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Community structure of Anthomyiidae (Diptera) of six peat-bogs in the Šumava Mts (Czech Republic)

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Abstract: The species composition of the family Anthomyiidae in six peat-bogs in the Šumava Mts is analysed with regards to dominance, constancy, seasonal occurrence and type of distribution of each species. Anthomyiid communities in all sites are compared based on the number of species, species richness, diversity and equitability indices, as well as coefficients of similarity and Principal Components Analysis (PCA). Three collecting methods are compared: yellow pan water traps (439 specimens/43 species), sweeping (93/18) and Malaise traps (97/22). Three species, *Pegoplata aestiva* (24.17%), *Delia platura* (14.47%), and *Hylemya nigrimana* (11.29%) were eudominant, two further species were dominant: *Delia cardui* (8.74%) and *Botanophila fugax* (8.27%). Two species, *Botanophilia fugax* and *Delia platura,* were found in all study sites. These species, together with those collected in five sites (*Delia cardui, Heterostylodes nominabilis* and *Hylemya vagans*), had a constancy rate higher than 75% and belonged to the category of euconstant species.

Key words: Anthomyiidae; community analysis; peat-bog; Šumava Mts; Czech Republic

Introduction

The Anthomyiidae are typical calyptrate flies of small to medium size, and are yellow, brown, grey or black in colour. The distinguishing characteristic of this family is that vein A1 extends to the wing margin. This feature separates Anthomyiidae from the related families of Muscidae and Fanniidae.

Anthomyiid flies are a relatively large and economically important family of Diptera. The larvae are primarily phytophagous (genera *Botanophila, Delia, Chirosia, Pegomya, Phorbia*) and some of them are important pests in agriculture, horticulture and forestry. They feed on different kinds of cereals and vegetables, or on the cones of coniferous trees (*Strobilomyia* spp.). The larvae of some species can be found in fungi (genera *Botanophila, Pegomya*), while others develop in decaying organic material, e.g., *Hylemya urbica* van der Wulp, 1896 and *Mycophaga testacea* (Gimmerthal, 1834), or in the excrements of mammals or in birds' nests. A few species are parasitoids (*Acyglossa* spp.) or cleptoparasites (genera *Eustalomyia, Leucophora*).

Approximately 600 species occur in Europe (Michelsen 2005), 227 of which have been recorded in the Czech Republic (Komzáková et al. 2005; Komzáková 2006a, b; Komzáková & Barták 2007).

The basic manual for species identification is Hennig's monograph in Lindner's "Die Fliegen der palaearktischen Region" (Hennig 1966–1976). Some later revisions may be found in, e.g., Ackland (1970, 1993), Michelsen (1979, 1980, 1988a, b, 1994), Michelsen & Baéz (1985), and Ackland & Michelsen (1987). A recent key to the Palaearctic genera was prepared by Suwa & Darwas (1998).

The species of the whole order Diptera have never been studied systematically in the territory of the Šumava Mts. The only comprehensive, however, short and much outdated paper is that by Vimmer (1927), with some taxa given only on a generic level. A few other papers dealing with individual families and/or sites were published; they have been listed by Barták (1998), however, no reliable data concerning the family Anthomyiidae from the Czech part of the mountain range is available, with the exception of a very recent paper by Komzáková & Barták (2007). From the Bavarian part of the Šumava Mts, 30 species of Anthomyiidae were listed by Barták (1998).

Peat-bog fauna of Diptera in the Šumava Mts has been thoroughly studied only recently by Roháček and Barták, the results being partly published (Roháček et al. 1998; Barták & Roháček 1999, 2000; Roháček & Barták 1999a, b; Kubík et al. 1999; Šifner et al. 1999; Černý et al. 2004) and by Barták & Kubík (results partly published in Barták & Vujić 2004; Barták 2004). The present paper represents a continuation of these studies. The other peat-bogs thoroughly studied in the Czech Republic are those in North Moravia (Jeseníky Mts and Králický Sněžník Mts); the results dealing with Acalyptrate Diptera have been only partly published (for references see Roháček & Barták 1999).

Material and methods

In the years 1996 and 1997, regular monthly samplings (from May/June till September/October) were performed by means of three collecting methods in six selected peat-bogs in the Šumava Mts. All male specimens of the family Anthomyiidae were identified and the data obtained have been processed by common methods of synecological analyses. Female specimens were not included in the analysis because female identification of anthomyiids has not yet been resolved, and the keys to their identification are still lacking in many genera.

Description of study sites

(Co-ordinates measured by means of GPS 38, recently corrected according to http://www.mapy.cz/).

Hraniční (Luzenská) slať peat-bog (48°56′56″ N, 13°29′16″ E, 1,170 m a.s.l.). A small raised peat-bog situated about 8.5 km south of the village of Modrava. Climatic conditions are very cold, with patches of old snow visible even in the beginning of June. The anthropogenic influences are rather weak (no exploitation of peat, surrounding forests represent climax spruce formations with only very slight forestall management). The sampling site was situated in the centre of the peat-bog, next to one of the small lakes, and only the Malaise trap was exposed near the forest edge.

Jezerní slať peat-bog (49°02′24″ N, 13°34′22″ E, 1,070 m a.s.l.). A large watershed raised peat-bog situated between the villages of Kvilda and Horská Kvilda. Part of the peat-bog is damaged by the former mining of peat, even the surrounding forests have been altered into even-aged Norway spruce monocultures; close to the east margin of peat-bog there are anthropogeneous meadows and pastures. The sampling site was situated within the less damaged part of the peat-bog close to the dwarf pine growth.

