Mutualism & Commensalism

Definitions

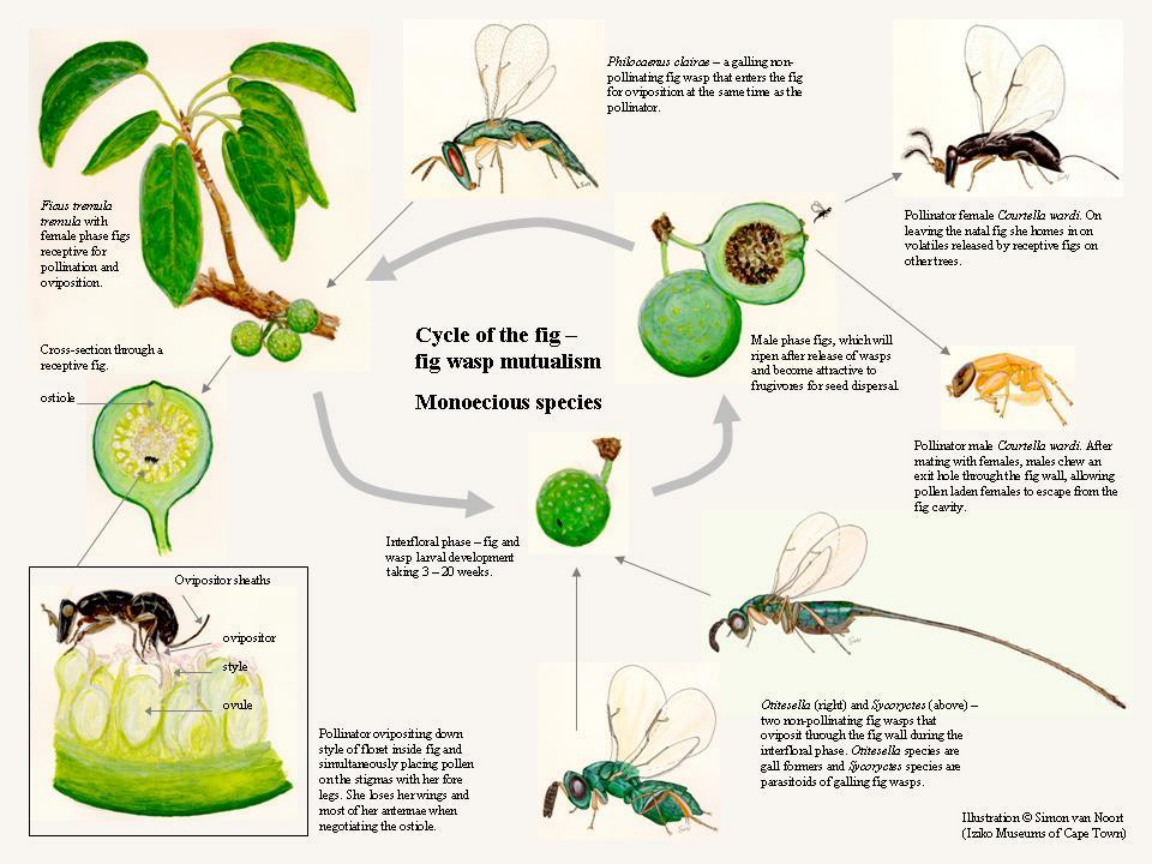
- Mutualism – *An interspecific interaction or set of interspecific interactions in which all participants obtain a fitness benefit from the interaction*
- Commensalism – *An interspecific interaction in which one species obtains a fitness benefit from the interaction and the other species is unaffected*

	Mutualism	Commensalism	Antagonistic	Competitive
Species 1	+	+	+	-
Species 2	+	0	-	-

Mutualism and commensalism are far less understood than antagonism and competition

Classification of mutualisms

- Obligate/Facultative



- Fig-Fig wasp pollination mutualism
- Approx 700 fig species and 350 known wasp species, the majority of known relationships are one-to-one

