

Histopathological studies reveal that some plant-derived compounds induce physiological damage in adult mosquitoes that likely contributes to reduced longevity. Essential oils from *Ageratum conyzoides* caused degeneration in compound eyes, muscular tissues, gut epithelium, *Malpighian tubules*, and ovarian cells in *Aedes aegypti* adults (Pintong et al., 2020). Such tissue damage impairs vital functions including feeding and reproduction, thereby limiting mosquito population growth over time. This evidence supports the use of botanical insecticides not only for immediate toxicity but also for long-term vector control through lifespan reduction (Figure 3).

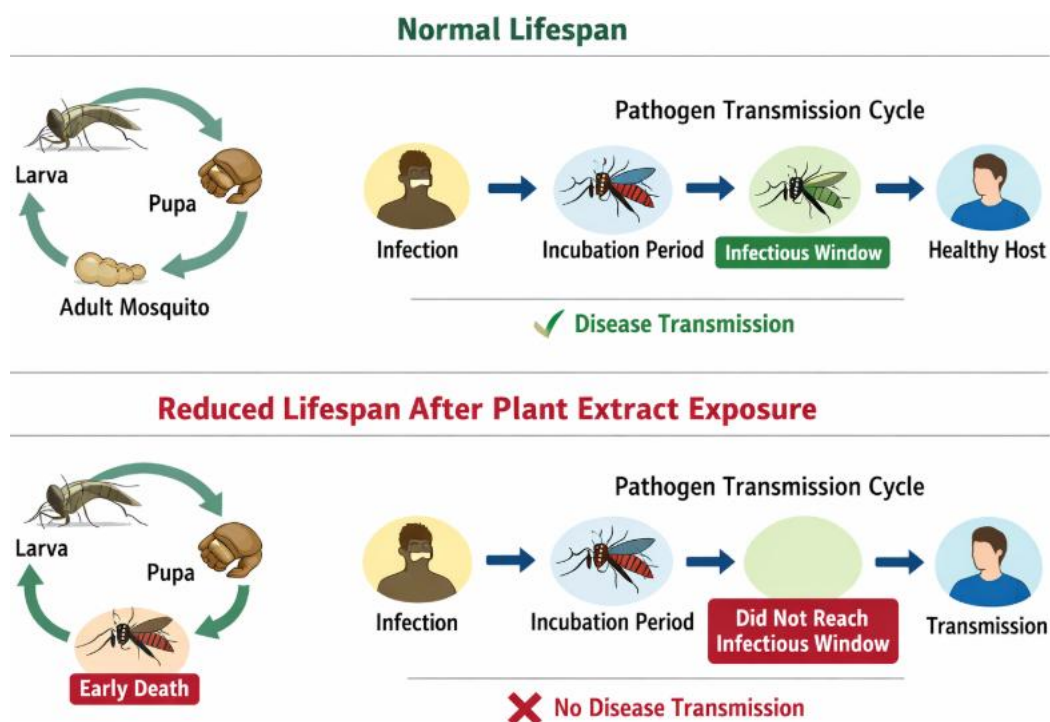


Figure 3 Conceptual diagram illustrating how reduced adult mosquito lifespan limits the transmission potential of malaria parasites by shortening the infectious period

5.3 Effects on blood-feeding behavior and reproductive capacity

Plant extracts can alter blood-feeding behavior in adult mosquitoes by acting as repellents or irritants that reduce host-seeking activity. The irritant and repellent effects observed with essential oils from *Cymbopogon winterianus* and *Thymus vulgaris* suggest disruption of normal feeding patterns in *Anopheles gambiae* adults (Delétré et al., 2013). By decreasing successful blood meals, these extracts may lower pathogen transmission rates indirectly through behavioral modification rather than direct toxicity alone.

Moreover, some botanical compounds negatively affect reproductive capacity by causing ovarian degeneration or reducing egg production. Histopathological alterations induced by *Ageratum conyzoides* essential oils included ovarian cell degeneration in *Aedes aegypti* females (Pintong et al., 2020), which likely translates into decreased fecundity. Although detailed quantitative data on reproductive inhibition are limited for *Anopheles* species specifically, these findings indicate that plant-based products may impair mosquito population growth through multiple physiological pathways beyond immediate lethality.

6 Mechanism of Action Analysis

6.1 Effects on the nervous system

Plant extracts exert significant neurotoxic effects on mosquitoes, primarily targeting their nervous system to disrupt normal physiological functions. Many secondary metabolites found in these extracts, such as alkaloids, flavonoids, and terpenoids, interfere with nerve impulse transmission by affecting ion channels and neurotransmitter receptors, leading to paralysis and death of mosquito larvae and adults (Pavela et al., 2019;