The Ecological Niche Part 2: Specialists vs. Generalists

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Biol 417: Evolutionary Ecology

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Review

Last lecture we saw how the concept of the ecological niche provided evolutionary ecologists with a framework for understanding species' place in the natural world.

In particular, we focused on how niche overlap related to the potential for competition and competitive exclusion.

Overlap without competition cont.

Hutchinson (1957) laid out assumptions to translate the **qualitative** concept of a niche into a **quantitative** concept. Making these assumptions introduced three important limitations/properties into his framework:

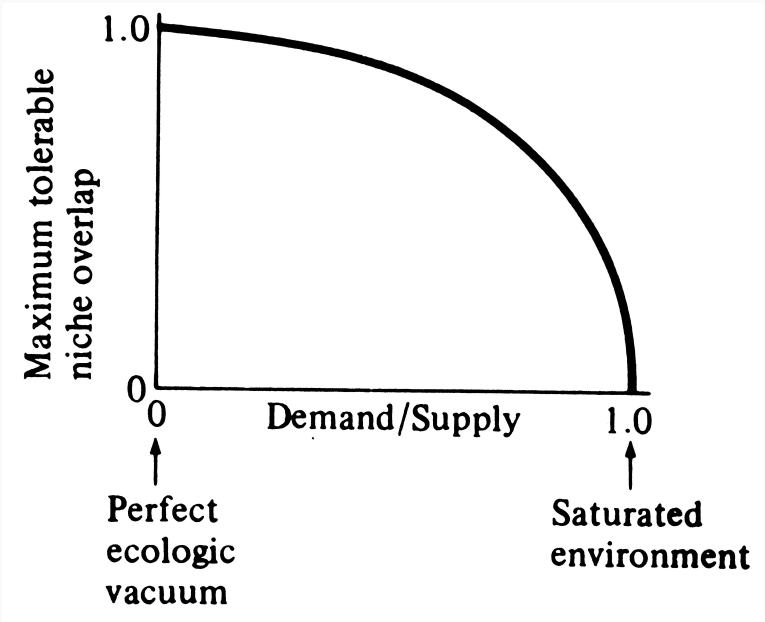
1. Saturation
2. Dimensionality
3. Non-competitive interactions

Saturation

Hutchinson (1957) assumed that the world is completely saturated.

Under this scenario, any niche space given is niche space lost, so competition is fierce. Are we prepared to make that assumption?

The amount of tolerable overlap will depend on resource availability.

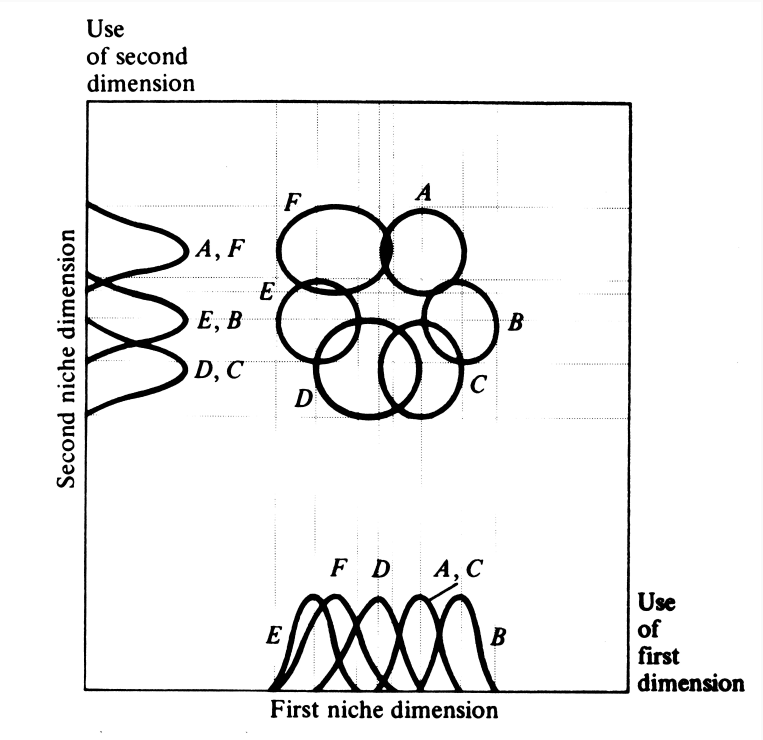


Source: Pianka (2000)

Dimensionality

Hutchinson (1957) defined an n-dimensional hypervolume.

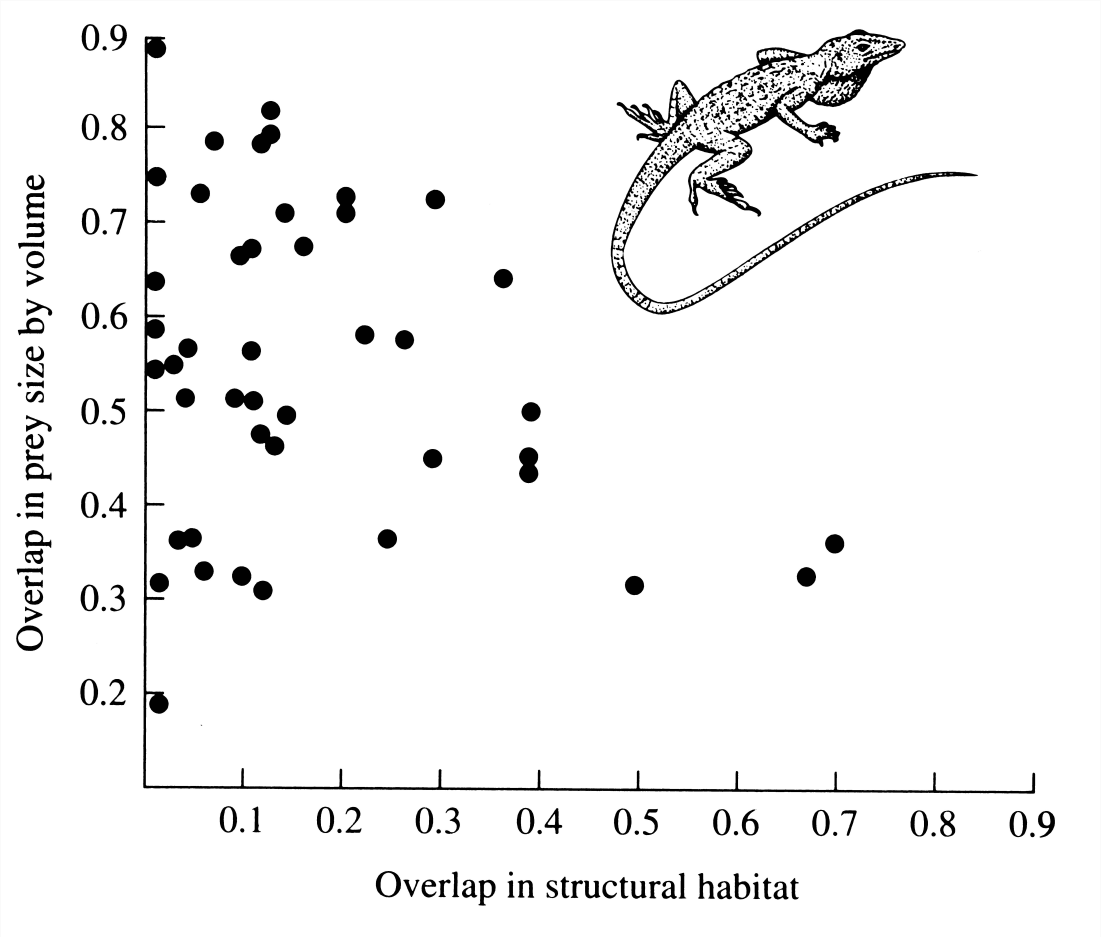
Niches are usually evaluated across 1-2 axes, but overlap on one dimension doesn't mean overlap across the entire hypervolume.



