Two-species interactions

Types	Response of Sp A	Response of Sp B
Competition	-	-
Predation	+	-
Parasitism	+	-
Parasitoidism	+	-
Herbivory	+	-
Neutral		
Mutualism		
Commensalism		
Amensalism		

Two-species interactions

Types	Response of Sp A	Response of Sp B
Competition	-	-
Predation	+	-
Parasitism	+	-
Parasitoidism	+	-
Herbivory	+	-
Neutral	0	0
Mutualism	+	+
Commensalism	+	0
Amensalism	-	0

Species competition

Ch.13 Molles 3rd ed, 2005

Ch.6 Townsend, Harper, Begon 2nd ed, 2003

Competition– key condition?

- Share common resource
- Limit of resource

Modes of Competition

- Competing methods:
  - Interference: Direct aggressive interaction between individuals.
  - Exploitation (resource cmp): Rate of utilizing resource
- Competing subjects:
  - Intraspecific: Competition with members of their own species.
  - Interspecific: Competition between individuals of two species

Outlines

1. Resource limitation.
2. Niche
3. Mathematical and laboratory models
4. Ecolg. and evolut. influences on niches.
    1. Coexistance
    2. Assemble rule

Chapter Concepts

I. Studies of Intraspecific competition provide evidence for resource limitation.

- A key role in slowing pop growth at high density
  - Sigmoidal growth pattern
- Ex. Plant growth rate, Planthoppers growth

Resource Competition

- Intraspecific Competition - Herbaceous Plants
  - Plant growth rates and weights have been found to increase in low density populations.
  - Competition for resources is more intense at higher population densities.
    - leads to mortality among competing plants.
    - **Self-thinning**

Intraspecific Competition Among Planthoppers

- *Denno and Roderick,* demonstrated intraspecific competition within populations of planthopper, *Prokelesisia marginata (*Homoptera)
  - Probably result of limited resources.
  - → body length, develp time, survivorship

Chapter Concepts

II. A **niche** reflects the environmental requirements of a species.

- History of niche concepts:
  - Grinnell 1917, 24- Physical environment
  - Elton 1927-- Biological interactions
- Niche: summarizes environmental factors that influence growth, survival, and reproduction of a species. (current view)

Niches

- *Hutchinson:*
- defined niche as "*a n-dimensional hyper-volume*"
  - n equates the number of environmental factors important to survival and reproduction of a species.
- Fundamental niche –no species interactions
- Realized niche: includes interactions such as competition that may restrict environments where a species may live.

Ex. Feeding Niches of Galapagos Finches

- *Grant* found differences in beak size among ground finches translates directly into diet.
- Size (& hardness) of seeds eaten can measured by estimating by measuring beak depths.
- Effect of 1977 drought?

Ex. Feeding Niches of Galapagos Finches

- *Grant* found differences in beak size among ground finches translates directly into diet.
  - Size of seeds eaten can measured by estimating by measuring beak depths.
    - Individuals with deepest beaks fed on hardest seeds.
  - After 1977 drought, remaining seeds were very hard.
  - thus mortality was most heavy in birds with smaller beaks.
  - → pop was dominated by larger birds at the end of the drought.

Chapter Concepts

III. Mathematical and laboratory models provide theoretical foundation for studying competitive interactions in nature.

- *Metz* summarized characters of models:
  - Abstractions and simplifications of nature.
  - Man-made construct; partly empirical and partly deductive.
  - Used to provide insights into natural phenomena.

Mathematic model--Lotka-Volterra Model

- Vito Volterra 1926, for explaining changes in the composition of a marine fish community in response to reduced fishing during WW I.
- Alfred Lotka 1932 independetly repeated Volterra's analysis and extended it to pop density change during competition.

Mathematic model-- Lotka-Volterra Model for 1 species

$$\frac{dN}{dt} = r_m N\left(\frac{K-N}{K}\right)$$

Logistic model for population growth,
r: the per capita rate of increase
r_m: intrinsic rates of increase

L-V Model for two sp

$$\frac{dN_1}{dt} = r_{m1} N_1 \left(\frac{K_1 - N_1 - \alpha N_2}{K_1} \right)$$

$$\frac{dN_2}{dt} = r_{m2} N_2 \left(\frac{K_2 - N_2 - \beta N_1}{K_2} \right)$$

α β: effect between individual of each species.

