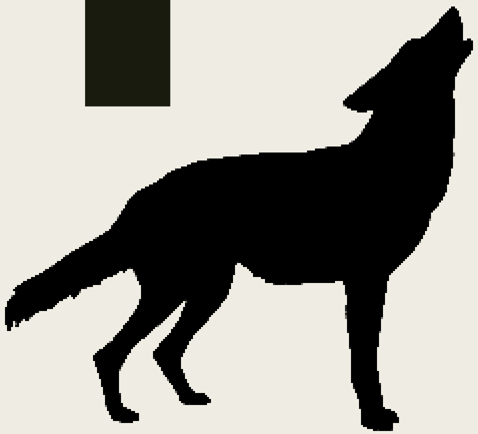
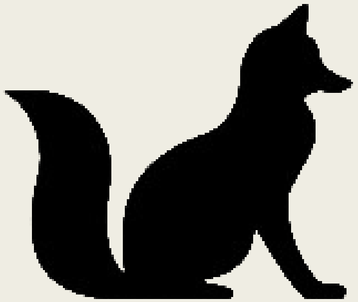
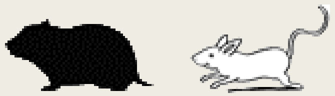
THREE-PREY SWITCHING BEHAVIOR OF TWO GENERALIST PREDATORS WITH ASYMMETRIC INTRAGUILD PREDATION: A COYOTE-FOX-TWO RODENTS SYSTEM

RDI BMB – 16 mai 2023 – Besançon

Ségolène Lireux







An interaction Ecology - Mathematics

- Ecology
- Mathematics

Pr. Francis Raoul

Dr. Michael Coeurdassier

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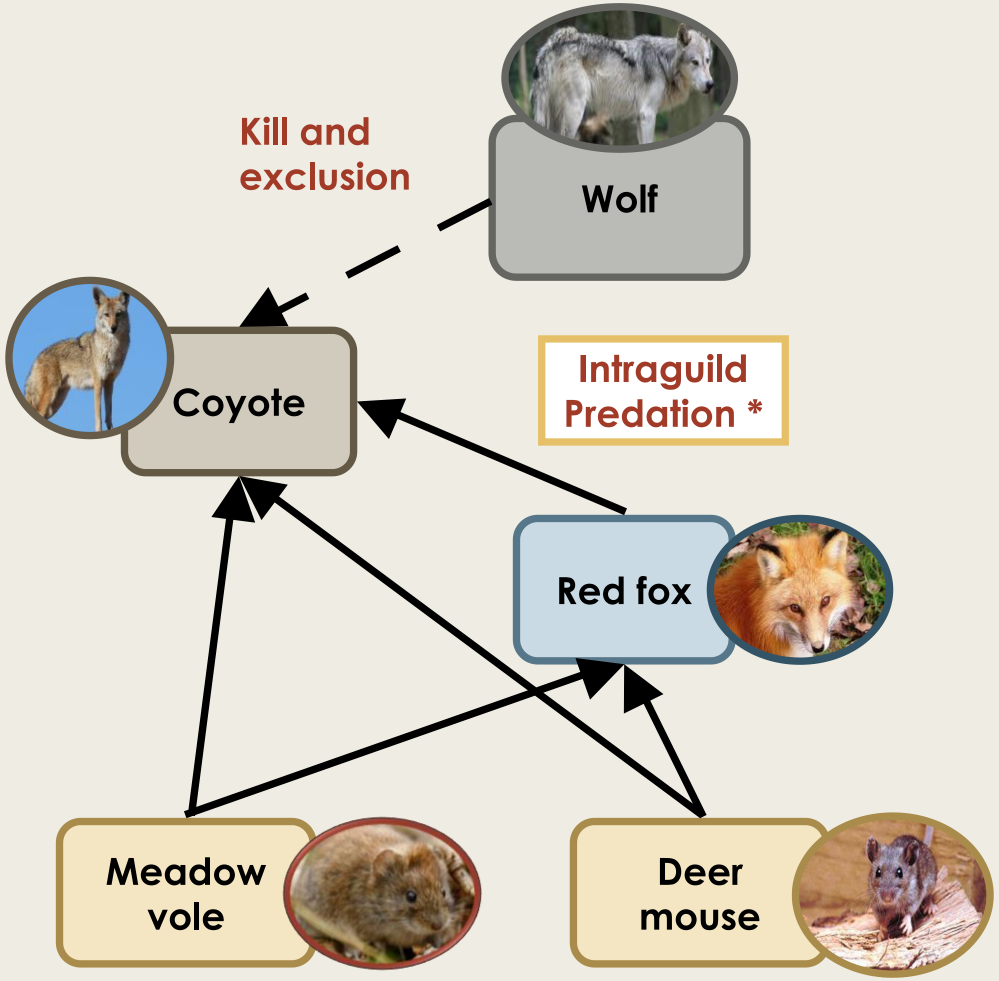
Antoine Perasso

Pr. Ezio Venturino
University of Turin

CONTEXT



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

Modelling specificities

- Multi-prey model
- Multi predators model with several emergent effects:
  - Competition
  - Exclusion
  - Intraguild predation

