Specialising on Change Part 2: Dormancy

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Biol 417: Evolutionary Ecology

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Housekeeping & Review

Housekeeping

- Nothing from me.

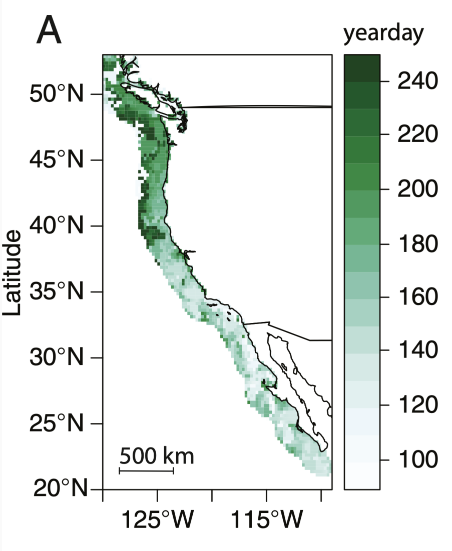
Review

Last lecture we covered how environmental change opens up niche space.

If the changes are predictable in space and/or time, species can specialise on this change, and this can happen over evolutionary or ecological timescales.

We focused primarily on ecological timescales (migration in particular). Behavioural adaptations to change are immediately accessible and can provide a boost to fitness, but they're not necessarily efficient and can be refined over evolutionary timescales.

Migration



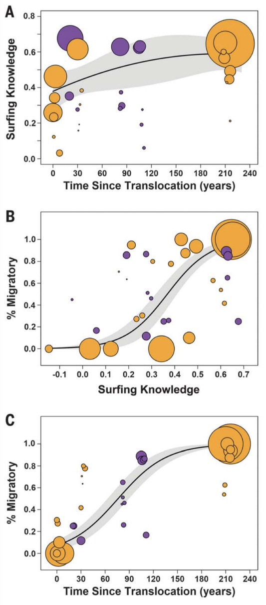
(Abrahms *et al.*, 2019)

In the Pacific Ocean, blue whales surf seasonal green ups in chlorophyl (krill).

Abrahms *et al.* (2019) used a decade worth of tracking data and computer simulations to show that surfing alone wasn't efficient (can follow noise instead of signal).

Only when she included memory were the whales were able to optimally migrate along the spatio-temporal gradient in productivity.

Cultural transmission

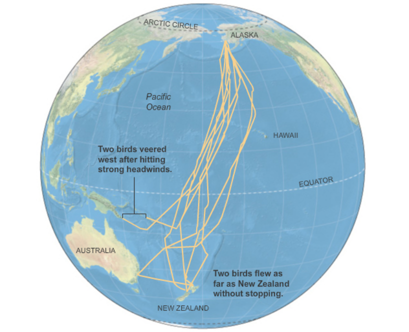


(Jesmer *et al.*, 2018)

Newly translocated populations don't migrate (no purely genetic effect).

Populations with a collective knowledge on how to surf local green waves will migrate.

It takes generations to build up that knowledge, which can only happen if learning is passed on from generation to generation.

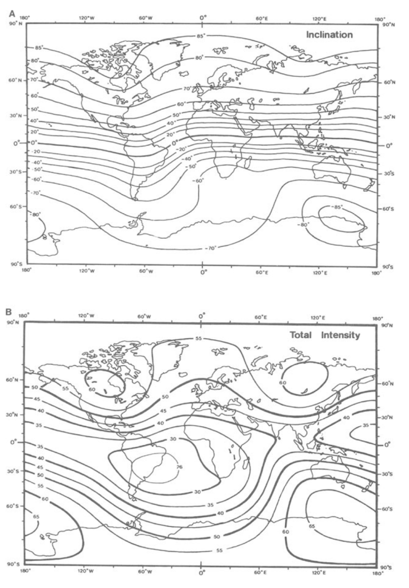


source: Animal Navigation

Birds migrate over substantial distances with few landmarks.

Missing a target destination can be energetically costly and leave them out of sync with the rest of the population (reproductive costs).

Navigation cont.



(Wiltschko & Wiltschko, 1988)

Over evolutionary timescales they have evolved mechanisms for detecting local changes in the earth's magnetic field to orient themselves and making their migrations more efficient (faster, further, more efficient routes).