Mathematical Model -- Lotka Volterra

- Effect of interspecific competition on pop. growth of each species:
- $dN_1 / dt = r_{m1}N_1 ((K_1-N_1- \alpha_{12}N_2) / K_1)$
  $dN_2 / dt = r_{m2}N_2 ((K_2-N_2- \alpha_{21}N_1) / K_2)$

  - $\alpha_{12:}$ effect of individual of species 2 on rate of pop. growth of species 1.
  - $\alpha_{21:}$ effect of individual of species 1 on rate of pop. growth of species 2.

Lotka-Volterra Model

- Predict pop growth for the two species will stop when:
- For sp 1: $N_1 = k_1 - \alpha_{12} N_2$

  $(k_1, \ k_1/\alpha_{12})$
- For sp 2: $N_2 = k_2 - \alpha_{21} N_1$

  $(k_2/\alpha_{21} , k_2)$

  or $(k_2/\beta , k_2)$

- **Zero Growth Isoclines**
  - Above: pop. Increasing
  - Below: pop. Decreasing

When two species coexist,

- $k_1/\alpha_{12} > k_2 \rightarrow K_1 > k_2\alpha_{12}$
- $k_2/\alpha_{21} > K_1 \rightarrow K_2 > K_1\ \alpha_{21}$

$\rightarrow 1 > \alpha_{12} * \alpha_{21}$

Lotka-Volterra Model

- In general, LV predicts coexistence of two species when interspecific competition is weaker than intraspecific competition.

Evidence for interspecific competition

- In the laboratory
  - Ex. Paramecium
  - Ex. Flour Beetle

Paramecia Lab Experiments

- Gause, *Paramecium caudatum*, *P. aurelia*
- in two different concentrations of *Bacillus pyocyaneus*.

