What can zoos contribute to amphibian conservation?

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Herpetology

The History of Amphibians in Zoos

Conservation through Education

Primary role of zoos in amphibian conservation

Raise awareness with the visiting public about the wonders of amphibian diversity

Be an ambassador for amphibians…

This is not what I'm going to talk about.

Beyond the general zoo visitors…

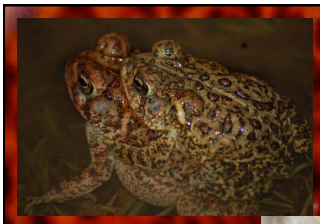
- *In situ* and *ex situ* research
  - Distributional surveys
  - Population monitoring
  - Ecological study
  - Genetic evaluation
  - Diet/Nutrition
  - Captive reproduction
  - …
- Head starting and supplemental releases
- Captive assurance populations
- Reintroductions
- **Capacity Building**

1980s-1990s

Houston Toad
(*Anaxyrus houstonensis*)

Wyoming Toad
(*Anaxyrus baxteri*)

Puerto Rican Crested Toad
(*Peltophryne lemur*)

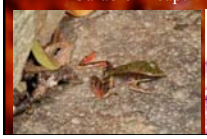


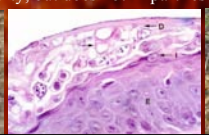
In Europe…

Mallorcan Midwife Toad
(*Alytes mutelensis)*

"Chytrid" Fungus

- *Batrachochytridium dendrobatidis*
- First identified in 1998
  - Longcore JE, Pessier AP, Nichols DK. (1999). Batrachochytrium Dendrobatidis gen. et sp. nov., a chytrid pathogenic to amphibians. *Mycologia* **91**(2): 219-227.
- Pathogenic fungus implicated in widespread global amphibian declines and extinctions
- Infects skin of amphibians
  - Respiration
  - Osmoregulation
  - Electrolyte balance
- Curable in captivity, but does not impart resistance





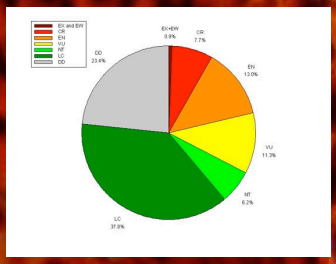
Early 2000s

"Captive assurance populations"

"For a species facing an enigmatic decline, the only conservation option currently available is captive breeding"

Stuart et al., 2004. Science 306:1783–1785

IUCN 2005 GAA



Call to action from the scientific community

Mendelson *et al.* (2006). **Science.**

POLICY FORUM

BIODIVERSITY

Confronting Amphibian Declines and Extinctions

Stopping further global losses of amphibian populations and species requires an unprecedented conservation response.

Joseph R. Mendelson III,* Karen R. Lips, Ronald W. Gagliardo, George B. Rabb, James P. Collins, James E. Diffendorfer, Peter Daszak, Roberto Ibáñez D., Kevin C. Zippel, Dwight P. Lawson, Kevin M. Wright, Simon N. Stuart, Claude Gascon, Hélio R. da Silva, Patricia A. Burrowes, Rafael L. Joglar, Enrique La Marca, Stefan Lötters, Louis H. du Preez, Ché Weldon, Alex Hyatt, José Vicente Rodríguez-Mahecha, Susan Hunt, Helen Robertson, Brad Lock, Christopher J. Raxworthy, Darrel R. Frost, Robert C. Lacy, Ross A. Alford, Jonathan A. Campbell, Gabriela Parra-Olea, Federico Bolaños, José Joaquín Calvo Domingo, Tim Halliday, James B. Murphy, Marvalee H. Wake, Luis A. Coloma, Sergius L. Kuzmin, Mark Stanley Price, Kim M. Howell, Michael Lau, Rohan Pethiyagoda, Michelle Boone, Michael J. Lannoo, Andrew R. Blaustein, Andy Dobson, Richard A. Griffiths, Martha L. Crump, David B. Wake, Edmund D. Brodie Jr.

