Amphibian ecology and evolution

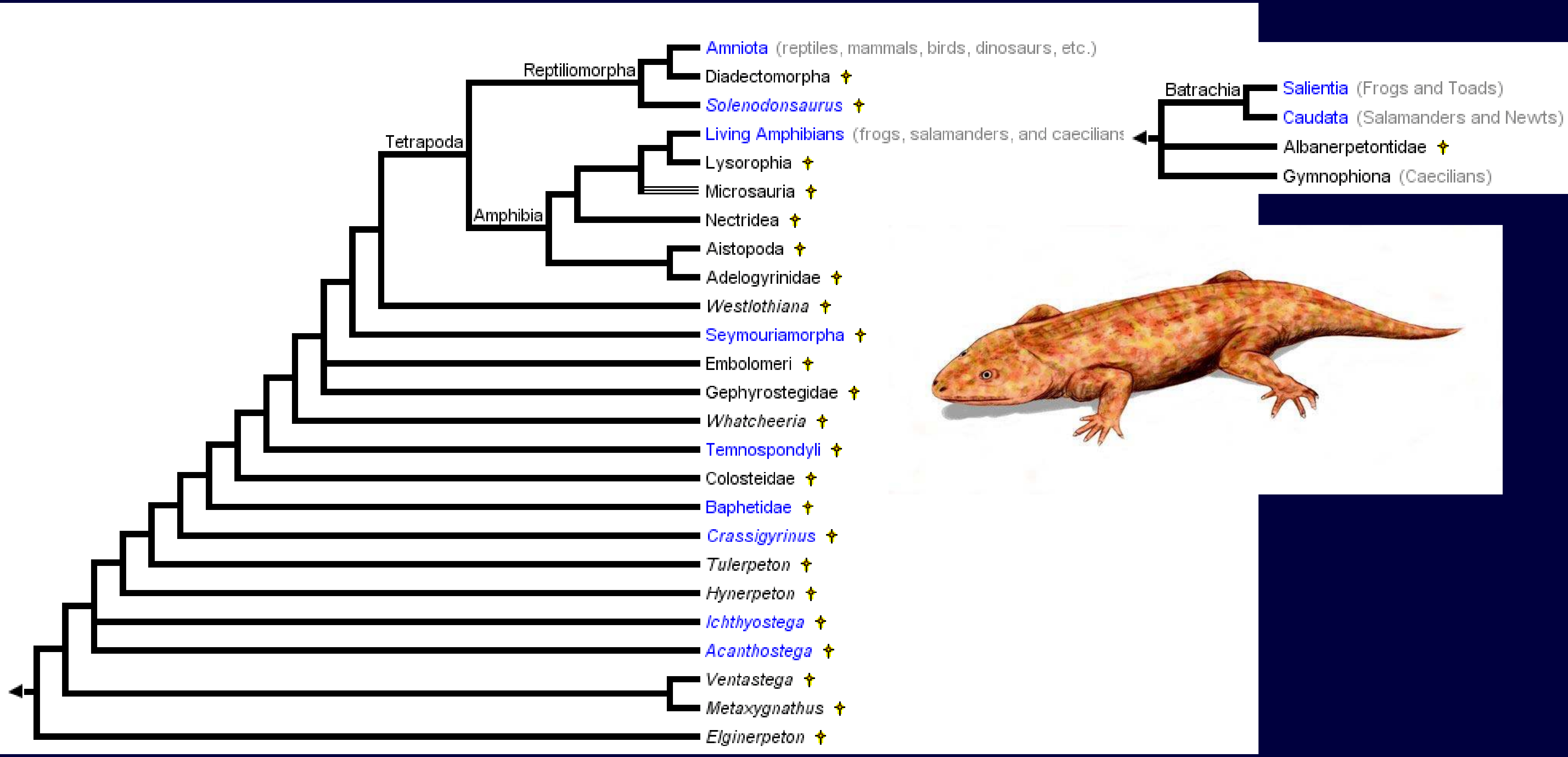
Limnology

Lecture 14

Outline

- Amphibian diversity
- Amphibian life histories
- Evolution

Phylogeny



Reptiliomorpha
Tetrapoda
Amphibia
Amniota (reptiles, mammals, birds, dinosaurs, etc.)
Diadectomorpha
Solenodonsaurus
Living Amphibians (frogs, salamanders, and caecilians
Lysorophia
Microsauria
Nectridea
Aistopoda
Adelogyrinidae
Westlothiana
Seymouriamorpha
Embolomeri
Gephyrostegidae
Whatcheeria
Temnospondyli
Colosteidae
Baphetidae
Crassigyrinus
Tulerpeton
Hynerpeton
Ichthyostega
Acanthostega
Ventastega
Metaxygnathus
Elginerpeton
Batrachia
Salientia (Frogs and Toads)
Caudata (Salamanders and Newts)
Albanerpetontidae
Gymnophiona (Caecilians)

First amphibians

375 million years ago

Major groups

Anurans (frogs)
four legs as adults
no tail as adults

Caudata (newts and salamanders)
four legs as adults
a tail as adults

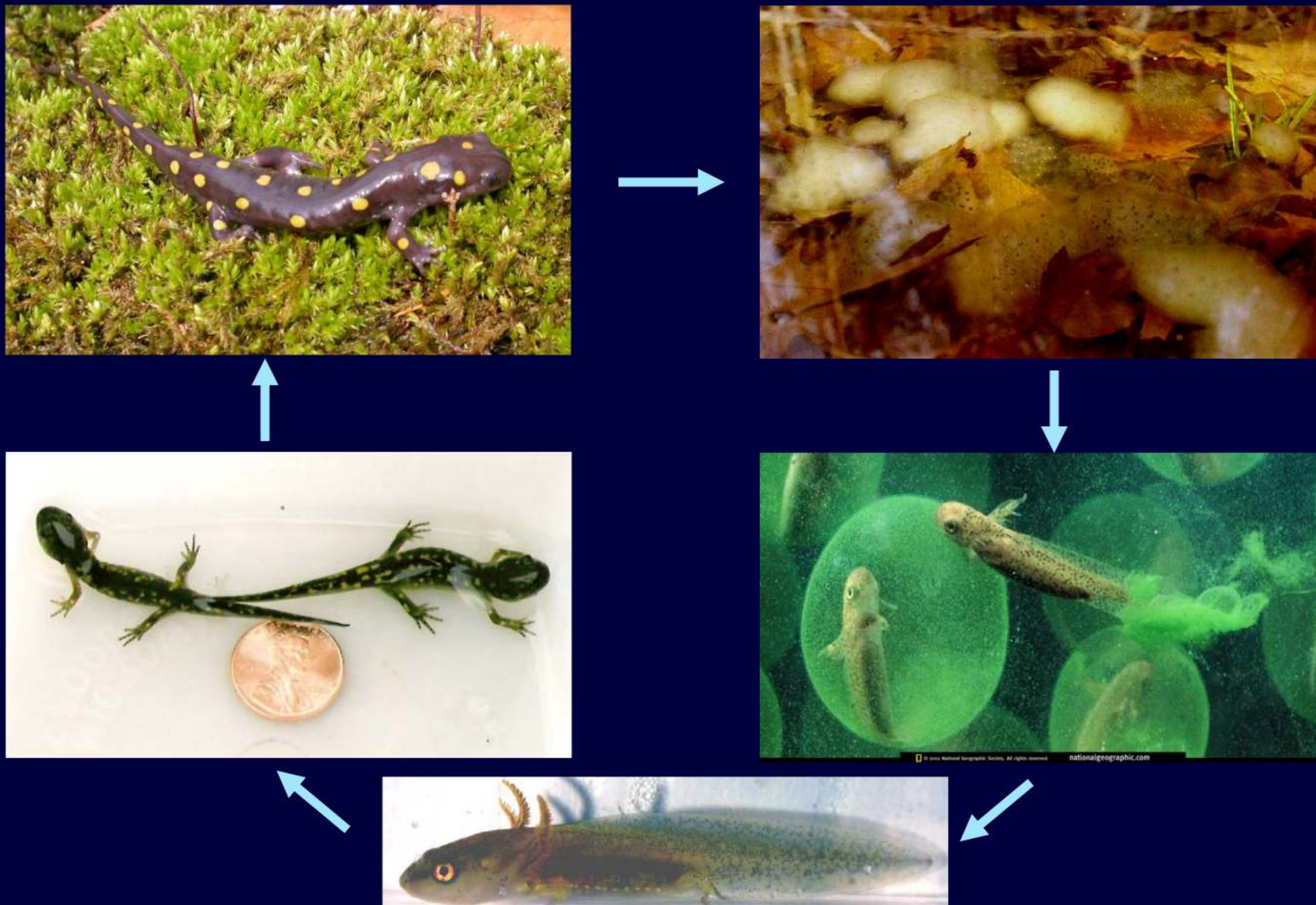
Gymnophiona or **Caecilians** (rubber eels)
no legs
most have no tail

