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The first confirmed records of the invasive and epidemiologically significant mosquito species *Aedes albopictus* (Diptera: Culicidae) in southern Ukraine

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abstract

This article reports the first confirmed records of the invasive and epidemiologically significant mosquito species *Aedes albopictus* (Skuse, 1894) (Diptera: Culicidae) in southern Ukraine, namely within the city of Odesa and its environs. This species is currently the only representative of the subgenus *Stegomyia* Theobald, 1901 recorded in Ukraine, which makes its discovery in the southern region of the country particularly important in the field of national entomology and epidemiology, as well as a significant event for the study of biodiversity and epidemiological safety in Ukraine. When conducting monitoring studies in the warm period of 2023, we recorded the beginning of the invasion of the exotic for the territory of Ukraine species of blood-sucking mosquitoes *A. albopictus*. Eleven locations with the presence of reproducing populations of the species *A. albopictus* were identified: ten are located within the administrative districts of Odesa, and one in the village of Tairove, north of the city. The total number of specimens caught during the 2023 research season was 228 individuals (137 larvae and 91 adults). The detection of reproductive populations of *A. albopictus* in Odesa and its surroundings clearly demonstrates the species' adaptive potential and the onset of its expansion in southern Ukraine. The appearance of *A. albopictus* in the studied area indicates active ecological and climatic changes that may lead to the invasion of other species that may pose a threat to biodiversity and epidemiological security in the southern region of our country. The detection of dense foci of *A. albopictus* near the port infrastructure in Odesa indicates that the species was introduced through the sea port, and the presence of larval stages in remote areas of the city indicates further dispersal and successful acclimatisation under the conditions of the south of Ukraine. The detection of the epidemiologically dangerous species *A. albopictus* and the high risk of further spread of its population within southern Ukraine and to other climatically favourable regions of the country, requires urgent development and implementation of a comprehensive system of control and preventive epidemiological measures, particularly in urbanised areas and near transport hubs.

Перші підтверджені знахідки інвазійного та епідеміологічно значущого виду комарів *Aedes albopictus* (Diptera: Culicidae) на Півдні України

Віталій Рудік, Євген Коржов

Резюме. У статті представлено перші знахідки інвазійного, епідеміологічно небезпечного виду комарів *Aedes albopictus* (Skuse, 1894) (Diptera: Culicidae) на Півдні України, зокрема в межах міста Одеси та його околиць. Виявлений вид наразі є єдиним представником підроду *Stegomyia* Theobald, 1901 на території України, що надає його появі у південному регіоні країни особливого значення для розширення наукових знань у галузях вітчизняної ентомології та епідеміології, а також є важливою подією для вивчення біорізноманіття та епідемічної безпеки України. Під час моніторингових досліджень у теплий період 2023 року було зафіксовано початкові етапи інвазії чужорідного для фауни України виду кровосисних комарів *A. albopictus*. Виявлено 11 локалітетів із присутністю відтворюваних популяцій: десять із них розташовані в межах адміністративних районів м. Одеси та один — у селищі Таїрове, на південний захід від межі міста. Загалом протягом сезону досліджень зібрано 228 особин (137 личинок і 91 імаго). Виявлення відтворюваних популяцій *A. albopictus* в Одесі та її околицях демонструє значний адаптаційний потенціал і початок експансії цього виду комарів на Півдні України. Поява *A. albopictus* у досліджуваній місцевості свідчить про активні екологічні та кліматичні зміни, які можуть сприяти інвазії інших видів, потенційно небезпечних для біорізноманіття та епідеміологічної безпеки південного регіону країни. Виявлення щільних осередків виду поблизу портової інфраструктури в Одесі вказує на можливе морське занесення, а наявність личинкових стадій виду у віддалених районах міста свідчить про розширення ареалу існування та успішну його акліматизацію в умовах Півдня України. Виявлення епідеміологічно небезпечного виду *A. albopictus* та висока ймовірність подальшого поширення інтродукованої популяції в межах Південної України, із потенційним розширенням до інших кліматично сприятливих регіонів, зумовлюють нагальну потребу у розробці та впровадженні комплексної системи епідеміологічного нагляду, контролю та профілактики, особливо в урбанізованих районах та поблизу транспортних вузлів.

