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Seasonal dynamics of mosquito occurrence in the Lower Dyje River Basin at the Czech-Slovak-Austrian border

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Abstract
During 2009–2011, a total of 45 two-day captures of mosquitoes (Insecta: Diptera: Culicidae) were made at six sites in the Lower Dyje River Basin. Trapping was performed from early April through the end of October using Centers for Disease Control and Prevention (CDC) miniature light traps baited with carbon dioxide (CO_2). In total, 415,218 female mosquitoes belonging to six genera and 30 species were captured. In early April, only small numbers of wintering species females (*Culex pipiens s.l.*, *Culiseta annulata* and *Anopheles maculipennis s.l.*) were detected. From mid-April, there was a sharp increase in the occurrence of snow-melt species (*Aedes cataphylla*, *Ae. intrudens* and, sporadically, *Ae. communis* and *Ae. leucomelas*, totalling 2090 females). Their occurrence peaked in early May, but they gradually ceased flying in during June. *Ae. sticticus* females also became active starting in late April, while *Ae. cantans s.l.*, *Ae. vexans*, *Ae. rossicus* and other species were active from early May. The greatest occurrence of mosquitoes was recorded in summer months (from mid-June through the end of August). In this period, the dominant species were *Ae. vexans* (49.70–80.20%) and *Ae. sticticus* (6.14–25.62%). The species *Ae. rossicus*, *Ae. cantans s.l.*, *Cx. pipiens s.l.* and *Cx. modestus* also were very abundant from mid-June to late July. The occurrence of mosquitoes decreased rapidly during September. In the second half of October, only small numbers of *Ae. vexans*, *An. claviger* and *Cx. pipiens s.l.* females were captured, while *Ae. cinereus s.l.*, *Ae. rossicus*, *Ae. sticticus*, *Cx. modestus*, *An. maculipennis s.l.* and *An. plumbeus* were seen only very sporadically.

Keywords: *Czech Republic, South Moravia,* Aedes vexans*,* Culex modestus*, seasonal dynamics*

Introduction

The lowlands of South Moravia are among the Czech Republic's most important areas in terms of mosquito (Insecta: Diptera: Culicidae) occurrence. Numerous wetlands exist along the lower courses of the Morava and Dyje rivers and their tributaries. Extensive alluvial forests and systems of lakes also are found there. In the second half of the twentieth century, a system of reservoirs was constructed along the River Dyje (Nové Mlýny). Frequent flooding in the summer causes extreme abundance of certain mosquito species, especially *Aedes vexans* and *Ae. sticticus*. The importance of breeding grounds is increased by their position in the border region with Lower Austria and western Slovakia. Certain viruses, such as the Ťahyňa Virus (TAHV) and West Nile Virus (WNV), have been isolated from the local mosquitoes (Danielová et al. 1972; Málková et al. 1974; Bárdoš et al. 1978; Hubálek et al. 1998, 2000, 2010, and Bakonyi et al. 2005). An endemic incidence of malaria was noted here until the mid-twentieth century (Rosický & Havlík 1951; Havlík & Rosický 1952). That there are a number of locations here serving as migration stops for migrating birds, as well as important bird nesting grounds, may also play an important role (Zuna-Krátký et al. 2000; Chytil & Macháček 2002). The importance of birds as possible reservoirs was studied by, for example, Hubálek (2004), Hubálek et al. (2008), and Juřicová et al. (2009).

In addition to the importance of mosquitoes as possible disease vectors, considerable attention is traditionally devoted also in South Moravia to their occurrence in relation to mosquito calamities

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(Kramář & Weiser 1951; Novák 1957). Faunistic studies with various foci are also numerous (Palička 1967; Olejníček et al. 2004; Minář et al. 2007; Rettich et al. 2007; Šebesta et al. 2012). Observations from adjacent areas of west and south Slovakia are also numerous (Labuda 1977; Jalili et al. 1999; Jalili & Halgoš 2004; Strelková & Halgoš 2012). Much attention has been dedicated to the daily activity of mosquitoes, and especially their population dynamics in Europe (Potapov et al. 1973; Jaenson 1988; Caglar et al. 2003; Ponçon et al. 2007a,b; Aldemir et al. 2010; Balenghien et al. 2010). Among nearby locations, studies from Croatia (Merdič & Lovakovič 2001; Merdič & Boca 2004; Sudarič Bogojevič et al. 2009) and Poland (Wegner 2009) have been published. In South Moravia, as well as in the Czech Republic as a whole, however, similar research has so far been conducted only rarely (Šebesta et al. 2010, 2011).

The purpose of this paper is to describe changes in mosquito occurrence over the course of the year, and thereby enable better organization of protection for the human population in the monitored area. The results may also serve as a basis for coordinating efforts to implement anti-mosquito preventative measures in the surrounding areas of Moravia, Austria and Slovakia. Primary attention is devoted to flood mosquito species and potential vectors for human diseases.

Materials and methods

Sites

Six sites were selected for the purposes of the research, so that all biotopes important for the occurrence of mosquitoes in South Moravia were represented (Figure 1). The Sedlec site [48°47′N, 16°43′E, 176 m above sea level (a.s.l.)] is located at the edge of a town, on the embankment of Nesyt Pond. Nesyt is the largest pond in Moravia (322 ha) and it is the first in the Lednice pond system. The site consists of a group of bushes and low trees (*Salix fragilis*) growing on the periphery between the pond's embankment vegetation and a meadow. The bank of the pond is densely vegetated, mostly by reeds (*Phragmites australis*). The meadow is part of the Slanisko National Natural Reserve and is characterized by the occurrence of halophilous flora and fauna (e.g., *Scorzonera parviflora*, *Tripolium pannonicum*, *Spergularia salina*, *Bucculatrix maritima*, *Coleophora halophilella*). The Lednice site (48°47′N, 16°49′E, 159 m a.s.l.) is situated on the edge of Mlýnský Pond. Mlýnský Pond has an area of 107 ha and is the last in the Lednice pond system. The site consists of dense reed vegetation (*Phragmites australis*) and a group of bushes and low trees, mostly willows (*Salix fragilis*). Both sites are located in a Natura 2000 Special Protection Area for birds (Horal et al. 2004).

Alluvial forests and wet meadows are represented by three locations: Křivé jezero, Kančí obora and Soutok. The alluvial forest vegetation is mainly composed of *Salix* spp. *Populus* spp. *Quercus robur, Fraxinus angustifolia*, *Tilia cordata* and *Carpinus betulus*; on the wet meadows, *Alopecurus pratensis*, *Poa pratensis* and *Carex praecox* are abundant. The Křivé jezero site (48°51′N, 16°44′E, 163 m a.s.l.) lies in the valley of the River Dyje in the vicinity of the Nové Mlýny reservoirs. As it is a nature preserve, it is only minimally influenced by human activities. The collection spot was at the edge of an alluvial forest. The Kančí obora site (48°46′N, 16°5′E, 153 m a.s.l.) is located approximately 14 km from the Křivé jezero site, downstream following the Dyje. An alluvial forest is situated between Břeclav, the district town, and the town of Lednice. The nearby Lednice chateau was formerly a summer estate of the Lichtenstein noble family, and the entire area is one of the most popular tourist sites in South Moravia. The collection spot is situated at the edge of alluvial forest approximately 500 m from Břeclav. The Soutok site (48°39′N, 16°58′E, 147 m a.s.l.) consists of extensive alluvial forests and meadows. The collection point is situated in the vicinity of the confluence of the rivers Morava and Dyje and is remote from residential areas (9 km from the town of Lanžhot). The distance from the Kančí obora site is approximately 15 km. The collection spot was on the edge of a forest and in the vicinity of a large meadow and a small pond. The Křivé jezero and Soutok sites are located in a Natura 2000 Special Protection Area for birds.

The Lanžhot site (48°43′N, 16°58′E, 151 m a.s.l.) consists of a farmstead with a house and several small stables. Farm animals are stabled here, in particular horses. It is situated on the edge of an alluvial forest (the Soutok game preserve) about 800 m from the town of Lanžhot. There is also a small pond on the farmstead and meadows surround it. The collection point was at the edge of the farmstead in brushy growth by a small brook.

