

Original paper

Mosquito diversity in an urban landscape: species composition and a new record of *Culiseta longiareolata* law, Poland

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ABSTRACT. Climate change, globalisation, and land use transformation are driving the redistribution of mosquito species (Diptera: Culicidae), with urban areas becoming hotspots for both native and invasive taxa. This study assessed mosquito species diversity in Wrocław, SW Poland, based on CDC trap collections from 14 sites between May and October 2024. A total of 17,104 adult mosquitoes were collected, of which 16,728 (97.8%) were identified to species level. Fifteen species across five genera were recorded, with *Aedes vexans* dominating the assemblage (68.7%), followed by *Coquillettidia richiardii* (9.8%). Molecular analyses confirmed all morphologically identified species. Mosquito abundance peaked in July and August, although some locations showed earlier seasonal maxima. Species such as *Ae. vexans*, *Cq. richiardii*, and *Culex pipiens* s.l./*Cx. torrentium* were present at all sites, while others were more localised. Notably, *Culiseta longiareolata*, previously unrecorded in Poland, was detected at a single urban site, contributing to recent evidence of a northward shift in its European distribution. Although based on only two individuals, this finding may indicate an early signal of a northward range of extension rather than evidence of established populations. These results underscore the value of continuous urban mosquito surveillance for documenting changes in species composition, detecting potential range shifts, and assessing public health risks under changing environmental conditions.

Keywords: *Culiseta longiareolata*, mosquito diversity, Poland, first record

Introduction

Climate change, globalization, and land use change are increasingly recognized as major drivers of the global redistribution of vector species, including mosquitoes (Diptera: Culicidae), which transmit a wide range of pathogens responsible for vector-borne diseases including malaria, dengue, chikungunya, and West Nile virus [1–3]. In recent decades, the expansion of mosquito populations into previously non-endemic areas has become a growing concern, particularly in temperate regions of Europe. Urban environments are especially vulnerable to these changes, as they provide favourable conditions for mosquito development, including abundant breeding habitats, stable microclimates, and high human population density

[4–6]. These conditions not only support the proliferation of native species but also facilitate the establishment of invasive taxa.

Consequently, continuous, and systematic monitoring of mosquito populations in urban areas is essential not only to detect shifts in species composition but also to identify the emergence of new or non-native species that may pose public health threats. Despite growing awareness of these risks, mosquito surveillance in Central and Eastern Europe remains fragmented and limited in scope. In Poland, for example, there is no comprehensive nationwide monitoring programme, and systematic studies are largely restricted to urban areas, with rural regions receiving far less attention [7]. As of early 2024, the mosquito fauna of Poland comprised 51 species belonging to five genera: *Aedes*,