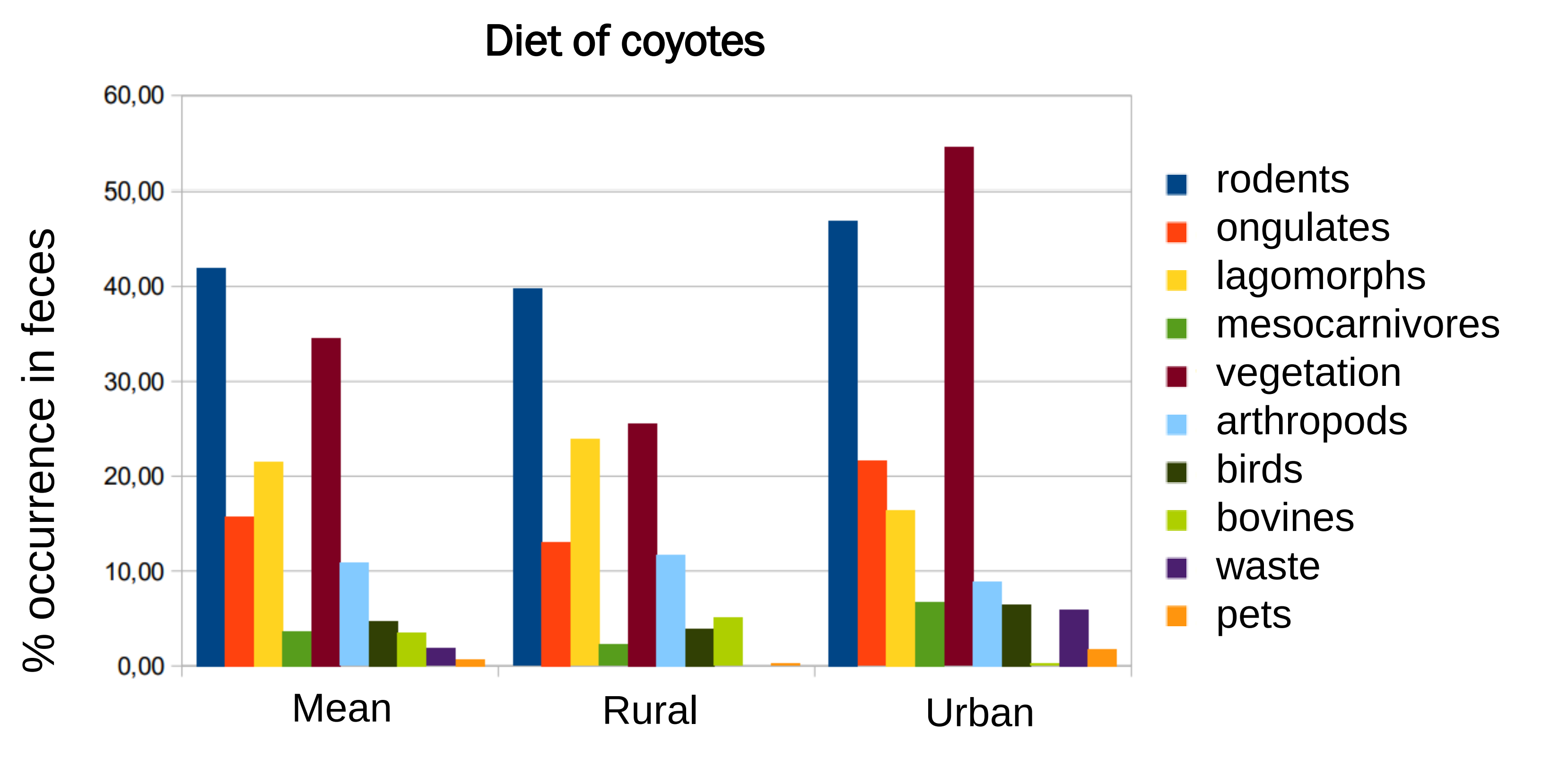
  ⇒ Total predation decreased
- Generalist predators

Data from Romig *et al.* 2017, Flagel *et al.* 2017

CONTEXT

- Rural vs. Urban contexts

Foxes and coyotes densities higher in cities (Fedriani *et al.* 2020, Banfield *et al.* 1977, Rosatte *et al.* 1991)



Yaël Henriet, data from litterature review

- Outbreaks of voles in rural areas:
  Densities from 5 to 427 ind/ha (Witmer *et al.*, 2010)

- Top-down control can be exercised on coyotes:
  - presence of wolves (Flagel *et al.* 2017)
  - shooting (Chamberlain *et al.* 2001)

