

AMPHIBIA: ANURA: BUFONIDAE

Peltophryne lemur

Catalogue of American Amphibians and Reptiles.

Díaz-Lameiro, A.M., J.L. Herrera, D. Barber, R. Powell, and F. Bird-Pico. 2010. *Peltophryne lemur*.

***Peltophryne lemur* (Cope)**
Puerto Rican Crested Toad, Sapo Concho

Peltophryne lemur Cope 1868:311. Type-locality, "Puerto Rico". Holotype, unlocated (see **Nomenclatural History**).

Peltophryne gutturosus: Peters 1876:709.

Bufo gutturosus: Gundlach 1881:314.

Bufo panayensis Seoane 1881:12. Type-locality, "Panay [Philippines]". Holotype, unlocated (see **Remarks**).

Bufo lemur: Stejneger 1904:570.

Bufo turpis Barbour 1917:102. Type-locality, "Virgin Gorda, British Virgin Islands." Holotype, Museum of Comparative Zoology (MCZ) 4099, adult, collected by J.L. Peters in February 1917 (not examined by authors).

Peltophryne lemur: Pregill 1981a:273.

• **CONTENT.** *Peltophryne lemur* is monotypic (Beauclerc et al. 2009), although northern populations (now extirpated; Johnson 1999) are distinct from the southern populations on Puerto Rico (CBSG 2005).

• **DEFINITION.** *Peltophryne lemur* is a moderately sized toad, with females measuring to 120 mm SVL and males to ~85 mm (Rivero 1998). The snout is short and flattened, projecting far beyond the mouth. The upper "lip" forms a strongly projecting bony rim (lores and canthi rostrales are very concave). Supraciliary cranial crests are well elevated. The dorsum is covered with numerous, subrounded tubercles with rugose surfaces (Schwartz and Henderson 1991; Matos-Torres 2006).

The dorsal ground color typically is a dull clay color with a strong olive wash, although some individuals are dark olive or yellow to grayish. The venter is tan, dirty white, or flesh-colored posteriorly, and strongly reddish on the undersides of the thighs (Schwartz



FIGURE 1. *Peltophryne lemur* in amplexus in the Guanica National Forest (photograph by J.P. Segarra).



FIGURE 2. An adult female *Peltophryne lemur* in the Guanica National Forest (photograph by Carlos Pacheco).

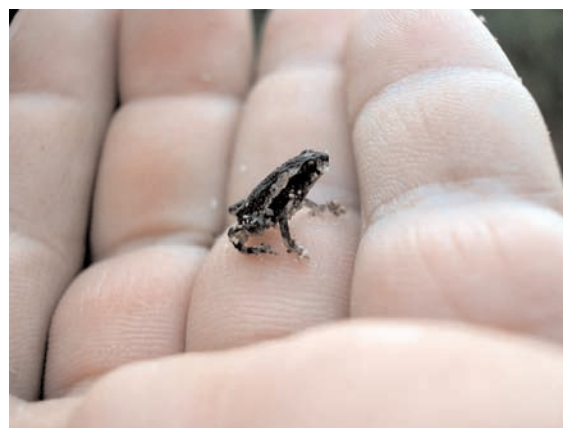


FIGURE 3. Juvenile *Peltophryne lemur* in the Guanica National Forest (photograph by Carlos Pacheco).

and Henderson 1991; Matos-Torres 2006).

Sexual dimorphism is pronounced (Rivero et al. 1980; Rivero and Segui 1992). Females are notably larger than males and bears more prominent cranial crests. Males usually have a more yellowish ground color and proportionately larger "warts."

• **DIAGNOSIS.** *Peltophryne lemur* can be distinguished from the only other toad found in Puerto Rico (*Rhinella* [formerly *Bufo* or *Chaunus*] *marina*; Frost et al. 2006; Chaparro et al. 2007) by the following combination of characteristics: more prominent cranial crest, smaller size (SVL of *R. marina* can exceed 200 mm), a "snorkel-shaped" nose, inferior "shark-like" mouth, and small, round paratoid glands (those of *R. marina* are as long as the head and taper posteriorly) (Rivero 1978, 1998; Rivero and Segui 1992).