Ключові слова: інвазійні види, фауністичне обстеження, трансмісивні захворювання, моніторинг біорізноманіття, Причорноморський регіон, Одеська область.

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Introduction

In the 21st century, global climate change, intensified migration processes, and the expansion of transport infrastructure have facilitated the active spread of invasive species of haematophagous mosquitoes (Diptera: Culicidae) capable of transmitting pathogens of vector-borne diseases. This has led to increased concerns regarding both the resurgence of known pathogens and the emergence of novel ones in previously unaffected regions.

One such invasive species is the Asian tiger mosquito, *Aedes (Stegomyia) albopictus* (Skuse, 1894), currently regarded as the most widespread among the invasive *Aedes* species recorded in Europe [ECDC 2023]. Originally native to Southeast Asia, *A. albopictus* has, since the late 20th century, rapidly expanded into other parts of the world, including Europe, the Americas, and Africa, posing epidemiological threats in newly colonised areas [Kraemer *et al.* 2015].

The rapid range expansion of *A. albopictus*, particularly into urban and anthropogenically transformed ecosystems, has been driven by a combination of biological and anthropogenic factors. Firstly, the species' ability to reproduce in artificial containers, such as used car tyres, facilitates the formation of numerous microhabitats even within highly transformed urban environments [Paupy *et al.* 2009]. Secondly, intercontinental transport—especially maritime cargo shipping—has played a key role in introducing eggs and larvae into new regions [Medlock *et al.* 2015]. Air travel is also significant, allowing for the rapid dispersal of individuals across large distances [Ibáñez-Justicia *et al.* 2020]. At national and regional scales, the primary routes of *A. albopictus* dispersal remain ground-based: road and rail transport contribute to the gradual colonisation of new areas within continents [Lühken *et al.*

2023; Giunti *et al.* 2023]. In particular, public and private vehicles, especially along major motorways, are considered among the principal drivers of the species' spread in Europe [Flacio *et al.* 2016; Medlock *et al.* 2017]. Finally, the exceptional ecological plasticity of *A. albopictus* enables it to adapt to a wide range of climatic and landscape conditions, supporting the establishment of stable populations beyond its native range [Bonizzoni *et al.* 2013]. Collectively, these factors underpin the remarkable invasive capacity of the species at a global scale.

The epidemiological threat posed by *A. albopictus* lies in its ability to transmit over 30 pathogens [Paupy *et al.* 2009; Vanlandingham *et al.* 2016]. In Europe, it is a prominent vector of Zika, chikungunya, West Nile, and dengue viruses, supporting local transmission cycles and contributing to outbreaks of the associated febrile illnesses [Gould *et al.* 2010; Amraoui & Failloux 2016; Giron *et al.* 2019]. Additionally, the species serves as a vector for *Dirofilaria* nematodes [Cancrini *et al.* 2007].

The establishment of stable *A. albopictus* populations in Black Sea basin countries (such as Turkey and Romania [Oter *et al.* 2013; Fălcuţă *et al.* 2020; ECDC 2023]), the recent introduction of this species into Moldova [Șuleșco *et al.* 2021], and literature reports of its occurrence in the Crimean Peninsula [Babytskiy *et al.* 2023] suggest a trend of expansion into areas adjacent to southern Ukraine. Given the current climatic and ecological conditions of southern Ukraine, we previously predicted a high likelihood of the species' invasion and subsequent acclimatisation in this region [Kutishchev *et al.* 2022; Rudik & Korzhov 2024].

The aim of this study was to detect the presence of the invasive species *A. albopictus* in Odesa Oblast, located in southern Ukraine.