Meteorological data

With its average temperature of 9.3°C, Southeast Moravia is one of the warmest areas of the Czech Republic. Annual precipitation averages around 490 mm. Temperature in the year 2009 was above average (annual average 10.1°C), while 2010 was

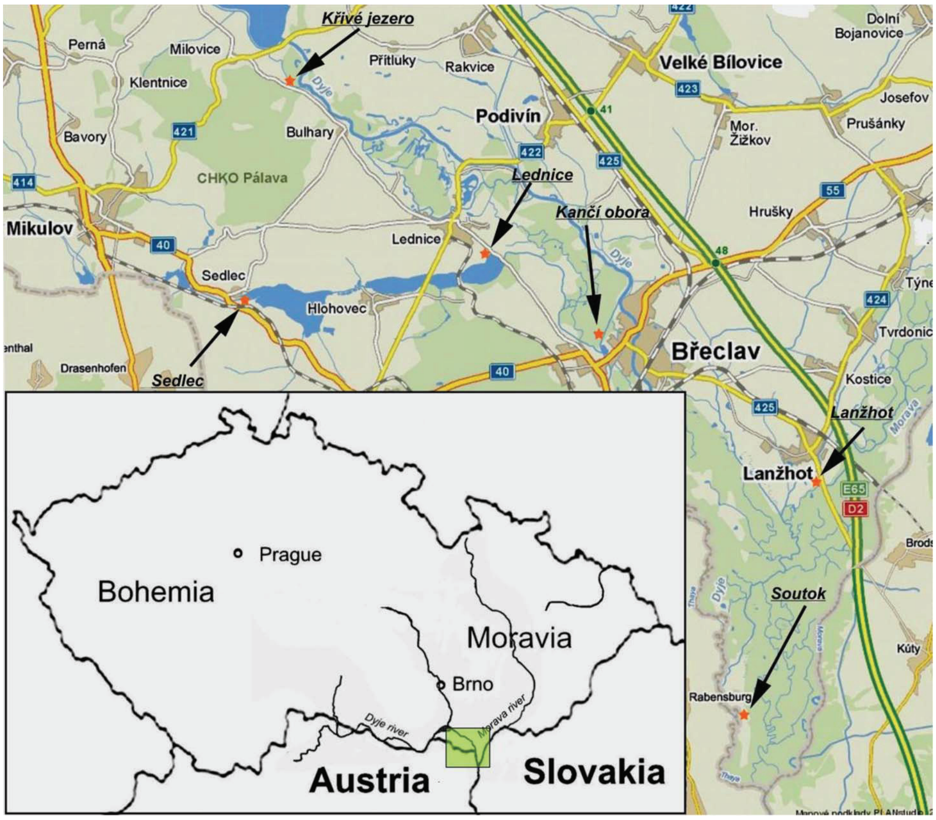

Figure 1. Map of study sites in the Czech Republic.

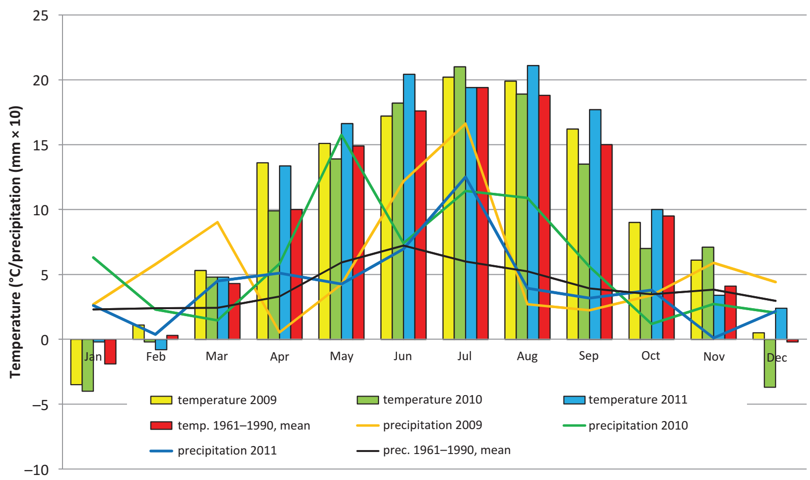

Figure 2. Mean monthly air temperature (°C) and monthly sum of precipitation (mm × 10) in the study area for 2009–2011 and comparison with long-term averages (Kobylí; data from Czech Hydrometeorological Institute in Brno).

slightly below average (8.9°C). Regarding precipitation, both years were significantly above average (697.2 mm in 2009, 142.3% of the norm; 729.4 mm in 2010, 148.9% of the norm). In 2011, the temperatures were slightly above average and precipitation about average (Figure 2). Rivers substantially overflowed only in 2010 (Figure 3).

Collecting method

Centers for Disease Control and Prevention (CDC) miniature light traps with carbon dioxide (CO_2)-dry ice (BioQuip Products, Inc., Rancho Dominiquez, CA, USA) were used. The traps were hung in protected places at a height of 1 m above the ground. They were exposed overnight (approximately from

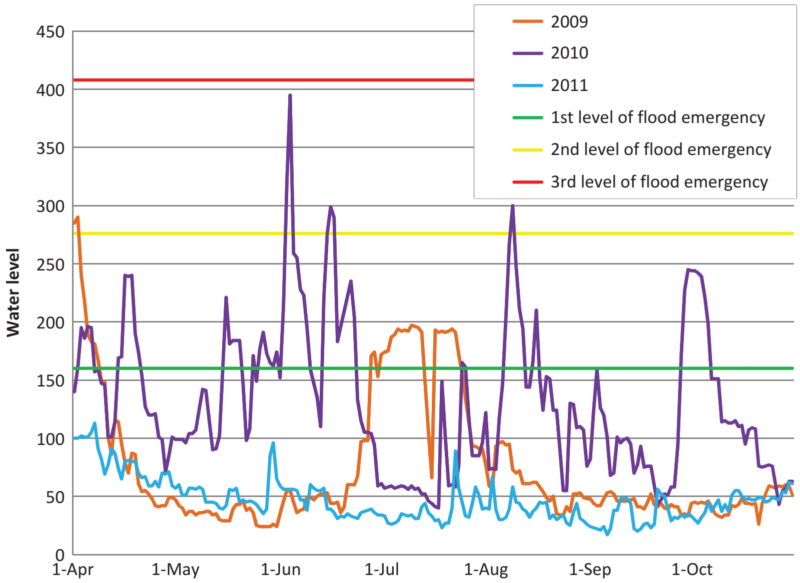

Figure 3. Height of water column in the River Dyje (cm) during 2009–2011 and levels for declaring individual levels of flood emergency.

16:00 until 8:00 the following day), always for two consecutive days. The interval between collections was 14 days. The study ran from early April until the end of October. Male mosquitoes, which were sporadically caught by the traps, were not included in the results. In addition to these methods, adult mosquitoes were captured by sweeping vegetation and/or by using an aspirator. Sweeping captured mainly males for more precise determination of species. Aspirators were used to capture especially females of *Anopheles maculipennis s.l.*, which were allowed to lay eggs in the laboratory. Stage IV larvae and pupae were also used for identification of certain mosquito species, and these were collected from water using a dense net with a diameter of 18 cm. Larvae were identified using keys, and pupae were raised into adults.

Identification

Identification was performed using keys by Kramář (1958) and Becker et al. (2010). Species determinations which were not reliably possible according to females are listed under common names in the results: *Ae. cantans s.l.* (*Ae. cantans* + *Ae. annulipes*), *Ae. cinereus s.l.* (*Ae. cinereus* + *Ae. geminus*) and *An. maculipennis s.l.* (*An. maculipennis* + *An. messeae*). In the species overview, the inventory was supplemented with species ascertained by determination of larvae and males. In order to determine *An. maculipennis s.l.*, eggs of females captured in the stables at the Lanžhot site were used. The presence of the species *Culex torrentium* was not ascertained due to a low number of acquired males (also with captured females it was not always possible to reliably differentiate) and any possible females are included within *Cx. pipiens s.l.*

Statistical analysis

The results are expressed as mean ± standard deviation (SD). GraphPad Prism 5 (GraphPad Software Inc., San Diego, CA, USA) was used for the descriptive statistics. Statistical analyses were made using one-way analysis of variance (ANOVA), and differences between treatments were compared using Tukey's range test. Two-way ANOVA was used for comparing differences between factors.

