

RESEARCH ARTICLE

First record of *Aedes albopictus* in Principat d'Andorra

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Abstract

The tiger mosquito *Aedes albopictus* (Skuse, 1894) is an invasive species that is progressively expanding its range in many countries. This study assesses the diversity of mosquito species present in Principat d'Andorra and explores the potential occurrence of the invasive alien species *Ae. albopictus*. Systematic monitoring was conducted during eight sampling campaigns in July–October 2025. BG-Sentinel 2 traps and aspirators were used to collect adult mosquitoes, while ovitraps and larval surveys were employed to detect eggs and larvae. *Aedes albopictus* was detected for the first time in Andorra in summer 2025. Furthermore, the study confirms the presence of the species in all developmental stages (egg, larva, and adult), which suggests it has probably become established. All records were from the southernmost parts of the country: Sant Julià de Lòria, Andorra la Vella, and Escaldes-Engordany. These findings highlight the urgent need for integrated vector management, comprehensive risk assessment, and effective communication strategies to mitigate the potential public health impacts associated with this invasive species.

Keywords

invasive species, tiger mosquito, Culicidae, Pyrenees, vector species

1 Introduction

The tiger mosquito *Aedes (Stegomyia) albopictus* (Skuse, 1894) (Diptera: Culicidae) is an invasive species native to southeast Asia (Gratz, 2004; Marabuto and Rebelo, 2018). It is currently regarded globally as the most invasive vector species and in recent decades, has become one of the fastest-spreading animal species (Benedict *et al.*, 2007; Bonizzoni *et al.*, 2013). This mosquito exhibits its remarkable ecological plasticity and has successfully colonised temperate and tropical regions on all

continents except Antarctica (Bonizzoni *et al.*, 2013; Swan *et al.*, 2022). Its global spread has been largely facilitated by international trade, particularly through the transport of used tyres (Benedict *et al.*, 2007; Gratz, 2004; Swan *et al.*, 2022) and ornamental plants such as lucky bamboo (Bocková *et al.*, 2013; Scholte *et al.*, 2007), both of which provide suitable breeding habitats. In addition, its ability to tolerate low temperatures and exploit diverse habitats further enhance its invasive potential (Goiri *et al.*, 2020). Moreover, its eggs are highly resistant to desiccation, which enhances survival

during prolonged dry periods and contributes significantly to the rapid expansion and establishment of this species in new areas (Benelli *et al.*, 2020).

Aedes albopictus was first detected in Europe in 1979, in Albania, and has subsequently spread across much of the continent, including countries such as Italy, France, Spain, and Portugal (Aranda *et al.*, 2006; Bocková *et al.*, 2013; ECDC, 2025; Marabuto and Rebelo, 2018; Scholte *et al.*, 2007; Swan *et al.*, 2022). In areas bordering the Principat d'Andorra, the tiger mosquito has expanded into several neighbouring municipalities in Catalonia, to the south (Departament de Medi Ambient i Sostenibilitat, 2025), as well as into the French departments of Ariège and Pyrénées-Orientales (Ministère du Travail, de la Santé et des Solidarités, 2025).

As a recognised vector of several arboviruses including chikungunya, dengue, and Zika, *Ae. albopictus* poses a significant threat to public health (Bohers *et al.*, 2024; Bonizzoni *et al.*, 2013; Gratz, 2004). Moreover, autochthonous outbreaks have already been reported in Europe, demonstrating local transmission of some of these diseases in areas where this invasive mosquito has become established (Bohers *et al.*, 2024; Martinet *et al.*, 2019). Its aggressive daytime biting behaviour (Benedict *et al.*, 2007) and ability to thrive in urban environments negatively affect human quality of life and may even have direct economic consequences (Halasa *et al.*, 2014).

In Principat d'Andorra information on mosquito biodiversity has been available since 2004 and 2016 as a result of two comprehensive studies conducted by the former Institut d'Estudis Andorrans (IEA) in

collaboration with and under the scientific guidance of the Servei de Control de Mosquits del Consell Comarcal del Baix Llobregat (SCM). These two studies provided valuable data on the biodiversity and distribution of the culicid fauna of Principat d'Andorra, even though neither detected the presence of the tiger mosquito (Aranda and Macías, 2016; Escosa and Aranda, 2004).

In light of this information, a new survey of the mosquitos in Andorra was undertaken whose primary objectives were to monitor the potential spread of *Ae. albopictus* and update and complete the national inventory of vector species.