Cryptochrome 4

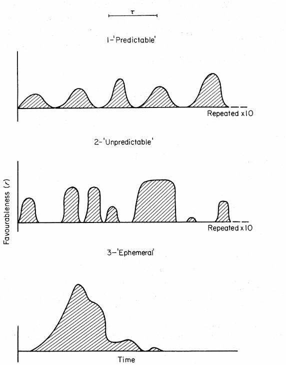
eBird

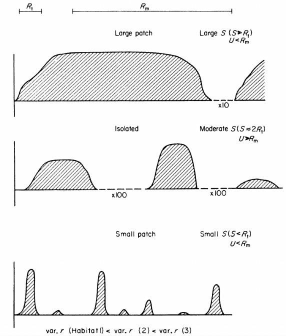
Cryptochrome 4 is a protein located in the retinas of the birds.

Xu *et al.* (2021) found that cryptochrome 4 (CRY4) from the night-migratory European robin (*Erithacus rubecula*) is magnetically sensitive in vitro, and more so than CRY4 from non-migratory chickens (*G. gallus*) and pigeons (*C. livia*).

Southwood (1977)

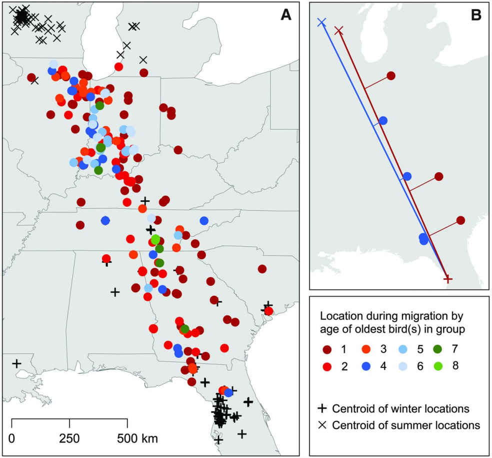
In general, adaptations that increase $\frac{R_m}{U}$ should be favoured by selection (faster, further, more efficient, etc...).



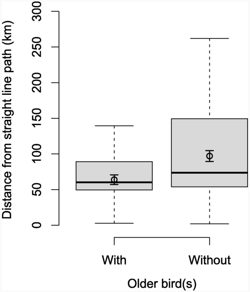


Southwood (1977)

Increase $\frac{R_m}{U}$



(Mueller *et al.*, 2013)



(Mueller *et al.*, 2013)

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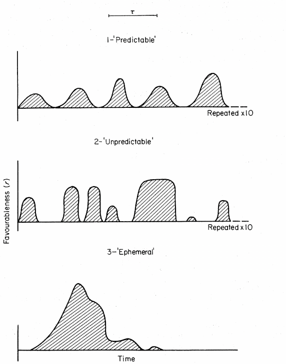
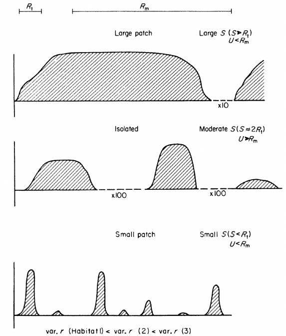
What about τ?





Southwood (1977)

Southwood (1977)

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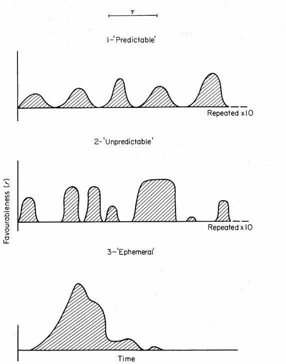
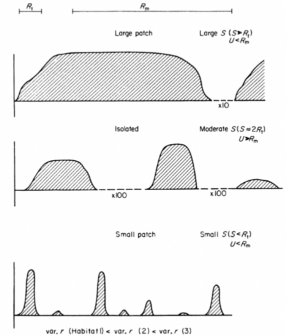
What about τ? Hasn't been studied yet...



