Aquatic Reptiles & Amphibians:

Review of modern groups
Select biology and physiology
Major topics related to environment & disease

PHC6937
Brian A Stacy, DVM, PhD, DACVP
Aquatic Animal Health
Lecture outline

- Herps as indicator species

- Review of amphibians & reptiles
  - Modern groups
  - Select biology and physiology
  - Ecological and economic importance
  - Key health topics of concern for each group
Reptiles & amphibians as indicator species


- Presence indicates the presence of a set of other species and whose absence indicates the lack of that entire set of species
- Keystone species
- Presence indicates human-created abiotic conditions such as air or water pollution
- A dominant species that provides much of the biomass or number of individuals in an area
- Indicates particular environmental conditions such as certain soil or rock types
- Sensitive to environmental changes, such as global warming or modified fire regimes (sometimes called a bioindicator species), and serves as an early warning indicator
- Reflect the effects of a disturbance regime or the efficacy of efforts to mitigate disturbance effects
Extant amphibians – 3 lineages

- **Anura – Frogs & toads**
  - Cosmopolitan, except where limited by cold & dry habitat

- **Urodela – Salamanders & newts**
  - Primarily North America and Eurasia

- **Gymnophiona – Caecilians**
  - Pantropical
Amphibians - common biological features

- Two-phase life cycle / Metamorphosis
  - Obligate or facultative neoteny
  - Second, limited metamorphosis
- External fertilization / unshelled eggs
  - Internal fertilization in some salamanders
  - Viviparous, marsupial, mouth-brooding forms
- Permeable skin
  - Cutaneous respiration (also lungs & gills)
- Characteristic ear sensory anatomy
- Pedicellate teeth
Amphibians – Ecological importance

- Amphibians as indicator species
  - Species and community levels
  - Perceived sensitivity to “environmental stress” due to permeable skin and biphasic life cycle
  - Exposure during life stages to aquatic and atmospheric principles
  - Repositories of bioindicator chemicals
  - Locally abundant, low-cost sampling

- Critical predators & prey

Neoplastic Skin Lesions in Salamanders from a Sewage Lagoon Containing Perylene

Rose and Harshbarger (1) reported that tiger salamanders living in a sewage sedimentation lagoon had a high incidence of neoplastic skin lesions (including cancer) and suggested a chemical etiology for these neoplasms. In a search for a chemical agent, they reported 300 parts per million of perylene and a trace of benzopyrene (isomer not given) in this lagoon’s sediment. They suggested that the source of perylene was related to jet aircraft activity on a nearby runway. We believe that this is not the correct source of perylene in this lagoon.

The presence of a single polycyclic aromatic hydrocarbon (PAH), rather than a complex mixture, usually indicates a natural source rather than anthropogenic input (2). In fact, high concentrations of perylene (and the absence of other PAH) have been reported for a number of sediments: Saanich Inlet, SCIENCE, VOL. 198
Amphibians – Food, pets, and more….

**Food:** Estimated 180 million to >1 billion frogs harvested/year

**Research:** *Xenopus* species are widely used in research

**Invasive species:** Displacement of native species

**Pet trade:** Many species, largely unmonitored

**Live bait industry:** Many species, largely unmonitored
Amphibian population declines

- Estimated 32% of amphibian species currently are in decline

- Identified threats include:
  - Habitat loss
  - Introduction of invasive species and pathogens
  - Increasing UVB exposure
  - Pollution (agricultural, acidification, etc.)

- Initially debated as an over-reaction to natural or random phenomena
  - Historical variation in amphibian population, lack of data based on long-term monitoring

- Now well regarded as catastrophic phenomena with extinction rates far surpassing background rates

Key Health Topics

- Chytridiomycosis
- Ranavirus infections
- Malformations
- UV radiation
- Habitat acidification
- Climate change
Chytridiomycosis

- Etiologic agent: *Batrachochytrium dendrobatidis* (Sporozootic fungus)
- Associated with multiple amphibian population declines
- First described in 1998 during mass mortality events in Panama and Australia
- Oldest known record: 1938, *Xenopus laevis*

Some hypotheses generated since discovery:

- Organism is endemic and declines only recently recognized
- Organism endemic and recently became more pathogenic
- Organism is endemic and attains enhanced pathogenic potential when combined with other factors
  - Climate-linked epidemic hypothesis
- Introduced invasive pathogen
Outbreaks may be insidious, persistent, and easily overlooked.

Prevalence varies by season, elevation, and region (higher in cooler, moist environments).

Apparent variation in species susceptibility.

Widespread subclinical infection documented in some areas.

Mortality in postmetanephric frogs & toads.
Chytridiomycosis

- **Point: Evidence for climate-linked epidemic hypothesis**

- **Counterpoint: Data support introduction of invasive pathogen hypothesis**
  - Lips KA et al., 2008. Riding the wave: reconciling the roles of disease and climate change in amphibian declines. PloS Biology 6: 441-454

- **Blame it all on *Xenopus***?

