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Quiescence and its Effects in the *Aedes aegypti* Population

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Due to the capacity of several species of mosquitoes to carry vector-borne diseases, several models, including those composed of systems of differential equations, have been developed to describe its population dynamics [1, 4]. It is known that in the presence of adverse weather conditions, *Aedes aegypti* mosquitoes employ a survival strategy called quiescence, in which, once their eggs dry up, development stops to maintain viability for periods lasting up to several months [2]. Although quiescence allows a prolonged likelihood of survival for mosquito eggs, quiescence can also negatively affect mosquito development [3]. In this work, we incorporate the effects of quiescence into a population model. The proposed model, covers female mosquito populations. This model is divided into four phases of mosquito development: Eggs (E), Larvae (L), Pupae (P), and Mature adults (M)

$$\frac{dE(t)}{dt} = \frac{1}{2}\phi(t)\left(1-\frac{E(t)}{K(t)}\right)M(t) - (\sigma_e(t)\epsilon(\tau)+\mu_e(t))E(t), \quad (1)$$

$$\frac{dL(t)}{dt} = \sigma_e(t)\epsilon(\tau)E(t) - (\sigma_l(t)+\mu_l(t))L(t), \quad (2)$$

$$\frac{dP(t)}{dt} = \sigma_l(t)L(t) - (\sigma_p(t)+\mu_p(t))P(t), \quad (3)$$

$$\frac{dM(t)}{dt} = \sigma_p(t)P(t) - \mu_m(t)M(t), \quad (4)$$

where the precipitation-dependent carrying capacity is given by $K(t) = C(1 + \alpha\ P_n(t))$.

To measure changes in the viability of mosquito eggs due to quiescence's effects, we introduce a factor $\epsilon = \alpha e^{-\beta\tau}$ to the egg hatching rate; where τ is the number of continuous days in which the precipitation is less than a specific amount, and has the form:

$$\tau_k = \begin{cases} 0 & \text{if } precip_k > 1 \text{ mm} \\ \tau_{k-1}+1 & \text{if } precip_k \leq 1 \text{ mm} \end{cases} \quad (5)$$

where parameters α and β are obtained using a regression curve on experimental data from [3]. With k being the timestamp of the time series. The following values are obtained: $\alpha = 0.9568$ and $\beta = 0.0442$, with parameter errors for 5.1952 and 0.0065 for each parameter respectively.

To visualize the effects of quiescence on the mosquito population, four scenarios are analyzed (see Figure 1). In Scenario (a), low temperature and precipitation keep mosquito populations low, but quiescence enables egg survival and hatching when rain returns. In Scenario (b), high temperatures increase population, but low precipitation limits growth. Scenario (c) shows population growth during rainfall and decline during drought. In Scenario (d), high precipitation and temperature create ideal conditions, minimizing quiescence drawbacks and maintaining high populations throughout the simulation.

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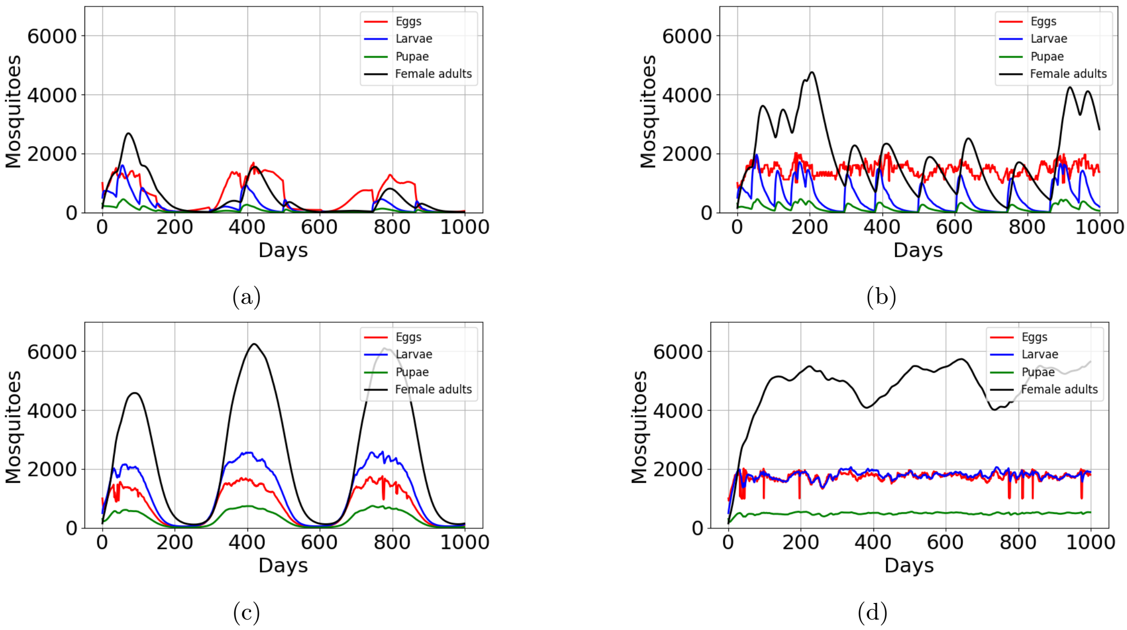

Figure 1: Mosquito population in scenarios with $\delta = 1$ [mm]. (a) shows the simulation results for Scenario (a). (b) shows the simulation results for Scenario (b). (c) shows the simulation results for Scenario (c). (d) shows the simulation results for Scenario (d). Source: Own elaboration

Observe that quiescence allows the population to persist in adverse conditions, but this ability has limits since, in long periods of drought, the population decreases. In further work, it is possible to establish a precipitation threshold based on empirical data linking rainfall patterns to mosquito capture rates, this would allow for a more accurate analysis of factors affecting mosquito behavior.

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