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(RESEARCH ARTICLE)

Spatio-temporal distribution and influence of physico-chemical parameters on Culicidae larval habitats in the department of Saint-Louis (Senegal)

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Abstract

The proliferation of mosquitoes in urban and peri-urban areas is a major public health problem in Senegal, particularly in the department of Saint-Louis, where ecological conditions and human activities favour their development. This study aims to analyse the spatio-temporal distribution of mosquito breeding sites and to assess the influence of physico-chemical parameters on larval abundance. Three surveys were conducted in each municipality of the Saint-Louis department during the 2024 rainy season. Larval habitats were characterised, larval densities measured and physico-chemical parameters (temperature, pH, conductivity and salinity) analysed. A total of 143 larval habitats were identified between August and October 2024, of which 128 were positive for larvae, including both natural and artificial habitats. Seven species of Culicidae belonging to the genera *Anopheles*, *Aedes* and *Culex* were identified. *Anopheles* and *Culex* larvae were mainly associated with natural breeding sites such as ponds, puddles and watercourses, while *Aedes* dominated artificial breeding sites of anthropogenic origin, particularly tyres and domestic containers. Urban and peri-urban areas (Saint-Louis and Gandon) had the highest larval diversity, linked to human density, agricultural activities and inadequate sanitation systems. Rural areas (Mpal, Fass Ngom and Ndiebène Gandiol) showed lower diversity but a high proportion of artificial domestic breeding sites. Physicochemical analysis reveals a preference of *Culex* for alkaline and eutrophic waters, *Aedes* for low-mineralised fresh waters, while *Anopheles* shows broad ecological tolerance. These results highlight the importance of integrated management of larval breeding sites in vector control strategies.

Keywords: Culicidae; Larval Habitats; Spatio-Temporal Distribution; Physico-Chemical Parameters; Saint-Louis; Senegal**.**

1. Introduction

Mosquitoes (Culicidae) are among the main vectors of infectious diseases worldwide. Three genera dominate in the transmission of these diseases: *Anopheles*, *Aedes* and *Culex*. These species exploit a wide variety of larval habitats, ranging from natural environments (ponds, puddles, backwaters) to anthropogenic water collections [1]. Some of these species cause serious vector-borne diseases such as malaria, dengue fever, chikungunya, yellow fever, Rift Valley fever and lymphatic filariasis [2]. These diseases are now a major global public health issue. According to the latest report from the World Health Organisation [3], malaria affected approximately 263 million people in 2023, causing nearly 597 000 deaths. In the same year, there were an estimated 500 000 cases of chikungunya (400 deaths), while in 2024, dengue fever reached a record 14.6 million cases worldwide, resulting in more than 12 000 deaths. The African

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continent remains the region most severely affected, with the highest morbidity and mortality rates. In Senegal, several epidemics of dengue fever and yellow fever have been reported in recent years in various regions, including Saint-Louis [4]. More recently, in September 2025, the first cases of Rift Valley fever have been recorded in this same region [5]. This resurgence of epidemics illustrates the increased vulnerability of northern Senegal, particularly the department of Saint-Louis, to emerging vector-borne diseases. This situation can be explained in part by the ecological and climatic characteristics of the region, which provide favourable conditions for mosquito proliferation. Variations in temperature, salinity and pH of surface waters influence the specific composition and spatial distribution of larvae [6,7]. In addition, recurrent flooding, inadequate sanitation, rapid urbanisation, soil salinisation and the intensification of human activities contribute to the diversification of available larval habitats [8,9]. In this context, the implementation of effective vector control strategies relies on in-depth knowledge of the bioecology and population dynamics of mosquitoes. However, recent data on these aspects remain limited in the Saint-Louis region. Thus, the present study aims to determine the spatio-temporal distribution and characterise the physico-chemical parameters of mosquito breeding sites in the department of Saint-Louis (Senegal).

2. Materials and methods

2.1. Study area

The study was conducted in the department of Saint-Louis, located in northern Senegal between 16°00'00'"N latitude and 16°27'00"' W longitude. It is bordered to the north by the department of Dagana, to the south and east by the region of Louga, and to the west by the Atlantic Ocean. It covers an area of approximately 19 010 km². Its climate, which is Sahelian in type, is dominated by maritime trade winds and is characterised by three seasons: a hot and humid rainy season from July to September; a cool dry season from October to March; and a hot dry season from April to June. The department currently has five municipalities: Saint-Louis, Gandon, Ndiébène Gandiol, Fass Ngom and Mpal. These localities are distinguished by their hydrological diversity, with floodplains, temporary ponds and basins that favour the proliferation of mosquitoes. The municipality of Saint-Louis, characterised by flat terrain (1.7–2.8 m above sea level) and sandy formations of varying texture, is highly vulnerable to flooding linked to the Senegal River [10,11]. The municipalities of Gandon and Ndiébène Gandiol benefit from a dense hydrographic network influenced by the river and its tributaries, while Fass Ngom remains poorly drained. This geomorphological and hydrological configuration gives the area a complex character and marked exposure to river and coastal dynamics [12].

2.2. Survey and characterisation of larval habitats

The study was carried out in three phases corresponding to the beginning (end of August), middle (end of September) and end (end of October) of the 2024 wintering season. In each municipality, all localities were surveyed in order to identify and characterise mosquito larval habitats. Each larval habitat listed was geolocated using a positioning system (GPS). The surface area of the shelter was estimated in order to classify it into two categories: small shelters (< 10 m²) and large shelters (> 10 m²). The presence or absence of larvae was systematically checked. The nature of the breeding site was characterised according to its origin (natural or artificial) and type (tyre, pond, bucket, ditch, barrel, basin, etc.). The nature of the breeding site was also specified as permanent or temporary, and the surrounding land use was classified into four categories: housing, pasture, road or natural vegetation. The physical and chemical parameters of the water in each breeding site were measured using a ZSRHH 5-in-1 multi-parameter device, which determined electrical conductivity (EC), pH, salinity and temperature.

