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Daily and seasonal variation in the activity of potential vector mosquitoes

Research Article

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Abstract: In the course of season 2010 (May-September), three 2-day trappings of female mosquitoes were carried out at two sites in order to determine the daily activity of the common mosquito species (e.g. species from genus *Culex, Aedes, Ochlerotatus, Anopheles*, *etc*.) in the area. CDC light traps filled with CO_2 and placed at a height of 1 m were used to trap individuals, and were sampled every 2 h. A total of 19,604 female mosquitoes from 20 identifiable species were trapped: 7,549 at Sedlec and 12,055 at Kančí obora. The activity of the major species of mosquitoes in South Moravia differed throughout the course of the day. Calamity species of the genus *Aedes* and *Ochlerotatus* remained active throughout the day and night, but with different course. *Aedes vexans, Ae. cinereus,* and *Ae. rossicus* were most active in the late afternoon and highly active for most of the night. *Ochlerotatus sticticus* was captured most often in the afternoon, and its abundance decreased rapidly before sunset. The activity of *Oc. cantans* s.l. *(Oc. cantans + Oc. annulipes)* females varied little during the day and night. The daily activity for the main vectors of West Nile virus, *Culex pipiens* and *Cx. modestus*, were totally different from that of other species. *Cx. pipiens* females showed significant night activity, while *Cx. modestus* was most active in the evening. Nighttime activity was also observed in female mosquitoes of the genus *Anopheles*.

Keywords: *Czech Republic • South Moravia • Aedes vexans • Ochlerotatus sticticus • Culex modestus • Culex pipiens • Daily activity • West Nile Virus • Ťahyňa virus*

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1. Introduction

Numerous studies have been conducted on mosquitoes in southeastern Moravia, Czech Republic. Floodplain forests and alluvial plains along the lower reaches of the Morava and Dyje rivers combine in this region forming a complex of ponds that create very good conditions for mosquito reproduction. Great attention has been devoted to researching mosquito outbreaks, which occur relatively frequently in this area [1,2], while faunistic works are also numerous [3-9]. Especially significant are studies focusing on mosquitoes as potential vectors of pathogenic agents, particularly viruses [10-15]. However, in Moravia, as in the rest of Europe, research on seasonal dynamics of the most prominent mosquito species and their daily activity has been largely neglected. Nevertheless, some studies have examined the seasonal dynamics of mosquitoes in Croatia, France and the Czech Republic [9,16-18].

Daily activity is often monitored in association with the incidence of malaria (see e.g. Rubio-Palis and Curtis [19]; da Rocha *et al.* [20]) or yellow fever (e.g. Chadee *et al.* [21]). Furthermore, daily activity of the mosquito species of medical or veterinary importance has been monitored in Brazil [22], Parris Island (South Carolina) [23], France [24] and Sweden [25].

This study aims to describe changes throughout the season (May – September) in the daily activity of eudominant and dominant species of mosquitoes, which are potential vectors of infectious agents. The term

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"potential vector" refers to the potential to transmit an infectious agent in the conditions of South Moravia rather than in the sense of vector competence (WHO definition).

2. Experimental Procedures

2.1 Sites

This study was conducted at two sites in the Lower Morava Biosphere Reserve in southeastern Moravia (Figure 1). This region frequently experiences calamity incidences of mosquitoes, and agents of human disease, including West Nile Virus (WNV), have been isolated from these insects [12,13]. The Sedlec site (48°47'N, 16°43'E, 176 m a.s.l.) is located on the edge of the Nesyt pond, the largest in Moravia with its area of 322 ha. Situated at the Slanisko National Nature Reserve, the site consists of a group of bushes and low trees (*Salix fragilis* L.) growing on the border between a dense vegetation on the pond's bank (comprised primarily of reeds *Phragmites australis* (Cav.) Steud.)) and a meadow with significant representation of halophilic flora and fauna (e.g., *Scorzonera parviflora* Jacq., *Tripolium pannonicum* (Jacq.), *Spergularia salina* (J. et C. Pressl)).

The Kančí obora site (48°46'N, 16°52'E, 157 m a.s.l.) is located approximately 500 m from the district town of Břeclav. This site is located within a floodplain forest (*Quercus robur* L., *Fraxinus angustifolia* Vahl, *Populus spp., Tilia cordata* Mill, *Carpinus betulus* L.) and is often flooded with water from the Dyje River. There are numerous breeding places for vector mosquito species of the *Aedes* and *Ochlerotatus* genera, and female mosquitoes are readily able to fly to the surrounding villages, including town of Břeclav. The two study sites are approximately 12 km from one another.

2.2 Meteorological data

The South Moravia region is characterized by a relatively warm and dry climate. With an average daily temperature of 9.3°C, it is the warmest area in the Czech Republic outside of Prague. With a total annual precipitation of 490 mm, it is among the drier regions of the country. However, precipitation in 2010 was significantly above average compared to recent years and, in particular, the long-term average (Figure 2). From January through September, 669.8 mm of snow and rainfall were recorded (Kobylí station, data from the Czech Hydrometeorological Institute), which represents 172.9% of the norm for that period. Above-average precipitation levels were recorded in most months. Only in February and June were the precipitation levels average, while in March, the monthly precipitation was slightly below average. This long term above-average precipitation was accompanied by a high incidence of mosquitoes from May to October.