Classification of mutualisms

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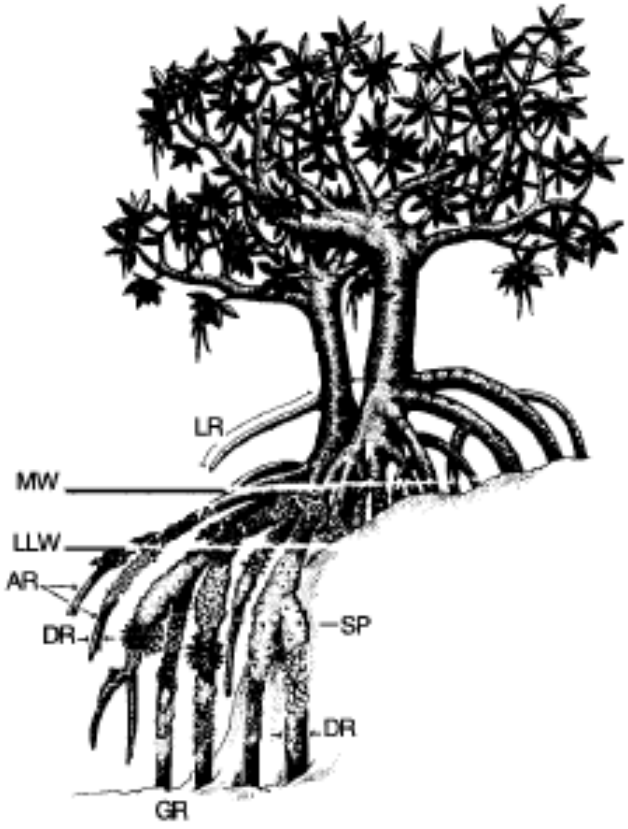

Fire sponge (*Tedania ignis*)

Ellison et al. (1996)

Classification of mutualisms

- Fitness currency exchanged
  - Resource-Resource
  - Resource-Service
  - Service-Service

"Resources" here means materials that provide nutrition, which enhances physiological condition and fitness, e.g., carbohydrates, nutrients, water

"Services" here means process that promote fitness, but do not involve exchange of materials, e.g., pollination, cleaning, and protection

Classification of mutualisms

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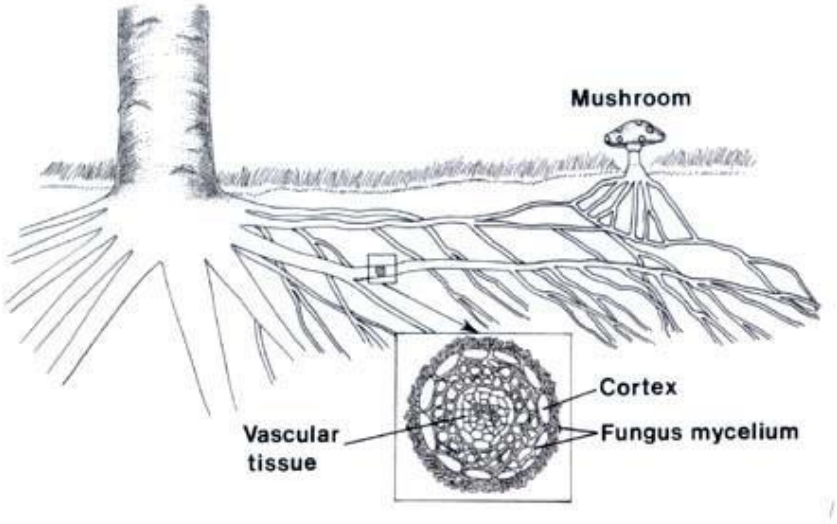
Plant-mycorrhizae relationships are a resource-resource exchange where the mycorrhizae provide nutrients (phosphate ions, nitrogen) acquired from low concentrations in the soil in exchange for glucose/sucrose acquired by the plant through photosynthesis



Classification of mutualisms

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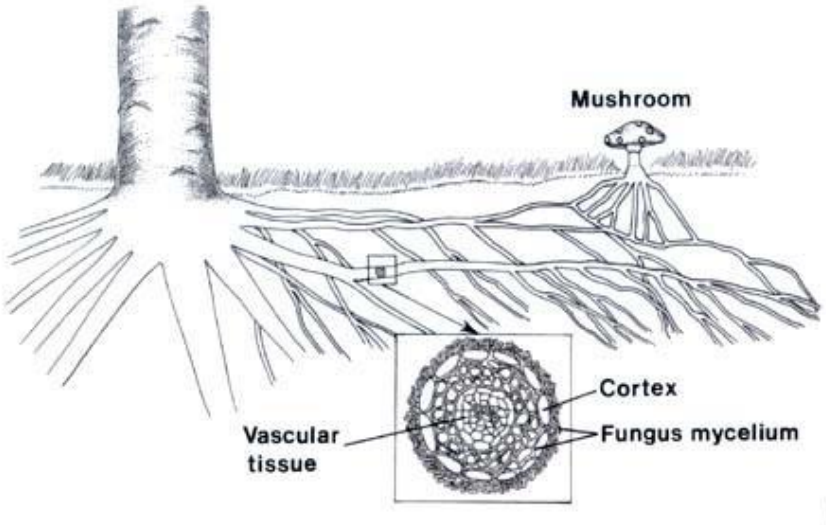