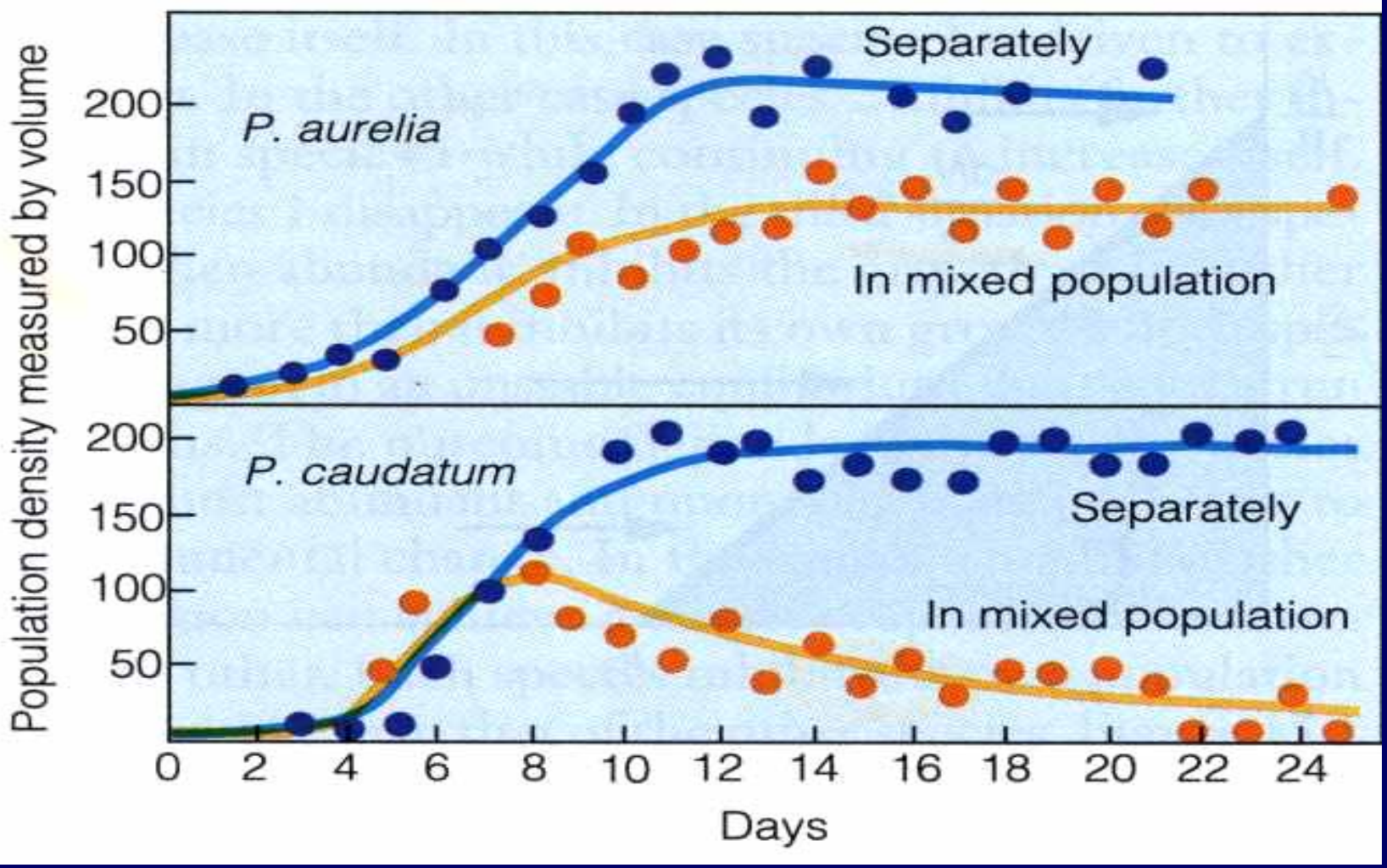


Figure 15.2 Competition experiments with two ciliated protozoans, *Paramecium aurelia* and *P. caudatum*, grown separately and in a mixed culture. In a mixed culture *P. aurelia* outcompetes *P. caudatum*, and the result is competitive exclusion.

- When grown alone, carrying capacity determined by intraspecific competition.
- When grown together, *P caudatum* quickly declined.

- Reduced resource supplies increased competition.

Competitive exclusion principle = Gause's Principle

- An Russian ecologist, GF Gause
- Two species with identical niches cannot coexist indefinitely. One will be a better competitor and thus have higher fitness and eventually exclude the other.

