

Ecology and Natural History of Cave-dwelling Salamanders with an emphasis on the Tennessee Cave Salamander Complex

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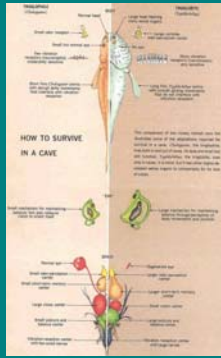
Cave Colonization by Vertebrates

- Limited by:
 - Darkness
 - Scarcity of Food
 - Dimension of Cavities
- Classification:
 - Troglobite (Plethodontidae and Proteidae)
 - Troglophile (Ambystomatidae, Dicamptodontidae, Hynobiidae, Plethodontidae, Salamandridae)
 - Troglaxene
 - Accidental
- 9 troglobitic salamanders
 - 8 in North America
 - All but 2 are paedomorphic
- No sympatry

Phenotypic Characters Associated with Cave-dwelling Salamanders

Morphological	Physiological	Behavioral
	<u>Reduced or Lost</u>	
Eyes	Metabolism	Response to light
Visual brain centers	Circadian rhythms	Aggression
Pigmentation	Fecundity	Aggregation
Body size	Egg volume	
	Metamorphosis	
	<u>Enlarged or Lengthened</u>	
Chemo- and mechanosensors	Life span	Response to vibration
Nonvisual brain centers	Lipid storage	
Limbs	Larval period	

Cave-associated Traits



Cave Development

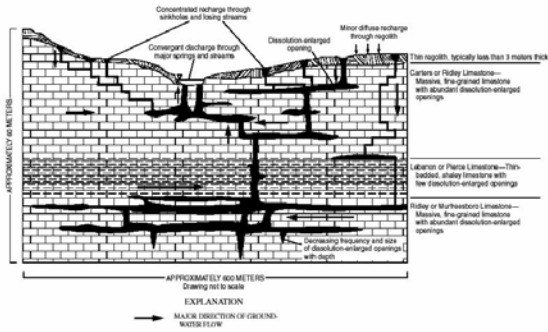
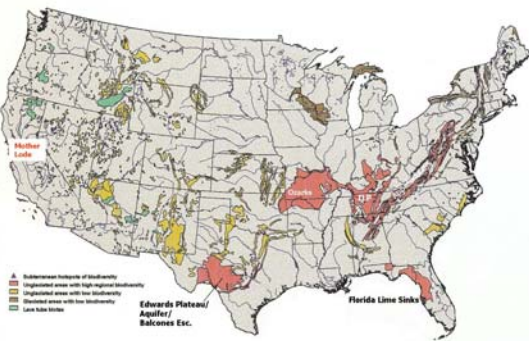
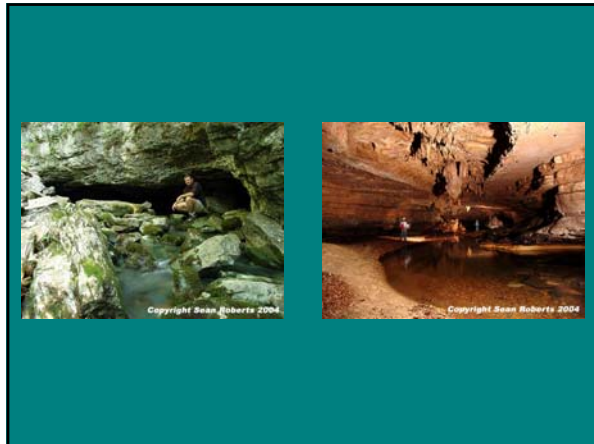



Figure 6. Generalized hydrogeologic section through the inner Central Basin of Tennessee. (Modified from Zusswiler, 1978.)





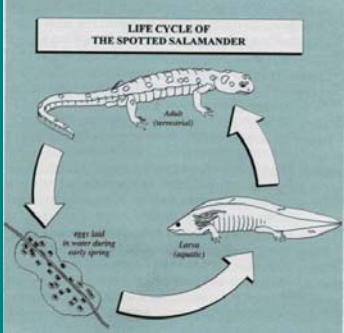
Tennessee Cave Salamander Complex
Gyrinophilus palleucus and *G. gulolineatus*

- Aquatic troglobitic salamander
- Endemic to subterranean waters of central and east TN, northern AL, and northwest GA
- Little known about life history and ecology of the complex



Warren County, TN 2004 (M Niemiller)