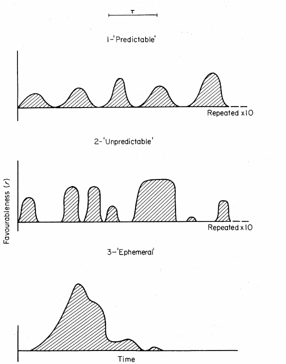


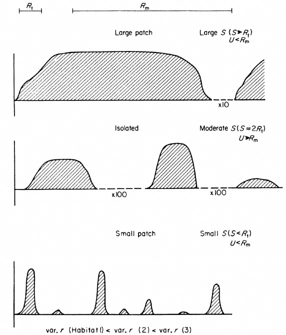
Southwood (1977)

In situ adaptations

In situ adaptations

Migration leverages species' vagility (R_m) to overcome local unfavourability by moving somewhere with better conditions.

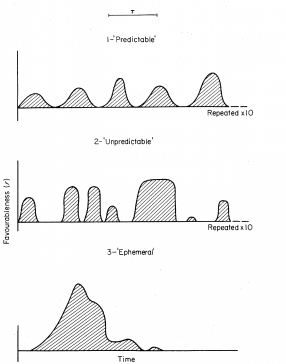


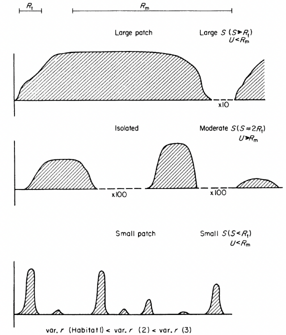


Southwood (1977)

In situ adaptations

When lifespans (τ) permit, species can also evolve adaptations that allow them to 'ride out' unfavourable period(s) *in situ*.





Southwood (1977)

In situ adaptations

Behaviour can enable species to cope *in situ* to some degree...

Denning

Source: slate.com

Burrowing

Source: plunketts.net

Food caching

Source: www.newyorkupstate.com

... but is unlikely to be efficient without evolutionary adaptations.

- Fat storage
- Dormancy
- Cope with anoxia

- Strong forelimbs
- Claws/Teeth
- Dormancy

- Memory
- Food pouches

Dormancy

Env. Change and Niche Space cont.

Dormancy is a period in an organism's life cycle when growth, development, and physical activity are temporarily stopped.

Dormancy can take many forms:

- Torpor
- Hibernation
- Aestivation
- Diapause
- etc...

The general idea is that biological activity is put on pause so that energy can be conserved during times of scarcity.

Pred. vs. cons. dormancy

Organisms can synchronise entry into dormant phases with target environmental conditions through **predictive** or **consequential** means.

Predictive

Predictive dormancy occurs when organisms enter dormancy **before** the onset of adverse conditions (e.g., plants using photoperiod and decreasing temperature to predict the onset of winter).

Consequential

Consequential dormancy occurs when organisms enter dormancy **after** adverse conditions have arisen (typically occurs in unpredictable habitats).

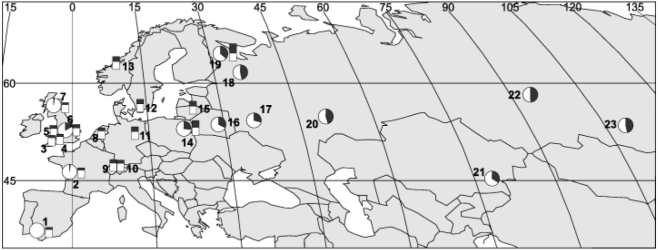
Torpor

Torpor is a state of decreased physiological activity, usually accompanied by reduced body temperature (5-35 °C) and metabolic rate (50 - 95%).

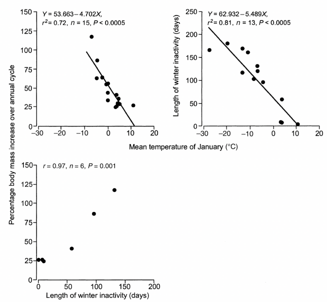
The evolution of torpor likely accompanied the development of homeothermy. Homeothermy allows animals to remain active in locations where other species can not, but comes with a high energetic cost. Torpor gives species control over the extent to which homeostasis is maintained (Geiser *et al.*, 2017; Geiser, 2020).

Flexible and can be switched on and off as needed and is primarily **consequential**.

European badgers



Kowalczyk *et al.* (2003)



Kowalczyk *et al.* (2003)

European badgers (*Meles meles*) exhibit flexible torpor that depends on winter severity (e.g., 0 days in Spain vs. 180 days in Russia).