Source: Pianka (2000)

Dimensionality cont.

In *Anolis spp.* lizards, pairs of species with high dietary overlap often exploit different structural microhabitats.



Source: Schoener (1968)

Non-competitive interactions

Hutchinson (1957) focused on competitive interactions and assumed any niche overlap decreased r_0

... but there are many conditions where niche overlap can increase r_0 (e.g., predator saturation, many eyes, etc...).

Source: http://www.clydesideimages.co.uk/

Niche & Competition Take Homes

The concept of the niche is central to evolutionary ecology (understand a species' fundamental vs. realised niche and you can understand much of its evolutionary ecology).

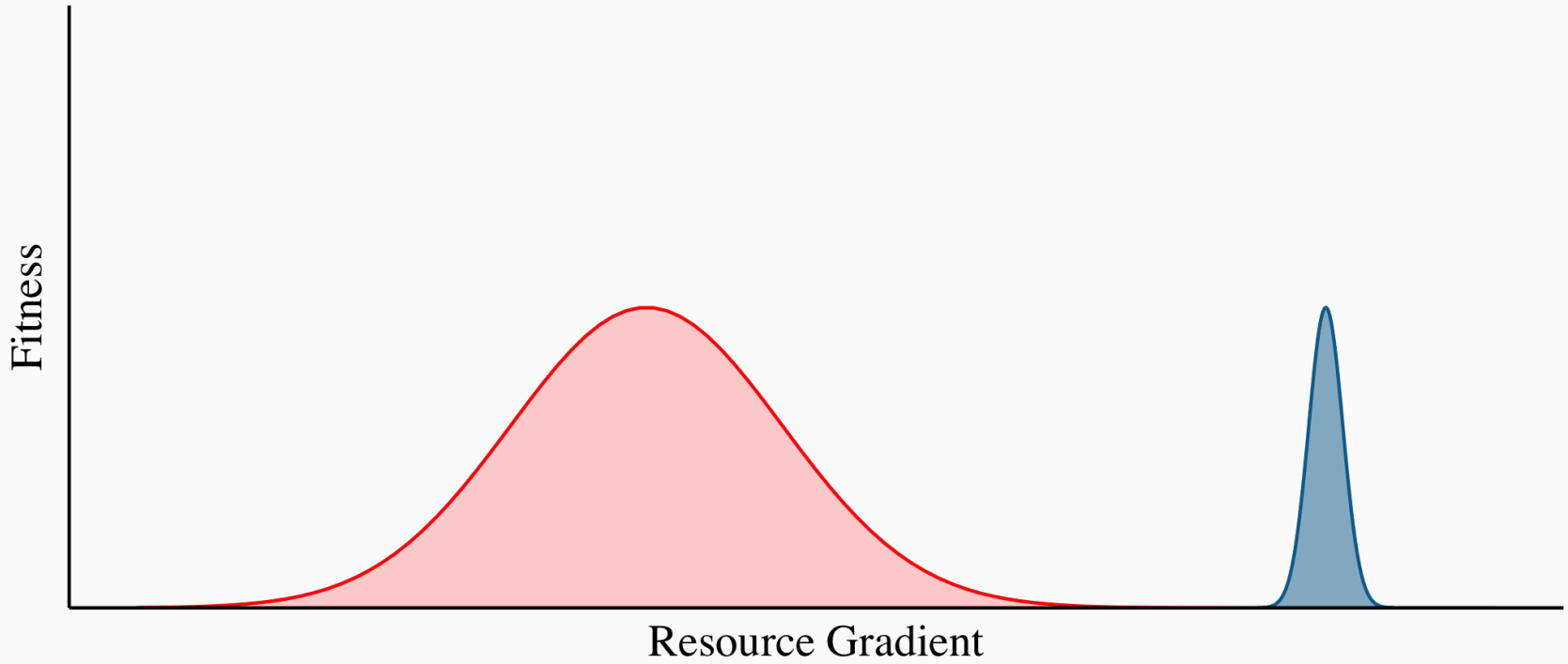
Quantifying a species' entire niche space is borderline impossible, but quantifying too few dimensions can ignore important separation.

There is no perfect framework for studying niches, but in doing so we have learned a lot about how species exist and co-exist.