An interaction Ecology - Mathematics

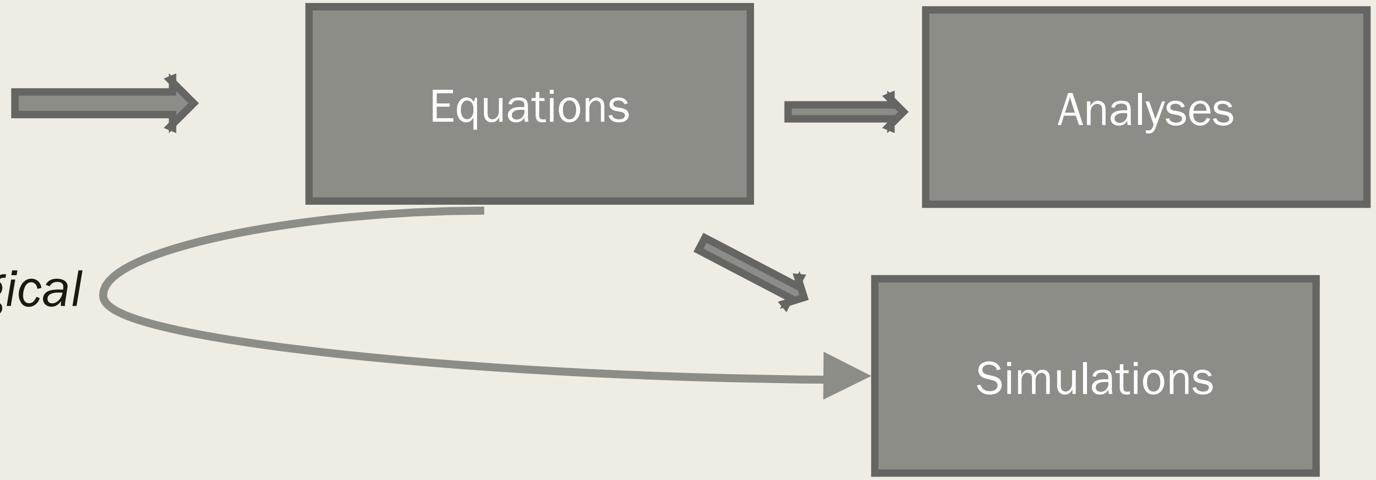
- Ecology

Ecological question

Dimensional biological parameters

Realist models

- Mathematics



An interaction Ecology - Mathematics

- Ecology

  Ecological question

  Dimensional parameters

  Realist models

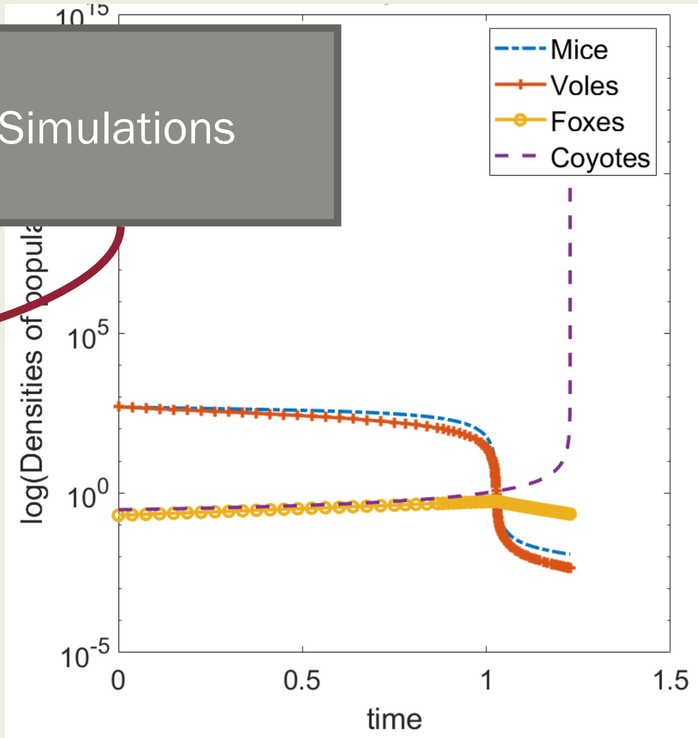
- Mathematics

Equations

Analyses

Simulations

Relevant simulations



An interaction Ecology - Mathematics

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Dimensional parameters

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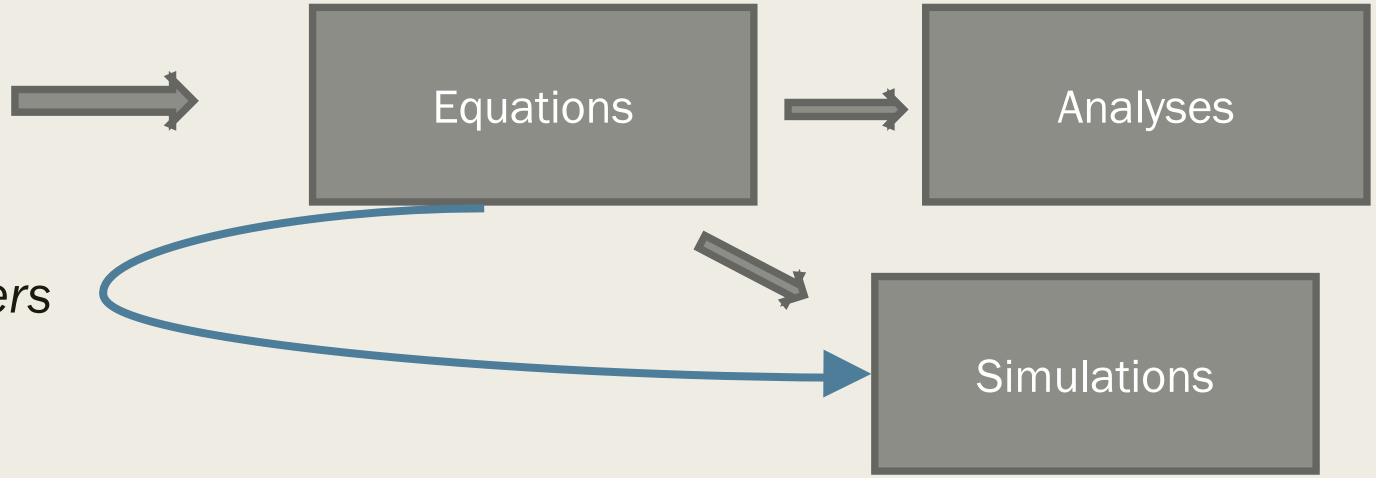
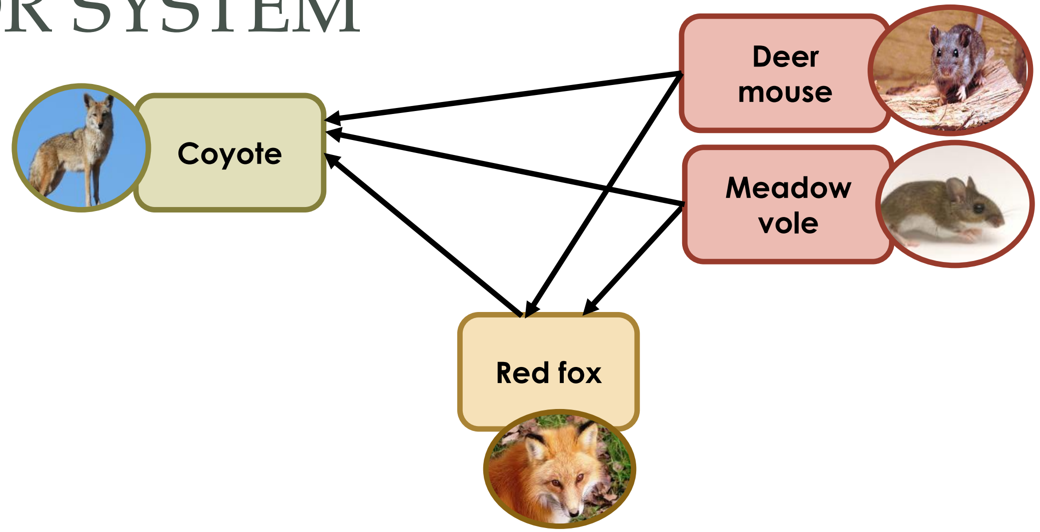


Relevant simulations

CONSTRUCTION OF PREY/PREDATOR SYSTEM



- Adapted from Wei *et al.*, 2019, *Math Comput Simul,* finalized thanks to discussion with Alessandro Massolo (ecologist, parasitologist, University of Pisa)
- 2 generalist predators with intraguild predation, *2* preys, Holling equations

