Pest Control by Generalist Predators Depends on Prey Density and Predator Effectiveness

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ABSTRACT: Integrated Pest Management (IPM) strategies increasingly incorporate natural predators of pest species to reduce the abundance and persistence of pest species in agricultural settings. Specialist predators and parasitoids have been demonstrated to be successful tools to reduce the damage from invertebrate pest species, but less research has focused on the effectiveness of generalist predators to reduce the abundance of vertebrate pest species. To investigate this, we employed a case study of a globally used IPM tactic: the use of barn owls (*Tyto alba*) for rodent biocontrol. When used as a biocontrol agent, barn owls are typically recruited to the area through the installation of nest boxes in agricultural fields. Anecdotal evidence suggests that barn owls forage within the agricultural fields and reduce rodent pest populations, but no replicated studies that monitor both rodent and owl populations exist to date. We developed models of this system, parameterized using published data on barn owls depredating pocket gophers (*Thomomys* spp.) and voles (*Microtus* spp.) in California agricultural fields.

Using the model, we sought to understand how effectively generalist predators (i.e., predators that are not numerically responsive to the density of a single prey species) might control vertebrate pest species. In this case, the generalist predator density is determined by the land manager through installation of nest boxes and not dependent on the density of pest species on the landscape. We found that the equilibrium density of the pest population is determined by three key parameters. The first is the scaled half-saturation constant, which describes the density of the pest species when the predator's feeding rate is half the maximum. The second is the scaled predator density, an index of how many predators are present and preying on the target pest species. The third controls the shape of the functional response of the pest species and describes the strength of the predator's preference for more abundant prey.

To determine how the existence and local stability of pocket gopher or vole population equilibria varied across parameter space, we used bifurcation analysis. This revealed that, depending on predator abundance and efficiency, the pest species can persist at stable equilibria at high abundance, low (or zero) abundance, or both. Bi-stability could occur in biologically realistic parameter values, suggesting that barn owls may sometimes control rodent populations, but it depends on initial conditions. These findings suggest that generalist predators can be an effective tool in IPM strategies, but their success depends on both the predator density and the efficiency of the predator.

KEY WORDS: barn owls, biocontrol, generalist predators, Integrated Pest Management, pocket gophers, predator-prey models, *Tyto alba*, voles

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