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The evolution of ant–plant coexistence and castration

András Szilágyi, István Scheuring
Eötvös University, Budapest, Hungary

David P. Edwards, Jerome Orivel
University of East Anglia, Norwich

Jerome Orivel
UMR-CNRS Univ. Toulouse, France

Douglas W. Yu
ECEC, Kunming Institute of Biology, Yunnan, China

Motivation:
The *Cordia-Allomerus-Azteca* system

- Ant-plant symbioses are one of the most tractable model for the study of mutualism and **parasitism**

- We have got field data to make and parameterize a simple model

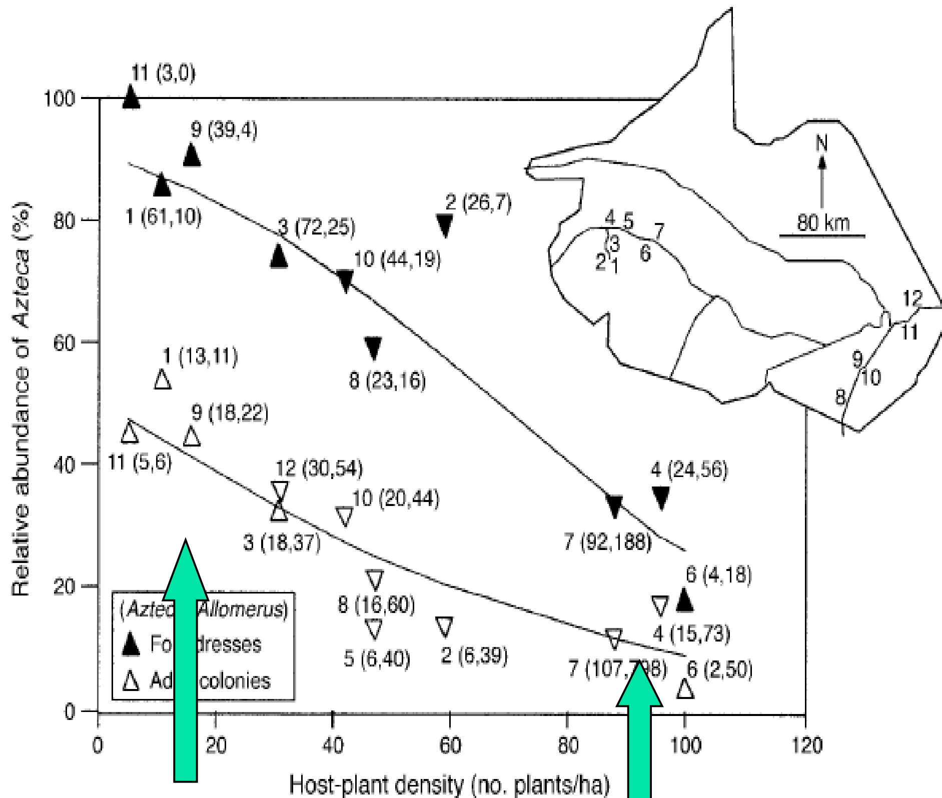
Motivation: The *Cordia-Allomerus-Azteca* system

- *Cordia nodosa*: domatia and food for the ants
- *Azteca* species: pure mutualists
- *Allomerus cf. Demerarae* protects host, but castrates the plant

Motivation:
The *Cordia-Allomerus-Azteca* system

- Relative abundance of the ant species depends on the host-plant density
- Polymorphism in the intensity of castration

Yu et al. *Ecology*, **82** 1761-1771, 2001



High level of castration

Low level of castration

The problem – *The tragedy of the commons*

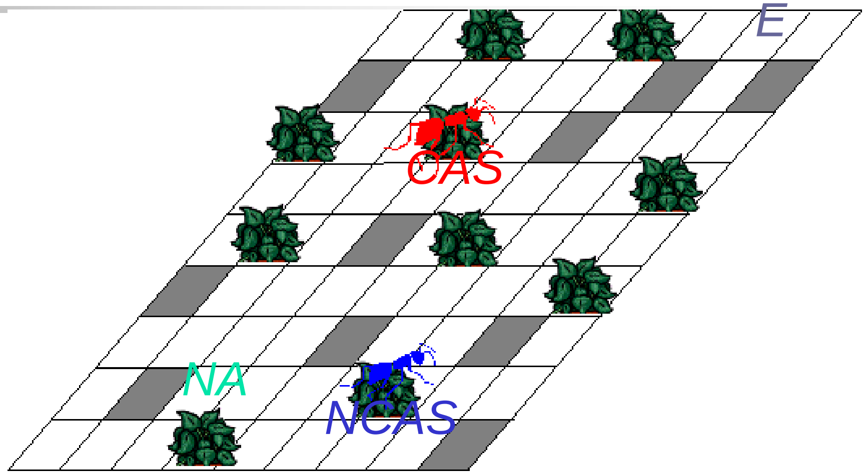
- What mechanisms generate the equilibrium level of castration in the *Allomerus-Cordia* system?