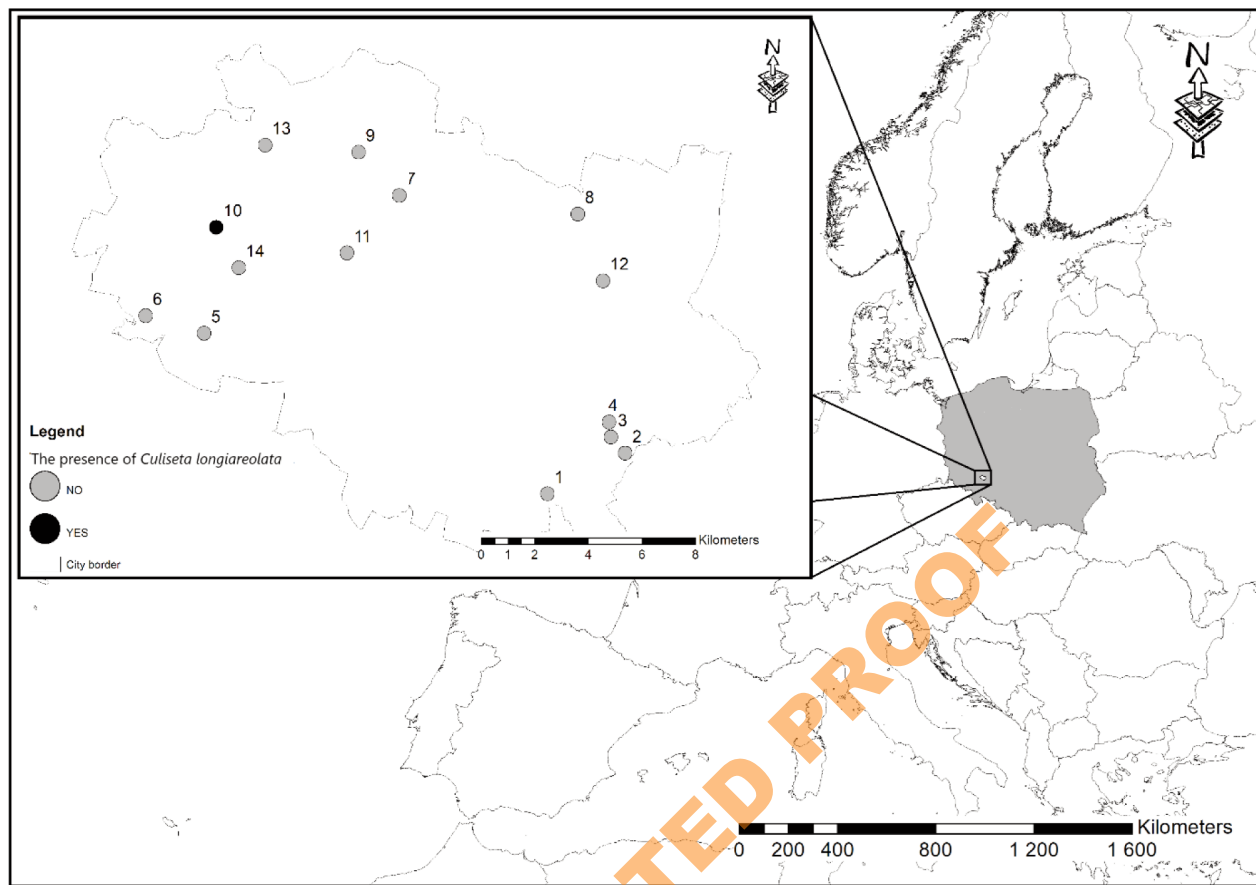


Figure 1. Distribution of CDC mosquito traps deployed in Wrocław in 2024 (grey points). The location where *Culiseta longiareolata* was first detected is marked (black points)

Anopheles, *Coquillettidia*, *Culiseta*, and *Culex* [7]. However, this diversity may be underestimated due to historical gaps in surveillance.

The recent establishment of the invasive species *Aedes japonicus* across much of southern Poland – despite being confirmed only in 2023 – illustrates the consequences of limited monitoring efforts [8]. Similarly, the recent detection of *Anopheles daciae* and *Anopheles hyrcanus* in Wrocław, an area under regular mosquito surveillance, highlights the importance of sustained urban monitoring programmes [9,10]. In contrast to many regions of Poland where surveillance has been sporadic or absent, Wrocław serves as a valuable reference site for assessing mosquito diversity in urban environments. As a large city with a heterogeneous landscape and dense infrastructure, it offers conditions particularly conducive to mosquito proliferation and vector persistence.

This study aims to assess the current species diversity of mosquitoes in the urban area of Wrocław, with particular emphasis on the first recorded presence of *Culiseta longiareolata* in

Poland. This thermophilic species, previously unrecorded in the country, is primarily associated with Mediterranean and subtropical regions, and its detection may reflect broader ecological shifts linked to climate change. The findings highlight the importance of long-term urban entomological surveillance in documenting changes in species distributions and support the need for expanded monitoring efforts across Poland and Central Europe.

