MOSQUITO FAUNA AND RISK OF MOSQUITO-BORNE DISEASES IN THE CAPITAL CITY BRATISLAVA, SLOVAKIA – THE RESULTS OF PRELIMINARY MONITORING

Marianna Dzidová[1], Viktória Čabanová[2], Eduard Stloukal[1] & Martina Miterpáková[2]

[1] Department of Zoology, Faculty of Natural Sciences, Comenius University, Mlynská dolina B–1, SK – 842 15 Bratislava, Slovakia [stloukal@fns.uniba.sk]
[2] Institute of Parasitology. Slovak Academy of Sciences. Hlinkova 3, 040 01 Košice. Slovakia [cabanova@saske.sk]

Abstract: Mosquitoes (Diptera, Culicidae) are the main vectors of dangerous parasites and other pathogens worldwide. In Slovakia, high attention was paid to mosquito monitoring in the past, but any records from the last decade are very rare and do not reflect rising epidemiological importance. Moreover, valuable data regarding mosquito fauna from cities and urban areas are completely absent. Therefore, the aim of the present study was mosquito mapping in highly populated urban environment of the capital city Bratislava, Slovakia. Within the study, 6261 female mosquitoes were collected. Based on morphological identification, harvested females belong to ten species – *Aedes cinereus/geminus*, *Aedes vexans, Anopheles hyrcanus, Anopheles maculipennis complex, Anopheles plumbeus, Coquillettidia richiardii, Culex pipiens complex, Ochlerotatus cantans, Ochlerotatus caspius, and Ochlerotatus sticticus*. The largest number of mosquitoes, 6093 individuals, were recorded in the Devínske jazero area, outskirt part of the city. Regarding seasonal fluctuation, the largest number of the mosquitoes were trapped during the July and August. All species recorded during the our study represent important vectors of mosquito-borne pathogens. For this reason, permanent monitoring of mosquito fauna could be high recommended also in other urban areas.

Key words: mosquitoes, Culicidae, urban environment, Bratislava, Slovakia.

INTRODUCTION

Mosquitoes of the genera *Anopheles*, *Aedes*, and *Culex* as well as other genera of Culicidae (Diptera) are the main vectors of dangerous parasites and other pathogens in the world. In the last period, more attention have been paid to those blood-feeding insect due to emergence of Zika virus and, in Europe, some filarial (*Dirofilaria* spp., *Setaria* spp.) and viral (West Nile virus – WNV, Chikungunya) diseases. Growing interest of researchers is focused on monitoring of mosquito fauna and its risk for human and animal health, thereby this topic attracts not only attention of scientists, but also the governments and public authorities (Czajka et al. 2012; Hubálek 2008; Lebl et al. 2015; Miterpáková et al. 2016; Sikka et al. 2016; Šebesta et al. 2010; Vazquez-Prokopec et al. 2010).

Urban areas increase survival, breeding success, and activity pathogen vectors (like *Culex pipiens*) and it correlates with human population density.

Dzidová M, Čabanová V, Stloukal E & Miterpáková M 2016: Fluctuation of mosquito species in capital city of Slovakia in years 2015 and 2016. *Folia faunistica Slovaca*, 21 (3): 245–250.
[in English]
Received 1 December 2016 ~ Accepted 20 December 2016 ~ Published 29 December 2016

e–ISSN 1336–4529 ISSN 1335–7522

The collection of data on the presence, absence, and abundance of vectors is an important factor to estimate the risk for the transmission of vector-borne diseases (Braks et al. 2011). However, data on the abundance of Culicidae are rare for European cities (Merdić et al. 2010; Krüger et al. 2014), and almost do not exist for Slovakia.

The aim of this study is to investigate the species composition of Culicidae in the city of Bratislava, Slovakia and to determine the importance of the captured species in the transmission of mosquito-borne diseases known for the region, and discuss the possible risk for the spread of those diseases within the city of Bratislava.

Increasing risk of pathogens transferred by mosquitoes and rising interest of public health and veterinary issues emphasize the importance of regular review of mosquito fauna at regional and national levels. Such studies brought information on newly reported, invasive southern European thermophilic mosquitoes spreading to north to Slovakia due to climate changes, e.g. *Culex theileri*, *Anopheles hyrcanus* and *Aedes albopictus* (Bitušík & Hrabinová 1998; Bocková et al. 2013a; Halgoš & Benková 2004; Halgoš & Petrus 1996) as well as provide information on changes in population structure as result of the environmental influences (Jalili 1995; Jalili et al. 1999; Labuda 1977, 1980; Labuda et al. 1979; Michalková 2004; Olejníček et al. 2003; Strelková & Halgoš 2012). The total number of Culicidae species known from Slovakia is as high as 49 (Országh 2004; Országh et al. 2001) and 30 of them do occur in Bratislava or close vicinity of the city.

Slovakia belong to countries which paid high attention to research on Culicidae (e.g. Minář et al. 2007; Okáli & Labuda 1988). Recent data on occurrence and distribution of mosquitoes are included mostly in research on pathogens transferred by them, especially in relation to viroses and dirofilariosis (Bárdoš & Danihelová 1959; Miterpáková et al. 2008; Stloukal et al. 2013).

While in the past the high attention was paid to mosquito monitoring in Slovakia, the records from last decade are very rare. The latest works were published by Strelková & Halgoš (2012) and Bocková et al. (2013). The mentioned researches covered areas of the Morava River and the Košická kotlina Basin, respectively. Nevertheless, valuable data regarding mosquito fauna from cities and urban areas are completely absent.

Therefore, the aim of the present study was mosquito mapping in urban environment of the capital city Bratislava, Slovakia. Highly populous areas and high diversity of urban habitats in the city were selected as sampling localities. The obtained data of the occurrence and the abundance of anthropophilic and zoophilic mosquito species enable evaluation of potential risk of mosquito-borne diseases in Bratislava.

