. Fauna blanokřídlých Čech zahrnuje 838 druhů (PÁDR 1989), které sehrávají významnou roli nejen jako opylovači, ale především jako součást spektra přirozených nepřátel lesních škůdců a regulátoři rovnováhy v lesních ekosystémech. KULA a TYRNER (2000) uvádějí z porostů břízy celkem 159 druhů.

Cílem příspěvku je doložit faunu žahadlovitých (Aculeata) v porostech smrku a jejich význam.

Faunistické sběry se uskutečnily na území Děčínské pískovcové vrchoviny – Lesní správa Sněžník v porostech smrku ztepilého [*Picea abies* (L.) KARST.] metodou Moerickeho žlutých misek. Kontrola probíhala odděleně z nízko a vysoko položených misek v sedmidenním intervalu v období 15. 4.–15. 10. (1990–1999).

Faunistická pestrost se ve sledovaných smrkových porostech v období 1990–1994 a 1995–1999 zásadně neměnila. Včely *Andrena lapponica, A. nitida* a r. *Halictus, Cleptes semiauratus* a obecně kutilky (Sphecidae) jednoznačně preferovaly porosty uvolněné a prosvětlené před porosty uzavřenými a bez bylinného podrostu, kde se především vyskytovala vosa *Vespula vulgaris. Dolichovespula norvegica* neprojevila výraznější závislost na světlostních poměrech sledovaných porostů (tab. 2).

Z Jaccardova indexu vyplývá, že nejvyšší podobnost druhového spektra (66,7) byla mezi lokalitou Tisá (bříza) a Malý dub (smrk). Oba porosty je možné klasifikovat jako stinné, zapojené, se sníženými světlostními poměry a sníženou potravní nabídkou pro imaga predatorních i parazitoidních Aculeata (tab. 3).

Ve smrkových porostech bylo celkem zjištěno 103 druhů Hymenoptera (Aculeata) a zcela převládají druhy málo náročné na teplotu s rozšířením eurosibiřským, středoevropským a druhy submontánní nebo montánní. V porovnání porostů poškozených exhalacemi (a tím uvolněných) a porostů zapojených byl počet druhů vyšší v prvním typu. Významné zastoupení druhů čeledi Vespidae ve smrkových porostech je možné přičíst jejich potravní vazbě na zvýšenou početnost mšic a puklic (zejména v imisemi zasažených prostech), které produkují medovici (HOLOPAINEN et al. 1999). Zvláště *Vespula vulgaris* je eurytopní druh dominující i v jiných typech lesních biotopů (SKIBIŃSKA 1989). Početný výskyt včel *Andrena lapponica* je důsledkem výskytu hlavní živné rostliny (*Vaccinium myrtillus* – KOCOUREK 1966) a *Andrena nitida* je široce rozšířený polylektický druh bez vyhraněných termopreferencí. Vysoká dominance druhů r. *Halictus* v r. 1992 (24,4 %) souvisí s terénními úpravami buldozerem a obnažením minerálního substrátu, ve kterém druhy hnízdí. *Cleptes semiauratus* v podmínkách smrkového lesa parazituje v kokonech pilatky *Pachynematus scutellatus* (HTG.), které samice vyhledává na zemi (MARTINEK 1951). Tento parazitoid významně omezuje výskyt pilatky škodící na smrku a populační maxima *Cleptes semiauratus* jsou reakcí na zvýšenou hladinu výskytu jeho hostitele. Pokles dominance kutilek *Pemphredon lugubris, Trypoxylon clavicerum* a *T. minus* lze vysvětlit průměrným zvýšením zápoje korun při sukcesi smrkových porostů a tím sníženou insolací. Vysoké zastoupení *Nysson spinosus* nelze vysvětlit, neboť potenciální hostitelé (*Gorytes* sp.) buď nebyli vůbec zastoupeni, nebo mají velmi nízké zastoupení (*Argogorytes mystaceus*).

Corresponding author:

Prof. Ing. EMANUEL KULA, CSc., Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 127, fax: + 420 545 211 422, e-mail: kula@mendelu.cz