Materials and Methods

Field surveys were conducted during the warm season of 2023 (from May to October) in the western part of Odesa Raion, Odesa Oblast. Priority was given to sites considered potentially favourable for the introduction and establishment of *A. albopictus.* Location selection was based on ecological suitability, the degree of anthropogenic disturbance, and proximity to potential introduction routes, namely the Odesa Commercial Seaport and the Chornomorsk Fishing Port. In total, over 200 potential habitats were surveyed across 14 settlements: Odesa, Ovidiopol, Biliaivka, Burlacha Balka, Velykyi Dalnyk, Velykodolynske, Dachne, Malodolynske, Maiaky, Mizhlymanske, Sukhyi Lyman, Tairove, Troitske, and Yasky.

Adult mosquitoes were collected during daytime and evening hours using aspirators and collection tubes during landing or resting. Larvae were sampled from natural and artificial aquatic habitats using dippers, trays, and pipettes. All specimens were preserved in 70% ethanol. Morphological identification was performed under MBS-1 and Carl Zeiss (Primo Star 5) microscopes using standard taxonomic keys [Gutsevich *et al.* 1970; Gunay *et al.* 2017; Becker *et al.* 2020].

Results and Discussion

During the warm season of 2023, a total of 72 field samples were collected within the study area. In total, 1265 mosquito specimens representing various developmental stages (larvae and adults) were captured. Among the mosquito species typical for the region, the invasive species *A. albopictus*, previously unrecorded in Ukraine, was identified for the first time in Odesa Oblast.

This species was detected in samples collected between August and October. A total of 228 *A. albopictus* specimens were identified: 137 larvae and 91 adults. The simultaneous detection of individuals at both developmental stages provides strong evidence for the establishment of a stable, reproductively active population within the surveyed urbanised areas.

The presence of *A. albopictus* was confirmed in 11 localities, of which 10 were located within the administrative districts of the city of Odesa (Kyivskyi, Peresypskyi, Primorskyi, and Khadzhybeiskyi), and one in the settlement of Tairove, situated near the city boundary (Fig. 1).