Materials and Methods

Adult mosquito collection methods

Trapping was carried out from May to October 2024 using CDC traps. These traps were deployed at 14 locations (Figure 1), strategically distributed across the city to estimate mosquito abundance and species composition as evenly as possible throughout Wrocław, SW Poland, covering both green spaces and built-up urban areas. Mosquito trapping was carried out eight times between the second half of May and early October: once in May

Table 1. Species composition and abundance of mosquitoes collected in Wrocław in the year 2024

Genus/ species	<i>Anopheles</i>					<i>Aedes</i>					<i>Culiseta</i>	<i>Coquil lettidia</i>	<i>Culex</i>	Unmarked TOTAL			
	<i>An. claviger</i> s.l.	<i>An. maculipennis</i> s.l.	<i>An. plumbeus</i>	<i>An. hyrcanus</i> s.l	<i>Ae. annulipes</i>	<i>Ae. cantans</i>	<i>Ae. caspius</i>	<i>Ae. cinereus</i>	<i>Ae. geniculatus</i>	<i>Ae. sticticus</i>	<i>Ae. vexans</i>	<i>Cs. annulata</i>	<i>Cs. longiareolata</i>	<i>Cq. richiardii</i>	<i>Cx.pipiens</i> s.l. <i>/torrentum</i>		
Number	117	158	217	17	1079	391	3	104	14	415	11732	212	2	1677	590	367	17104
Percentage share (%)	0.7	0.9	1.3	0.1	6.3	2.3	<0.1	0.6	0.1	2.4	68.6	1.2	<0.1	9.8	3.4	2.2	100.0
TOTAL (%)	3.0					80.3					1.3		9.8	3.4	2.2	100.0	

and October, and twice per month during the remaining months (i.e., in both the first and second halves of each month). No trapping was conducted in September due to heavy rainfall and flooding in parts of Lower Silesia, which made monitoring difficult and limited access to trap deployment sites. Traps were set between 16:00 and 18:00 and operated until approximately 08:00 the following day. Captured adult mosquitoes were euthanised by freezing at −20°C for a minimum of one hour.

Species identification

Specimens identification was performed based on morphological characteristics using a stereoscopic microscope, following the identification keys for Culicidae [11]. One of the two morphologically identified *Cs. longiareolata* specimens was randomly selected and analysed molecularly using the mitochondrial *COI* gene to confirm species identification. Amplification was carried out with the universal primers LCO1490 (5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3') and HCO2198 (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3') [26]. A single *COI* sequence was obtained and compared with GenBank references using the BLAST tool to confirm species identity (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>).

Phylogenetic analysis

Obtained *COI* sequences together with selected reference sequences retrieved from GenBank were aligned and trimmed to a uniform length of 568 base pairs. The final dataset consisted of 14 sequences with no gaps or ambiguous nucleotides. Phylogenetic relationships were constructed using

the Neighbor-Joining method implemented in MEGA version 10, based on Kimura 2-parameter genetic distances. The robustness of tree topology was assessed using 1,000 bootstrap replicates. Sites containing gaps or missing data were treated using complete deletion. A sequence of *An. hyrcanus* was used as an outgroup to root the tree.

Results

In total, 17,104 adult mosquitoes were collected from 14 locations (Figure 1). Of these, 16,728 were identified to species level, while 376 individuals (2.2%) remained undetermined. Fifteen mosquito species were identified, representing five genera: *Anopheles* (3.0%), *Aedes* (80.3%), *Culiseta* (1.3%), *Coquillettidia* (9.8%), and *Culex* (3.4%) (Table 1). The mosquito assemblage was dominated by *Aedes vexans*, which accounted for 68.6% of all collected specimens, followed by *Coquillettidia richiardii* (9.8%). Species with moderate relative abundance included *Ae. annulipes* (6.4%), *Cx. pipiens* s.l./*Cx. torrentium* (3.4%), *Ae. sticticus* (2.4%), *Ae. cantans* (2.3%), *Anopheles plumbeus* (1.3%), and *Culiseta annulata* (1.2%). The remaining species occurred at proportions below 1% of the total catch (Table 1).