The Shannon-Weaver diversity index (H'), equitability index (E) and dominance index (C) were monitored for each year.

Results

Extreme weather fluctuations were recorded in 2009 and 2010, which markedly affected the occurrence of mosquitoes. In the second half of June and the first half of July 2009, South Moravia was hit by strong storms accompanied by local inundations, although rivers did not overflow. In May 2010, the weather was exceptionally rainy, which caused the rivers to rise and overflow. The rainy weather continued throughout most of the summer, and so the floods were very extensive and long-enduring. In 2011, the summer was relatively dry and summer inundations did not occur at all (Figures 2 and 3). This had a marked effect on the occurrence of mosquitoes (Figures 4–6; Tables I–IV).

In the course of the research during 2009–2011, a total of 415,218 females were captured using the CDC miniature light traps. The presence of 30 species in total within six genera was proven. The following species were determined: *Anopheles maculipennis* Meigen, *An. messeae* Falleroni, *An. claviger* (Meigen), *An. hyrcanus* (Pallas), *An. plumbeus* Stephens, *Aedes cinereus* Meigen, *Ae. geminus* Peus, *Ae. rossicus* Dolbeskin, Goritzkaja & Mitrofanova, *Ae. vexans* (Meigen), *Ae. annulipes* (Meigen), *Ae. cantans* (Meigen), *Ae. caspius* (Pallas), *Ae. cataphylla* Dyar, *Ae. communis* (De Geer), *Ae. dorsalis* (Meigen), *Ae. excrucians* (Walker), *Ae. flavescens* (Müller), *Ae. geniculatus* (Olivier), *Ae. intrudens* Dyar, *Ae. leucomelas* (Meigen), *Ae. rusticus* (Rossi), *Ae. sticticus* (Meigen), *Culex martinii* Medschid, *Cx.*

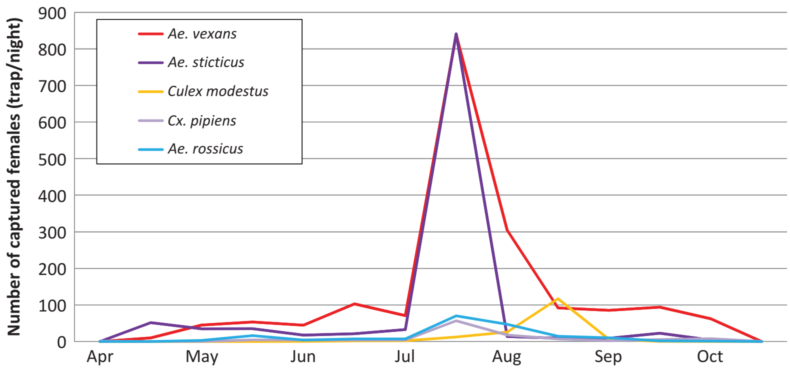

Figure 4. Dynamics for occurrence of selected mosquito species during 2009 (capture recalculated per 1 trap and 1 night). In addition to the usual spring inundations, in July 2009 there were local floods due to repeated severe storms, although the rivers did not overflow.

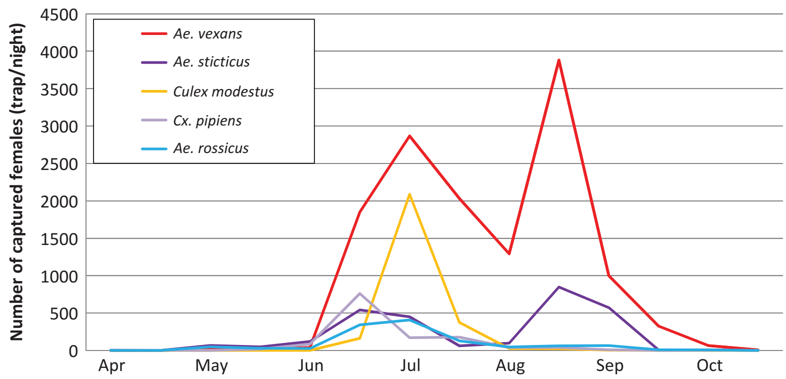

Figure 5. Dynamics for occurrence of selected mosquito species during 2010. In addition to the spring inundations, in summer 2010 there were repeated floods due to exceptionally abundant precipitation and overflowing of the rivers.

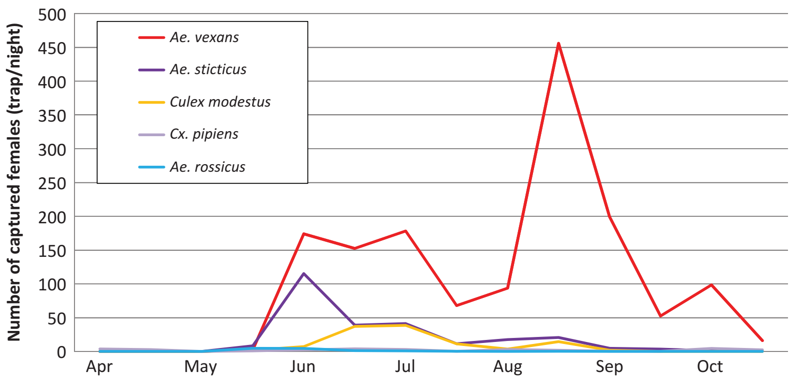

Figure 6. Dynamics for occurrence of selected mosquito species during 2011. In 2011, only spring inundations in the usual extent occurred. Summer flooding did not occur.

Table I. Representation individual mosquito species. The number of captured specimens (No), relative abundance (%) and classification of dominance (CD): eudominance (ED, more than 10%), dominant (D, 5–10%), subdominant (SD, 2–5%), recedent (R, 1–2%) and subrecedent (SR, less than 1%). ED and D are marked in bold. C – dominance index; H' – Shannon-Weaver diversity index; E – equitability index.

Species	2009			2010			2011			Total		
	No	%	CD	No	%	CD	No	%	CD	No	%	CD
An. claviger	454	0.66	SR	1128	0.36	SR	224	0.67	SR	1806	0.43	SR
An. hyrcanus	15	0.02	SR	148	0.05	SR	142	0.43	SR	305	0.07	SR
An. maculipennis s.l.	702	1.02	SR	2668	0.85	SR	822	2.47	SD	4192	1.01	R
An. plumbeus	218	0.32	SR	59	0.02	SR	54	0.16	SR	331	0.08	SR
Ae. cantans s.l.	2480	3.61	SD	3960	1.26	R	3678	11.07	ED	10118	2.44	SD
Ae. caspius	17	0.02	SR	53	0.02	SR	6	0.02	SR	76	0.02	SR
Ae. cataphylla	789	1.15	R	428	0.14	SR	62	0.19	SR	1279	0.31	SR
Ae. cinereus s.l.	1676	2.44	SD	2514	0.80	SR	427	1.29	R	4617	1.11	R
Ae. communis	–			2	< 0.01	SR	1	< 0.01	SR	3	< 0.01	SR
Ae. dorsalis	1	< 0.01	SR	–			–			1	< 0.01	SR
Ae. excrucians	56	0.08	SR	76	0.02	SR	34	0.10	SR	166	0.04	SR
Ae. flavescens	20	0.03	SR	57	0.02	SR	17	0.05	SR	94	0.02	SR
Ae. geniculatus	1	< 0.01	SR	38	0.01	SR	13	0.04	SR	52	0.01	SR
Ae. intrudens	405	0.59	SR	371	0.12	SR	26	0.08	SR	802	0.19	SR
Ae. leucomelas	2	< 0.01	SR	4	< 0.01	SR	–			6	< 0.01	SR
Ae. rossicus	3,022	4.40	SD	18,226	**5.82**	**D**	200	0.60	SR	**21,448**	**5.17**	**D**
Ae. rusticus	–			1	< 0.01	SR	–			1	< 0.01	SR
Ae. sticticus	**23,206**	**33.79**	**ED**	**40,325**	**12.87**	**ED**	**4,544**	**13.68**	**ED**	**68,075**	**16.40**	**ED**
Ae. vexans	**31,704**	**46.16**	**ED**	**182,998**	**58.41**	**ED**	**19,978**	**60.13**	**ED**	**234,680**	**56.52**	**ED**
Cq. richiardii	461	0.67	SR	691	0.22	SR	1001	3.01	SD	2153	0.52	SR
Cs. annulata	135	0.20	SR	477	0.15	SR	136	0.41	SR	748	0.18	SR
Cs. morsitans	–			6	< 0.01	SR	1	< 0.01	SR	7	< 0.01	SR
Cx. martinii	–			1	< 0.01	SR	–			1	< 0.01	SR
Cx. modestus	1238	1.80	R	34,134	**10.89**	**ED**	1475	4.44	SD	36,847	**8.87**	**D**
Cx. pipiens s.l.	2069	3.01	SD	27,941	**7.96**	**D**	377	1.13	SR	27,387	**6.60**	**D**
Cx. territans	1	< 0.01	SR	2	< 0.01	SR	4	0.01	SR	7	< 0.01	SR
Ur. unguiculata	5	0.01	SR	6	< 0.01	SR	5	0.02	SR	16	< 0.01	SR
Total specimens	68,678			313,314			33,227			415,218		
Total species	23			26			23			27		
C	0.33			0.38			0.40			0.36		
H´	1.49			1.39			1.42			1.47		
E	0.47			0.43			0.45			0.44		