Mycorrhizae are classified into two groups:

(1) The hyphae of *ectomycorrhizae* do not invade individual cells within the root

(2) *Endomycorrhizae*, by contrast, penetrate individual cells within the root

Mutualism vs. pathogenicity can be *environment-dependent*

Classification of mutualisms

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Amphiprion ocellaris

Clownfish and anemonefish (genera *Premnas* and *Amphiprion*) have a lipid- and glycoprotein-rich mucus membrane which provides immunity to the toxin of the host anemone. The tentacles of the host provide protection against predators while the fish function as lures drawing prey into the vicinity of the anemone.

Amphiprion percula

Classification of mutualisms

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Cleaner fish (examples among wrasses, catfishes, and gobies) remove parasites and dead tissue and receive protection

Labroides dimidiatus (a wrasse) associated with the grouper *Epinephelus tukula*

Service-Service exchanges are rare

Classification of mutualisms

- Pairwise/Diffuse

Classification of mutualisms

- Pairwise/Diffuse

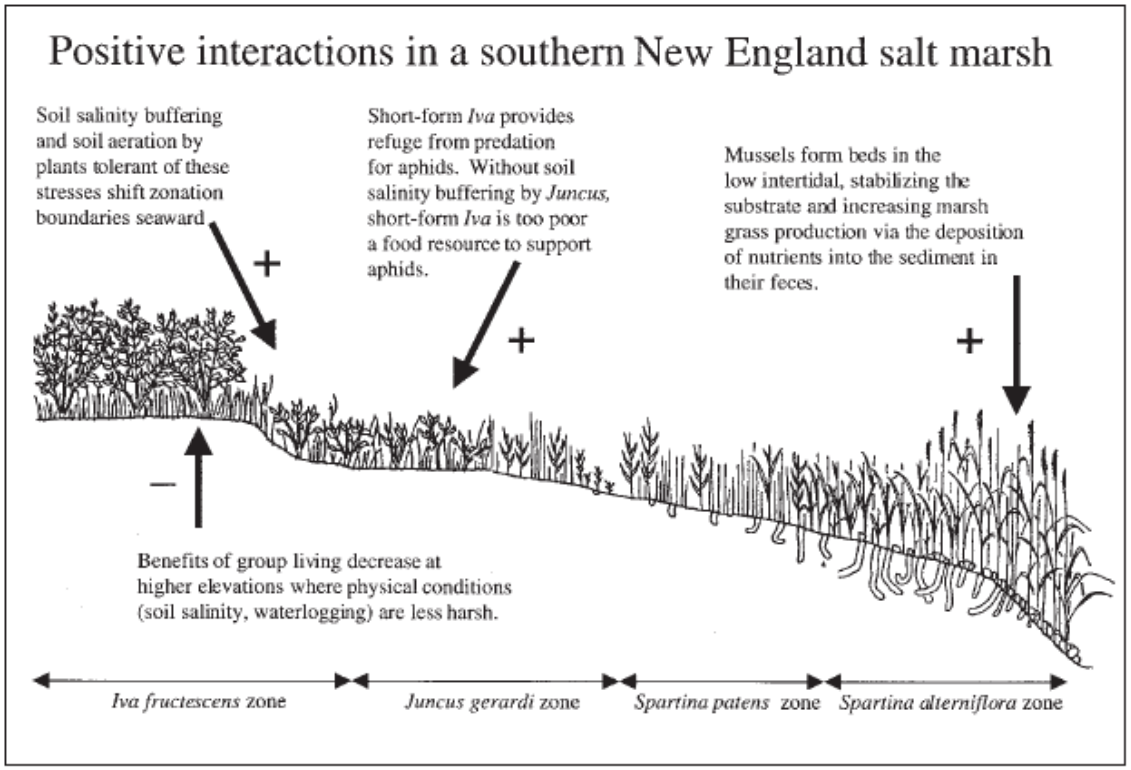


Figure 2. Positive interactions in southern New England salt marsh communities. Figure modified from Bertness and Leonard (1997).