Size differences !

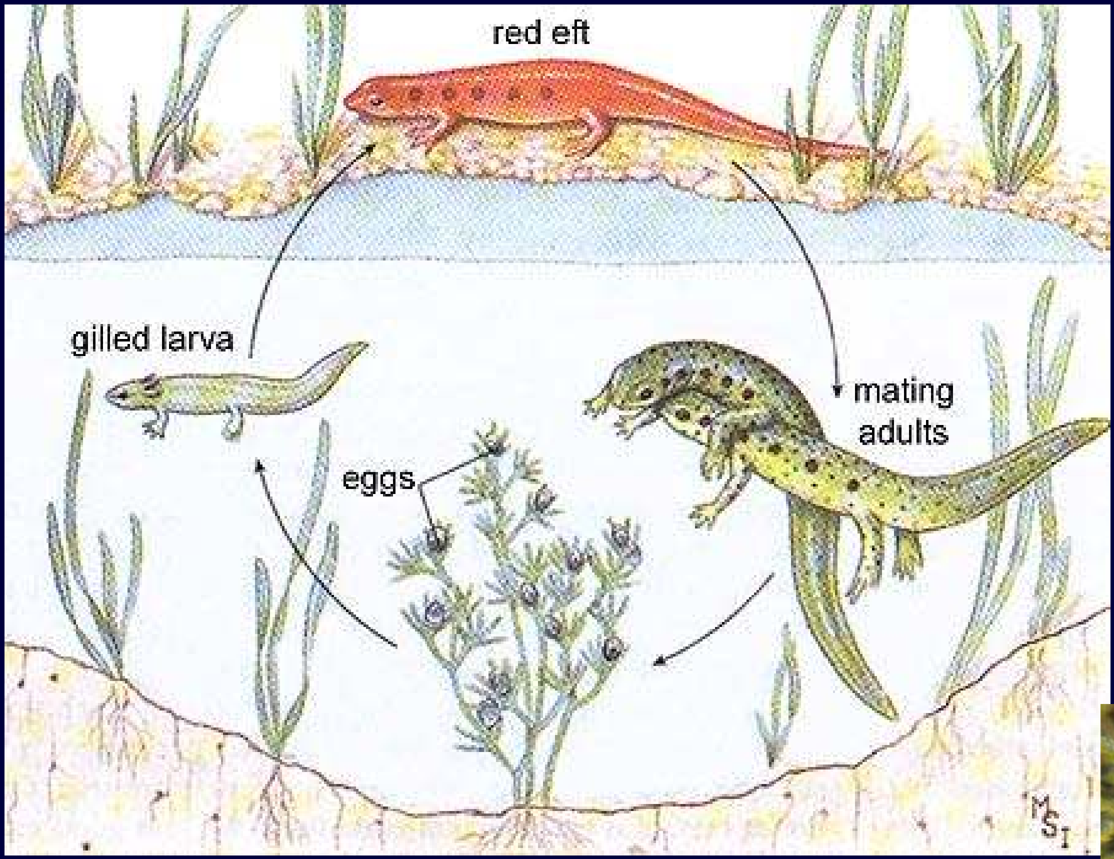
Japanese Giant Salamander

Patch-nosed salamander

Spotted salamanders (*Ambystoma maculatum*)



Newt life history



Facultative paedomorphosis

Tiger salamander –
metamorph and paedomorph

Terrestrial development

Slimy salamander –
Completely terrestrial

Marbled salamander –
Semi-terrestrial

Stomach development

Gastric brooding frog–
Turns off stomach acid

Complex life cycle

Risky – requires two suitable habitats

- High predation in aquatic environment

- High mortality during transitory stage

Why go into the water at all ?

No paedomorphic frogs?

Why go in the water at all?
Theory on complex life cycles

1. Transient, but plentiful, resource
   e.g., rapid decomposition of leaf matter in spring

2. Rapid growth over terrestrial environment

3. Especially filter-feeding tadpoles, efficient at small size

Wassersug 1975

Why leave the water at all? Theory on complex life cycles

1. Pond drying

2. Pond freezing

3.

When to leave the water?