  The problem is similar to the *tragedy of commons*
  - The higher castration level gives advantage the owner
  - There are no effects reducing level of castration
  - Castration level is increasing and the system collapses

Mean-field computation leads to similar results

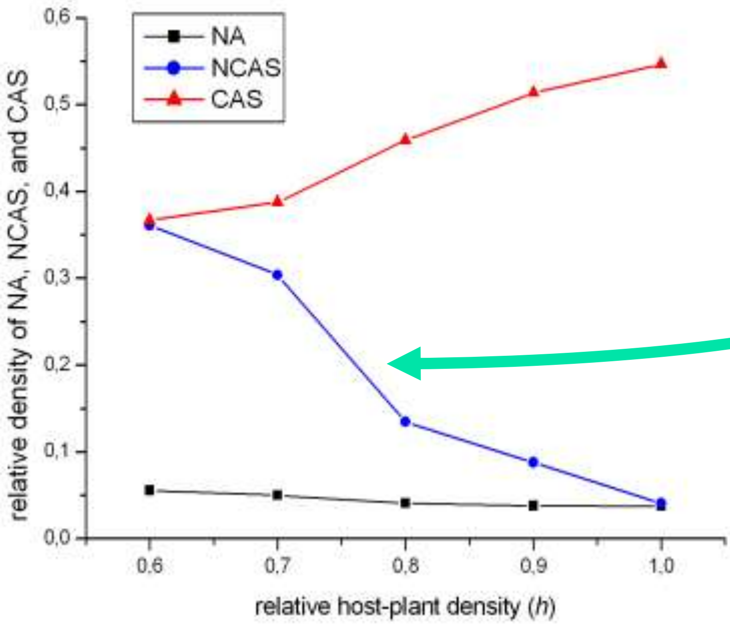
To escape from the tragedy of the commons, we need to take *spatial relations* and *trade-offs* into consideration.