Chalupská slať peat-bog (48°59′52″ N, 13°39′36″ E, 860 m a.s.l.). A large valley raised peat-bog situated about 1 km north of the village of Borová Lada. A great part of the peat-bog has been damaged by peat mining (even if the exploitation no long proceeds, old drainage canals dry this part of the site). Very much like Jezerní slať, there are even-aged Norway spruce monocultures, meadows and pastures in the close vicinity of the peat-bog. The sampling site was situated in the exploited part of the peat-bog, close to dwarf pine growth.

Malá Niva peat-bog (48°54′34″ N, 13°49′18″ E, 750 m a.s.l.). A valley raised peat-bog situated about 3 km south-east of the village of Lenora. The peat-bog is surrounded by even-aged Norway spruce monocultures, and the Vltava River flows in its close vicinity. The ecotones are damaged by the picking and removing of dead wood by holidaymakers from the nearby standing camping site "Soumarský most". The entire peat-bog is sparsely overgrown by *Pinus rotundata*. Sampling sites were situated along the edge of the peat-bog near forest ecotone.

Pěkná peat-bog (48°51′05″ N, 13°54′43″ E, 730 m a.s.l.). A valley peat-bog situated about 2 km west of the village of Pěkná. Pěkná peat-bog, together with the well known Mrtvý Luh peat-bog form a part of a large complex called Vltavský Luh Reserve. Peat has never been mined here. In the close vicinity, there is a sparse growth of birch; the more distant surroundings are formed by even-aged Norway spruce monocultures. The water regime is strongly influenced by the nearby flowing Vltava River.

Kyselovský les peat-bog (48°41′24″ N, 14°03′25″ E, 725 m a.s.l.). A valley peat-bog and one of the warmest in the mountain range. Many parts of this peat-bog were damaged by flooding of the Lipno water reservoir, leaving only a narrow open strip (some 10 m in width) just along its edge. Changes in water levels of the lake strongly influence the water regime of the peat-bog. The sampling site was situated just on the boundary between the narrow open part of the peat-bog and the edge of its *Pinus rotundata* growth, sweeping was performed also along *Carex* meadow ecotone.

Collecting methods

1. Sweeping. Each sample consisted of 400 strokes with a 50 cm diameter sweeping net (except on 29.9.1996, when only 200 strokes were applied due to bad weather conditions), the telescopic handle of the net was 150 cm long. The swept materials were killed by means of ethylacetate and put directly into 70% ethylalcohol (in 1996), whereas in 1997 the material was processed by means of the photoeclector and killed by sulphurdioxide (the method was described by Barták 1995).

2. Yellow pan water traps. Plastic dishes (diameter 13 cm, depth 3 cm), in which ice-cream cakes are sold, were used. The inner side was painted by yellow Industrol ®6200 paint. Each sample consisted of 100 trap-days, in accordance with the method described by Barták (1997), on 29.9.1996 only 50 trap-days were used owing to bad weather conditions. Pan traps were filled with pure water and detergent (Jar®, 5 ml dissolved in 10 L of water), and then emptied every 24 hours.

3. Malaise traps. The trapezoid type (without a hind wall) was used, traps were made of dederon® and the collecting head was filled with 96% ethylalcohol. Traps were inserted at the beginning of the season and exposed until the last sampling date. Collecting heads were emptied each month on regular sampling dates.

For a detailed description of the trapping methods including photos see Roháček et al. (1998).

Methods of synecological analyses

The structure and comparison of Diptera communities of the six peat-bogs were expressed by means of the following quantitative characters: (1) number of species, (2) species dominance and constancy, (3) indices of diversity and equitability, (4) index of similarity, and (5) index of species richness. Detailed methods and formulas including a detailed interpretation of individual indices have been provided by Spellerberg (1995), Begon et al. (1997), and Smith & Smith (2006).

Symbols and formulas used: The dominance of individual species is expressed as: DO = Ni/N. 100 (%), where N = the total number of specimens (629), Ni = the total number of specimens of i^{th} species. The species with DO $\geq$ 5 are considered dominant, with DO $\geq$ 10 as eudominant.

Constancy is the percentage of sites in which the species occurred, out of the total number of sites under study: C = Ls/L × 100 (%), where L = the total number of sites (= 6), Ls = number of sites in which the species was found. Species with C $\geq$ 50 are considered constant, with C $\geq$ 75 as euconstant.

Simpson's index of diversity: $D = 1/\sum p_i^2$ and equitability: E = D/Nd, where p_i = Ni/N × Nd = number of species found in a given site, N = number of specimens of the site, Ni = number of specimens of i^{th} species in the site.

Shannon's index of diversity: $H = -\sum p_i \ln p_i$ and equitability: J = H/ln Nd, where symbols are the same as in Simpson's indices.

Similarities between sites were calculated by means of the percent similarity method (PS index, see Smith & Smith

Table 1. Distribution, dominances, and constancies of the recorded anthomyiid species.

