PREDATOR'S PREY PREFERENCE AND FOOD WEBS STABILITY

Michel Iskin da Silveira Costa

Lucas Del Bianco Faria

Laboratório Nacional de Computação Científica, Av. Getúlio Vargas, 333-Quitandinha, Petrópolis-RJ, 25651 - 070, Brazil. Phone: + 55, 24 2233 6008. (michel@lncc.br)Setor de Ecologia, Departamento de Biologia, Universidade Federal de Lavras-Lavras-MG, 32700 - 000, Brazil. Phone: +55 35 38291926. (lfaria@ufla.br)

INTRODUCTION

Ecological systems dynamics can be extremely complex due, in part, to the possibly large number of interacting species. As a relevant character of these interactions, it is commonly found in nature that predators have a wide diet range, consuming more than one prey item (e.g., generalist predator, intraguild predation and omnivory). A common feature in modeling works is prey preference structure which can be embedded in two settings (sensu Holt, 1983): (1) non - switching predators; (2) switching predators. The first setting portrays a fixed predator behavior with respect to the density of its alternative prey. The second is based upon the relative prey densities, within the frame of predator switching sensu Murdoch and Oaten (1975). In this light, theoretical studies have been performed to assess the effect of predator's prey preference on consumer - resource dynamics, spurring a lively theoretical debate about the relation among species interaction strength, diversity and stability in food webs (McCann *et al.*, 998; Faria *et al.*, 008).

OBJECTIVES

In this work, for a specific consumer - resource model, i.e., apparent competition, and an omnivory system, it is shown that the presented preference structures can have a marked effect on the ultimate dynamics. This may point to the importance of the choice of predator's prey preference structure in the analysis of diversity - stability issues in food web theory.

MATERIAL AND METHODS

Consumer - resource dynamics models and predator's prey preference

The common structure of the models to be analyzed consists of two non - interacting prey, N1, N2, which share a predator, P (an apparent competition module).

Within the non - switching framework, the apparent competition model with the prey preference structure presented in Faria *et al.*, 008 (hereinafter named preference structure 1) can have the following form:

aqui vai um modelo matemático (1)

while for the switching framework with the preference structure presented in Post (2000) (hereinafter named preference structure 2), the model takes on the form:

aqui vai um modelo matemático (2)

where ri and Ki (i = 1, 2) are the prey specific growth rates and carrying capacities, respectively; c is the efficiency conversion of prey biomass into predator growth; a is the predator attack rate and Th is the predator handling time; d is the predator per capita mortality rate. In model (1) and (2) p ($0 \leq p \leq 1$) is the preference parameter for consumption of prey 2 (in the context of model (2) p is also called bias in switching response (Matsuda *et al.*, 986)). However, the precise interpretation of the preference parameter p is different in these two models: in model (1) it represents the fraction of actual searching time (i.e., not counting handling time) allocated to searching for prey of species 2, whereas in model (2) it represents a weighing factor such that the fraction of the total time spent searching for plus the handling of either prey species is proportional to their weighed frequency in the population, with p being the weighing factor for species 2 and 1 - p for species 1.

Omnivory dynamics models and predator's prey preference

The omnivory model to be analyzed is characterized by a logistic growth of the resource population (R), functional response type II for both the consumer (C) on resource and predator (P) on resource and consumer. McCann and Hastings (1997) have investigated the omnivory intensity role in the dynamics of the food chain model (1) by adding a non - switching selection term w to the predator functional and numerical response type II as shown in model (2) (hereinafter named non - switching model (NSW)):

aqui vai um modelo matemático (3)

Resorting to the formulation of preference put forward by Post *et al.*, (2000), the omnivory model with switching be-

havior (hereinafter named switching model (SW)) takes on the form:

aqui vai um modelo matemático (4)

where R, C and P are resource, consumer and predator densities, respectively; K is the resource carrying capacity; R_0, R_{02} are the half - saturation densities of the resource (R) and C_0 the half - saturation density of the consumer (C); x_c, x_p are the mass - specific metabolic rates of consumer and predator species, respectively; y_c, y_{pr} and y_{pc} are measures of ingestion rate of consumer species and predator (Yodzis & Innes, 1992; McCann & Yodzis, 1994) and p is the preference term.

