

# AMPHIBIAN DECLINES

---

THE CONSERVATION STATUS OF UNITED STATES SPECIES

Edited by

MICHAEL LANNOO

UNIVERSITY OF CALIFORNIA PRESS  
*Berkeley Los Angeles London*

University of California Press  
Berkeley and Los Angeles, California

University of California Press, Ltd.  
London, England

© 2005 by the Regents of the University of California

Library of Congress Cataloging-in-Publication Data

Amphibian declines: The conservation status of United States species

/ edited by Michael Lannoo.

p. cm.

Includes bibliographical references and index.

ISBN 0-520-23592-4 (cloth : alk. paper)

1. Amphibian declines. 2. Amphibian declines—United States. I.

Lannoo, Michael

QL644.7.A48 2005

333.95'78—dc22

2004015272

Printed in Canada

10 09 08 07 06 05

10 9 8 7 6 5 4 3 2 1

The paper used in this publication meets the minimum requirements  
of ANSI/NISO Z39.48-1992 (R 1997) (*Permanence of Paper*).

mats or *Fimbristylis* (Rabb, 1966; Bruce, 1971; Foard and Auth, 1990).

iii. Larval polymorphisms. Unknown and unlikely.

iv. Features of metamorphosis. In North Carolina populations, metamorphosis occurred after 1 or 2 yr of development when larvae were 27–42 mm SVL (Bruce, 1971). In Georgia, metamorphic individuals measured between 30 and 35 mm SVL (Foard and Auth, 1990), presumably also 1 or 2 yr post-hatching. While Bruce indicated that metamorphosis is most common in spring and summer, there are no corresponding data on timing of metamorphosis for the Georgia population.

v. Post-metamorphic migrations. Most pond-breeding salamanders (e.g., those of the genera *Ambystoma* and *Notophthalmus*) migrate from the nuptial/natal site following metamorphosis; many-lined salamanders are a clear exception to this trend. Juveniles and adults are primarily aquatic and appear to stay within or at least near the pond of origin.

vi. Neoteny. Perennibranchism, the retention of external gills throughout life, is not known, but these aquatic salamanders demonstrate some degree of reproductive acceleration when compared to their closest relatives in the genera *Gyrinophilus* and *Pseudotriton* (Ryan and Bruce, 2000).

D. Juvenile Habitat. Because post-metamorphic individuals are still predominantly aquatic, the larval, juvenile, and adult habitat characteristics are essentially the same (see Petranka, 1998).

E. Adult Habitat. Many-lined salamanders are usually aquatic, especially in permanent water, but occasionally found on land under logs in damp situations (Brimley, 1909, 1939; Bishop, 1943; Rabb, 1966; Bruce, 1971; Foard and Auth, 1990). Means (2000) refers to these animals as “technically a wetland species” living their entire larval and metamorphosed life in shallow, acid waters of Lower Coastal Plain swampy streams, coming onto land only occasionally. Most abundant in pools and slow streams such as gum and cypress swamps, woodland ponds, borrow pits, canals, and drainage ditches. Ryan and Bruce (2000), following Rabb (1966), note they are usually restricted to swamps, ditches, and sluggish streams of the Atlantic Coastal Plain. Animals can be collected by raking out dead leaves and detritus or by searching in and under *Sphagnum* sp. mats (Bishop, 1943; Rabb, 1966). However, adults occasionally are captured terrestrially.

F. Home Range Size. No studies to date have investigated home range size (or even the presence thereof) in many-lined salamanders.

G. Territories. Unknown. However, it may be safe to speculate that many-lined salamanders do not maintain distinct territories as opposed to many other plethodontid salamanders that are highly territorial. Because these are aquatic sala-

manders, marking territories via conventional methods (see Jaeger, 1988; Jaeger and Forrester, 1993) is problematic.

H. Aestivation/Avoiding Desiccation. Foard and Auth (1990) reported digging up many-lined salamander adults from exposed riverbeds during drought conditions. Individuals were found singly in small cavities measuring “about two-thirds their body length and twice their body width.” It is unknown how long the individuals were in these cavities or how long they would be capable of remaining there.