Species	DI	DO (%)	C (%)
Alliopsis pilitarsis (Stein, 1900)	PA	0.16	17
Alliopsis silvestris (Fallén, 1824)	HO	0.48	34
Anthomyia liturata (Robineau-Desvoidy, 1830)	E	0.16	17
Botanophila biciliaris (Pandellé, 1900)	HO	0.48	17
Botanophila brunneilinea (Zetterstedt, 1845)	WPA	0.16	17
Botanophila fugax (Meigen, 1826)	HO	8.27	100
Botanophila profuga (Stein, 1916)	HO	0.48	34
Botanophila sericea (Malloch, 1920)	TNE	0.16	17
Botanophila silvatica (Robineau-Desvoidy, 1830)	TNE	1.91	34
Botanophila striolata (Fallén, 1824)	PA	0.32	34
Botanophila varicolor (Meigen, 1826)	E	0.32	34
Delia cardui (Meigen, 1826)	HO	8.74	84
Delia echinata (Séguy, 1923)	HO+OR	0.32	34
Delia fallax (Loew, 1873).	WPA	0.48	34
Delia florilega (Zetterstedt, 1845)	HO	0.16	17
Delia lamelliseta (Stein, 1900).	TNE	0.16	17
Delia longicauda (Strobl, 1898)	HO	0.16	17
Delia platura (Meigen, 1826)	C	14.47	100
Delia radicum (L., 1758)	HO	0.16	17
Delia tarsifimbria (Pandellé, 1900)	TE	0.16	17
Delia tenuiventris (Zetterstedt, 1860)	HO	0.95	34
Eutrichota praepotens (Wiedemann, 1817)	PA	0.32	17
Heterostylodes nominabilis (Collin, 1947)	E	1.59	83
Heterostylodes obscurus (Macquart, 1835)	E	0.16	17
Hydrophoria lancifer (Harris, 1780)	HO	1.43	50
Hydrophoria linogrisea (Meigen, 1826)	E	0.48	34
Hydrophoria ruralis (Meigen, 1826)	PA	0.48	34
Hydrophoria silvicola (Robineau-Desvoidy, 1830)	HO	0.64	34
Hylemya nigrimana (Meigen, 1826)	PA	11.29	34
Hylemya urbica van der Wulp, 1896	HO	0.48	17
Hylemya vagans (Panzer, 1798)	PA	2.07	83
Hylemya variata (Fallén, 1823)	WPA	3.82	67
Hylemyza partita (Meigen, 1826)	HO	3.02	50
Lasiomma latipenne (Zetterstedt, 1838)	HO	0.32	17
Lasiomma picipes (Meigen, 1826)	HO	0.16	17
Mycophaga testacea (Gimmerthal, 1834)	PA	0.32	34
Paradelia intersecta (Meigen, 1826)	HO	0.79	34
Paregle audacula (Harris, 1780)	C	0.32	34
Pegomya bicolor (Wiedemann, 1817)	HO	0.64	34
Pegomya flavifrons (Walker, 1849)	HO	0.16	17
Pegomya fulgens (Meigen, 1826)	E	0.16	17
Pegomya winthemi (Meigen, 1826)	HO	0.16	17
Pegoplata aestiva (Meigen, 1826)	PA+OR	24.17	67
Pegoplata infirma (Meigen, 1826)	HO	0.16	17
Pegoplata palposa (Stein, 1897)	HO	0.48	17
Phorbia atrogrisea Tiensuu, 1935	PA	0.16	17
Phorbia curvicauda (Zetterstedt, 1845)	PA	0.16	17
Phorbia fumigata (Meigen, 1826)	HO	0.16	17
Phorbia moliniaris (Karl, 1917)	TNE	4.61	50
Phorbia sepia (Meigen, 1826).	TNE	0.16	17
Subhylemyia longula (Fallén, 1824)	HO+OR	0.16	17
Zaphne caudata (Zetterstedt, 1855)	E	0.16	17
Zaphne divisa (Meigen, 1826)	HO	0.95	34
Zaphne inuncta (Zetterstedt, 1838)	PA	0.48	17
Zaphne proxima (Malloch, 1920)	HO	0.64	17
Zaphne wierzejskii (Mik, 1867)	HO	0.16	17

Explanations: DO (%) – dominance; C (%) – constancy; DI – distribution (C – Cosmopolitan, E – European, HO – Holarctic, PA – Palaearctic, PA + OR – Palaearctic plus Oriental, TE – Temperate European, TNE – Temperate and North European, WPA – West Palaearctic).

2006). To calculate the PS index, first we tabulated species abundance in each community and then we added the lowest common value for each species shared by the communities (this index value goes from 0 – when the two communities have no species in common, to 100 when the relative abundances of all species in the two communities are identical).

Margalef's index of species richness: P = (Nd – 1)/log N, where symbols are the same as in Simpson's indices.

Principal Components Analysis (PCA)

To analyze the main variation in the species data we performed the Principal Components Analysis. Data were square root transformed to suppress the influence of dominant species, and covariance matrix was used. The number of species and specimens, as well as Shannon's index of diversity and altitude were used as passive explanatory variables and projected in the ordination diagram. Spearman correlations of these explanatory variables and the first four PCA axes were counted.

The PCA analysis was computed using the CANOCO 4.5 package (ter Braak & Šmilauer 2002). The correlations of the explanatory variables and PCA axes were counted in Statistica for Windows 9.0.

Zoogeographical analysis

It was performed by means of geoelements. The distribution of each species was taken from Michelsen (2005). We distinguished the following geoelements: Cosmopolitan (all species with Holarctic plus Oriental distribution or broader), European, Holarctic, Palaearctic, Palaearctic plus Oriental, Temperate European (including Central European montane species), Temperate and North European, West Palaearctic (e.g., Europe plus North Africa, Europe plus Near East, Europe plus Transcaucasia).

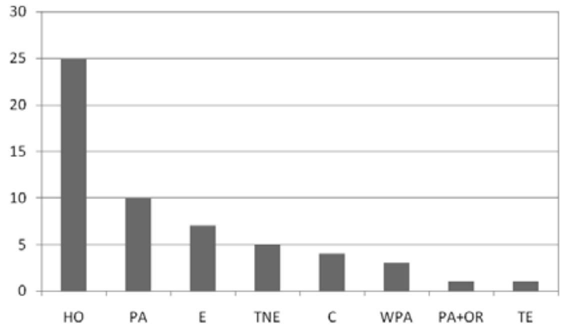

Fig. 1. Proportion of geoelements in the anthomyiid fauna in the Šumava peat-bogs. Explanations: 0–30: number of species, C – Cosmopolitan, E – European, HO – Holarctic, PA – Palaearctic, PA + OR –Palaearctic plus Oriental, TE – Temperate European, TNE – Temperate and North European, WPA – West Palaearctic.

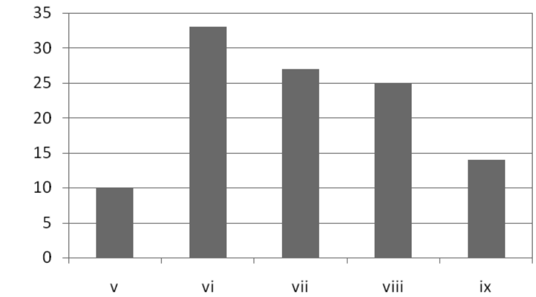

Fig. 2. Number of anthomyiid species caught in individual sampling months. Explanations: 0–35: the number of species caught in the six study sites, v–ix – months.

Results

Species composition analysis

Altogether 56 species of the family Anthomyiidae (= 24.7% of all species of the family known to occur in the Czech Republic) have been recorded from the six peat-bog sites under study. They are listed in Appendix 1 with complete faunistic data. The nomenclature of species follows Michelsen (2005). Dominances, constancies, and distribution patterns are given in Table 1.

Dominance

Three species, *Pegoplata aestiva* (24.17%), *Delia platura* (14.47%), and *Hylemya nigrimana* (11.29%) were eudominant, two further species were dominant: *Delia cardui* (8.74%) and *Botanophila fugax* (8.27%). Three additional species (*Phorbia molinaris* 4.61%, *Hylemya variata* 3.82% and *Hylemya vagans* 2.07%) were subdominant. Other species did not exceed a dominance value of 2% and were recedent or subrecedent. The total proportion of dominant and eudominant species represented 8.9% of all species found, and 66.93% of specimens.

Constancy

Altogether two species were found in all study sites, *Botanophilia fugax* and *Delia platura.* These species, together with those collected in five sites (*Delia cardui, Heterostylodes nominabilis* and *Hylemya vagans*) had a constancy value higher than 75% and belonged to the category of euconstant species. The euconstant species represented 8.9% of all species found and 35.1% of specimens. Further five species were found in 3–4 sites, i.e., forming constant species: *Hydrophoria lancifer, Hylemya variata, Hylemyza partita, Pegoplata aestiva* and *Phorbia moliniaris.* Constant species formed 8.9% of species (37.1% specimens).

Zoogeographical analysis

Results of the zoogeographical analysis are given in Fig. 1. The majority of species recorded were species with broad distribution: Holarctic (25 species, 44.6%) and Palaearctic (10 species, 17.9%), followed by European (7 species, 12.5%), Temperate and North European (5 species, 8.9%), Cosmopolitan (4 species, 7.1%), and West Palaearctic (3 species, 5.3%) species. One species (1.8%) represented each: Temperate European and Palaearctic plus Oriental species.

Seasonal occurrence

The results of the seasonal catch of species are given in Fig. 2. The maximum number of species (33) was recorded in June. The total number of specimens recorded in successive months is given in Fig. 3. With respect to Malaise traps, the number of specimens was divided by two, with each half assigned to both months. The maximum number of specimens was caught in July (210).

Comparison of the six sites

A comparison of the six peat-bogs with regards to number of specimens, number of species, species richness and coefficients of diversity and equitability are given in Table 2. The highest values of species richness and the highest number of species were found in the Ky-

Table 2. Comparison of the six peat-bogs with regards to the number of anthomyiid specimens, number of species, species richness and indices of diversity and equitability. The highest values are printed in bold.

Peat bog	No. of specimens	No. of species	Species richness index	$D = 1/\sum p_i^2$	E = D/Nd	$H = -\sum p_i \ln p_i$	J = H/ln Nd
HS	156	16	6.84	3.14	0.20	1.66	0.60
JS	**237**	22	8.84	5.49	0.25	2.13	0.69
CHS	41	11	6.20	4.76	0.43	1.89	0.79
MN	40	20	11.86	**14.04**	**0.70**	**2.80**	**0.94**
RP	24	11	7.25	5.76	0.52	2.06	0.86
KL	131	**30**	**13.70**	8.91	0.30	2.65	0.78

Explanations: CHS – Chalupská slať, D – Simpson's index of diversity and equitability (E), H – Shannon's index of diversity and equitability (J), HS – Hraniční (Luzenská) slať, JS – Jezerní slať, KL – Kyselovský les, MN – Malá Niva, RP – Pěkná.