Niche Breadth

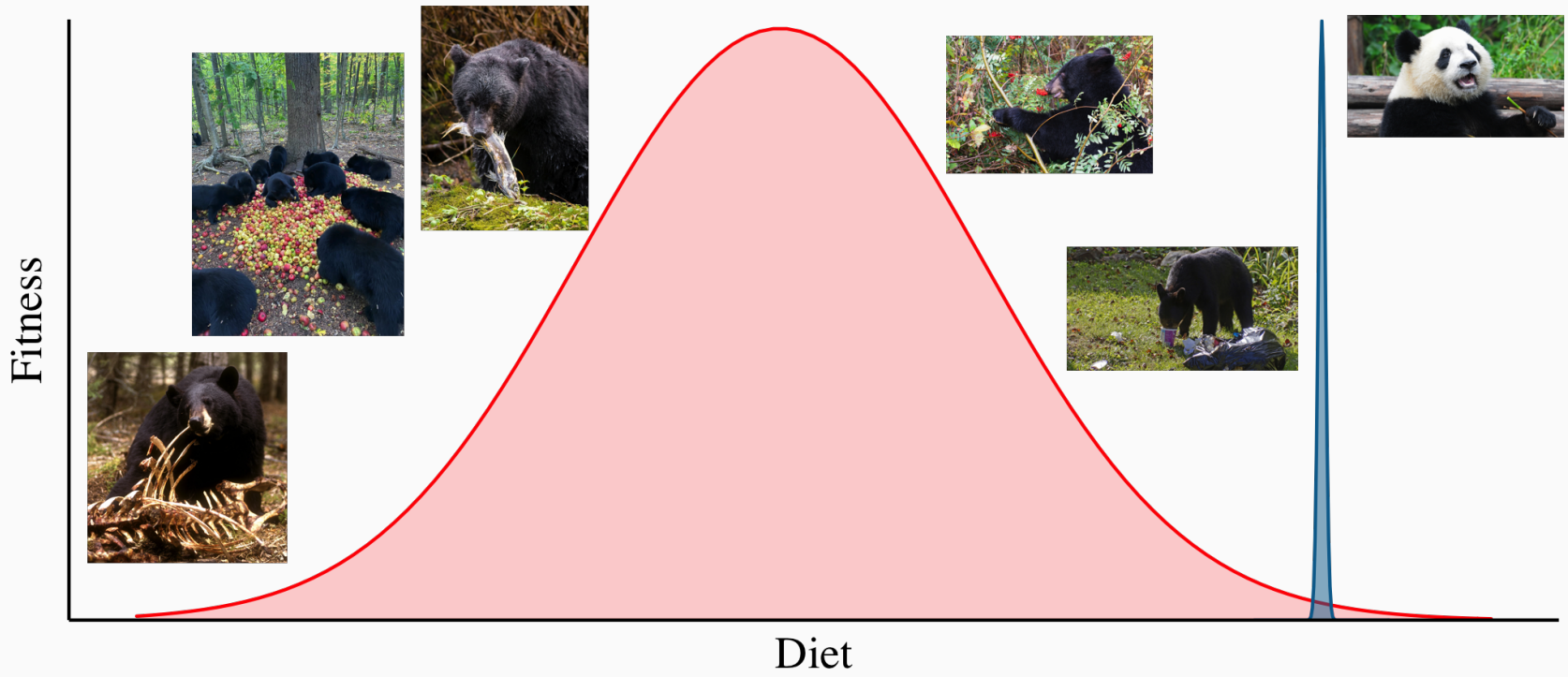
Niche breadth

In studying species' niche ecologists quickly learned that some species have smaller niche spaces than others.



Dietary breadth

Example: Bamboo shoots make up 99% of the diet of Pandas (*Ailuropoda melanoleuca*), black bears (*Ursus americanus*) eat just about anything they come across.



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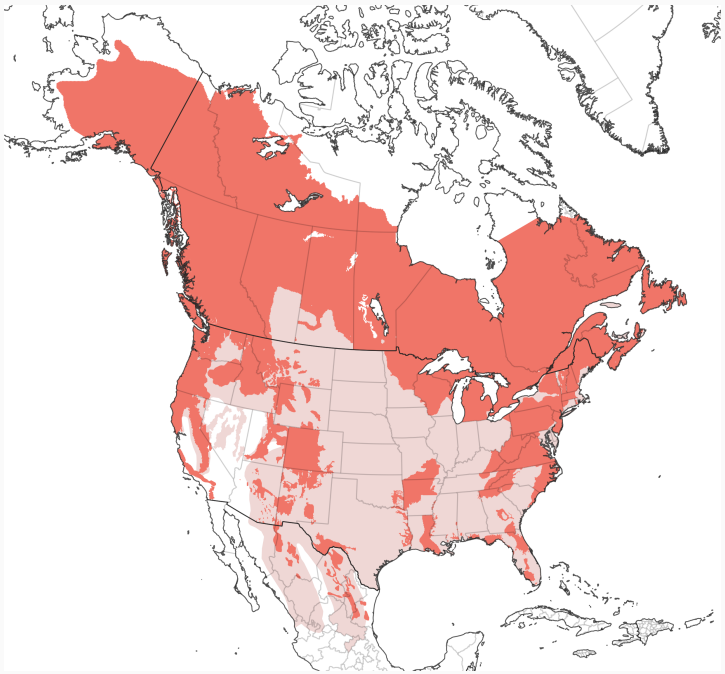

Source: Wikipedia

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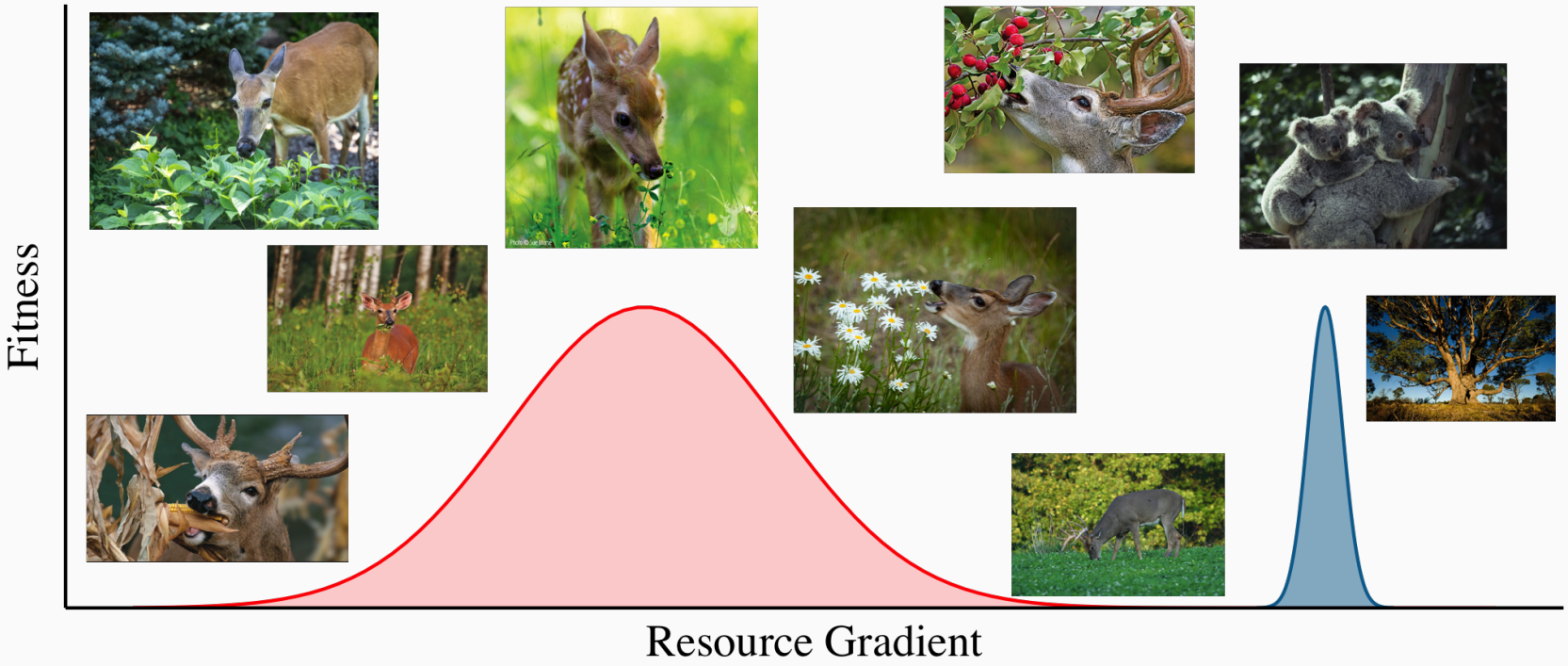
Dietary breadth cont.

Example: Koalas (*Phascolarctos cinereus*) forage exclusively on eucalyptus leaves, white tailed deer (*Odocoileus virginianus*) have a broad diet of leaves, shoots, mushrooms, nuts, fruits, etc...