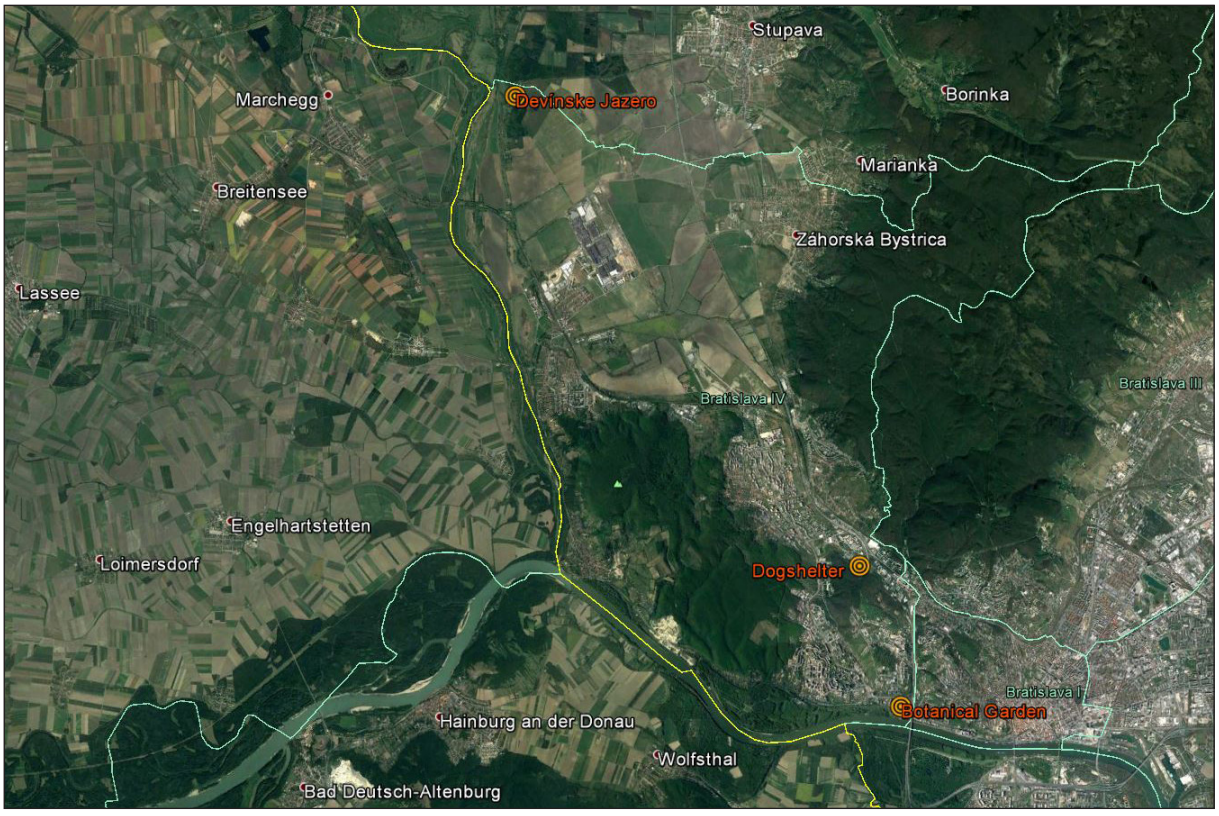

Figure 1. Map of the mosquito sampling sites in Bratislava, Slovakia (Devínske Jazero , Dog shelter, Botanic garden).

MATERIAL AND METHODS

Mosquito trapping and identification

The sampling techniques included CO_2 release, BG Sentinel traps (Biogents AG, Regensburg, Germany) equipped with CO_2, and a specific lure (Sweet ScentTM), Malaise trap and exhausters. A trapping event lasted for 24 h, with the exception of samples of a week lasting exposure.

Biogents Mosquitaire CO2 (BG-Mosquitaire CO2) (figure 1) is an excellent and eco-friendly trap for all mosquito species and other flying bloodfeeding insects. The sturdy plastic trap designed to be placed for your garden and has been tried and tested worldwide. It uses the same patented capture technology of all Biogents' traps with the additional use of pure carbon dioxide (CO2) which is an attractive key element of human respiration and the most important attractant for blood-feeding insects.

BG-Sentinel trap (figure 2), the professional collapsible mosquito trap, used with and without carbon dioxide.

Between June 2015 and September 2016, mosquitoes were caught weekly for 24 hours by carbon dioxide mosquito traps (Biogents, Germany) and Malaise trap, and stored in deep freezer (-20 °C) until their identification. Female mosquitoes were identified using morphological characteristics according to the identification key of Becker et al. (2010). Unfortunately, some material could be classified only to genera (because of its damage during the trapping) as *Aedes* spp., *Anopheles* spp. and *Culex* spp.

Sampling area

Three different sampling sites were selected for our study in Bratislava, the capital city of Slovakia, based on the high density of potential human and animal host for anthropophilic and zoophilic mosquitoes species. Bratislava (48° latitude) is situated on the state borders of Slovakia with Hungary and Austria, at north-western tip in Pannonian lowland, at south-western part of the country.

Town is situated on the banks of the Danube river, on junction of Pannonian lowland, Záhorská nížina lowland, and Vienna basin (Wiener Becken), reaching up to the westernmost slopes of the Carpathian mountain range.

Mosquito fauna is prominently affected by presence of Danube and Morava rivers with periodic floods, reaching even in centre of the city. Climatic condition for this area is characteristic by mild climate with average year temperature of 10 °C (with the highest average temperature 25 °C in August and the lowest average temperature approximately -5 °C in January) and average year humidity of 77.5 % (Climate Atlas of Slovakia 2015). The rivers nearby the city are surrounded by fragments of humid flooded forest sides of lowlands.

Humid temperate climate with warm summers, with about 20 hot days per year (maximum temperatures reaching over 30 °C) fulfils requirements for possible major outbreaks of vector-borne diseases, especially under climate warming scenarios with increasing numbers of hot days.

Sampling sites (figure 1)

Sampling site 1 – Devínske Jazero, N 48° 16′, E 16° 58′ – garden zone between flooded area of the Morava river and forests. Devínske Jazero is a garden zone situated in an outskirt of the city along the innundation area of the river, surrounded by meadows and forests. This area is characteristic by periodic floods of the Morava river with size even 12 km^2.

