Specialising on Change Part 5: Correlative effects

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Biol 417: Evolutionary Ecology

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Housekeeping & Review

Housekeeping

- No office hours next week.

Review

We have been covering how specialising on predictable environmental change via migration, dormancy, burrowing, storing energy reserves, moulting, etc... allows species to capitalise on niche space that gets opened up by environmental change.

... but it also places species down certain evolutionary paths, opening up some doors, closing others, and generating new challenges (e.g., reliance on energy reserves, exposure to variable weather, increased predation risk during dormant periods, seasonal mating opportunities, migrating over large distances, etc...).

Today will discuss some of the consequences of adaptations for specialising on predictable environmental change.

Adaptations to Change

We have seen how species respond to change over two timescales:

Ecological

Leverage behavioural plasticity to overcome challenges.

Benefit: More immediately accessible, better suited to short term stochasticity.

Cost: Limited in scope.

Evolutionary

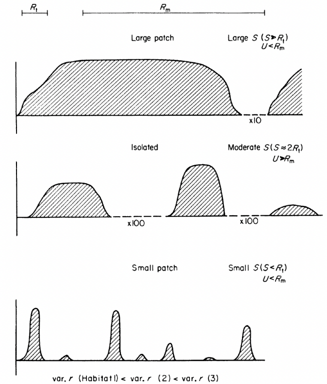
Modify genomes to better match new conditions.

Benefit: Takes generations to occur, but can allow adaptations out of the range of behavioural plasticity.

Cost: Change in trait values can impose constraints in other aspects of a species' ecology.

Correlative Effects of Migration

Migration



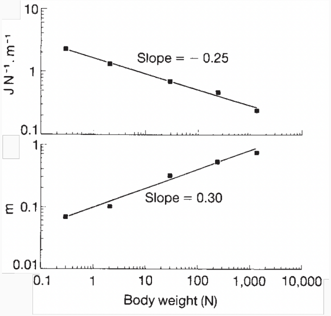
Southwood (1977)

Migration requires that animals be able to efficiently move between patches.

Evolution will favour traits that increase vagility (R_t and R_m).

Can you think of any adaptations that increase vagility?

Transport costs



Kram & Taylor (1990)

Source: CBC

Moving across large distances is energetically costly.

For transportation by walking, larger animals with longer legs and step lengths have lower energetic costs per g (Kram & Taylor, 1990).

For walking migrants, large body sizes and long legs are favoured by selection.

Cursoriality favours long, thin limbs with elbows designed like hinges because walking involves lots of front/back bending with little rotation (Samuels *et al.*, 2013).

Source: CBC

Source: Wikipedia

Hinge like joint morphology also supports larger body sizes than more flexible (supinated) joints (Samuels *et al.*, 2013).

Cursoriality cont.

Source: CBC

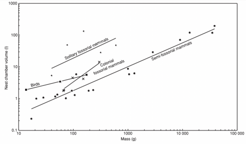
Source: Wikipedia

Limb dexterity and locomotion are conflicting functions (Andersson, 2004).

Selection for cursoriality and long limbs allows for migrants to cover large distances, but leaves them incapable of carrying out activities that require dexterity (digging, climbing, object manipulation, grappling, etc...).

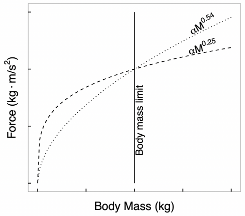
Correlative Effects of Burrowing

Burrows can provide animals with microclimates that improve survival, growth, and reproduction, but constructing a burrow is energetically expensive and increases with body size.



Source: White (2005)

The energetic costs of burrow construction increases with body size (White, 2005).



Source: Noonan (2015)

The energetic cost of digging scales with body size with an exponent of 0.54, wheres the amount of muscular force available scales with an exponent of 0.25 (Noonan, 2015).

As a consequence, small body size is selected for in burrowing species (Nevo, 1999).









Burrowing and body size

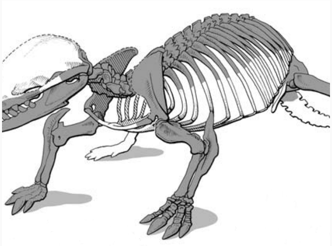
Small animals have greater energetic expenses per gram than large animals (Brown *et al.*, 1993).

