2.2 Types of typical ecosystems

Tropical regions encompass a variety of ecosystems that provide diverse habitats for mosquitoes, including dense forests, wetlands, agricultural landscapes, and urban areas. Forested environments offer shaded breeding sites such as tree holes and leaf axils, supporting species adapted to sylvatic habitats. Wetlands and rice paddies create extensive aquatic habitats favorable for larval development of several vector species like Anopheles mosquitoes associated with malaria transmission. Urban environments introduce artificial containers and water storage systems that serve as prolific breeding grounds for *Aedes aegypti* and *Aedes albopictus*, vectors responsible for dengue and other arboviral diseases (García-Súarez et al., 2024; Nayak et al., 2025). The heterogeneity of these ecosystems influences mosquito community composition by providing niches suited to different species' ecological preferences.

Land use changes such as urbanization significantly alter habitat availability and microclimatic conditions within tropical landscapes. Urban areas often experience higher temperatures (urban heat island effect) and reduced vegetation cover compared to natural habitats, which can favor certain mosquito species over others. Fragmented urban landscapes with mixed residential and cropland areas have been identified as hotspots for Aedes breeding due to abundant artificial containers combined with suitable climatic conditions. Conversely, natural wetlands maintain stable populations of other vector species like Mansonia mosquitoes that rely on aquatic vegetation during their immature stages. Thus, ecosystem type strongly shapes the spatial distribution patterns of mosquitoes by influencing habitat suitability at local scales (Bennett et al., 2021; García-Súarez et al., 2024).

2.3 Major mosquito species and their distribution patterns

Several key mosquito species dominate tropical environments due to their adaptability to diverse habitats and climatic conditions. Among these are *Aedes aegypti* and *Aedes albopictus*, which are primary vectors of dengue virus; their distributions often overlap but show microhabitat preferences influenced by vegetation cover and urbanization gradients. For instance, *Ae. albopictus* tends to be more abundant in vegetated suburban or rural areas with higher humidity levels, whereas *Ae. aegypti* thrives in densely populated urban settings with warmer microclimates (Bennett et al., 2021; Abdullah et al., 2025). Both species exhibit seasonal fluctuations linked to rainfall patterns that create breeding sites in artificial containers.

Anopheline mosquitoes responsible for malaria transmission also display distinct spatial distributions shaped by ecological factors such as water quality parameters (pH, salinity), illumination levels in breeding sites, temperature ranges, and predator presence. Species like *Anopheles vagus* dominate rice-growing agroecosystems where flooded fields provide ideal larval habitats. Climatic variables including temperature peaks around 23°C~24°C combined with high relative humidity optimize biting rates for several Anopheles species (Arisanti et al., 2025). Additionally, Culex mosquitoes are widespread across various tropical habitats due to their tolerance of diverse environmental conditions but show abundance patterns influenced by diurnal temperature ranges (García-Súarez et al., 2024). Understanding these species-specific distribution patterns is crucial for targeted vector surveillance and control strategies tailored to local ecological contexts.

3 Seasonal Dynamics of Mosquito Populations

3.1 Variations in mosquito population density across seasons

Mosquito populations in tropical environments exhibit pronounced seasonal fluctuations, often characterized by peaks in abundance during or shortly after the rainy season when breeding habitats are most abundant. Studies monitoring mosquito activity have documented bimodal or unimodal seasonal patterns depending on local climatic conditions and species composition. For example, research conducted in Mediterranean botanical gardens showed that adult mosquito abundance followed a seasonal pattern influenced by temperature but with two distinct peaks linked to cumulative rainfall events, highlighting the complex interplay between climate and mosquito life cycles (Blanco-Sierra et al., 2024). Similarly, long-term surveillance across urbanization gradients in Yucatan, Mexico, revealed that mosquito densities varied significantly over the year, with higher captures during wetter months and lower numbers during dry periods, reflecting the dependence of larval habitats on precipitation (García-Súarez et al., 2024).