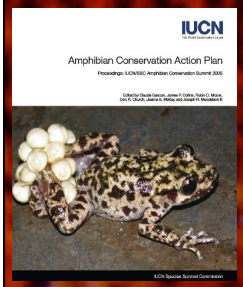
Amphibian declines and extinctions are global and rapid: 32.5% of 5743 described species are threatened, with at least 9, and perhaps 122, becoming extinct since 1980 (1). Species have disappeared across the entire taxonomic group and in nearly all regions of the planet. These figures are probably underestimates as entire clades of species are threat-

ians and to garner and administer funds. Thus, we call for formation of The Amphibian Survival Alliance (ASA)—led by an international secretariat of the Amphibian Specialist Group of the Species Survival Commission of IUCN (World Conservation Union). An initial 5-year budget requires at least US $400 million.

Conservation activities should remain in

The Panamanian Golden Frog, *Atelopus zeteki*, is nearly extinct in the wild as a combined result of habitat change, illegal collecting, and fungal disease; the species is currently secure in several ex situ programs.

Amphibian Conservation Action Plan (ACAP), 2007



1. Expand understanding of the causes of declines and extinctions
2. Document amphibian diversity, and how it is changing
3. Develop and implement long-term conservation programs
4. Provide emergency response to immediate crises


What have I done about it?


AMAZING
AMPHIBIANS

Unintended consequences of captive breeding + reintroduction

Walker *et al*. 2008. **Current Biology.**

Magazine
R853

Invasive pathogens threaten species recovery programs

Susan F. Walker[1,*], Jaime Bosch[2], Timothy Y. James[3], Anastasia P. Litvintseva[4], Juan Antonio Oliver Valls[5], Samuel Piña[6], Gerardo Garcia[7], Ghislaine Abadie Rosa[8], Andrew A. Cunningham[9], Sarah Hole[7], Richard Griffiths[8] and Matthew C. Fisher[1]

Captive breeding and re-introduction is integral to the recovery of many threatened species [1], but such practices carry an associated risk of introducing exotic and potentially unknown pathogens into naïve settings. Amphibians

Spain [6] led to the first report of chytridiomycosis in a wild European amphibian population. In Europe, the pathogen is now known to be widespread [7] and our unpublished data). The finding of a dead *A. muletensis* juvenile in 2004, and the subsequent confirmation of a *B. dendrobatidis*-positive status prompted us to screen archived captive populations of *A. muletensis* that had been used for re-introductions; to examine the pattern of occurrence of infection in native *A. muletensis* populations; and to determine the multilocus genotypes of isolates of *B. dendrobatidis* from Mallorca relative to other localities worldwide.

Our screening of archived mortalities of captive *A. muletensis* using whole-genome amplification, quantitative PCR [8] and histology found clear evidence of *B.*

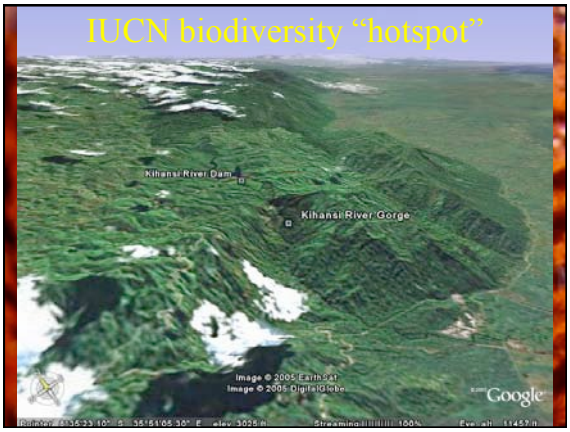
archived in 1991, three were positive for *B. dendrobatidis*.

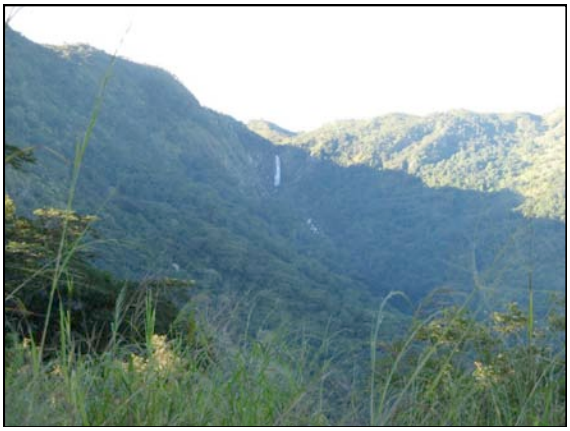
Surveillance of wild populations in Mallorca found that *B. dendrobatidis* was present in four of the 21 populations surveyed. The distribution of *B. dendrobatidis* among the larval populations was heterogeneous and highly clustered (Potthoff-Whittinghill test statistic, $p < 0.001$; Figure 1; Table S2 in the Supplemental data). In two of these infected populations, Cocó de sa Bova and Torrent des Ferrerets, a prevalence of, or almost, 100% was recorded. The population at Cocó de sa Bova received animals from the aforementioned breeding facility in 1991. Multilocus genotypes from five Mallorcan isolates of *B. dendrobatidis* were all identical to each other, and different to those known from both mainland Spain and the UK (Figure 2). This finding