Tradeoff between growth/mortality in water and land

Minimize mortality/growth (u/g) in two habitats

Take more risk in rapid growth environment

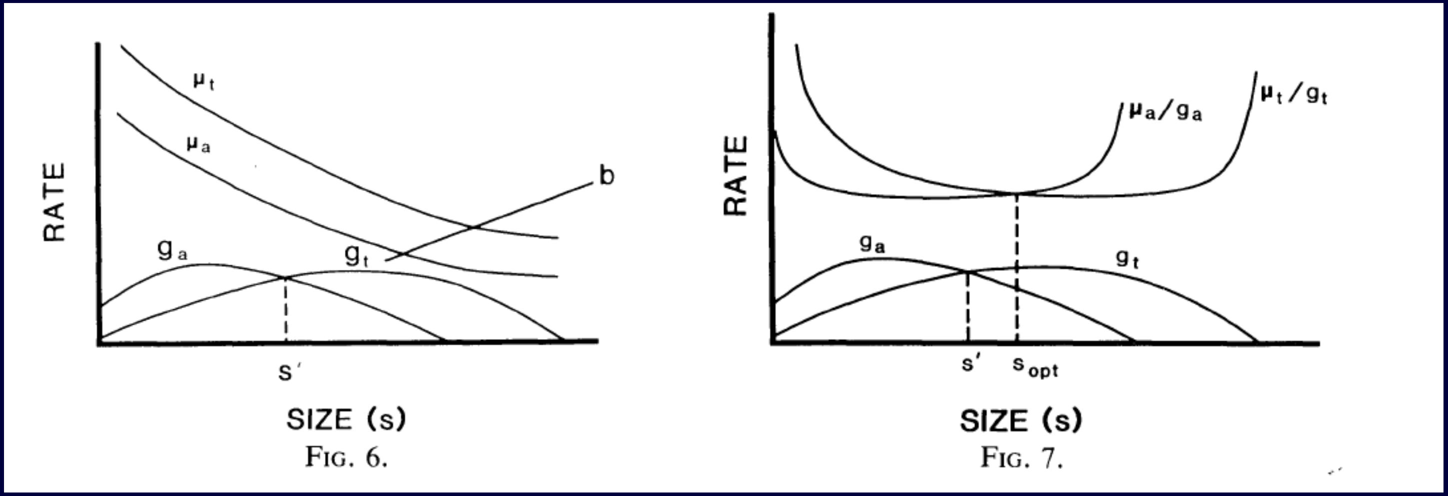


Fig. 6. Fig. 7.

Werner 1986

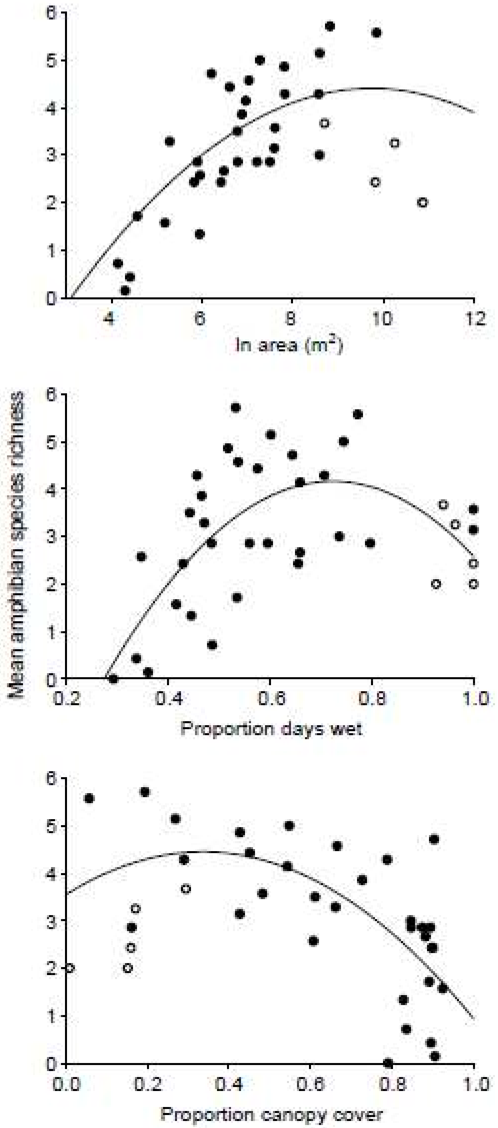


Fig. 3. Mean amphibian species richness of the E. S. George Reserve ponds as a function of pond area, hydroperoid and canopy cover. Closed symbols represent ponds lacking fish; open symbols represent ponds with fish (for three of these for the years before extirpation of fish). For area, a quadratic equation provided a significantly better fit than linear (quadratic; $R^2 = 0.56$, $F_{1,34} = 21.4$, $p < 0.001$; quadratic vs linear, $F_{1,34} = 9.3$, $p = 0.005$). This was also the case for hydroperoid (quadratic; $R^2 = 0.41$, $F_{1,34} = 11.6$, $p < 0.001$; quadratic vs linear, $F_{1,34} = 13.1$, $p < 0.001$), and canopy cover (quadratic; $R^2 = 0.40$, $F_{1,34} = 11.5$, $p < 0.001$; quadratic vs linear, $F_{1,34} = 6.1$, $p = 0.025$).

Determinants of amphibian diversity

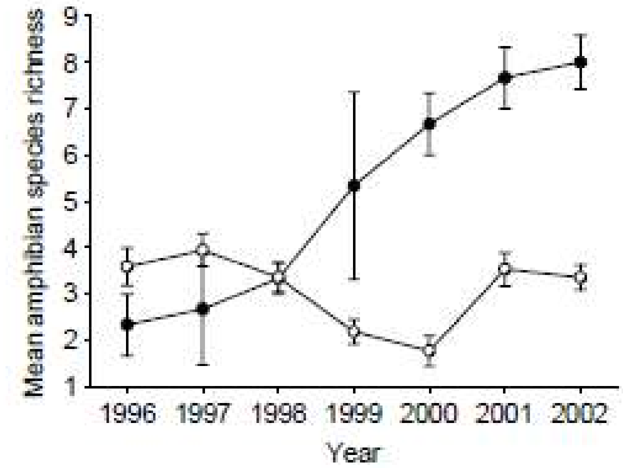
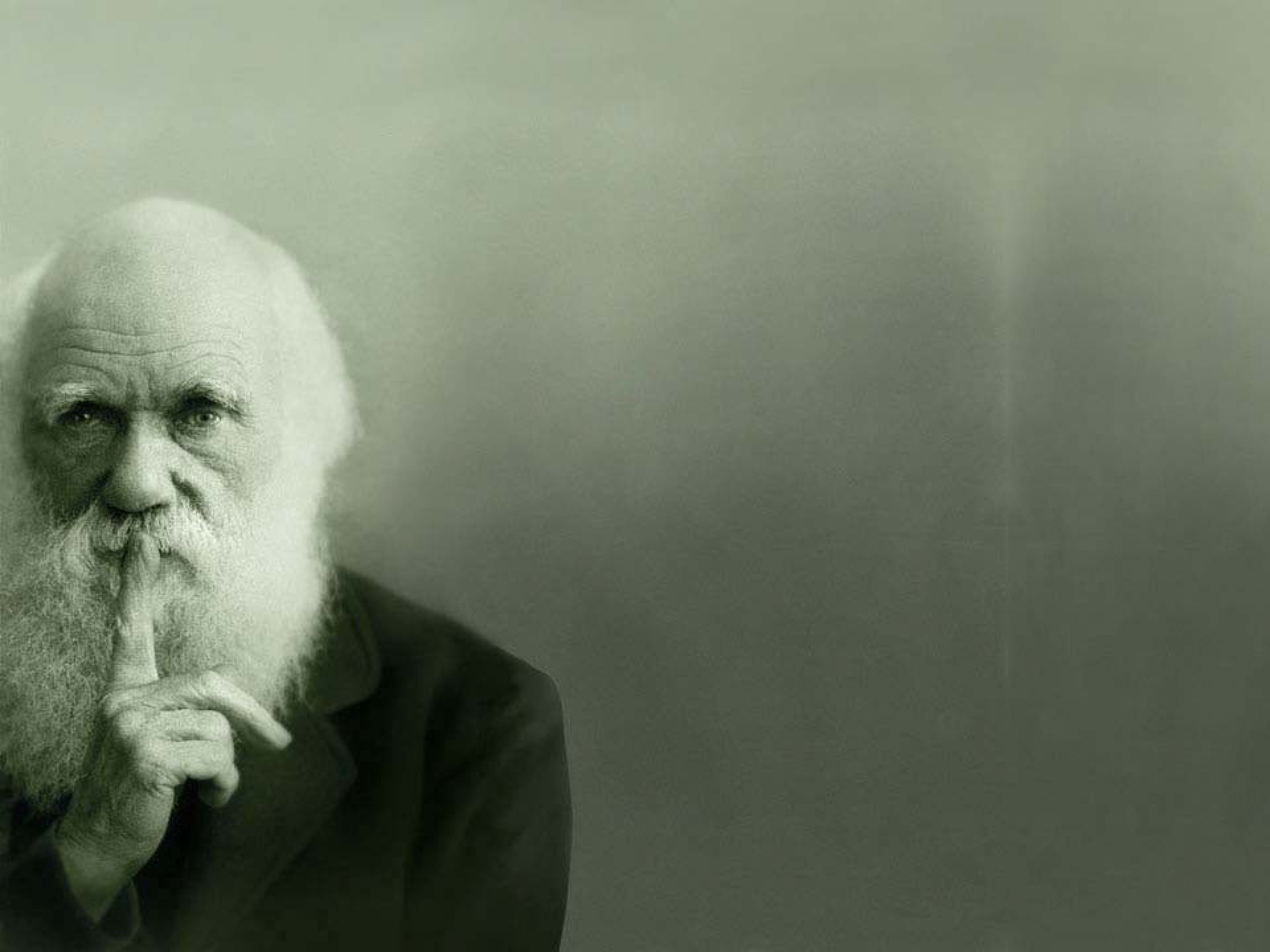