Sampling site 2 – Dog shelter Sloboda zvierat, Bratislava, N 48° 10′, E 17° 4′; dozens of hutches for few hundreds of dogs, situated near deciduous forest, in short distance from urban areas and zoological garden. Dog shelter is surrounded by deciduous forest in wider city centre, with expectation of high density of animal hosts.

Sampling site 3 – Botanic garden of the Comenius University, N 48° 9′, E 17° 4′; botanic garden with green houses, ponds, fountains, near the center of capital city, on the banks of the Danube River). This area was selected based on supposition of high density of human hosts, e.g. visitors of botanic garden and Danube waterfront, which is located next to this area.

RESULTS AND DISCUSSION

In this study, 6261 female mosquitoes were collected in years 2015 and 2016. Based on morphology identification, harvested females belongs to ten species – *Aedes cinereus / geminus*, *Aedes vexans*, *Anopheles hyrcanus*, *Anopheles maculipennis* complex, *Anopheles plumbeus*, *Coquillettidia richiardii*, *Culex pipiens* complex, *Ochlerotatus cantans, Ochlerotatus caspius*, *Ochlerotatus sticticus* (Table 1). This finding represents more than 20 % of all mosquito species previously detected in various regions of Slovakia (Bocková et al. 2013a; Halgoš & Benková 2004; Halgoš & Petrus 1996; Országh et al. 2001).

The most abundant species was *Ae. vexans* with more than 2600 collected individuals during the studied period. The second most numerous group consists of females belonging to *Culex pipiens* complex. On the contrary, only one individual was caught from *An. hyrcanus* and *Och. cantans* species (Table 1).

Table 1. Abundance of mosquito species in three different sampling sites in Bratislava, Slovakia, within the period of June 2015 to September 2016.

Species	Devínske Jazero	Botanic garden	Dog shelter
Ae. cinereus/ geminus	4	1	
Ae. vexans	2661	12	
Aedes spp.	695		2
An. hyrcanus	1		
An. maculipennis complex	126		
An. plumbeus			7
Anopheles spp.	1		
Cq. richiardii	15		
Cx. pipiens complex	1980	44	17
Culex spp.	219		11
Oc. cantans	1		
Oc. caspius	3		
Oc. sticticus	387	5	1

Table 2. Monthly fluctuation of individual mosquito species trapped in the capital city of Bratislava, Slovakia.

Species	June	July	August	September
Ae. cinereus/ geminus			○	
Ae. vexans	○	○	○	○
An. hyrcanus		○		
An. maculipennis complex	○	○	○	○
An. plumbeus				○
Cq. richiardii	○	○	○	
Cx. pipiens complex	○	○	○	○
Oc. cantans		○		
Oc. caspius		○	○	
Oc. sticticus	○	○	○	○

The largest number of mosquitoes, 6093 individuals, were recorded in the Devínske Jazero, outskirt part of the city where mainly recreational garden-plots are situated. Not only high abundance, but also the highest variability of mosquito species was distinguishing for this locality. The reason could be an extensive floodplain area of Morava river occurred here. That could be testified also by extreme abundance of floodplain mosquito species, *Ae. vexans*, recorded in this area. Additionally, in Devínske jazero one female of An. hyrcanus was found. *An. hyrcanus* was for the first time recorded in Slovakia by Halgoš & Benková (2004), and later in 2012 (Strelková & Halgoš 2012). Then, here presented finding in Devínske Jazero confirms this invasive Mediterranean species and an important vector of malaria has been unambiguously domiciliated in an actual environmental conditions of Slovakia.

In other two localities (dog shelter and botanical garden) significantly less number of mosquitoes were found as compared with Devínske Jazero, just 38 and 62 individuals. That could be caused by different environmental and climatic conditions in the city centre were these sampling sites are situated (warm and dry climate and an absence of floods within the sampling period). However, the results from these sampling localities give an interest point of view for our study. The most abundant species recorded in dog shelter and botanical garden was *Cx. pipiens* complex, similarly as in research of Lebl et al. 2015 from Vienna city. The floodplain mosquito species, *Ae. vexans*, was trapped in the area of botanical garden but missed in dog shelter. On the other hand, deciduous forest surrounded dog shelter creates suitable habitat for another important vector of malaria, *An. plumbeus*, which was found only in this sampling site.