2.3. Sampling and measurement of larval densities

Mosquito larvae were sampled using the standard dipping technique with a ladle and a 350 ml container [13]. In breeding sites larger than 10 m², ten samples were taken from eight areas, with two additional samples taken from the most representative areas. In breeding sites smaller than 10 m², six samples were taken from four points, with repetitions in the most representative areas. The water collected was poured into a tray with a white bottom for counting the larvae, then returned to the shelter before each new sample was taken. In small containers (tyre tracks, tyres, puddles, buckets), when the total volume exceeded 350 ml, the entire volume of water was sampled and three successive sub-samples of 350 ml were taken. However, when the volume of water was less than 350 ml, it was considered as a single sample. *Anopheles* larvae were counted separately, while Culicinae (*Aedes* and *Culex*) larvae were counted together. The distinction between the *Aedes* and *Culex* genera was made after microscopic identification. The average larval density (larvae/dip) was calculated by dividing the total number of larvae by the number of samples taken. Larvae and nymphs were collected using a net, sorted into groups: one group comprised *Culicinae* (*Aedes* and *Culex*) and the other comprised only *Anophelinae*, then each group was preserved in absolute ethanol. Each bottle was labelled with the date, genus, municipality and location of collection.

2.4. Identification of larvae

The pupae were kept in perforated plastic jars and transported to the laboratory of the Faculty of Health Sciences at Gaston Berger University in Saint-Louis (UGB) for emergence. The emerged *Aedes* adults were collected using a mouth aspirator and then exposed to −5 °C for five minutes. They were then stored in Eppendorf tubes containing silica gel separated by fine cotton wool. Morphological identification of larvae and adults was carried out using the identification keys for Culicidae in Senegal [14] and the illustrated dichotomous keys for the identification of female mosquitoes and larvae (Diptera: Culicidae) [15]. The morphological identification of *Aedes* adults was confirmed by qPCR, while *Anopheles* larvae were identified by PCR.

2.5. Statistical analyses

The collected data were entered and processed using Microsoft Excel 2021 to calculate specific frequencies and describe the habitats according to their characteristics (type, nature, size and vegetation cover). Correlations between the proportion of larval genera and the physical and chemical parameters of the breeding sites were analysed using R software (version 4.3.2), with a significance threshold set at $p < 0.05$. The geographical distribution of larval breeding sites in the department of Saint-Louis was mapped using QGIS-OSGeo4W software (version 3.40.4).

3. Results

3.1. Typology and frequency of mosquito breeding sites

In the department of Saint-Louis, a total of 143 breeding sites were identified, distributed unevenly among the municipalities: 86 breeding sites in the municipality of Saint-Louis (80 positive and 6 negative), 38 in Gandon (32 positive and 6 negative), 10 in Ndiébène Gandiol (9 positive and 1 negative), 6 in Mpal (4 positive and 2 negative) and 3 positive breeding sites in Fass Ngom. These breeding sites have been identified and divided into 15 distinct categories. These include 37 ponds, 34 puddles, 11 streams, 5 buckets, a canary, 8 basins, 11 barrels, 3 concrete tanks, 9 tyre tracks, a bottle, 9 gutters, an in-ground swimming pool, 6 septic tanks, a brick and 6 abandoned tyres (Figure1).

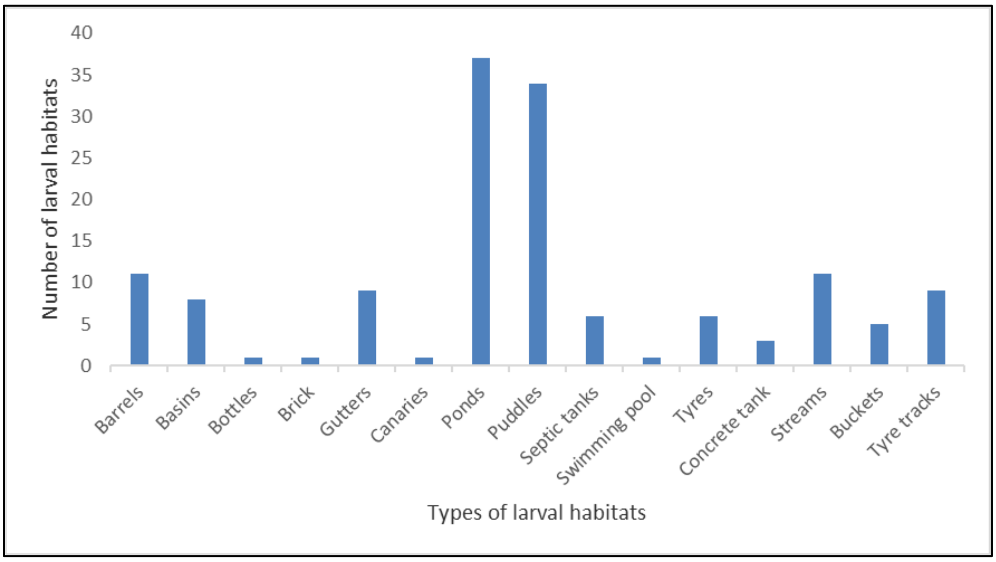

Figure 1 Abundance of the types of habitats studied in the department of Saint-Louis

Figure 2 shows the different types of larval habitats recorded in the five municipalities of Saint-Louis.

