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REVIEW

Emerging mosquito invaders: Range expansion and revised checklist of Culicidae in the Czech Republic and Slovakia

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Abstract

Mosquitoes are significant vectors of numerous medically important pathogens, including viruses, bacteria, protozoa, and nematodes. Invasive mosquito species, primarily of Asian origin, are rapidly expanding across Europe, thereby elevating the risk of dengue, Zika, and chikungunya outbreaks in urban areas. This updated checklist builds upon and significantly expands the previous version published in the second electronic edition of the Checklist of Diptera of the Czech Republic and Slovakia, covering the family Culicidae (Meigen, 1818). The earlier checklist documented 50 species in total: 45 from Czech Republic (39 in Bohemia and 39 in Moravia) and 50 from Slovakia. The current revision recognizes 55 species, of which 51 occur in the Czech Republic (48 in Bohemia and 43 in Moravia) and 54 in Slovakia. The checklist is based on a critical review of the faunistic literature and includes newly recorded species. In addition to synthesizing data from previously published literature, this study incorporates newly recorded invasive mosquito species—*Aedes albopictus*, *Ae. japonicus japonicus*, and *Ae. koreicus* and provides an overview of their distributional expansion and ecological characteristics. Their establishment and ongoing spread represent a significant epidemiological risk, particularly in the context of climate change, increasing international trade, and growing human mobility, which facilitate both mosquito dispersal and pathogen introduction.

Keywords Culicidae · Mosquitoes · Biodiversity · Faunistic · New records · Invasive alien species · Central Europe

Introduction

Mosquitoes (Culicidae) represents one of the most thoroughly studied families of Diptera, primarily due to their medical and veterinary significance. Females of many species are blood-feeding (hematophagous) and act as vectors transmitting various pathogens to humans and animals, including arboviruses (e.g. causative agents of dengue, Zika, chikungunya, and yellow fever), *Plasmodium* spp. (causing malaria), and filarial worms (e.g. causative agents of elephantiasis, dirofilariosis, setariosis). According to the World Health Organization (WHO), vector-borne diseases account for more than 17% of all infectious diseases and are responsible for over 700,000 deaths annually (WHO 2024).

Regular entomological surveillance is especially relevant in the global context of climate change and urbanization, which are creating new ecological opportunities for invasive *Aedes* mosquitoes, including medically important species such as *Aedes aegypti* and *Aedes albopictus* (Kraemer et al. 2019).

Globally, approximately 3,570 species and 130 subspecies of mosquitoes have been described, divided between the subfamilies of Anophelinae (about 510 species/subspecies)

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and Culicinae (about 3,190 species/subspecies) (Wilkerson et al. 2021). More than 100 species are known from Europe (Snow and Ramsdale 2003). In the Czech Republic, 51 mosquito species have been recorded (48 in Bohemia and 43 in Moravia), while Slovakia hosts 54 confirmed species. These numbers reflect both long-term sampling efforts and more recent faunistic surveys. The last general faunistic review covering both countries was published in the Electronic Catalogue of Diptera, version 2 (Országh et al. 2009), while dedicated catalogues of Slovak species were published earlier (Jalili et al. 2000a; Országh 2004). Distribution maps for mosquito species in Slovakia were provided by Országh et al. (2001), offering a valuable biogeographic overview.

Methods

Mosquito identification in the Czech and Slovak territories primarily follows the comprehensive monograph by Kramář (1958), which remains a cornerstone of regional taxonomy. Additional identification keys can be found in the works of Mončadskij (1951), Mihályi and Sztankay-Gulyás (1963), Mohrig (1969), Dahl (1997) and Becker et al. (2010). In some cases, molecular tools (e.g. COI barcoding) were used to confirm species identity.

Scientific names of mosquito genera, subgenera, species and subspecies follow the rules of the International Code of Zoological Nomenclature (ICZN) and are aligned with the updated global classification published by Wilkerson et al. (2021).

Results and discussion

In the second electronic version of the Checklist of Diptera of the Czech Republic and Slovakia (Országh et al. 2009), a total of 50 mosquito species were listed: 45 from Czech Republic (39 in Bohemia and 39 in Moravia) and 50 from Slovakia. The updated checklist now includes 55 species in total, reflecting both newly recorded taxa and recent taxonomic revisions. Currently, 51 species are known from Czech Republic (48 in Bohemia and 43 in Moravia) and 54 species from Slovakia. The observed increase in species diversity can be attributed to several factors: intensified field surveys, improved identification techniques, mainly the use of molecular methods.