Regarding seasonal fluctuation, the largest number of the mosquitoes were trapped during the July and August. Only four most abundant species, *Ae.*

vexans, An. maculipennis complex, *Cx. pipiens* complex and *Och. sticticus*, were presented in the whole sampling period, from June to September. Three species, *Ae. cinereus* / *geminus*, *An. hyrcanus* and *Och. cantans*, all represented just by one exemplar caught in our study, were found only in July and August (Table 2).

All species recorded during the our study represent important vectors of mosquito-borne pathogens. *Ae. vexans* is known as vector of West Nile virus, Usutu virus, Tahyna virus, as well as filaroid nematodes *Dirofilaria* spp., which were detected in Bratislava district with prevalence of 11.5% in canine population (Miterpáková et al. 2016). *Culex pipiens* complex can transmit either Sindbis virus and *Plasmodium* spp. Moreover, the main vector of *Plasmodium* spp. (causative agent of malaria), *An. maculipennis* complex, is also responsible for spreading of *Dirofilaria* spp. and WNS. And the last one species, *Och. sticticus* can transmit Tahyna virus and *Dirofilaria* spp. (Gratz 2004).

The results of our preliminary study provide an evidence that in Bratislava, the capital city of Slovakia, high risk for transmission of dangerous mosquito-borne diseases exists. For this reason, permanent monitoring of mosquito fauna could be high recommended also in others urban areas.

ACKNOWLEDGEMENT

The authors are grateful the Sloboda zvierat, the Botanical Garden and Edvis s.r.o. for their help and support. The work was supported by the project "Application Centre for Protection of Humans, Animals and Plants against Parasites" (code ITMS: 26220220018), supported by the Research & Development Operational Programme funded by the ERDF (1.0).

REFERENCES

Bárdoš V & Danielová V, 1959: The Ťahyňa virus – a virus isolated from mosquitoes in Czechoslovakia. J. Hyg. Epidemiol. Microbiol. Immunol. 3: 264–276

Becker N, Petric D, Zgomba M, Boase C, Madon M, Dahl C & Kaiser A. 2010: Mosquitoes and their control. Springer, Heidelberg, Dordrecht, New York, 577 pp.

Biogents, 2016: Biogents: Mosquito traps with superior capture rates. http://www.biogents.com/mosquito-traps/#1482413542213-4bb8c94a-d48b, retrieved on 25. 11. 2016.

Bitušík P & Hrabinová S, 1998: Uranotaenia unguiculata (Diptera, Culicidae) – first record from Slovakia. Biologia 53 (5): 664

Bocková E, Kočišová A & Letková V, 2013a: First record of Aedes albopictus in Slovakia. Acta Parasitologica 58: 603–606.

Bocková E, Kočišová A & Hlavatá H. 2013b: Evaluation of species composition and seasonal dynamics of mosquito larvae in the Košice Basin during 2010 and 2011. Biologia 68: 337–344.