Fig. 4. Mean amphibian species richness of E. S. George Reserve ponds across years. Closed symbols represent ponds that lost fish in the fall of 1998 or during 1999 (West Marsh Dam Pond, Fishhook Marsh and Southwest Swamp); open symbols are all other ponds.

Loss of fish

Werner et al. 2007



Microgeographic adaptation to wetland light regimes

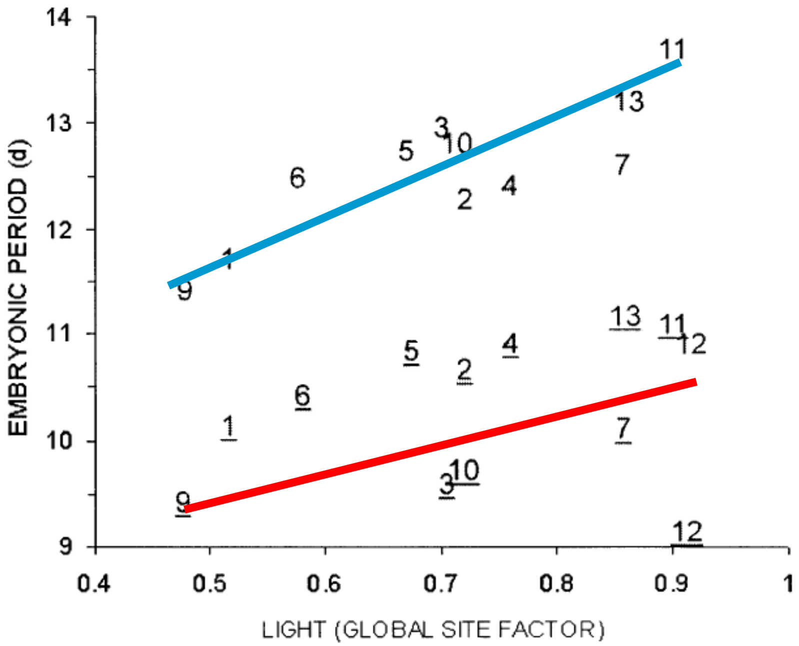
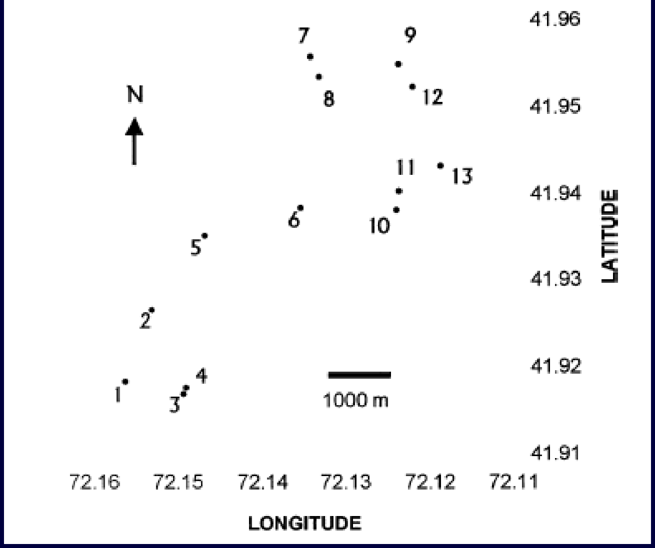


FIG. 3. Estimated embryonic period for wood frogs collected from 12 different wetlands and reared in low or high temperature incubators. Embryonic period is plotted against global site factor of the natal wetland. Global site factor is a measure of the light environment ranging from zero in total darkness to one in unobstructed, full sunlight. The response of embryos from each wetland is marked with a plain (low temperature) or underlined (high temperature) number that refers to the wetland numbers presented in Figure 1. Wetland no. 12 (Morse Bog) was identified as an outlier and excluded from statistical analyses except where indicated otherwise.

