

Catalogue of American Amphibians and Reptiles.

Miller, B.T. and M.L. Niemiller. 2012. *Gyrinophilus palleucus*.

***Gyrinophilus palleucus* McCrady
Tennessee Cave Salamander**

Gyrinophilus palleucus McCrady 1954:201. Type-locality, "Sinking Cove Cave (altitude 900 feet) in a hardwood climax forest at the north end of Sinking Cove, Franklin County, Tennessee, 5 miles west of Sherwood across Burned Stand Ridge, and 15 miles southwest of Sewanee." Holotype, Field Museum of Natural History (FMNH) 72585, a female collected in January 1944 by E. McCrady (not examined by authors).

Pseudotriton palleucus: Blair 1961:499.

• **CONTENT.** Two subspecies are recognized: *Gyrinophilus palleucus palleucus* and *G. p. necturoides*.

• **DEFINITION.** *Gyrinophilus palleucus* is a relatively large (most salamanders found range from 70–105 mm SVL) and robust stygobitic salamander. Larviform individuals have 3 pairs of gill rami extending from the posterolateral margin of the broad head. Each ramus supports 2 rows of 21–33 pale to pink gill fimbriae. Labial folds are present. Although considerable variation in eye size exists among populations, the iris is seldom visible and the distance from the tip of the snout to the anterior margin of the lidless eye is 4 to 5 times the diameter of the eye (Figure 1). The broad and bluntly rounded snout lacks a canthus rostralis and nasolabial grooves, but bears 2 tiny nostrils. The internal nares open at the posterolateral margin of the vomerine teeth. Teeth of the jaws and palate are in single rows. The single premaxilla bears 20–29 teeth, whereas the paired vomers each bear 14–17 teeth and the paired pterygoids each bear 7–13 teeth. The maxillae are absent in larviform individuals; hence, no maxillary teeth are present. The trunk has 16–19 costal grooves (from axilla to groin, inclusive) and typically is longer than the tail. The limbs are stout and relatively short; 6–8 intercostal grooves are present between adpressed limbs. There are 4 toes on the front feet, and 5 toes on the hind feet. The digits are not webbed. The relative length of the toes on the forefoot is $I < (II < IV) < III$, and on the hindfoot, $I < V < II < (IV < III)$, with digits in parentheses either being of equal length or the order of the 2 digits varying among individuals. The tail is stout, thickest at the base and tapering posteriorly, laterally compressed, and relatively short (never exceeding, although occasionally equaling, the body length). The tail is approximately 3 times the length of the head. The caudal fin does not extend onto the body, but begins as a low ridge at the midline of the base and extends posteriorly towards the tail tip. Approximately 1/4 to 1/3 the distance to the tip, the ridge enlarges to a thin, translucent membrane that extends beyond the muscular tail tip to the venter, such that the tail has a distinct paddle-shaped appearance (Figure 2). Small larvae



FIGURE 1. Adult *Gyrinophilus palleucus necturoides* from the Elk River drainage system in Coffee (above) and Grundy (below) counties, Tennessee. Photographs by Brad Glorioso (above) and Matthew L. Niemiller (below).

lack dark spots and are uniformly pale or lightly stippled (Figure 2). Depending on the locality, the coloration of large larvae, presumed paedomorphic adults, and metamorphosed individuals is similar to that of small larvae, or more heavily pigmented and spotted (Figs. 1, 2, and 3). The venter and undersurfaces of the limbs and ventral third of the tail are flesh-colored. The lateralis system is well developed



FIGURE 2. An adult *G. p. palleucus* from the lower Tennessee River drainage system in Marion County, Tennessee (photograph by Matthew L. Niemiller).



FIGURE 3. A larval *Gyrinophilus p. palleucus* from the Crow Creek drainage system in Franklin County, Tennessee (photograph by Matthew L. Niemiller).

on the head and body, and often is apparent as a distinct pattern of unpigmented sensory pores along each side of the body, beginning at the gills and extending onto the basal half of the tail. A few metamorphosed individuals have been observed (Figure 5). Metamorphs have an undivided premaxilla that bears 15–18 teeth ($n = 2$), and paired prevomerines, maxillae and parasphenoids that bear 20–21 teeth ($n = 2$), 25–26 teeth ($n = 1$), and 58/59 teeth ($n = 1$) each, respectively (Brandon et al. 1986; Yeatman and Miller 1985). There are 18–19 trunk vertebrae ($n = 2$) (Brandon et al. 1986; Yeatman and Miller 1985). The eyelids are well formed, the labials and tail fin are reduced from the larviform condition, and the tail is laterally compressed. The nasolabial grooves are well developed. Gills are completely reabsorbed, but gill scars remain. Eggs and embryos have not been described.