Evidence for interspecific competition

- In the laboratory
  - Ex. Paramecium
  - Ex. Flour Beetle

Chapter Concepts

IV. Competition can have significant ecological and evolutionary influences on the niches of species.

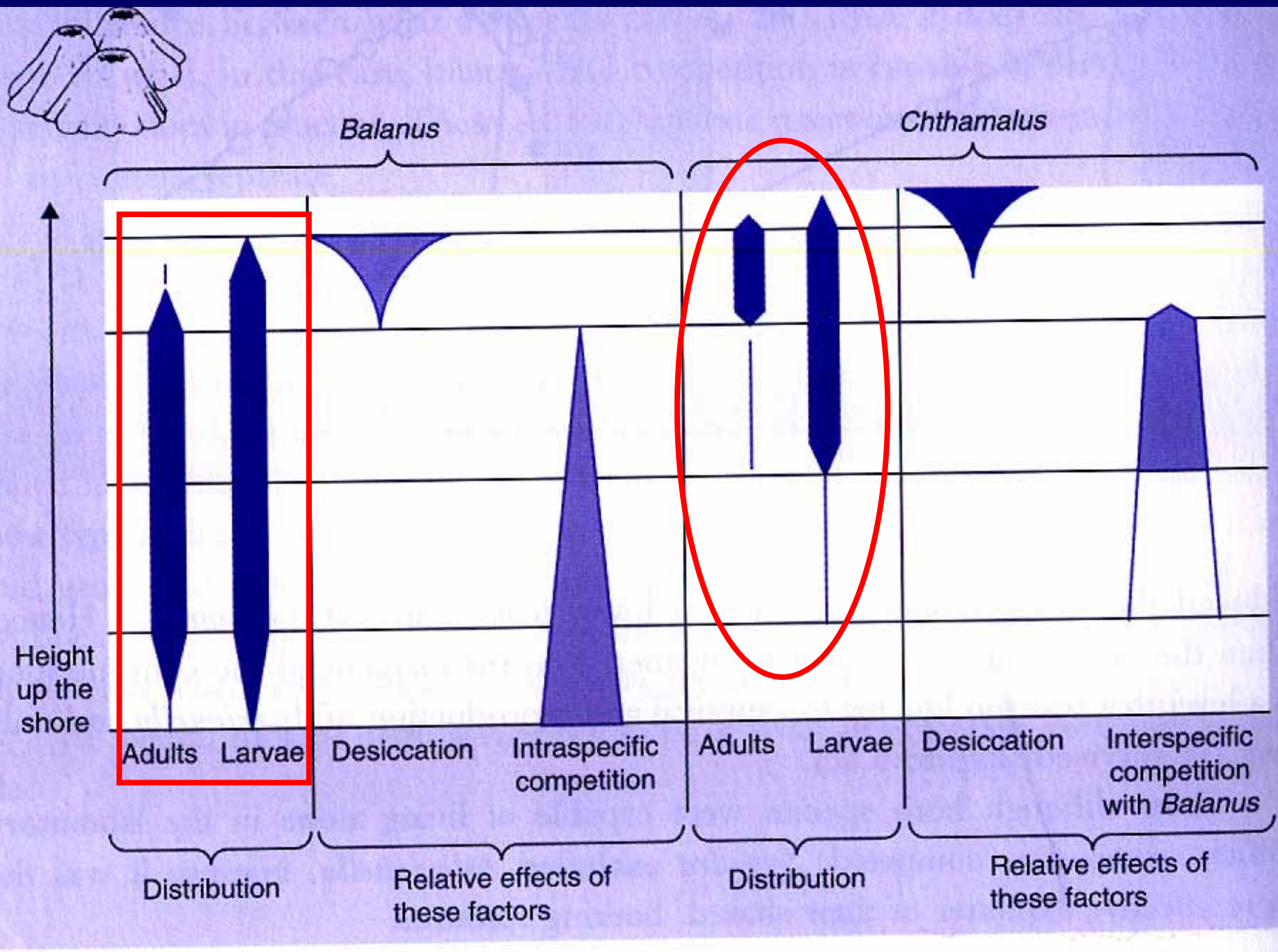
- Evidence in the field
  - Ex. Barnacle
  - Ex. Small rodents
  - Ex. Galapagos finches

Competition Examples

- *Barnacles: Balanus* play a role in determining lower limit of *Chthamalus* within intertidal zone. (Connell)
  - Did no account for all observed patterns.

The intertidal distribution of *Chthamalus stellatus & Balanus balanoides*

- Competition evidence?
- Removal exp: remove B. → C. could persisted
  - Not remove, B. grew over and crushed the smaller C. individuals when they occurred in the same zone.→ direct interference
- Why not exclude C. totally?
  - B. appears unable to survive the desiccating conditions


Balanus
Chthamalus
Height up the shore
Adults
Larvae
Desiccation
Intraspecific competition
Adults
Larvae
Desiccation
Interspecific competition with Balanus
Distribution
Relative effects of these factors
Distribution
Relative effects of these factors

Competition and Niches

- Competition can restrict species to their realized niches.
- But if competitive interactions are strong and pervasive enough, they may produce an evolutionary response in the competitor population.

→ Changes fundamental niche.

IV. Competition can have significant ecological and evolutionary influences on the niches of species.

- Evidence in the field
  - Ex. Barnacle
  - Ex. Small rodents
  - Ex. Galapagos finches

Brown studied competition among rodents in Chihuahuan Desert

a) Kangaroo rat, *Dipodomys* spp, a large granivore

b) A pocket mouse, *Pergonathus* sp. a small granivore

Competition Examples

- *Brown,* rodents, Chihuahuan Desert.
- Predicted: if competition among rodents is mainly for food, then if remove larger granivorous rodents
  - → effect on small granivorous ones?
  - → effect on Insectivorous ones?
- Results supported hypothesis.