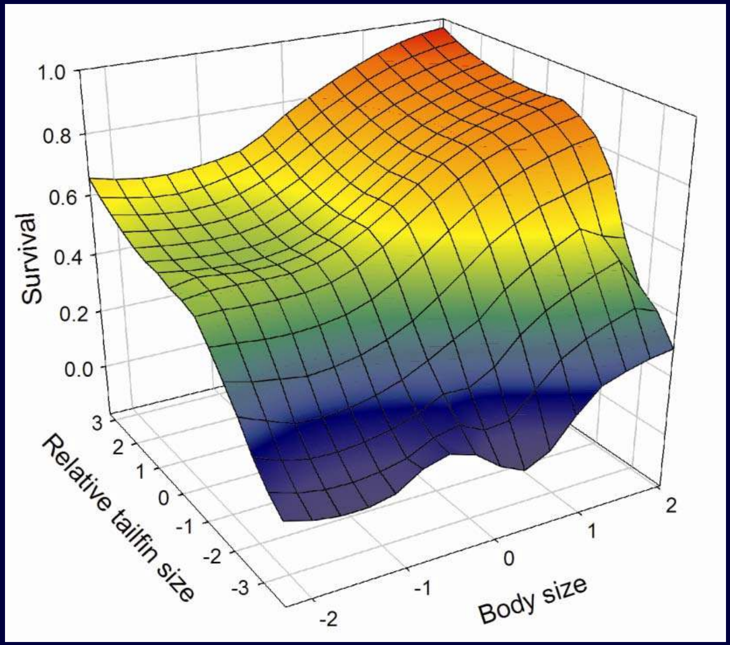


Countergradient selection – ramped up trait for org. in “poor” situation

Dominant predators differ in selection

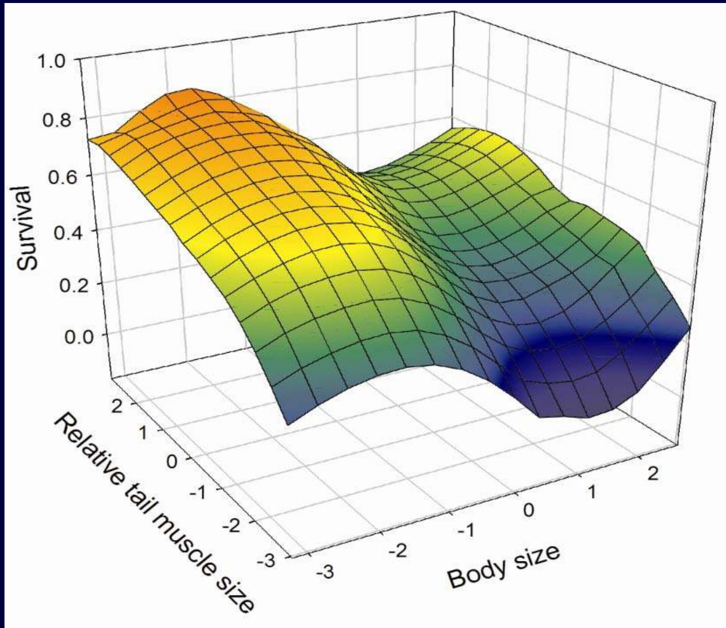
Gape-limited

Marbled salamander larva
Ambystoma opacum

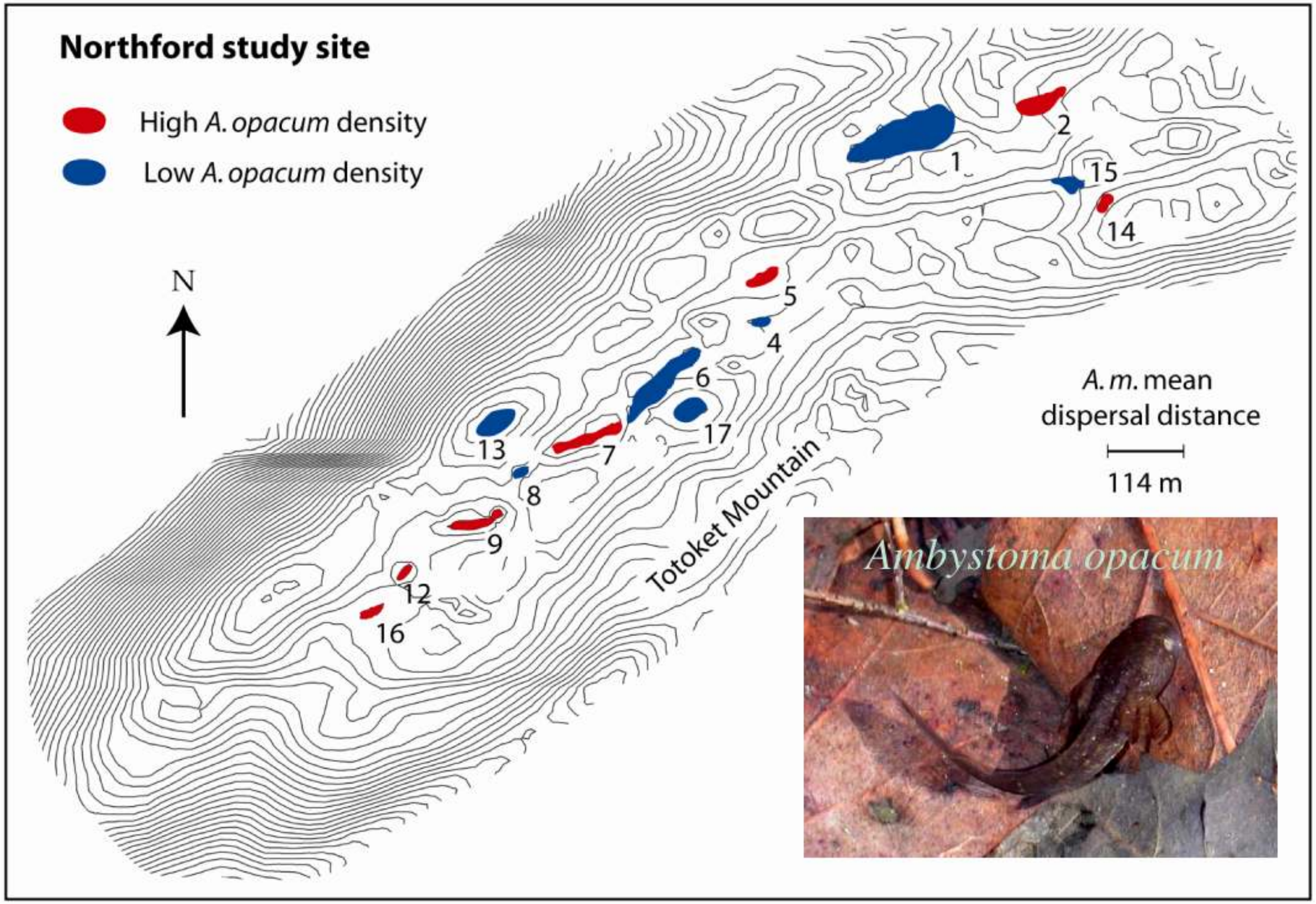


Gape-unconstrained