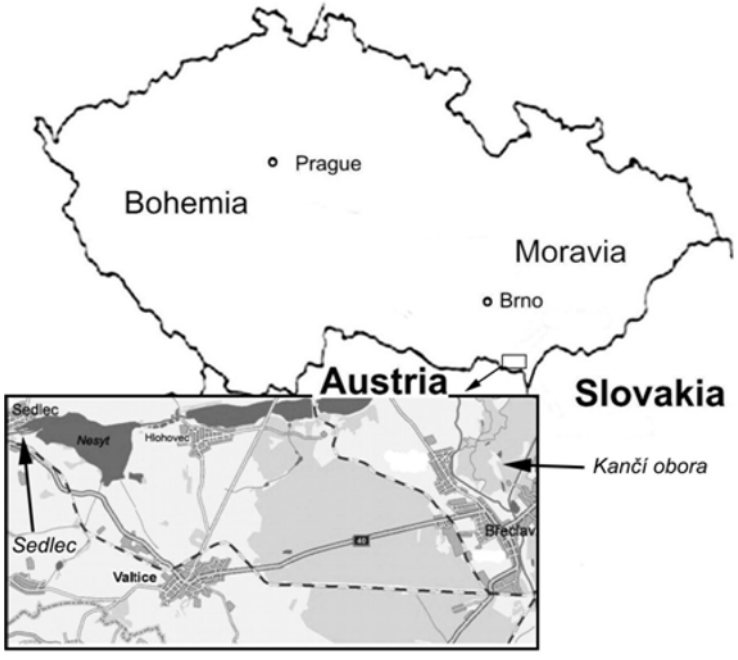

Figure 1. Map showing study sites in the Czech Republic.

2.3 Trapping method

To trap female mosquitoes, we used CDC miniature light traps with carbon dioxide (BioQuip Products, Inc., Rancho Dominiquez, CA, U.S.A.) supplemented by dry ice hung at a height of 1 m. Specimens were collected during three sampling trips (25–27 May, 20–22 June, and 31 August–2 September) in order to reflect any potential changes in activity throughout the spring and summer season. The traps were deployed at 14:00 Central European Summer Time and mosquitoes were collected every 2 h over the next 48 h. For each sampling period, the numbers of females caught in each 2 h period were summed.

2.4 Identification

Mosquito species were identified using keys from Kramář [26] and Becker [27]. For some species, the reliable identification of females was impossible, and these individuals are classified under a common name. The probable incidence of other species whose long-term presence is confirmed at the given locations (e.g. *Culex pipiens* Linnaeus and *Cx. torrentium* Martini) are presented in the Results and Discussion sections in parentheses.

2.5 Statistical analysis

The relative abundance of each species was calculated separately for each sampling trip. The following scale of dominance was used: more than 10% of the total number of Culicidae captured per sampling trip was regarded as eudominant (ED), 5–10% as dominant (D), 2–5% as subdominant (SD), 1–2% as recedent (R), and less than 1% as subrecedent (SR). The index of dominance (C), Shannon-Weaver diversity index (H'), and equitability index (E) were calculated for each sampling trip.

3. Results

A total of 19,604 females were trapped in total during the three sampling trips: 12,055 females at Kančí obora (Table 1) and 7,549 at Sedlec (Table 2). The two locations, which represent two different biotopes, are differentiated not only by the quantity of mosquitoes captured, but also by the species composition both among sampling trips and during the course of the day (Table 1-4).

At Sedlec, *Culex modestus* Ficalbi was a clearly dominant species from May to the end of June (Table 2, 4), with the highest capture (6,952 females) recorded in the second sampling trip (20–22 June). However, between 31 August and 2 September when the incidence of *Aedes vexans* (Meigen) and, to a lesser extent, *Ochlerotatus sticticus* (Meigen) peaked, only 225 *Cx. modestus* individuals were captured.

In contrast, populations of the calamity species, *Ae. vexans* and *Oc. sticticus,* were predominant in Kančí obora (Table 1 and 3) and peaked at the end of August; the highest capture (7,460 individuals) occurred during the third sampling trip from the 31 August to the 2 September, while the lowest capture (880 individuals) occurred during the first sampling period from 25 to the 27 May.

By comparing the total number of females captured during the observed periods, the calamity species *Ae. vexans* (5,326 females) and *Oc. sticticus* (4,261 females) were found to be dominant in Kančí obora's alluvial forest biotope. In the vicinity of the Nesyt pond at Sedlec, on the other hand, *Cx. modestus* was dominant with a total of 7,130 trapped females (Table 1-5). Female *Cx. pipiens* cannot be distinguished from *Cx. torrentium* Martini, and as both occur in South Moravia, these species were counted together with a total of 780 females captured. *Oc. cantans* s.l. (676 females), *Ae. rossicus* Dolbeskin, Gorickaja & Mitrofanova (424 individuals) and *Ae. cinereus* (362) were also abundant (Table 1-5). The species *An. hyrcanus* (Pallas) (135 individuals), which was only trapped at Sedlec, was also relatively abundant (Table 2, 4).