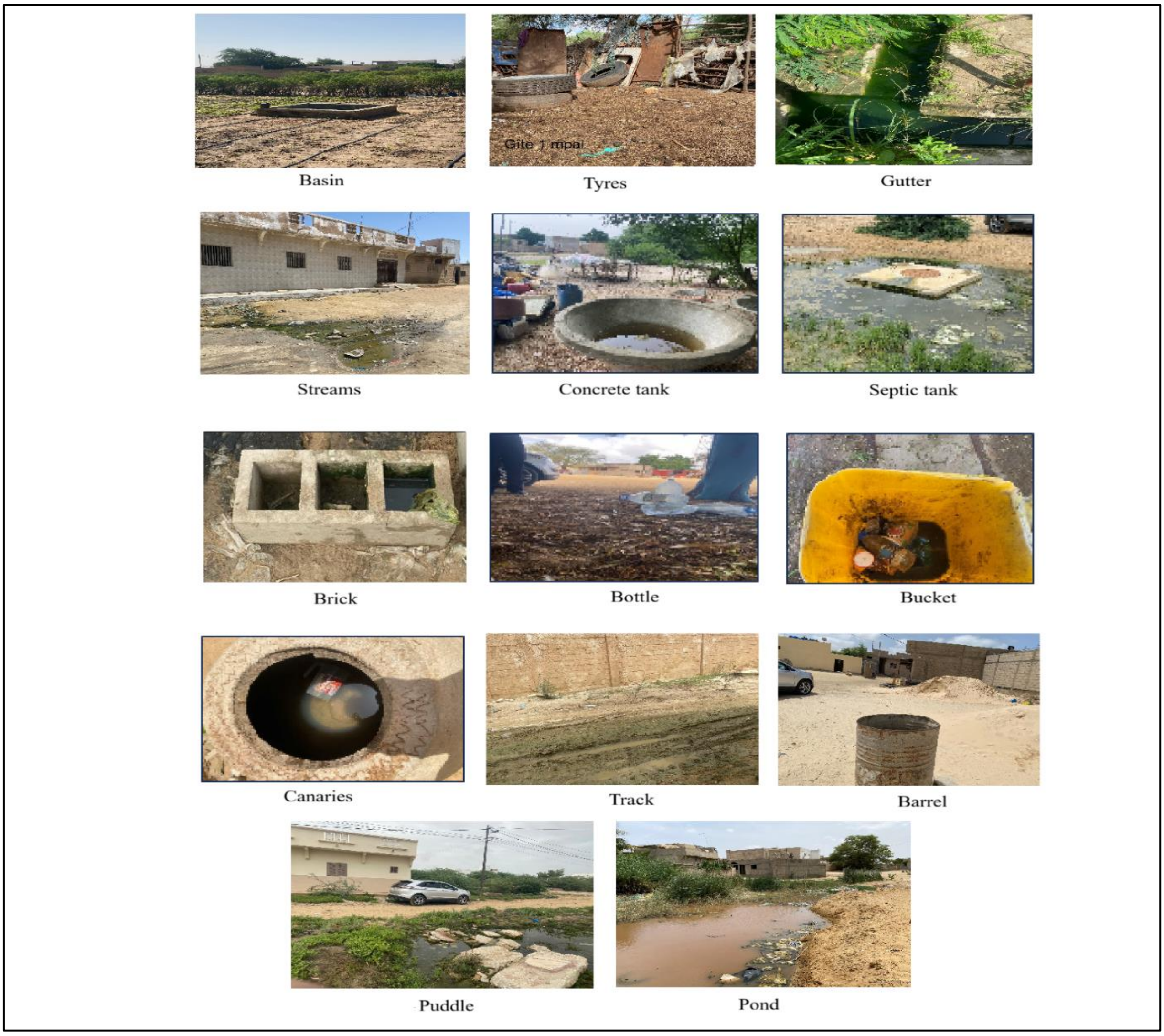

Figure 2 Images of the different types of accommodation surveyed

Table 1 shows that these types of accommodation do not have the same frequency in every municipality. The municipalities of Saint-Louis and Gandon stand out for their high diversity of shelters, with 12 types recorded in each, while Ndiébène Gandiol has 8, Mpal 4 and Fass Ngom only 3. In Saint-Louis, the shelters are mainly natural, dominated by puddles (34%), ponds (29%) and streams (11%), reflecting the marked influence of local hydrological conditions. However, in Gandon, the distribution of habitats is more balanced between natural and artificial habitats: ponds (26%) coexist with anthropogenic habitats such as barrels (16%) and basins (13%). In the municipalities of Ndiébène Gandiol, Fass Ngom and Mpal, artificial habitats clearly predominate. Barrels account for 30% of habitats in Ndiébène Gandiol, while in Fass Ngom, basins (34%), tyres (33%) and canaries (33%) are the most common. In Mpal, tyres make up the majority of habitats observed (50%).

Table 1 Frequency and distribution of the types of accommodation studied according to municipality

Characteristics of larval habitats		**Saint-Louis**	**Gandon**	**Ndiébène Gandiol**	**Fass Ngom**	**Mpal**
Percentage of larval habitats		(%)	(%)	(%)	(%)	(%)
	Ponds	29%	26%	10%	-	16%
	Puddles	34%	8%	10%	-	17%
	Streams	11%	5%	-	-	-
	Basins	1%	13%	10%	34%	-

Types of larval habitats	Barrels	2%	16%	30%	-	-
	Gutters	6%	5%	20%	-	-
	Tyres	1%	3%	-	33%	50%
	Septic tank	4%	8%	-	-	-
	Concrete tank	-	5%	10%	-	-
	Buckets	1%	5%	10%	-	17%
	Tracks	9%	3%	-		-
	Canaries	-	-	-	33%	-
	Bottles	-	3%	-	-	-
	Swimming pool	1%	-	-	-	-
	Brick	1%	-	-	-	-
Nature of larval habitats	Natural	69,7	39,5	40	-	33,3
	Artificial	30,3	60,5	60	100	66,7
Characters	Permanent	33,7	36,8	30	66	0
	Temporary	66,3	63,2	70	34	100
Presence of vegetation	Yes	31,4	26,3	-	-	16,7
	No	68,6	73,7	100	100	83,3

In terms of time, Figure 3 shows a notable evolution in the typology of roosts that was highlighted during the three wintering periods. At the beginning of the season, natural roosts, mainly ponds (38%) and puddles (15%), clearly dominated. Although a relatively wide variety of artificial shelters were recorded during this period, their frequency remained low, with the exception of barrels, which also accounted for 15% of the shelters identified. From the middle of the rainy season onwards, increased rainfall led to a proliferation of temporary natural shelters. The frequency of puddles increased from 15% to 25%, reaching a maximum of 30% at the end of the season. Streams, which were absent at the beginning of the rainy season, appeared in the middle of the season (8%) before reaching 15% at the end of the rainy season. Conversely, the frequency of ponds gradually decreased from 35% at the start of the rainy season to 23% in the middle of the season and then to 18% at the end of the rainy season. Artificial shelters, on the other hand, remained relatively constant throughout the study period, although their frequency remained low. However, a reduction in their diversity was observed at the end of the wintering period, suggesting that these shelters became less available or less used as the season progressed.

