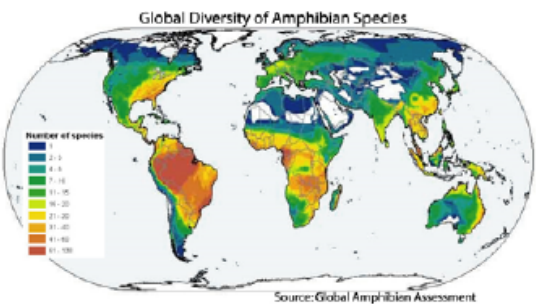
Lecture Roadmap

- Introduction & definition
- Estivation
- Hibernation or Overwintering
- Supplement reading



Amphibian occurs in wide range over the world.

3 Main challenges to survival

- Starvation
- Cold → Hibernation
- Drought → Estivation

Physiological problem is “How to survive to next breeding or active period while conserving as many as resources as possible?”.

Definitions

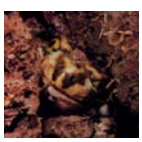
Estivation : a state of reduce metabolism seen most commonly in anurans inhabiting periodically dry habitats and become inactive.

Hibernation or Overwintering: a state of reduce metabolism seen most commonly in anurans inhabiting cold environments,

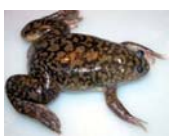
however, this may mean a state of controlled torpor and reduce body temperature if small endothermic by mammalian physiologist

Other words: Dormancy, Torpor Brumation





Estivation



Life-history of Estivators

General behavior and ecology

- Highly terrestrial
- Nocturnal and fossorial.
- Spend 7-10 months/ year for Estivation.
- Eggs and Larva develop quickly
- Can occur several months when condition are favorable

Who do estivation?

• Adult anurans that inhabits in xeric area, or area which prolonged drought which surface water is disappeared. Most of them aestivate in burrow.

Striped Marsh Frog
Limnodynastes peronii

Desert Rain Frog
Breviceps macrops

Northern Burrowing Frog
Neobatrachus aquilonius

Northern Spadefoot
Notaden melanoscaphus

Western Spadefoot Toad
Scaphiopus hammondii

Couch's spadefoot toad
Scaphiopus couchii

Who do estivation?

•Some aquatic amphibians such as anurans and salamanders. This group do estivation in mud or build cocoon.

African clawed frog,
Xenopus laevis

Horned Frogs
Ceratophrys ornata

African Bullfrog
Pyxicephalus adspersus

•Larva of some salamanders

Greater siren,*Siren lacertina*

Tiger Salamander,*Ambysotoma trigrinum*

Cue for entering and breaking of estivation

- Rain and High Humidity
- Photoperiod
- Temperature

The ability to estivate during periods of adverse condition allows some anuran to survive in truly extreme environment.

Burrow Microenvironment

The most important physical variables on burrows are;

Temperature

much lower and less variable than surface, However, variable may occur depending on season, depth, geographic location and soil types

Soil water tension

is function of water content, particle size and soil chemistry.

Concentration of respiratory gases

depend on respiration of estivator and other organisms in soil and soil gas permeability. Little known about gas concentration around amphibian burrows.

Burrows

Burrow location

Non randomly distribution, usually in area which shallow water table or where soil moisture closer in surface

Burrow selection

Terrestrial anurans will search for suitable place for burrows while aquatic estivator has little choice

Depth of burrows can changing due to soil moisture for example in *Scaphiopus* average burrow depth in fall around 20 cm reach to 50-70 cm in midwinter



Cocoon

•3 types; multiple layers of shed stratum, single stratum of corneum and a layer of secreted mucus.

• reduced water loss and evaporate

•found in *Lepidobatrachus llanensis*, *Ceratophrys ornata*, *Pyxicephalus adsperus* and also in *Siren intermedia* (cocoon derived from mucus) for example

Urea and Electrolyte Balance

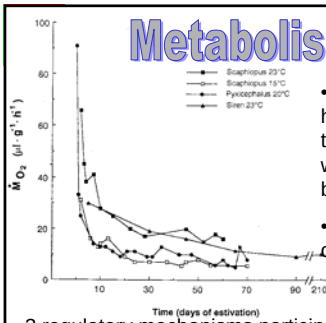
• Amphibians still continue their metabolism during estivation and metabolite products such as urea will harm to life.

• During estivation plasma urea of *Scaphiopus couchii* increasing to 200-300 mM

• This concentration may help to maintain water uptake from moisture soil but will denature proteins and disturb enzymes activities.

• In anurans, counterbalance of this substance by trimethylamine oxide, betaine, and sarcosine.

Metabolism Reduction



•Reduction of metabolism will help estivators to prolong their estivation and emerge with sufficient reserves to breed.

• O_2 uptake decreases to 30% of resting within 3 hrs.

3 regulatory mechanisms participate in metabolic depression

1) alteration of enzyme/protein acitivity

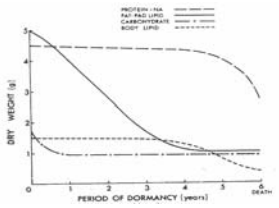
2) changes in the subcellular location of enzymes

3) regulation of the anabolic uses of carbohydrate

Fuel Reserves

• Amphibians reserve their fuel in term of triglyceride which found in abdominal fat body and lipids which found in liver and other organs.