Regarding the public health importance of mosquitoes, malaria was endemic in the former Czechoslovakia until 1959. Later in 1963, Czechoslovakia was officially declared malaria-free by the WHO, after which research on malaria vectors gradually declined. Although malaria has been eliminated in both countries, potential vectors (anopheline mosquitoes) capable of transmitting *Plasmodium* parasites remain widely present. Nevertheless, in the context of increasing international travel, population mobility, and environmental changes, the re-emergence of malaria transmission cannot be entirely excluded (Jalili et al. 2000b). Following the elimination of malaria, mosquito research in Czechoslovakia regained significance after their role as vectors of arboviruses in Central Europe was recognized. Bardos and Danielova (1959) isolated an entirely new mosquito-borne arbovirus, Ťahyňa, and later another arbovirus, Čalovo, was discovered (Bardos and Cupkova 1962). West Nile virus was isolated by Labuda et al. (1974), and there is also evidence of another arbovirus, Sindbis (Ernek et al. 1973) isolated from reed warbler. Worldwide, more than 500 arthropod-borne viruses (arboviruses) have been identified, about 300 of which are transmitted by mosquitoes, and approximately 100 are known to infect humans or be of medical importance (WHO 2025a, b). Among vector arthropods invading new territories, defined as the processes of arrival, establishment, and spread, mosquitoes have historically been particularly successful (Lounibos 2002; Kampen and Werner 2014).

Furthermore, the recent range expansions, presumably driven by ongoing environmental and climatic changes, have likely facilitated the establishment and subsequent detection of previously unrecorded as well as non-native invasive species. This expansion has been driven not only by climate change but also by the growth of international trade and travel (Radici et al. 2025). Thus far, several invasive mosquito species have been introduced into many European countries, where they have subsequently established viable populations. To date in the Czech Republic and Slovakia, three invasive mosquito species of East and Southeast Asian origin have been recorded.

Aedes albopictus, commonly known as the Asian tiger mosquito, is an invasive species that was introduced into Europe in the late twentieth century (Adhami and Reiter 1998). Since then, it has spread widely and has been recorded in more than 25 European countries. To date, the European Centre for Disease Prevention and Control (ECDC) classifies *Ae. albopictus* as established in 13 of these countries, particularly in the Mediterranean region. The species has the capacity to transmit more than 20 arboviruses, including dengue, chikungunya, and Zika, which has raised significant public health concerns. Its expanding distribution across Europe represents a growing threat to public health (ECDC 2025).

A highly ranked invasive culicid species (Kampen and Werner 2014) is the Asian bush mosquito, also known as the Asian rock pool mosquito, *Ae. japonicus japonicus* (Theobald, 1901). It originates from East Asia and the Far East, where it represents one of four subspecies of *Ae. j. japonicus*. Similar to *Ae. albopictus*, its geographical expansion has been largely facilitated by human activities, particularly the international

Table 1 Checklist of mosquitoes of the Czech Republic (CZ - Bohemia B, Moravia M) and Slovakia (SK)