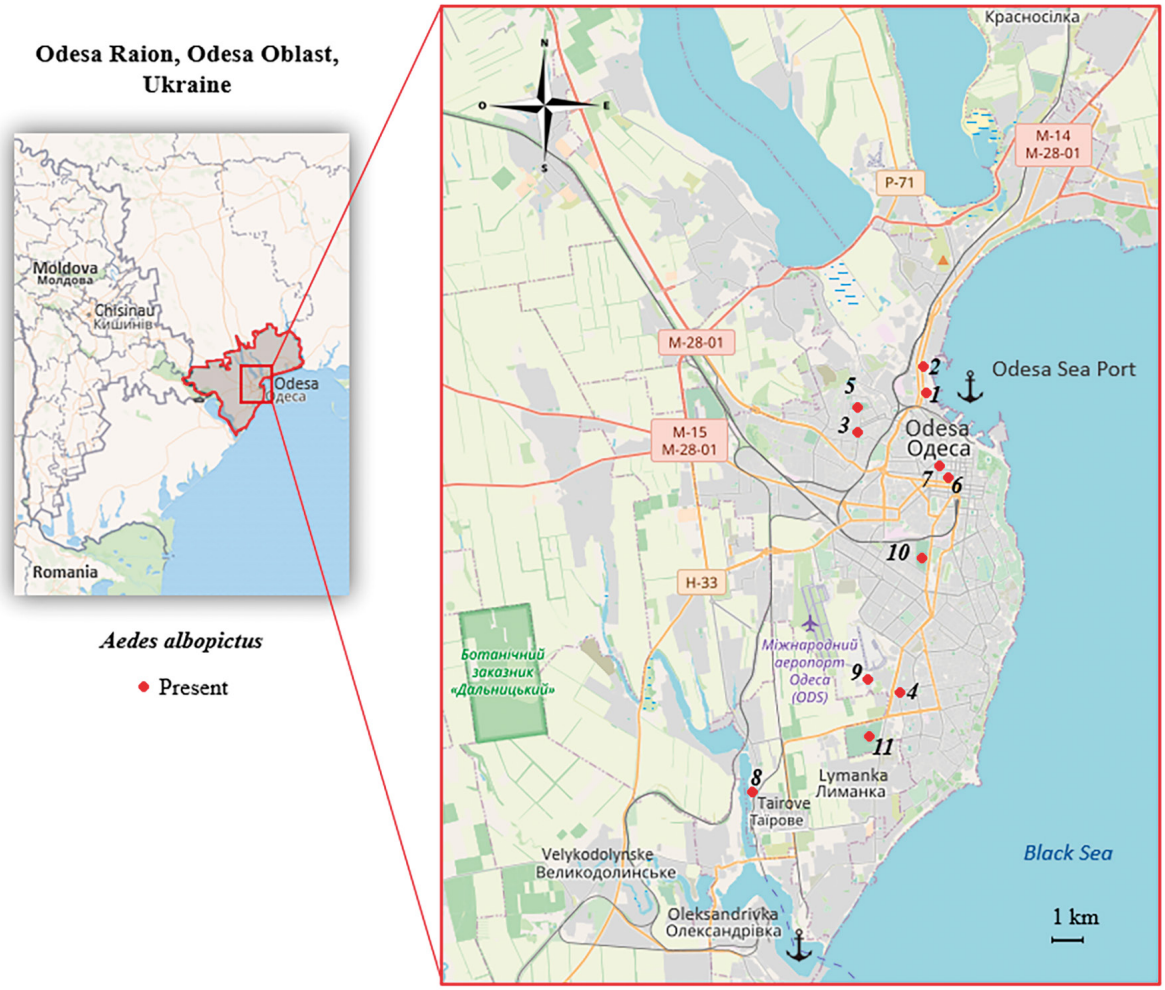

Fig. 1. Map of the city of Odesa and adjacent areas showing the localities where *Aedes albopictus* was detected in 2023. *Peresypskyi district*: (*1, 2*) residential area adjacent to Peresypsky Bridge, in the immediate vicinity of the Odesa Sea Port; (*3*) park within a residential area; (*5*) Slobidske Cemetery. *Primorskyi district*: (*6, 7*) central part of the city. *Khadzhybeiskyi district*: (*10*) Second Christian Cemetery. *Kyivskyi district*: (*4*) residential area; (*9*) industrial zone; (*11*) Novomiske Cemetery. *Surroundings of Odesa*: (*8*) the village of Tairove.

Рис. 1. Мапа міста Одеса та прилеглих територій із зазначенням локалітетів виявлення *Aedes albopictus* у 2023 році. *Пересипський район:* (*1, 2*) житловий масив, що прилягає до Пересипського мосту, в безпосередній близькості до Одеського морського порту; (*3*) паркова зона житлового масиву; (*5*) Слобідське кладовище. *Приморський район:* (*6, 7*) центральна частина міста. *Хаджибейский район:* (*10*) Друге Християнське кладовище. *Київський район:* (*4*) житловий масив; (*9*) промислова зона; (*11*) Новоміське кладовище. *Околиці м. Одеси:* (*8*) с. Таїрове.

Differences in the number of *A. albopictus* individuals, their sex, and developmental stages collected in different localities are presented in Table 1.

The highest abundance of individuals (across all developmental stages) was recorded in the Peresypskyi district, particularly at sites located in close proximity to the Port of Odesa. This spatial-ecological characteristic of the localities suggests that the initial introduction of the species may have occurred via maritime transport, followed by the spread of *A. albopictus* within the urban environment. At the same time, considering the presence of established *A. albopictus* populations in neighbouring regions, introduction via overland transportation cannot be ruled out. The detection of larvae in the Kyivskyi and Khadzhybeiskyi districts indicates a gradual expansion of the species' range within the city. In the village of Tairove, only adult specimens were recorded, which likely points to an early stage of dispersal involving passive transportation of individual mosquitoes.