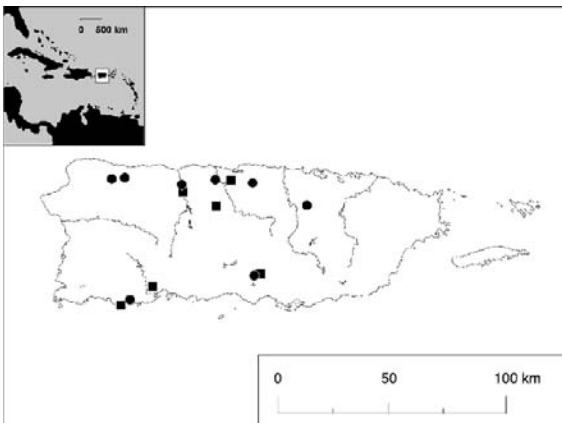
• **DESCRIPTIONS.** In addition to the original description by Cope (1868), other descriptions are in Schmidt (1920, 1928), Rivero (1978, 1998), Rivero et al. (1980), Schwartz and Henderson (1991), and Lentini (2003).

• **ILLUSTRATIONS.** Color photographs are in Rivero (1978, 1998), Rivero and Segui (1992), Fraser (2003), Anonymous (2005), Barber (2007a,b, 2008),



FIGURE 4. Metamorphosing *Peltophryne lemur* in the Guanica National Forest (photograph by Carlos Pacheco).

and Johnson and Barber (2008). Grant (1932a), Rivero (1978), Rivero et al. (1980), Olsen (1984), Schwartz and Henderson (1985), Capo (1991), Anonymous (1991), Rivero and Segui (1992), Johnson (1994), CBSG (2003), Joglar (2003), Delgado-Esquilin (2006), Maldonado-Arrigoitia (2006), and Henderson and Powell (2009) included black-and-white photographs. Stejneger (1904), Schmidt (1928), Joglar (1998), CBSG (2003), and Lentini (2003) included line drawings. Line drawings of the skull are in Pramuk (2000), and Pramuk (2002) also included line drawings of vertebrae, the pelvis, and phalanges. Photographs of the skull are in Pregill (1981a). Line drawings of a tadpole are in Rivero and Segui (1992). Black-and-white photographs of tadpoles are in Delgado-Esquilin (2006) and Maldonado-Arrigoitia (2006). Color photographs also are available on-line at <<http://www.sapoconcho.com>>, <<http://www.crestedtoadssp.org/gal/main.php/v/toad/>>, and <<http://www.kingsnake.com/westindian/metazoa9.html>>.



MAP. Distribution of *Peltophryne lemur* (modified from Lentini 2003): dots mark historical locality records, circles indicate localities where populations are known to be extant (see **Distribution**). The type-locality is too imprecise to plot.

• **DISTRIBUTION.** *Peltophryne lemur* occurred on Puerto Rico and Virgin Gorda (Schwartz and Thomas 1975; Thomas 1999; Hedges et al. 2004; Angulo

2008). One individual was found in 1978 on St. John (Norton 1997, 1998). In Puerto Rico, the species is known from a few widely scattered lowland localities, including northern and southern coastal areas (Schwartz 1978; Schwartz et al. 1978; Frost 1985; Schwartz and Henderson 1988; Joglar 1999) where it occurs in semiarid, rocky areas, especially in dry forests near the coast (Schwartz and Henderson 1991).

Historical records from Puerto Rico include Bayamon, Arecibo, Barceloneta, Vega Baja, Coamo, Ponce, Guanica, Isabela and Quebradillas (Schmidt 1928; Schwartz and Henderson 1991; Rivero 1998; Joglar 1999). Currently, the only known wild population is associated with temporary natural ponds in the Guanica National Forest and on adjacent private properties (CBSG 2005; Barber 2009). Toads were released in artificial ponds at El Tallonal Privet Nature Reserve (Flores 2008). The species is almost certainly extirpated on Virgin Gorda (MacLean 1982; W.E. Rainey in Johnson 1988), and is considered extirpated throughout the U.S. Virgin Islands (Platenberg and Boulon 2006).

Schwartz and Henderson (1991) provided a distribution map. Maps showing historical and current localities are in CBSG (2003) and Lentini (2003).