Salamander Life Cycle



Pale Salamander
Gyrinophilus palleucus palleucus



Big Mouth Cave Salamander
Gyrinophilus p. necturoides



Berry Cave Salamander
Gyrinophilus gulolineatus



Spring Salamander
Gyrinophilus porphyriticus

- Aquatic and terrestrial troglophile
- Range from mountains of east TN to Cumberland Plateau
- Larvae resemble *G. pallescens* in appearance but differ in eye size and head shape



Cannon County, TN 2005 (B Miller)

Spring Salamander
Gyrinophilus porphyriticus



Blue Ridge Spring Salamander
Gyrinophilus porphyriticus danielsi



***G. palleucus* or *G. porphyriticus*?**



TN Cave Salamander adult
Rutherford Co., TN



Spring Salamander larva
DeKalb Co., TN

***G. p. necturoides* and the
Stone Cave *G. porphyriticus*?**



Frick's Cave, Walker Co. GA



Coffee Co., TN *G. porphyriticus*



In Search of ...
The Tennessee Cave Salamander



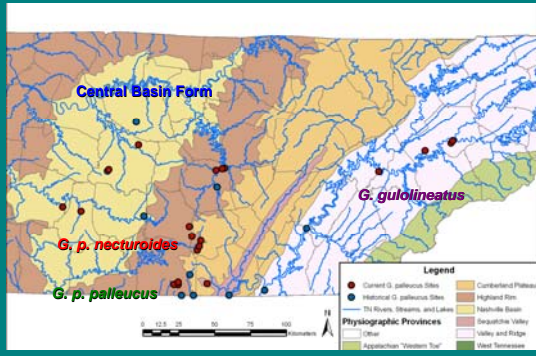
Processing TN Cave
Salamanders



VI Alpha Tag Implanted



TN Cave Salamander Distribution



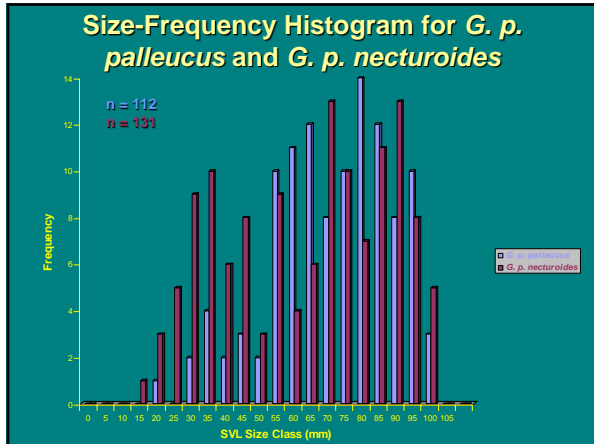
Comparative numbers of Tennessee Cave Salamanders observed in selected historic sites from previous and the current study.

Cave	1980s ¹	1990-91 Survey	Current Study
Franklin County			
Cave Cove Cave	NA	32 (2 visits)	71 (2 visits)
Custard Hollow Cave	10	0 (2 visits)	66 (2 visits)
Lost Cove Cave	0	1 (1 visit)	0 (2 visits)
Sinking Cove Cave	NA	NA	73 (3 visits)
Grundy County			
Big Mouth Cave	8	6 (3 visits)	320 (12 visits)
Knox County			
Cruze Cave	NA	18 (2 visits)	368 (7 visits)
Meade Quarry Cave	NA	NA	22 (2 visits)
Mud Flats Cave	24	7 (2 visits)	15 (4 visits)
Roane County			
Berry Cave	21	2 (2 visits)	5 (2 visits)
Rutherford County			
Herring Cave	3	0 (1 visit)	12 (4 visits)
Snail Shell Cave ²	NA	0 (1 visit)	3 (2 visits)

NA - Data not available

¹ - Based on historic data from 1983-1989 in Caldwell and Copeland (1992)

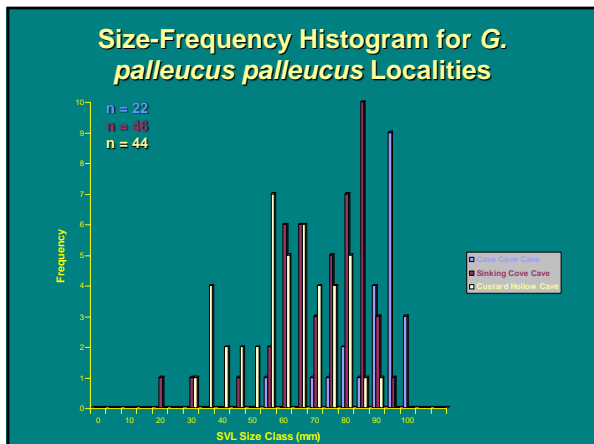
² - Snail Shell Cave system including Echo, Nanna, and Snail Shell Cave