• **DIAGNOSIS.** *Gyrinophilus palleucus* is a member of the *Gyrinophilus palleucus* species group that includes *Gyrinophilus palleucus palleucus*, *G. p. necturoides* and *G. gulolineatus*. *Gyrinophilus palleucus* is distinguished from *G. gulolineatus* and other congeners (*G. porphyriticus* and *G. subterraneus*) by a



FIGURE 4. A transformed adult *G. palleucus* from the lower Tennessee River drainage system in Jackson County, Alabama (photograph by Matthew L. Niemiller).

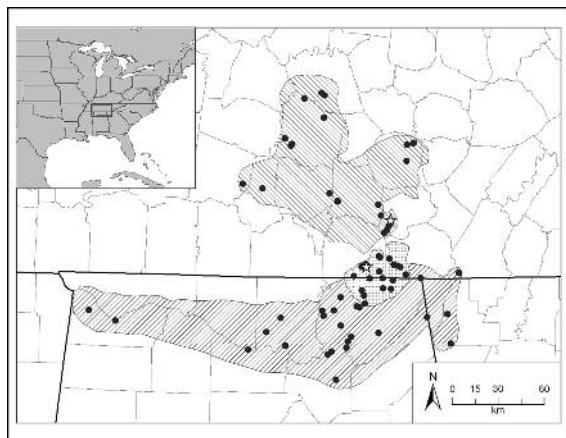
combination of morphology, coloration, and genetics. Larviform *G. p. palleucus* are distinguished from larviform *G. gulolineatus* by their overall uniformly pale dorsal coloration, uniformly colored chin and throat, and by narrower head. *Gyrinophilus p. palleucus* also have more trunk vertebrae (18 in 52% of *G. p. palleucus* vs 80% of *G. gulolineatus*). *Gyrinophilus gulolineatus* also attains a greater size (up to 136 mm SVL). Metamorphosed specimens of *G. palleucus* and *G. gulolineatus* differ in tooth counts, relative eye size, and division of the premaxillary bone. In general, metamorphosed *G. p. palleucus* have fewer maxillary (51 vs. 79), prevomerine (maximum of 40 vs. 76), and premaxillary teeth (15 vs. 25). Parasphenoid teeth number 117 in *G. palleucus* but are absent in *G. gulolineatus*. The premaxillary bone is undivided in *G. p. palleucus*, but divided in *G. gulolineatus*. The eyes are smaller and less conspicuous in *G. p. palleucus*. Both *G. p. palleucus* and *G. p. necturoides* have smaller eyes, typically lacking a discernible iris, than do larval *G. porphyriticus*. Eye diameter is $1/4$ – $1/5$ the length of the snout in *G. p. palleucus* and *G. p. necturoides*, whereas it is $>1/3$ the length of the snout in *G. porphyriticus*. Larvae of the two subspecies of *G. palleucus* also have greater numbers of teeth on the palate and upper jaw than *G. porphyriticus*; each prevomer averages 25 (16 in *G. porphyriticus*), the pterygoid (20 vs. 14), and each premaxilla (32 vs. 26). Allozyme data (Addison Wynn, pers. comm.) support the recognition of two species within the *G. palleucus* complex: *G. palleucus* and *G. gulolineatus*. Mitochondrial and nuclear DNA data are also consistent with recognition of two species (Niemiller et al. 2008, 2009).

• **DESCRIPTIONS.** McCrady (1954) and Lazell and Brandon (1962) provided detailed descriptions of larviform *G. p. palleucus* and *G. p. necturoides*, respectively. Beachy (2005), Brandon (1966, 1967), Miller and Niemiller (2008), Mount (1975), Petranka (1998), and Simmons (1975) provided general descriptions of *G. p. palleucus* or *G. p. necturoides*. Brandon et al. (1986), Miller (1995), and Yeatman and Miller (1985) described naturally metamorphosed individuals. Dent and Kirby Smith (1963) and Yeatman (1967) described individuals induced to undergo metamorphosis.