Species of the genus *Aedes* and *Ochlerotatus* exhibited activity throughout the day. *Ae. vexans*, the most prominent vector of Ťahyňa virus in South Moravia, was the most abundant species and could be observed throughout the day, though it was most abundant in the late afternoon and early evening (Figure 3). *Ochlerotatus sticticus* was especially active in the afternoon whereas its activity was low during the

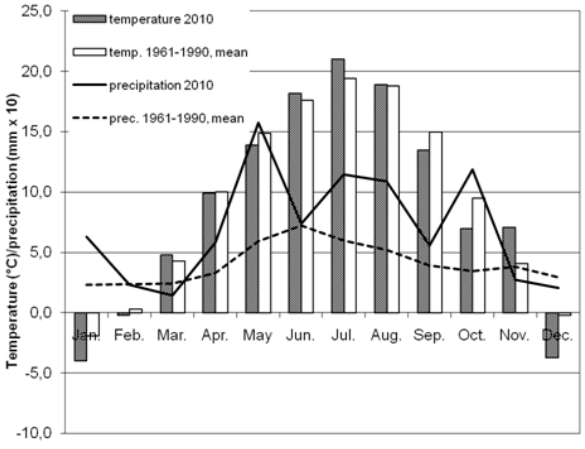

Figure 2. Mean monthly air temperature (°C) and monthly precipitation totals (mm x 10) in the study area for 2010 and the long-term average (1961-1990; Kobylí weather station; data from Czech Hydrometeorological Institute in Brno).

Species/time of day	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	24:00	Total
An. maculipennis s.l.	5	2	6	2	5	2	2	0	4	1	3	6	38
An claviger	1	0	0	2	0	0	0	0	0	0	1	0	4
An. plumbeus	0	0	5	5	1	0	1	1	1	4	1	0	19
An. hyrcanus	0	0	0	0	0	0	0	0	0	0	0	0	0
Ae. cinereus	23	17	9	14	16	12	2	19	13	49	47	35	256
Ae. rossicus	19	18	12	12	23	36	12	32	33	72	86	42	397
Ae. vexans	304	318	320	357	518	141	206	411	431	963	552	386	4907
Oc. cantans s.l.	8	12	14	11	41	82	63	67	41	35	29	28	431
Oc. caspius	0	0	0	0	0	0	0	0	1	0	0	0	1
Oc. cataphylla	0	0	1	0	2	4	3	7	0	2	1	0	20
Oc. excrucians	0	0	0	0	0	0	0	1	1	0	0	0	2
Oc. flavescens	0	0	0	0	0	0	0	0	0	0	0	0	0
Oc. geniculatus	0	0	0	0	0	0	0	0	1	8	1	0	10
Oc. leucomelas	0	0	0	0	0	0	0	0	1	0	0	0	1
Oc. sticticus	28	39	46	96	437	648	443	528	1038	789	101	56	4249
Cx. modestus	6	12	6	3	69	129	197	232	263	173	48	14	1152
Cx. pipiens	128	63	34	2	1	0	0	0	0	1	151	161	541
Cs. annulata	1	6	1	0	0	0	1	0	2	1	1	2	15
Cq. richiardii	0	1	1	3	0	0	1	0	0	1	4	1	12
Ur. unguicullata	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	523	488	455	507	1113	1054	931	1298	1830	2099	1026	731	12055

Table 1. Total number of female mosquitoes for all species captured at Kančí obora.

Species/time of day	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	24:00	Total
An. maculipennis s.l.	10	8	4	1	0	1	0	0	0	0	2	34	60
An claviger	16	10	8	11	1	0	0	0	10	21	12	8	97
An. plumbeus	0	0	0	0	0	0	0	0	0	0	0	0	0
An. hyrcanus	21	9	6	0	0	0	0	0	1	1	48	49	135
Ae. cinereus	24	5	2	2	0	2	1	1	5	4	15	45	106
Ae. rossicus	4	0	2	0	0	0	1	1	0	2	7	10	27
Ae. vexans	51	37	78	12	8	1	2	6	6	26	88	104	419
Oc. cantans s.l.	64	24	40	4	4	3	0	9	7	14	13	63	245
Oc. caspius	0	0	0	1	0	0	0	1	0	0	0	0	2
Oc. cataphylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Oc. excrucians	0	0	0	0	0	0	0	0	0	0	0	0	0
Oc. flavescens	37	22	4	2	3	1	2	2	3	6	1	30	113
Oc. geniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Oc. leucomelas	0	0	0	0	0	0	0	0	0	0	0	0	0
Oc. sticticus	0	0	0	3	0	0	0	2	1	3	1	2	12
Cx. modestus	183	93	55	23	92	161	577	469	1215	1679	971	460	5978
Cx. pipiens	78	31	8	0	2	0	0	0	0	0	50	70	239
Cs. annulata	2	3	7	1	0	0	0	0	1	2	2	3	21
Cq. richiardii	18	14	13	1	1	1	0	0	0	3	11	26	88
Ur. unguicullata	4	1	1	0	0	0	0	0	0	0	0	1	7
Total	512	257	228	61	111	170	583	491	1249	1761	1221	905	7549

Table 2. Total number of female mosquitoes for all species captured at Sedlec.