• **FOSSIL RECORD.** Fossils are known from Late Pleistocene cave deposits in Camuy and Morovis, Puerto Rico (Pregill 1981b; Pregill and Olson 1981).

• **PERTINENT LITERATURE.** References to *Peltophryne lemur* are arranged by topic: **biogeography** (Pramuk 2001), **captive breeding** (Olsen 1984; Paine 1984, 1987, 1989; Miller 1985; Paine and Duval 1985; Johnson and Paine 1989a, 1989b; Paine et al. 1989; Smith and Paine 1989; Anonymous 1991; Capo 1991; Devison 1991; Lee 1992; Pough 1992; Johnson 1994, 1999; Wiese 1994; Wiese and Hutchins 1994; Bloxam and Tonge 1995; Thomas and Joglar 1995; Joglar 1999, 2007; Restani and Marzluff 2002; Fraser 2003; Lentini 2003, 2006; Barber 2007a,b, 2008; Crawshaw 2007; Vitt and Caldwell 2009), **comparative morphology** (Pregill 1981a; USFWS 1992; Pramuk 2000, 2002), **competition with introduced species** (Rivero 1978, 1980, 1998; Miller 1985; Paine and Duval 1985; Johnson 1989a; USFWS 1992; Wiese 1994; Ross 2007; Flores 2008), **conservation** (Raffaele 1973; Paine 1987; USFWS 1987, 1992, 2008; Johnson 1989a,b, 1999; Paine et al. 1989; Devison 1991; Lee 1992; Wiese and Hutchins 1994; Restani and Marzluff 2002; Hedges et al. 2004; Matos-Torres 2006; Barber 2007b, 2008; Crawshaw 2007; Joglar 2007; Ross 2007; Angulo 2008; Flores 2008; Johnson and Barber 2008; Milmo 2008; USFWS 2008; Beauclerc et al. 2009; Zippel 2009), **diet** (Schmidt 1920; García-Díaz 1967; Devison 1991; Rivero and Segui 1992; Valdes et al. 1999), **diseases and parasites** (García-Díaz 1967; Ali et al. 1982; Paine et al. 1989; Crawshaw 2007), **distribution** (Moreno 1985; Barbour 1914, 1917; Schmidt 1920, 1928; Grant 1932a; Schwartz and Thomas 1975; Thomas and Thomas 1977; Rivero 1978, 1998; Schwartz 1978; Schwartz et al. 1978;

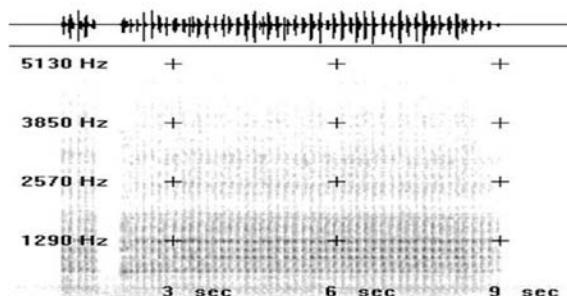


FIGURE 5. Audiospectrogram of the call of *Peltophryne lemur*.

Rivero et al. 1980; MacLean 1982; Frost 1985; Schwartz and Henderson 1985, 1988, 1991; USFWS 1987, 1992; Lee 1992; Rivero and Segui 1992; Norton 1997; Hedges 1999; Thomas 1999; Lentini 2003; CBSG 2005; Delgado-Esquilin 2006; Barber 2009), **natural history** (García-Díaz 1967; Rivero 1978, 1998; Rivero et al. 1980; USFWS 1987; Johnson 1989a, 1999; Schwartz and Henderson 1991; Lee 1992; Hedges 1992; Norton 1998; Henderson and Powell 1999, 2009; Lentini 2003; Hedges et al. 2004; Crawshaw 2007; Ross 2007; Angulo 2008), **genetics** (Paine et al. 1989; Pramuk 2002; Beauclerc 2006; Beauclerc et al. 2009), **history** (Grant 1932a; Moreno 1985; USFWS 1987; Paine et al. 1989; Rivero and Segui 1992; Joglar 2005; Estremera 2006), **longevity in captivity** (K. Murphy in Slavens and Slavens 2003), **metamorphosis** (Rivero and Segui 1992), **phylogenetics** (Pramuk 2001, 2002; Goebel 2005), **population density** (Moreno 1985; Lentini 2003), **predation** (Johnson 1989a; Lee 1992; Flores 2008), **reasons for endangered status** (USFWS 1987; Lee 1992; Hedges 1992), **releases in Puerto Rico** (Miller 1985; Paine 1987; Johnson 1989a,b, 1990, 1999; Devison 1991; Bloxam and Tonge 1995; Paine and Duval 1985; Lentini 2000; CBSG 2003; Anonymous 2005, 2006; Delgado-Esquilin 2006; Maldonado-Arriagoitia 2006; Barber 2007a,b; Joglar 2007; Flores 2008), **reproduction** (Rivero et al. 1980; Paine 1984; Moreno 1985; USFWS 1987, 1992; Hedges 1992; Rivero and Segui 1992; Johnson 1994; Rivero 1998;