I. Seasonal Migrations. Because of the almost exclusively aquatic life style, seasonal migrations are unlikely.

J. Torpor (Hibernation). Unlikely, given that many-lined salamanders live in a region that does not regularly experience extended sub-freezing temperatures.

K. Interspecific Associations/Exclusions. According to Petranka (1998), many-lined salamanders are found in association with other amphibians, but competitive and/or predatory interactions are poorly understood. Means (2000) notes that many-lined salamanders are found in association with mud salamanders (*Pseudotriton montanus*), dwarf salamanders (*Eurycea quadridigitata*), and southern dusky salamanders (*Desmognathus auriculatus*). Other species found by Bruce (1971) to be in association with many-lined salamanders include lesser sirens (*Siren intermedia*), two-toed amphiumas (*Amphiuma means*), and several anurans such as southern cricket frogs (*Acris gryllus*), southern leopard frogs (*Rana sphenoccephala*), and carpenter frogs (*R. virgatipes*).

L. Age/Size at Reproductive Maturity. In males, maturation follows metamorphosis. In females, maturation is delayed until 1 yr following metamorphosis. Therefore, males reproduce in the autumn following metamorphosis, when about 21–33 mo old and 33–40 mm SVL (Bruce, 1971; Ryan and Bruce, 2000). Unlike males, females remain juveniles for >1 yr after metamorphosing and do not reproduce for the first time until 3 or 4 yr old and between 37–45 mm SVL (Bruce, 1971; Ryan and Bruce, 2000). Adults range from 63–112 mm TL, with slightly <1/2 length being tail (Rabb, 1966). Despite the asynchrony in the attainment of maturation, there appears to be no sexual size dimorphism (Bruce, 1971; see also Petranka, 1998).

M. Longevity. Unknown.

N. Feeding Behavior. While they share the same habitat, the prey of post-metamorphic many-lined salamanders differs from larvae in terms of the diversity of prey taken and the relative abundances. Only seven taxa were represented in the guts of larvae, whereas twice as many taxa were present in the gut of adults (Foard and Auth, 1990). The most common prey items were still isopods (52% of all stomachs investigated; only 37% in larvae), with amphipods a distant second (21%).

No other taxa were represented in >5% of the 161 transformed individuals examined. Most of the time, transformed individuals feed off the bottom, consuming larger prey items than larvae. However, they are capable of feeding off the surface, as long as their limbs are in contact with the substrate, and may in fact feed on terrestrial invertebrates (e.g., lepidopterans, coleopterans, chilipodans, and formicidians) during periods of heavy rainfall. Foard and Auth (1990) speculated that the terrestrial invertebrates were swept into the aquatic habitats during the rainfall, but because adults are known to occasionally leave wetlands (which would be most likely during periods of significant rainfall) it should not be ruled out that some terrestrial feeding occurs.

O. Predators. Unknown, but Petranka (1998) states that natural predators probably include aquatic snakes, fishes, wading birds, and invertebrates such as dragonfly naiads and dytiscid beetle larvae. Bruce (1971) documented several species of snakes in many-lined salamander habitats, including at least two species, southern water snakes (*Nerodia fasciata*) and black swamp snakes (*Seminatrix pygaea*), likely to feed on aquatic salamanders.

P. Anti-Predator Mechanisms. Many salamanders are well known for their defensive displays and postures (e.g., Brodie, 1977), but virtually all species for which such behaviors are known are at least partially, if not altogether, terrestrial. Defensive displays are likely ineffective in murky waters such as those inhabited by many-lined salamanders. Accordingly, there is no record of defensive posturing in this species, and it is unlikely that such behaviors exist.

Q. Diseases. Unknown.

R. Parasites. Gut parasites were common in Foard and Auth's (1990) samples; nearly half of all the guts examined contained at least one endoparasite, most commonly the acanthocephalan, *Pilum pilum*. They speculate that parasitism was a result of gastropod ingestion; however, they did not record gastropods in the gut contents of any animals investigated.

#### 4. Conservation.

Many-lined salamanders are one of the more poorly known plethodontids. Loss of populations has undoubtedly occurred with wetland drainage, but this has not been documented. Mitchell (1991) describes their conservation status as Undetermined. Wetland destruction is likely a primary threat to their long-term persistence.