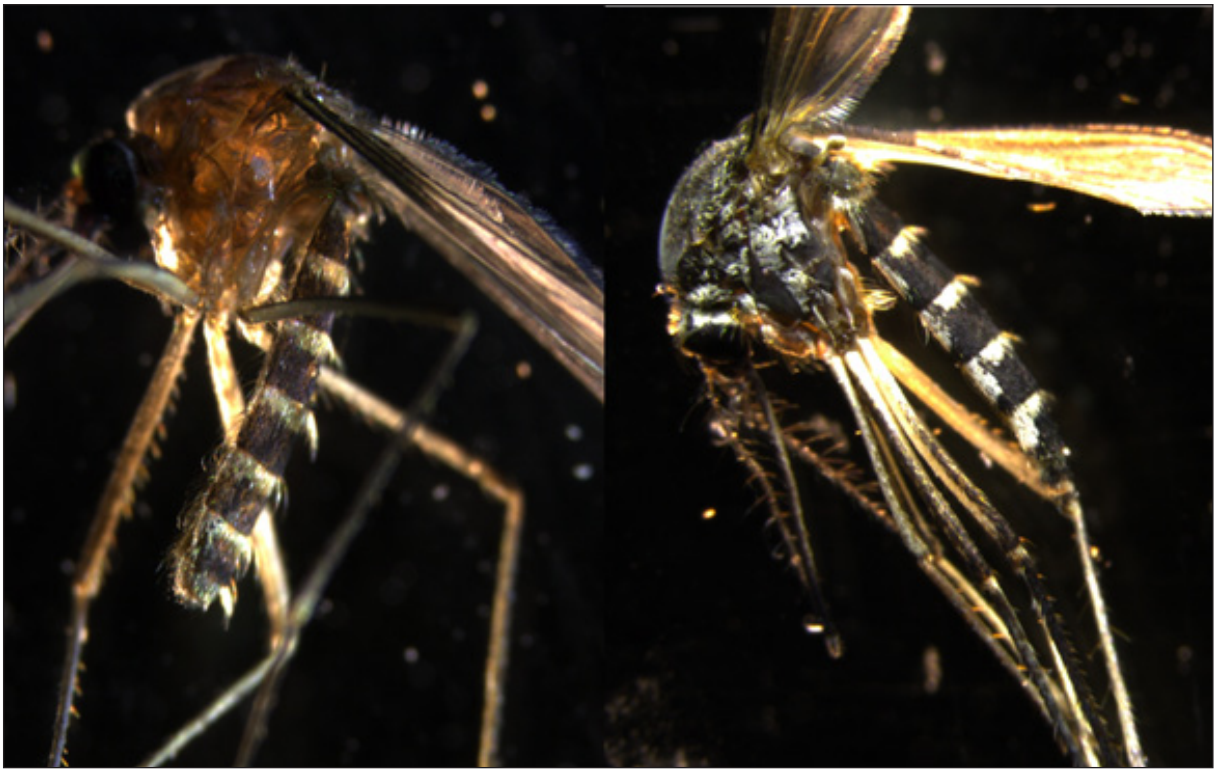

Figure 1. The most abundant mosquito species in Bratislava, Slovakia – *Culex pipiens* complex (left) and *Aedes vexans* (right).

Braks M, Van Der Giessen J, Kretzschmar M, Van Pelt W, Scholte E-J, Reusken C, Zeller H, Van Bortel W & Sprong H, 2011: Towards an integrated approach in surveillance of vector-borne diseases in Europe. Parasit Vectors 4: 192. doi: 10.1186/1756-3305-4-192.

Climate Atlas of Slovakia, 2015: Slovak Hydrometeorological Institute. Bratislava, Slovakia. ISBN 978-80-88907-90-9.

Czajka C, Becker N, Poppert S, Jöst H, Schmidt-Chanasir J & Krüger A, 2012: Molecular detection of Setaria tundra (Nematoda: Filarioidea) and an unidentified filarial species in mosquitoes in Germany. Parasit Vectors 5: 14.

Gratz NG, 2004: The mosquito-borne infections of Europe. European Mosquito Bulletin 17: 1–4.

Halgoš J & Benková I, 2004: First record of Anopheles hyrcanus (Dipetra: Culicidae) from Slovakia. Biologia 59: 15, 68.

Halgoš J & Petrus O, 1996: First record of Culex theileri (Diptera, Culicidae) in Slovakia. Biologia, Bratislava 51: 190

Hubálek Z, 2008: Mosquito-borne viruses in Europe. Parasitol Res. 103: 29–43. doi: 10.1007/s00436-008-1064-7

Jalili NA, 1995: A faunistic review and virological testing of mosquitoes in Western Slovakia between 1991–1993. Dipterol. Bohemoslov. 7: 77–82

Jalili N, Halgoš J, Ondriska F & Brestovský J, 1999: Mosquito communities of the Morava flood plain area during floods in 1997. Dipterol. Bohemoslov. 9: 77–81.