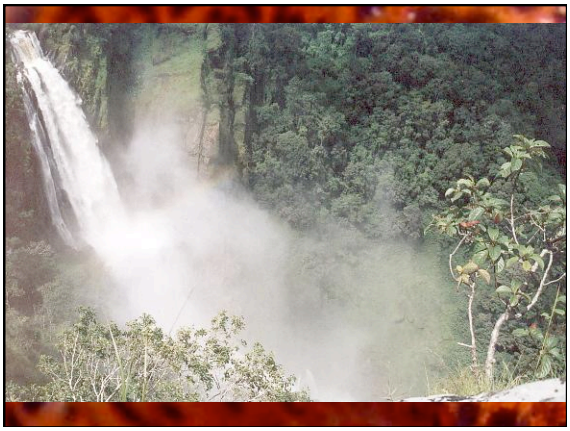
The Genus *Nectophrynoides*

- Bufonidae – "true" toads
- At least 17 (30+?) species, 5 new described in 2004, many more awaiting description.
- Entire genus listed under Appendix I of CITES.
- All endemic to the Eastern Arc mountains of Tanzania: mainly Usambara, Udzungwa, Uluguru, Rubeho, and Nguru.

IUCN biodiversity "hotspot"

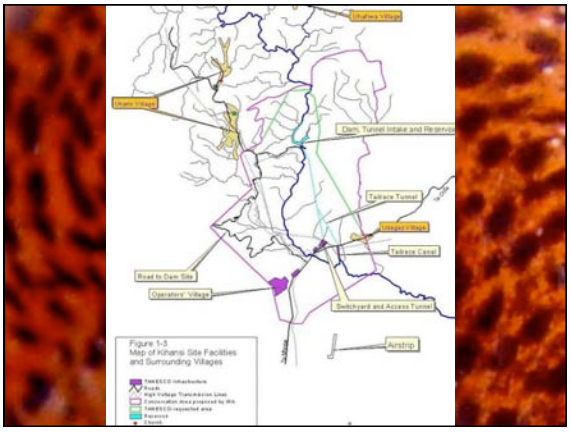




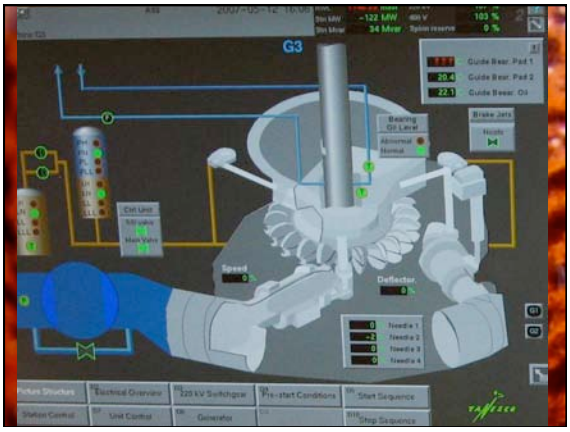


Lower Kihansi Hydropower Project (LKHP)

- $272 million USD
- 180 MW of CO2-free electricity
  - Up to 30% of Tanzania's power during extreme drought
- Funded in part by the World Bank
- Planned since early 1980s, began construction in 1993
- Tiny ecological footprint (20 ha)…


Dam, Tunnel Intake and Reservoir
Tailrace Tunnel
Tailrace Canal
Road to Dam Site
Operators' Village
Switchyard and Access Tunnel
Airstrip
Figure 1-3
Map of Kihansi Site Facilities
and Surrounding Villages