Table 1. **Abundance, sex, and developmental stages of** *Aedes albopictus* **individuals detected within Odesa and its surroundings in August–October 2023**

Таблиця 1. **Чисельність, стать та стадії розвитку виявлених особин** *Aedes albopictus* **в межах міста Одеси та її околиць у серпні–жовтні 2023 року**

Locality, district	Date of detection	Site No. (Fig. 1)	Abundance (specimens)		Description of biotopes and associated artificial containers	Approximate coordinates (°N, °E)
			Imago (adults)	Larvae		
Odesa, Peresypskyi district	10.08.2023	1	27♀	18	Urban residential area adjacent to the port zone, bowl	46.500086; 30.723045
	11.08.2023	2	3♀	16	Urban residential area adjacent to the port zone, tyre	46.500987; 30.725519
	14.08.2023	3	12♀ 5♂	30	Urban residential area, park, bucket and canister	46.486534; 30.696227
	16.09.2023	5	6♀ 1♂	46	Cemetery, plastic bottles, granite vase	46.497508; 30.690953
Odesa, Primorskyi district	21.09.2023	6	2♀	0	Urban residential area, courtyard	46.474368; 30.730985
	26.09.2023	7	11♀	0	Urban residential area, courtyard	46.481035; 30.730223
Odesa, Kyivskyi district	28.08.2023	4	1♀	0	Lift of a residential building	46.401685; 30.710162
	27.09.2023	9	3♀	7	Vehicle service station, plastic bucket	46.406638; 30.697119
	27.09.2023	11	7♀	11	Cemetery, plastic bottle	46.395635; 30.703346
Odesa, Khadzhybeiskyi district	27.09.2023	10	6♀	9	Cemetery, glass jar	46.452534; 30.726631
Tairove, Odesa Oblast	22.09.2023	8	7 ♀	0	Village outskirts near the estuary	46.369213; 30.645161
Total specimens			91	137		
			228			

Most of the localities where *A. albopictus* was detected were characterised by the presence of artificial, anthropogenic containers that served as breeding sites. These microhabitats included plastic and glass bottles, buckets, car tyres, waste bins, and cemetery flower vases in which rainwater or residual water from grave maintenance had accumulated. In most surveyed localities, both larvae and adult mosquitoes were found concurrently, indicating stable functioning of local populations and reproductive activity of the species within the urban environment. Adult specimens were predominantly concentrated in shaded and humid areas with dense vegetation, which provided suitable microclimatic conditions for daytime resting, thermoregulation, and shelter. In none of the artificial aquatic biotopes containing *A. albopictus* larvae were larvae of native mosquito species recorded. This may indicate a high degree of ecological plasticity of the invasive species, its adaptation to small temporary water bodies of anthropogenic origin, and its ability to exploit resources that are either unsuitable for or unoccupied by local species.

The morphological characteristics of *A. albopictus* in all collected specimens corresponded to the descriptions provided in both classical and contemporary identification keys [Gutsevich *et al.* 1970; Becker *et al.* 2020].

In adult specimens (imago), a distinct snow-white longitudinal stripe was observed on the black scutum, tapering towards its posterior end (Fig. 2 *a–d*). Two fine, short white stripes were present on the posterior half of the scutum (Fig. 2 *b–d*). The scutellum exhibited prominent white scales on all three lobes (Fig. 2 *b–c*). The lateral surfaces of the thorax, scutum, and abdominal segments were covered with white-silvery patches. The proboscis was dark in colour. The maxillary palps bore white scales at their apices. A longitudinal line of white scales extended along the head from the anterior to the posterior margin. The basal parts of the abdominal tergites were bordered with narrow bands of silvery scales, which narrowed centrally (Fig. 2 *f*).