*Typhlotriton (Eurycea) spelaeus* Stejneger, 1893

GROTTO SALAMANDER

Dante B. Fenolio, Stanley E. Trauth

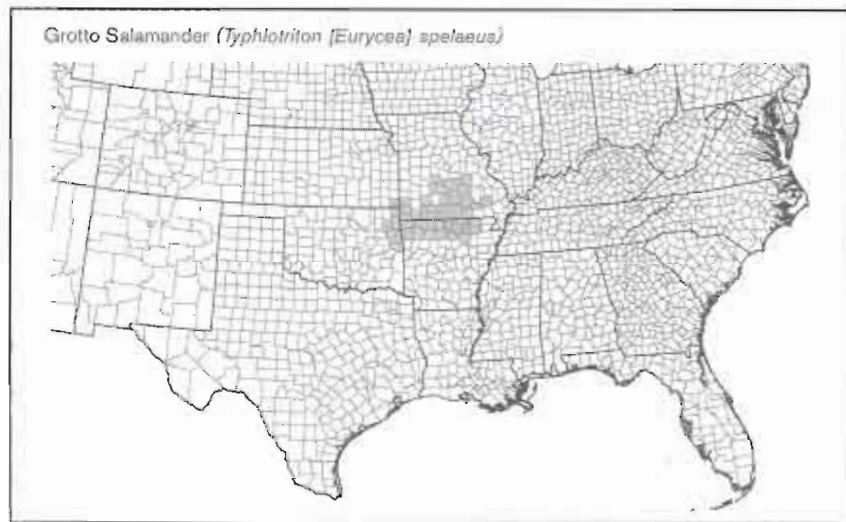
#### 1. Historical versus Current Distribution.

The modern distribution of grotto salamanders (*Typhlotriton [Eurycea] spelaeus*;

sometimes called "ghost lizards" by local citizens; DiSilvestro, 1983) spans the Salem and Springfield regions of the Ozark uplift in Missouri, Oklahoma, extreme southeastern Kansas, and Arkansas. Grotto salamanders currently have no fossil record (Brandon, 1970).

Oklahoma primarily during a 2-yr period (1975–76).

Detailed records of sightings, and in some cases even numerical records of encounters, can be found in speleological society newsletters and peer-reviewed journals dating as far back as the 1930s



Grotto salamanders and other probable close relatives, including Texas blind salamanders (*Eurycea rathbuni*) and Georgia blind salamanders (*Haidetriton wallacei*), may have evolved from proto-*Eurycea* stock (Wake, 1966; Brandon, 1971b; see also Bowett and Chippindale, 2004). Origins of this species remain speculative, but at least one hypothesis suggests grotto salamanders evolved in the Ozark Plateau—the "Interior Highlands" (Dowling, 1956). The Interior Highlands were not covered by shallow seas of the Cretaceous and provided a refuge from the glaciers of the Pleistocene epoch because the southward push of the ice stopped at the base of the plateau. Toward the end of the Pliocene, an arid stage may have drastically affected Kansas and the Ozarks. According to the hypothesis, these climactic changes drove the ancestors of *Typhlotriton* below ground, along with the ancestors of this region's cave fish and cave crayfish fauna.

## 2. Historical versus Current Abundance.

Historical versus current abundance is generally unknown. Rudolph (1980) found larval grotto salamanders in densities of over 10/m<sup>2</sup> in an epigeic spring, compared to fewer than 2/m<sup>2</sup> in a cave habitat. Smith (1959) examined several hundred larvae predominantly from a single spring in Independence County, Arkansas. Over a 7.5-yr period (1960–68), 220 adults were collected from a single cave in Shannon County, Missouri (Brandon, 1971a; Besharse and Brandon, 1974). Rudolph (1978) examined 111 larvae from a single spring run in northeast

(Blair, 1939). Some of these notes, combined with recent surveys of the same systems, demonstrate stable populations of grotto salamanders for >25 yr (Rimbach, 1968; Looney and Puckett, 1970; Looney, 1973; Graening and Brown, 2000; Graening et al., 2001).