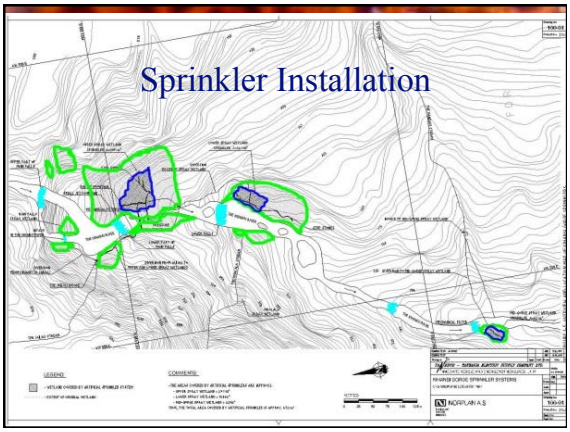

1750m


G3
Guide Bear. Pad 1
Guide Bear. Pad 2
Guide Bear. Oil
Bearing Oil Level
Brake Jets
Oil Unit
Speed
Deflector
Needle 1
Needle 2
Needle 3
Needle 4

Remediation Effort

- Sprinklers and spray jets installed in areas of spray wetlands in hopes of reviving ecosystem (after 9 month delay…)
- 499 Kihansi Spray Toads sent to the Bronx Zoo in the fall of 2000, 230 of these immediately sent to the Detroit Zoo
- Ongoing studies of vegetation, insect communities, amphibians in the gorge

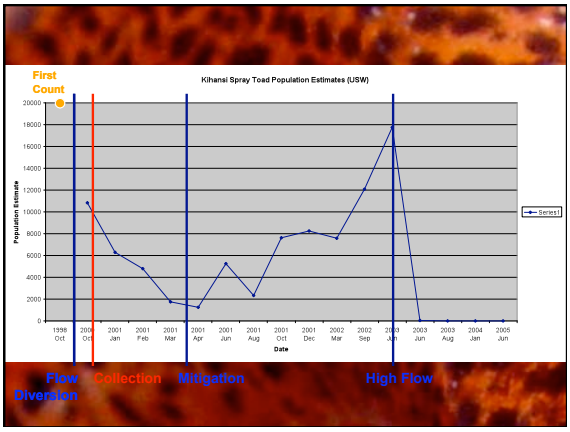
Sprinkler Installation



Problems with Sprinklers

- Gravity fed system
- Natural silt in river clogged nozzles

- Installation of settling tanks to remove silt
- Full time maintenance staff



Captive Spray Toads

- 499 Kihansi Spray Toads sent to the Bronx Zoo in the fall of 2000, 230 of these immediately sent to the Detroit Zoo
- Approximately half of toads brought in from wild died in subsequent weeks due to parasitic lungworms
- With medication and husbandry changes the parasite was controlled
- Captive animals were breeding readily and population rebounded by late 2001

Other zoos became involved

- Baltimore Zoo, MD
- Oklahoma City Zoo, OK
- Buffalo Zoo, NY
- **Toledo Zoo, OH**

At the Toledo Zoo

- First 24 spray toads received Feb 2002
- Initial problems with nutrition resulted in losses and subsequent husbandry changes
  - R.O. → Carbon filtered H_2O
  - Substrate changed: gravel → live moss
  - Changes in vitamin/mineral supplements
  - UV lighting: blacklight → **halogen**



Captive Care

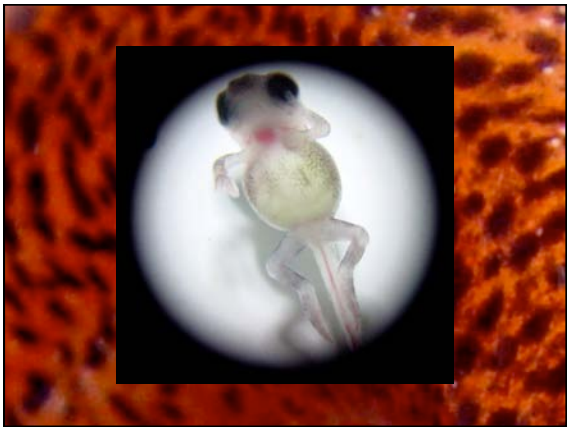
- 22 hour misting cycle
- Feed on:
  - **Pinhead crickets**
  - Wingless fruit flies
  - Bean beetles
  - Soldier fly larvae
  - **Springtails**
  - Misc. inverts in tank
    - Isopods
    - Mites