Sub-family ANOPHELINAE	Subgenus	Species					Notes
Genus *Anopheles* Meigen, 1818	*Anopheles Meigen, 1818*						
		atroparvus van Thiel, 1927	CZ		M	SK	1)
		claviger (Meigen, 1804)	CZ	B	M	SK	
		daciae Linton, Nicolescu & Harbach, 2004	**CZ**	**B**	**M**	**SK**	2, 3)
		hyrcanus (Pallas, 1771)	CZ	**B**	M	SK	4)
		maculipennis s.s. Meigen, 1818	CZ	B	M	SK	
		messeae Falleroni, 1926	CZ	B	M	SK	
		plumbeus Stephens, 1828	CZ	B	M	SK	
Sub-family CULICINAE							
Tribe AEDINI							
Genus *Aedes* Meigen, 1818							
	Aedes Meigen, 1818	*cinereus* s.l. Meigen, 1818	CZ	B	M	SK	
		geminus Peus, 1970	**CZ**	**B**		SK	5)
		rossicus Dolbeshkin, Gorickaja & Mitrofanova, 1930	CZ	B	M	SK	
	Aedimorphus Theobald, 1903	*vexans* (Meigen, 1830)	CZ	B	M	SK	
	Dahliana Reinert, Harbach & Kitching, 2006						
		geniculatus (Olivier, 1791)	CZ	B	M	SK	6)
	Hulecoeteomyia Theobald, 1904	*japonicus* (Theobald, 1901)	**CZ**	**B**	**M**	**SK**	7)
		koreicus (Edwards, 1917)	**CZ**	**B**	**M**	**SK**	8)
	Ochlerotatus Lynch Arribálzaga, 1891						9)
		annulipes (Meigen, 1830)	CZ	B	M	SK	
		behningi Martini, 1926				SK	
		cantans (Meigen, 1818)	CZ	B	M	SK	
		caspius (Pallas, 1771)	CZ	B	M	SK	
		cataphylla Dyar, 1916	CZ	B	M	SK	
		communis (de Geer, 1776)	CZ	B	M	SK	
		cyprius Ludlow, 1920				SK	
		detritus Haliday, 1833				SK	10)
		diantaeus Howard, Dyar & Knab, 1912	CZ	B	M	SK	
		dorsalis (Meigen, 1830)	CZ	B	M	SK	
		excrucians (Walker, 1856)	CZ	B	M	SK	
		flavescens (Müller, 1764)	CZ	B	M	SK	
		hungaricus Mihályi, 1955				SK	
		intrudens Dyar, 1919	CZ	B	M	SK	
		leucomelas (Meigen, 1804)	CZ	B	M	SK	
		nigrinus (Eckstein, 1918)	**CZ**		**M**	SK	11)
		pulcritarsis (Rondani, 1872)	CZ	B		SK	
		pullatus (Coquillett, 1904)	CZ	B		SK	
		punctor (Kirby, 1837)	CZ	B	M	SK	
		riparius Dyar & Knab, 1907	CZ	B			
		sticticus (Meigen, 1838)	CZ	B	M	SK	
	Rusticoidus Shevchenko & Prudkina, 1973						
		refiki Medschid, 1928	CZ	**B**	M	SK	12)
		rusticus (Rossi, 1790)	CZ	B	M	SK	
	Stegomyia Theobald, 1901						
		albopictus (Skuse, 1895)	**CZ**	**B**	**M**	**SK**	13)
Tribe CULICINI							
Genus *Culex* Linnaeus, 1758							
	Barraudius Edwards, 1921						
		modestus Ficalbi, 1890	CZ	B	M	SK	

Table 1 (continued)

Sub-family ANOPHELINAE	Subgenus	Species					Notes
	Culex Linnaeus, 1758						
		pipiens f. *pipiens* Linnaeus, 1758	CZ	B	M	SK	
		pipiens f. *molestus* Forskål, 1775	CZ	B	M	SK	
		theileri Theobald, 1903				SK	
		torrentium Martini, 1925	CZ	B	M	SK	
	Maillotia Theobald, 1907						
		hortensis Ficalbi, 1889	CZ	B		SK	
	Neoculex Dyar, 1905						
		martinii Medschid, 1930	CZ		M	SK	[14]
		territans Walker, 1856	CZ	B	M	SK	
Tribe CULISETINI							
Genus *Culiseta* Felt, 1904							
	Allotheobaldia Brolemann, 1919						
		longiareolata (Macquart, 1838)	**CZ**	**B**		SK	[15]
	Culicella Felt, 1904						
		fumipennis (Stephens, 1825)	CZ	B			
		morsitans (Theobald, 1901)	CZ	B	M	SK	
		ochroptera (Peus, 1935)	CZ	B		SK	
	Culiseta Felt, 1904						
		alaskaensis (Ludlow, 1906)	CZ	B	M	SK	[16]
		annulata (Schrank, 1776)	CZ	B	M	SK	
		glaphyroptera (Schiner, 1864)	CZ	B	M	SK	
		subochrea (Edwards, 1921)	CZ	B	M	SK	[17]
Tribe MANSONIINI							
Genus *Coquillettidia* Dyar, 1905							
	Coquillettidia Dyar, 1905						
		richiardii (Ficalbi, 1889)	CZ	B	M	SK	
Tribe URANOTAENIINI							
Genus *Uranotaenia* Lynch Arribálzaga, 1891							
	Pseudoficalbia Theobald, 1912						
		unguiculata Edwards, 1913	CZ	**B**	M	SK	[18]

Comments

New records are in bold and relevant annotations are provided:

[1] in PCV2 (previous checklist version) also as *An. labranchiae* Falleroni, 1926 (see Jalili et al. 2000a)

[2,3] records in Blažejová et al. (2018) and Rettich and Imrichová (2020)

[4] record for Bohemia added Rettich and Imrichová (2019)

[5] record for Czech Republic added Rettich and Imrichová (2019)

[6] in PCV2 in genus *Aedes* (see Reinert et al. 2006)

[7] records in Čabanová et al. (2021), Jalili et al. (2022) and Vojtíšek et al. (2022a)

