

transmission. This holistic approach is critical for advancing toward malaria elimination goals globally (Musoke et al., 2023; Otolorin et al., 2025).

2 Biological and Ecological Characteristics of Malaria Vectors

2.1 Major vector species and their distribution

The primary malaria vectors in sub-Saharan Africa include *Anopheles gambiae*, *Anopheles arabiensis*, *Anopheles funestus*, and *Anopheles coluzzii*, with *An. funestus* dominating transmission in many parts of east and southern Africa. This species is notable for its preference for permanent and semi-permanent aquatic habitats such as river streams, ponds, swamps, and spring-fed pools, enabling it to sustain populations year-round and mediate over 85% of malaria transmission events in some regions despite insecticide resistance challenges (Kahamba et al., 2022). In addition to these major vectors, secondary vectors like *Anopheles merus* along the East and Southern African coast are increasingly recognized for their role in residual malaria transmission due to their exophilic behavior and insecticide resistance; these species have expanded their geographical range and vectorial capacity over time (Bartilol et al., 2021).

In India, the major malaria vectors include species complexes such as *Anopheles culicifacies* and *Anopheles fluviatilis*, which exhibit distinct biological traits across diverse ecosystems. These vectors show varying resting behaviors-*An. culicifacies* is mainly endophilic except in some regions where behavioral shifts are observed-and display widespread insecticide resistance that complicates control efforts. Understanding the distribution patterns of sibling species within these complexes is critical for tailoring effective vector control strategies aligned with India's malaria elimination goals (Figure 1) (Subbarao et al., 2019; Rahi et al., 2022).

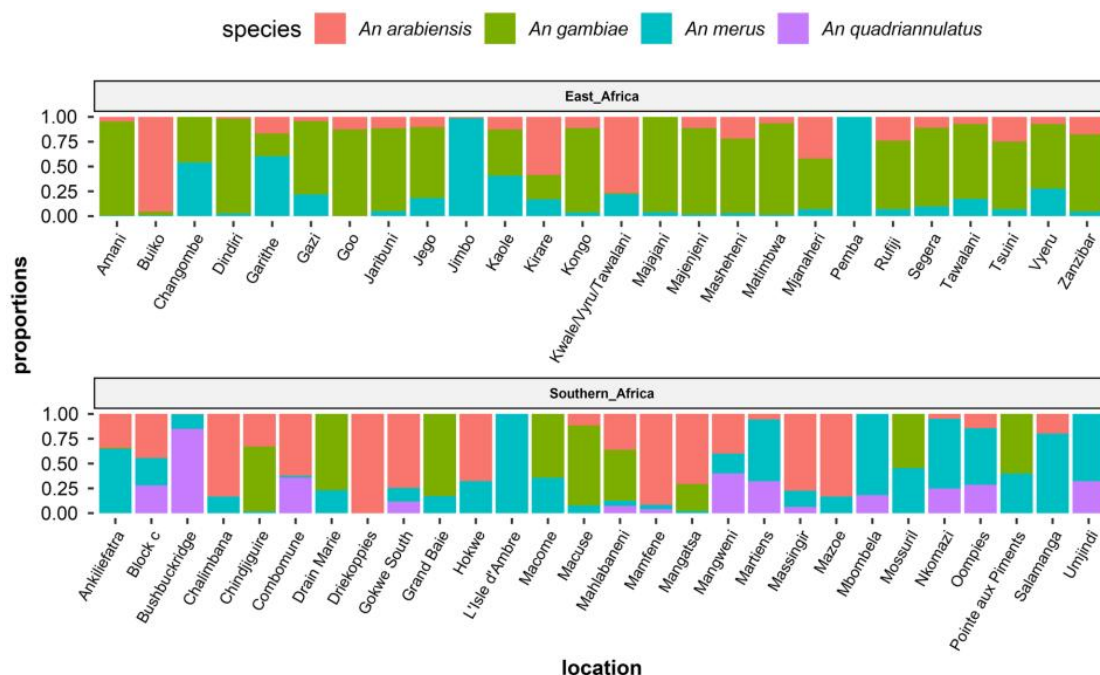


Figure 1 Proportions of *An. Gambiae* complex members: *An. Gambiae* (s.s.), *An. merus*, *An. quadriannulatus* and *An. arabiensis* in the different collection sites along the East and Southern African Coast. However, in Changombe, Drain Marie, Grand Baie, L'Isle d'Ambre, Pemba and Pointe aux Piments, *An. gambiae* (s.l.) were identified using a salt tolerance test and classified as saltwater *An. Gambiae* represented as *An. merus* in the figure or non-saltwater *An. Gambiae* (*An. arabiensis*, *An. quadriannulatus*, *An. Gambiae*), which are represented as *An. Gambiae* (Adopted from Subbarao et al., 2019)

2.2 Life cycle, feeding behavior, and reproductive traits

Malaria vectors undergo a complex life cycle involving aquatic larval stages followed by adult emergence; the duration and success of each stage are influenced by ecological conditions. For example, *An. funestus* females predominantly feed indoors on humans but can exhibit zoophagy in areas with abundant livestock; both males and females rest indoors, which makes them susceptible to indoor interventions despite some reports of outdoor biting