- **Why widespread and subclinical in some areas (eastern NA) and associated with catastrophic die-offs in others?**
  - Rothermel BB, et al., 2008. Widespread occurrence of amphibian chytrid fungus *Batrachochytridium dendrobatidis* in the southeastern USA. Diseases of Aquatic Organisms 82: 3-18

- **Next logical step: Broad phylogenetic study?**
Ranavirus (Iridovirus) infections

- First regarded as “orphan” viruses, then increasing recognition as important pathogens starting ~20 years ago
- May be actual disease agent in classic cases of “red leg syndrome” – missed for years
- Primarily larval salamanders, tadpoles, and recent metamorphs
  - Asymptomatic adult carriers suspected
- Multi-organ pathological lesions

**Epizootiology**
- Outbreaks with >90% mortality
- In North America:
  - Primarily have involved widespread, abundant species
  - May be precipitated by dense crowding
  - Summer months

• Commercial trade potential source for introduction

  • Picco AM & Collins JP, 2008. Amphibian commerce as a likely source of pathogen pollution
    Conservation Biology 22: 1582-1589
Malformations

- Documented for since the 1700’s
- Populations with high prevalence source of concern in recent years
- Complex issue with variation in observations and trends at various sites
- Four major causes identified (USGS NWHC):
  - Trematode infections near limb buds
  - Contaminants
  - Injuries inflicted by predators
  - Nutritional deficiencies

Johnson PT, et al., Aquatic eutrophication promotes pathogenic infection in amphibians. PNAS 104: 15781-86
Ultraviolet radiation

- Levels of UV radiation reaching earth’s surface have increased since the 1970’s

- Amphibians thought to be susceptible to lethal and sublethal effects due, especially due to shell-less eggs
  - Deformities, poor survival, endocrine disruption

- Actual effect unknown, laboratory results mixed

Anthropogenic habitat acidification

- Cause by atmospheric deposition of sulfate and nitrogen
- Concern as a contributor to amphibian population declines
- Acidic habitats (natural and anthropogenic) known to preclude some species
- Sub-lethal and lethal effects also known
- Clear association with amphibian declines not demonstrated

Global climate change

- Obvious concern with desiccation / loss of wetlands

- Confounding influence for other problems
  - Pathogens
  - Disease spread, manifestation

McMenamin SK, et al., 2008. Climate change and wetland desiccation cause amphibian decline in Yellowstone National Park. PNAS 105: 16988-93
Extant reptiles – 2 lineages

- Anapsids
  - Turtles & tortoises

- Diapsids
  - Crocodilians, birds, tuataras, lizards, snakes
Reptiles - some biological features

- Many “uniquely reptilian” traits are less obvious features of anatomy
- Shelled, amniotic eggs
  - Viviparous forms
- Heavily keratinized skin
- Ectothermic
  - Various degrees of endothermy exhibited by marine turtles
- Temperature dependent sex determination
  - Crocodilians, chelonians, some lizards
  - Multiple patterns

Knowledge base on diseases of reptiles is heavily biased towards captive animals
Reptilian phenomena

Breeding aggregations of red-sided garter snakes in Manitoba Canada

Olive ridley turtle arribadas

Complex life histories, distant migrations of marine turtles

Maternal protection in prehensile-tail skinks
Reptiles – Ecological importance

- **Indicator species**
  - Numerous regarded as indicator species for wetlands, tropical marine, lake and river systems
  - Ecological requirements of many are precise and well-studied
  - Keystone species
  - Repositories of heavy metals and contaminants

- **Important predator & prey species**
Reptiles – Other important points

**Commerce:** Turtle farming and wild turtle trade is a multi-million dollar industry and is at the core of a conservation crisis for some species.

**Invasive species:** Many examples.

**Human conflicts:** Snake bite and big predators.

**Commerce:** Crocodilian ranching / farming is a multi-million dollar industry and a conservation tool.
Reptilian population declines - big problem with less press

- More reptilian species than amphibians listed under ESA and IUCN

- Often go unreported, unmonitored

- Habitat degradation the key concern

- Greater home ranges, may be more susceptible to habitat fragmentation and threats that cross geopolitical borders

Select topics related to environmental stress/disturbance & reptiles

- Degradation / loss of nesting habitat
- Temperature-dependent sex determination and climate change
- Pollution / contamination
- Harmful algal blooms
- Enigmatic diseases / mortality events
Fibropapillomatosis of marine turtles

- Best studied and most significant in green turtles
- Panzootic, prevalence has increased from the 1980’s through present day
- Associated with herpesviral infection, but cofactors strongly suspected
- 22% of stranded turtles in Florida, highest prevalence on Gulf coast (51.9%)
Reptiles and mass mortality events

- Documented in turtles and crocodilians worldwide
  - American alligators, Lake Griffin 2000
  - Gharial, Northern India 2008
  - Nile crocodiles, South Africa 2008-2009
  - Loggerhead sea turtles, Florida 2000/01, 2006
  - Freshwater turtles, Florida 2007 (2 events), 2009?
Important points

- Reptiles and amphibians are diverse groups of animals with a broad range of unique features and adaptation to aquatic environments
- Both include well-recognized indicator species
- Worldwide declines are of great concern and will result in further extinctions and regional extirpations in coming years
- Critical areas of concern are habitat loss, introduction of pathogens, invasive species, pollution, climate change, non-sustainable use, and other anthropogenic influences
Questions