• Just before estivation, the fat bodies represent about 3-4.5% if body mass, although it may be extremely variables.

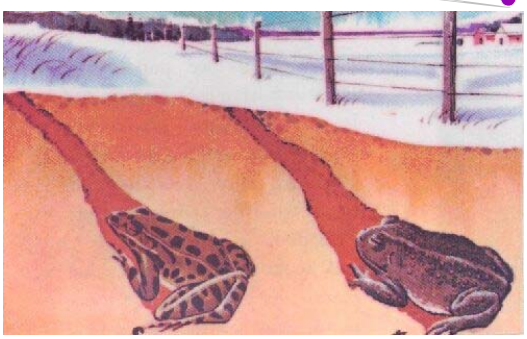


• Carbohydrate will use at start of estivation

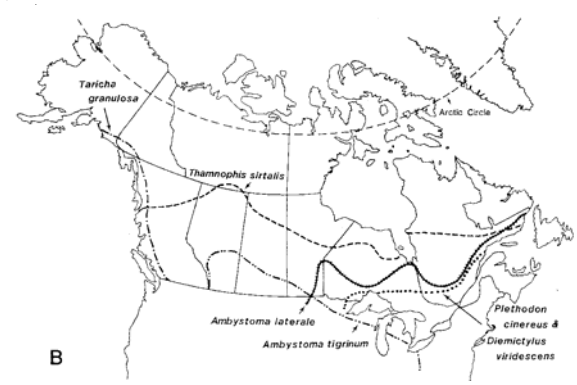
• Major energy source is fat body

• Protein is used at the end of extreme estivation

Hibernation/Overwintering



Northern limits of some Northern American Amphibians



Responses to Cold and Starvation

To survive over prolong cold and starvation, hibernators will use same basic strategies;

a) accumulation of fuel reserves prior to winter

b) adjustments to cellular membranes and proteins to optimize low temperature function.

Overwintering Microenvironment

3 strategies for overwintering

•**Underwater hibernators** will save from freezing but may suffered from anoxia or hypoxia or predators.

• **Terrestrial hibernators** will save from predators or predators but may frost under severe weather.

• **Burrowers hibernators** may safer but may challenged with freezing.

Winter Mortality

• May reaching 50% of population of *Plethodon cinereus* and *Eurycea bilineata* Vernberg (1953)

• High mortal rate may episodic rather than routine.

• In aquatic animals, usually concern with anoxia.

Terrestrial Hibermation

Useful Options to survive in cold weather are a) avoid to expose subzero temperature or b) to tolerate freezing point.

Most terrestrial amphibian choose avoidance strategy but some (*Rana sylvatica, Hyla versicolor, H. crucifer and Pseudacris triseriata*)choose to tolerate ice formation in extracellular fluid space.

To avoid subzero temperature…..

• Finding well-aerated, stable temperature and moist hibenacula.

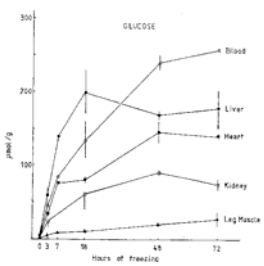
• Have stored enough reserved energy.

To tolerate subzero temperature…..

• Biochemical adaptation for tolerate freezing

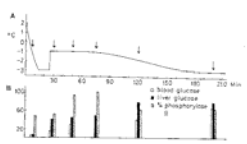
- control of extracellular ice
- regulation of cell volume
- protection of subcellular organization
- viability in the frozen state

Cryoprotectants



Course of glucose accumulation by organs of *Rana sylvatica*

Key substance for cryoprotectant is glucose while glycerol, and dimethylsulfoxide are equally effective.



Triggering and accumulation of glucose cryoprotectants of *Rana sylvatica*

Aquatic Hibermation

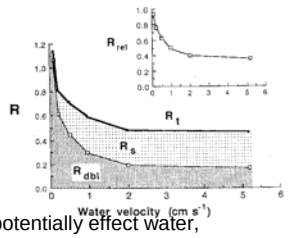
Anaerobiosis

• annoxic circumstance will occurs when water completely covering with ice or snow

• in *Rana pipens* at 5º C, Blood pH increasing 0.7 unit and lactate increasing sixty fold so animal will be stunt and can not move.

• Urodels less suffer to low oxygen concentration than anurans do.

Boundary layers



•are layers next to skin which potentially effect water, ion, and gas exchange in submerged amphibian

• boundary layer is physiological significant depend on its thickness.

• boundary layer likely to be problem of underwater hibernators in still water.

Direction for Future Research

• Microenvironments surrounded both estivators and hibernators

• Mechanisms of metabolic reduction

• More understanding in physiological problem such as effect of CO2, cardio vascular function and control for example.

Additional websites

http://www.freeonlineresearchpapers.com/hibernation-patterns-various-frogs-review-homeostatis