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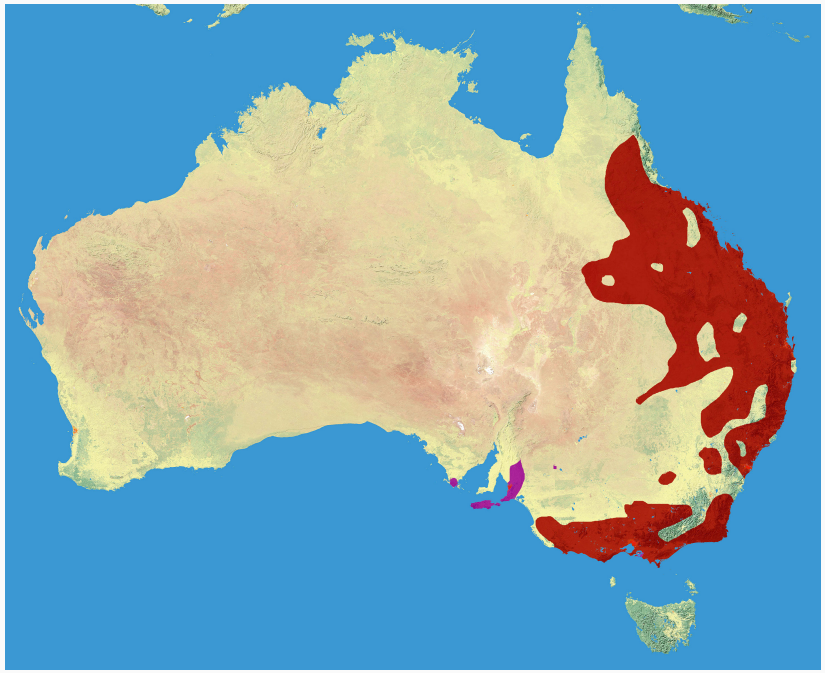


Source: Wikipedia

Niche breadth cont.

Species with narrow niches are termed **specialists**.

> Typified by narrow tolerance limits, specific habitat requirements, globally rare (but can be locally abundant).

Species with broad niches are termed **generalists**

> Typified by wide tolerance limits, flexible habitat requirements, wider ranges and more abundant.

Evolution of specialisation

Specialists

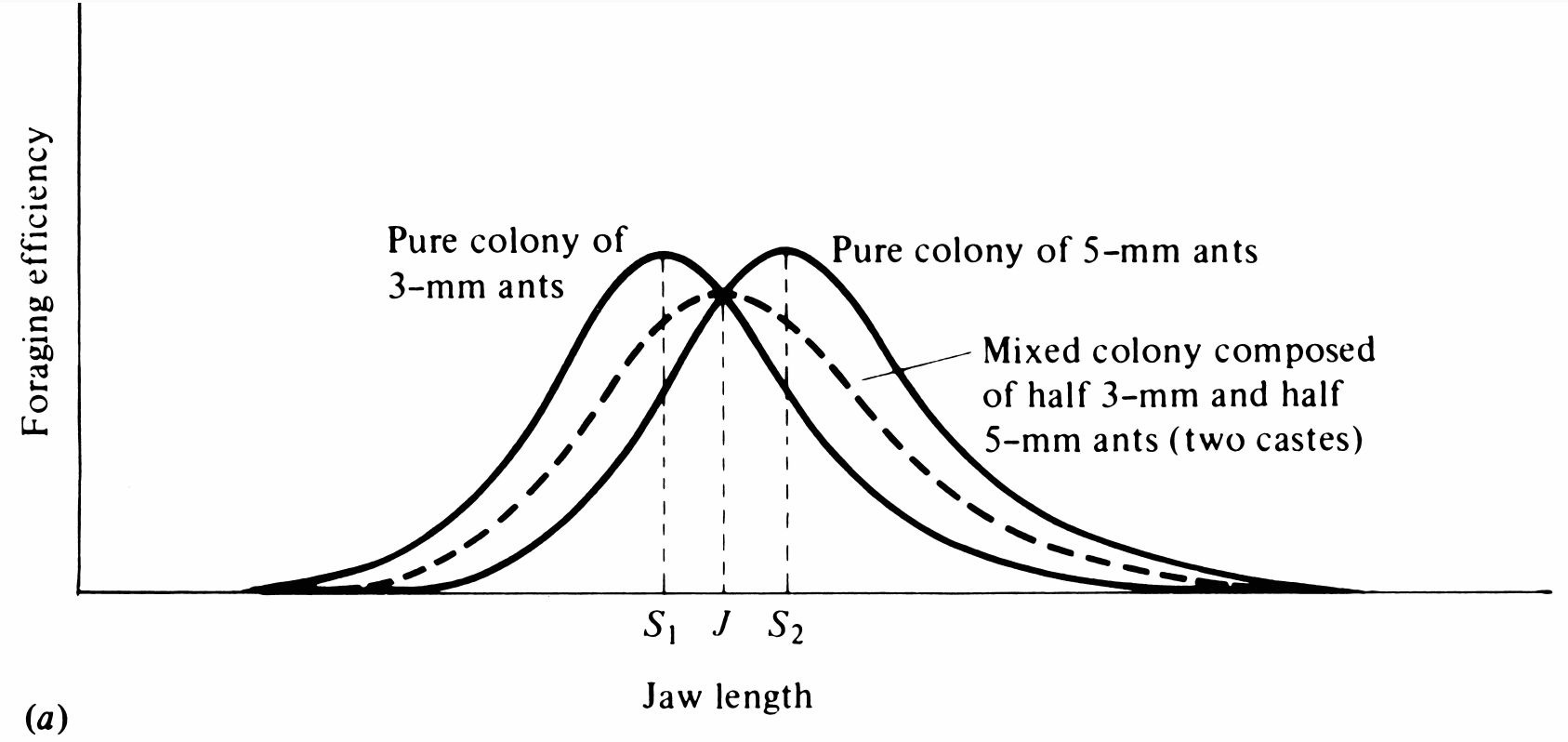
Generalists can exploit more resources, occupy more habitats, and are usually more abundant.

If specialisation involves becoming less abundant, how can this be favoured by natural selection when faced with competition against generalists?

Lizard jaws

Imagine a population of lizards foraging on ants of different sizes (MacArthur & Connell, 1966).

If the ants are $\sim$ similar in size, the generalist strategy will win out.