Joglar 2003; Maldonado-Arriagoitia 2006; Matos-Torres 2006), **sexual dimorphism** (Rivero et al. 1980; Rivero and Segui 1992; USFWS 1992; Valdes et al. 1999), **systematics** (Pramuk 1999, 2001, 2002), **tadpoles** (Rivero 1980; Smith and Paine 1989), and **taxonomy** (Cope 1868; Barbour 1917; Schmidt 1920; Rivero 1978, 1998; Pregill 1981a; USFWS 1992; Crother 1999; Pramuk 2002; Frost et al. 2006).

This species also is included in **guides or checklists**, or is mentioned in longer works by Barbour (1914, 1930, 1935, 1937), Burrowes et al. (2003), Cerame-Vivas (2000), Dodd (1991), Frost (2009), Grant (1932b,c), Hass et al. (2001), Heatwole et al. (1981), Joglar (1998), Joglar and Burrowes (1996), Lazell (1983), MacLean (1977), Marcellini (1994), Neill (1958), Powell et al. (1996), Schwartz and Thomas (1975), Schwartz et al. (1978), and Tuffly and Comer (2005).

• **NOMENCLATURAL HISTORY.** The original generic name (*Peltophryne*) was assigned by Fitzinger (1843). Cope (1869) described the species, but used the generic name *Peltaphryne*. Stejneger (1904) reassigned the species to *Bufo*, which prevailed until Pregill (1981) resurrected the genus *Peltophryne*. Schwartz and Henderson (1985) incorrectly used *Peltaphryne*. Subsequently, the species has been variously assigned to *Bufo* (e.g., Hedges 1992; Henderson and Powell 2009) and *Peltophryne* (e.g., Frost et al. 2006).

• **REMARKS.** Taylor (1920), speaking of *Bufo panayensis* Seaone, noted that “this species and a snake, *Piesigaster boettgeri* Seaone, were reported as originating in Panay. As a matter of fact, they are both West Indian species; the toad is *Bufo lemur*, and the snake is *Epicrates inornatus* Reinhardt.”

Peltophryne lemur is listed as “critically endangered” on the IUCN Red List (Hedges et al. 2004; Angulo 2008) and as “threatened” by the U.S. Fish and Wildlife Service (USFWS 2008). It was listed in 1994 (Groombridge 1994) and 1996 (Baillie and Groombridge 1996) as “vulnerable.” Moreno (1991) listed it as “endangered.” See also **Distribution**.

• **ETYMOLOGY.** The species name is from the Latin for “ghost” or “spirit” (Rivero 1978, 1998); the inference is unknown.

LITERATURE CITED

- Ali, J.H., J. Riley, and J.T. Self. 1982. Amphibians as definitive hosts for pentastomids: *Raillietiella bufonis* n.sp. from *Bufo lemur* in Puerto Rico and a reassessment of *Raillietiella indica* Geddoelst, 1921. Syst. Parasitol. 4:279–284.
- Angulo, A. 2008. *Peltophryne lemur*. In IUCN 2008. 2008 IUCN Red List of Threatened Species. <<http://www.iucnredlist.org>>.
- Anonymous. 1991. Totally extinct? Not if zoos can help it. Sci. News 140(20):316.
- . 2005. Liberados 5,000 sapos: Intentan preservar especies autoctonas en Bosque de Guanica.