Mice
$$\frac{dX_1}{dt} = r_1 X_1(t)\left(1 - \frac{X_1(t)}{K_1}\right)$$

Voles
$$\frac{dX_2}{dt} = r_2 X_2(t)\left(1 - \frac{X_2(t)}{K_2}\right)$$

Logistic growth

Foxes
$$\frac{dF}{dt} = r_F F(t)\left(1 - \frac{F(t)}{K_F}\right)$$

Coyotes
$$\frac{dC}{dt} = r_C C(t)\left(1 - \frac{C(t)}{K_C}\right)$$

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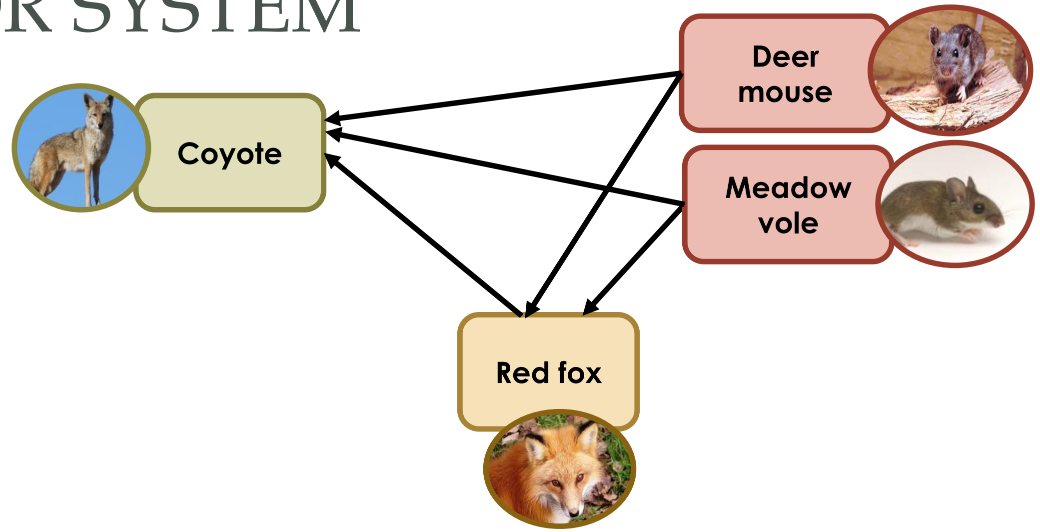

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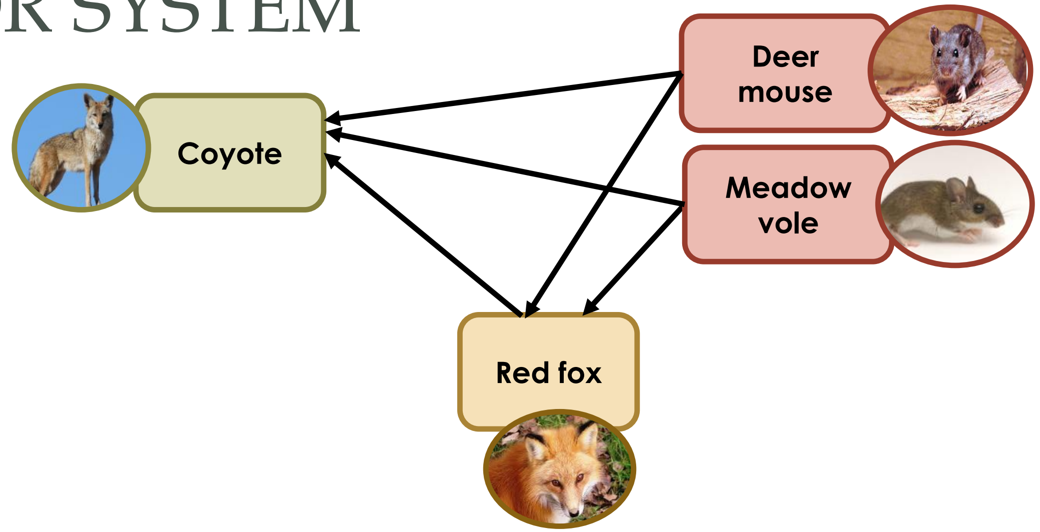
Predation of foxes on prey 1

CONSTRUCTION OF PREY/PREDATOR SYSTEM



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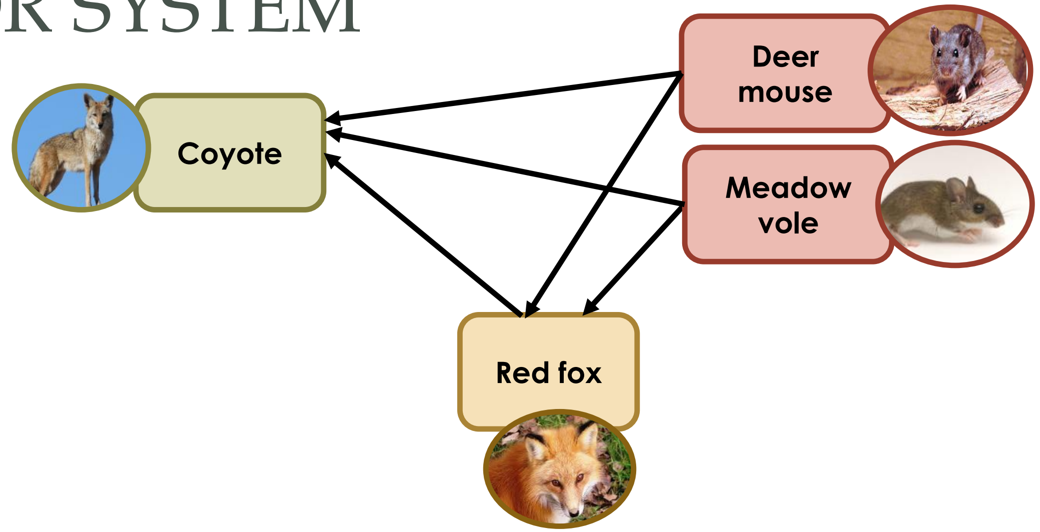
Voles $$\frac{dX_2}{dt} = r_2 X_2(t)\left(1 - \frac{X_2(t)}{K_2}\right) - \phi_{\mathbf{F},\mathbf{2}} F(t)$$