Spartina alterniflora as keystone facilitator in communities exposed to high wave action

Population Dynamics

- Lotka-Volterra competition model modified for mutualisms

$$\frac{dN_1}{dt} = r_1 N_1 \frac{K_1 + m_1 N_2 - N_1}{K_1}$$

$$\frac{dN_2}{dt} = r_2 N_2 \frac{K_2 + m_2 N_1 - N_2}{K_2}$$

Population Dynamics

- Nullclines

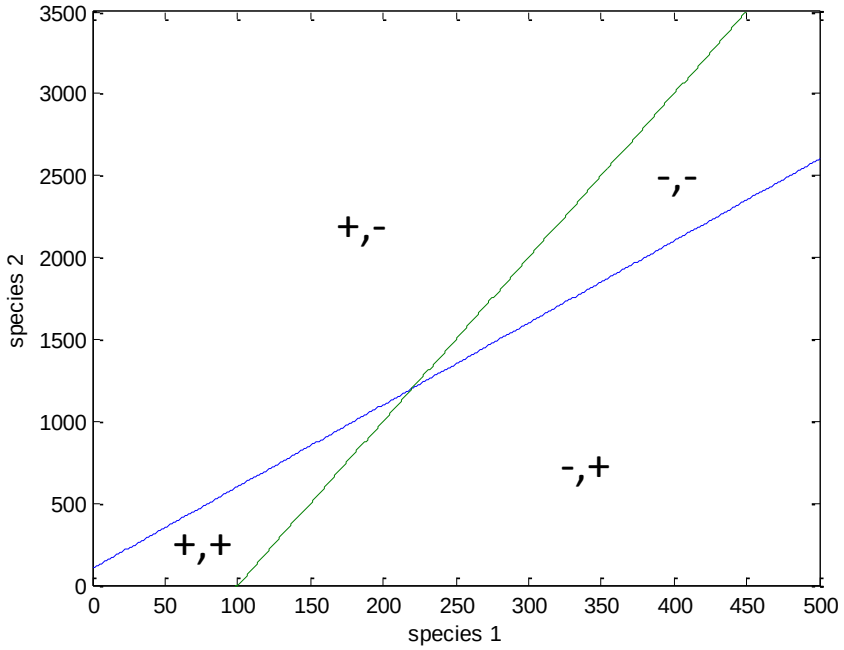
$$N_1^* = K_1 + m_1 N_2 \rightarrow N_2 = \frac{N_1^* - K_1}{m_1}$$

