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DYNAMIC ANALYSIS OF A FRACTIONAL ORDER THREE–LEVEL FOOD CHAIN MODEL

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Abstract. Food chains in the environment are highly nonlinear and interdependent systems. When these systems are modeled using simple sets of ordinary differential equations, these models can exhibit very rich and complex mathematical behaviors. The present paper deals with the mathematical behaviors of a nutrient-autotroph-herbivore model where the herbivore species is assumed to have a commercial value. The dynamical behavior of the system is investigated from the point of view of stability. Numerical analysis reveals the chaotic behavior in a narrow region of the parameter space for biologically realistic parameter values of the model system. Our analytical findings are illustrated through computer simulation. Biological implications of our analytical findings are addressed critically.

Keywords. Three–level food chain model; Routh–Hurwitz stability conditions; computer simulation; dynamic analysis.

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1 Introduction

The three–level food–chain was first studied by Rosenzweig in the famous paper on the paradox of enrichment [2], where he wrote "Man must be very careful in attempting to enrich an ecosystem in order to increase its food yield. There is a real chance that such activity may result in decimation of the food species that are wanted in greater abundance". Rosenzweig's analysis is based on a three–level food–chain composed of a logistic prey x_1, a predator x_2 and a super-predator x_3 with saturating functional response. The model which is called Rosenzweig–MacArthur takes the form: