Adding complexity to a model with switching behaviour and intraguild predation: from two to three-prey functional responses

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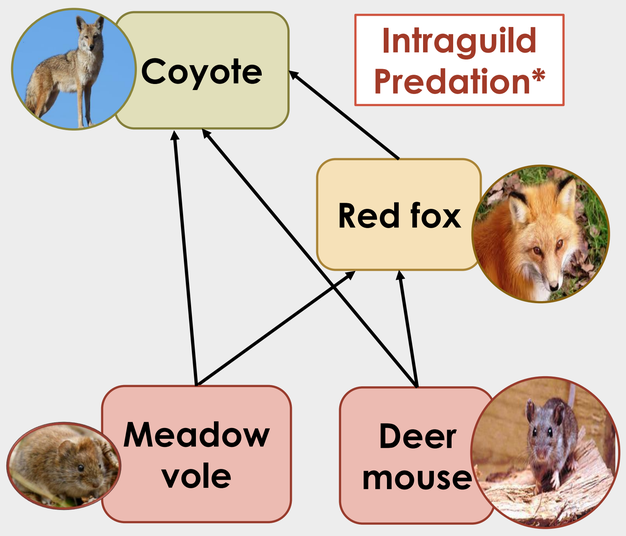
INTRODUCTION

Key words
Intraguild predation, generalist predators, switching behavior.

Switching: A species is disproportionately represented in the diet of a predator when the species is abundant relative to other prey, and disproportionately small when the species is relatively rare (see Murdoch, 1969).

This propriety has not been studied in case for preys > 2.



Flagel *et al*. 2017, *J. Mammal*

* : a predator and one of its preys share a same prey

MODEL

Adapted from Wei *et al.*, 2019, *Math Comput Simul*, for two generalist predators with intraguild predation and *n* preys :

Logistic growth — Predation of foxes on prey k — Predation of coyotes on prey k

$$\text{Prey k} \quad \dot{x_k}(t) = r_k x_k(t)\left(1-\frac{x_k(t)}{K_k}\right) - \phi_{\mathbf{F},\mathbf{k}}\mathbf{F(t)} - \phi_{\mathbf{C},\mathbf{k}}\mathbf{C(t)}$$

$$\text{Foxes} \quad \dot{F}(t) = r_F F(t)\left(1-\frac{F(t)}{K_F}\right) - \mathbf{I_{C,F}C(t)}$$

Intraguild predation of coyotes on foxes

$$\text{Coyotes} \quad \dot{C}(t) = r_C C(t)\left(1-\frac{C(t)}{K_C}\right)$$

Each functional response is of Beddington DeAngelis form.

Attack rates

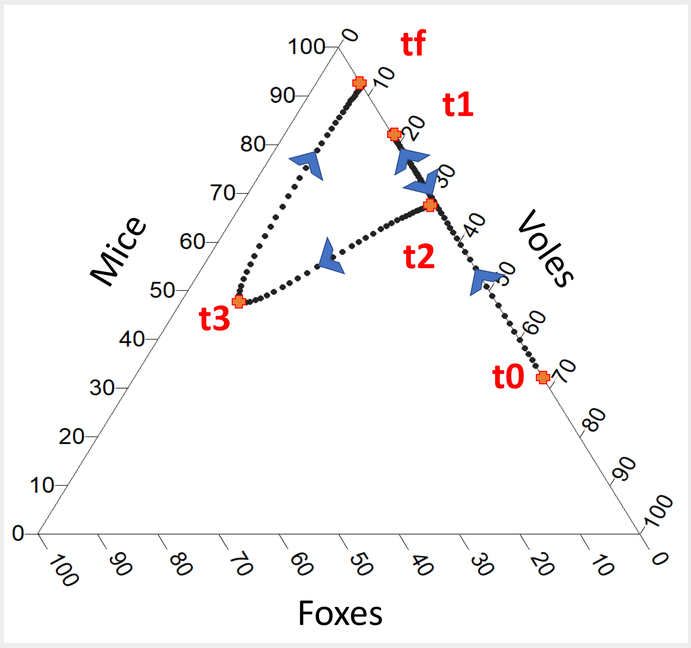
Holling III type

$$\mathbf{I_{C,F}} = \frac{\mathbf{p_3 F(t)^2}}{\mathbf{H_2} + \sum_{\mathbf{k=1}}^{\mathbf{n}} \alpha_{\mathbf{2,k}}\mathbf{p_{2,k}}\mathbf{x_k(t)^2} + \beta_{\mathbf{2}}\mathbf{p_3}\mathbf{F(t)^2} + \gamma\mathbf{C(t)}}$$

Half saturation constant — Handling times — Interference between coyotes

RESULT 1 - Four phases in the diet of coyotes

Figure 1: Proportion of each item in the diet of coyotes along time (%)



Parameters are set given realistic values. Attack rates on voles are twice bigger than on mice. Attack rate on foxes is low compare to others.

We divide the time series in four intervals, corresponding to different phases in the diet of coyotes.