$$N_2^* = K_2 + m_2 N_1$$

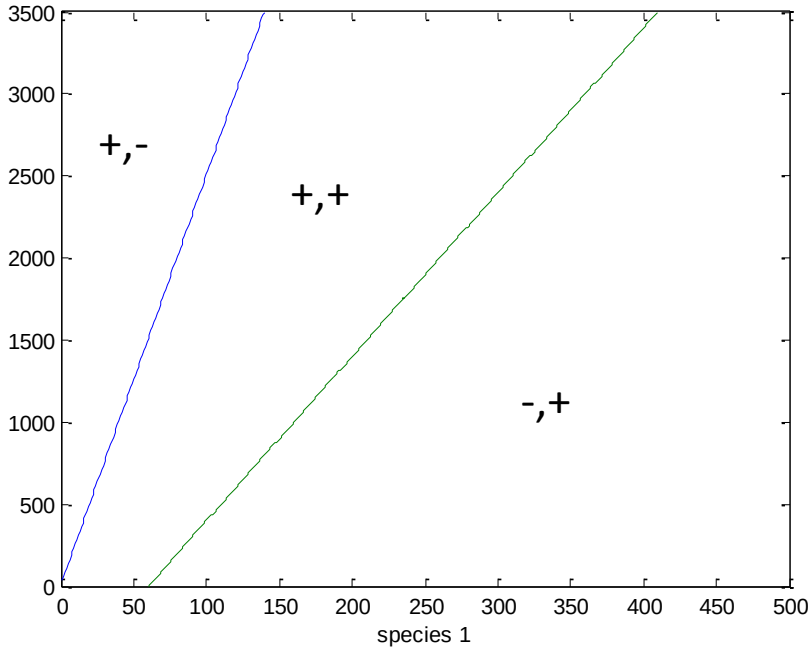
Population Dynamics

- Two possible scenarios

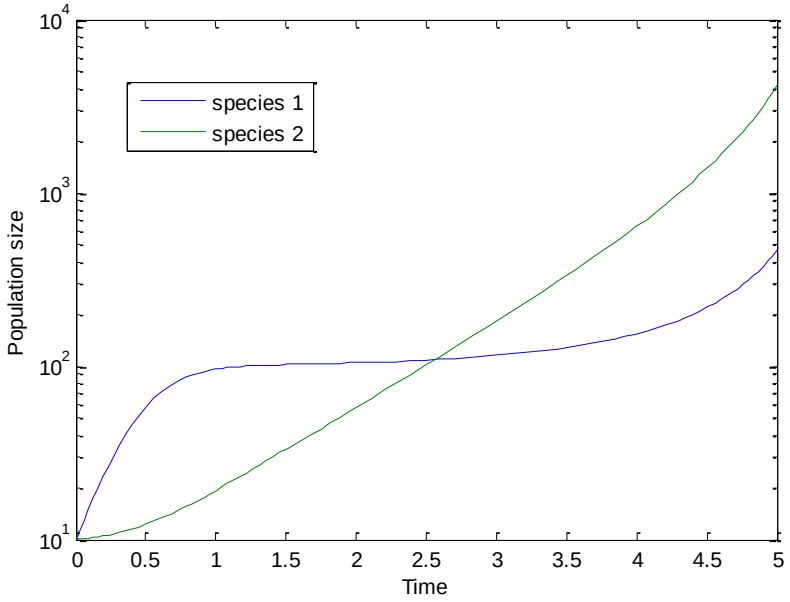
Stable equilibrium

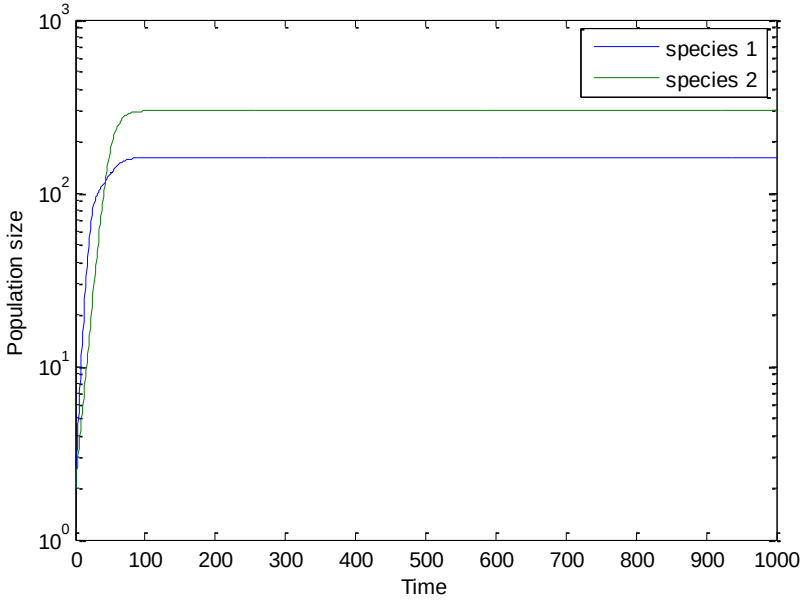


Runaway population growth



Population Dynamics





Conclusion: Mutualisms tend either to be unstable, or can very quickly become unstable

So, why are there so many mutualisms?

Conditions favoring mutualisms (stress)

- *Stress (def): An extrinsic force that severely reduces the fitness of an individual or population.*

