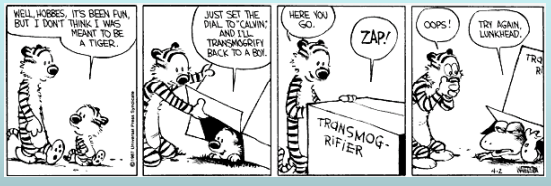
Metamorphosis Ecology

Teresa Moody

Presentation Outline

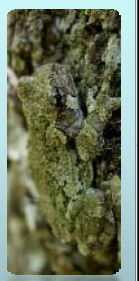
- Introduction
  - Metamorphosis
  - Stress factors
- Current research
  - Pond drying
  - Sublethal atrazine and nitrate
  - Plasticity of African clawed frog metamorphosis
- Future research
- Overview



Introduction

Complex life cycle

- Biphasic life strategy
  - Aquatic and terrestrial environments
- Ecological niches
  - Tadpoles: mostly herbivores
  - Adults: carnivores
- Adaptations from the complex cycle
  - Caecilians: terrestrial eggs, viviparity
  - Salamanders: paedomorphic, direct development
  - Anurans: direct development



Caecilian Birth

Video

http://news.nationalgeographic.com/news/2012/02/pictures/120221-limbless-amphibians-caecilians-new-species-science/#/new-species-burrowing-caecilian-egg-closeup_44946_600x450.jpg

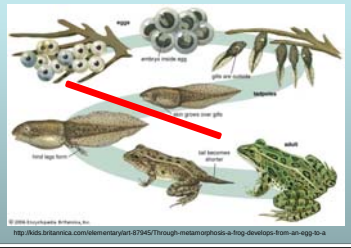
Salamander care

Complete Metamorphosis

Parental Assistance

Anuran Metamorphosis

- Complex
  - Different for each group of Anurans
- Egg – Tadpole – Juvenile - Adult



http://kids.britannica.com/elementary/art-87945/Through-metamorphosis-a-frog-develops-from-an-egg-to-a

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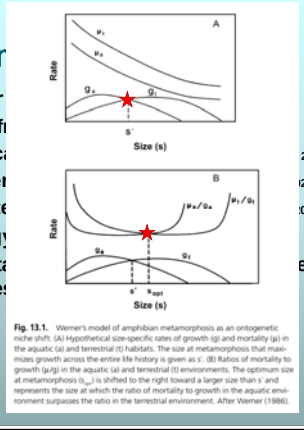


Fig. 13.1. Werner's model of amphibian metamorphosis as an ontogenetic niche shift. (A) Hypothetical size-specific rates of growth (g) and mortality (μ) in the aquatic (a) and terrestrial (t) habitats. The size at metamorphosis that maximizes growth across the entire life history is given as s'. (B) Ratios of mortality to growth (μ_a/g_a) in the aquatic (a) and terrestrial (t) environments. The optimum size at metamorphosis (s_{opt}) is shifted to the right toward a larger size than s' and represents the size at which the ratio of mortality to growth in the aquatic environment surpasses the ratio in the terrestrial environment. After Werner (1986).

2002)
2)
000)

(Wells, 2007)

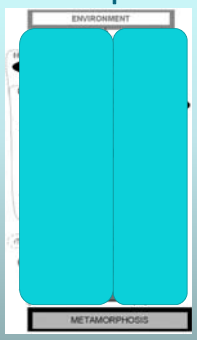
Habitats

- Bullfrog: 1-3 years (Bruening, 2002)
  - Permanent water
- African clawed frog: 6-8 weeks (Garvey, 2002)
  - Aquatic
- American toad: 30-70 days (Grossman, 2002)
  - Ponds
- Eastern Spadefoot: 12-40 days (Byers, 2000)
  - Ephemeral ponds

Thyroid

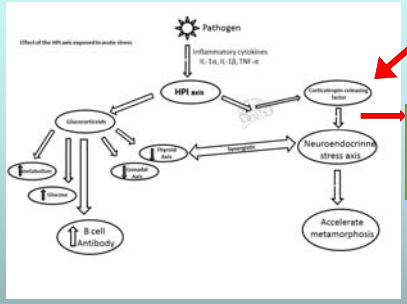
- Hormomal control
- Gene expression
  - Frogs and salamanders
- Growth and differentiation
- Small in early development
- Controlled by pituitary, which is controlled by hypothalamus
- Amphibian larvae can speed up or slow down process

Environmental Impacts



(Shirey, 2006)

Stressor impact



Activates adrenal and thyroid hormones

Brenes, pers. comm.