## 3. Life History Features.

**A. Breeding.** Reproduction is likely aquatic.

**i. Breeding migrations.** Observations in some caves suggest that individuals move seasonally to and from small fissures, cracks, and crevices. Animals may aggregate in larger cave systems during and shortly after the wettest times of the year. These movements serve a dual purpose: reproduction and foraging. Prey densities in larger caverns are highest at this time (Hendricks and Kezer, 1958; Brandon, 1971a). Pyle (1964) indicated that breeding occurred year-round, although sexing of individuals in this study was questionable. Other authors have mentioned the ease of clearly observing light-colored eggs through the flanks and ventral surface of adult females (Barden and Kezer, 1944; Kezer, 1952b; Brandon, 1962; personal observations). Brandon (1971a) indicated that food may be limiting in these troglobitic systems and may provide sufficient nutrients for females to breed only every second or third year.

Breeding likely involves the transfer of a spermatophore from a male to a female, but neither this nor the courting behaviors have been observed.

**ii. Breeding habitat.** Reproduction and egg deposition occur within caves. Adults mate during the summer (May–August; Brandon, 1971a), and females oviposit from 1–4 mo after mating (Smith, 1960).

## B. Eggs.

**i. Egg deposition sites.** Females oviposit in cryptic sites within caves, possibly in the water and within the rock rubble or immediately above a water source on a damp surface, where high humidity prevents the desiccation of the egg mass. In the laboratory, a female given pituitary gland implants deposited four eggs in the water and nine more attached to the moist surface of a rock above the water line (Barden and Kezer, 1944). Eggs, larvae in gelatinous egg membranes, and newly hatched larvae were attached singly to the edges of rocks in a cave waterway (Smith, 1960; but see Brandon, 1962).

**ii. Clutch size.** Thirteen eggs were produced by a female given pituitary implants; the eggs were 2.7–3.0 mm in diameter (Barden and Kezer, 1944; Brandon, 1966d; Trauth et al., 1990). Hatchlings average 13 mm SVL (range 10–16 mm; Brandon, 1965c, 1970) and were found from mid-December to January (Smith, 1959, 1960).

## C. Larvae/Metamorphosis.

**i. Length of larval stage.** Larvae have been collected throughout the year (Pyle, 1964; Brandon, 1971a,b; Collins, 1993). Cold water temperatures and, in some cases, low food availability may hinder accurate assessment of larval age due to slower growth rates relative to above-ground *Eurycea*. The larval period apparently lasts 2–3 yr (Hendricks and Kezer, 1958; Brandon, 1966d, 1971a,b; Rudolph, 1980; Trauth et al., 1990), although data are limited.

Recently hatched larvae range from 10–16 mm SVL, and a second size class, representing approximately 1 yr of age, ranged from 22–30 mm SVL (Rudolph, 1978); maximum larval size is 60 mm SVL. Larvae are known to drift from cave waterways, out through the cave entrance, and into above-ground portions of the same stream. Larvae generally remain within 12 m of the mouth of natal caves (Rudolph, 1978). Whether they migrate back into natal caves or are swept downstream, perhaps to colonize other cave systems, is unknown (Brandon, 1971b; see also Petranksa, 1998). Larvae collected from caves tend to be lighter than larvae from surface streams and can be solid pink or a silvery-blue color. Post-metamorphic individuals range from 38–57 mm SVL (Besharse and Brandon, 1974).

**ii. Larval requirements.** Epigeic larvae are more pigmented than larvae from deep inside caves. Above-ground larvae occur in springs with clear water and sand or gravel substrates with little silt (Smith, 1960), as well as in streams associated with a nearby subterranean system; larvae can also be observed in waterways of the deepest accessible reaches of caves

(Hendricks and Kezer, 1958; Brandon, 1971b). Below-ground aquatic habitats where larvae have been observed include flowing waterways as well as rimstone pools (Bretz et al., 1983; personal observations). Preliminary evidence indicates larvae may move through phreatic passages (flooded caves, solution channels, and fault lines), possibly between cave systems and throughout the expanse of aquifers (V. Brahanna, personal communication). In a comparison of five spring-inhabiting species, grotto salamander larvae preferred cooler waters (Rudolph, 1980). Water characteristics of larval habitats have been collected at a number of locations: water temperature typically ranges from 5.5–16.5°C in springs (Smith, 1960; Rudolph, 1980) and from 11–16°C in caves (Pyle, 1964; Rudolph, 1980). The pH values collected for springs and caves range from 6.0–7.5 (Smith, 1960; Pyle, 1964; G.O. Graening, personal communication).