Krüger A, Börstler J, Badusche M, Lühken R, Garms R & Tannich E, 2014: Mosquitoes (Diptera: Culicidae) of metropolitan Hamburg, Germany. Parasitol Res. 113: 2907–2914. doi: 10.1007/s00436-014-3952-3

Labuda M, 1977: Mosquitoes (Diptera, Culicidae) in Lowland Záhorská nížina (western Slovakia). Entomol. Probl., Bratislava, 14: 123–173. [in Slovak]

Labuda M, 1980: Species of subgenus Aedes s. str. (Diptera: Culicidae) in Czechoslovakia, Dipterol. Bohemoslov. 2: 329–335.

Labuda M, Kožuch O & Nosek J, 1979: Distribution of mosquitoes with an accent on the man-attacking species in Western Slovakia, Práce Slov. Entomol. Spol. SAV 1: 153–160.

Lebl K, Zittra C, Silbermayr K, Obwaller A, Berer D, Brugger K, Walter M, Pinior B, Fuehrer H-P & Rubel F, 2015: Mosquitoes (Diptera: Culicidae) and their relevance as disease vectors in the city of Vienna, Austria. Parasitol Res. 114: 707–713. doi: 10.1007/s00436-014-4237-6

Merdić E, Bogojević M, Boca I & Turić N, 2010: Determined and estimated mosquito (Diptera, Culicidae) fauna in the city of Osijek, Croatia, using dry-ice baited CDC traps. Period Biol. 112: 201–205.

Michalková V, 2004: Phenology of mosquito species (Diptera, Culicidae) in the inundation area of the River Morava. Master thesis, Comenius University, Bratislava, Slovakia [in Slovak]

Minář J, Halgoš J, Bartálová A & Jalili N, 2007: Current climatic change and its impact on mosquito fauna in conditions of Slovakia and Czech republic, Acta Zool. Univ. Comen, 47 (2): 177–182.

Miterpáková M, Antolová D, Hurníková Z & Dubinský P, 2008: Dirofilariosis in Slovakia — a new endemic area in Central Europe, Helminthologia 45 (1): 20–23.

Miterpáková M, Iglódyová A, Čabanová V, Stloukal E & Miklisová D. 2016: Canine dirofilariosis endemic in Central Europe – 10 years of epidemiological study in Slovakia. Parasitol Res. 115: 2389–2395. doi: 10.1007/s00436-016-4989-2.

Okáli I & Labuda M, 1988: History of malaria research in Slovakia. Entomol. Probl. 18: 233–251. [in Slovak]

Olejníček J, Gelbič I & Minář J, 2003: Changes in mosquito diversity in the lower Morava and Dyje basin caused by catastrophic floods and global warming. Folia Faunistica Slovaca 8: 61–62 [in Czech]

Országh I, 2004: Catalogue of mosquitoes (Diptera: Culicidae) of Slovakia. Biologia, Bratislava 59 (Suppl. 15): 69–156.

Országh I, Halgoš J, Jalili N & Labuda M, 2001: Mosquitoes (Diptera, Culicidae) of Slovakia II. European Mosquito Bulletin 11, 1-26.

Sikka V, Chattu VK, Popli RK, Galwankar SC, Kelkar D, Sawicki SG, Stawicki SP & Papadimos TJ, 2016: The Emergence of Zika Virus as a Global Health Security Threat: A Review and a Consensus Statement of the INDUSEM Joint working Group (JWG). J Glob Infect Dis. 8: 3–15. doi: 10.4103/0974-777X.176140.

Stloukal E, Čabanová V & Stloukalová V, 2013: HDU model for identification of the risk regions on dirofilariosis occurrence in Slovakia. Folia faunistica Slovaca, 18: 303–308.

Strelková L & Halgoš J, 2012: Mosquitoes (Diptera, Culicidae) of the Morava River floodplain, Slovakia. Central European Journal of Biology, 7 (5): 917–926.

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. J Vector Ecol 35: 156–162.

Vazquez-Prokopec G, Chaves L, Ritchie S, Davis J, Kitron U, 2010: Unforeseen costs of cutting mosquito surveillance budgets. PLoS Negl Trop Dis. 4:e858. doi: 10.1371/journal.pntd.0000858