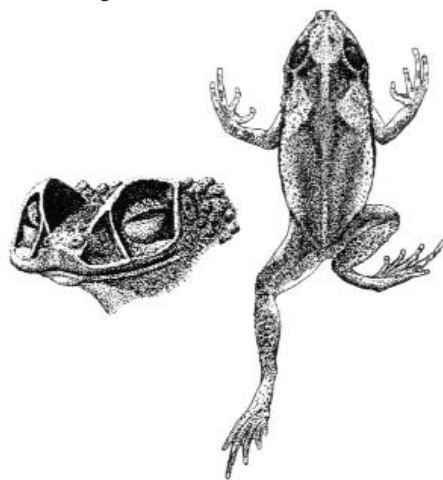


FIGURE 5. Head of *Peltophryne lemur* (from Stejneger 1904) and habitus of juveniles (from Schmidt 1928).

- Periodico El Nuevo Dia Orlando, 23 de Noviembre de 2005:15.
- . 2006. Finca arecibeña albergara población de Sapos Concho. Periódico Primera Hora. 12 de Mayo de 2006:24
- Baillie, J. and B. Groombridge. 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.
- Barber, D. 2007a. Action plan for the conservation of the Puerto Rican Crested Toad (*Peltophryne lemur*). In S. Grow and V. Poole (eds.), Conservation Resource Manual. Amer. Zoo Aquar. Assoc. (AZA), Silver Spring, Maryland.
- . 2007b. Cooperative amphibian programs in AZA. Connect (AZA), February 2007:13.
 - . 2008. Building conservation partnerships with zoos. Endangered Species Bull. 32(2):18–19.
 - . 2009. New PRCT population discovered. Amphib. Conserv., Monthly Rept., January 2009.
- Barbour, T. 1914. A contribution to the zoögeography of the West Indies, with especial reference to amphibians and reptiles. Mem. Mus. Comp. Zoöl. 44: 205–359 + 1 pl.
- . 1917. Notes on herpetology of the Virgin Islands. Proc. Biol. Soc. Washington 30:97–104.
 - . 1930. A list of Antillean reptiles and amphibians. Zoologica (N.Y.) 11:61–116.
 - . 1935. A second list of Antillean reptiles and amphibians. Zoologica (N.Y.) 19:77–141.
 - . 1937. Third list of Antillean reptiles and amphibians. Bull. Mus. Comp. Zoöl. 82:77–166.
- Beauclerc, K. 2006. Genetic structure of Puerto Rican Crested Toad populations: Applications to recovery. In CBSG, Population and Habitat Viability Analysis for the Puerto Rican Crested Toad. Final Report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.
- , R. Johnson, and B.N. White. 2009. Genetic rescue of an inbred captive population of the critically endangered Puerto Rican Crested Toad (*Peltophryne lemur*) by mixing lineages. Conserv. Genet.: in press.
- Bloxam, Q.M.C. and S.J. Tonge. 1995. Amphibians: Suitable candidates for breeding-release programmes. Rev. Indust. Org. 4:636–644.
- Burrowes, P.A., R.L. Joglar, and D.E. Green. 2004. Potential causes for amphibian declines in Puerto Rico. Herpetologica 60:141–154.
- Capo, M. 1991. Crested Toads get chance for survival in Puerto Rico. The San Juan Star, 2 December 1991, pp. 2,4.
- CBSG (IUCN/SSC Conservation Breeding Specialist Group). 2003. Puerto Rican Crested Toad Population and Habitat Viability Assessment: Briefing Book. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.
- . 2005. Population and Habitat Viability Analysis for the Puerto Rican Crested Toad, Final Report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.
- Cerame-Vivas, M.J. 2000. Ecología, Puerto Rico y Pensamiento Crítico: Para el Nuevo Milenio. Hato Rey, Publ. Puertorriqueñas, Río Piedras.
- Chaparro, J.C., J.B. Pramuk, and A.G. Gluesenkamp. 2007. A new species of arboreal *Rhinella* (Anura: Bufonidae) from cloud forest of southeastern Peru. Herpetologica 63:203–212.
- Cope, E.D. 1868. Sixth contribution to the herpetology of tropical America. Proc. Acad. Nat. Sci. Philadelphia 20:305–313.
- Crother, B.I. 1999. Evolutionary relationships, p. 269–334. In B.I. Crother (ed.). Caribbean Amphibians and Reptiles. Academic Press, San Diego, California.
- Crawshaw, G. 2007. Veterinary participation in Puerto Rican Crested Toad Program, p. 126–136. In M.E. Fowler and R.E. Miller, Zoo and Wild Animal Medicine Current Therapy. Elsevier, St. Louis, Missouri.
- Delgado-Esquilin, G. 2006. De fiesta el Sapo Concho: Se intenta reestablecer la especie en el norte. Periodico El Nuevo Dia, 31 de Mayo de 2006:94–95.
- Devison, D. 1991. Management program and breeding of the Puerto Rican Crested Toad at Metro Toronto Zoo, p. 53–59. In Proceeding of the Sixteenth American Association of Zoo Keepers Conference, Amer. Assoc. Zoo Keepers, New Orleans, Louisiana.
- Dodd, C.K., Jr. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: Are there conservation strategies that really work? Herpetologica 47:336–350.
- Estremera, E.R. 2006. Historia natural del Sapo Concho en Quebradillas. In CBSG, Population and Habitat Viability Analysis for the Puerto Rican Crested Toad. Final Report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.
- Flores, I.M. 2008. First release of the Puerto Rican Crested Toad (*Bufo {Peltophryne} lemur*) tadpoles in northern Puerto Rico. Final Report. U.S. Fish and Wildlife Service, Boqueron, Puerto Rico.
- Fraser, L. 2003. Zoos: Contributing to the conservation of amphibians. Croaks and Trills 8(2):4.
- Frost, D.R. 1985. Amphibian Species of the World. A Taxonomic and Geographical Reference. Allen Press and Assoc. Syst. Coll., Lawrence, Kansas.
- . 2009. Amphibian Species of the World: An Online Reference. Version 5.3 (12 February 2009). <<http://research.amnh.org/herpetology/amphibia/index.html>>.
- , T. Grant, J. Faivovich, R.H. Bain, A. Haas, C.F.B. Haddad, R.O. de Sá, A. Channing, M. Wilkinson, S.C. Donnellan, C.J. Raxworthy, J.A. Campbell, B.L. Blotto, P. Moler, R.C. Drewes, R.A. Nussbaum, J.D. Lynch, D.M. Green, and W.C. Wheeler. 2006. The amphibian tree of life. Bull. Amer. Mus. Nat. Hist. (297):1–370.
- García-Díaz, J. 1967. Rediscovery of *Bufo lemur* (Cope) and additional records of reptiles from Puerto Rico. Stahlia (10):1–6.
- Grant, C. 1932a. *Bufo lemur*, a rare Puerto Rican toad. J. Dept. Agric. Porto Rico 16:41–42.
- . 1932b. The growth of herpetology in the Puerto Rico and Virgin Island area J. Dept. Agric. Porto