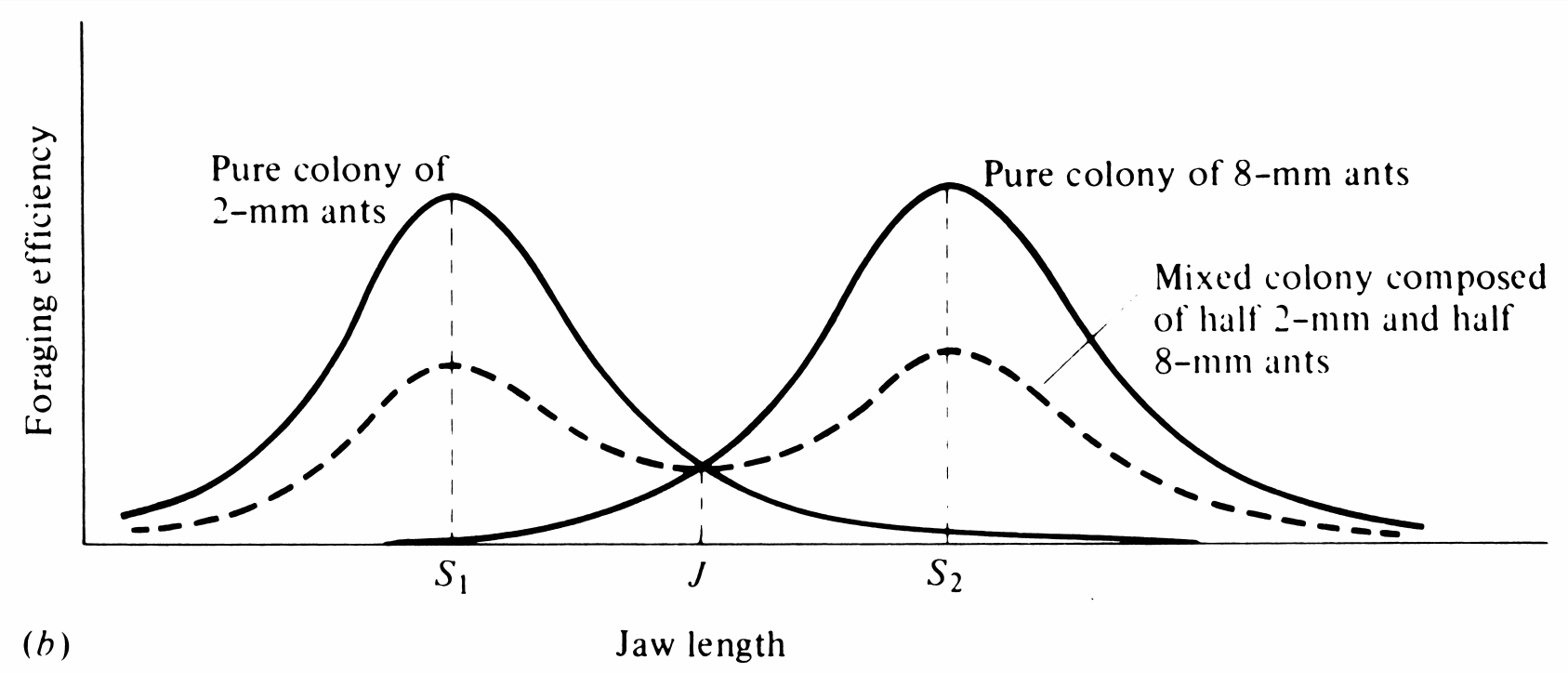


Source: Pianka (2000) after MacArthur & Connell (1966)

Lizard jaws cont.

Imagine a population of lizards foraging on ants of different sizes (MacArthur & Connell, 1966).

If the ants are very different in size, the specialist strategies will win out.



Source: Pianka (2000) after MacArthur & Connell (1966)

Spec. and resource abundance

Not all environmental conditions favour specialisation.

In resource-sparse environments with low productivity, individuals can not usually afford to specialise (specialising on a single resource is not sufficient for supporting growth and reproduction).

As a result niche breadth should increase as resource availability decreases.

Spec. and resource abundance cont.

Resource poor env.

When resources are rare, encounters with food items are low and search times are high.

Broad dietary niches increase encounter rates and decrease search times.

Natural selection should favour a generalist strategy.

Resource rich env.

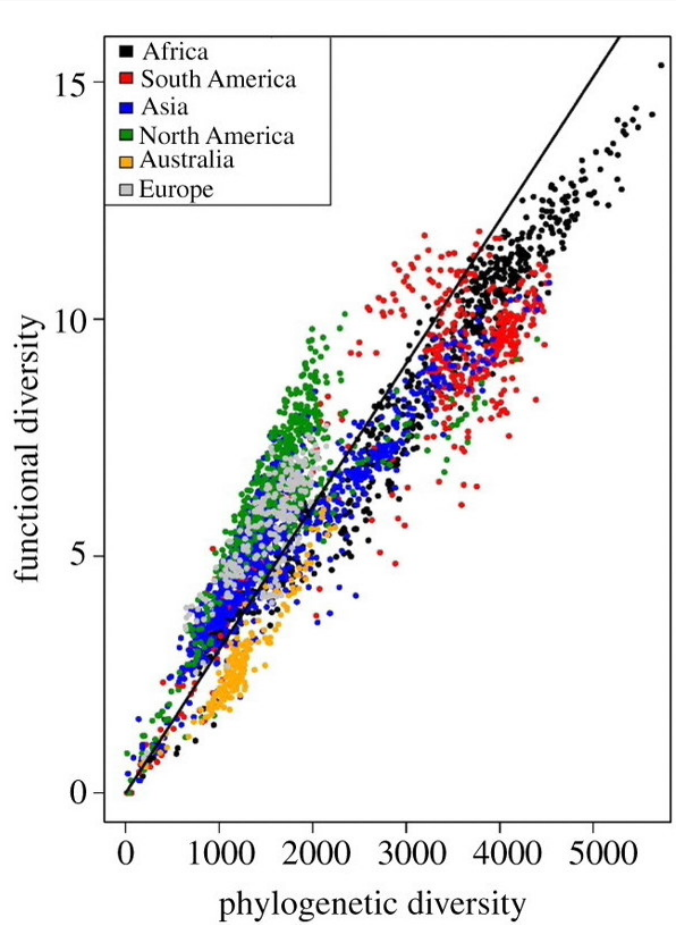
When resources are abundant, encounters with food items are high and search times are low.

Broad dietary niches don't necessarily increase encounter rates and decrease search times.

Natural selection should favour specialist strategies that decrease handling times.

Mammalian diversity

Safi *et al.* (2011) looked at the relationship between phylogenetic diversity (PD) and functional diversity (FD) for terrestrial mammals .



Source: Safi *et al.* (2011)