modestus Ficalbi, *Cx. pipiens* Linnaeus, *Cx. territans* Walker, *Culiseta annulata* (Schrank), *Cs. morsitans* (Theobald), *Coquilletidia richardii* (Ficalbi) and *Uranotaenia unguiculata* Edwards (Tables I and V).

Dominant occurrence was determined especially among the calamity and inundation species *Ae. vexans* (234,680 specimens, 56.52%), *Ae. sticticus* (68,075, 16.40%) and *Ae. rossicus* (21,448, 5.17%).

In comparing the representation of these species at the locations within a single biotope, no significant differences were determined in species representation between the alluvial forest sites Křivé jezero, Kančí Obora and Soutok ($P = 0.4609$, $F = 0.8267$) or between the pond sites Sedlec and Lednice ($P = 0.5706$, $t = 0.5914$, df = 8). Nor were there significant differences among different biotopes, these being ponds, alluvial forest and farmstead ($P = 0.1470$, $F = 2.259$). However, significant differences were observed between the locations of alluvial forest and pond biotopes ($P = 0.0029^{**}$, $F = 44.33$) and between the Soutok (alluvial forest) and Lanžhot (farmstead) sites ($P = 0.0023^{**}$, $F = 49.72$). The most notably significant difference was recorded between the alluvial forest sites collectively and the Lanžhot farmstead ($P = 0.0007^{***}$, $F = 89.90$).

Comparisons of collections between years at Sedlec (2009, 2010 and 2011) showed there were no statistically significant differences between years in relation to the species collected ($P = 0.0584$, $F = 1.921$). Differences between years (column factor) were significant ($P = 0.0053^{**}$, $F = 5.370$), but no significant differences were found in the factor species ($P = 0.0556$, $F = 2.348$).

In comparing collections between years at Kančí Obora (2009, 2010 and 2011), there again were no statistically significant differences between years

Table II. Proportional representation of individual species of mosquitoes and total amount of captured females in the year 2009.

	April		May		June		July		August		September		October	
	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
An claviger		0.61	0.92	1.7	1.99	2.84	1.55	0.35	0.65	0.72	1.1	0.57	2.6	
An. hyrcanus			0.06	0.05				0.02		0.13	0.14		0.1	
An. maculipennis s. l.	10.71	0.08	0.34	1.16	3.12	3.55	2.89	0.78	1.2	0.98	0.89			
An. plumbeus		0.08	0.06	0.14	0.27	0.57	1.05	0.15	0.53	1.7	1.38	0.45	0.83	
Ae. cantans s. l.		0.15	19.26	12.9	25.13	19.61	24.87	0.7	0.27	0.25	0.14			
Ae. caspius								0.03			0.07		0.21	
Ae. cataphylla		24.53	10.95	7.05	5.77	1.24								
Ae. cinereus s. l.		0.91	5.16	10.53	5.31	6.29	6.28	1.21	3.65	2.76	4.13	3.95	2.08	
Ae. communis														
Ae. dorsalis		0.08												
Ae. excrucians			0.69	0.51	0.4	0.36	0.42		0.08	0.04				
Ae. flavescens			0.06	0.46	0.33	0.04			0.04					
Ae. geniculatus												0.06		
Ae. intrudens		16.58	4.93	4.64										
Ae. leucomelas			0.11											
Ae. rossicus		0.08	2.23	9	3.25	3.02	3.56	3.71	11.06	7.35	8.4	1.21	1.14	
Ae. rusticus														
Ae. sticticus		47.01	23.84	19.58	14.06	9.13	16.33	44.58	3.25	4.54	7.5	17.39	5.3	
Ae. vexans		9.08	31.06	29.74	35.68	43.84	35.59	44.46	71.61	46.79	70.34	71.72	77.47	
Cx. martinii														
Cx. modestus					0.13	0.67	1.09	0.65	3.02	29.81	2.62	0.06		
Cx. pipiens s. l.	57.14	0.45	0.34	2.51	3.25	1.71	2.05	3	4.18	3.48	1.65	4.27	9.66	100
Cx. territans													0.1	
Cs. annulata	32.14	0.38		0.65	1.13	0.36	0.29	0.07	0.33	0.59	0.21	0.13	0.52	
Cs. morsitans														
Cq. richiardii					0.2	6.79	4.02	0.28	0.12	0,76	1,45	0,06		
Ur. unguicullata									0.02	0.08		0.13		
Number of captured females	28	1321	1745	2155	1508	2815	2388	45,274	5100	2355	1453	1570	963	2

in relation to the species collected (P = 0.7496, F = 0.6329). Differences between years (column factor) were, however, very significant (P = 0.0003*** F = 5.524), as was true also for the factor species (P = 0.0010**, F = 7.138).

Sites were compared within individual years. For 2009, statistical analysis showed that collections at Kančí obora (alluvial forest) and Sedlec (pond) did not differ significantly in considering the factor year with species collected (P = 0.7496, F = 0.6329). Differences between years (column factor) were very significant (P = 0.0003***, F = 5.524), and differences for the factor species were highly significant (P = 0.0010**, F = 7.138).

Comparison between collections for 2010 at Kančí obora and Sedlec showed there were no significant differences in considering the factor year with species collected (P = 0.0708, F = 2.211). Differences between years (column factor) were significant (P = 0.0.0104, F = 6.751) while significant differences were found also with the factor species (P = 0.0107, F = 3.414).

Again comparing Sedlec and Kančí obora, statistical analysis for 2011 showed very highly significant differences for the factor year in relation to species collected (P ≤ 0.0001 F = 8.472). Differences in the column factor were very highly significant (P = 0.0001, F = 15.43), and significant differences were found also for the factor species (P ≤ 0.0001, F = 7.023).

In the first half of April, only sporadic occurrence of species overwintering in the female stage was recorded (*Cx. pipiens s.l.*, 70.39%; *Cs. annulata*, 14.53%; and *An. maculipennis s.l.*, 14.53%). Average capture in this period was 4.97 specimens per trap per night (Table V, Figures 7 and 8). In the second half of April, there was a sharp increase in capture rate (41.56 specimens per trap per night). Snow-melt species (*Ae. cataphylla*, *Ae. intrudens*, sporadically also *Ae. communis* and *Ae. leucomelas*) were notably represented, at 17.28 specimens per trap per night (41.56% from the total number of captured mosquitoes), as was *Ae. sticticus* (17.25 specimens per trap, 41.51%). The occurrence of snow-melt species peaked in the first half of May (19.56 specimens per trap per night, 16.58%) and ceased in June. In May, the occurrence of mosquitoes was increasing (118 specimens per trap per night in the first half of the month, 153.3 specimens in the second half). The species *Ae. sticticus* (28.66% of all captured

Table III. Proportional representation of individual species of mosquitoes and total amount of captured females in the year 2010.