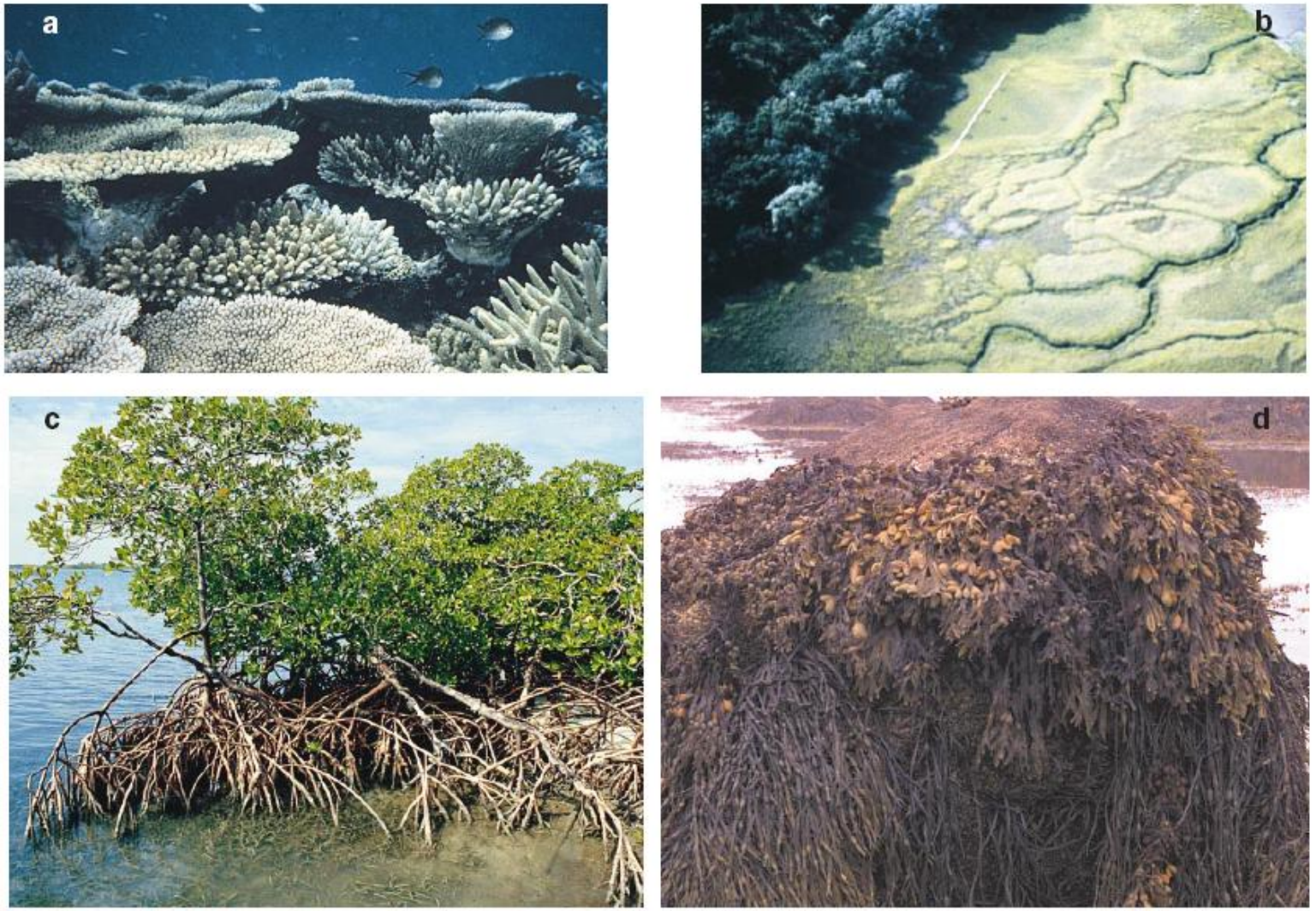
Stresses can be:

- Physiological (e.g., temperature, salinity, drought conditions)
- Physical (e.g., direct effects of wind, waves, currents)
- Biotic (e.g., competition, predation, disease)

Physiological & Physical Stress

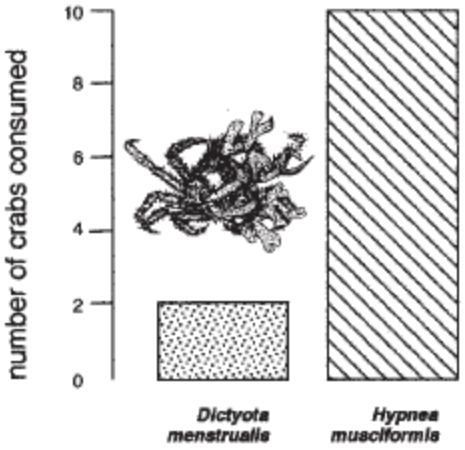
- How do communities respond to physiological and physical stress?
- Often through *ecosystem engineering*
- *Ecosystem engineering (def.): Modification of the physical or chemical properties of the environment by a species that affects the fitness of one or more other species in that environment.*