- From t0 to t1: Positive switching pattern with two prey: mice and voles (see figure 2)

  At t1: Local maximum representation of mice in the diet

- From t1 to t2: Same pattern as in [t0-t1], opposite direction.

  At t2: Foxes enter significantly in the diet

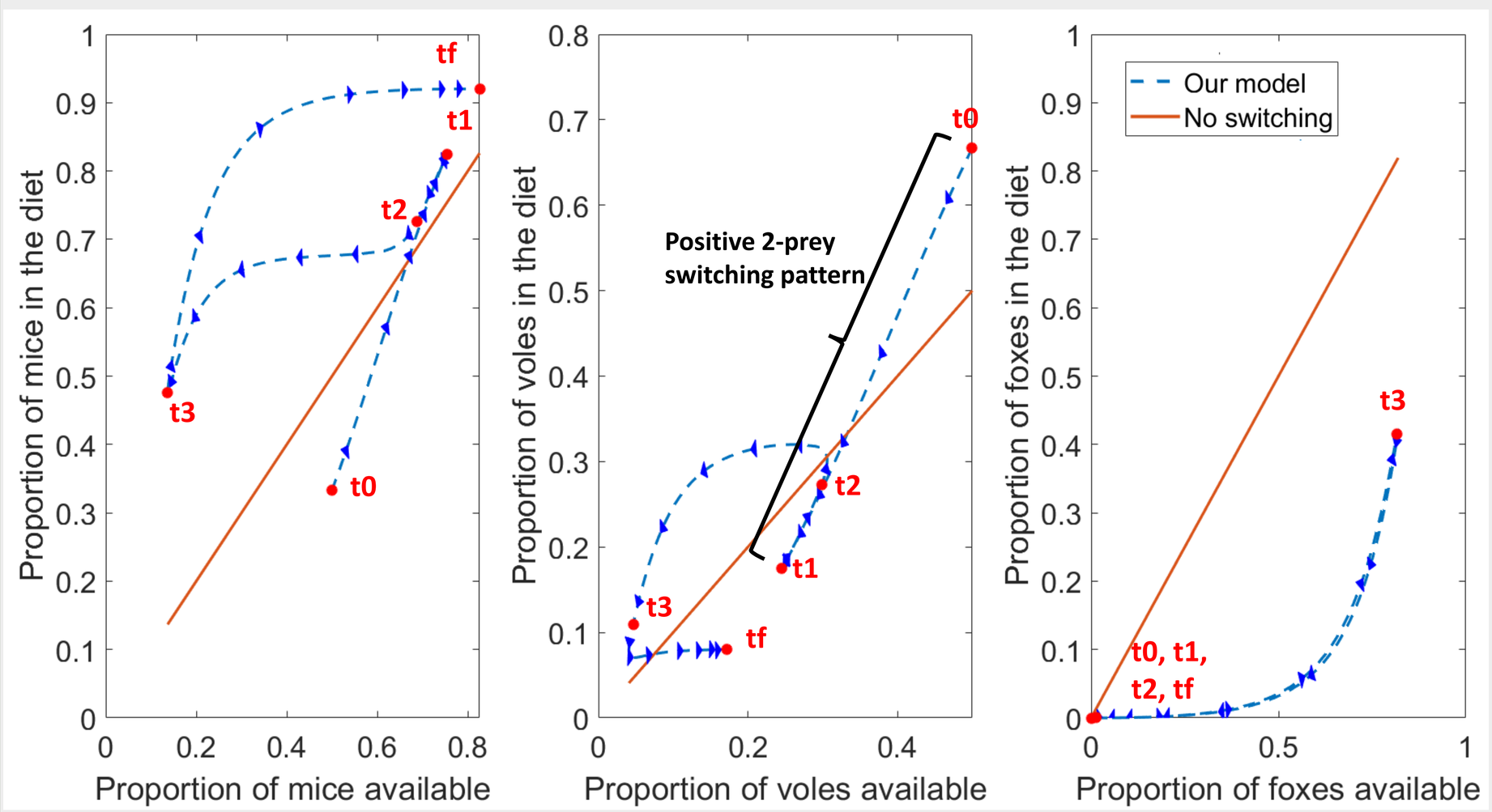
- **From t2 to t3: 3-prey transition.**

  At t3: Maximal representation of foxes in the diet

- From t3 to tf: 2-prey like system between foxes and "rodents".

RESULT 2 - Focus on the 3-prey transition phase

Figure 2: We represent the proportion of each prey in the total feeding (sum of the functional responses of all prey) (Y-axes) relative to its proportion in the total available food (sum of the densities of all prey) (X-axes) along time.



From t2 to t3: 3-prey transition

No classical switching pattern is observed during this phase, as 3 prey are present.

Explanation:

Mice and voles become more and more rare.

⇒ Foxes are now more and more interesting to eat until they reach a maximum at t3, even if they are not the preferred prey.

⇒ This predation on foxes release pressure on rodents, that can increase again from t3 to the end.

Intraguild predation is a transitional phenomenon that occurs when other alternative prey become relatively scarce.