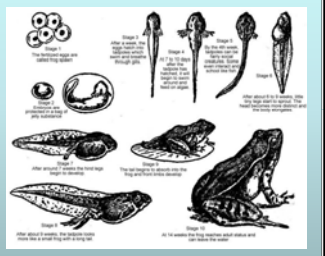
Stress Response

- Too small at critical point = death
- If close to appropriate size
  - Increase foraging
  - Increase mobilization reserves

Video

Metamorphic interruptions

- Pond desiccation
- Predation
- Chemical
  - Cattle
  - Agriculture
  - Medications
- Diseases
  - Parasites
  - Viruses
  - Fungus
- Climate



Current Research

Effects of pond drying on morphological and life-history traits in the anuran *Rhinella spinulosa* (Anura: Bufonidae)

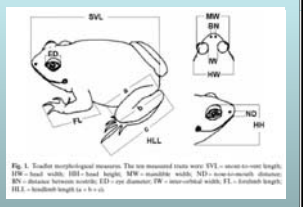
M. Márquez-García[1], M. Correa-Solís[1], M. Sallaberry[2] and M.A. Méndez[1,2]

- Lab tests
  - Vertical sides
  - Constant temperatures
  - Density control
- Needed natural test
  - Shoreline recession
  - Diverse ponds

http://calphotos.berkeley.edu/cgi/img_query?enlarge=0000+0000+0711+0794

Pond Drying Effects

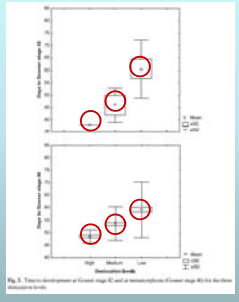
- Hypotheses
  - Pond drying will increase development rate
  - Lower desiccation will yield longer hind-limbs
- Measured juvenile toads at 10 ponds:
  - Low: 86-92 days
  - Medium: 65-78 days
  - High: 51-57 days



(Marquez-Garcia et al., 2009)

Significant Results

- Eye diameter
- Hind-limb length
- Nose-to-mouth distance
- Days until development were shortest for the high desiccation ponds



(Marquez-Garcia et al., 2009)

Pond-drying effects

- Chemicals from desiccation
- Smaller emergent frogs may have lower survival
  - Water loss
  - Less ability to jump

http://www.skolaimages.com/stock/displayimage-5684-Drying-pond-on-coastal-plain-ANWR-Alaska.html

EFFECTS OF SUBLETHAL CONCENTRATIONS OF ATRAZINE AND NITRATE ON METAMORPHOSIS OF THE AFRICAN CLAWED FROG

KAREN BROWN SULLIVAN* and KARLA M. SPENCE
Department of Biological Sciences, 1845 N. Fairmount, Wichita State University, Wichita, Kansas 67260-0026, USA

- Atrazine toxicity: 0.41 mg/L
- Typical water: 0.20 µg/L
- Sub-lethal concentrations affect:
  - Tiger salamanders (75 µg/L)
  - Gray Treefrogs (20 µg/L)
- Nitrate toxicity: 90 mg/L
- Typical water:
  - 10 mg/L (US)
  - 100 mg/L (World)
- Sub-lethal concentrations affect:
  - *Litoria caerula* (40 mg/L)
  - American toad (40 mg/L)

http://www.rub-uni-bochum.de/hcl/forschung/index_en.html

Significant Results

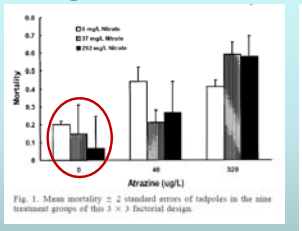


Fig. 1. Mean mortality ± 2 standard errors of tadpoles in the nine treatment groups of this 3 × 3 factorial design.

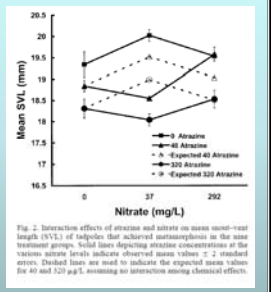


Fig. 2. Interaction effects of atrazine and nitrate on mean snout–vent length (SVL) of tadpoles that achieved metamorphosis in the nine treatment groups. Solid lines depicting atrazine concentrations at the various nitrate levels indicate observed mean values ± 2 standard errors. Dashed lines are used to indicate the expected mean values for 40 and 320 µg/L, assuming no interaction among chemical effects.