	April		May		June		July		August		September		October	
	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
An claviger		0.76	0.16	0.17	0.22	0.20	0.07	1.13	0.56	0.33	0.53	0.57	3.49	13.24
An. hyrcanus			0.04	0.17		0.02	0.01	0.13	0.04	0.05	0.18	0.02		
An. maculipennis s. l.	11.63	3.79	0.85	5.35	0.64	1.25	0.79	1.25	0.80	0.23	0.07	0.12		0.74
An. plumbeus					0.03	0.01	0.01	0.04	0.05			0.28	0.92	
Ae. cantans s. l.			12.13	10.87	5.23	1.31	1.72	1.68	0.28	0.13				
Ae. caspius			0.04	0.04	0.03		0.01	0.01	0.01	0.02	0.02	0.50	0.09	
Ae. cataphylla		9.85	7.72	7.56	1.14									
Ae. cinereus s. l.			2.71	4.18	1.45	0.71	1.00	1.07	0.43	0.39	0.67	1.00	2.57	1.47
Ae. communis		1.52												
Ae. dorsalis														
Ae. excrucians			1.09	0.54	0.03	0.02		0.03						
Ae. flavescens			0.16	0.13	0.03	0.05	0.01							
Ae. geniculatus					0.03				0.07	0.02	0.03		0.09	
Ae. intrudens		48.48	9.22	3.01	0.19									
Ae. leucomelas				0.17										
Ae. rossicus			23.44	15.21	8.52	9.03	6.53	4.37	3.09	1.26	3.88	2.68	7.63	2.94
Ae. rusticus			0.04											
Ae. sticticus			32.38	24.36	39.87	14.23	7.21	2.12	6.37	17.25	34.09	1.54	8.92	0.74
Ae. vexans			9.74	12.91	12.67	48.63	45.91	68.79	83.86	78.95	59.60	92.67	72.52	64.71
Cx. martinii					0.03									
Cx. modestus		14.39		0.42	0.33	4.28	33.43	12.70	1.67	0.46	0.22	0.09		1.47
Cx. pipiens s. l.	75.58	18.94	0.16	9.11	28.51	20.02	2.74	6.02	2.57	0.83	0.56	0.28	3.58	14.71
Cx. territans	1.16													
Cs. annulata	11.63	2.27	0.12	5.81	1.06	0.15	0.07	0.13	0.09	0.03	0.05	0.17	0.09	
Cs. morsitans												0.05		
Cq. richiardii						0.08	0.50	0.50	0.11	0.05	0.08	0.02		
Ur. unguicullata								0.01					0.09	
Number of captured females	86	132	2474	2393	3592	91,262	74,931	35,445	18,475	58,969	20,117	4214	1088	136

females in the first half of the month, 20.04% in the second half), *Ae. cantans s.l.* (15.12% and 17.60%), *Aedes rossicus* (14.60% and 11.13%) and *Ae. vexans* (14.44% and 17.72%) reached eudominant or dominant representation. *Ae. cinereus s.l.* (8.14%) and *Cx. pipiens s.l.* (5.11%) reached this representation in the second half of the month.

Another marked increase occurred in the second half of June (2,332.71 specimens per trap per night versus 349.33 in the first half of June), and the high occurrence of mosquitoes continued until the end of August (Figure 9). For this entire period, the species *Ae. vexans* (35.23–80.20%), *Ae. sticticus* (6.14–25.63%), and *Ae. rossicus* (1.37–8.51%) were dominant. The species *Cx. pipiens* (2.61–18.75%) and *Cx. modestus* (4.46–31.21%) also were very abundant until the end of July.

In September, a rapid decrement in mosquito occurrence was recorded (672.08 specimens per trap per night in the first half of the month but only 180.33 in the second half) (Figure 10). In the second half of October only females of *Ae. vexans*, *An. claviger* and *Cx. pipiens s.l.* were regularly determined, and the occurrence of other species (*Ae. cinereus s.l.*, *Ae. rossicus* a *Ae. sticticus, Cx. modestus, An. maculipennis s.l.* and *An. plumbeus*) was only sporadic.

Discussion

Captures were performed from early April to the end of October. This time period was established based upon observations as to the usual start and end of mosquitoes' discernible activity. Spring activity occurs after warming, which usually occurs in March. Spring months, however, are characterized by considerable variability in weather. Although in certain years temperatures above 20°C are sporadically recorded already in March (20.7°C on 20 March 2007), in May temperatures may drop to zero, which can temporarily limit mosquito activity (early May 2011). The numbers of snow melt mosquitoes depend partially on precipitation, but, in this period, the water level in rivers is more important and is determined by the snow level in the mountains during the winter months and the speed of its thawing. Mosquito activity rapidly decreases in the second half of October, when cooling frequently occurs and some days temperatures even drop below the freezing

Table IV. Proportional representation of individual species of mosquitoes and total amount of captured females in the year 2011.

	April		May		June		July		August		September		October	
	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
An claviger					0.29	1.13	0.60	0.20	0.41	0.43	1.45	2.97	1.24	5.83
An. hyrcanus				0.10	0.01	0.5	1.11		0.47	0.18	2.51		0.23	
An. maculipennis s. l.	20.00	20.93	14.29	9.38	1.96	3.03	4.57	4.55	4.35	0.76	0.19			
An. plumbeus				0.21	0.09	0.21	0.20	0.07	0.18	0.07	0.42	0.85		0.42
Ae. cantans s. l.			21.43	44.64	18.65	18.30	11.40	8.22	5.82	0.08				
Ae. caspius				0.21	0.03					0.02				
Ae. cataphylla				4.54	0.19									
Ae. cinereus s. l.			28.57	12.58	1.72	1.36	0.82	0.27	0.29	0.20	0.08	0.56	1.00	0.83
Ae. communis				0.10										
Ae. dorsalis														
Ae. excrucians			10.71	2.68	0.03	0.03		0.07						
Ae. flavescens				0.82	0.08					0.02				
Ae. geniculatus				0.10	0.02		0.02		0.06	0.12	0.04			
Ae. intrudens			21.43	1.96	0.01									
Ae. leucomelas														
Ae. rossicus			3.57	5.77	1.13	0.38	0.24	0.13	0.06	0.07		0.14	0.08	
Ae. rusticus														
Ae. sticticus				10.41	28.92	12.01	11.00	9.22	12.41	4.09	2.10	5.93	1.08	0.83
Ae. vexans				2.89	43.63	46.93	47.45	54.41	66.18	89.79	91.16	88.84	91.27	80.00
Cx. martinii														
Cx. modestus				2.27	1.82	11.39	10.25	8.96	2.53	2.84	0.80	0.14	0.08	
Cx. pipiens s. l.	69.23	74.42		1.03	0.59	1.23	0.78	0.7	2.06	0.35	0.23	0.42	4.10	12.08
Cx. territans						0.05	0.04							
Cs. annulata	10.77	4.65		0.31	0.34	0.33	0.42	0.13	0.88	0.16	0.76	0.14	0.85	
Cs. morsitans					0.01									
Cq. richiardii					0.47	3.57	11.05	13.50	4.29	0.61	0.27			
Ur. unguicullata							0.04			0.03			0.08	
Number of captured females	65	43	28	970	9572	3897	4508	1496	1700	6081	2625	708	1294	240

point (–3.6°C on 28 October 2010), although in certain years warm weather lasts until November, when limited mosquito activity can also be encountered (20.1°C on 5 November 2010).

In relation to expected changes in climate and related increased incidence of extreme conditions (Kyselý 2009, 2010), the weather's influence upon the occurrence of mosquitoes is becoming a focal point of interest. Considerable differences in mosquito occurrence were also recorded between 2009, 2010 and 2011 (Figures 4–6; Tables III–V) and were caused mainly by different amounts of precipitation, its distribution through the year, and the related flow rates of rivers.

The genus *Aedes* was subject to extensive revision in recent years, wherein the sub-genus *Ochlerotatus* was promoted to a separate genus (Reinert 2000) (*Oc. annulipes*, *Oc. cantans*, *Oc. caspius*, *Oc. cataphylla, Oc. communis*, *Oc. dorsalis, Oc. excrucians*, *Oc. flavescens*, *Oc. geniculatus*, *Oc. intrudens*, *Oc. leucomelas*, *Oc. rusticus*, *Oc. sticticus*). In the following years, several more genera were created (Reinert et al. 2009). Since, in view of the fact that these changes are not generally accepted and many authors still use the traditional division of the single genus *Aedes* into sub-genera (Savage 2005) and a new division will be more precise in the future, the authors choose to keep a united genus *Aedes* for the sake of better comprehensibility.