Predation of foxes on prey 2

Foxes $$\frac{dF}{dt} = r_F F(t)\left(1 - \frac{F(t)}{K_F}\right)$$

Coyotes $$\frac{dC}{dt} = r_C C(t)\left(1 - \frac{C(t)}{K_C}\right)$$

CONSTRUCTION OF PREY/PREDATOR SYSTEM



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Predation of coyotes on prey 1

Foxes $$\frac{dF}{dt} = r_F F(t)\left(1 - \frac{F(t)}{K_F}\right)$$

Coyotes $$\frac{dC}{dt} = r_C C(t)\left(1 - \frac{C(t)}{K_C}\right)$$

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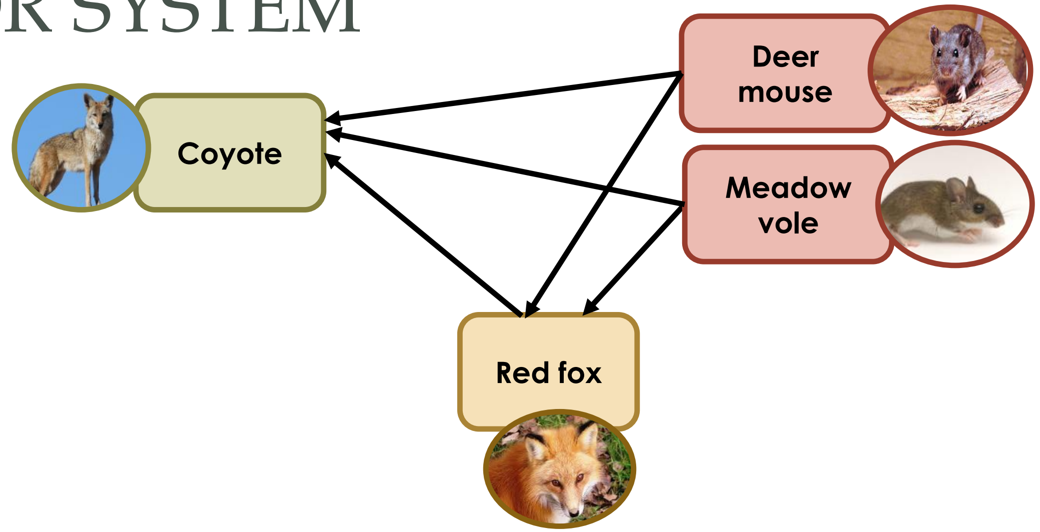

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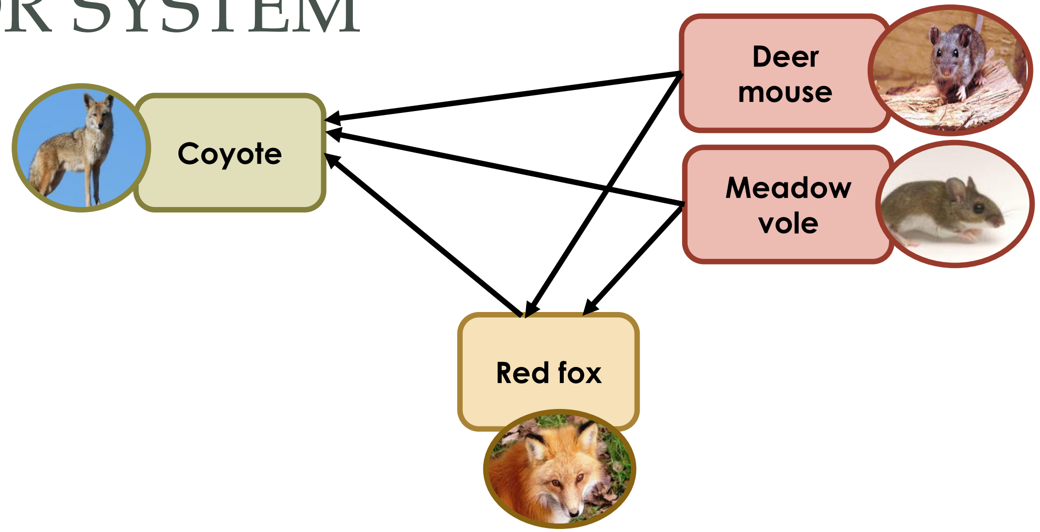

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Foxes

$$\frac{dF}{dt} = r_F F(t)\left(1 - \frac{F(t)}{K_F}\right) - \phi_{\mathbf{C},\mathbf{F}} C(t)$$

Intraguild predation

Coyotes

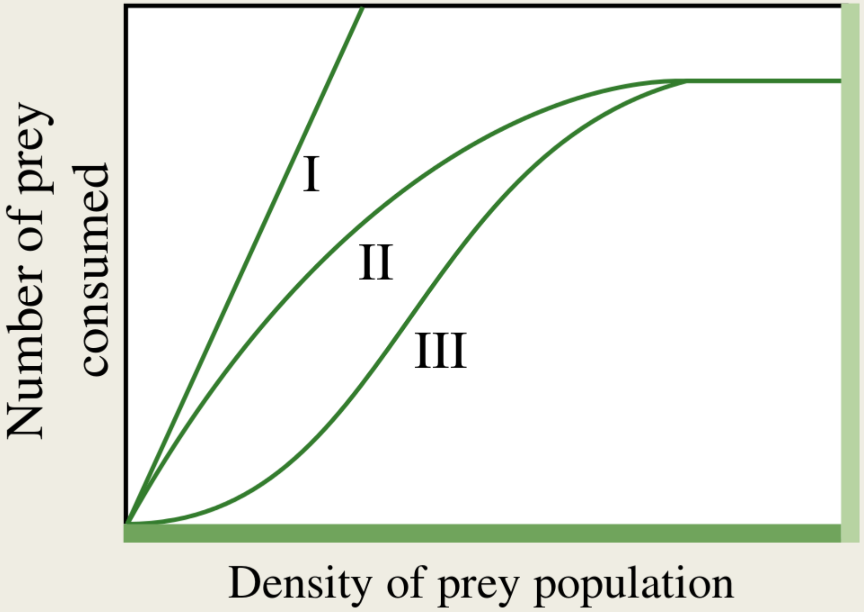
$$\frac{dC}{dt} = r_C C(t)\left(1 - \frac{C(t)}{K_C}\right)$$