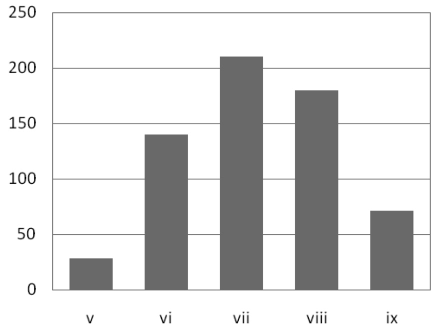

Fig. 3. Total number of anthomyiid specimens recorded in successive months (May – September). Explanations: 0–250: the total number of specimens caught in the six study sites, v–ix – months.

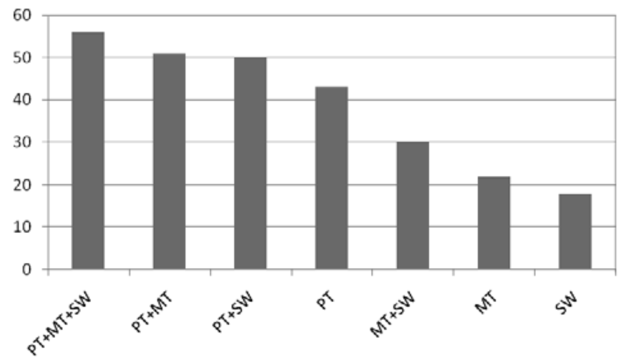

Fig. 4. Total number of anthomyiid species caught by all three methods and all their combinations. Explanations: 0–60: number of species, MT – Malaise traps, PT – yellow pan traps, SW – sweeping.

selovský les Mire which was the warmest and at the lowest altitude of all the mires under study. The highest values of both indices of diversity and equitability were found in Malá Niva Mire. In contrast to this, the lowest values of species diversity and equitability indices were found in the case of the highest altitude, in the Hraniční slať Mire.

Hraniční slať and Jezerní slať peat-bogs displayed the highest similarity value. Pěkná Peat-bog is the most dissimilar compared to the other sites.

A comparison of the six peat-bogs using Principal Component Analysis (PCA) is given in Fig. 5. The 1st axis of PCA explained 58.8% and the 2nd axis explained 18.9% of the total variance; the first four axes together covered 95% of the total variance. The unusually large part of the explained variance is caused by the small number of the study sites. The 1st axis was significantly correlated to Shannon's index (negatively), and the number of specimens (positively). The relationship between the PCA axes, altitude and number of species were insignificant.

Comparison of the three collecting methods

The highest number of species and specimens, and simultaneously the highest index of species richness was gained with the yellow pan water trap method which yielded 43 species (76.8%) and 439 specimens (69.8%). By sweeping, on the contrary, the smallest number of specimens (93 = 14.8%) and species (18 = 32.1%) was caught.

The total number of species caught by all three methods and all their combinations is given in Fig. 4. The most productive two method combination is that of the pan traps and Malaise traps. By means of these two methods combined we caught 51 species, which accounts for 91.1% of all species recorded, however, the combination of pan traps with sweeping, which yielded 50 species (89.3%), was nearly equally productive. The relatively time consuming sweeping method added only five species to this combination (on average only a single male specimen was obtained after more than 100 strokes with the sweeping net!).

In collecting anthomyiids, the Malaise trap and sweeping methods showed the most significant similarities. In contrast, the pan trap method proved to be the most dissimilar when compared to the others.

Only eight species were recorded by all three methods simultaneously. This means that only 14.2% of species present in a site can be detected by any one of the three sampling methods. This clearly demonstrates the fact that none of them can be used alone for monitoring Anthomyiidae in adequate detail.

The most important records

Botanophila profuga (Stein, 1916). The species is known from Europe and East Palearctic Region. First record from Bohemia.

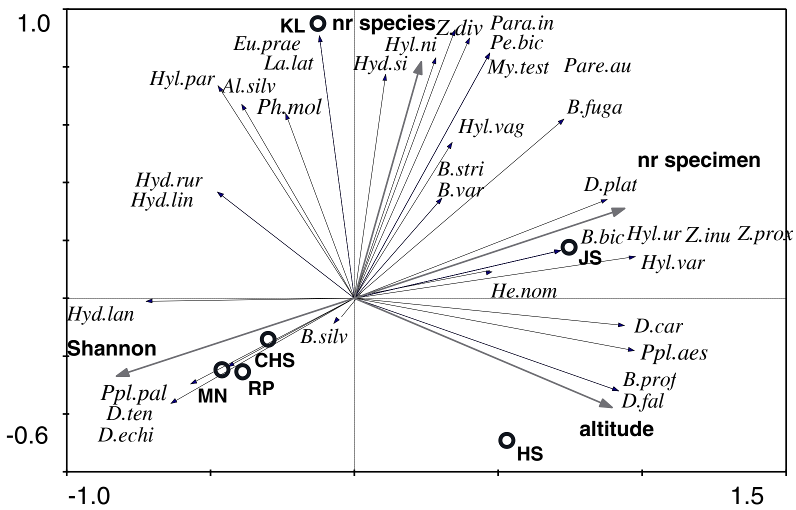

Fig. 5. Triplot of Principal Components Analysis on covariance matrix of anthomyiid species abundance data: the first two axes. Explanatory variables are projected post-hoc. Data after square root transformation. The species with only 1 specimen recorded were omitted from the graph. Explanations: CHS – Chalupská slať, HS – Hraniční (Luzenská) slať, JS – Jezerní slať, KL – Kyselovský les, MN – Malá Niva, RP – Pěkná. For abbreviations of species names see Table 1.