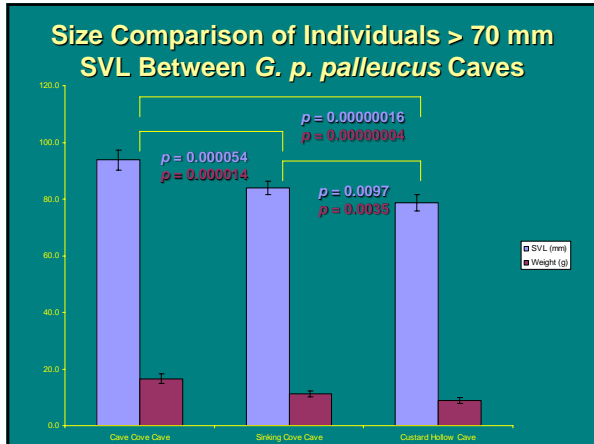


Size Class Information (in SVL) for *Gyrinophilus palleucus*

Species	15-55 mm	56+ mm	Total
<i>G. p. palleucus</i>	14 (13%)	98 (87%)	112
<i>G. p. necturoides</i>	45 (34%)	86 (66%)	131
All Caves ¹	68 (25%)	201 (75%)	269

¹ - except Cruze Cave and Meades Quarry Cave

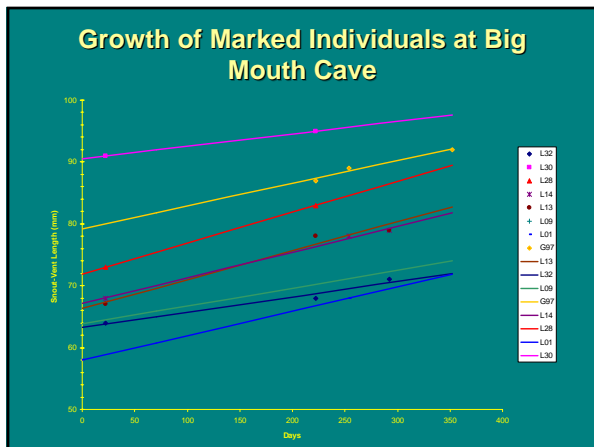




Big Mouth Cave Population Size

Time of Last Capture	1	2	3	4	5	6
29 Jun 2004	1	2	1	1	1	0
21 Jul 2004	2		8	9	1	2
06 Feb 2005	3			4	5	1
10 Mar 2005	4				6	2
17 Apr 2005	5					6
16 Jun 2005	6					
Total marked (m_i)	0	2	9	14	13	11
Total unmarked (u_i)	6	24	22	13	6	8
Total caught ($n_i = m_i + u_i$)	6	26	31	27	19	19
Total released (s_i)	6	26	31	27	19	19
Juveniles unmarked	4	2	3	6	6	6

- ca. 365 m stream passage
- Jolly-Seber estimate of 97.1 individuals
- Schnabel estimate of 153.0 individuals



G. p. palleucus and *G. p. necturoides* Juveniles



Franklin County, TN August 2004
(M Niemiller) 24 mm SVL



Coffee County, TN October 2004
(M Niemiller) 26 mm SVL

Potential Predation by Crayfish (*Cambarus sp.*)

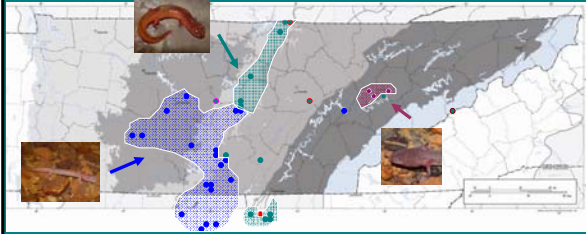


Roane County, TN, Mar. 2005

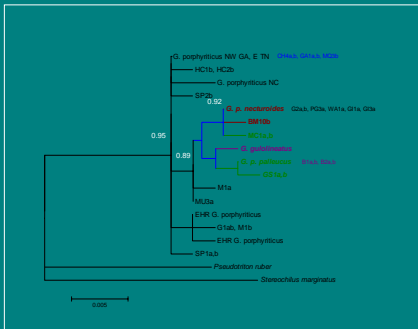
Other Predators?