The genus *Culiseta* was represented by two species: *Cs. annulata* (1.2%) and *Cs. longiareolata* (<0.1%). The latter was represented by only two individuals, one collected on 30–31 July 2024 and the other on 13–14 August 2024, both at site 10 (16° 53' 03.98" E, 51° 08' 54.52" N), which also exhibited the lowest overall mosquito abundance (Table 1). Site 10 is situated in the western part of the city, within a low-density residential area

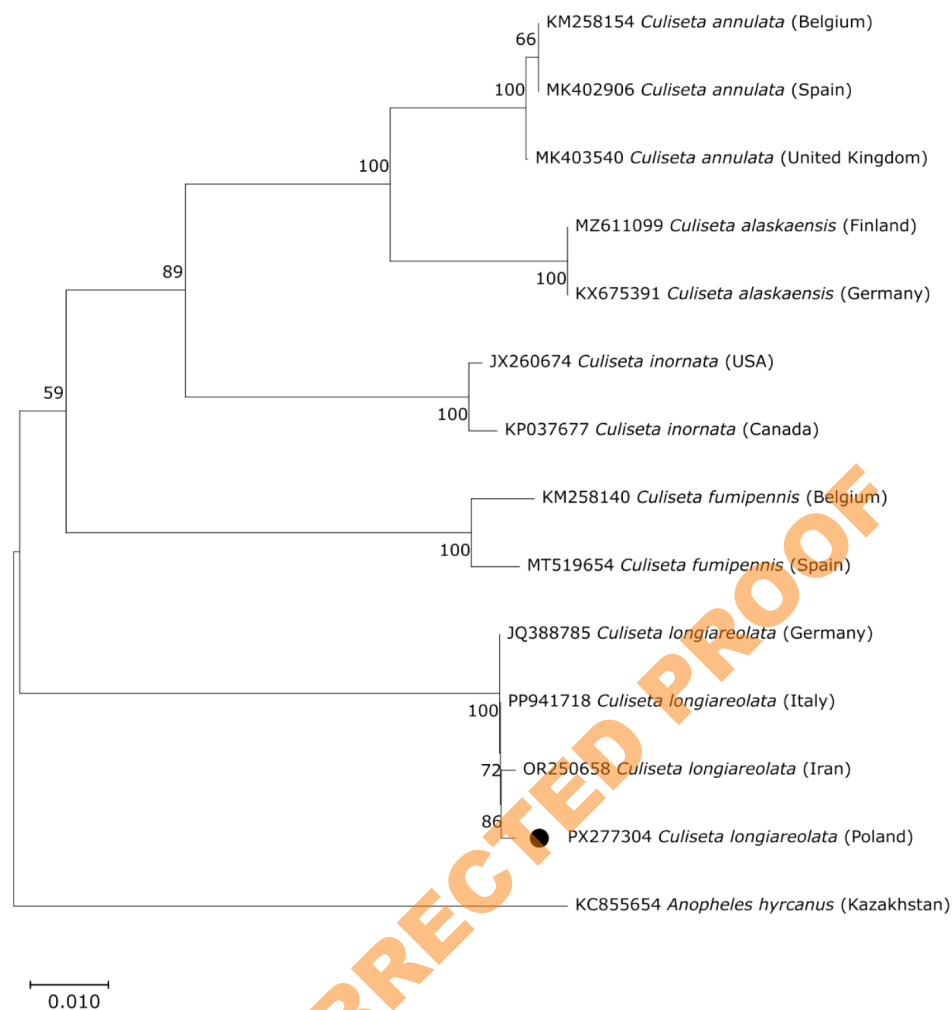


Figure 2. Neighbor-Joining phylogenetic tree based on mitochondrial cytochrome oxidase subunit I (COI) sequences (568 bp) inferred using Kimura 2-parameter genetic distances in MEGA version 10. The sequence obtained in this study is marked with a circle. Bootstrap support values at nodes are based on 1,000 replicates. *Anopheles hyrcanus* was used as the outgroup to root the tree

Table 2. Number of mosquitoes collected by month of collection in the area of Wrocław in 2024 using CDC light traps

