Stability Analysis of Detritus-Based Food Chains in Sri Lankan Mangroves: An Allometric Parameterization and Hopf Bifurcation Framework

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Mangrove ecosystems importantly support complex detritus-based food chains; however, their stability analysis is limited due to lack of availability of field data. This study focuses on the ecological sustainability and mathematical stability of a tri-trophic detritus-based food chain (detritus-prey-predator) at the Bolgoda wetland mangrove ecosystem of Sri Lanka. Demographic and interaction parameters, which are difficult to measure in the field, were substituted in terms of achievable parameters by using allometric scaling laws. A modified three-dimensional Holling-Tanner model with a dynamic carrying capacity is used to analyze the system. As the detritus input rate varies, bifurcation analysis (qualitative behaviour as parameter varies) of the system identified three important dynamic regimes. The study found that, at lower detritus input rate, coexistence equilibrium is stable but beyond the Hopf bifurcation point, stability of the food chain becomes unstable, and oscillations in prey and predator densities are observed. In addition, beyond the existence threshold, only the predator-free equilibrium exists, and the coexistence equilibrium had disappeared. This analysis predicts the most suitable detritus input rate ($\rho < 0.172474$) for the sustainability of the tri-tropic detritus-based food chain in Bolgoda wetland, which is useful for decision making in mangrove ecosystem management in Sri Lanka.

Keywords: *Modeling, Detritus, Mangrove ecosystem, Holling-Tanner model, Bifurcation analysis*