mtDNA Haplotype Distribution



RAG-1 ML Phylogram



RAG-1 Haplotype Distribution



Divergence Among Major Clades

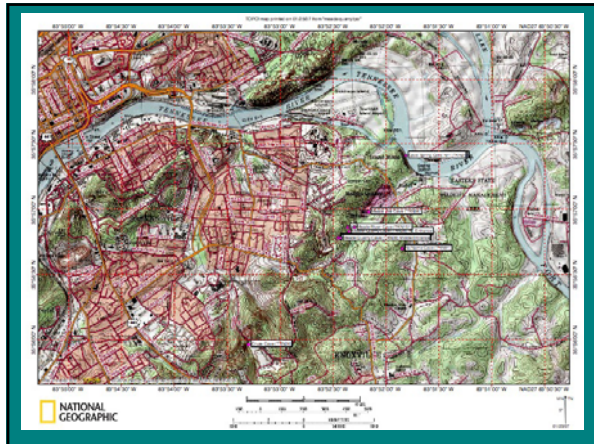
	<i>G. pallidus</i>	<i>G. guibineatus</i>	A	B	C	D	E
<i>G. pallidus</i>	0.1 - 0.9%						
<i>G. guibineatus</i>	1.2 - 1.5%	0.1 - 0.4%					
A	1.4 - 2.5%	2.0 - 2.7%	0.1 - 2.1%				
B	2.2 - 2.4%	2.7 - 2.9%	2.1 - 2.9%	0.0 - 0.0%			
C	2.8 - 3.1%	2.9 - 3.1%	2.8 - 3.5%	3.2 - 3.4%	0.9 - 0.9%		
D	3.4 - 4.0%	3.8 - 4.3%	3.6 - 4.5%	3.8 - 4.2%	3.4 - 3.9%	0.1 - 2.2%	NA
E	4.7 - 4.9%	4.8 - 5.1%	4.7 - 5.3%	5.0 - 5.0%	4.8 - 4.9%	4.8 - 5.0%	

	<i>G. pallidus</i>	<i>G. guibineatus</i>	A	B	C	D	E
<i>G. pallidus</i>	0.05 - 1.80 Myr						
<i>G. guibineatus</i>	0.60 - 3.20 Myr	0.05 - 0.80 Myr					
A	0.70 - 5.00 Myr	1.00 - 5.40 Myr	0.05 - 4.20 Myr				
B	1.10 - 4.50 Myr	1.35 - 5.80 Myr	1.05 - 5.80 Myr	0.00 - 0.00 Myr			
C	1.40 - 6.20 Myr	1.45 - 6.20 Myr	1.40 - 7.00 Myr	1.60 - 6.80 Myr	0.45 - 1.80 Myr		
D	1.70 - 8.00 Myr	1.90 - 8.60 Myr	1.80 - 9.00 Myr	1.90 - 8.40 Myr	1.70 - 7.80 Myr	0.05 - 4.40 Myr	
E	2.35 - 9.80 Myr	2.40 - 10.20 Myr	2.35 - 10.80 Myr	2.50 - 10.80 Myr	2.40 - 9.90 Myr	2.40 - 10.00 Myr	NA



Meade Quarry Cave *Gyrinophilus* sp.





TAG Amphibian Cave Survey

- 122 caves, 213 surveys
- Amphibians: 14 salamanders (2818 records), 10 frogs (312 records)
- Reptiles: 3 snakes (5 records), 1 lizard (1 record), 1 turtle (3 records)