	25.-27.5.2010			20.-22.7.2010			31.8.-2.9.2010			Total		
Species	No	%	CD	No	%	CD	No	%	CD	No	%	CD
An. maculipennis s.l.	13	1.48	R	15	0.40	SR	10	0.13	SR	38	0.32	SR
An claviger				1	0.03	SR	3	0.04	SR	4	0.03	SR
An. plumbeus	2	0.23	SR	11	0.30	SR	6	0.08	SR	19	0.16	SR
Ae. cinereus	25	2.84	SD	116	3.12	SD	115	1.54	R	256	2.12	SD
Ae. rossicus	**48**	**5.45**	**D**	**281**	**7.56**	**D**	68	0.91	SR	397	3.29	SD
Ae. vexans	**49**	**5.57**	**D**	**747**	**20.11**	**ED**	**4111**	**55.11**	**ED**	**4907**	**40.71**	**ED**
Oc. cantans s.l.	**175**	**19.89**	**ED**	**252**	**6.78**	**D**	4	0.05	SR	431	3.58	SD
Oc. caspius							1	0.01	SR	1	0.01	SR
Oc. cataphylla	20	2.27	SD							20	0.17	SR
Oc. excrucians	2	0.23	SR							2	0.02	SR
Oc. geniculatus	1	0.11	SR	4	0.11	SR	5	0.07	SR	10	0.08	SR
Oc. leucomelas	1	0.11	SR							1	0.01	SR
Oc. sticticus	**184**	**20.91**	**ED**	**975**	**26.24**	**ED**	**3090**	**41.42**	**ED**	**4249**	**35.25**	**ED**
Cx. modestus	14	1.59	R	**1130**	**30.42**	**ED**	8	0.11	SR	**1152**	**9.56**	**D**
Cx. pipiens	**336**	**38.18**	**ED**	175	4.71	SD	30	0.40	SR	541	4.49	SD
Cs. annulata	10	1.14	R	2	0.05	SR	3	0.04	SR	15	0.12	SR
Cq. richiardii				6	0.16	SR	6	0.08	SR	12	0.10	SR
Total specimens	880			3715			7460			12055		
Total species	14			13			14			17		
C	0.24			0.22			0.48			0.30		
H´	1.74			1.71			0.87			1.48		
E	0.66			0.67			0.33			0.52		

Table 3. List of species collected during each sampling trip at Kančí obora, including number of individuals (No), relative abundance (%), classification of dominance (CD) (eudominant – ED; dominant – D; subdominant – SD; recedent – R; subrecedent – SR) and index of dominance (C). ED and D species are in bold.

	25.-27.5.2010			20.-22.7.2010			31.8.-2.9.2010			Total		
Species	No	%	CD	No	%	CD	No	%	CD	No	%	CD
An. maculipennis s.l.				56	0.81	SR	4	1.78	R	60	0.79	SR
An claviger				31	0.45	SR	**66**	**29.33**	**ED**	97	1.28	R
An. hyrcanus	1	0.27	SR	97	1.40	R	**37**	**16.44**	**ED**	135	1.79	R
Ae. cinereus	**57**	**15.32**	**ED**	47	0.68	SR	2	0.89	SR	106	1.40	R
Ae. rossicus	14	3.76	SD	12	0.17	SR	1	0.44	SR	27	0.36	SR
Ae. vexans	17	4.57	SD	345	4.96	SD	**57**	**25.33**	**ED**	**419**	**5.55**	**D**
Oc. cantans s.l.	**33**	**8.87**	**D**	212	3.05	SD				245	3.25	SD
Oc. caspius	1	0.27	SR				1	0.44	SR	2	0.03	SR
Oc. flavescens	**110**	**29.57**	**ED**	3	0.04	SR				113	1.50	R
Oc. sticticus	2	0.54	SR	5	0.07	SR	5	2.22	SD	12	0.16	SR
Cx. modestus	6	1.61	R	**5938**	**85.41**	**ED**	**34**	**15.11**	**ED**	**5978**	**79.19**	**ED**
Cx. pipiens	**129**	**34.68**	**ED**	106	1.52	R	4	1.78	R	239	3.17	SD
Cs. annulata	2	0.54	SR	15	0.22	SR	4	1.78	R	21	0.28	SR
Cq. richiardii				78	1.12	R	10	4.44	SD	88	1.17	R
Ur. unguicullata				7	0.10	SR				7	0.09	SR
Total specimens	372			6952			225			7549		
Total species	11			14			12			15		
C	0.24			0.73			0.20			0.63		
H´	1.65			0.70			1.82			0.96		
E	0.69			0.27			0.73			0.35		

Table 4. List of species collected during each sampling trip at Sedlec, including number of individuals (No), relative abundance (%), classification of dominance (CD) (eudominant – ED; dominant – D; subdominant – SD; recedent – R; subrecedent – SR) and index of dominance (C). ED and D species are in bold.

nighttime and morning hours (Figure 3). *Oc. cantans* s.l., *Ae. cinereus* s.l., and *Ae. rossicus* also exhibited activity throughout the sampling period, with the activity of the latter two peaking in late afternoon hours and at the onset of night (Figure 4, Table 1, 2).