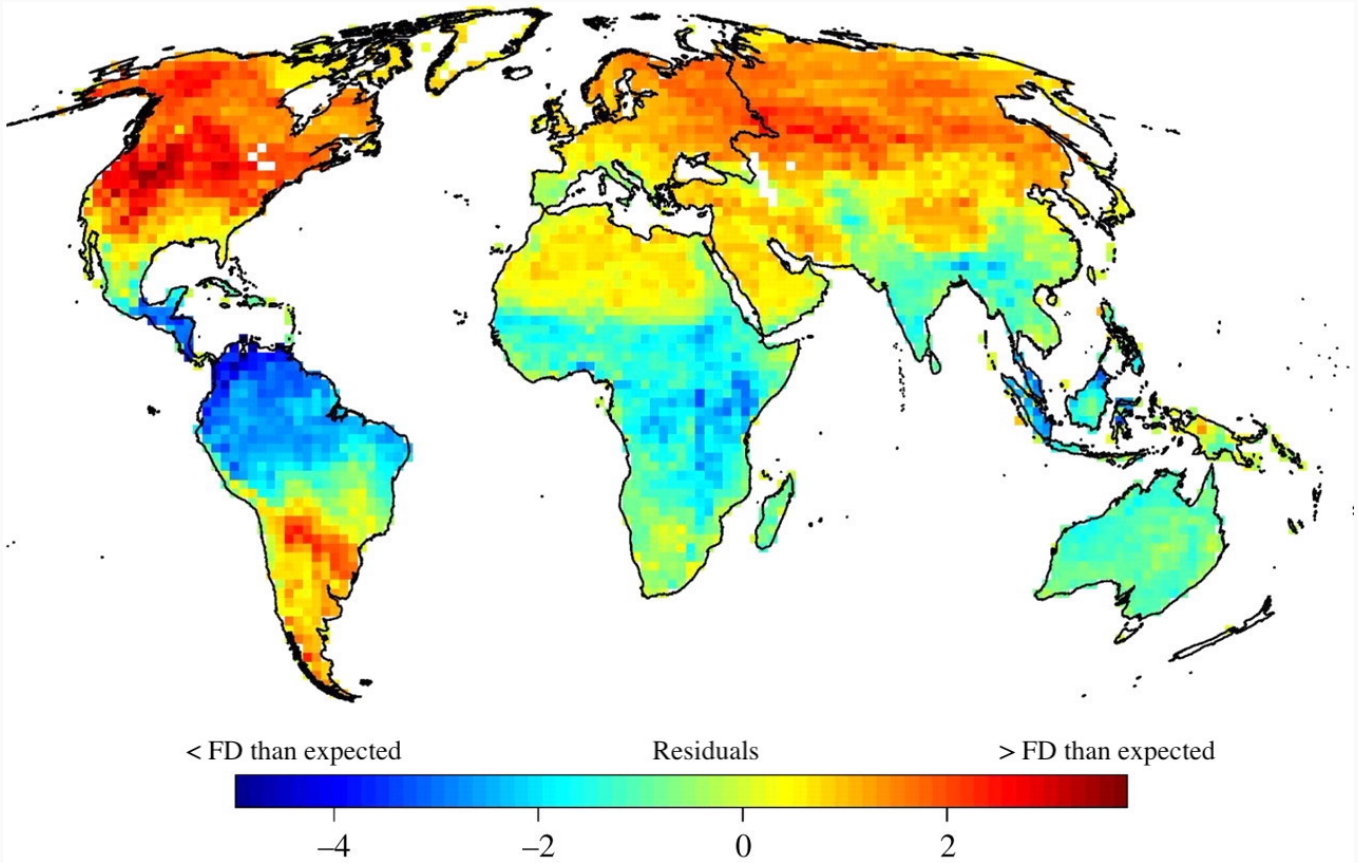
Positive correlation between PD and FD.

Many regions had **more** FD than would be expected by local PD (generalists).

Many regions had **less** FD than would be expected by local PD (speialists).

Mammalian diversity cont.

A map of the residuals shows lower than expected functional diversity in the tropics (i.e., species have smaller niche spaces on average) and vice versa in the global north.



Source: Safi *et al.* (2011)

Specialisation and stochasticity

Predictability will also influence the extent to which specialisation is favoured.

Stable env.

When resources are predictable, flexible acquisition strategies are not necessary.

Devoting resources to maintaining a broad niche is wasteful.

Natural selection should favour a specialist strategy.

Stochastic env.

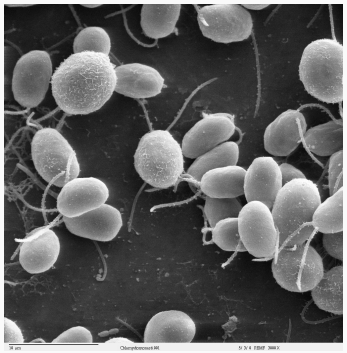
When resources are stochastic, flexible acquisition strategies are beneficial.

Devoting resources to maintaining a broad niche can maximise resource acquisition.

Natural selection should favour a generalist strategy.

Chlamydomonas reinhardtii

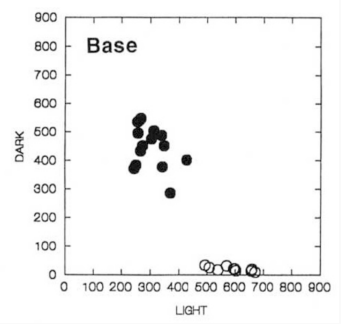
C. reinhardtii is a species of algae that can feed via both photosynthesis and heterotrophy.



Source: Wikipedia

Reboud & Bell (1997) reared *C. reinhardtii* in two conditions: light vs. dark for 1000 generations. Result?

Led to the evolution of light-specialists and dark specialists in each pop.



Reboud & Bell (1997)

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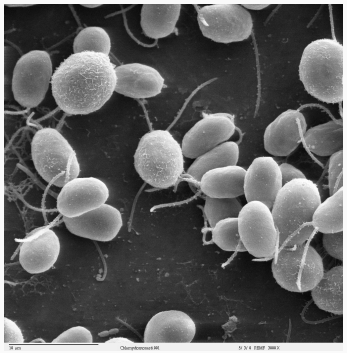
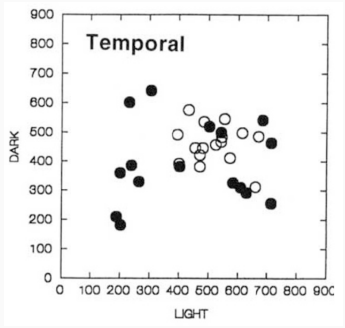


Source: Wikipedia

They then reared each pop under temporal variation in light/dark for 200 generations. Result?

Temporal variation in resource availability led to the evolution of a pop. of generalists



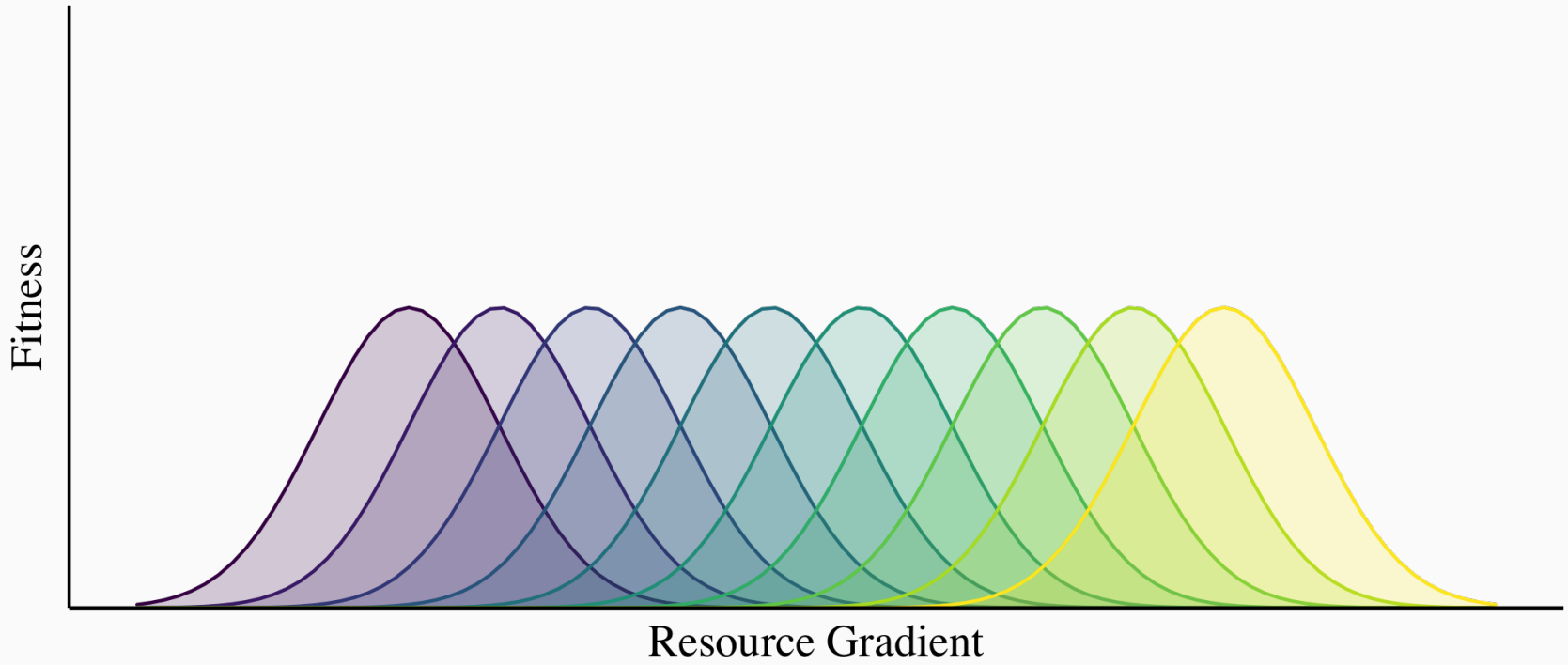
Reboud & Bell (1997)