Month	Sites														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
May	256	8	101	33	97	83	154	323	261	46	64	78	52	21	1577
June	133	412	291	567	274	20	258	326	459	72	143	184	63	39	3241
July	147	422	2657	328	198	119	344	146	230	45	409	204	154	124	5527
August	141	193	2518	99	548	61	282	243	633	101	449	557	320	225	6370
October	13	57	96	26	21	52	3	18	14	7	16	14	30	22	389
Total	690	1092	5663	1053	1138	335	1041	1056	1597	271	1081	1037	619	431	17104



Figure 3. Female *Culiseta longiareolata* collected in Wrocław, SW Poland

characterized by detached houses. These properties have gardens that use buckets and barrels, among other water storage containers, to irrigate plants. The Bystrzyca River's natural valley is located 400 meters west of the *Cs. longiareolata* collection site, while green areas are located 100 m to the north. Notably, regular mosquito monitoring and population control programs are implemented in both the urban area and the river valley, which may have an impact on the dynamics of the local mosquito population.

Molecular analysis confirmed the taxonomic identity of *Cs. longiareolata* (GenBank accession number: PX277304; Figs. 2 and 3). The *COI* sequence obtained from one *Cs. longiareolata* specimen from Wrocław showed more than 99.0% similarity to reference sequences OR250658 (Iran), JQ388785 (Germany), and PP941718 (Italy) deposited in GenBank, supporting its phylogenetic placement within *Cs. longiareolata*.

Mosquitoes were collected throughout the sampling season, with overall abundance peaking in July and August. However, at several sites (4, 5, 8, 9, and 10), higher numbers were recorded in June than in July, with particularly high catches observed at sites 4 and 8 (Table 2).

Total mosquito abundance varied markedly among sampling sites, ranging from 271 individuals

at site 10 to 5,663 at site 3. Widespread species such as *Ae. vexans*, *Ae. sticticus*, *Cs. annulata*, *Cq. richiardii*, and *Cx. pipiens* s.l./*Cx. torrentium* were present at all sites (Figure 4). In contrast, rarer species exhibited more localised distributions. Notably, *Aedes caspius* was detected exclusively at site 13, while *Cs. longiareolata* occurred only at site 10 (Figure 4).

Discussion

The monitoring of mosquito fauna using CDC traps in Wrocław between May and October 2024 revealed the widespread presence of mosquitoes across all study sites. The distribution of mosquitoes varied significantly across months and between sites. This indicates both temporal and spatial variation in mosquito abundance during the study period, with peak overall abundance observed in July and August, although some sites showed higher numbers in June. This variation reflects the influence of environmental conditions and habitat heterogeneity on mosquito population dynamics.

A total of 15 mosquito species from five genera (*Anopheles*, *Aedes*, *Culiseta*, *Coquillettidia*, and *Culex*) were identified. This diversity points to the presence of a variety of breeding sites, supporting species with different ecological preferences. *Aedes*



Figure 4. Data matrix ordered by final totals for species richness (sites in rows) and abundance (species in columns). Cells filled with colour indicate that a species was found at a site. An increase in colour intensity indicates a higher abundance of individuals of a species

vexans was the dominant species recorded during the study. It is a polycyclic mosquito that predominantly breeds in temporarily flooded habitats, particularly in river or lake floodplains with variable water levels [11]. It cannot be ruled out that its dominance was partly influenced by the heavy rainfall and flooding in parts of Lower Silesia, which was noted in September 2024.

Aedes vexans was also one of the most widespread and abundant species across all sampling sites. Its dominance is consistent with previous studies highlighting its adaptability to floodplain habitats and its ability to rapidly colonise temporary water bodies [unpublished data; 7,10–12]. However, its ecological importance is likely to be greater outside urban areas, where its preferred breeding sites are more common and wildlife abundance is higher. Given its known role as a potential vector of several arboviruses, its high abundance may have epidemiological implications, particularly in areas with suitable environmental conditions [13].