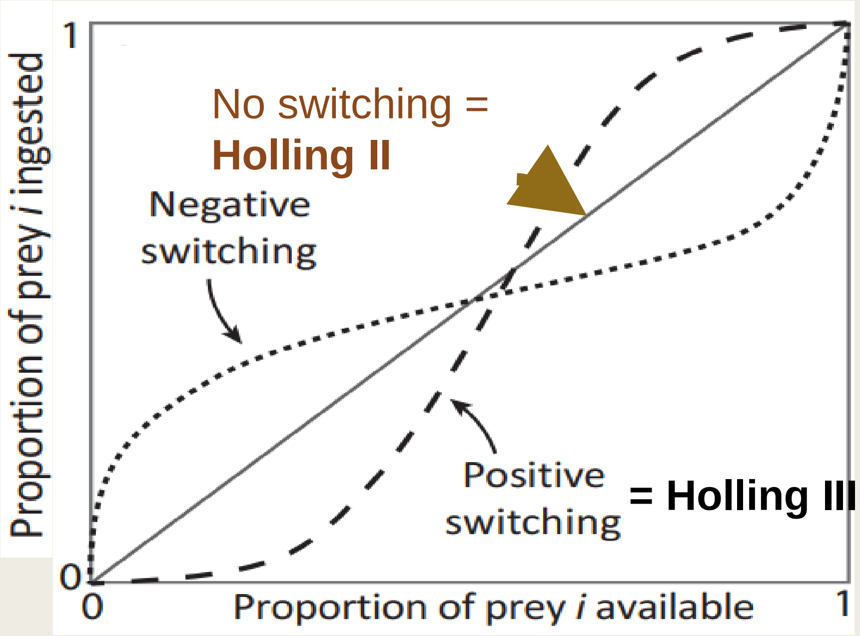
CONSTRUCTION OF PREY/PREDATOR SYSTEM

- Holling type III

$$\phi_{\mathbf{F},\mathbf{1}} = \frac{p_1 X_1(t)^2}{1 + hp_1 X_1(t)^2 + hp_2 X_2(t)^2}$$

Attack rates Handling times





Switching

⇒ Known to stabilize coexistence of species

⇒ Observed for foxes and coyotes

Baudrot *et al*. 2016, *Ecology*

CALCULATION OF PARAMETERS

- **Carrying capacity:** maximal density observed, different according to context
- **Intrinsic growth rate**

$$r = b - m$$

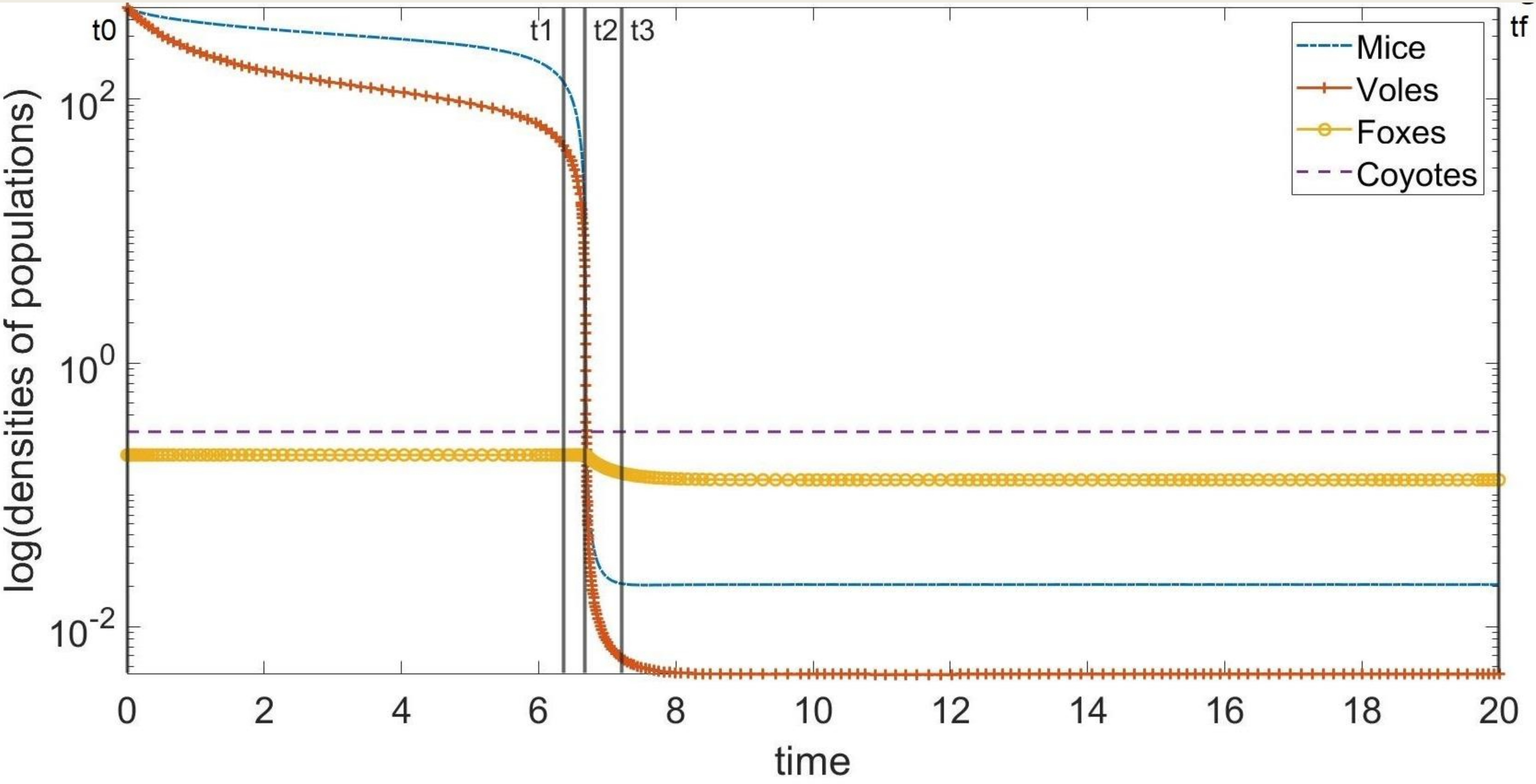
Intrinsic birth rate (b)