Small animals can't store as much body fat per gram as large animals, meaning they can't survive long periods of dormancy (Lindstedt & Boyce, 1985).

The energetic costs of locomotion per gram increase as body size decreases, meaning they can't move over large distances efficiently (Kram & Taylor, 1990).

Burrowing and limb morphology

Burrowing selects for thick, supinated limbs with think humeri, elongated ulnae, and short digits to provide stable elbow joints and the force needed to dislodge soil without experiencing physical damage (Samuels *et al.*, 2013).



Source: National Geographic

Because limb dexterity and locomotion are conflicting functions, burrowers typically have poor locomotion and lumbering movement (Andersson, 2004).

Digging and digit morphology

Although scratch diggers have supinated limbs, selection favours stable joints and short digits.

European mole *(Talpa europaea)*

Source: Wikipedia

Arboreality requires supinated limbs, but also flexible joints and long digits.

Brown capuchin *(Cebus apella)*

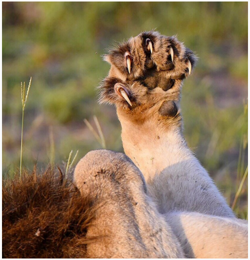
Source: Fine Art America; Millard H. Sharp

Climbing and digging are conflicting functions and scratch diggers are typically poor climbers (Andersson, 2004).

Scratch digging and claw morphology

Scratch digging requires strong flat claws for dislodging rocks and soil without breaking.

Grappling predation requires thin, sharp, curved claws for hooking onto prey.



Source: Quora

The two claw morphologies are incompatible with one another (i.e., burrowing limits predation mechanisms and predation limits burrowing capacity).

The burrow microclimate

We learned how burrows provide stable temperatures that improve growth, survival, and fitness, but living underground also comes with challenges:

- High humidity (encourages bacterial growth).
- High ecto/endo parasite concentrations.
- Low oxygen and high CO_2.
- Dusty (can accumulate in eyes and lungs).
- Dark (maintaining eyes is wasteful).
- Prone to flooding or collapse if poorly designed/placed.

Burrowing species need to develop a suite of secondary adaptations to successfully survive and reproduce underground.

Correlative Effects of Dormancy

Seasonal Mating/Breeding

Many species rely on dormancy to survive through unfavourable periods. This conserves energy, but means all other activities need to come to a halt.

Challenge: Best time to give birth is immediately at the start of the favourable period, but mating and gestation can reduce the amount of time offspring have to grow.

Solution (i): Delayed implantation. After mating, fertilized ova enter embryonic diapause at the blastocyst stage.

Solution (ii): Superfetation. Oestrous cycle may continue during embryonic diapause, allowing conception during pregnancy.

Seasonal Mating/Breeding cont.

Superfetation and delayed implantation allows animals to precisely time the birth of offspring with seasonal availability in resources.

Because mating, gestation, and birth are not continuous (Yamaguchi *et al.*, 2006):

- Mating can happen at any time in the year (lekking and rutting behaviour is unlikely).
- Mate guarding is inefficient (territoriality less likely).
- Polyandry (female has more than one male mate) is facilitated.
- Female fitness can increase via a reduced risk of infanticide by males through paternity confusion.

Social dynamics are completely altered by seasonal breeding.

Predating on seasonal specialists

Preying on migrants

Predators that prey on migratory species need to catch prey that are large, fleet-footed, and can easily cover large distances.

This favours large body sizes and cursorial limb morphologies (with correlative effects on the rest of their ecology).

Source: Neal Weisenberg, Outdoor Canada

Source: YouTube

Preying on burrowers

Predators that prey on burrowing species need to catch prey that live underground in burrows, with sometimes complicated tunnel systems.

This favours small, elongate body sizes and short limbs for lithe pursuit, or digging power for prey excavation (with correlative effects on the rest of their ecology).

Least weasel *(Mustela nivalis)*

Honey badger *(Mellivora capensis)*

Source: Wikipedia

Take home messages

Specialising on predictable environmental change via migration, dormancy, burrowing, storing energy reserves, moulting, etc... allows species to capitalise on otherwise open niche space.

... but doing this efficiently this requires specialised adaptations that generate new challenges and impact many other aspects of a species' ecology (even driving the evolution of other species).

Biogeography and environmental conditions play major roles in shaping species' ecology and provide important context for understanding why species' occupy certain niche spaces vs others.

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