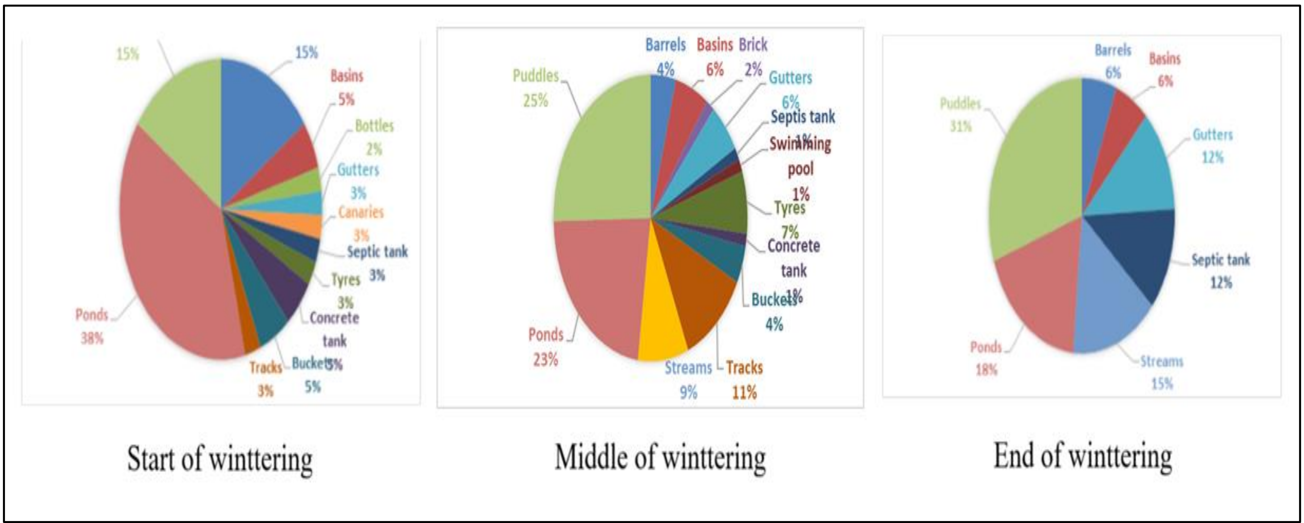

Figure 3 Temporal evolution of the types of habitats studied according to prospecting periods

3.2. Specific diversity of culicid fauna

Identifications revealed the presence of seven (7) mosquito species divided into three (3) genera, including *Culex*, *Aedes* and *Anopheles*. Overall, *Aedes* was represented by two (2) species, namely *Aedes aegypti* and *Ae. simpsoni*. The genus *Anopheles* consists of three (3) species: *Anopheles arabiensis*, *An. melas* and *An. gambiae s.s.*. However, no species of the genus *Culex* were identified. Among the two hundred and sixty-two (262) species of mosquitoes identified belonging to the *Anopheles* and *Aedes* genera, *Anopheles arabiensis* was the most abundant, followed by *Aedes aegypti*, then *Anopheles melas*, *Aedes simpsoni* and *Anopheles gambiae* in last place. *Anopheles* larvae accounted for 76.34% of the mosquitoes identified, and *Aedes* larvae accounted for 23.66%. The species richness of Culicidae larvae varied significantly between the different municipalities studied (Table 2). In urban and peri-urban municipalities (Saint-Louis and Gandon), *Anopheles gambiae s.l.* was the most abundant species. However, *Aedes aegypti* was the second most frequent species in these areas. Unlike urban and peri-urban areas, *Aedes aegypti* was the most frequent species in rural areas (Mpal, Fass Ngom and Ndiébène Gandiol). However, no *Anopheles* positive breeding sites were identified in Mpal and Fass Ngom.

Table 2 Diversity of Culicidae fauna in the department of Saint-Louis

Municipality	Genres	Species
Saint-Louis	*Anopheles, Aedes, Culex*	*An. Arabiensis, An. melas, An. gambiae, Ae. aegypti, Ae. simpsoni, Lutzia tigripes, Cx. sp*
Gandon	*Anopheles, Aedes, Culex*	*An. arabiensis, Ae. aegypti, Lutzia tigripes, Cx. sp*
Fass Ngom	*Aedes, Culex*	*Ae. aegypti, Ae. simpsoni, Lutzia tigripes, Cx. sp*
Mpal	*Aedes, Culex*	*Ae. aegypti, Ae. simpsoni, Cx. sp*
Ndiébène Gandiol	*Anopheles, Aedes, Culex*	*An. arabiensis, An. melas, Ae. aegypti, Lutzia tigripes, Cx. sp*

3.3. Distribution of Culicidae larvae according to larval habitat type

Species of the genus *Anopheles* and those of the genus *Culex* were identified in almost all types of larval habitats surveyed, with the exception of canaries and bottles for *Anopheles*. However, their frequency varied according to the type of habitat. *Anopheles* and *Culex* larvae were abundant in natural breeding sites such as ponds (17.5% for *Anopheles* and 16.1% for *Culex*), puddles (19.6% for *Anopheles* and 19.5% for *Culex*) and streams (7.7% for *Anopheles* and 4.9% for *Culex*). However, *Culex* larvae were also significant in anthropogenic breeding sites such as gutters (4.9%), septic tanks (3%) and tyre tracks (3%). *Anopheles* larvae were found in unusual breeding sites such as septic tanks and gutters, with respective frequencies of 3% and 6.3%. No *Aedes* larvae were identified in gutters, septic tanks, tyre tracks or streams. However, larvae of this genus were more common in anthropogenic breeding sites such as barrels (6%), tyres (3.5%) and buckets (5%) (Figure 4).

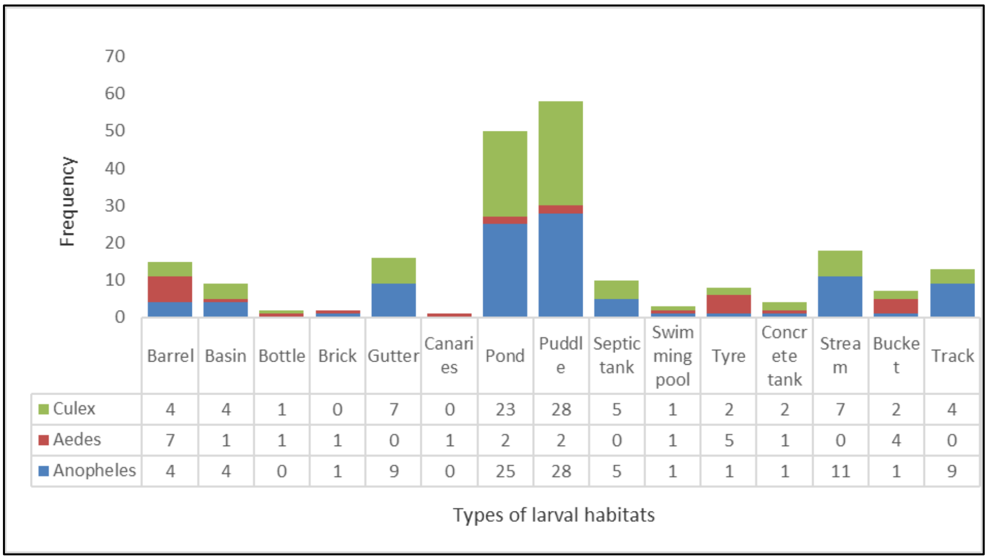

Figure 4 Frequency of larvae of each genus of Culicidae according to the types of breeding sites studied