Delia fallax (Loew, 1873). The species has been recorded in Europe (Switzerland, Czech Republic, Slovakia, Romania, Hungary, France and Austria) and the Near East. This species is classified as endangered for the Czech Republic (Rozkošný & Barták 2005).

Zaphne caudata (Zetterstedt, 1855). The species is distributed in Europe, predominantly in the mountains. First record from Bohemia.

Zaphne inuncta (Zetterstedt, 1838). This mountain species occurs in Europe and the East Paleartic region. There is little information on the life history of *Zaphne* spp. but this species [as *Z. hyalipennis* (Zetterstedt, 1855)] was reared from owl pellets (Hennig 1966–1976). Three specimens recorded here actually represented the first findings of this species from the Czech Republic, however they were published prior to this paper according to the specimens caught subsequently (2000) in Antygl (Šumava Mts – Komzáková & Barták 2007). Second record from the Czech Republic.

Zaphne proxima Malloch, 1920. This predominantly mountain species occurs in North and Central Europe, the East Palearctic region and Nearctic region. Four specimens recorded here actually represented the first findings of this species from the Czech Republic, however they were published prior to this paper according to the specimens caught subsequently (2000) in Rokytecká slať peat bog (Šumava Mts – Komzáková & Barták 2007). Second record from the Czech Republic.

Discussion and conclusions

Altogether 629 specimens of the family Anthomyiidae representing 56 species were found by means of three collecting methods in six peat-bogs in the Šumava Mts (Hraniční – Luzenská slať, Jezerní slať, Chalupská slať, Malá Niva, Pěkná, Kyselovský les) situated at different altitudes (from 725 to 1,170 m a.s.l.).

Three species, *Pegoplata aestiva*, *Delia platura,* and *Hylemya nigrimana*, were eudominant, a further two species were dominant: *Delia cardui* and *Botanophila fugax.* All these species are commonly known and widely spread. The total proportion of dominant and eudominant species represented 8.9% of all species found (in other families elaborated to date this proportion varied from 3.5% in Acalyptrata to 28.6% in Scathophagidae) and they covered 66.93% of specimens (ranging from 46.1 in Acalyptrata to 85.9 in Scathophagidae; for citations see below).

Altogether two species were found in all the sites under study, viz *Botanophilia fugax* and *Delia platura.* These species, together with those collected in five sites (*Delia cardui, Heterostylodes nominabilis* and *Hylemya vagans*) had constancy levels higher than 75%, and belonged to the category of euconstant species. Euconstant species represented 8.9% of all species found (this proportion varied from 6.1% in Acalyptrata to 23.8% in Scathophagidae) and 35.1% of specimens (ranging from 35.5% in Acalyptrata to 86.9% in Chloropidae). Further five species were found in 3–4 sites, i.e., forming constant species: *Hydrophoria lancifer, Hylemya variata, Hylemyza partita, Pegoplata aestiva* and *Phorbia moliniaris.* Constant species formed 8.9% of species (37.1% specimens). Only *Phorbia moliniaris* is species typical of peat-bogs because its larvae live in *Molinia coerulea* and other species of the family Ericaeae. The other aforenamed species are very common and their larvae are coprophagous, saprophagous or phytophagous.

The highest values of species richness and the highest number of species were found in the Kyselovský les mire which was the warmest and at the lowest altitude situated of all the mires under study. The highest values of both indices of diversity and equitability were found in Malá Niva mire. In contrast, the lowest values of species diversity and equitability indices were found at highest altitude, the Hraniční slať mire. The altitude-dependent community properties were revealed practically in all families studied here up to now: low values of synecological indices in high altitude mires (Jezerní and Hraniční slať) and much higher values in lower altitude mires (Chalupská slať, Malá Niva and Kyselovský les). These results agree with findings in the families Sphaeroceridae (Roháček & Barták 1999a), Chloropidae (Kubík et al. 1999), Empididae (Barták & Roháček 1999), Acalyptrata (Roháček & Barták 1999b), Hybotidae (Barták & Roháček 2000) and Scathophagidae (Šifner et al. 1999).

Hraniční slať and Jezerní slať peat-bogs display the highest similarity value. Both represent the highest altitude peat-bogs under study. Pěkná peat-bog was the most dissimilar when compared to the other sites. These results can hardly be compared with previous studies because another similarity index was used. However, Jezerní slať often belonged to the category of peat-bogs that showed the most similarities to the others (e.g., in Agromyzidae – Černý et al. 2004) while Pěkná mire belonged to the category of peat bogs least similar to the others.

The highest number of species and specimens and, simultaneously, the highest index of species richness was gained with the yellow pan water trap method which yielded 43 species (76.8%) and 439 specimens (69.8%). This was in sharp contrast to almost all other studied families, where (except chloropids) the most efficient were Malaise traps. Sweeping, on the other hand, caught the smallest number of specimens (93 = 14.8%) as well as species (18 = 32.1%), similar as in most other studied groups of Diptera (with the exception of chloropids).

Eight species were recorded by using all three methods simultaneously. This means that only 14.2% of species present in a site can be detected by any one of the three sampling methods and that no method alone can be used for detailed monitoring of Anthomyiidae. This result is in contrast with findings in Agromyzidae (13.5% of species were detected by all methods simultaneously), and in Acalyptrata (14.9%). A slightly higher number of species was detected by any given method in the case of Hybotidae (19.4%), Empididae (28.2%), and Scathophagidae (28.6%), and even more in Chloropidae (33.3%). A more detailed comparison of the dipteran fauna from the six sites under study was presented by Barták (1999).

