use. Therefore, integrating local entomological surveillance data with environmental monitoring is critical to identify precise windows for intervention. Mathematical models incorporating seasonality and time-dependent control parameters have been used to determine optimal strategies combining insecticide spraying and environmental decontamination. These studies reveal that while insecticide application alone may not fully eliminate vector populations, combining it with habitat management yields significantly better outcomes. Similarly, pest management research highlights that targeting specific life stages or age groups during vulnerable seasonal periods maximizes population suppression. Early-season interventions often reduce reproductive potential and seedbank densities in invasive species control, suggesting analogous benefits in mosquito management by preempting population buildup. Overall, adaptive timing of control efforts informed by seasonal dynamics enhances resource efficiency and public health impact.

Habitat management through environmental modification plays a crucial role in reducing mosquito breeding sites and interrupting transmission cycles. Environmental interventions such as removal of standing water, vegetation management, and sanitation reduce larval habitats and adult resting sites, thereby lowering vector densities. Studies emphasize that environmental decontamination can be more effective than insecticide spraying alone when integrated into control programs. Additionally, managing invasive plant species or modifying landscape features influences habitat suitability for mosquitoes by altering microclimatic conditions and resource availability. Such habitat-focused strategies complement chemical controls by addressing underlying ecological drivers of mosquito proliferation. The success of habitat management depends on understanding spatial heterogeneity and temporal changes in breeding site distribution. Remote sensing and GIS tools facilitate identification of high-risk habitats for targeted interventions, while community engagement enhances sustainability of environmental measures. Moreover, combining biological controls such as natural predators or parasitoids with habitat modification offers promising integrated pest management approaches that reduce reliance on chemicals. However, challenges remain in balancing effective habitat alteration with conservation goals and minimizing impacts on non-target species. Thus, environmentally based interventions require careful planning tailored to local ecological contexts to optimize public health benefits.

Effective mosquito control informed by seasonal dynamics and habitat characteristics has direct implications for reducing the burden of mosquito-borne diseases in tropical regions where transmission is often intense year-round but fluctuates seasonally. Timing interventions to coincide with periods preceding population peaks can lower infection rates more efficiently than random or calendar-based schedules (Huang et al., 2020; Morreale et al., 2024). This approach is particularly important in urbanizing tropical areas where land use changes alter vector ecology unpredictably. Integrating entomological surveillance data into disease models improves prediction accuracy for outbreak risk and guides resource allocation. Furthermore, combining chemical controls with environmental management addresses both adult vectors and immature stages, enhancing overall program efficacy while mitigating insecticide resistance development. Public health strategies must also consider socio-economic factors influencing community participation in habitat reduction efforts to ensure sustained impact. Advances in modeling optimal control strategies incorporating human behavior and vector ecology provide frameworks for designing cost-effective interventions adapted to local conditions. Ultimately, leveraging knowledge of seasonal mosquito dynamics alongside habitat management strengthens integrated vector management programs critical for controlling tropical diseases such as malaria, dengue, chikungunya, and Zika.

Acknowledgments

Thanks to the animal research team for their support and help in data collection and data collection.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.