Small and intermediate-sized larvae have functional eyes that degenerate in older larvae and adults; eyelids of adults may grow over vestigial eyes in some adults (Smith, 1960; Stone, 1964a; Brandon, 1970; Besharse and Brandon, 1974, 1976). Data suggest that larvae regularly exposed to light may retain vision for longer periods than larvae maintained in darkness (Noble and Pope, 1928; Besharse and Brandon, 1976). Laboratory manipulation has shown that functional eyes of larvae that are surgically removed and then grafted back in place can regenerate the optic nerve and at least some degree of vision (Stone, 1964b).

a. *Food.* Larvae feed on small invertebrates and may employ a mix of sit-and-wait (Dodd, 1980; see also Petranka, 1998) and active foraging (personal observations) behaviors. Isopods (*Lirceus happinae*) form the bulk of the diet in some populations (Smith, 1948a,b). In other populations, diets are more diverse and include snails, dipteran larvae, annelids, arachnids, ostracods, copepods, amphipods, decapods (specifically small crayfish), diplopods, ephemeropteran nymphs, plecopteran nymphs, homopterans, hymenopterans, coleopterans, trichopterans, lepidopterans, centipedes, and other salamander (*Eurycea* sp.) larvae (Brandon, 1971a; Rudolph, 1980).

b. *Cover.* Surface larvae are secretive, being found during the day in gravel or under flat rocks (Smith, 1960). In some instances, larvae have been found at depths  $\leq 0.75$  m in rock rubble (Smith, 1960).

iii. *Larval polymorphisms.* Unknown.

iv. *Features of metamorphosis.* Larvae metamorphose from 85–96 mm TL.

v. *Post-metamorphic migrations.* Larvae approaching metamorphosis that live outside a cave are believed to return to subterranean retreats to complete metamorphosis; no adults have been found outside caves (Brandon, 1971b). The fact

that larvae are readily found in springs and waterways, even a good distance from the mouth of a cave, may indicate that larval dispersion enables genetic exchange between populations (Brandon, 1971b).

vi. *Neoteny.* Some authors have indicated that gilled adults may occur in nature (Bishop, 1944; Mohr, 1950; Smith, 1960); although Brandon (1966d) found no evidence to support this idea. Reproductive maturity occurs near the time of metamorphosis.

D. *Juvenile Habitat.* Likely to be no different than adult habitats. The juvenile stage is short; sexual maturity appears to occur at, or shortly after, metamorphosis (Brandon, 1966d).

E. *Adult Habitat.* Adults are limited to limestone caves and underground passages in the karst formations of the Ozark Plateau and are most frequently found beyond the twilight zone on moist rock walls (Hendricks and Kezer, 1958; Brandon, 1971a).

F. *Home Range Size.* Unknown.

G. *Territories.* Unknown.

H. *Aestivation/Avoiding Desiccation.* Unlikely.

I. *Seasonal Migrations.* See "Breeding migrations" above.

J. *Torpor (Hibernation).* Unlikely.

K. *Interspecific Associations/Exclusions.* In a study investigating competition among five species of larval salamanders in the Ozarks, Rudolph (1980) found that grotto salamander larvae commonly inhabit spring headwaters and areas of subsequent drainages in conjunction with other salamander larvae. These spring habitats have the highest prey abundances, reduced temperature fluctuations (and cooler temperatures), a decreased likelihood of desiccation from receding waters, the least exposure to floods, an ease of reentering subterranean habitats, and the least exposure to predatory fish species. The study suggested that grotto salamander larvae occurring in low to moderate densities will displace larvae of at least two other salamander species, cave salamanders (*Eurycea lucifuga*) and long-tailed salamanders (*E. longicauda*), through aggressive behavior and predation. In some springs examined, larval grotto salamanders in moderate to high densities entirely eliminated larvae of other species. According to Rudolph (1980), only Oklahoma salamanders (*E. tynerensis*) can consistently coexist with larval grotto salamanders, but only at reduced densities and when well-developed gravel substrates provide cover. If grotto salamander larvae are absent or are removed from spring habitat, larvae from the other species will successfully colonize until grotto salamander populations become reestablished. The aggressive behavior of the larvae is not directed exclusively to other species; physical damage to conspecifics has been noted as well.