In the adjacent areas of western Slovakia, extensive mosquito research has been conducted, for example, by Labuda (1977), who detected 27 mosquito species there. Among newer studies, the occurrence of mosquitoes in southwestern Slovakia was studied by Jalili et al. (1999) and in 2009 and 2010 by Strelková & Halgoš (2012). In the latter study, the authors detected the occurrence of 28 mosquito species by sweeping adult mosquitoes from vegetation. The species *Ae. vexans*, *Ae. sticticus*, *Ae. rossicus* and *Ae. cinereus* were most represented there.

The closest research from neighbouring states on seasonal dynamics was conducted in Croatia (Osijek) by Sudarič Bogojevič et al. (2009). That work was carried out over 10 years (1995–2004), and 207,136 specimens belonging to 20 species and seven genera were captured using CDC traps. Collections were performed from May through to the end of September. The species composition of mosquitoes was similar to that presented here. *Ae. vexans* had eudominant or dominant representation

Table V. Average capture of mosquitoes in Centers for Disease Control and Prevention (CDC) traps (number of specimens per trap per capture day).

Species	April		May		June		July		August		September		October		April–October
	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31	
An. claviger	0	0.25	0.56	0.75	1.57	7.19	3.17	13.43	4.00	6.53	4.44	1.50	2.19	0.89	3.34
An. hyrcanus	0	0	0.06	0.17	0.02	0.57	1.50	1.24	0.42	1.14	2.92	0.03	0.11	0	0.56
An. maculipennis s.l.	0.72	0.42	0.86	6.78	6.14	32.40	24.11	20.60	7.86	5.64	0.89	0.14	0	0.03	7.76
An. plumbeus	0	0.03	0.03	0.14	0.33	0.71	1.08	1.95	1.08	1.22	0.89	0.69	0.50	0.03	0.61
Ae. cantans s.l.	0	0.06	17.83	26.97	56.00	58.52	66.67	24.69	4.58	2.47	0.06	0	0	0	18.74
Ae. caspius	0	0	0.03	0.08	0.10	0.07	0.14	0.38	0.03	0.36	0.17	0.58	0.08	0	0.14
Ae. cataphylla	0	9.36	10.61	10.47	3.48	0.88	0	0	0	0	0	0	0	0	2.37
Ae. cinereus s.l.	0	0.33	4.58	12.47	7.07	20.95	25.97	22.14	7.53	8.56	5.47	3.00	1.69	0.11	8.55
Ae. communis	0	0.06	0	0	0.03	0	0	0	0	0	0	0	0	0	0.01
Ae. dorsalis	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	< 0.01
Ae. excrucians	0	0	1.17	1.39	0.24	0.69	0.36	0.36	0.11	0.06	0.03	0	0	0	0.31
Ae. flavescens	0	0	0.14	0.58	0.33	1.07	0.14	0.02	0.06	0.03	0	0	0	0	0.17
Ae. geniculatus	0	0	0	0.03	0.07	0.07	0.06	0.02	0.39	0.53	0.19	0.03	0.03	0	0.10
Ae. intrudens	0	7.86	8.89	5.31	0.19	0	0	0	0	0	0	0	0	0	1.49
Ae. leucomelas	02	0	0.06	0.11	0	0	0	0	0	0	0	0	0	0	0.01
Ae. rossicus	0	0.03	17.22	17.06	11.02	198.6	138.6	76.93	31.53	25.58	25.06	3.69	2.64	0.11	39.72
Ae. rusticus	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	< 0.01
Ae. sticticus	0	17.25	33.81	30.72	105.1	326.6	174.6	501.7	43.14	292.4	195.1	10.6	4.50	0.08	126.1
Ae. vexans	0	3.33	21.75	27.17	123.1	1130	1039	1079	563.1	1476	427.9	157.2	75.44	7.78	434.6
Cq. richiardii	0	0	0	0	1.14	9.52	26.89	12.02	2.78	2.36	1.25	0.06	0	0	3.99
Cs. annulata	0.72	0.28	0.08	4.33	2.10	3.74	2.08	1.93	1.33	1.22	0.92	0.28	0.47	0	1.39
Cs. morsitans	0	0	0	0	0.02	0	0.08	0	0	0	0.03	0.06	0	0	0.01
Cx. martinii	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	< 0.01
Cx. modestus	0	0.53	0	0.89	4.48	104.1	709.4	117.5	14.06	31.89	2.86	0.17	0.03	0.06	68.24
Cx. pipiens s.l.	3.50	1.75	0.23	7.83	26.88	437.3	59.36	83.31	20.08	16.42	3.94	2.28	5.14	1.42	50.72
Cx. territans	0.03	0	0	0	0	0.05	0.08	0	0	0	0	0	0.03	0	0.01
Ur. unguiculata	0	0	0	0	0	0	0.06	0.10	0.03	0.14	0	0.06	0.06	0	0.03
All species	4.97	41.56	118.0	153.3	349.3	2333	2273	1958	702.1	1872	672.1	180.3	92.92	10.5	768.9

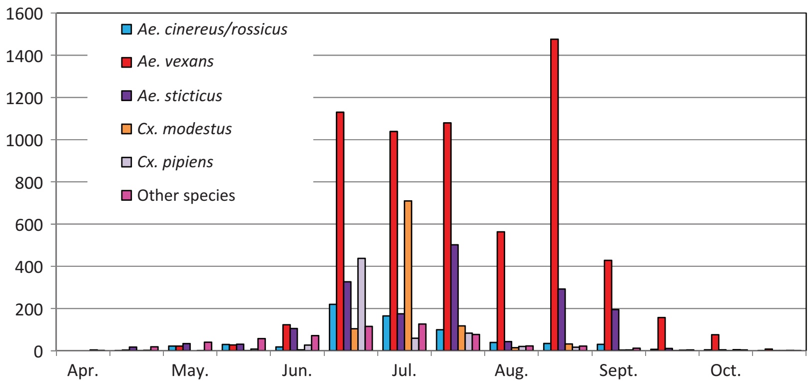

Figure 7. Average capture of mosquitoes in Centers for Disease Control and Prevention (CDC) traps during 2009–2011 (number of specimens per trap per capture day).

there (75%), and it had 56.52% representation in the present study of the Lower Dyje River Valley. *Ae. sticticus* had accounted for 13.34% in Croatia (16.40% in the Lower Dyje River Valley) and *Cx. pipiens* for 5.86% (6.60% in the Lower Dyje River Valley). By contrast, the species *Cx. modestus* and *Aedes rossicus*, which had significant representation in the Lower Dyje River Valley (8.87% and 5.17%, respectively), had been scarce in Croatia's Osijek (0.16% and 0.34%). In Osijek, the capture of snow-melt species was very low, which can be related to a later starting date of collection. In contrast to the Lower Dyje River Valley, the peak of occurrence in Osijek was reached already from the very start of trapping and *Ae. vexans* was the dominant species already in May. During 1995–2002, Merdič & Boca

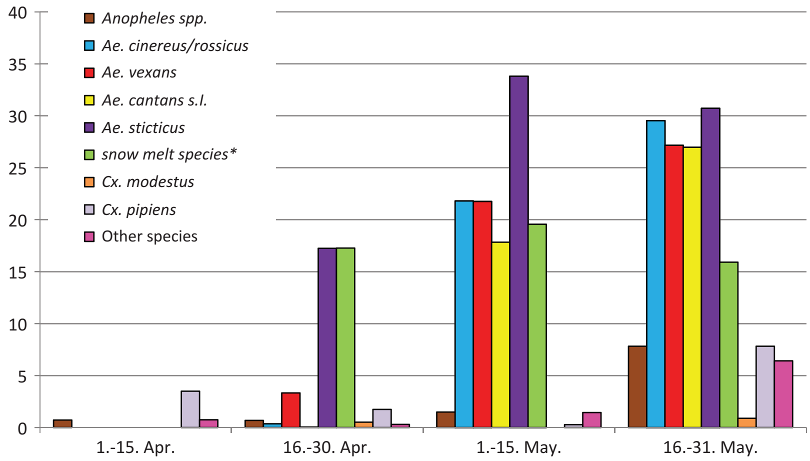

Figure 8. Average capture of mosquitoes in Centers for Disease Control and Prevention (CDC) traps during spring of 2009–2011 (number of specimens per trap per capture day). *Snow melt species = *Ae. cataphylla*, *Ae. communis*, *Ae. leucomelas*, *Ae. intrudens.*