The result of the PCA suggests that the major variation in the data was due to a change in the number of specimens, thus causing diversity among the sites. The effect of altitude on species richness or on the number of specimens was statistically insignificant due to the low number of collecting sites.

The triplot of the PCA (Fig. 5) showed that the species composition of Hraniční slať, Jezerní slať, and Kyselovský les differed markedly from other collecting sites as well as from each other. Hraniční slať, located in the highest altitude, is the coldest and least influenced by human activity. Kyselovský les is the warmest, and is strongly influenced by human activity and the spillage of the Lipno dam. It had the highest number of species. The remoteness of Jezerní slať in the triplot, a site with natural conditions most resembling Chalupská slať, was probably caused by the high abundances of species with coprophagous larvae, i.e., *Pegoplata aestiva* and *Hylemya* sp., due to the occurrence of pastures in the site's vicinity. Chalupská slať, Pěkná peat-bog and Malá Niva mire, sites at medium altitude, have similar species compositions. It is probable that a characteristic of vegetation as another passive explanatory variable in the analysis would serve to account for the differences in the species composition at the collecting sites.

Two species reported here represented the first findings from the territory of the Czech Republic (*Zaphne inuncta* and *Z. proxima*), however, both had been previously published based on later records. Therefore both records are only the second in the Czech Republic. Further two species were recorded for the first time in Bohemia (*Zaphne caudata* and *Botanophila profuga*). A single species found (*Delia fallax*) is classified as locally endangered.

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Appendix 1. List of recorded anthomyiid species in peat-bogs in the Šumava Mts with collecting methods and sampling dates.

Alliopsis pilitarsis (Stein, 1900). MN: PT, v, 1.
Alliopsis silvestris (Fallén, 1824). KL: PT, vii, 2, MN: PT, vi, 1.
Anthomyia liturata (Robineau-Desvoidy, 1830). KL: SW, viii, 1.
Botanophila biciliaris (Pandellé, 1900). JS: PT, vii, 3.
Botanophila brunneilinea (Zetterstedt, 1845). CHS: SW, ix, 1.
Botanophila fugax (Meigen, 1826). HS: PT, vi, 2, viii, 1, SW, viii, 2, MT, vii, 2, CHS: SW, viii, 2, ix, 1, JS: MT, vii–viii, 9, viii–ix, 2, PT, vii, 4, viii, 7, KL: MT, viii–ix, 5, SW, viii, 5, PT, viii, 5, MN: MT, vi–vii, 1, SW, vii, 2, viii, 1, RP: PT, vii,1.
Botanophila profuga (Stein, 1916). HS: SW, viii, 2, JS: PT, vii, 1.
Botanophila sericea (Malloch, 1920). CHS: SW, vi, 1.
Botanophila silvatica (Robineau-Desvoidy, 1830). CHS: SW, vii, 4, viii, 2, PT, vii, 5, JS: PT, viii, 1.
Botanophila striolata (Fallén, 1824). HS: PT, vi, 1, KL: PT, v, 1.
Botanophila varicolor (Meigen, 1826). HS: PT, vi, 1, KL, MT, v, 1.
Delia cardui (Meigen, 1826). HS: SW, vii, 7, viii, 7, MT, vii–viii, 2, PT, viii, 13, ix, 1, CHS: SW, viii, 1, PT, vii, 1, JS: MT, vii–viii, 1, SW, viii, 2, PT, vii, 9, viii, 6, KL: PT, viii, 4, RP: SW, vi, 1
Delia echinata (Séguy, 1923). CHS: PT, vii, 1, MN: PT, viii, 1.
Delia fallax (Loew, 1873). HS: PT, vi, 2, JS: PT, viii, 1.
Delia florilega (Zetterstedt, 1845). KL: PT, vii, 1.
Delia lamelliseta (Stein, 1900). MN: MT, vi-vii, 1.
Delia longicauda (Strobl, 1898). MN: SW, vi, 1.
Delia platura (Meigen, 1826). HS: SW, vii, 3, viii, 1, PT, vi, 1, viii, 6, CHS: SW, vii, 1, viii, 2, JS: MT, vii–viii, 13, viii–ix, 1, SW, vii, 2, PT, vii, 33, viii, 14, KL: MT, viii–ix, 2, PT, vi, 4, vii, 3, ix–x, 3, MN: MT, vi–vii, 1, RP: PT, vii, 1.
Delia radicum (L., 1758). HS: PT, vi, 1.
Delia tarsifimbria (Pandellé, 1900).KL: PT, viii, 1.
Delia tenuiventris (Zetterstedt, 1860). MN: MT, vii–viii, 1, SW, vii, 3, RP: SW, vii, 2.
Eutrichota praepotens (Wiedemann, 1817). KL: PT, viii, 2.
Heterostylodes nominabilis (Collin, 1947). HS: PT, viii, 3, JS: PT, vii, 2, KL: MT, v, 2, MN: PT, vi, 2, RP: PT, vi, 1.
Heterostylodes obscurus (Macquart, 1835). MN: PT, vi, 1.
Hydrophoria lancifer (Harris, 1780). KL: PT, vi, 1, MN: PT, vi, 2, SW, vi, 3, RP: PT, vi, 3.
Hydrophoria linogrisea (Meigen, 1826). KL: PT, ix–x, 1, MN: MT, v–vi, 1, PT, viii, 1.
Hydrophoria ruralis (Meigen, 1826). KL: PT, vi, 1, MN: PT, viii, 2.
Hydrophoria silvicola (Robineau-Desvoidy, 1830). JS: PT, vii, 1KL: MT, v, 2, RP: PT, vi, 1.
Hylemya nigrimana (Meigen, 1826). HS: SW, vii, 1, PT, viii, 2, ix, 3, CHS: SW, ix, 11, PT, vii, 3, JS: PT, vii, 10, ix, 6, KL: MT, viii–ix, 3, PT, vi, 4, vii, 8, viii, 6 ix–x, 9, MN: MT, vi–vii, 1, PT, vi, 3, RP: PT, vii, 1.
Hylemya urbica van der Wulp, 1896. JS: MT, vi–vii, 1, PT, vii, 2.
Hylemya vagans (Panzer, 1798). JS: PT, vii, 1, viii, 1, ix, 3, MT, viii–ix, 1, KL: PT, vi, 1, ix–x, 1, MN: SW, viii, 1, RP: PT, vi, 3, vii, 1.
Hylemya variata (Fallén, 1823). HS: SW, vii, 2, viii, 1, PT, vi, 2, ix, 2, CHS: SW, ix, 1, JS: MT, vi–vii, 2, vii–viii, 1, PT, vii, 1, viii, 2, ix, 5, SW, viii, 1, ix, 2, KL, MT, v, 1, SW, vi, 1.
Hylemyza partita (Meigen, 1826). CHS: SW, vii, 1, viii, 2, KL: MT, viii–ix, 13, MN: SW, vii, 3.
Lasiomma latipenne (Zetterstedt, 1838). KL: PT, vi, 2.
Lasiomma picipes (Meigen, 1826). KL: MT, viii-ix, 1.
Mycophaga testacea (Gimmerthal, 1834). JS: PT, ix, 1, KL: PT, ix-x, 1.
Paradelia intersecta (Meigen, 1826). JS: MT, viii–ix, 2, KL: MT, viii–ix, 3.
Paregle audacula (Harris, 1780). JS: PT, viii, 1, KL: PT, vi, 1.
Pegomya bicolor (Wiedemann, 1817). JS: MT, vi–vii, 2, KL: MT, v, 2.
Pegomya flavifrons (Walker, 1849). KL: PT, viii, 1.
Pegomya fulgens (Meigen, 1826). RP: MT, vii–viii, 1.
Pegomya winthemi (Meigen, 1826). CHS: PT, vii, 1.
Pegoplata aestiva (Meigen, 1826). HS: SW, vii, 1, MT, vi–vii, 2, viii–ix, 1, PT, vi, 65, viii, 12, JS: MT, vii–viii, 1, PT, vii, 50, viii, 18, ix, 1, KL: PT, vii, 1.
Pegoplata infirma (Meigen, 1826). JS: MT, vi–vii, 1.
Pegoplata palposa (Stein, 1897). MN: PT, vi, 3.
Phorbia atrogrisea Tiensuu, 1935. MN: PT, v, 1.
Phorbia curvicauda (Zetterstedt, 1845). MN: PT, vi, 1.
Phorbia fumigata (Meigen, 1826). HS: PT, vi, 1.