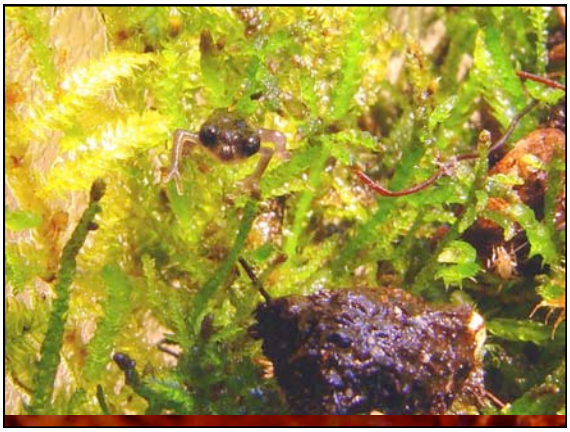
Captive Insights

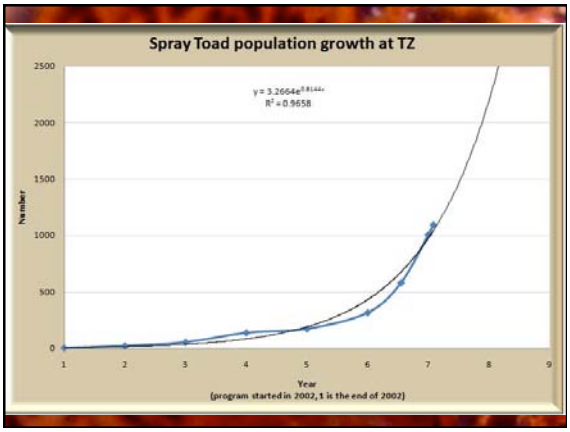
Ultrasonic Calling?

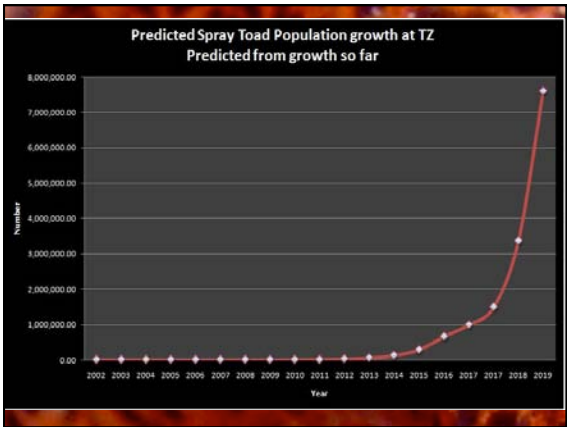
- Corinne Richards – University of Michigan
  - Studied male-male combat and interactions at Detroit and Toledo Zoos
  - Found ultrasonic component to calls, still uncertain if toads can hear these frequencies