Intrinsic mortality rate (m)

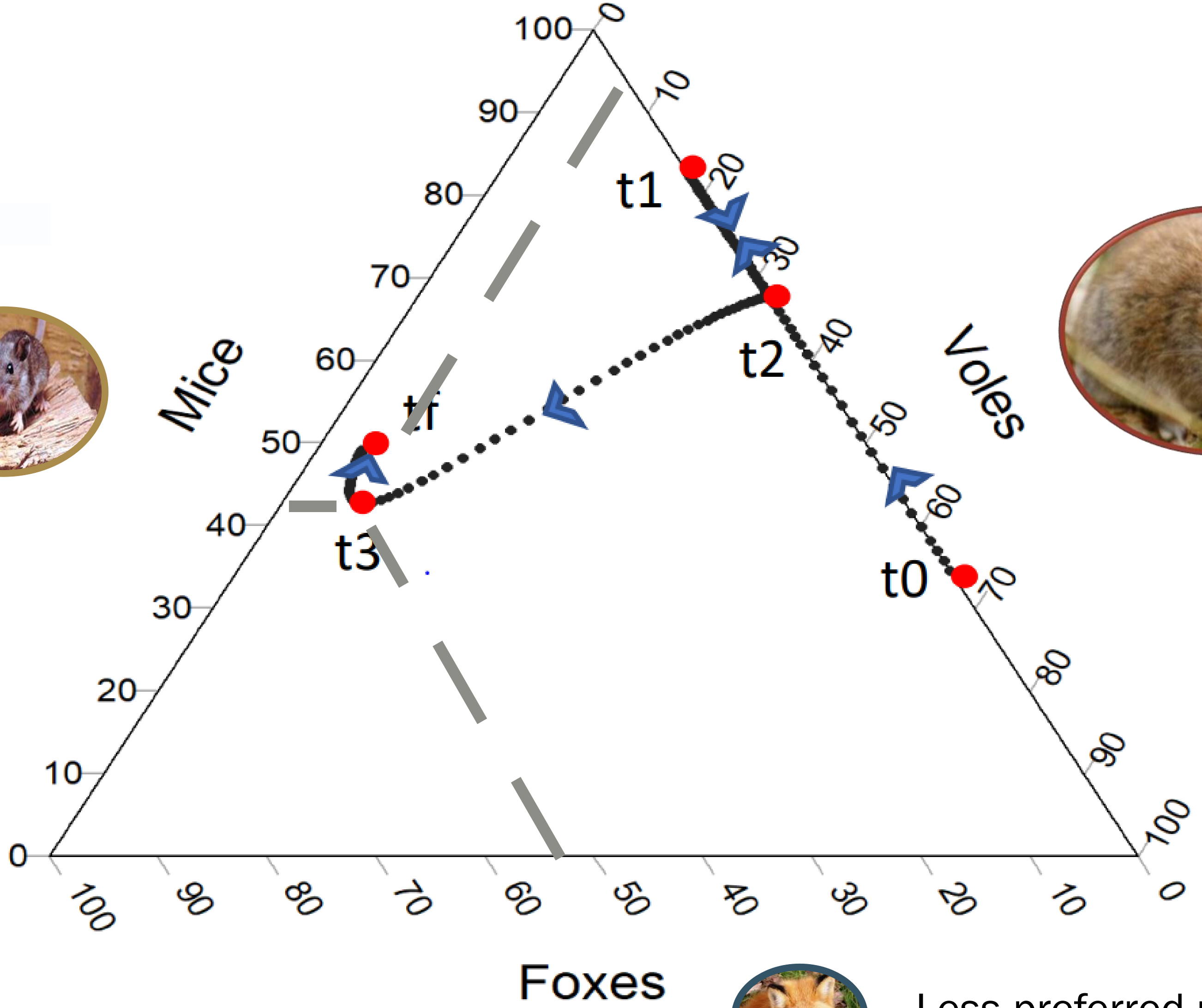
- Energetic needs calculated thanks to Field Metabolic Rate (Laundré et al. 2003) AND Energy given by a single prey
- Rodents represents ca. 50% of the diet of both predators in all context.
- Voles are a preferred prey because they are bigger: **$p_2 = 2p_1$**

=> Calculation of attack rates.