The abundance of the WNV vector *Culex modestus* was exceptionally high during the 2010 season, exceeding the abundances recorded from previous years [9]. The increased incidence of this species can be explained by above-average rainfall at the end of spring and during the summer (Figure 2). Its daily activity reached a distinct peak in the late afternoon hours, while at night its activity decreased rapidly and it was trapped only occasionally in the morning (Figure 3). Another

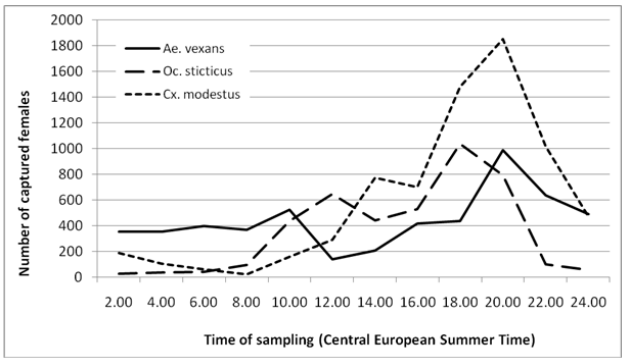

Figure 3. Daily activity of dominant mosquito species (total per sampling trip summed from the two locations).

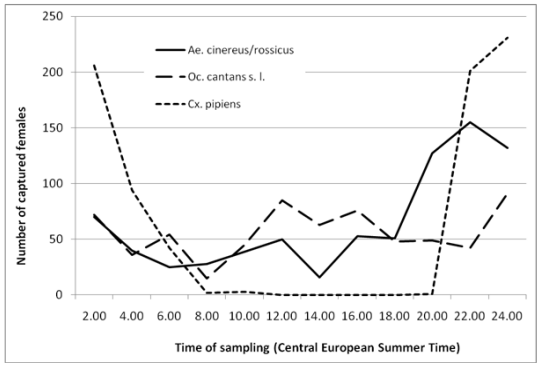

Figure 4. Daily activity of other common mosquito species (total per sampling trip summed from the two locations).

	25.-27.5.2010			20.-22.7.2010			31.8.-2.9.2010			Total		
Species	No	%	CD	No	%	CD	No	%	CD	No	%	CD
An. maculipennis s.l.	13	1.04	R	71	0.67	SR	14	0.18	SR	98	0.50	SR
An claviger				32	0.30	SR	69	0.90	SR	101	0.52	SR
An. plumbeus	2	0.16	SR	11	0.10	SR	6	0.08	SR	19	0.10	SR
An. hyrcanus	1	0.08	SR	97	0.91	SR	37	0.48	SR	135	0.69	SR
Ae. cinereus	**82**	**6.55**	**D**	163	1.53	R	117	1.52	R	362	1.85	R
Ae. rossicus	62	4.95	SD	293	2.75	SD	69	0.90	SR	424	2.16	SD
Ae. vexans	**66**	**5.27**	**D**	**1092**	**10.24**	**ED**	**4168**	**54.24**	**ED**	**5326**	**27.17**	**ED**
Oc. cantans s.l.	**208**	**16.61**	**ED**	464	4.35	SD	4	0.05	SR	676	3.45	SD
Oc. caspius	1	0.08	SR				2	0.03	SR	3	0.02	SR
Oc. cataphylla	20	1.60	R							20	0.10	SR
Oc. excrucians	2	0.16	SR							2	0.01	SR
Oc. flavescens	**110**	**8.79**	**D**	3	0.03	SR				113	0.58	SR
Oc. geniculatus	1	0.08	SR	4	0.04	SR	5	0.07	SR	10	0.05	SR
Oc. leucomelas	1	0.08	SR							1	0.01	SR
Oc. sticticus	**186**	**14.86**	**ED**	**980**	**9.19**	**D**	**3095**	**40.27**	**ED**	**4261**	**21.74**	**ED**
Cx. modestus	20	1.60	R	**7068**	**66.26**	**ED**	42	0.55	SR	**7130**	**36.37**	**ED**
Cx. pipiens	**465**	**37.14**	**ED**	281	2.63	SD	34	0.44	SR	780	3.98	SD
Cs. annulata	12	0.96	SR	17	0.16	SR	7	0.09	SR	36	0.18	SR
Cq. richiardii				84	0.79	SR	16	0.21	SR	100	0.51	SR
Ur. unguicullata				7	0.07	SR				7	0.04	SR
Total specimens	1252			10667			7695			19604		
Total species	17			16			15			20		
C	0.21			0.46			0.46			0.26		
H´	1.91			1.28			0.97			1.63		
E	0.80			0.49			0.39			0.60		