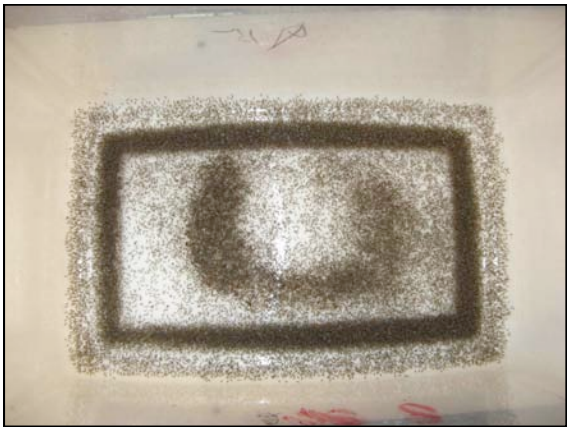
Premature births



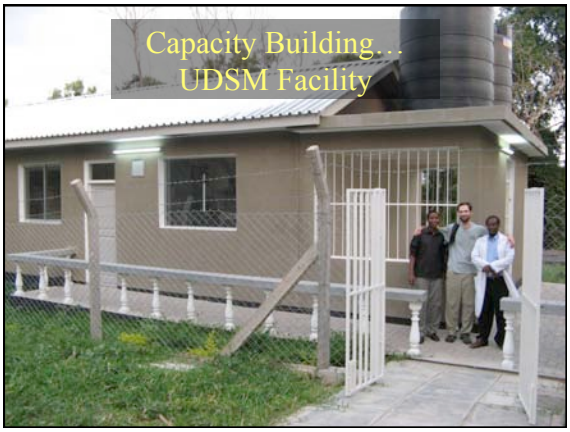


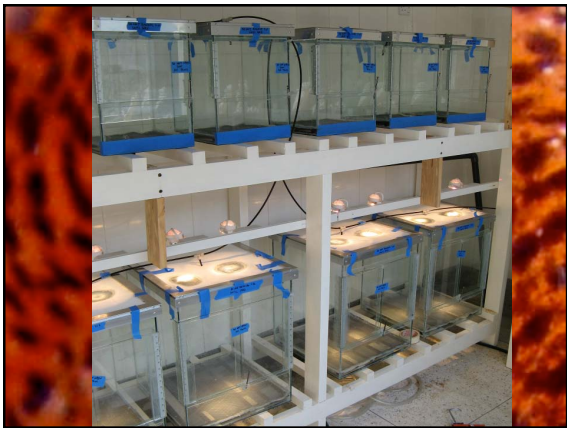

Spray Toad population growth at TZ
y = 3.2664e^0.8144x
R² = 0.9658
2500
2000
1500
1000
500
0
Number
1
2
3
4
5
6
7
8
9
Year
(program started in 2002, 1 is the end of 2002)


Predicted Spray Toad Population growth at TZ
Predicted from growth so far
8,000,000.00
7,000,000.00
6,000,000.00
5,000,000.00
4,000,000.00
3,000,000.00
2,000,000.00
1,000,000.00
0.00
Number
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2017 2018 2019
Year




Other challenges to survival…

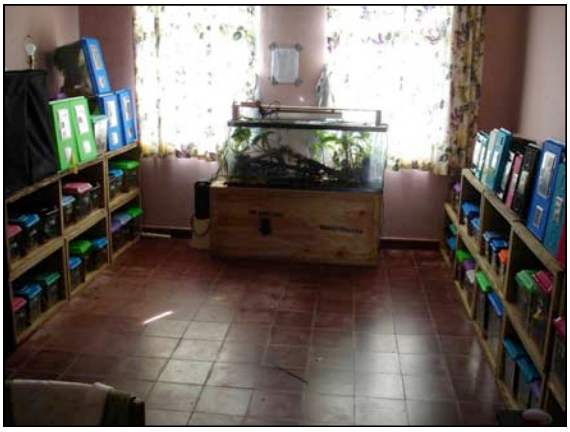

Capacity Building…
UDSM Facility



Long-term Goals

- Controlling captive population size…
- Return animals for captive colony in Tanzania (UDSM)
  - In situ captive animals utilizing local resources
  - Design facilities and train staff with knowledge of species gained in U.S. zoos
- Determine if Kihansi gorge is suitable habitat
- *Prevent introduction of disease from captivity*
  - Histopathology
  - Genetic evaluation of parasites
  - Sentinal animal trials

Panamanian Golden Frog
(*Atelopus zeteki*)




Gastrotheca cornuta

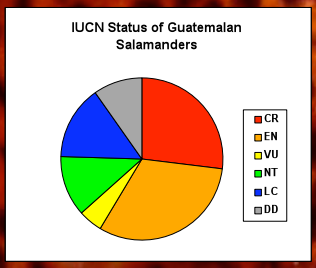
Guatemala?

Guatemala

- 108,890 sq km (compared to 109,220 for TN)
- 41* described caudate species in 8 genera
  - *Not shabby at all…
- All Bolitoglossine taxa (Plethodontidae)
- Likely more species awaiting description/ discovery
- Most surveying/descriptions conducted by UC-Berkeley in the 1970s

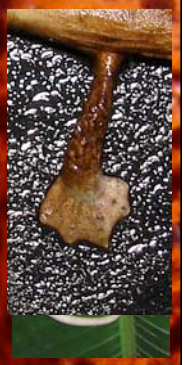
Conservation Status

- Due to political situation, little work conducted in 1980s
- Surveys in the late 1990s revealed dramatic declines, extirpations, extinctions? of both salamanders and their associated predators
  - Chytridiomycosis?
  - Climate Change?



Bolitoglossa

- Tropical "web-footed" salamanders
- Abysmal record in captivity
- i.e. very challenging group for captive assurance populations
- pilot husbandry work underway with 2 species at the Toledo Zoo
  - *B. rufescens* (LC)
  - *B. conanti* (EN)