IV. Competition can have significant ecological and evolutionary influences on the niches of species.

- Evidence in the field
  - Ex. Barnacle
  - Ex. Small rodents
  - Ex. Galapagos finches

Character Displacement

- interspecific competition has been predicted to lead to directional selection for reduced niche overlap.
- Ex. Galapagos finches
  - *Geospiza fortis* (medium ground finch),
  - *G. fuliginosa* (small ground finch)

6 criteria for character displacement

M. Taper & T Case (1992)

- 1. diff bwt sympatric > allopatric populations
- 2. have a genetic basis
- 3. not due to original diff in founder pops
- 4. variations have effect on use of resource
- 5. competition demonstrated
- 6. not explained by resource availability
  - (e.g. no diff of food availability on both sites)

⁕ Coexistance Factors

- Ecological factors
  - Variation in space & time

  (= Environmental heterogeneity)
- Evolutionary factors
  - Competition ghost
  - Character displacement

Ecological Coexistance

- Environmental heterogeneity
  =spatial and temporal variation
- Ex. Mussels and sea palm (alga)
  - Coast of Washington, gap formation

Coexistance factors- Evolutionary factors

- Competition ghost
  - Ex. Israeli rodents
- Character displacement
  - Ex. Canadian sticklebacks (fish)
  - Ex. Galapagos finches

Coexistance factors- Evolutionary factors

- **Competition ghost**
- Ex. Israeli rodents
  - (*Meriones*-blue, *Gerbillus*-pink)
  - a niche differentiation of the realized niches, but also fundamental niches.

How significant is interspecific competition in practice?

- The prevalence of current competition
  - Surveys of published studies
- Effect on the assembling of a community? Assembly rule exists? through competition or mere by chance (= neutral models)

How widespread is intersp competitonin Nature?

- 2 Surveys (1983), current competition
- Schoener, 164 studies, 390 sp, 150 exp
  - 90% of studies, 57-76% of species show significant competition
- Connell, 72 studies, 215 sp, 527 exp
  - Most studies, >50% species, 40% exp show significant competition
  - large>small org., Marine > terrestrial

Critiques:

Conclusion could be exaggerated

- Biased selection and reported studies
- too less exp on phytophagous insects
- More studies in temperate & mainland area

Is species in a community randomly assembled? (**Neutral model**)

- Prediction: competing sp should be arranged **regularly** rather than **randomly** in niche space