Table 5. List of species collected during each sampling trip at Kančí obora and Sedlec, including number of individuals (No), relative abundance (%), classification of dominance (CD) (eudominant – ED; dominant – D; subdominant – SD; recedent – R; subrecedent – SR) and index of dominance (C). ED and D species are in bold.

important vector of WNV in this area, *Cx. pipiens*, exhibited nighttime activity with peak capture rates around midnight; its activity during the day was minimal (Figure 4). Mosquitoes of the genus *Anopheles* (vectors of malaria) exhibited mostly nighttime activity (Table 1, 2). This genus of mosquito is represented at the study location by the species *An. claviger* (Meigen) (101 females), *An. maculipennis* s.l. (98 females), and *An. plumbeus* Stephens (19 females). Capture of the recently discovered species *An. hyrcanus* Pallas (135 females) was relatively high at Sedlec, but was only caught here. Differences in mosquito species within each collection are shown in Figures 5, 6 and 7.

4. Discussion

Our results show that the daily activity of potential disease vector mosquitoes differs between the study locations and species. Similar activity was observed among species belonging to the *Aedes* and *Ochlerotatus* genera. Species of the genus *Culex (Cx. pipiens* and *Cx. modestus)*, on the other hand, differed in activity.

Mosquitoes of the genus *Anopheles* are very closely monitored worldwide due to their ability to transmit malaria. Therefore, we draw particular attention to the activity of *An. hyrcanus* at Sedlec (Nesyt pond), which have increased in abundance since 2007 and 2008 [9]. Until the middle of the 20th century, South Moravia was a malaria affected area [28]. Due to the current presence of refugee camps in this region, the potential reintroduction of this disease is once again an issue of discussion and concern, particularly at a time when the abundance of suitable vectors is increasing. Mosquitoes of the genus *Anopheles* were present in the samples in relatively small numbers representing 353 individuals of all species or 1.8% of the total number of individuals caught. They were almost exclusively nocturnal, as is reported in studies worldwide [19,20]. From the subgenus *Anopheles maculipennis*, the species *An. atroparvus* van Thiel, *An. labranchiae* Falleroni, *An. maculipennis* (Meigen), and *An. messeae* Falleroni [29] were found.

The most abundant vector species caught were *Ae. vexans* and *Oc. sticticus*, while *Oc. cantans* s.l., *Ae. rossicus* and *Ae. cinereus* were significantly less abundant. High incidence of the above mentioned species was also reported in earlier work devoted to mosquito calamities in Moravia [8]. In addition, the species *Oc. nnulipes* (Meigen) (as determined by the body structure of trapped males) also occurred frequently. However, it is not always possible to reliably distinguish females of this species from *Oc. cantans* s.l.

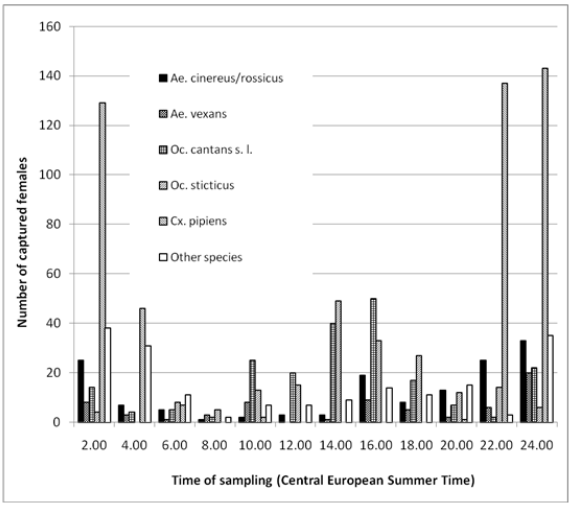

Figure 5. Daily activity of mosquitoes during 25–27 May 2010 (total per sampling trip summed from the two locations). Sunrise 4:58; sunset 20:50.

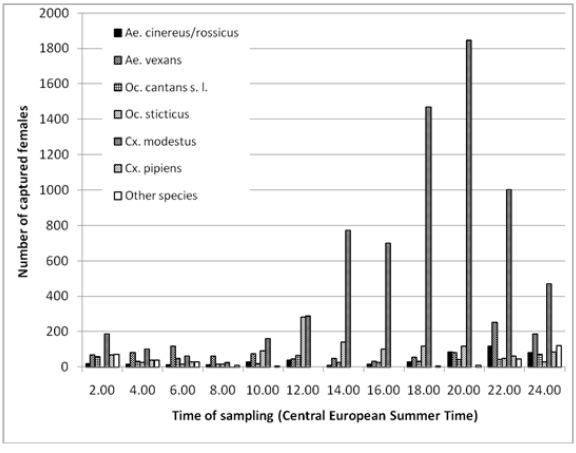

Figure 6. Daily activity of mosquitoes during 20–22 July 2010 (total per sampling trip summed from the two locations). Sunrise 5:11; sunset 20:58.