In females, the cerci are short. In males, the hypopygium exhibits characteristic morphological features: claspettes are absent; the basal protuberance of the gonocoxite is elongated and covered with setae; the apical protuberance is absent; the gonostylus is simple, elongated, and expanded apically; the posterior margin of tergite IX bears a central projection (Fig. 2 *j*). The fore and mid tarsi exhibit short white basal rings on tarsomeres I–II. On the hind legs, tarsomeres I–IV possess broad white

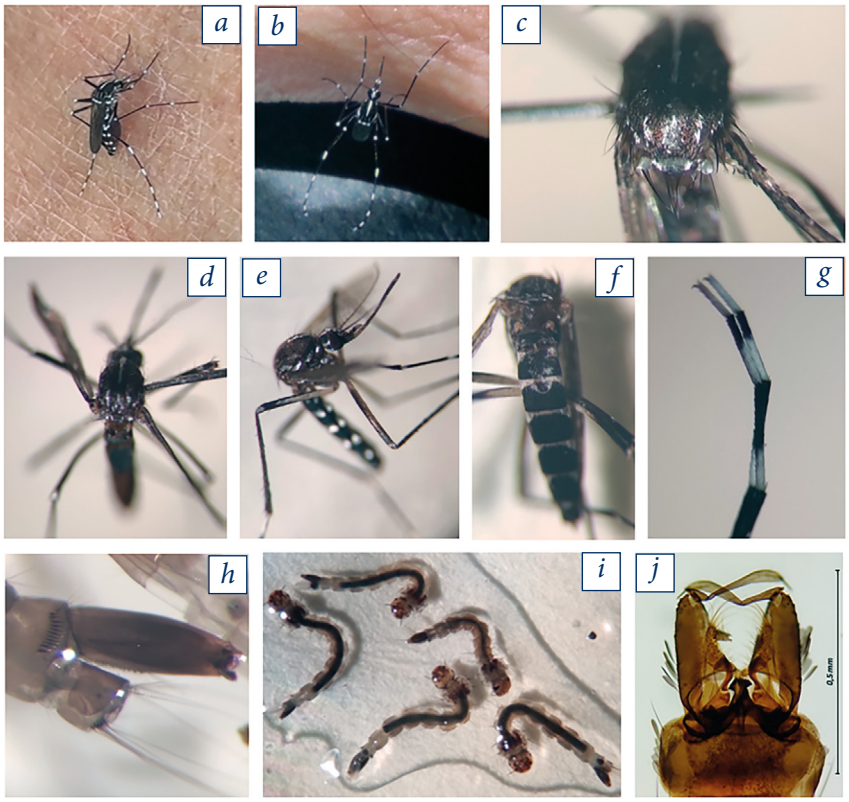

Fig. 2. Morphological features of *Aedes albopictus* adults and larvae found in Odesa Raion in 2023: (*a, b*) general view of an adult female feeding on a human host; (*c*) dorsal view of the scutum and scutellum of an adult female; (*d*) dorsal view of a female's scutum with a characteristic white stripe; (*e*) lateral view of the thoracic segment and femur of a female's hind legs, (*f*) tergites of the abdomen of an adult female; (*g*) tarsomeres of the hind legs; (*h*) siphon, VIII and IX segments of a larva (IV stage); (*i*) larvae, IV stage; (*j*) male hypopygium, ventral view.

Рис. 2. Морфологічні особливості імаго та личинок *Aedes albopictus*, виявлених в Одеському районі у 2023 р.: (*a, b*) доросла самка під час живлення на людині (загальний вигляд); (*c*) дорсальний вигляд щита (scutum) і щитка (scutellum); (*d*) дорсальний вигляд скутума самки з характерною білою смугою; (*e*) латеральний вигляд огруддя і стегна задніх ніг самки; (*f*) тергіти черевця дорослої самки; (*g*) тарзомери задніх ніг; (*h*) сифон, VIII і IX членики личинки (IV стадія); (*i*) личинки IV стадії; (*j*) гіпопігій самця, вентрально.

rings, while the fifth tarsomere is entirely white (Fig. 2 *g*). The femur bears a silvery stripe (Fig. 2 *e*). The tarsal claws are simple, without teeth. The wings are transparent, with narrow scales along all veins.