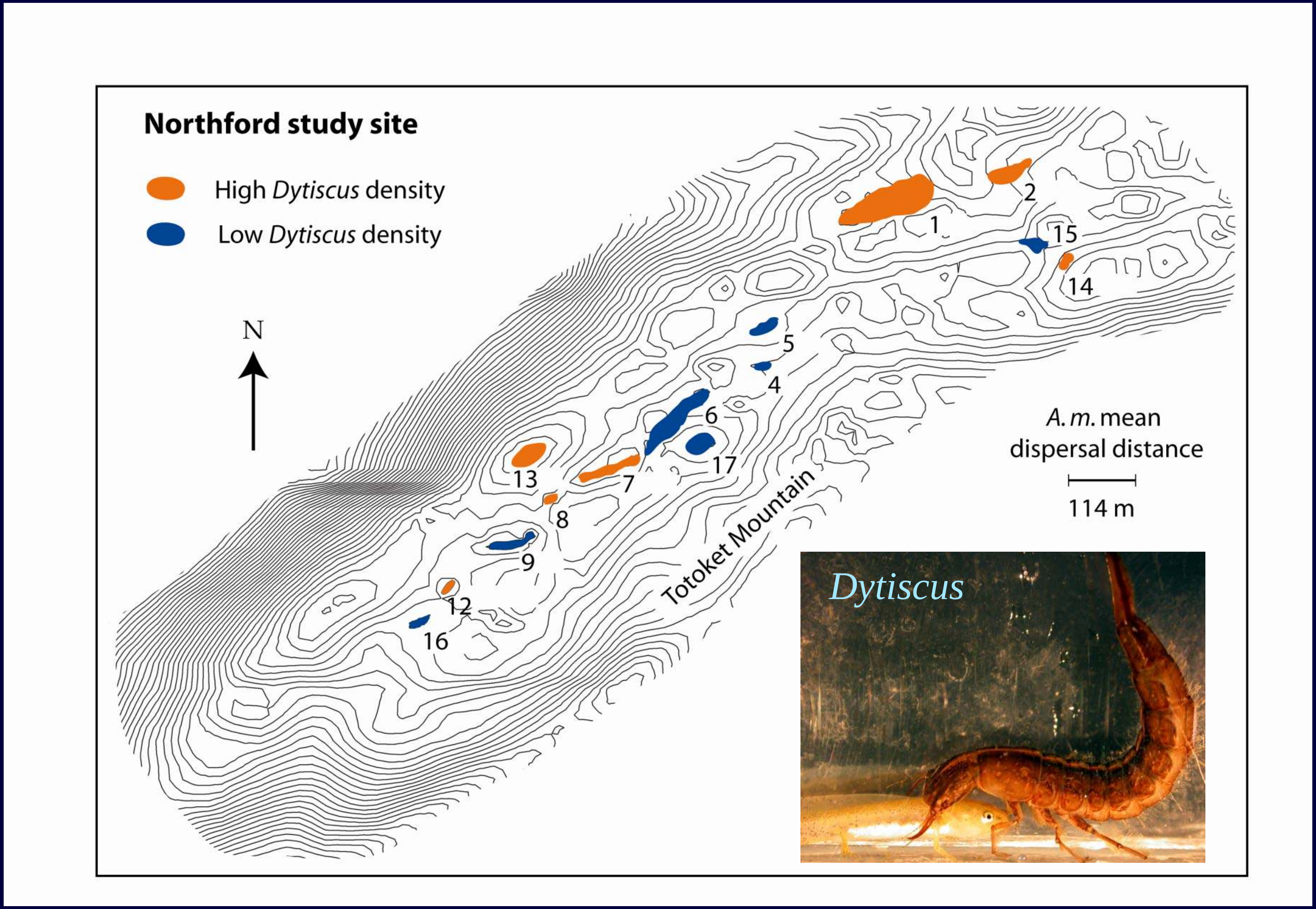
Diving beetle larva
Dytiscus



Local variation in predation risk



Local variation in predation risk



Local foraging adaptation

Do prey forage more intensely in ponds with high gape-limited (*A. opacum*) predation risk?

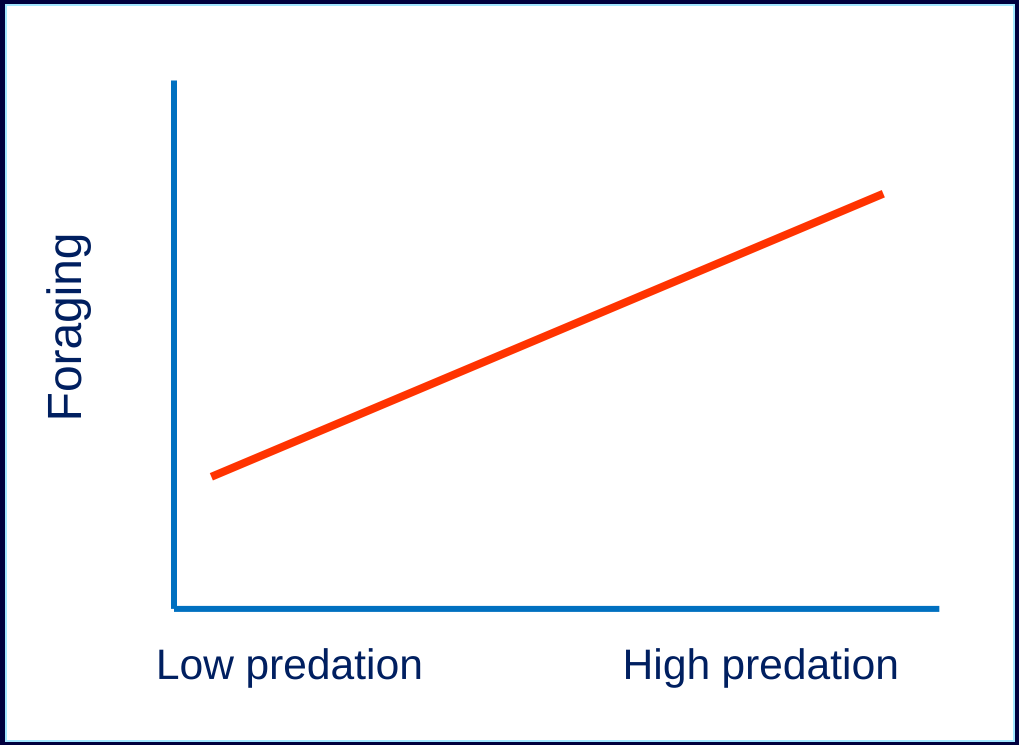
Experiment:

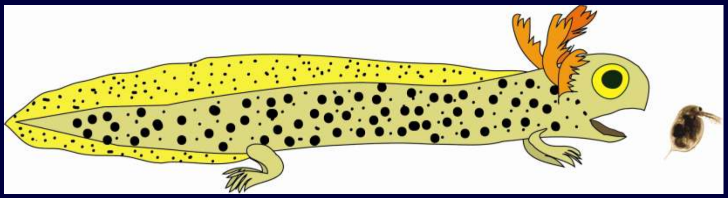
Common garden, lab

Exposed to *A. opacum* cues

5 siblings, 5 families, 10 populations

Local foraging microgeographic adaptations

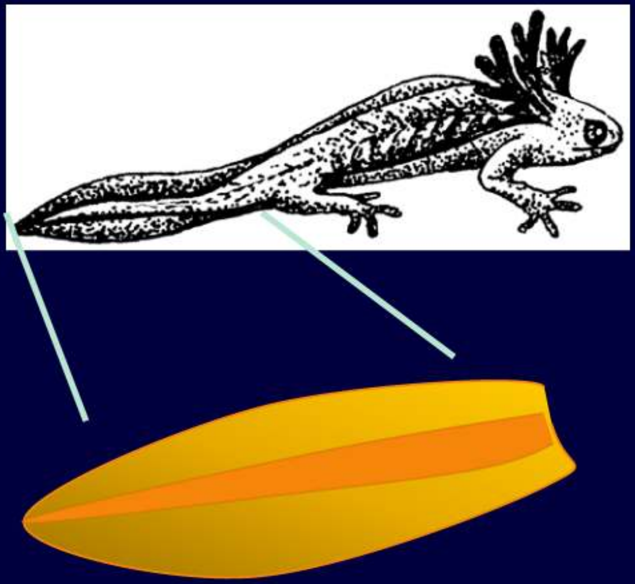




Foraging rate on zooplankton prey

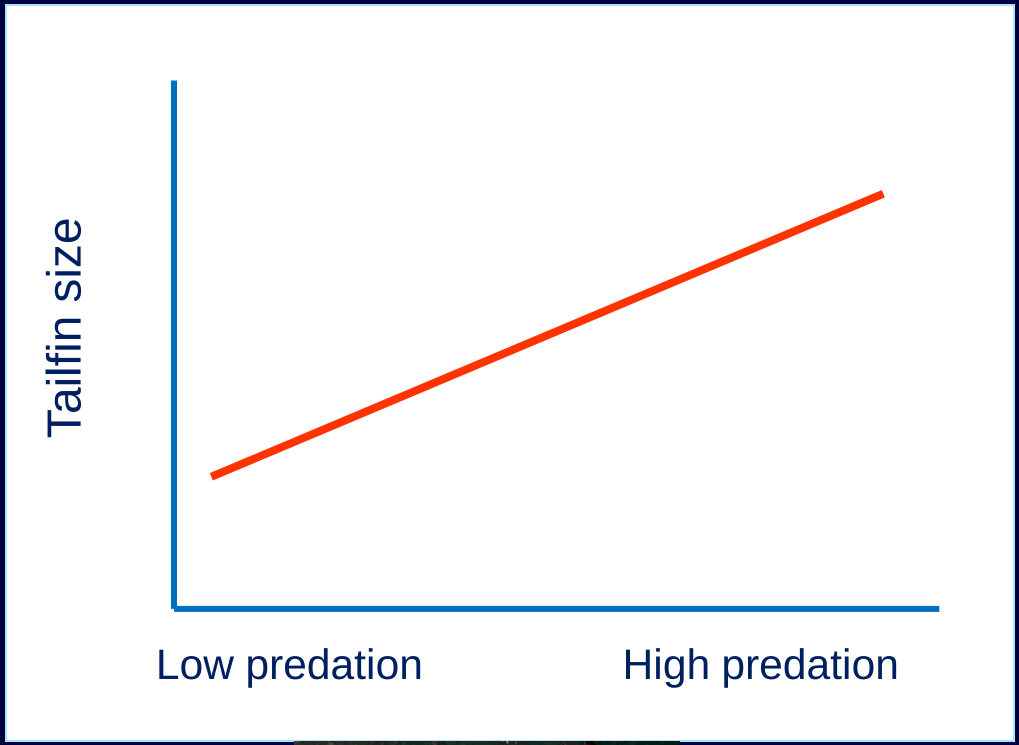
Urban 2007, *PNAS*

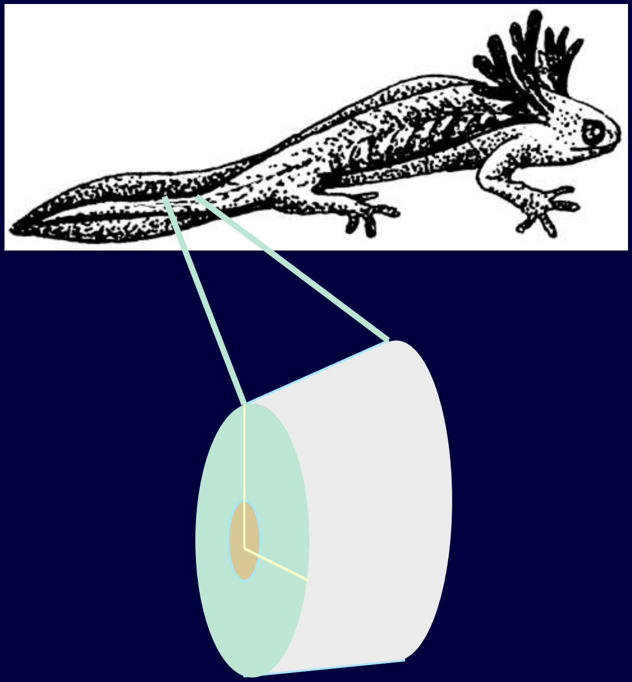
Local foraging microgeographic adaptations



Relative tailfin area

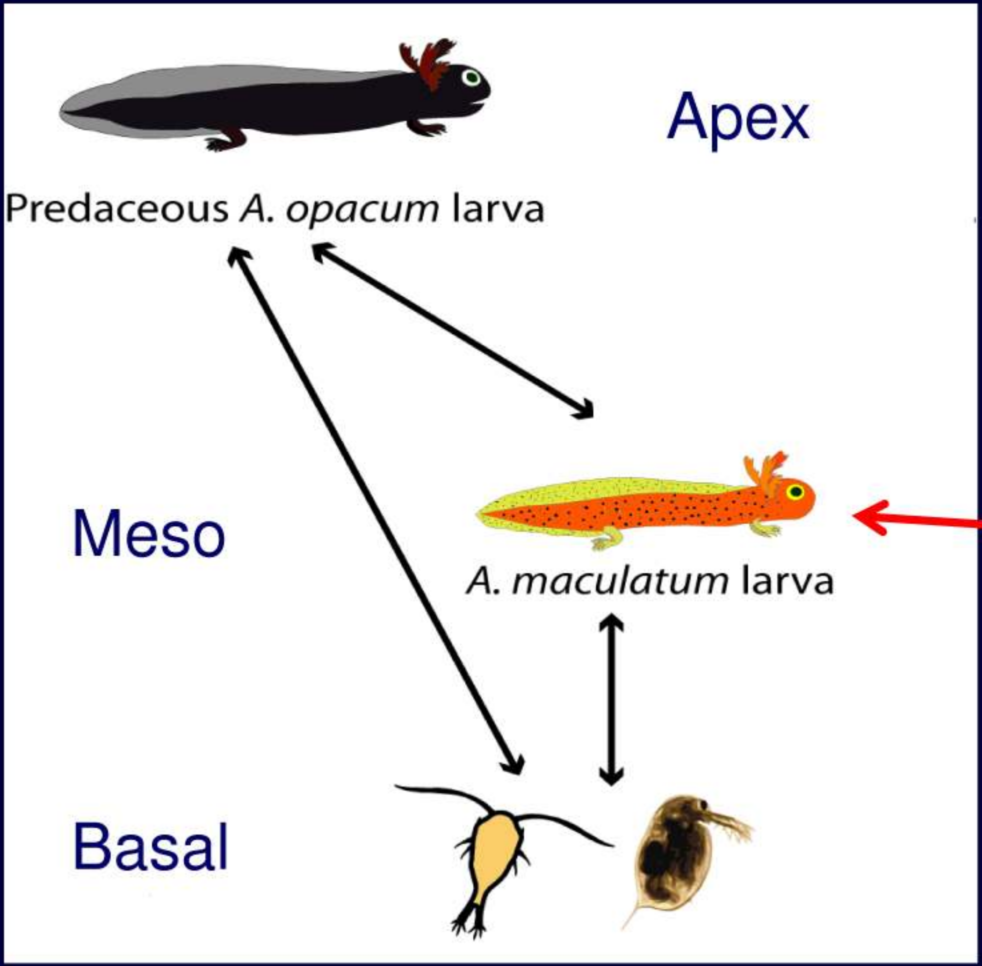
Local foraging microgeographic adaptations