• **ILLUSTRATIONS.** Color photographs of *Gyrinophilus palleucus* are in Behler and King (1979), Coborn (1993), Godwin (2008), Mitchell and Gibbons (2010), Raffaelli (2007), Simbeck (1995), and Stuart et al. (2008), color photographs of larviform *G. p. palleucus* are in Goricki et al. 2012, Miller and Niemiller (2008, 2011), Niemiller (2006), Niemiller and Miller (2005), and Stuart et al. (2008), and color photographs of *G. p. necturoides* are in Goricki et al. (2012), Petranka (1998), Miller and Niemiller (2008, 2011), Niemiller (2006), and Niemiller and Miller (2005). Smith (1978) provided a color illustration of *Gyrinophilus palleucus*, and Simmons (1975) photographs of cross-sections through the testis of a 66-

mm paedomorphic male from Jess Elliot Cave, Alabama. Black-and-white photographs of larviform *Gyrinophilus p. palleucus* are in Barr (1961), Godwin (2005), Lazell and Brandon (1965), Miller and Niemiller (2005), Mount (1975), Niemiller et al. (2009), and Yeatman (1967). A black-and-white photograph of a metamorphosed adult male is in Brandon et al. (1986), and dorsal and lateral views of a metamorph are in Simmons (1976b). A line drawing (dorsal view) of a larviform female is in McCrady (1954). Line drawings of the skull of metamorphs are in Yeatman (1967) and Yeatman and Miller (1985), and radiographs of the skull of a metamorph and of a larviform individual are in Brandon et al. (1986). Yeatman (1967) also provided line drawings of the skull of a larviform individual. Dent and Kirby-Smith (1963) provided black-and-white photographs of salamanders in various stages of metamorphosis, sections of the eye of larviform and transformed individuals, and radiographs of the anterior half of larviform and transformed salamanders. Yeatman (1967) provided black-and-white photographs of metamorphs and of the skeleton of a cleared and stained metamorph. Black-and-white photographs of sections of the cloaca of a metamorphosed male and of larviform females are in Sever (1986). Black-and-white photographs of larviform *Gyrinophilus p. necturoides* (dorsal and lateral views) and of a section of the head, including the eye, are in Lazell and Brandon (1965). Lazell and Brandon (1962) provided black-and-white photographs of a spermatophore protruding from the cloaca of a larviform male.

• **DISTRIBUTION.** *Gyrinophilus palleucus* is associated with subterranean waters in central and southern middle Tennessee, northern Alabama, and northwestern Georgia. *Gyrinophilus p. palleucus* occurs in the Crow Creek drainage of southern middle Tennessee (Franklin and Marion counties) and northeast



MAP. Distribution of *Gyrinophilus palleucus*. Stars indicate type-localities of *G. p. palleucus* (stippled) and *G. p. necturoides* (forward slashmarks). Localities from which populations have not been identified to subspecies are contained in the polygon with the back slashmarks. Dots represent known localities. All plotted localities represent museum or literature records.

Alabama (Jackson County) associated with caves of the eastern escarpment of the Cumberland Plateau. *Gyrinophilus p. necturoides* inhabits caves within the Collins, Elk, Duck, and Stones River drainages within the Inner Nashville Basin, Eastern Highland Rim, and western escarpment of the Cumberland Plateau of Tennessee. Additional populations not assigned to subspecies have been found on Lookout Mountain (DeKalb County, Alabama, Hamilton County, Tennessee, and Walker County, Georgia), Pigeon Mountain in Walker County, Georgia, and throughout much of the Tennessee River drainage in northern Alabama in Colbert, Jackson, Limestone, Madison, and Marshall counties. Distribution is discussed in Beachy (2005), Brandon (1966, 1967a), Buhlmann (2001), Cooper (1968), Cooper and Cooper (1968), Eager and Hatcher (1980), Godwin (2008), Hollingsworth et al. (1997), Lazell and Brandon (1962), McCrady (1954), Miller and Niemiller (2008, 2011), Mount (1975), Niemiller (2006), Niemiller et al. (2008, 2009, 2011), Petranka (1998), Redmond (1985), Redmond and Scott (1996), and Simmons (1975). Distributional maps are in Bartlett and Bartlett (2006), Beachy (2005), Brandon (1967a), Godwin (2008), Miller and Niemiller (2008, 2011), Mitchell and Gibbons (2010), Mount (1975), Niemiller (2006), Niemiller et al. (2008, 2009, 2011), Petranka (2008), Redmond and Scott (1996), and Simmons (1975).

• **FOSSIL RECORD.** None (Holman 2006).

