Precipitation-Driven Dynamics of Culex Mosquito Vectors in a Kenyan Highland Ecosystem: Implications for Rift Valley Fever Emergence Under Climate Variability

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Background: Rift Valley Fever (RVF) is a mosquito-borne zoonotic disease whose outbreaks are closely linked to extreme rainfall events. However, the influence of precipitation on vector abundance and diversity in high-altitude ecosystems remains poorly understood.
Methods: A repeated cross-sectional study was conducted in Nyandarua County, Kenya, during dry (January 2021), long rain (July 2020), and short rain (November 2021) seasons. Mosquitoes were collected using CDC light traps from 33 homesteads. Satellite-derived rainfall data (2015–2021) were obtained via ClimateSERV. Morphological identification was followed by molecular characterization using mitochondrial CO1 gene sequencing and phylogenetic analysis.
Results: Rainfall patterns showed marked inter-annual variability. Mosquito abundance was lowest in the dry season (97 mosquitoes) and highest during the short rains (366 mosquitoes), corresponding to mean rainfall of 17.4 mm and 33.9 mm, respectively. Five Culex species were identified: Cx. pipiens (57.8%), Cx. theileri (15.8%), Cx. vansomereni (2.7%), Cx. perexiguus (2.5%), and Cx. rima. Cx. pipiens dominated all seasons. Phylogenetic analysis revealed that Nyandarua Cx. pipiens clustered with Turkish strains but differed from other Kenyan isolates. Simpson diversity index was highest during short rains (0.44), while Shannon index peaked during long rains (1.38). Significant species variation was observed across villages during short rains ($p = 0.000$).
Conclusion: Precipitation variability drives Culex vector abundance and diversity in Nyandarua highlands, potentially increasing RVF transmission risk. These findings highlight the need for climate-integrated surveillance in emerging high-altitude zones.