Dynamics in the rural context, no outbreak



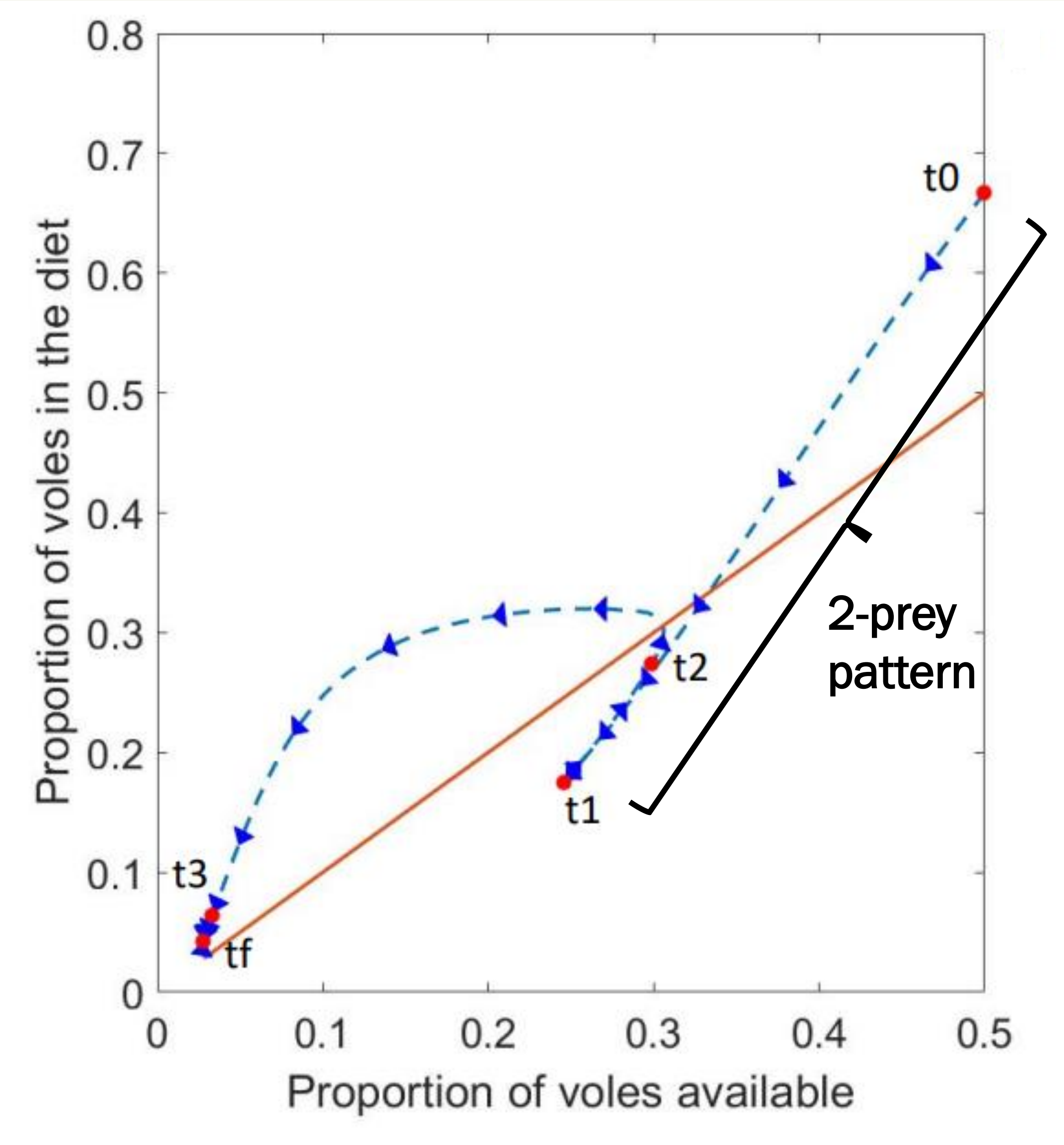
% Presence in the Diet of Coyotes (#)



Preferred prey

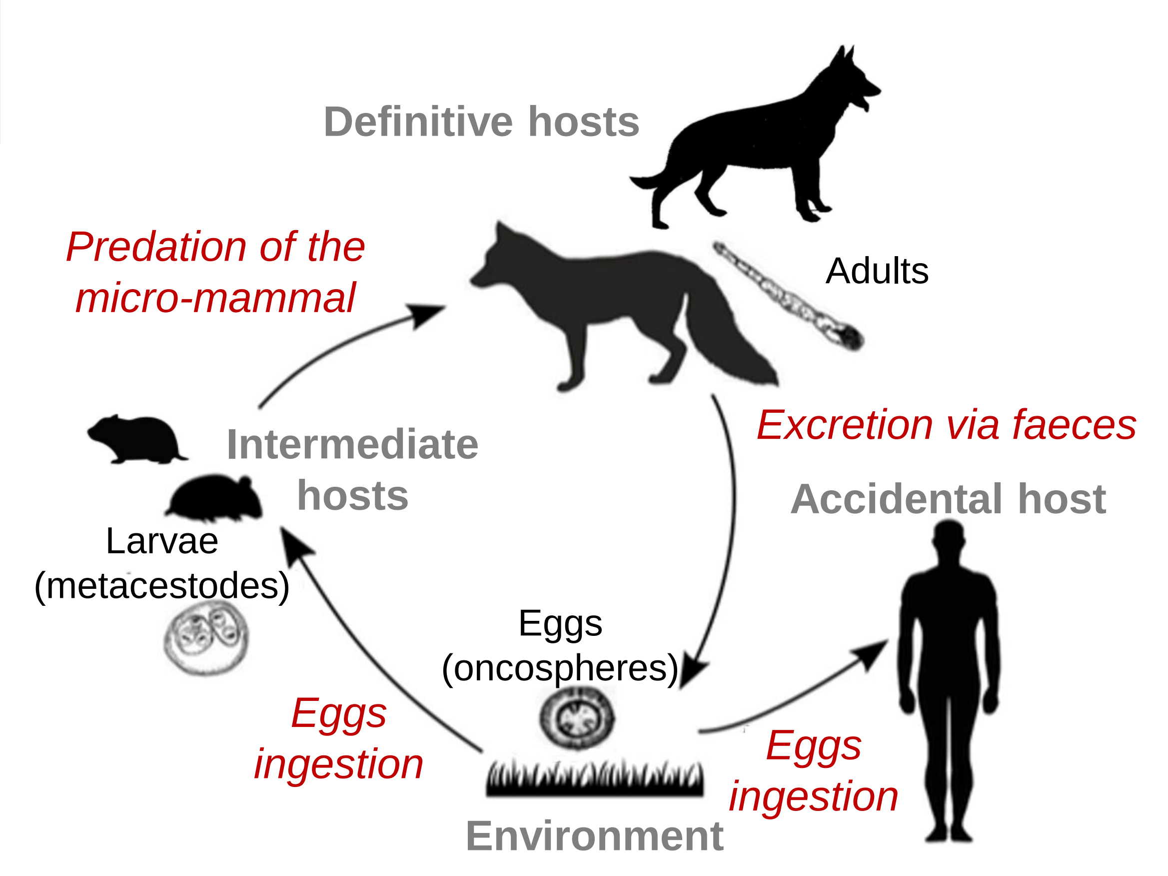
Less-preferred prey

3-prey switching



Last part of my PhD

Echinococcus multilocularis
Class : *Cestoda*
Family : *Taeniidae*



Life cycle of *Echinococcus multilocularis,*
Adapted from Baudrot *et al*. 2016

Goals

- To build an eco-epidemic model
- Calculation of R_0