3.4. Spatial dynamics of culicid larvae

The municipalities of Saint-Louis and Gandon are characterised by a high diversity of breeding sites, hosting larvae of *Anopheles*, *Culex* and *Aedes*, as well as mixed breeding sites hosting several genera simultaneously. Figure 6 shows that *Anopheles* and *Culex* positive breeding sites were predominant, with frequencies of 86.1% and 72.1% in Saint-Louis, and 60.5% and 57.9% in Gandon, respectively. Mixed breeding sites, on the other hand, presented different combinations of genera: some housed two genera (*Anopheles–Culex*, *Anopheles–Aedes* or *Culex–Aedes*), while others housed all three genera simultaneously. In Ndiébène Gandiol, positive breeding sites for *Anopheles*, *Culex* and *Aedes* were identified, with *Aedes* breeding sites predominating, accounting for 50% of positive breeding sites. The rural communes of Mpal and Fass Ngom showed limited diversity: in Mpal, the breeding sites were mainly positive for *Aedes* (66.7%) and *Culex* (33.3%), while in Fass Ngom, all breeding sites w Moving from Gandon towards the urban area (Saint-Louis), there is a marked predominance of *Anopheles* and *Culex* positive lodgings. Conversely, moving away from Gandon towards rural areas (Ndiébène Gandiol, Mpal and Fass Ngom), these breeding sites gradually declined, giving way to an increase in *Aedes*-positive breeding sites. This distribution suggests a spatial structure of culicid populations, influenced by the degree of urbanisation and the nature of available breeding sites (Figure 5).

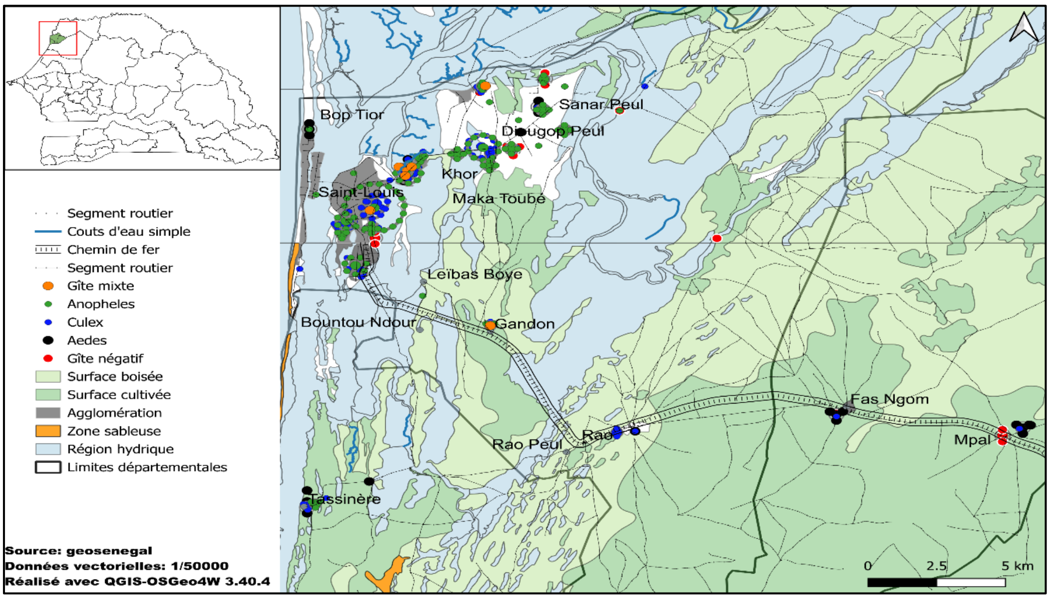

Figure 5 Mapping of Culicidae larval habitats in the department of Saint-Louis at the beginning, middle and end of the rainy season (August 2024 – October 2024)

3.5. Temporal dynamics of positive breeding sites according to culicid genus

The temporal evolution of positive larval breeding sites revealed distinct trends according to genus. The number of *Anopheles* positive breeding sites at the start of the rainy season (19) increased sharply in the middle of the season, peaking at 53, before declining at the end of the rainy season (28). *Anopheles arabiensis* was the dominant species throughout the study period in most of the municipalities surveyed, with the exception of Mpal and Fass Ngom, where *Anopheles* positive breeding sites were virtually absent. *Culex* positive breeding sites showed a more stable dynamic, with relatively high numbers throughout the season: 23 breeding sites at the beginning of the rainy season, 41 in the middle and 26 at the end of the season. These breeding sites were found in all the municipalities studied, reflecting the wide distribution of the *Culex* genus. However, *Aedes* positive breeding sites remained few in number during the rainy season, with a gradual downward trend from 14 breeding sites in the middle of the season to 3 breeding sites at the end of the rainy season. *Aedes aegypti* was the predominant species compared to *Aedes simpsoni* throughout the wintering period (Figure 6).

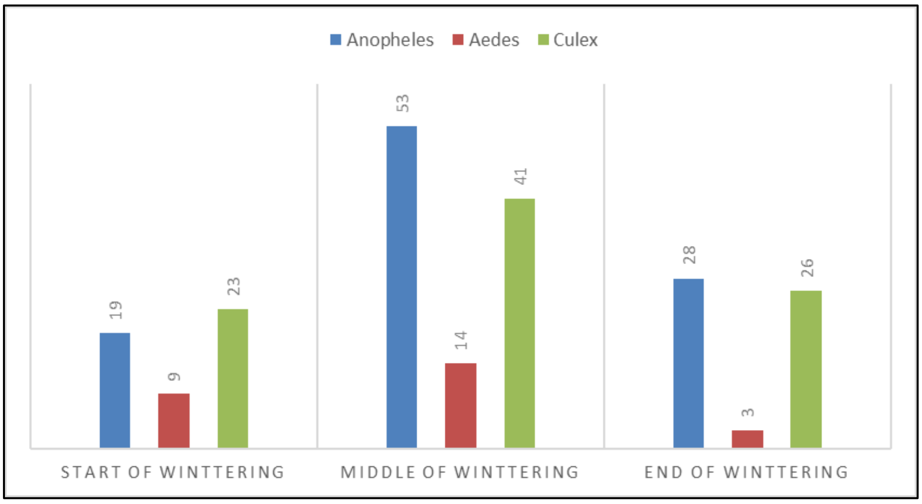

Figure 6 Temporary distribution of identified Culicidae genera according to survey periods

3.6. Influence of physicochemical parameters (pH, temperature, salinity and conductivity) on the abundance of different mosquito genera

The density of *Anopheles* larvae showed a positive but non-significant correlation with pH ($p = 0.11$), salinity ($p = 0.16$), conductivity ($p = 0.39$) and temperature ($p = 0.44$) (Figure 7). However, a significant negative correlation was observed between these same physicochemical parameters and the density of *Aedes* larvae, with respective p-values of 0.00021, 0.0098, 0.024 and 0.046 (Figure 8). For *Culex* larvae, a positive but non-significant correlation was noted with conductivity ($p = 0.71$). Correlations with temperature, salinity and pH were negative. However, these relationships were found to be insignificant for temperature ($p = 0.58$) and salinity ($p = 0.91$), while the correlation with pH was found to be significant ($p = 0.0051$) (Figure 9).