Ecosystem engineers in aquatic environments



Stachowicz 2001

Biotic Stress I – Escaping Predation



Decorator crab obtains chemical camouflage from the brown alga *Dictoyota menstrualis*

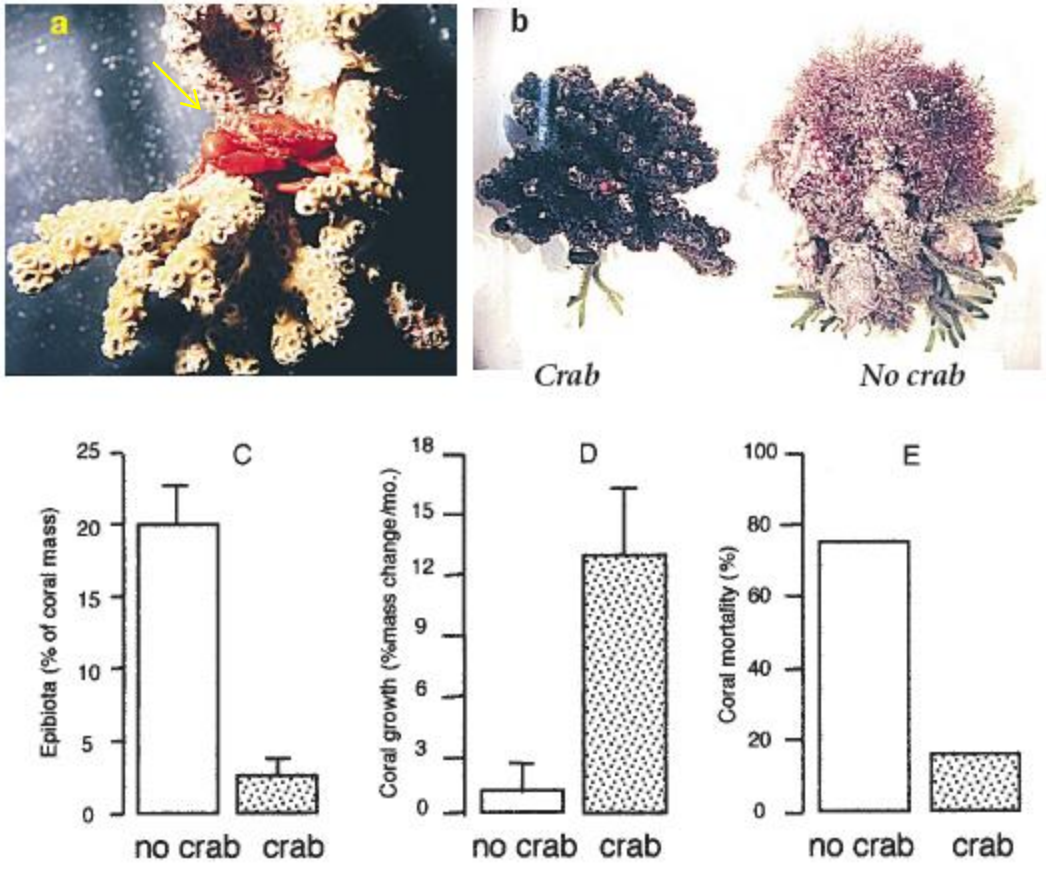
It is unknown if this relationship is mutualistic or commensal

Biotic stress may give rise to a latitudinal gradient in the propensity of mutualism

Stachowicz and Hay 1999

Biotic Stress II - Mediating Competition

Mithrax forceps



Stachowicz and Hay 1999

Shallow water (high light penetration) competition between corals and algae

Western Atlantic branching coral *Oculina arbuscula*

Herbivory by *M. forceps* increases coral fitness; Coral structure provides habitat and resource supply

"Keystone mutualist" (>300 invertebrate spp.)

Environment dependent mutualism

Summary

- Mutualism is a +/+ inter-specific interaction, Commensalism is a +/0 inter-specific interaction
- Mutualims may be
  - obligate/facultative
  - resource-resource/resource-service/service-service
  - pairwise/diffuse
- Mutualisms tend to be unstable
  - Often mutualisms are environment-dependent
- Stressful environments favor the emergence of mutualisms