The larvae are characterised by a short siphon (Fig. 2 *h–i*), which tapers from the middle towards the apex, the presence of a pecten with 8–14 teeth, and a well-developed brush with scales on the eighth abdominal segment (the scales are arranged in a single row and possess a pointed main spine). The anal papillae are rounded and longer than the saddle (Fig. 2 *h*). The saddle on the short anal segment extends laterally to the ventral margin. The antennal seta is simple and short.

Based on morphological features, *A. albopictus* is clearly distinguishable from the indigenous mosquito species of the Ukrainian fauna. Among the Ukrainian representatives of the genus *Aedes*, only one species—*Aedes (Finlaya) geniculatus* (Olivier, 1791)—exhibits a similar silvery-white scale pattern. In *A. geniculatus*, the light scales are predominantly located on the lateral areas of the thoracic and abdominal segments, as well as at the apices of the femora, while the remaining body parts remain dark. These visual traits enable the unequivocal differentiation of *A. albopictus* from this autochthonous species.

At present, due to its invasive spread, *A. albopictus* is the only representative of the subgenus *Stegomyia* Theobald, 1901 recorded in Ukraine. Compared to other members of this subgenus found in different parts of the world that display a similar scutal pattern, *A. albopictus* can be distinguished by the specific morphology of the hypopygium and the characteristic pigmentation of the fifth tarsomere on the hind legs.

Particular attention is drawn to the atypical behaviour of adult *A. albopictus* specimens, which markedly differs from that of native mosquito species. Females of this species are active throughout the daylight hours, with a peak in host-seeking aggressiveness observed during the evening. They are

characterised by agility, the ability to escape swiftly when threatened, and a distinctive posture with raised hind legs upon landing. Their approach is quiet and often goes unnoticed. Males form swarms in shaded, humid areas in proximity to breeding sites.

These findings constitute the first confirmed record of *A. albopictus* in Ukraine, with evidence supporting the establishment of localised populations. The detection of multiple developmental stages in several isolated urban foci indicates a mosaic pattern of distribution for this invasive species, predominantly within urbanised landscapes in southern Ukraine, particularly in and around the city of Odesa.

Conclusions

The newly detected invasive species *A. albopictus* holds significant entomological and epidemiological relevance for the southern region of Ukraine. At present, this species represents the sole recorded member of the subgenus *Stegomyia* Theobald, 1901 within the country. The emergence of tropical mosquito species in the study area primarily reflects ongoing ecological and climatic changes in the local environment. One possible consequence of such changes is the further invasion of other alien species, which may pose a potential threat to biodiversity and an epidemiological risk to the local population.

The identification of *A. albopictus* foci in areas of Odesa adjacent to port infrastructure suggests that maritime transportation may be a likely route of introduction. The detection of larval stages in more distant parts of the city and its surroundings indicates a gradual expansion of the introduced range of *A. albopictus* and confirms the suitability of local ecological and climatic conditions for its successful acclimatisation, which, in turn, facilitates the further spread of the species across southern Ukraine.

Given the recent detection and the high risk of further spread of the introduced *A. albopictus* population in southern Ukraine—with the potential for range expansion into other climatically suitable regions—there is an urgent need for continued faunistic surveys, as well as for the development and implementation of a comprehensive system of preventive and epidemiological control measures. Particular attention should be directed toward urbanised areas and transport hubs as potential foci of dispersal. The implementation of such measures will help reduce the risk of emergence and spread of infectious diseases exotic to Ukraine that are associated with this dangerous vector.

Declarations

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Conflict of interest. The authors declare no conflict of interest that could have influenced the content of this article.

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