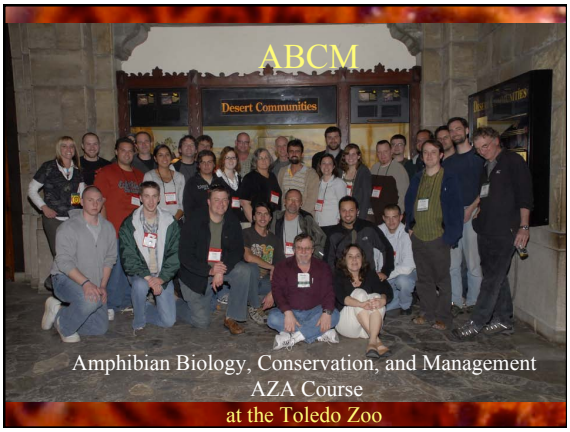


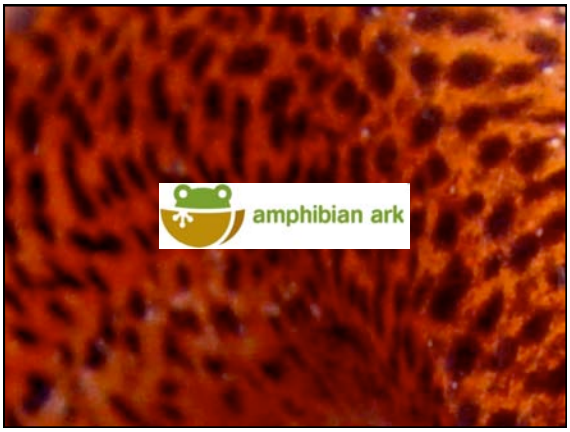
Project Goals

- Refine husbandry, captive reproduction
  - As in Panama, many taxa have barely been observed or studied
- Support *in situ* research
  - Identify cause(s) of declines
  - Survey and monitor remaining populations
- Establish *ex situ* facilities in Guatemala for captive assurance populations

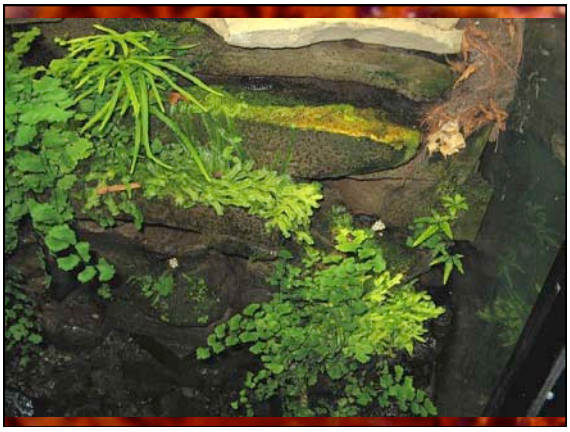
$

always a complicating factor.

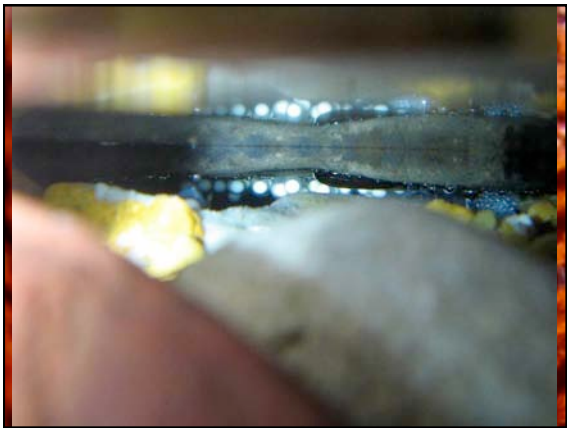


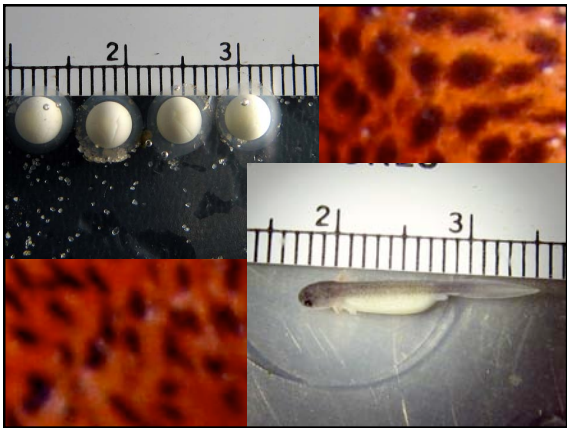

amphibian ark


Captive Reproduction of North American Plethodontids
Capacity building in the U.S.!




LIVING
CULTURES




2
3
2
3


Aneides aeneus
Plethodon petraeus
Gyrinophilus p. duryi
Plethodon yonahlossee


Thanks!