2 Materials and methods

Study area

The research was conducted in Principat d'Andorra (eastern Pyrenees), a mountainous country with elevations ranging from 848 to 2,942 m a.s.l., located approximately between 42° 25'–42° 39' N and 1° 24'–1° 47' E (Figure 1). The region has a predominantly sub-continental climate with Mediterranean influences, transitioning to a cold, sub-oceanic climate at higher elevations. Its varied topography and continentality determine precipitation patterns; summer is the wettest season, and the highest elevations receive up to six months of snow cover (November–April). Pronounced altitudinal gradients and varied terrain generate high habitat diversity within Andorra's 468 km², including forests, subalpine and alpine grasslands, screes and

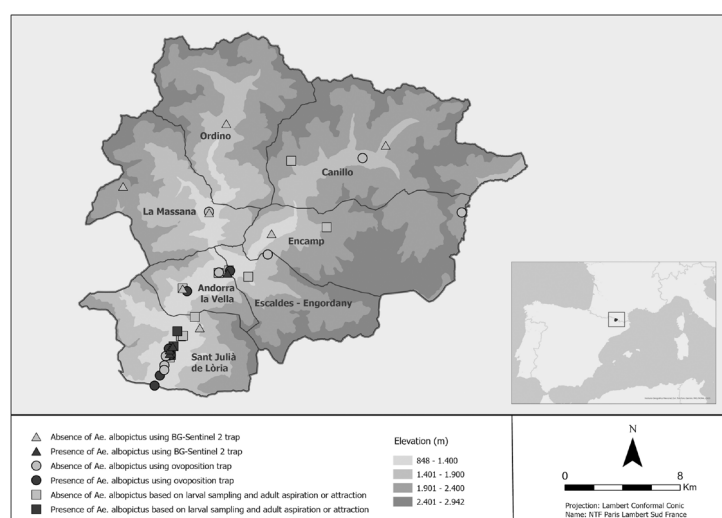


FIGURE 1 Map of the geographical situation of Principat d'Andorra showing the presence/absence of *Aedes albopictus* during the eight sampling campaigns conducted in 2025 in the seven Andorran parishes.

rocky outcrops, shrublands, and urban areas. As of 2024, Principat d'Andorra has approximately 88,000 inhabitants (Departament d'Estadística del Govern d'Andorra, 2025).

Methods

This study, which was conducted by Andorra Research + Innovation (AR+I), formerly IEA, in close collaboration with the SCM, and forms part of the mosquito and vector insect monitoring program run in Principat d'Andorra. This program operates within the framework of the One Health Andorran Commission [Interministerial Commission *Una Sola Salut* (CIUSS)], established by the Andorran Health and Environmental Government Departments (Ministeri de Medi Ambient, Agricultura i Ramaderia, and Ministeri de Salut del Govern d'Andorra). Created in 2025, the commission seeks to address the need for coordinated policies across human, animal, and environmental health sectors (BOPA, 2025).

The study comprised eight sampling campaigns, started in early July to mid-October 2025. It relied primarily on mosquito trap surveillance, complemented by several field surveys targeting larval habitats. Two trap types were employed, both recognised as highly effective for targeted mosquito surveillance: the Biogents Sentinel 2 trap (BG-Sentinel 2, BioGents GmbH, Regensburg, Germany) (Kröckel *et al.*, 2006; Farajollahi, 2009) and an oviposition trap (Becker *et al.*, 2010). Additionally, targeted surveys were conducted at previously identified larval breeding sites including storm drains and stagnant water bodies.

The BG-Sentinel 2 traps were operated biweekly for 24-hour sampling periods, using carbon dioxide (CO₂) as an attractant, supplied as dry ice. These traps are widely used due to their efficiency in capturing diurnal mosquito species, particularly *Ae. (Stg.) aegypti* (Linnaeus, 1762) and *Ae. albopictus* (Gibson-Corrado *et al.*, 2017; Reegan, 2024). By contrast, oviposition traps are designed to attract female mosquitoes seeking a site to lay their eggs. Each trap consisted of a black plastic container (250 ml volume), filled with dechlorinated water and a rough wooden tongue depressor, which serves as an oviposition substrate. A drainage hole placed 4 cm from the edge prevented overflow in case of heavy rain. Oviposition traps remained in place continuously throughout the four main months of the study (July–October). The wooden substrate was inspected and replaced every two weeks. These traps were specifically intended to target *Ae. albopictus* and act as an early

indicator of reproductive activity. The locations of both trap types were strategically selected in accordance with the study objectives.