L. *Age/Size at Reproductive Maturity.* Adults reach sexual maturity between 36–60 mm SVL (Smith, 1960). Both males and females have cirri, but males in breeding condition have longer, enlarged cirri. The mental gland in reproductively active males is located beneath the lower jaw (Brandon, 1971a). Reproductive females of lighter color have cream to white eggs that can be observed through the walls of the flanks and the ventral surface (Barden and Kezer, 1944; Kezer, 1952; Brandon, 1962; D. B. F., personal observations).

M. *Longevity.* A captive specimen lived nearly 12 yr (Snider and Bowler, 1992).

N. *Feeding Behavior.* While adult grotto salamanders may be top predators in some caves (Schwartz, 1976), potential predators of the salamanders have been identified in others (see "Predators" below). Adults forage on land as well as in the water (Mohr, 1950; Brandon, 1971a; D. B. F., personal observations). In the terrestrial environment, they commonly forage directly on guano piles (Black, 1971c; D. B. F., personal observations). Adult prey includes gnats, mosquito larvae, beetles (Brandon, 1971a), and isopods (Smith, 1948a). Adults climb into the webs of mycetophilid gnat (*Macrocera nobilis*) larvae to eat them (D. B. F., personal observations). Grotto salamanders are opportunistic predators, taking advantage of seasonal and regional prey availability. Ninety-six percent of the stomach contents of larvae from one cave were composed of a single species of isopod (*Lirceus happinae*); 80% of the prey of sympatric adults were the same isopod species (Smith, 1948b).

O. *Predators.* Larvae may be eaten by crayfish; adults appear to have few natural predators (Petranka, 1998); although green frogs (*Rana clamitans*) and pickerel frogs (*R. palustris*) are known to inhabit cave habitat at least seasonally, with many large enough to consume larvae and small, newly metamorphosed grotto salamanders. Raccoon (*Procyon lotor*) tracks in Ozark caves are common, even deep within caves, and it is possible that raccoons eat adult and larval grotto salamanders (D. B. F. and G. O. Graening, personal observations). Following flooding of their epigeal streams, grotto salamander larvae can be consumed by predatory fishes (Rudolph, 1980).

P. *Anti-Predator Mechanisms.* Individuals on walls or ledges above pools or streams drop into the water below when approached (D. B. F., personal observations).

Q. *Diseases.* Unknown.

R. *Parasites.* Isopods (*Lirceus happinae*) serve as prey for both larval and adult grotto salamanders and harbor a cestode parasite, *Ophiotaenia cestodes*, that infects larvae (Smith, 1948a). The nematode *Falcaustra catesbeianae* is found in Missouri populations (Dyer, 1975).

#### 4. Conservation.

Among natural threats, larval grotto salamanders are sensitive to flooding of epigeal streams. Only 20% of a population of larval grotto salamanders remained in a surface stream after heavy flooding (Rudolph, 1980). Moreover, grotto salamander larvae are consumed by predatory fishes (Rudolph, 1980; see also "Predators," above).

There are several human threats to grotto salamanders. Both aquatic larvae and adults share subterranean living space with several critically endangered aquatic organisms including troglobitic isopods and amphipods, troglobitic crayfish of the genus *Cambarus*, and amblyopsid cavefish. Studies of these syntopic species have produced a considerable amount of information about human threats to the subterranean aquatic environments of the Ozark Plateau. The threats that face these endangered organisms equally endanger syntopic grotto salamanders. Among the threats are deforestation and development of critical above-ground recharge zones (Means and Johnson, 1995; Culver et al., 1999; Graening, 2000), human dumping of materials above ground that drastically affect groundwater quality (Means, 1990; Culver et al., 1999; Graening, 2000), manipulation of nutrients in groundwater allowing above-ground species to move into below-ground habitat and compete with or consume troglobites (A. V. Brown et al., 1994), and inexperienced cave explorers damaging critical aquatic habitat, trampling animals, and over-collecting regardless of protective laws (Willis and Brown, 1985). Grotto salamanders in particular seem sensitive to disturbance or impurities introduced into subterranean waterways and caves. During commercialization of caves in Camden County, Missouri, grotto salamanders disappeared from areas of the cave that were electrically lighted. When the lighting was removed, the salamanders returned (Weaver, 1987). Surveys after a 1981 spill of approximately 80,000 l of liquid ammonia nitrate in Missouri found that grotto salamanders 21 km from the spill were killed as the contaminant moved through a connected, subterranean aquifer (Crunkilton, 1984). Grotto salamanders also suffer from the introduction of sport-fishes into their habitat (Rudolph, 1980). Because bat guano supplies many terrestrial cave invertebrates with food, decline of colonial bats in the Ozarks may affect prey abundance.