Sampling Localities



Cave Amphibian Records

Salamanders	Frogs
<i>Gyrinophilus gulolineatus</i> (44, TB)	<i>Rana palustris</i> (173, TX)
<i>Gyrinophilus palleucus</i> (676, TB)	<i>Rana clamitans</i> (100, TX)
<i>Gyrinophilus porphyriticus</i> (436, TP)	<i>Rana catesbeiana</i> (32, TX)
<i>Eurycea lucifuga</i> (851, TP)	<i>Rana sphenocephala</i> (1, AC)
<i>Eurycea longicauda</i> (78, TP)	<i>Bufo americanus</i> (1, AC)
<i>Eurycea cirrigera</i> (66, TX)	<i>Bufo fowleri</i> (1, AC)
<i>Pseudotriton ruber</i> (225, TP)	<i>Gastrophryne carolinensis</i> (1, AC)
<i>Plethodon dorsalis</i> (62, TX)	<i>Pseudacris crucifer</i> (1, AC)
<i>Plethodon glutinosus</i> (340, TX)	<i>Hyla chrysoscelis</i> (1, AC)
<i>Plethodon petraeus</i> (4, TX)	<i>Acris crepitans</i> (1, AC)
<i>Desmognathus abditus</i> (1, AC)	
<i>Desmognathus conanti</i> (33, TX/AC)	
<i>Hemidactylium scutatum</i> (1, AC)	
<i>Notophthalmus viridescens</i> (1, AC)	

Cave Reptile Records

Squamates	Turtles
<i>Crotalus horridus</i>	<i>Terrapene carolina</i> (3 records)
<i>Elaphe obsoleta</i> (3 records)	
<i>Nerodia sipedon</i>	
<i>Scincella lateralis</i>	

Spring Salamander *Gyrinophilus porphyriticus*



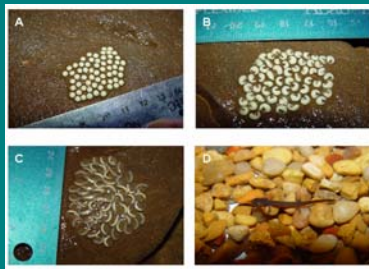
- 438 records
- 14 caves
- Adults and larvae
- Cannibalism
- Parasites

Southern Two-lined Salamander *Eurycea cirrigera*



- 66 records
- 8 caves
- Adults, larvae, and eggs
- Migration
- Oviposition

Eurycea cirrigera Egg Development



Eurycea cirrigera Egg Development

Egg Mass	Distance from Entrance (m)	Mass Surface Area (mm ²)	26 Jan	09 Feb	26 Feb
1	46	1408	61 (11) ¹	61 (31) ¹	60 (42)
2	53	1440	56 (26) ¹	53 (40) ¹	HT
3	56	1400	58 (29)		
4	59	1443	32 (37)	31 (43)	HT
5	64	986	61 (10)	46 (29)	HT
6	38	1426	54 (38)	HT	HT
7	91	1080		65 (19)	
8	38	2183			71 (21) ¹
9	61	1512			38 (38)

¹Adult female found in attendance of egg mass.

Long-tailed Salamander
Eurycea longicauda



- 78 records
- 15 caves
- Adults and larvae
- Partial courtship

Cave Salamander
Eurycea lucifuga



- 851 records
- 89 caves
- Adults, juveniles, larvae, and eggs
- Oviposition
- Parasites

Eurycea lucifuga flatworm infection



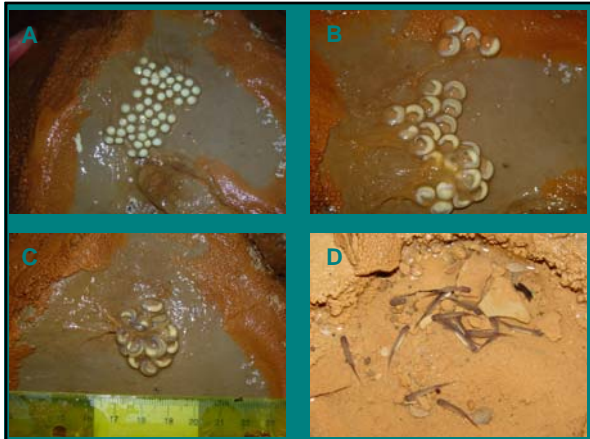
Red Salamander *Pseudotriton ruber*



- 225 records
- 25 caves
- Adults, juveniles, larvae, and eggs
- Oviposition
- Oophagy

Pseudotriton Oviposition





Pseudotriton ruber Oviposition



Zigzag Salamander
Plethodon dorsalis



- 851 records
- 14 caves
- Adults, juveniles, and eggs
- Oviposition

Northern Slimy Salamander
Plethodon glutinosus



- 340 records
- 30 caves
- Adults and juveniles
- Up to 102 individuals during a single survey

Pickerel Frog
Rana palustris

- 173 records
- 34 caves
- Adults and juveniles



Green Frog
Rana clamitans

- 100 records
- 27 caves
- Adults and juveniles





Any Questions?