Competition and specialisation

Niche compression

By governing resource availability, intense competition should favour specialisation.

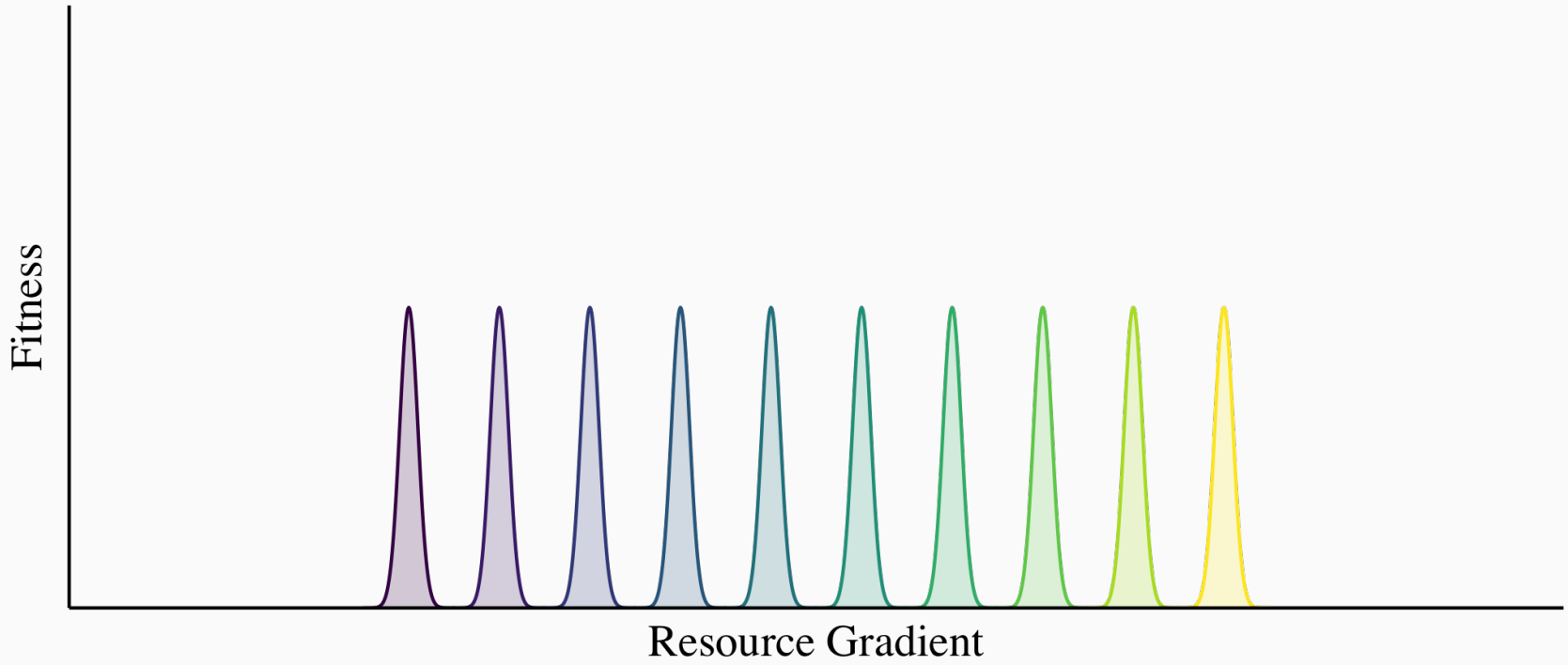
Species will be outcompeted at the tail ends of their niches



Niche compression

By governing resource availability, intense competition should favour specialisation.

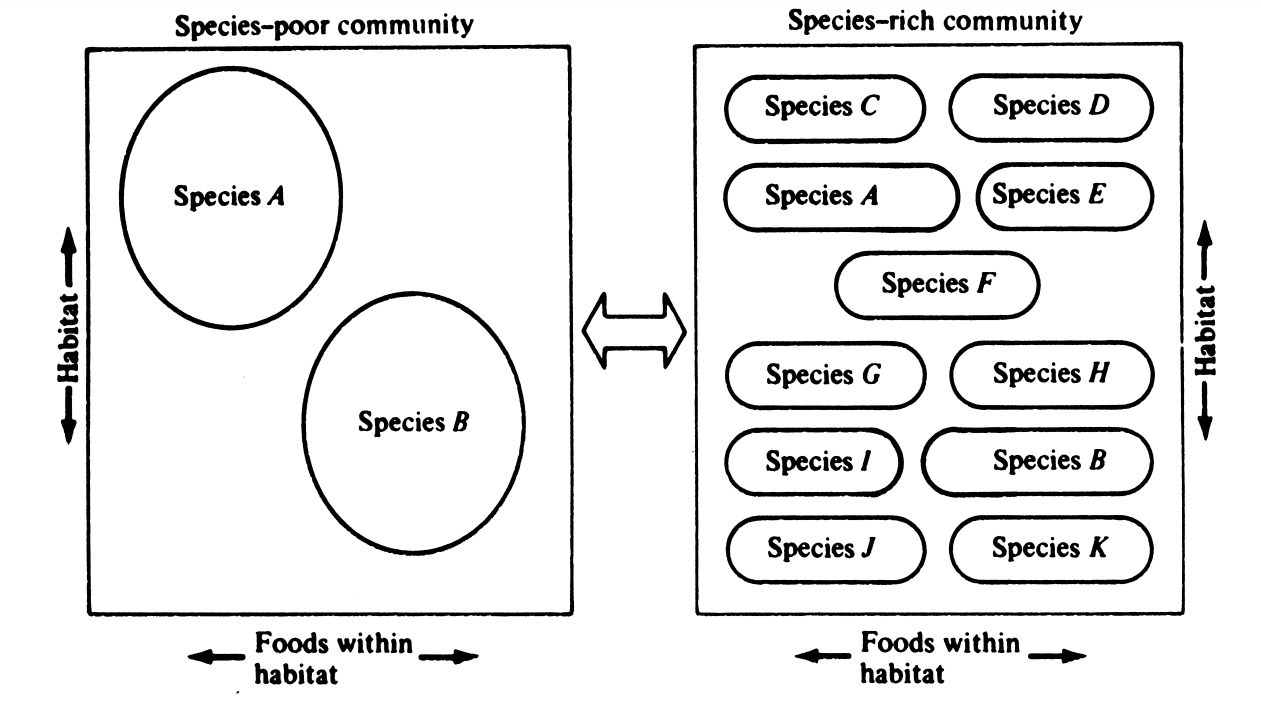
Niche breadth should reduce to minimise overlap and competition.