• **PERTINENT LITERATURE.** Most of the information on the biology of *G. palleucus* stems from only a handful of studies. Topics covered are as follows: **abundance** (Caldwell and Copeland 1992; Huntsman et al. 2011; Miller and Niemiller 2008; Simmons 1975), **activity cycles** (Simmons 1975), **adaptations to subterranean habitats** (Brandon 1971), **cannibalism** (Lazell and Brandon 1962; Simmons 1975), **checklists, keys, and similar compendia** (Altig and Ireland 1984; Culver et al. 2003; Dearolf 1956; Durand 2005; Nicholas 1960; Peck 1998; Powell et al. 1998, 2012; Redmond et al. 1990; Scott and Redmond 2002; Vandell 1965; Weber 2000, 2004), **cloacal anatomy and skin histology** (Sever 1986), **conservation** (Ashton 1986; Beachy 2005; Caldwell and Copeland 1992; Dodd 1997; Eager and Hatcher 1980; Hammerson and Beachy 2004; Hatcher 1981; Miller and Niemiller 2008; Mitchell et al. 1999; Petranka 1998; Simmons 1975; Raffaëlli 2007; Stuart et al. 2008), **diet** (Brandon 1967b; Huntsman et al. 2011; Lazell and Brandon 1962; Miller and Niemiller 2008; Simmons 1975), **eye function and structure** (Beharse and Brandon 1973), **feeding behavior** (Cooper and Cooper 1968), **feeding ecology** (Huntsman et al. 2011), **general accounts** (Bartlett and Bartlett 2006; Beachy 2005; Behler and King 1979; Brandon 1967; Cochran and Goin 1970; Conant and Collins 1998; Godwin 2004a,b, 2008; Miller and Niemiller 2011; Mitchell and Gibbons 2010; Mount 1975; Petranka 1998; Smith 1978; Stuart et al. 2008; Raffaëlli 2007; Stuart

et al. 2008), **growth rate** (Dent and Kirby Smith 1963; Huntsman et al. 2011), **habitat** (Caldwell and Copeland 1992; Simmons 1975), **hatchlings** (Simmons 1975), **karyotype** (Craig et al. 1956), **longevity** (Huntsman et al. 2011; Snider and Bowler 1992), **metamorphosis** (Blair 1961; Brandon et al. 1986; Dent and Kirby Smith 1963; Dent et al. 1955; Miller 1995; Miller and Niemiller 2008, Yeatman 1967; Yeatman and Miller 1985), **parasites** (Brandon 1967b; Simmons 1975), **paedomorphosis** (Bruce 1979; Ryan and Bruce 2000), **predation** (Lee 1969), **reproduction** (Simmons 1975), **skull anatomy** (Brandon et al. 1986; Martof and Rose 1962; Yeatman 1967; Yeatman and Miller 1985), **systematics and taxonomy** (Baldwin 2002; Brandon 1962, 1966; Niemiller 2006; Niemiller et al. 2008, 2009), **thermobiology** (Simmons 1975).

• **ETYMOLOGY.** The name *palleucus* (from the Greek ΠΑΛΛΕΥΚΟΣ, meaning ‘all white’) refers to the pale coloration of the nominal subspecies. The name *necturoides* (the suffix -ΟΙΔΕΣ from the Greek, meaning “similar to”) refers to the resemblance in dorsal coloration to salamanders of the genus *Necturus*.

• **COMMENT.** *Gyrinophilus palleucus* is presumably neotenic; large larviform individuals dominate all populations, a spermatophore has been found extruding from the cloacal lips of a sexually mature larviform male (Lazell and Brandon 1962), and mature sperm have been identified in sections of the testes in larviform males as small as 66 mm SVL (Simmons 1975). However, reproductive habits are poorly understood, and metamorphosed individuals have been found at several locations. Furthermore, individuals often undergo spontaneous metamorphosis in captivity and others can be induced to undergo metamorphosis with iodine or thyroid treatment (Dent and Kirby-Smith 1963). Additionally, dissection reveals that many large larviform individuals have immature reproductive tracts.

The Berry Cave Salamander (*Gyrinophilus gulolin-eatus*) was long considered to be a subspecies of *G. palleucus*. Consequently, earlier accounts (e.g. Petranksa 1998) that discussed *G. palleucus* mix information on the two species. Some authors (e.g. Sever 1986) provided locality data for each specimen they examined, and therefore information pertinent to each species can be sorted out.

1. *Gyrinophilus palleucus palleucus* Lazell and Brandon Pale Salamander

Gyrinophilus palleucus McCrady 1954:201. See species synonymy.

Gyrinophilus palleucus palleucus Lazell and Brandon 1962:302.

• **DEFINITION.** The dorsum is uniformly colored in larval and metamorphosed individuals. There are 18–19 trunk vertebrae.

1. *Gyrinophilus palleucus necturoides* Lazell and Brandon

Big Mouth Cave Salamander

Gyrinophilus palleucus necturoides Lazell and Brandon 1962:301. Type-locality, “Big Mouth Cave, near Pelham, Grundy Co., Tennessee.” Holotype, Museum of Comparative Zoology, Harvard University (MCZ) 34100, collected on 29 April 1961 by J.D. Lazell, Jr. (not examined by authors).

• **DEFINITION.** The dorsum of this subspecies is dark and spotted in larger larviform and metamorphosed individuals. There are usually 19, occasionally 20, trunk vertebrae.

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