Three of four states where grotto salamanders are found protect the species. The fourth state, Arkansas, is taking steps to protect the species as well (K. Irwin, Arkansas Game and Fish Commission, personal communication). Even with the state protection, habitat alteration poses the greatest threat to the species' survival. For example, a 1976 study of Cathedral Cave, Missouri, warned that the proposal

of an artificial lake in the region would eliminate all available habitat for the species in that cave system (Schwartz, 1976). The recovery of reduced colonies of colonial bats in the Ozarks is essential to sustain large deposits of guano in subterranean habitats, which in turn serve as food for many of the invertebrates that grotto salamanders rely on as prey. Currently, gray myotis (*Myotis grisescens*), only one of the three colonial bat species in the Ozarks, is showing signs of rebounding population numbers (S. Hensley, U.S. Fish and Wildlife Service, personal communication).

#### Family Proteidae

*Necturus alabamensis* Viosca, 1937

BLACK WARRIOR WATERDOG

Mark A. Bailey

##### 1. Historical versus Current Distribution.

The type locality of black warrior waterdogs (*Necturus alabamensis*) is the Black Warrior River, tributary of the Alabama River, near Tuscaloosa, Tuscaloosa County, Alabama (Viosca, 1937; Bailey and Moler, 2003). Black warrior waterdogs range through a restricted segment of north-central Alabama. They apparently are confined to medium-large streams of the upper Black Warrior River system above the Fall Line (Bart et al., 1997). Black warrior waterdogs are known from nine stream segments in four counties: Sipsy Fork and Brushy Creek in Winston County, Locust Fork and Blackburn Fork in Blount County, Mulberry Fork, Blackwater Creek, and Lost Creek in Walker County, and Yellow Creek and North River in Tuscaloosa County (Ashton and Peavy, 1986; Bart et al., 1997). Although their geographic distribution has not been clearly delineated, their range is thought to essentially mimic

that of flattened musk turtles (*Sternotherus depressus*; Ashton and Peavy, 1986; Guyer, 1997, 1998). Additional comments on the identity and distribution of black warrior waterdogs can be found in Gunter and Brode (1964), Brode (1969), Mount (1975), and Guttman et al. (1990). Neill (1963) commented on the distribution of "*N. alabamensis*," but considered distant Coastal Plain *Necturus* populations to be conspecific.

##### 2. Historical versus Current Abundance.

The historical abundance of black warrior waterdogs is poorly known, but a remarkably large series of 135 specimens was collected in late winter and spring of 1938 in pre-impoundment Mulberry Fork at Cordova, Walker County (Bart et al., 1997). Collection methods, effort, and collector are unknown. Black warrior waterdogs were recently documented (by single specimens) at two localities upstream from this site (Bailey, 1995; Guyer, 1997) and near the upper reaches of Bankhead Lake. However, there is no indication that waterdogs remain present anywhere in the densities that must have existed in 1938 to enable the collection of such a large number of animals. Mount (1981) estimated that sympatric flattened musk turtles no longer inhabited 27% of the stream miles of their historical occupation. The flattened musk turtle recovery plan (USFWS., 1990) suggests that only 142 out of 947 stream miles (15%) in the upper Black Warrior drainage may support flattened musk turtle populations, and there is no reason to assume conditions are different for black warrior waterdogs. The status of black warrior waterdogs in impoundments remains poorly known (Guyer, 1997). Bailey (1992, 1995) sampled for black warrior waterdogs at 77 sites scattered across the presumed range. Guyer (1997) re-sampled most of these sites