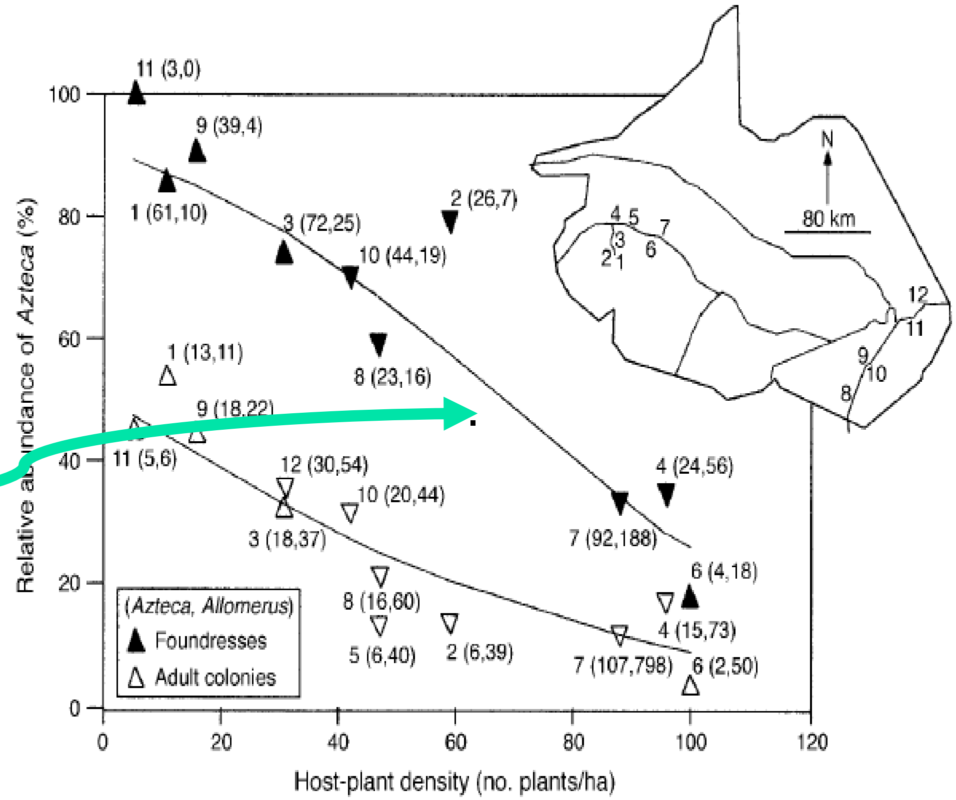
The model



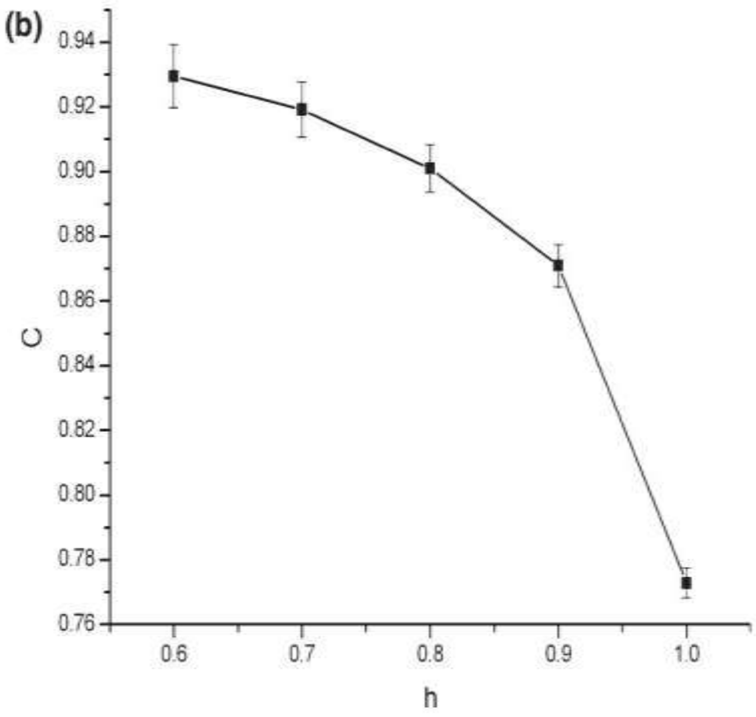
- The system occurs on an 500*500 grid, *h* fraction is suitable for plants ($0<h<1$)
- Four different states of a gridpoint
  - *E* – suitable and empty
  - *NA* – plants not yet inhabited (No Ant)
  - *CAS* – plant inhabited by castrating *Allomerus*
  - *NCAS* – plant inhabited by non-castrating *Azteca*
- Dispersal-fecundity trade-off
- Grid model with 12 parameters (suggested by field data)
- Dispersal distance and castration level evolve