Phorbia moliniaris (Karl, 1917). HS: MT, vi–vii, 1, KL: SW, vi, 5, MT, v, 7, PT, v, 8, RP: PT, v, 8

Phorbia sepia (Meigen, 1826). HS: PT, vi, 1.

Subhylemyia longula (Fallén, 1824). HS: SW, vii, 1.

Zaphne caudata (Zetterstedt, 1855). KL: PT, vi, 1.

Zaphne divisa (Meigen, 1826). JS: MT, vii–viii, 2, KL: MT, viii–ix, 1, PT, vi, 2, ix–x, 1.

Zaphne inuncta (Zetterstedt, 1838). JS: PT, vii, 3.

Zaphne proxima (Malloch, 1920). JS: PT, vii, 4.

Zaphne wierzejskii (Mik, 1867). MN: PT, v, 1.

Explanations. Sampling sites: CHS – Chalupská slať, HS – Hraniční (Luzenská) slať, JS – Jezerní slať, KL – Kyselovský les, MN – Malá Niva, RP – Pěkná. Sampling methods: MT – Malaise traps, PT – pan traps, SW – sweeping. Sampling dates: HS, CHS, JS – 1996 (MT: vi–vii = 2.vi.–5.vii (except MN, vi–vii. = 15.vi.–18.vii.), vii–viii = 5.vii.–7.viii., viii–ix = 5.viii.–6.ix., PT: vii = 5.–7.vii., viii = 5.–7.viii., ix = 28.–29.ix., SW: vi = 2.–5.vi., vii = 4.vii., viii = 6.viii., ix = 29.ix.); RP, KL and MN – 1997 (MP: v–vi = 15.v.–15.vi., vii–viii = 16.vii.–21.viii., viii–ix = 21.viii.–27.ix., PT: v. = 15.–17.v., vi = 14.–16.vi., vii = 16.–18.vii., viii = 21.–23.viii., ix.–x. = 29.ix.–1.x., SW: vi = 15.vi., vii = 4. and 17.vii., viii = 22. viii.).