Site selection was based on multiple criteria, including altitude, proximity to livestock, and areas with high traffic density, the latter considered a potential pathway for the accidental introduction of the tiger mosquito (Zayed *et al.*, 2024). Monitoring and control efforts were focused on the parish of Sant Julià de Lòria, located in the southernmost part of the country. This parish borders Catalonia (Spain), where the presence of the tiger mosquito has been confirmed (Departament de Medi Ambient i Sostenibilitat, 2025) and is therefore considered a potential entry site for this invasive alien species. Specifically, BG-Sentinel 2 traps were deployed at 11 sampling locations, with a highest concentration in this southern parish, whereas oviposition traps were installed at 15 sites, prioritising areas with high tourist vehicle traffic, particularly in Sant Julià de Lòria (see Supplementary Table S1 for site details). During fieldwork, adults trying to bite the authors were captured using an entomological aspirator (Prokopack, John W. Hock Company, Gainesville). Larvae were collected using dippers from all water-holding containers found, such as cemetery vases and storm drains.

After collection, samples were preserved to prevent damage or deterioration. Mosquitoes captured with BG-Sentinel 2 traps were killed by freezing at -30 °C, then allowed to dry at room temperature for 2–3 days. Specimens were subsequently stored in sealed containers with silica gel to prevent the build-up of humidity. Wooden sticks collected from Oviposition traps were air-dried at room temperature. For complementary larval surveys, specimens were collected in labelled containers, and then transferred to vials with 70% ethanol for subsequent identification. Following preservation, mosquito specimens from all trap types were identified based on morphological characteristics using a stereomicroscope and the taxonomic keys in Becker *et al.* (2010) and Schaffner *et al.* (2001). Wooden sticks for eggs were submerged, and larvae were reared to the fourth instar or adult stage to confirm species identification.

3 Results

Aedes albopictus was recorded for the first time in Principat d'Andorra during the initial campaign in July 2025. Following this initial detection, the species



FIGURE 2 Adult of *Aedes albopictus* detected in the Principat d'Andorra.

was consistently detected throughout summer and early autumn 2025, with all developmental stages observed, including adults, larvae, and eggs.

Adult individuals were detected using BG-Sentinel 2 traps and an aspirator during fieldwork (Figure 2). Larvae were detected both in oviposition traps and in artificial water-holding containers, particularly those commonly found in environments such as cemeteries, which are known to provide suitable breeding habitats. Adult specimens were recorded in the parishes of Sant Julià de Lòria and Andorra la Vella, while larvae were detected exclusively in Sant Julià de Lòria. Eggs were recorded at multiple locations across the country. Notably, 59 eggs were recorded on a single wooden stick from an oviposition trap deployed in Sant Julià de Lòria during the final sampling period in late October. Positive Oviposition traps were recorded in the parishes of Sant Julià de Lòria, Andorra la Vella, and Escaldes-Engordany (see Supplementary Table S1 for detailed results).

All locations where *Ae. albopictus* was detected are situated in the southern part of the country, specifically in the parishes of Sant Julià de Lòria (42° 28' N, 1° 29' E), with its main village at an elevation of 912 m a.s.l., Andorra la Vella (42° 30' N, 1° 31' E) at 1,035 m, and Escaldes-Engordany (42° 30' N, 1° 32' E) at 1,045 m (Institut d'Estadística d'Andorra, n.d.). These three parishes are predominantly residential, with populations ranging from approximately 25,900 inhabitants in Andorra la Vella to 10,650 in Sant Julià de Lòria (Departament d'Estadística del Govern d'Andorra, n.d.). Sant Julià de Lòria lies approximately 15 km north of the nearest village in Catalonia (Spain), where this mosquito species has also been reported. By contrast, traps deployed in the remaining parishes in the country –all located at greater average altitudes– yielded negative results across all survey campaigns, and no adults, larvae, or eggs were detected. Positive and negative sites

are shown in Figure 2 and Table 1, and further details of each site, including dates of the positive findings, are reported in Supplementary Table S1.