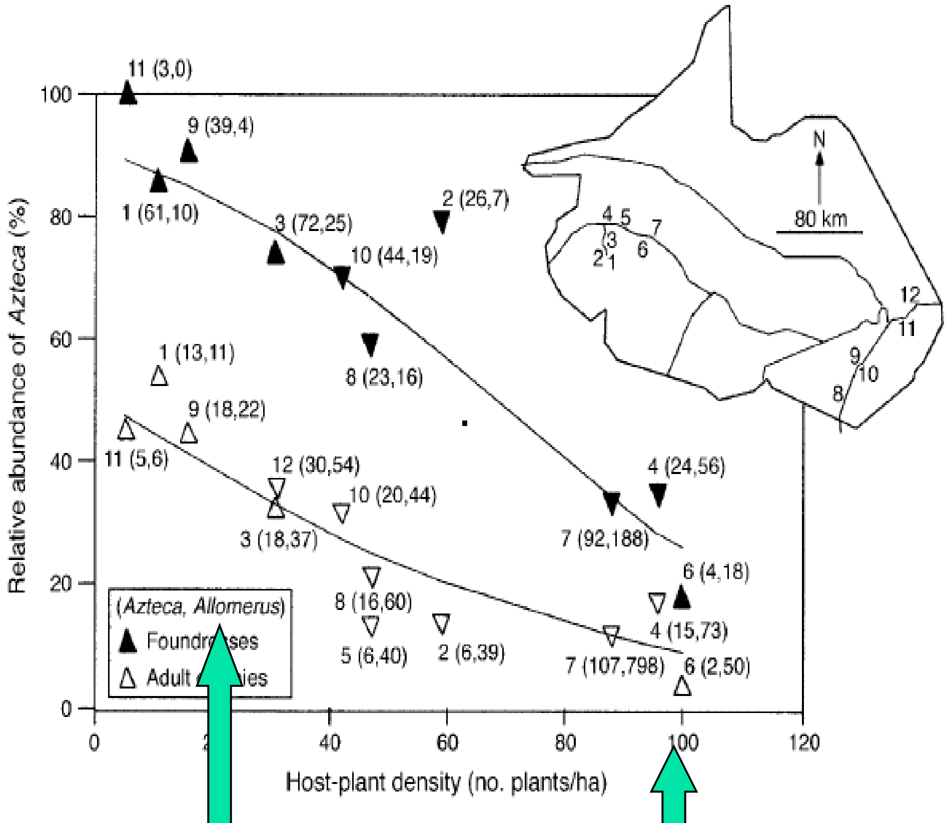
Results – densities





Results – castration level

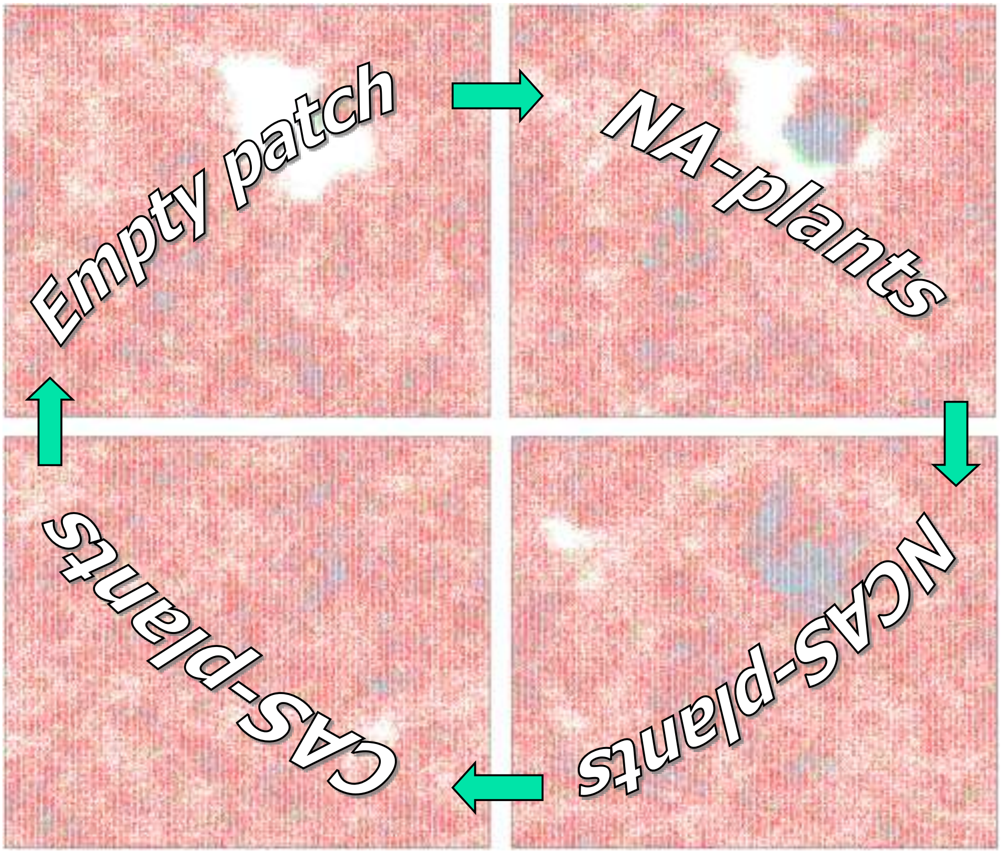




High level of castration

Low level of castration

Cyclic competition hierarchy



- Cyclic competition hierarchy occurs
- We can explain the stable coexistence via a four-step Rock-Paper-Match-Scissors game

Conclusions

- We can avoid the tragedy of commons with spatially explicit modeling
- System reaches an intermediate level of castration
- With dispersal-fecundity trade-off and dispersal limitation the stable coexistence between NA-CAS-NCAS is possible
- We can explain the stable coexistence via a four-step Rock-Paper-Scissors game
- The evolution of castration level depends on the mutualistic species *Azteca* to a great extent
- These results are qualitatively consistent with the observed features in the *C. nodosa* system

Thank you
for your attention!