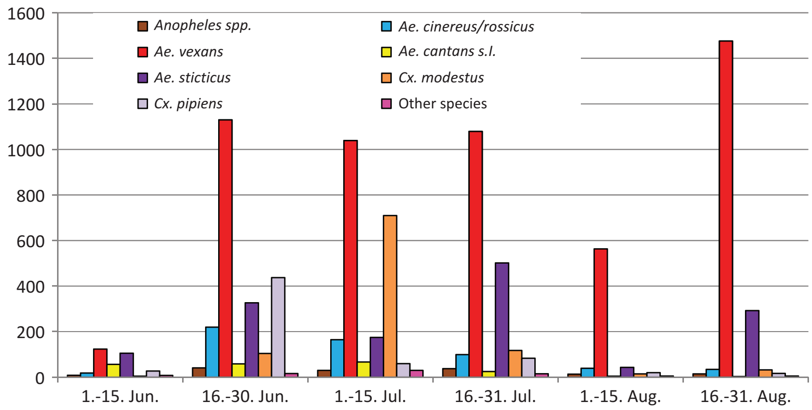

Figure 9. Average capture of mosquitoes in Centers for Disease Control and Prevention (CDC) traps during summer of 2009–2011 (number of specimens per trap per capture day).

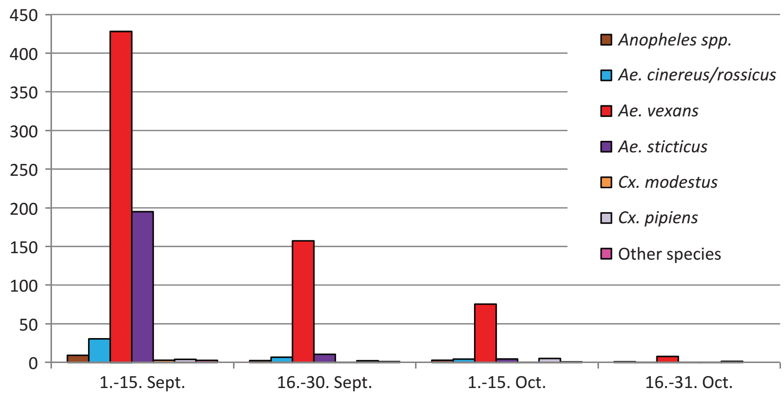

Figure 10. Average capture of mosquitoes in Centers for Disease Control and Prevention (CDC) traps during autumn of 2009–2011 (number of specimens per trap per capture day).

(2004) examined seasonal dynamics of the *An. maculipennis* complex mosquitoes in the same area of Croatia. Also in that study, the collection used CDC traps from May until September. A total of 3508 mosquito imagines were captured, and the highest occurrence was recorded in late July. In the Lower Dyje River Valley, the authors of the present paper captured a total of 1124 females of *An. ma-*

culipennis s.l. The seasonal dynamics were very similar here, with the peak of occurrence at the turn of June and July. The relative representation of individual species is affected also by the collection method, as species with markedly daytime activity (especially *Ae. sticticus*) are captured less frequently (Šebesta et al. 2011).

The results show there currently is no sharp boundary in South Moravia between the start of large-scale occurrence of snow-melt species and of species the occurrence of which is rather more typical for late spring and summer (*Ae. sticticus*, *Ae. vexans*, *Ae. rossicus*; Table V). This conclusion is in conformity with the research of Rettich et al. (2007) in South Moravia during the April floods of 2006 based on determination of captured larvae. In that year, in addition to the early spring and spring species *Ae. cataphylla* (20.40%), *Ae. intrudens* (7.10%) and *Ae. cantans/annulipes* (19.63%), the species *Ae. sticticus* (39.04%) and *Ae. vexans* (8.25%) also became dominant. Similar comparison with the findings from Croatia (Sudarič Bogojevič et al. 2009) is not possible in this case, as the first collection there was made as late as May 10 when most of the mosquito species occurring there were already found and the population was determined to be approaching its maximum. The capture of snow-melt species was already minimal in this period.

There are marked differences between the impacts upon human inhabitants from mosquitoes occurring in extreme abundance due to spring or summer inundations. Spring inundations are very frequent in South Moravia and occur almost every year. The species composition of mosquitoes is diverse during the floods, but the total occurrence of mosquitoes is significantly lower. We can expect increased collection already at the turn of April and May. During the summer floods, approximately 10× greater occurrence of mosquitoes was recorded, and in the alluvial forests only the species *Ae. vexans* and *Ae. sticticus* generally contributed in substantial proportions to this high occurrence, except that in some locations *Ae. rossicus* was also important. The various occurrence of mosquitoes after the spring and summer inundations in connection with the species composition indicates lower risks to the population in spring than in the summer. The population is mainly exposed to severe harassment by female mosquitoes. While spring species fly outside the area of alluvial forests only in small numbers and over short distances, it is typical especially of *Ae. vexans*, and in particular with summer flooding, to fly in massive numbers into residential areas. It is this species, too, that is the main vector of the Ťahyňa virus here. During the 1997 floods, TAHV antibodies were demonstrated in 53.8% of inhabitants who visited a doctor while WNV antibodies occurred in 2.1% (Hubálek et al. 1999). Some of these species (*Ae. vexans*, *Ae. rossicus*) act as vectors of the Ťahyňa virus (Danielová et al. 1972; Rosický & Málková 1980). Of WNV vectors, only *Cx. modestus* Ficalbi (36,846, 8.92%) and *Cx. pipiens s.l.* (27,305 specimens, 6.61%) were dominant species. In the threatened area of the lower Dyje river basin, there are 12 municipalities with more than 42,000 inhabitants. A considerable number of those inhabitants work in agriculture, and hiking and cycling are quite widespread here.

The localization of mosquito hatching grounds in the border area of Moravia (Czech Republic), Lower Austria and Western Slovakia reinforces the expediency of international coordination against mosquito population outbreaks.

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References

Aldemir A, Bedir H, Demirci B, Alten B. 2010. Biting activity of mosquito species (Diptera: Culicidae) in the Turkey-Armenia border area, Ararat Valley, Turkey. Journal of Medical Entomology 47:22–27.

Bakonyi T, Hubálek Z, Rudolf I, Nowotny N. 2005. Novel flavivirusor new lineage of West Nile virus, central Europe. Emerging Infectious Diseases 11:225–231.

Balenghien T, Carron A, Sinègre G, Bicout DJ. 2010. Mosquito density forecast from flooding: population dynamics model for *Aedes caspius* (Pallas). Bulletin of Entomological Research 100: 247–254.

Bárdoš V, Ryba J, Hubálek Z, Olejníček J. 1978. Virological examination of mosquito larvae from southern Moravia. Folia Parasitologica 25:75–78.

Becker N, Petrič D, Zgomba M, Boase C, Minoo M, Dahl Ch, Kaiser A. 2010. Mosquitoes and their control. 2nd ed. Dordrecht, London, New York: Springer Heidelberg.

Caglar SS, Alten B, Bellini R, Simsek F, Kaynas S. 2003. Comparison of nocturnal activities of mosquitoes (Diptera: Culicidae) sampled by New Jersey light traps and CO_2 traps in Belek, Turkey. Journal of Vector Ecology 28: 12–22.

Chytil J, Macháček P. 2002. Aves. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 106:63–120.

Danielová V, Hájková Z, Minář J, Ryba J. 1972. Virological investigation of mosquitoes in different seasons of the year at the natural focus of the Ťahyňa virus in southern Moravia. Folia Parasitologica 19:25–31.