4 Discussion and conclusion

We report the first detection of *Ae. albopictus* in the Pyrenean country, Principat d'Andorra. This new record challenges the predictions made by Oliveira *et al.* (2021), who, using a consensus approach combining published habitat suitability models at multiple spatial resolution (1–55 km) classified this region as environmentally unsuitable for the species, despite its proximity to suitable areas such as the northeast of the Iberian Peninsula and southern France. Notably, several territories adjacent to Principat d'Andorra have confirmed the presence of *Ae. albopictus*, including the Catalan counties of Alt Urgell, Pallars Sobirà, and Cerdanya (Departament de Medi Ambient i Sostenibilitat, 2025), and the French departments of Ariège and Pyrénées-Orientales (Ministère du Travail, de la Santé et des Solidarités, 2025). The proximity of the Principat d'Andorra to these neighbouring territories, combined with intense cross-border human mobility, may have played a significant role in the introduction of this vector species. Previous studies have demonstrated that frequent human and commercial movements between regions can promote the introduction and spread of exotic species, including the tiger mosquito (Martinet *et al.*, 2019; Zayed *et al.*, 2024).

The introduction of *Ae. albopictus* into Andorra is confirmed by the detection of individuals at all life stages (eggs, larvae, and adults). However, the species cannot yet be considered established, as evidence of local reproduction and overwintering remains lacking (ECDC, 2017). Climatic factors play a decisive role in the successful establishment of the tiger mosquito in new regions (Cunze *et al.*, 2016; Goiri *et al.*, 2020; Ibáñez-Justicia *et al.*, 2020). Among these, mean annual temperature (ideally above 10–11 °C) and mean January temperature (above 0 °C), considered the most critical period for egg survival, are regarded as the most limiting variables for species persistence (Cunze *et al.*, 2016; Goiri *et al.*, 2020). Andorra, with elevations ranging from 848 to 2,942 m a.s.l., hosts the majority of its population concentrated in lower-altitude parishes, particularly in the south. In these southern areas, mean January temperatures exceed 0 °C; however, mean annual temperatures remain below 11 °C (Batalla *et al.*, 2016). In addition, other environmental parameters, such as photoperiod

TABLE 1 Positive and negative sites with their coordinates.

ID Trap/sampling and location ¹	Parish	Coordinates	Altitude	Positive or Negative
BG-1. River	Sant Julià de Lòria	42.458610° / 1.487992°	870 m	positive
BG-2. Prat del Senzill	Sant Julià de Lòria	42.455483° / 1.486767°	890 m	positive
BG-3. Enclar	Andorra la Vella	42.460460° / 1.491548°	980 m	negative
BG-4. Rec de l'Obac	Escaldes-Engordany	42.498939° / 1.505309°	1,060 m	positive
BG-5. Camí de les Gravades	La Massana	42.503388° / 1.536646	1,230 m	negative
BG-6. Port de Cabús	La Massana	42.542814° / 1.518097°	2,100 m	negative
BG-7. Prada de Moles	Encamp	42.559430° / 1.445521°	1,220 m	negative
BG-8. Llueneres	Sant Julià de Lòria	42.530951° / 1.571232°	1,300 m	negative
BG-9. Ruta del Ferro	Ordino	42.472884° / 1.510510°	1,430 m	negative
BG-10. Vall d'Incles	Canillo	42.526680° / 1.574212°	1,780 m	negative
BG-11. Borda del Germà	Sant Julià de Lòria	42.571553° / 1.639089°	890 m	positive
Ov-1. Epizen	Sant Julià de Lòria	42.504641° / 1.569167°	870 m	negative
Ov-2. Benzinera River	Sant Julià de Lòria	42.464557° / 1.517860°	920 m	positive
Ov-3. River	Sant Julià de Lòria	42.453822° / 1.484218°	880 m	positive
Ov-4. Bombers	Andorra la Vella	42.453822° / 1.484218°	980 m	positive
Ov-5. Fener car-park	Escaldes-Engordany	42.491888° / 1.501338°	1,030 m	positive
Ov-6. Camí de les Gravades	La Massana	42.506118° / 1.533028°	1,230 m	negative
Ov-7. Engolasters car-park	Escaldes-Engordany	42.543744° / 1.517756°	1,630 m	negative
Ov-8. Parc Central car-park	Andorra la Vella	42.517751° / 1.568349°	1,005 m	negative
Ov-9. El Tarter car-park	Canillo	42.506244° / 1.527210°	1,670 m	negative
Ov-10. Pas de la Casa car-park	Encamp	42.578328° / 1.647983°	2,090 m	negative
Ov-11. Fontaneda 1	Sant Julià de Lòria	42.543573° / 1.754036°	950 m	positive
Ov-12. Fontaneda 2	Sant Julià de Lòria	42.458526° / 1.485786°	970 m	negative
Ov-13. Borda Sabaté 1	Sant Julià de Lòria	42.458274° / 1.486240°	860 m	negative
Ov-14. Borda Sabaté 2	Sant Julià de Lòria	42.446039° / 1.480550°	860 m	positive
Ov-15. Gossera	Sant Julià de Lòria	42.445219° / 1.480735°	870 m	positive

¹ Ov = Ovitrap; BG = BG-Sentinel 2 trap.

and precipitation also influence establishment success (Ibáñez-Justicia *et al.*, 2020). When comparing climatic and altitudinal conditions with other European mountainous regions, such as the Lazio region in Italy (Romiti *et al.*, 2022), our observation are consistent with the occurrence of *Ae. albopictus* established populations at elevations of, at least, 900 m a.s.l.. According to these criteria, we consider that Principat d'Andorra presents favourable climatic conditions for the establishment and potential spread of this species, particularly in lower-elevation areas of the country (Batalla *et al.*, 2016). These conditions are comparable to those reported for regions with similar climates, especially when urban microclimatic conditions are considered, such as the canton of Ticino in Switzerland where the tiger mosquito has become established (Neteler *et al.* 2013; Ravasi *et al.*, 2022). Continued monitoring will be essential to

assess population persistence, overwintering capacity, and future expansion within the country.

Numerous studies support the association between the increasing spread of invasive alien species such as the tiger mosquito – and, consequently, their potential for arbovirus transmission – and increasing temperatures and broader climate change (Laycock *et al.*, 2022; Radici *et al.*, 2025). Oliveira *et al.* (2021) project that, under future climate scenarios, up to 83% of urban areas worldwide may become suitable habitats for this species. This projection is further reinforced by Laporta *et al.* (2023), who demonstrated that Europe is becoming increasingly suitable for both *Ae. albopictus* and *Ae. aegypti*, thereby increasing the risk of transmission of the arboviruses they vector.

Regardless of the current extent of the *Ae. albopictus* incursion in Principat d'Andorra, experiences from

other countries clearly indicate that once this invasive mosquito becomes established, eradication is both challenging and costly. Accordingly, this study highlights the importance of rapid and coordinated action to prevent the widespread proliferation and long-term establishment of this species in Andorra (ECDC, 2017; Ministerio para la Transición Ecológica y el Reto Demográfico, 2013).

The detection of the tiger mosquito in Principat d'Andorra by this study has important public health and management implications. First, urgent measures should be implemented to prevent the species from becoming established in the country. In addition, the presence of this mosquito – a recognised vector of diseases such as dengue and chikungunya – emphasises the need for robust and proactive public health responses strategies to mitigate the risk of potential future outbreaks in the human population (Marabuto and Rebelo, 2018). These actions should be implemented through a multidisciplinary One Health approach, integrating the human, animal, and environmental health sectors. Furthermore, in line with the agreements established by the interministerial *Una Sola Salut* commission (CIUSS), the recent detection of *Ae. albopictus* in Principat d'Andorra as a newly introduced alien species obliges the drafting of a specific control plan. This plan is expected to be developed once additional data on species' distribution become available. The effectiveness of this plan will depend on the commitment and cooperation of local authorities, as well as the timely and efficient implementation of selected measures. Key components should include preventive and control actions aimed at containing and limiting mosquito spread, together with sustained public awareness campaigns. Public engagement is essential, as the adoption of preventive measures in private and domestic environments will be critical to limiting the spread of the mosquito and reducing associated health risks.

Supplementary material

Supplementary material can be found online at <https://doi.org/10.52004/2054930X-20261034> at Supplementary materials.

Table S1. Results (positive or negative), coordinates, and habitat characteristics of the sites monitored for the mosquito *Aedes albopictus* in Principat d'Andorra in July–October 2025.

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Authors' contributions

Conception and design of the study: all authors; Fieldwork: MDM, CA; Scientific guidance: CA; Writing: all authors; Review and editing: CA, CP. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest

The authors declare no competing interests.

Data availability

All data generated or analysed during this study are included in this published article and its supplementary information files.

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