Relative tail muscle cross-sectional area

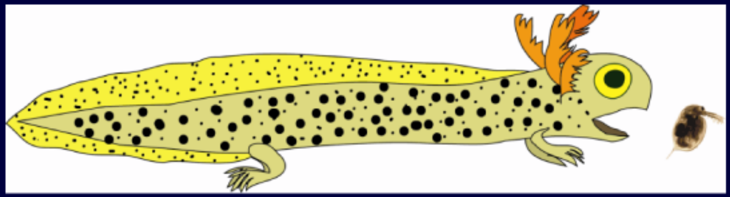
Temporary pond food web

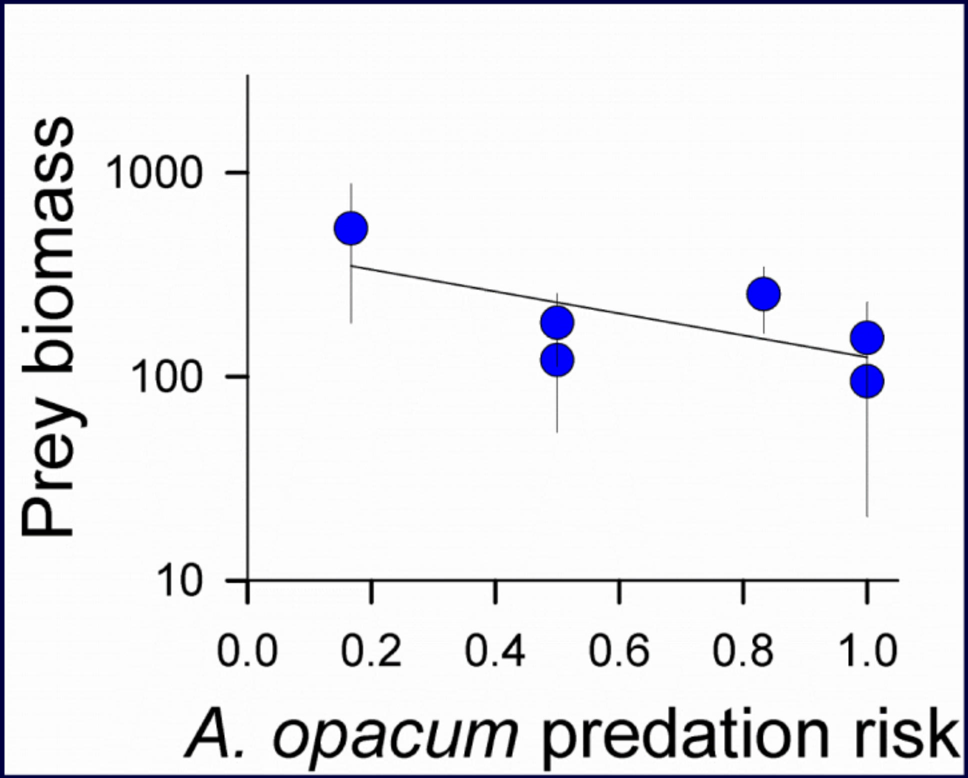


Evolution

Effect of adaptation on:

Prey community biomass

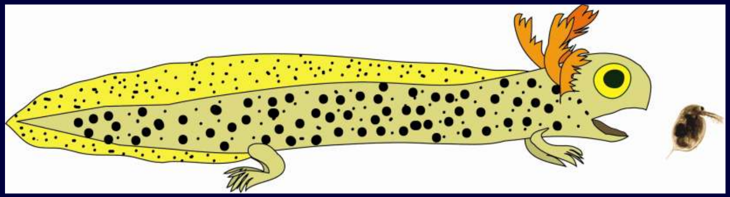


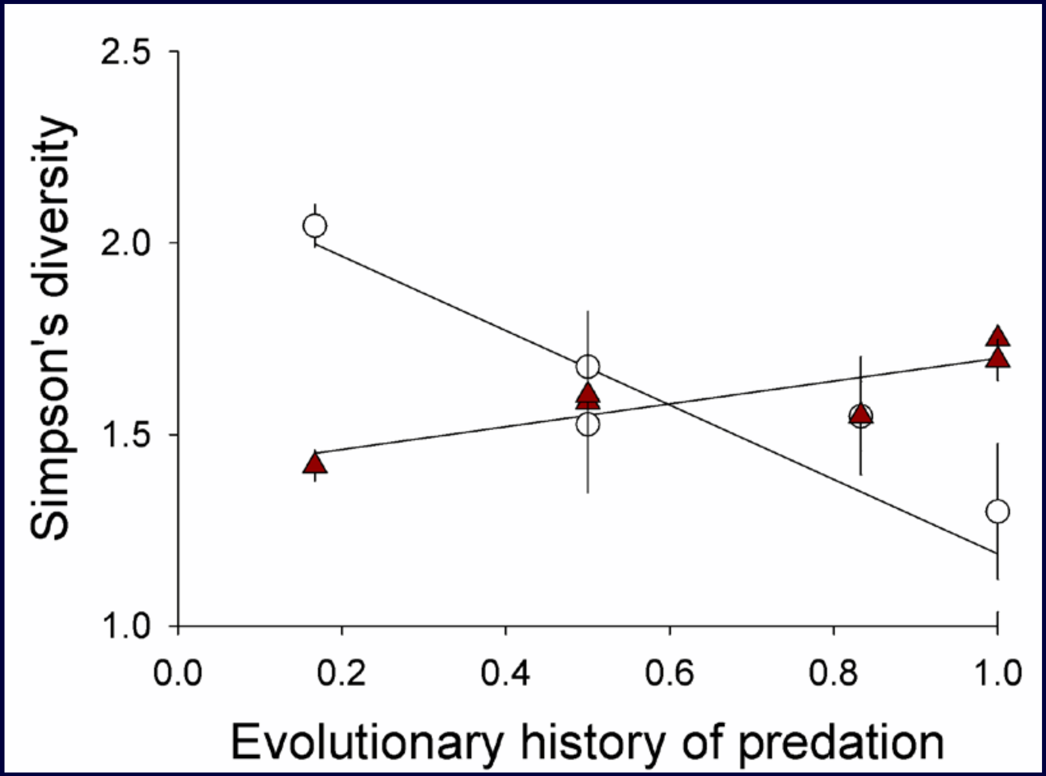


Urban 2013 *PRSB*

Effect of adaptation on:

Prey community diversity





Urban 2013 *PRSB*

evolutionary effects of spotted salamander

Community response	Ecological effects of apex predator	Effect of adapted spotted salamander
Biomass	↓	↓
Simpson's diversity	↓	↑

Eco-evolutionary dynamics