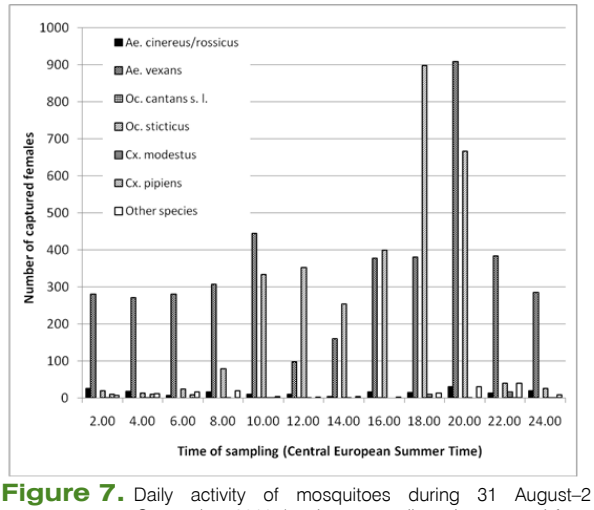

Figure 7. Daily activity of mosquitoes during 31 August–2 September 2010 (total per sampling trip summed from the two locations). Sunrise 6:08; sunset 19:40.

and therefore they are indicated together as the latter. Similarly, the abundance data for *Ae. cinereus* most likely includes species that cannot be distinguished according to females, including *Ae. geminus* Peus [8]. These species are active throughout the day, especially in the afternoon and evenings, which corresponds to the periods of greatest human activity, both work-related (farmers, forestry workers, gardeners) and recreational. Many of these species are also vectors of the Ťahyňa virus [11,15].

Species known as vectors of WNV were also highly abundant. The occurrence of the species *Cx. modestus*, in particular, was unusually high compared to previous years [9] and is likely the result of a spillover-effect from the nearby Lednice ponds where a severe outbreak was reported. This outbreak was caused by exceptionally rainy weather (Figure 2), which flooded the densely vegetated and reedy areas along the pond banks. This species is active and most likely to bite in the afternoon hours when humans are also most active. Although it was present in alarmingly high numbers, *Cx. modestus* was primarily abundant for only a short period of time in close proximity to ponds, and did not spread very much into surrounding areas. *Cx. pipiens*, another prominent WNV vector, was present to a much lesser extent and was active almost exclusively at night. Moreover, it is a predominantly ornithophilous species (prefers to feed on birds' blood) [9,26].

Similar results of mosquito activity also have been presented by Balenghien *et al.* [24], who captured mosquitoes using traps with birds and horses. Using different animals in mosquito traps gives information about the preference for food. Some of mosquito species e.g. *Cx. pipiens* in Central Europe prefer blood of birds and *Ae. vexans* or *Oc. sticticus* prefer blood of mammals. Similar to our findings, Balenghien *et al.* [24] found that *Ae. vexans* was the most abundant species (main vector) and was active throughout the day reaching its peak in the afternoon hours. Of the WNV vectors, they found that *Cx. pipiens* was active mostly at night whereas *Cx. modestus* was active throughout most of the day with its peak activity at night. These differences in results obtained may be due to the different climatic conditions of the two areas as well as to the methods of trapping. Breidenbaugh *et al*. [23] also reported all-day activity (24 hours) in *Aedes* spp. in South Carolina, in the United States. They found higher abundances of these species in the afternoon hours with a pronounced peak at sunset. However, Breidenbaugh *et al*. [23] did not distinguish differences in activity between individual species. Among *Culex* spp., Breidenbaugh *et al*. [23] found two discernable peaks in activity; one around sunset and the second after dark. Again for this genus, differences between individual species were not monitored. Breidenbaugh *et al*. [23] study predominantly concerned mosquitoes not occurring in Europe.

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References

[1] Kramář J., Weiser J, Flood-water mosquitoes on the Lower Morava River, Ent. Listy, 1951, 14, 170-177, (in Czech)

[2] Novák D., A summer mosquito calamity in the area of Hodonín in 1954, Zprávy krajského musea Gottwaldov (News of Regional Museum Gottwaldow), 1957, 4-5, 22-30, (in Czech)

[3] Palička P., Costribution to the study of mosquitoes (Diptera, Culicidae) occurring in some areas of central and south Moravia, Acta Entomol. Bohemoslov., 1967, 64, 69-78

[4] Vaňhara J., Rettich F., Culicidae. Diptera of the Pálava Biosphere Reserve of UNESCO, Folia Facultatis Scientiorum Naturalis Universitatis Purkynianae Brunensis, Biologia, 1998, 99, 97-105

[5] Olejníček J., Gelbič I., Minář J., Changes in mosquito diversity in the lower Morava and Dyje basin caused by catasthrophic floods and global warming, Folia Faunistica Slovaca, 2003, 8, 61-62, (in Czech)

[6] Olejníček J., Minář J., Gelbič I., Changes in biodiversity of mosquitoes in the years 2002-2003 caused by climatic changes in the Morava river basin, Acta Facultatis Ecologiae, 2004, 12, 115-121