Coquilleltidia richiardii was the second most abundant species recorded, although it accounted for only 9.8% of all collected specimens. This species typically breeds in various types of permanent or semi-permanent water bodies rich in hydrophilous vegetation. It is particularly associated with densely vegetated wetlands dominated by plant genera such as *Typha*, *Phragmites*, *Carex*, *Glyceria*, *Sparganium*, *Ranunculus*, and *Acorus* [11]. The larvae of *Cq. richiardii* exhibit a unique adaptation by attaching to submerged plant roots to obtain oxygen, which complicates both detection and control efforts [11,14]. This species is a known or suspected vector of several pathogens, including West Nile virus and filarial nematodes such as *Dirofilaria repens* and *D. immitis*, which pose health risks to both humans and animals [15,16].

Our study confirms the presence of *An. hyrcanus* s.l. within the Wrocław area. However, the species was found at only a few sites, indicating it's still limited distribution within the study area. This observation aligns with recent findings suggesting that *An. hyrcanus* s.l. is expanding its range in Europe, with new populations reported in countries such as Serbia, Slovakia, the Czech Republic, Austria, Germany (Brandenburg), and Poland – likely facilitated by ongoing climate warming trends [10,17].

Unexpectedly, *Cs. longiareolata* was detected for the first time in Wrocław. Although the species

was represented by only two specimens collected at a single site, this limited material does not allow definitive conclusions regarding its establishment or permanent presence in the Polish mosquito fauna. To our knowledge, this is the first molecularly confirmed observation of *Cs. longiareolata* in Poland; however, it should be interpreted as an isolated record rather than evidence of a stable population, suggesting a possible recent range expansion.

Culiseta longiareolata is a thermophilic and ornithophilic mosquito with a distribution spanning the southern Palaearctic region – from the Azores through Central Asia – and extending into the Ethiopian region, India, and Pakistan. In recent years, it has been recorded for the first time in Austria, Slovenia, Germany, Belgium, and the Netherlands [18–21], a pattern consistent with a gradual northward shift in its known range, likely driven by climate change and urbanization. Increasingly mild winters and warmer summers may facilitate the survival of this typically Mediterranean-associated species beyond its historical distribution [18].

The larvae of *Cs. longiareolata* are highly tolerant of polluted environments and develop in a wide range of temporary water bodies, including small ponds, puddles, rain pools, and artificial containers such as wooden or metal barrels, concrete tanks, and wells, often in association with *Cx. pipiens* [11,18]. Although it rarely occurs in natural water bodies such as pools or ditches, it has also been recorded in rock pools. It tends to avoid habitats with aquatic predators such as *Notonecta maculata* [22] and prefers relatively stable environments with low larval competition [23]. The species is capable of autogenous reproduction, which may enhance its capacity for rapid population increase under favourable conditions.

Since *Cs. longiareolata* has occasionally been reported from used tyres [24], passive transport via international trade cannot be excluded as a possible introduction pathway, as suggested for Germany [11]. A similar mechanism may also be relevant for its occurrence in Poland.

Culiseta longiareolata has been identified as a potential vector of several pathogens, including brucellosis, avian influenza, and West Nile virus [25]. Although its current detection in Poland is based on a very limited number of specimens, this finding underscores the importance of continued entomological surveillance in urban and peri-urban

areas where suitable breeding habitats may be abundant.

In conclusion, this study provides a comprehensive overview of mosquito species diversity and distribution in the Wrocław area during the 2024 mosquito season. A total of 15 species from five genera were identified, with *Ae. vexans* being the most abundant and widespread. The results highlight significant temporal and spatial variation in mosquito abundance, likely influenced by environmental conditions and habitat availability.

The detection of *Cs. longiareolata*, recorded for the first time in Poland, represents a biogeographically important finding. However, given that only two individuals were collected at a single site, this record should be interpreted as preliminary and does not provide evidence for the permanent establishment of the species within the Polish mosquito fauna. Nevertheless, its occurrence may reflect early stages of a northward range shift, potentially facilitated by climate change and anthropogenic environmental modification, and underscores the need for continued targeted surveillance to monitor its future presence and possible establishment.

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