mosquitoes (Vandergiessen et al., 2025). Sugar feeding behavior influenced by vegetation availability also affects adult fitness and population persistence across landscapes differing in ecological complexity (Vandergiessen et al., 2025). Understanding these biotic mechanisms alongside abiotic drivers is crucial for developing comprehensive models of mosquito ecology that inform targeted control measures addressing both environmental management and biological regulation.

6 Research Methods and Data Analysis Techniques

6.1 Mosquito sampling and monitoring methods

Mosquito sampling methods vary widely depending on the target life stage and species behavior, with adult trapping and larval surveys being the most common approaches. Adult mosquito collection often employs traps such as BG-Sentinel II (BGS), BG Gravid Traps (GAT), and sweep netting, each with distinct advantages. A multi-country study in Pacific Island nations found BGS traps to be the most effective in capturing a higher number of mosquitoes without significant species bias, making them suitable for routine surveillance in diverse tropical settings (Craig et al., 2025). Larval surveys complement adult trapping by identifying breeding sites through dipping or direct collection from aquatic habitats, providing critical data on immature stages that inform control strategies (Becker et al., 2010). Combining multiple sampling methods targeting different mosquito behaviors enhances surveillance comprehensiveness and reduces bias inherent in single-method approaches (Van De Straat et al., 2021).

Operational feasibility is a key consideration in selecting sampling techniques, especially in resource-limited or remote tropical environments. Simpler, durable tools that require minimal maintenance are preferred for sustained monitoring programs (Craig et al., 2025). Passive surveillance methods, including community-based reporting and citizen science initiatives, have gained traction as cost-effective supplements to active trapping by expanding spatial coverage and enabling early detection of invasive species (Kampen et al., 2015). Additionally, behavioral monitoring technologies such as high-resolution video tracking and AI-driven analysis offer promising avenues for detailed studies of mosquito activity patterns but remain underutilized in field surveillance (Javed et al., 2024). Overall, integrating diverse sampling tools tailored to local ecological contexts improves data quality for vector management.

6.2 Statistical and modeling approaches for data analysis

Analyzing mosquito population data requires robust statistical and modeling techniques to accurately estimate abundance, species composition, and temporal trends while managing large sample sizes efficiently. Subsampling methods have been developed to reduce labor-intensive processing of large mosquito collections without compromising accuracy. For instance, area-based subsampling of 20% of specimens provides reliable estimates of total numbers and dominant species proportions with acceptable error margins (~12% for specimen counts) (Jaworski et al., 2019). Image processing software like ImageJ has also demonstrated resilience and precision in digitized optical counting across varying sample conditions, offering an efficient alternative to manual enumeration (Faraji et al., 2025). These approaches enable timely decision-making critical for vector control interventions.

Modeling frameworks often incorporate generalized linear mixed models (GLMMs) to account for spatial-temporal variability and hierarchical data structures inherent in mosquito surveillance datasets (Craig et al., 2025). Multimethod sampling designs facilitate more comprehensive models by capturing diverse vector behaviors influencing disease transmission risk (Van De Straat et al., 2021). Advanced statistical analyses also support molecular xenomonitoring efforts by evaluating how different collection strategies affect parasite detection rates within mosquito populations (Reimer and Pryce, 2023). Integrating these quantitative tools with ecological knowledge enhances predictive capacity regarding population dynamics under changing environmental conditions. Thus, combining subsampling efficiency with sophisticated modeling strengthens entomological research outcomes.