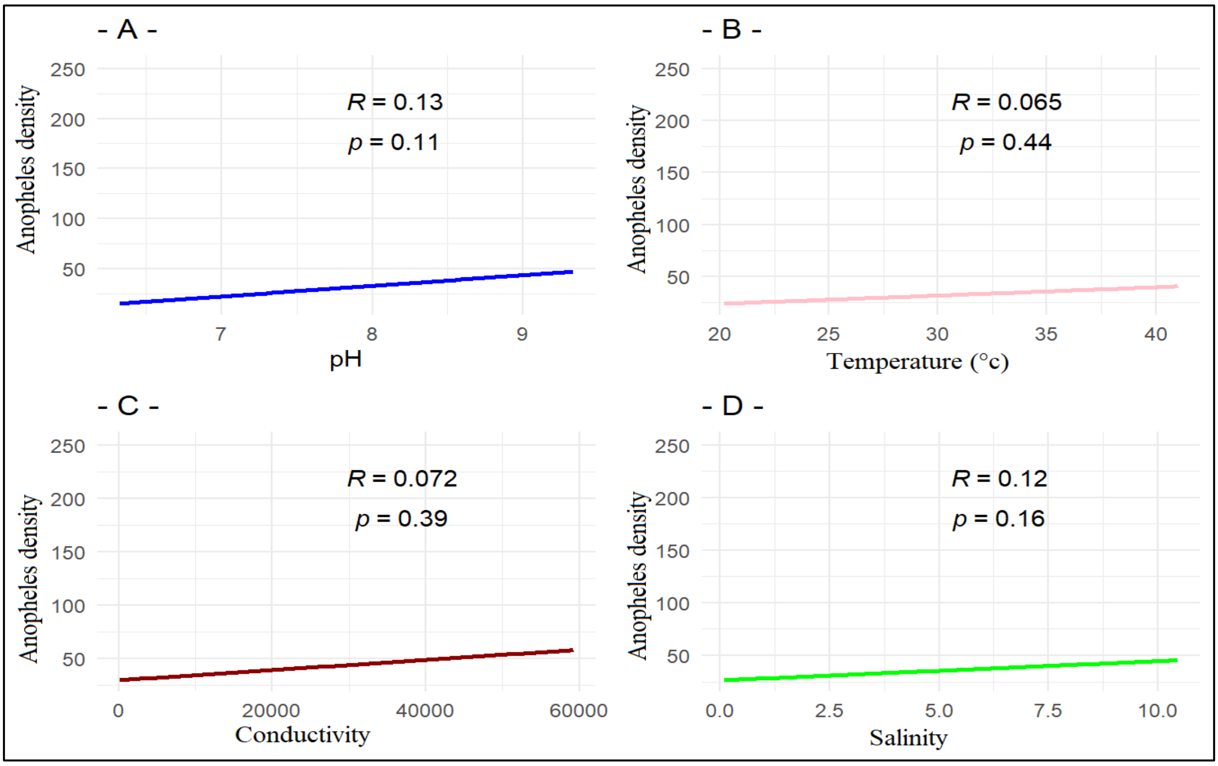

Figure 7 Influence of physicochemical parameters on *Anopheles* larval density

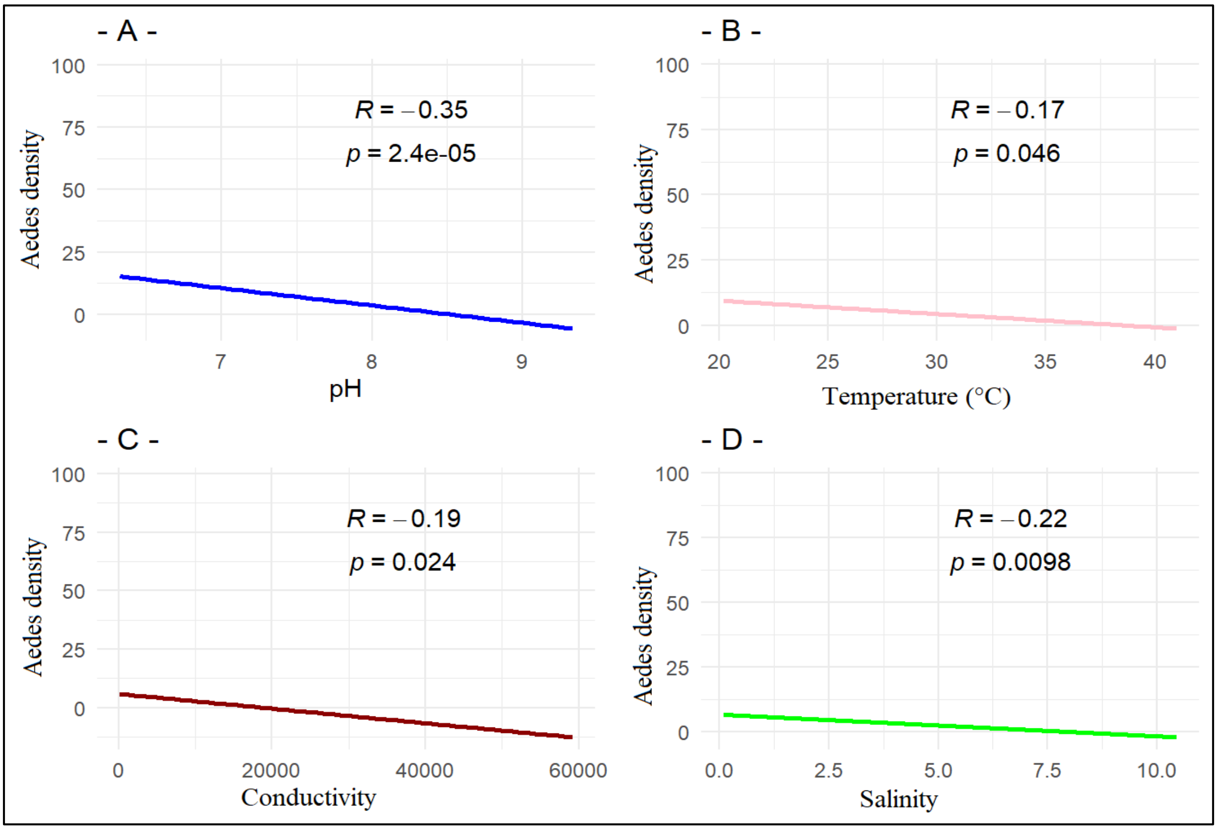

Figure 8 Influence of physicochemical parameters on *Aedes* larval density

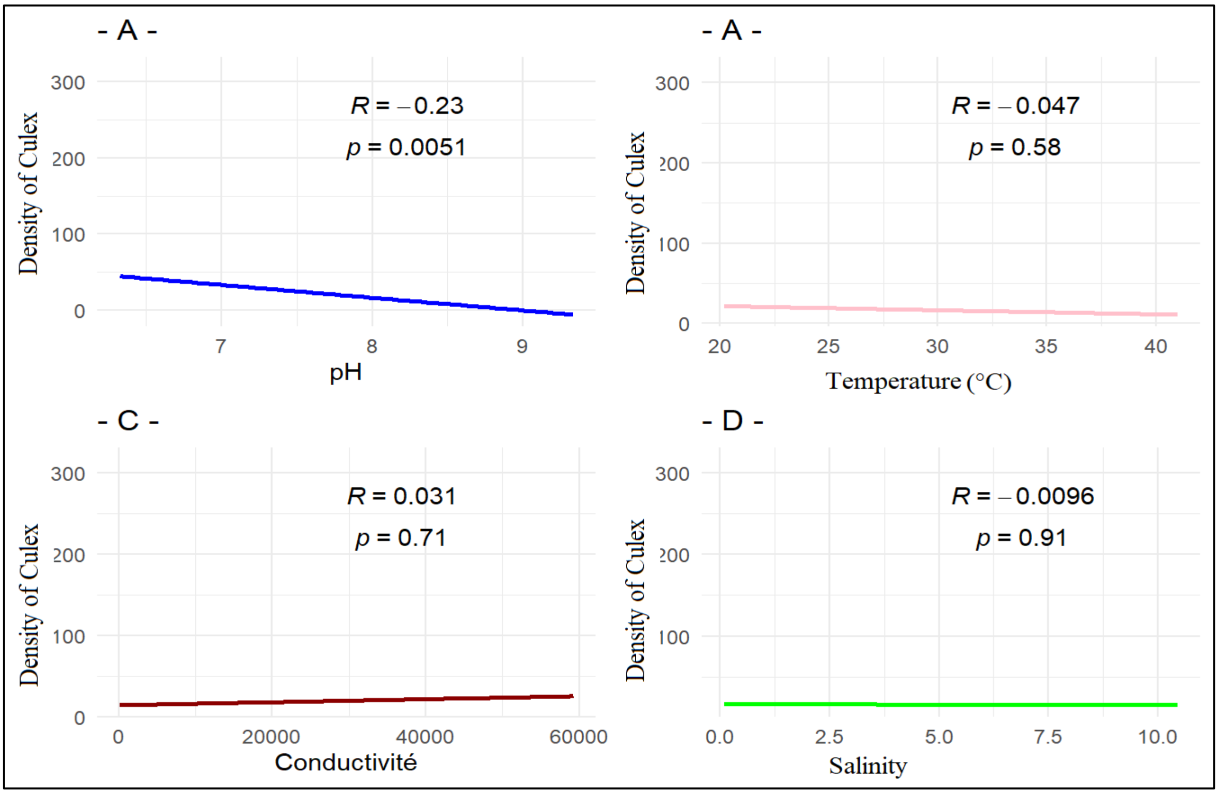

Figure 9 Influence of physicochemical parameters on *Culex* larval density

4. Discussion

This study has shown that, in the department of Saint-Louis, culicids colonise a wide variety of larval habitats, ranging from natural environments (ponds, puddles, streams) to anthropogenic environments (tyres, barrels, buckets, concrete tanks, canals, septic tanks, canaries, bricks, etc.). This wide range of breeding sites, also observed in other regions of Africa [16–18], reflects a marked ecological diversity influenced by both environmental factors (rainfall, soil type, topography) and anthropogenic factors (urbanisation, water storage, lack of sanitation). In the municipalities of Saint-Louis and Gandon, the high diversity of larval habitats observed could be linked to high anthropogenic pressure and a lack of sanitation, favouring the formation of artificial habitats. Furthermore, the coexistence of agricultural activities and human habitats in these semi-urban areas (Gandon) creates mixed environments where *Anopheles*, *Culex* and *Aedes* species develop simultaneously. The dominance of natural breeding sites in Saint-Louis and Gandon seems to be associated with the topography and hydrographic network of these areas, where rainfall favours the formation of puddles and temporary ponds during the rainy season. These results are similar to those of Mint Mohamed Lemine *et al* in Mauritania [19] and Tandina *et al* in Mali [20], confirming the key role of temporary habitats in vector-borne disease outbreaks. These ecological similarities reinforce the idea that northern Senegal is an epidemiological transition zone that is particularly sensitive to climate change. Conversely, in the municipalities of Ndiebène Gandiol, Fass Ngom and Mpal, the low diversity of breeding sites observed could be linked to the sandy nature of the soil, which is unfavourable to water retention, and to lower anthropogenic pressure. However, the significant presence of artificial breeding sites in these localities reflects domestic and agricultural practices (water storage, reuse of containers) that are conducive to the development of *Aedes*. The predominance of natural breeding sites during the rainy season confirms the strong dependence of larval dynamics on rainfall, as reported in other Sahelian regions [21,22]. Three genera of mosquitoes were identified in the breeding sites studied: *Anopheles*, *Aedes* and *Culex*. Urban and peri-urban municipalities (Saint-Louis and Gandon) had the greatest species diversity, due to the multiplicity of available breeding sites (ponds, ditches, containers, market gardens) and high human density.This diversity promotes high-risk vector cohabitation, particularly in the context of Rift Valley fever observed during the 2025 rainy season. The municipalities of Saint-Louis and Gandon are notable for their high frequency of positive *Anopheles* (86.05% and 60.53%, respectively) and *Culex* (72.09% and 57.89%) breeding sites. This abundance is probably linked to the availability of open, sunny breeding sites (ponds, puddles) favourable to the development of *Anopheles* larvae, as shown by certain authors [23,24] and urban organic pollution conducive to *Culex* [1,25]. Conversely, the dominance of *Aedes* positive breeding sites in rural areas such as Mpal, Fass Ngom and Ndiebène Gandiol could be linked to the predominance of temporary domestic containers used for water storage (tyres, barrels, canaries), as also shown by Kutomy *et al* [26]. The low frequency of *Anopheles* positive breeding sites in rural areas could be explained by the scarcity of suitable natural breeding sites, while the artificial breeding sites present did not meet the necessary conditions for their development. Similarly, the low occurrence of *Culex* in these areas reflects the low level of pollution in rural areas, as larvae of this genus are known to proliferate in eutrophic environments rich in organic matter [27]. The distribution of Culicidae larvae according to larval breeding site type reveals a clear differentiation in ecological preferences between the genera *Anopheles*, *Culex* and *Aedes*. Species of the first two genera were found in most of the breeding sites surveyed, while *Aedes* species were much more selective, limited to anthropogenic breeding sites such as barrels, tyres and buckets. *Anopheles* and *Culex* larvae were particularly abundant in natural breeding sites, including ponds, puddles and streams. These results are consistent with those of numerous previous studies [28–30]. This observation reflects a marked preference for stagnant or slow-flowing waters, often exposed to light and rich in aquatic vegetation, conditions favourable to their development. In *Anopheles* mosquitoes, this preference for clear, unpolluted water has already been demonstrated in several studies [17,31–33], which corresponds to its known ecology in rural and peri-urban areas. The *Culex* genus, however, shows greater ecological plasticity, as its larvae have also been found in anthropogenic breeding sites such as gutters, septic tanks and tyre tracks. This behaviour reflects a strong ability to adapt to more polluted environments rich in organic matter, enabling it to occupy both natural and artificial habitats. This tolerance could explain its widespread distribution in urban areas where polluted stagnant water is common. *Aedes* larvae, which are less common in natural and polluted breeding sites (gutters, streams, septic tanks), have been observed most frequently in artificial domestic breeding sites. This specialisation reflects a close adaptation to man-made environments, such as water storage containers or abandoned objects likely to retain small amounts of rainwater. These results confirm observations made in other studies showing that *Aedes* (particularly *Aedes aegypti* and *Aedes albopictus*) mainly exploit artificial breeding sites in urban and peri-urban areas [7,34,35]. From an epidemiological perspective, this specific distribution of larvae is of major importance. The dominance of *Anopheles* in natural breeding sites suggests an increased risk of malaria transmission in areas where these habitats are abundant. *Culex* mosquitoes, which thrive in polluted and artificial waters, could play a role in the transmission of numerous arboviruses in urban areas, such as the current epidemic of Rift Valley fever reported in several localities in Saint-Louis and elsewhere in the country. As for *Aedes* mosquitoes, their strong association with domestic containers reinforces their importance in the transmission of arboviruses such as dengue, chikungunya and Zika virus, particularly in densely populated areas. Analysis of the influence of physico-chemical parameters on the abundance of mosquito larvae reveals contrasting trends between the two genera. In *Anopheles*, the positive correlations observed with pH, salinity, conductivity and temperature, although not significant, suggest a wide ecological tolerance. This lack of marked dependence on physico-chemical factors indicates that other variables, such as the nature of the breeding site, vegetation