[8] records in Oboňa et al. (2020) (re-evaluated and negated in Čabanová et al. 2021) and Vojtíšek et al. (2022b), in Loziaková Peňazziová et al. (2026)

[9] in PCV2 all species in genus *Aedes* (Reinert 2000)

[10] in PCV2 omitted (see Trpiš 1965)

[11] in PCV2 omitted from CZ (M) (see Vaňhara 1987)

[12] record in Rettich and Imrichová (2019)

[13] records in Šebesta et al. (2012), Bocková et al. (2013), Rettich and Kulma (2018)

[14] in PCV2 omitted (see Trpiš 1956, Országh 2002)

[15] record in Rettich and Imrichová (2019)

[16] in Dvořák (2025)

[17] in PCV2 as subsp. in *Cs. annulata* (see Snow and Ramsdale 2003)

[18] records Bitušík and Hrabinová (1998), Rettich and Imrichová (2019)

trade in used tires. *Ae. j. japonicus* has become the third invasive mosquito species to be reported in Europe. Its distribution in Central Europe continues to expand. (Schaffner et al. 2009). The species produces eggs that exhibit resistance to freezing and desiccation, enabling them to remain in a state of diapause throughout the winter and to hatch once environmental conditions become favourable. This physiological adaptation facilitates passive dispersal through the transport of infested containers (Medlock et al. 2005). This species is one of the most widespread species of mosquitoes in the world (Kampen and Werner 2014).

Aedes koreicus is a container-breeding mosquito that oviposits in a wide range of artificial containers as well as in natural cavities, such as tree holes and rock pools, across urban, peri-urban, and natural environments. Its eggs exhibit prolonged viability and resistance to desiccation, facilitating passive dispersal via transportation pathways including aircraft, ships, and motor vehicles. It overwinters in cold-resistant eggs that hatch early in the following spring. Adults may persist for an extended seasonal period, thereby partially reducing larval competition with sympatric species (Montarsi et al. 2022).

Since invasive mosquito species capable of transmitting various arboviruses have been recorded in Slovakia and Czech Republic, it is essential that the competent authorities (e.g., ministries of health and funding agencies) allocate adequate resources for research, monitoring, and vector control. Further investigation and systematic surveillance are strongly recommended.

The updated list of mosquito species from the Czech Republic and Slovakia is given in Table 1.

Conclusions

The updated Checklist of Diptera of the Czech Republic and Slovakia, documents a notable increase in recorded mosquito diversity, with the total number of species rising from 50 to 55. Currently, 51 species are known from Czech Republic and 54 from Slovakia. This increase reflects not only intensified faunistic research but also advances in identification methods, including the application of molecular approaches. At the same time, recent environmental and climatic changes have likely facilitated range shifts and the establishment of previously unrecorded taxa.

Particularly significant is the confirmed presence of three invasive mosquito species of East and Southeast Asian origin in the Czech and Slovak Republics: *Ae. albopictus*, *Ae. j. japonicus*, and *Ae. koreicus*. These species possess ecological and physiological traits such as desiccation and cold resistant eggs, ecological plasticity, and adaptation to container breeding that facilitate their establishment and further spread in temperate regions. Their expansion has been strongly supported by globalization, particularly international trade and transport, as well as by ongoing climatic warming.

From a public health perspective, the establishment and potential further spread of invasive *Aedes* species are of considerable concern. In particular, *Ae. albopictus* is a competent vector of numerous arboviruses and represents a tangible risk for the introduction and local transmission of pathogens under suitable epidemiological conditions. Continuous monitoring, early detection, and coordinated cross border surveillance are therefore essential to track further spread, assess establishment status, and mitigate potential health risks.

Overall, the updated checklist not only provides a refined overview of mosquito biodiversity in Czech Republic and Slovakia but also highlights the dynamic nature of the regional culicid fauna in the context of global environmental change. Continued integrative research combining classical taxonomy, molecular tools, and active public engagement will be crucial for understanding and managing future developments in mosquito distribution and associated health implications.

Surveillance programs should integrate entomological monitoring, pathogen screening, and risk mapping to detect further spread and assess vector competence under local conditions. Control strategies should focus not only on these invasive species but also on other medically important native and established vector species that may contribute to pathogen transmission.

Comprehensive and sustained investigations are strongly recommended to better understand the ecology, seasonal dynamics, and distribution patterns of these species in Czech Republic and Slovakia. Such efforts are crucial for developing evidence-based prevention strategies and for strengthening national preparedness against emerging mosquito-borne diseases.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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