Havlík O, Rosický B.1952. The malaria in southern Moravia after the Second World War. Časopis lékařů českých:888–893 (in Czech).
Horal D, Horák P, Hubálek Z, Macháček P. 2004. Birds of the alluvial forest area of the Lower Morava and Dyje river basins. In: Hrib M, Kordiovský E, editors. Lužní les v Dyjskomoravské nivě. Břeclav: Moraviapress. pp. 395–411 (in Czech).
Hubálek Z. 2004. An annotated checklist of pathogenic microorganisms associated with migratory birds. Journal of Wildlife Diseases 40:639–659.
Hubálek Z, Halouzka J, Juřicová Z, Příkazský Z, Žáková J, Šebesta O. 1999. Surveillance of Mosquito-borne Viruses in Břeclav Area (Czech Republic) after the 1997 flood. Epidemiologie, Mikrobiologie, Imunologie 48:91–96 (in Czech).
Hubálek Z, Halouzka J, Juřicová Z, Šebesta O. 1998. First isolation of mosquito-borne West Nile virus in the Czech Republic. Acta Virologica 42:119–120.
Hubálek Z, Halouzka J, Juřicová Z, Šikutová S, Rudolf I, Honza M, Janková J, Chytil J, Marec F, Sitko I. 2008. Serologic survey of birds for West Nile flavivirus in Southern Moravia (Czech Republic). Vector-Borne and Zoonotic Diseases 8:659–666.
Hubálek Z, Rudolf I, Bakonyi T, Kazdová K, Halouzka J, Šebesta O, Šikutová S, Juřicová Z. Nowotny N. 2010. Vector-borne diseases, surveillance, prevention mosquito (Diptera: Culicidae) surveillance for arboviruses in an area endemic for West Nile (Lineage Rabensburg) and Ťahyňa viruses in Central Europe. Journal of Medical Entomology 47:466–472.
Hubálek Z, Savage HM, Halouzka J, Juřicová Z, Sanogo YO, Lusk S. 2000. West Nile virus investigations in South Moravia, Czechland. Viral Immunology 13:427–433.
Jaenson TG. 1988. Diel activity patterns of blood-seeking anthropophilic mosquitoes in central Sweden. Medical and Veterinary Entomology 2:177–187.
Jalili N, Halgoš J. 2004. Mosquito prevalence in the Komárno and Nové Zámky regions of southern Slovakia. European Mosquito Bulletin 18:30–36.
Jalili N, Halgoš J. Ondriska F, Brestovský J. 1999. Mosquito communities of the Morava flood plain area during floods in 1977. Dipterologica Bohemoslovaca 9:77–81.
Juřicová Z, Hubálek Z, Halouzka J, Šikutová S. 2009. Serological examination of songbirds (Passeriformes) for mosquito-borne viruses Sindbis, Ťahyňa, and Batai in a South Moravian wetland (Czech Republic). Vector-Borne and Zoonotic Diseases 9:295–299.
Kramář J. 1958. Bitting mosquitoes – Culicidae, Fauna ČSR, vol. 13. Praha: Nakladatelství ČSAV (in Czech).
Kramář J, Weiser J. 1951. Flood-water mosquitoes on the Lower Morava River. Zoologické a Entomologické Listy 14:170–177 in Czech).
Kyselý J. 2009. Trends in heavy precipitation in the Czech Republic over 1961–2005. International Journal of Climatology 29:1745–1758.
Kyselý J. 2010. Recent severe heat waves in central Europe: How to view them in a long-term prospect? International Journal of Climatology 30:89–109.
Labuda M. 1977. Mosquitoes (Diptera, Culicidae) in Záhorská nížina (west Slovakia). Entomologicke Problémy 14:123–173 (in Slovak).
Málková D, Danielová V, Minář J, Ryba J. 1974. Virological investigations of mosquitoes in some biotopes of southern Moravia in summer season 1972. Folia Parasitologica 2:363–372.
Merdić E, Boca I. 2004. Season dynamics of the *Anopheles maculipennis* complex in Osijek, Croatia. Journal of Vector Ecology 29:257–263.
Merdić E, Lovaković T. 2001. Population dynamic of *Aedes vexans* and *Ochlerotatus sticticus* in flooded areas of the River Drava in Osijek, Croatia. Journal of the American Mosquito Control Association 17:275–280.
Minář J, Halgoš J, Bartalová A, Jalili N. 2007. Current climatic change and its impact on mosquito fauna in conditions of Slovakia and Czech Republic. Acta Zoologica Universitatis Comenianae 47:177–182.
Novák D. 1957. A summer mosquito calamity in the area of Hodonín in 1954. Zprávy Krajského muzea v Gottwaldově, 4–5:22–30 (in Czech).
Olejníček J, Minář J, Gelbič I. 2004. Changes in biodiversity of mosquitoes in the years 2002–2003 caused by climatic changes in the Morava river basin. Acta Facultatis Ecologiae 12: 115–121.
Palička P. 1967. Contribution to the study of mosquitoes (Diptera, Culicidae) occurring in some areas of central and south Moravia. Acta Entomologica Bohemoslovaca 64:69–78.
Ponçon N, Toty C, L'Ambert G, Le Goff G, Brengues C, Schaffner F, Fontenille D. 2007a. Biology and dynamics of potential malaria vectors in Southern France. Malaria Journal 6:1–9.
Ponçon N, Toty C, L'Ambert G, Le Goff G, Brengues C, Schaffner F, Fontenille D. 2007b. Population dynamics of pest mosquitoes and potential malaria and West Nile virus vectors in relation to climatic factors and human activities in the Camargue, France. Medical and Veterinary Entomology 21:350–357.
Potapov AA, Vladimirova VV, Mel'nik TD, Bogdanova EN. 1973. Species composition and daily activities of mosquitoes and horseflies in the lower part of the Volga Delta. Meditsinskaia Parazitologiia i Parazitarnye Bolezni 42:6–11 (in Russian).
Reinert JF. 2000. New classification for the composite genus *Aedes* (Diptera: Culicidae: Aedini), elevation of subgenus *Ochlerotatus* to generic rank, reclasification of the subgenera and species. Journal of the American Mosquito Control Association 16:175–188.
Reinert JF, Harbach RE, Kitching IJ. 2009. Phylogeny and classification of tribe Aedini (Diptera: Culicidae) Zoological Journal of the Linnean Society 157:700–794.
Rettich F, Imrichová K, Šebesta O. 2007. Seasonal comparisons of the mosquito fauna in the flood plains of Bohemia and Moravia, Czech Republic. European Mosquito Bulletin 23:10–16.
Rosický B, Havlík O. 1951. The anophelism of southern Moravia. Entomologické Listy 14:119–130 (in Czech).
Rosický B., Málková D. 1980. Ťahyňa virus natural focus in southern Moravia. Rozpravy ČSAV. Řada Matematických a Přírodních Věd 90(7): 1–107.
Savage HM. 2005. Classification of mosquitoes in tribe Aedini (Diptera: Culicidae): Paraphylyphobia, and classification versus cladistic analysis. Journal of Medical Entomology 42: 923–927.
Šebesta O., Gelbič I., Minář J. 2012. Mosquitoes (Diptera: Culicidae) of the Lower Dyje River Basin (Podyjí) at the Czech-Austrian border. Central European Journal of Biology 7:288–298.
Šebesta O, Gelbič I, Peško J. 2011. Daily and seasonal variation in the activity of potential vector mosquitoes. Central European Journal of Biology 6:422–430.
Šebesta O, Halouzka J, Hubálek Z, Juřicová Z, Rudolf I, Šikutová S, Svobodová P, Reiter P. 2010. Mosquito (Diptera: Culicidae) fauna in an area endemic for West Nile virus. Journal of Vector Ecology 35:156–162.

Strelková L, Halgoš J. 2012. Mosquitoes (Diptera, Culicidae) of the Morava River floodplain, Slovakia. Central European Journal of Biology 6:917–926.

Sudarić Bogojević M, Merdić E, Turić N, Jeličić Ž, Zahirović Ž, Vručina I, Merdič S. 2009. Season dynamics of mosquitoes (Diptera: Culicidae) in Osijek (Croatia) for the period 1995–2004. Biologia 64:760–767.

Wegner E. 2009. A study of mosquito fauna (Diptera: Culicidae) and the phenology of the species recorded in Wilanów (Warsaw, Poland). European Mosquito Bulletin 27:23–32.

Zuna-Krátký T, Kalivodová W, Kürthy A, Horal D, Horák P. 2000. Die Vögel der March-Thaya-Auen im österreichisch-slowakisch-tschechischen Grenzraum. Distelverein: Deutsch-Wagram.