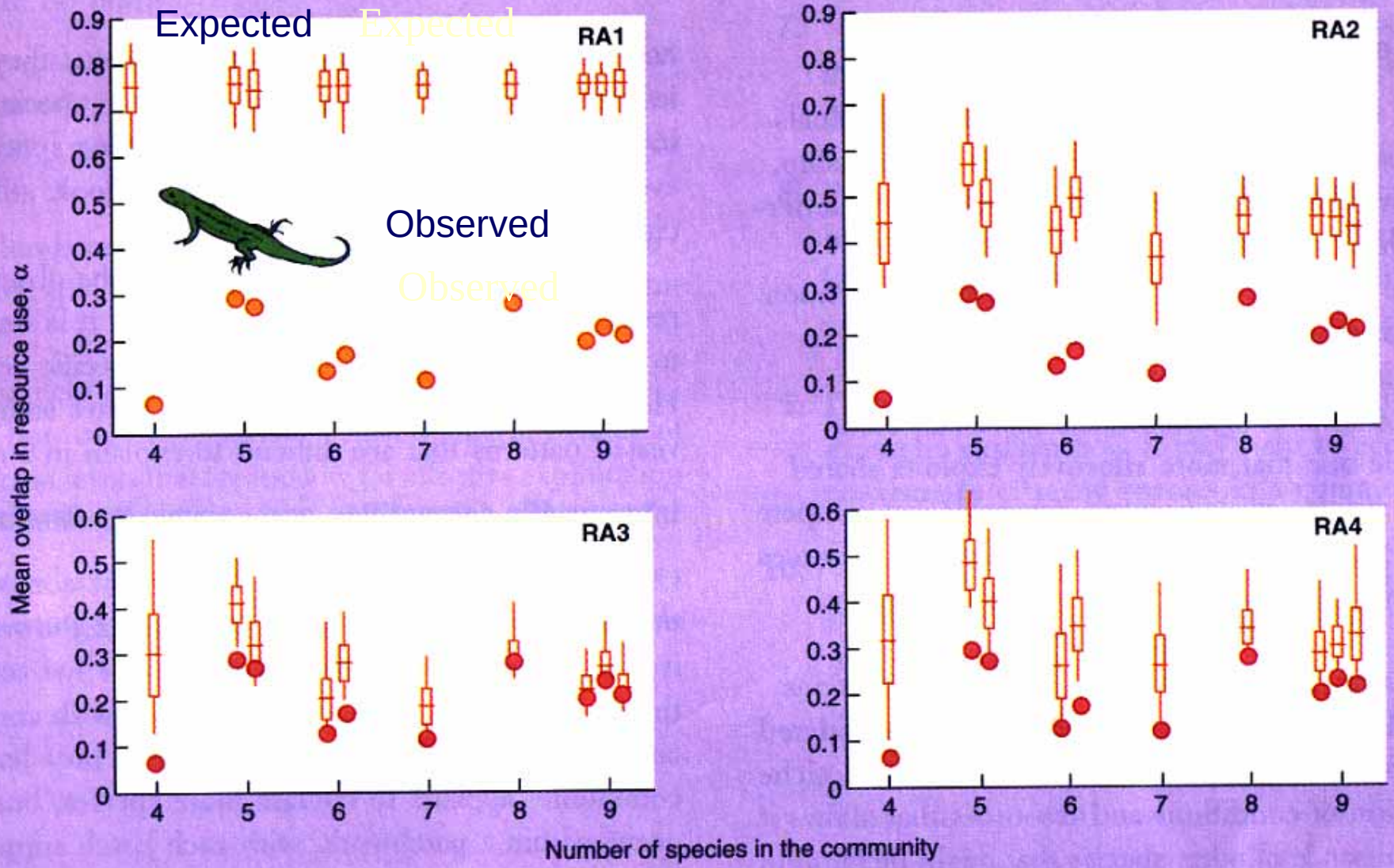
- Test for Neutral model *(null hypothesis)*:
  - the data are rearranged into a form representing what the data would looks like in the absence of interspecific competition.

10 N Am. Lizard communities
4-9 species, 20 food categories
Calculate mean resource overlap

Lowlor (1980): mean observed & expected resource overlap

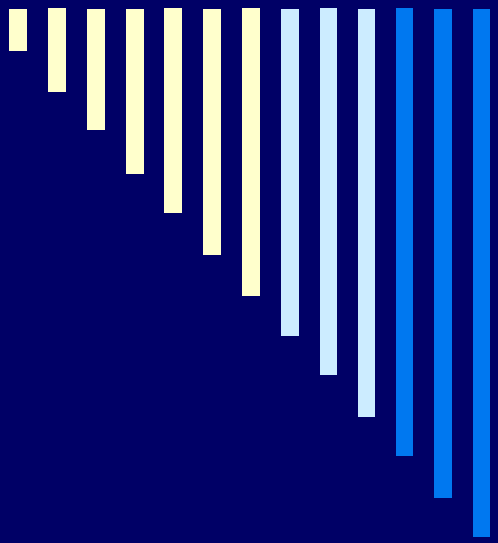
100 randomly constructed comm., 4 reorganization Algorithms (RA):

1: retained the mim original comm structure, 4: retained the most of the orig comm struct



Summary

- Studies of Intraspecific competition provide evidence for resource limitation.
- A niche reflects the environmental requirements of a species.
- Mathematical and laboratory models provide theoretical foundation for studying competitive interactions in nature.
- Competition can have significant ecological and evolutionary influences on the niches of species.
  - Ex. Character displacement, niche differentiation, competition ghost, free distribution..



E N D !