Tied to earthworm abundance rather than cold per se.

European badgers cont.

Noonan *et al.* (2014) studied the onset of torpor in a population of badgers in the U.K.

Under conditions where energy gains are likely (mild + humid), badgers are more active.

Under conditions where energy loses are likely (cold + dry), badgers are less active.

Under energetically challenging conditions, fat badgers are less active than thin badgers (can enter torpor and hold out).

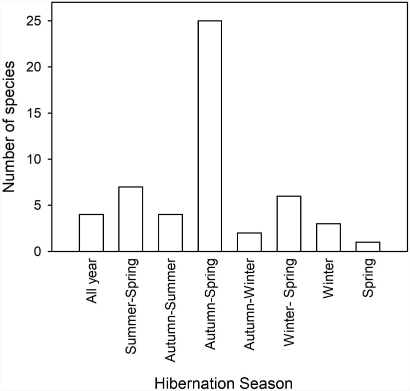
Hibernation

Like torpor, hibernation is a state of decreased physiological activity accompanied by reduced body temperature (below 0°C in arctic ground squirrels) and metabolic rate.

Torpor and hibernation likely form a continuum that rely on similar mechanisms (Geiser *et al.*, 2017; Geiser, 2020).

Generally inflexible, typically tied to seasonal changes in environmental conditions, and is primarily, but not necessarily, **predictive** (we will come back to this later in the course).

Hibernation cont.



Geiser (2020)

Seasonal hibernation typically occurs in the Autumn-Spring period, but can be tied to any season (depending on the species' needs).

A hibernation season lasting for more than 6 months is most common (Geiser, 2020).

Mostly occurs in sciurid rodents like ground squirrels, chipmunks and marmots (Geiser, 2020).

Aestivation

Aestivation is a state of dormancy that is entered in response to high temperatures and arid conditions with an ultimate goal of conserve energy and retaining water.

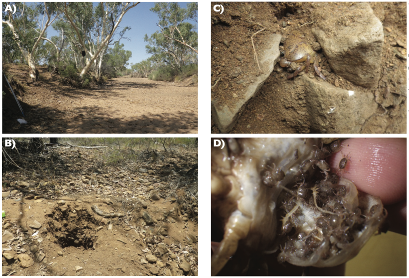
Unlike torpor and hibernation aestivation is a “light” state of dormancy that can be rapidly reversed.

Aestivation is not restricted to homeotherms and the physiological processes is nearly identical to hibernation (Storey & Storey, 2012).

Very flexible and can be switched on and off as needed and is primarily **consequential**.

Inland crab

Source: Jeremy Buckingham/Flickr



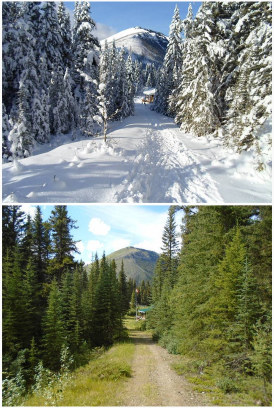
Waltham (2016)

Northern Australia is characterised by wet and dry seasons.

During the dry seasons, rivers are broken up into a series of disconnected waterholes and riverine species need to cope with these conditions.

The inland crab (*Austrothelphusa transversa*) retreats into burrow and aestivates until rivers flow again (Waltham, 2016).

Abscission and dormancy



Source: http://skierbob.ca

Plants have to cope with changing conditions *in situ*.

The leaves of deciduous trees are costly to maintain and would result in a net energetic loss if kept during cold, low-light periods, or hot dry periods.

Leaf loss allows plant to optimise their energetic balance (also reduces wind resistance in winter).

Inflexible and governed by physiological mechanisms that are tied to seasonal change (e.g., light levels and chlorophyll concentrations). Very much **predictive**.

Take home messages

Behavioural adaptations to change are immediately accessible, but are not necessarily efficient on their own.

If the changes are predictable, natural selection can produce adaptations that allow species to specialise on this change.

Entering a state of dormancy (reduced metabolic activity) to conserve energy and ‘ride out’ unfavourable periods is common adaptation that is seen across all taxa.

Dormancy on its own is useful, but can be refined when paired with other adaptations, more on this next lecture...

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