Niche compression cont.

Over **ecological** timescales behavioural modifications that decrease competition will be favoured.

Over **evolutionary** timescales physiological, morphological, etc.. modifications that decrease competition will be favoured.

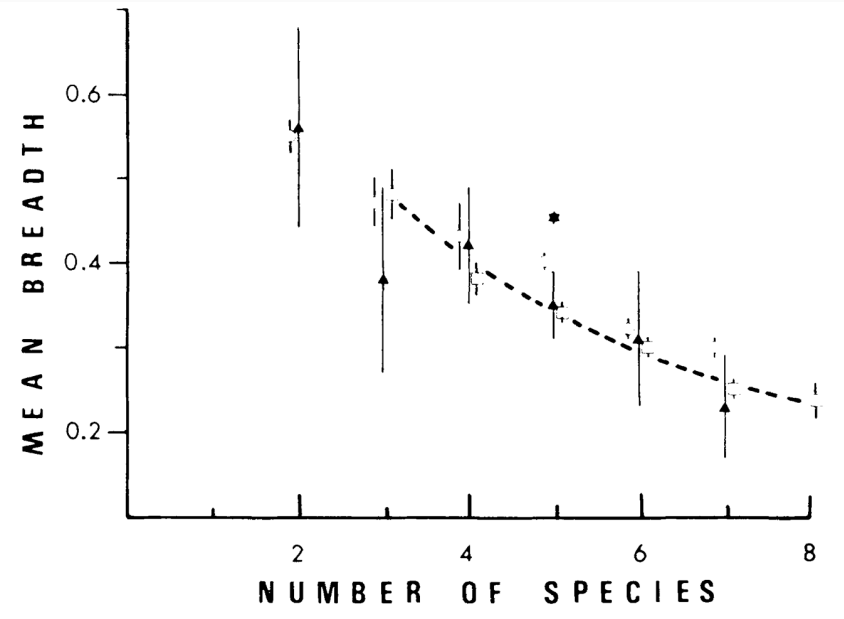


Source: Pianka (2000)

Niche compression example

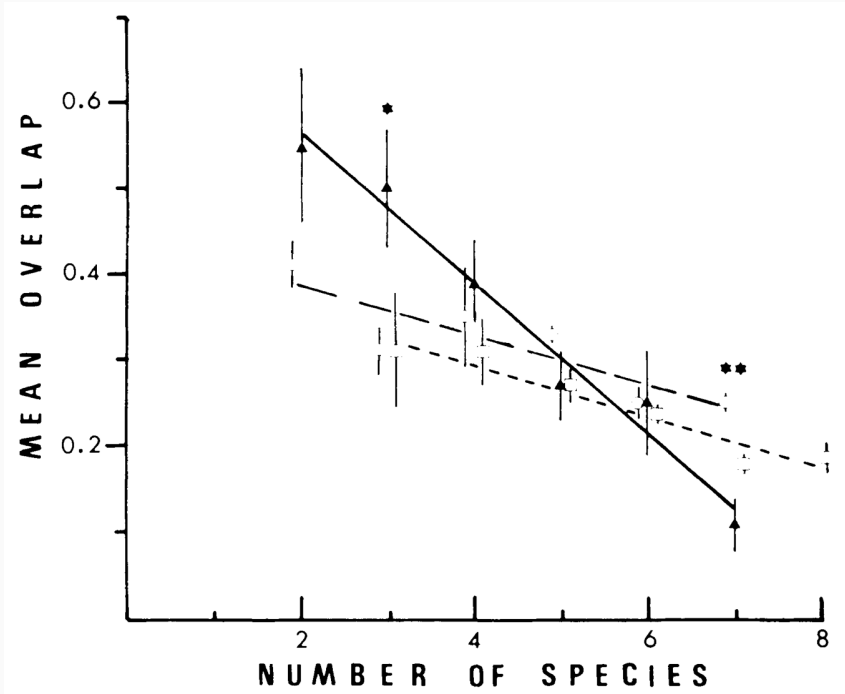
Fox (1981) looked at niche breadth (spatial), overlap (spatial), and richness in 9 species of ground-dwelling small mammals in eastern Australia.

Breadth



Source: Fox (1981)

Overlap

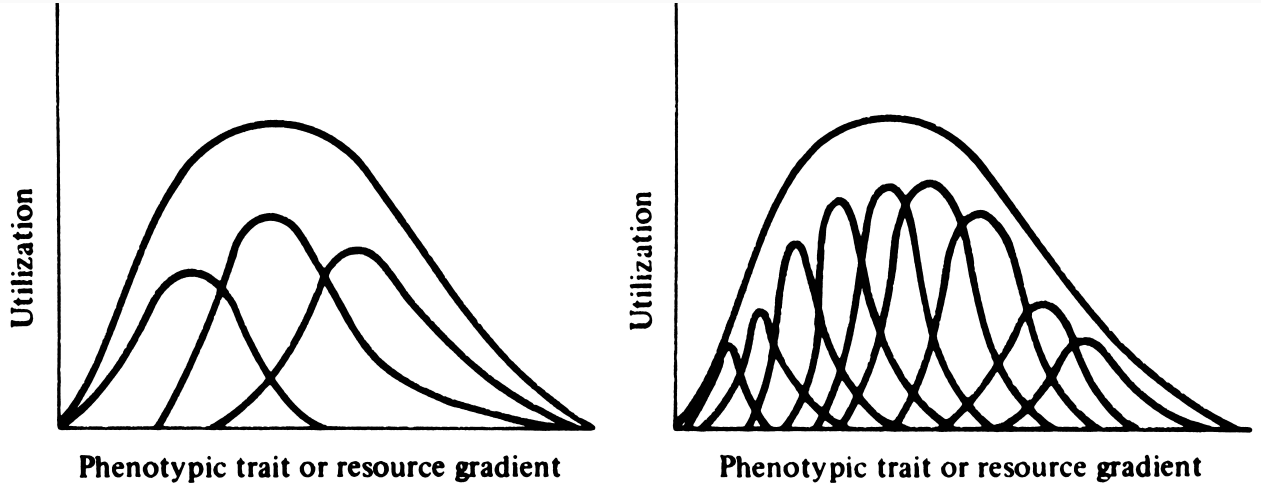


Source: Fox (1981)

Intra-specific niche breadth

The niche breadth of a population is governed by the individual niches of the individuals that make up the population.

The same factors that govern interspecific dynamics in niche breadth play out intra-specifically as well.



Source: Pianka (2000)

Take home messages

The niche concept provides a framework for understanding species' place in the natural world, how species exist and co-exist, and for making testable predictions about response to competition, habitat quality, environmental change, specialisation, etc...

Resource availability (μ) and predictability (σ^2) are expected to govern when specialist vs. generalist strategies are favourable.

Individual niches are nested in population niches, which are nested in species niches, etc... So scale is important.

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