[7] Minář J., Halgoš J., Bartalová A., Jalili N., Current climatic change and its impact on mosquito fauna in conditions of Slovakia and Czech Republic, Acta Zoologica Universitatis Comenianae, 2007, 47, 177-182

[8] Rettich F., Imrichová K., Šebesta O., Seasonal comparisons of the mosquito fauna in the flood

plains of Bohemia and Moravia, Czech Republic, European Mosquito Bulletin, 2007, 22, 10-16
[9] Šebesta O., Halouzka J., Hubálek Z., Juřicová Z., Rudolf I., Šikutová S., et al., Mosquito (Diptera: Culicidae) fauna in an area endemic for West Nile virus, J. Vector Ecol., 2010, 35, 156-162
[10] Danielová V., Hájková Z., Minář J., Ryba J., Virological investigation of mosquitoes in different seasons of the year at the natural focus of the Ťahyňa virus in southern Moravia, Folia Parasitol., 1972, 19, 25-31
[11] Rosický B., Málková D., Danielová V., Hájková Z., Holubová J., Kolman J.M., et al., Ťahyňa virus. Natural focus in southern Moravia, Rozpravy ČSAV, Řada matematicko-přírodních věd, 1980, 90, 1-107
[12] Bakonyi T., Hubálek Z., Rudolf I., Nowotny N., Novel flavivirus or new lineage of West Nile virus, Central Europe, Emerg. Infect. Dis., 2005, 11, 225-231
[13] Hubálek Z., Halouzka.J., Juřicová Z., Šebesta O., First isolation of mosquito-borne West Nile virus in the Czech Republic, Acta Virol., 1998, 42, 119-120
[14] Hubálek Z., Mosquito-borne viruses in Europe, Parasitol. Res., 2008, 103, 29-43
[15] Hubálek Z.I. Rudolf I., Bakonyi T., Kazdová K., Halouzka J., Šebesta O., et al., 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, J. Med. Entomol., 2010, 47, 466-472
[16] Merdič E., Boca I., Season dynamics of the Anopheles maculipennis complex in Osijek, Croatia, Vector Ecol., 2004, 29, 257-263
[17] Ponçon N., Toty C., L'ambert G., le Goff G., Brengues C., Schaffner F., et al., 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, Med. Vet. Entomol., 2007, 21, 350-357
[18] Sudavič Bogojevič M., Merdič E., Turič N., Jeličič Ž., Zahirovič Ž, Vručina I., et al., Season dynamics of mosquitoes (Diptera: Culicidae) in Osijek (Croatia) for the period 1995-2004, Biologia, 2009, 64, 760-767
[19] Rubio-Palis Y., Curtis C.F., Biting and resting behaviour of anophelines in western Venezuela and implications for control of malaria transmission, Med. Vet. Entomol., 1992, 6, 325-334
[20] da Rocha J.A., de Oliveira S.B., Póvoa M.M., Moreira L.A. , Krettli A.U., Malaria vectors in areas of Plasmodium falciparum epidemic transmission in the Amazon region, Brazil, Am. J. Trop. Med. Hyg., 2008, 78, 872-877
[21] Chadee D.D., Tikasingh E.S., Ganesh R., Seasonality, biting cycle and parity of the yellow fever vector mosquito Haemagogus janthinomys in Trinidad, Med. Vet. Entomol., 1992, 6, 143-148
[22] Klein T.A., Lima J.B., Tang A.T., Seasonal distribution and diel biting patterns of culicine mosquitoes in Costa Marques, Rondônia, Brazil. Mem. Inst. Oswaldo Cruz., 1992 87, 141-148
[23] Breidenbaugh M.S., Clark J.W., Brodeur R.M., de Szalay F. A., Seasonal and diel patterns of biting midges (Ceratopogonidae) and mosquitoes (Culicidae) on the parris Island Marine Corps Rescruit Depot, J. Vector Ecol., 2009, 34, 129-140
[24] Balenghien T., Fouque F., Sabatier P., Bicout D.J., Horse-, bird-, and human-seeking behavior and seasonal abundance of mosquitoes in a West Nile virus focus of southern France, J. Med. Entomol., 2006, 43, 936-946
[25] Jaenson T.G., Diel activity patterns of blood-seeking anthropophilic mosquitoes in central Sweden, Med. Vet. Entomol., 1988, 2, 177-187
[26] Kramář J., Bitting mosquitoes – Culicidae, Fauna ČSR, vol. 13, Nakladatelství ČSAV, Praha, 1958, (in Czech)
[27] Becker N., Petrič D., Boase C., Lane J., Zgomba M., Dahl C.H., et al., Mosquitoes and their control, Kluwer Academic/Plenum Publisher New York, Boston, Dordrecht, London, Moscow, 2003
[28] Havlík O., Rosický B., The malaria in south Moravia after the Second World War, Čas. lék. českých, 1952, 91, 888-893, (in Czech)
[29] Rosický B., Havlík O., The anophelism of southern Moravia, Ent. Listy, 1951, 14, 119-130, (in Czech)