- Atrazine alone
- Nitrate alone
- Combination

(Sullivan and Spence, 2003)

Atrazine and Nitrate Effects

- Smaller size at metamorphosis can mean:
  - Longer prereproductive periods
  - Smaller clutches once breeding is initiated
- Atrazine reduced size, delayed progression, and decreased hematocrit
- Direct or indirect hormonal effects

http://www.savethefrogs.com/actions/pesticides/atrazine/index.html

Plasticity of the duration of metamorphosis in the African clawed toad

P. T. Walsh, J. R. Downie & P. Monaghan

Division of Environmental and Evolutionary Biology, Institute of Biomedical and Life Sciences, University of Glasgow, Glasgow, UK

- Plasticity = easily shaped
- Minimizing predation risk crucial for success
- Temperature influence
  - Metamorphosis duration
    - Body size variation accounted for
  - Body condition
  - Predator avoidance using burst speed

http://www.sciencedaily.com/releases/2006/06/060616103718.htm

Significant results

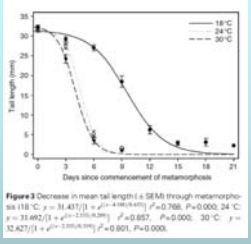


Figure 3 Decrease in mean tail length (± SEM) through metamorphosis (18 °C: $y = 31.437/(1 + e^{(x-4.186)/0.475})$, $r^2 = 0.768$, $P = 0.000$; 24 °C: $y = 33.462/(1 + e^{(x-2.535)/0.290})$, $r^2 = 0.857$, $P = 0.000$; 30 °C: $y = 32.627/(1 + e^{(x-3.955)/0.199})$, $r^2 = 0.901$, $P = 0.000$.

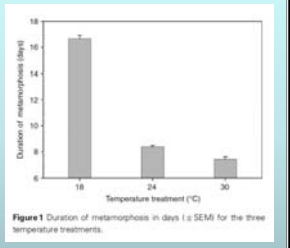


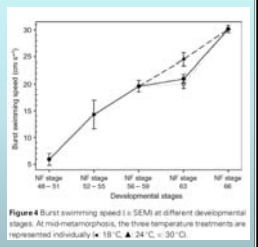
Figure 1 Duration of metamorphosis in days (± SEM) for the three temperature treatments.

- Duration
- Tail length
- Burst speed increased

(Walsh et al., 2007)

Temperature Effects

- Long metamorphosis:
  - Increases predation risk
- Highest speeds reached by metamorphs at 24 C
  - Adapted



(Walsh et al., 2007)

Future Research

Future research

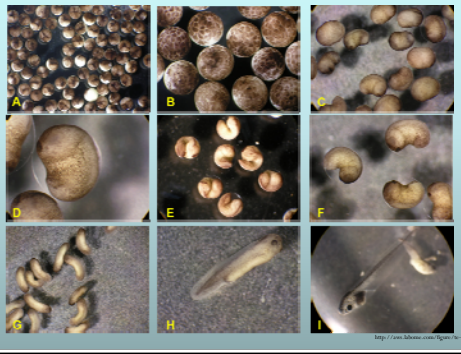
- Should include better base metamorphic times for comparison
- Compare populations from high and low predation areas
- Chemistry associated with desiccation in ponds
  - Lab tests to manipulate
- Body condition and temperature with other factors
- Sublethal effects of other chemical mixtures

References

- Bruening, S. 2002. "Lithobates catesbeianus" (On-line), Animal Diversity Web. Accessed February 26, 2013 at http://animaldiversity.ummz.umich.edu/accounts/Lithobates_catesbeianus/
- Byers, D. 2000. "Scaphiopus holbrookii" (On-line), Animal Diversity Web. Accessed February 26, 2013 at http://animaldiversity.ummz.umich.edu/accounts/Scaphiopus_holbrookii/
- Garvey, N. 2000. "Xenopus laevis" (On-line), Animal Diversity Web. Accessed February 26, 2013 at http://animaldiversity.ummz.umich.edu/accounts/Xenopus_laevis/
- Grossman, S. 2002. "Anaxyrus americanus" (On-line), Animal Diversity Web. Accessed February 26, 2013 at http://animaldiversity.ummz.umich.edu/accounts/Anaxyrus_americanus/
- Marquez-Garcia, M., M. Correa-Solis, M. Sallaberry and M. A. Mendez. 2009. Effects of pond drying on morphological and life-history traits in the anuran *Rhinella spinulosa* (Anura: Bufonidae). Evolutionary Ecology Research, 11:803-815.
- Shirey, E. A., A. J. Langerveld, D. Mihalko, and C. F. Ide. 2006. Polycholrinated biohenyl exposure delays metamorphosis and alters thyroid hormone system gene expression in *Xenopus laevis.* Environmental Research, 102(2): 205-214.
- Sullivan, K. B., and K. M. Spence. 2003. Effects of sublethal concentrations of atrazine and nitrate on metamorphosis of the African clawed frog. Environmental Toxicology and Chemistry, 22(3):627-635.
- Walsh, P. T., J. R. Downie, and P. Monaghan. 2007. Plasticity of the duration of metamorphosis in the African clawed toad. Journal of Zoology, 1:1-7.
- Wells, K. 2007. Ecology and Behavior of Amphibians. University of Chicago Press. 1162 p.

Overview

Questions?



Thank you!


MY HERITAGE? WELL I'M PART AUSTRIAN
AND A TAD-POLISH
SO MUCH FUN.COM