RESULTS AND DISCUSSION

Results
The analyses of the sections above purport to unfold the effects of prey preference of predators on the dynamical patterns of models (1-4). To this end variation of the preference parameter p is performed.

Apparent competition
For the preferences structures of both models the bifurcation diagram with long - term local maxima and minima for each species as a function of the preference parameter p ($0 \leq p \leq 1$) with environmental homogeneity, i.e., K1/K2=1, suggests that a stable system can be attained for intermediate values of p (model 1), while destabilization occurs for high values of p and around 0.5 (i.e. maximum degree of predator generalistic behavior). As for the preference structure the model 2 suggest that limit cycles occur for all p.

As for the minima population sizes of the prey species the non - switching preference term can lead the population minimum size of a specific prey species near to zero when the generalist turns its preference to this same prey (population density of prey 1 remains closer to zero for p < 0.5). Accordingly, for the same set of parameter values, the switching preference term can also lead a prey species closer to zero again if the generalist predator turns its preference to this same prey. However, this occurs for a larger range of p, (population density of prey 1 remains close to zero for p < 0.8).

Omnivory
The parameter values taken from the omnivory structure without preference are those which bring about chaotic solutions of a tritrophic food chain with functional response type II. By the same token as in the apparent competition setting, local maxima and minima were calculated for a range of preference p in non - switching model (NSW) and switching model (SW), respectively. The results are as follows:

The dynamics of the switching model becomes a two point cycle for 0 < p <0.02; for 0.02 < p <0.77, this cycle dynamics turn into a stable dynamics; it turns back into cycling dynamics for p > 0.77. On the other hand, in the non - switching model the chaotic dynamic can persist for relatively higher values of the selection term (p < 0.15). The stable dynamics range for NSW (0.35 < p < 0.65) is shorter than the stable dynamics range for the SW (0.02 < p < 0.77). The consumer species persistence is observed for all values of p in switching model, while for 0.6 < p

< 0.65, the consumer extinction occurs in non - switching model. Indeed, in the non - switching model the predator goes to extinction for p > 0.65, while the same happens in the switching model only for p > 0.97, increasing thus the range of coexistence in the omnivory food web.

Discussion

Some considerable effort has been expended in theoretical work to analyze issues such as palatability and enrichment, weak trophic interactions and food web stability (McCann et al., 998), trophic flow across habitats (Huxel and McCann, 1998), food web interactions and energetic flows (Teng and McCann, 2004). A common feature that appears in these works is predator's prey preference structure which, according to the cited references, can be modeled in the context of non - switching predators, (sensu Faria et al., 008) or in the context of switching predators (sensu Post et al., 000). In this work, apparent competition and omnivory system dynamics were shown to be strongly influenced by predator's prey preference structure.

A model of two non interacting prey with a shared predator (i.e., apparent competition) was analyzed under the effect of the two aforementioned structures of predator's prey preference. Within this context simulations evidenced a marked influence of the preference structure on the dynamics of these models. The preference structure 1 suggests that intermediate degrees of the preference parameter p can stabilize the consumer - resource dynamics (McCann, et al., 998; McCann 2000; Faria et al., 008), whereas the preference structure 2 generates instability for all degrees of the preference parameter p.

The main result concerning the influence of predator's prey preference on omnivory food web dynamics pointed to the fact that preference structure 2 stabilizes the omnivory model for a wider range of preference values p than its fixed (structure 1) preference counterpart. Moreover, unlike the non - switching preference (eq. 3), chaotic behavior does not occur for the switching preference structure (eq. 4). To sum it up, comparing with the non - switching structure dynamical results in McCann and Hastings (1997), the long - term analysis showed that switching structure is able to stabilize the omnivory food web for lower values of p by placing the population minima further away from the axes.

CONCLUSION

The results shown here point out the importance of preference modeling in the determination of long term food web dynamics. It is therefore suggested that dynamical analysis of systems where multiple prey are present-which is certainly the case of most natural food webs where an intricate mix of trophic interactions usually occurs - should consider alternative ways of preference modeling.

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