cover, predation or organic load, could play a more decisive role in the distribution of larvae. These results corroborate those reported by Mereta *et al* [36] and KOUADIO *et al* [37]. Indeed, their results showed that anopheles preferentially occupy clear, slightly alkaline waters, but have a high ecological plasticity that allows them to adapt to a variety of environments. Conversely, *Aedes* larval density shows significant negative correlations with all measured parameters, reflecting a preference for fresh, low-mineralised, slightly acidic and cooler waters. These conditions are characteristic of urban and peri-urban artificial breeding sites, which are often shaded and low in dissolved salts. These observations are consistent with those of Rueda [38], who showed that *Aedes* larval survival decreases significantly in saline environments or at high temperatures. This environmental sensitivity reflects the ecological specialisation of the *Aedes* genus, whose distribution is closely linked to the stability and physico-chemical quality of the aquatic environment. For the *Culex* genus, larval density shows a significant correlation with pH, indicating an affinity for slightly alkaline waters. Correlations with conductivity, salinity and temperature remain weak and insignificant. This trend reflects the ability of *Culex* to develop in eutrophic or slightly polluted environments, often rich in organic matter, which are characteristic of urbanised areas. These results are consistent with those reported by Muturi *et al* [39] and Selvan *et al* [6], highlighting the high ecological tolerance of this genus to variable physico-chemical conditions. These differences in adaptation could explain the spatial and seasonal variations in larval populations observed in the study areas. They also highlight the need to integrate physicochemical parameters into entomological surveillance and integrated vector management programmes, as environmental changes (urbanisation, salinisation, warming waters) are likely to alter the specific composition of larval communities and, consequently, the dynamics of vector-borne disease transmission. Further analysis, including other abiotic variables (dissolved oxygen, organic matter, turbidity) and multivariate statistical models, would refine our understanding of the relationships between environmental characteristics and mosquito distribution. Our results also highlight the importance of the nature of the larval habitat as a determining factor in mosquito distribution. They underscore the need to adopt targeted vector control strategies tailored to the specific ecology of each genus. The reduction or elimination of artificial breeding sites should be prioritised to limit *Aedes* populations, while the sanitation of wetlands and the management of stagnant water can contribute to the reduction of *Anopheles*. In addition, regular monitoring of polluted breeding sites is essential to control *Culex* mosquitoes and reduce the nuisance they cause.

5. Conclusion

The results show a high ecological diversity of Culicidae larval habitats in Saint-Louis, linked to environmental, climatic and human factors. The genera *Anopheles*, *Culex* and *Aedes* have distinct ecological preferences, reflecting their strong ability to adapt to natural and anthropised environments. This diversity promotes the coexistence of vector species in certain localities, increasing health risks. In a context of resurgence of vector-borne diseases in Senegal, these observations highlight the importance of implementing integrated and multisectoral vector management.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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