- Rico 16:401–404.
- . 1932c. Herpetology of Tortola; notes on Anegada and Virgin Gorda, British Virgin Islands. J. Dept. Agric. Porto Rico 16:339–346.
 - Goebel, A. 2005. Conservation Systematics: The *Bufo boreas* species group, p. 210–221. In M. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species. Univ. California Press, Berkeley.
 - Groombridge, B. 1994. 1994 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.
 - Gundlach, J. 1881. Apuntes para la fauna Puertorriquena, III. Anfíbios. An. Soc. Espan. Hist. Nat. 10: 305–317.
 - Hass, C.A., L.R. Maxson, and S.B. Hedges. 2001. Relationships and divergence times of West Indian amphibians and reptiles: Insights from albumin immunology, p. 175–189. In C.A. Woods and F.E. Sergile (eds.), Biogeography of the West Indies: Patterns and Perspectives. 2nd ed. CRS Press, Boca Raton, Florida.
 - Heatwole, H., R. Levins, and M.D. Byer. 1981. Biogeography of the Puerto Rican Bank. Atoll Res. Bull. (251):1–55.
 - Hedges, S.B. 1993. Global amphibian declines: A perspective from the Caribbean. Biodivers. Conserv. 2:290–303.
 - . 1999. Distribution patterns of amphibians in the West Indies, p. 211–254. In W.E. Duellman (ed.), Patterns of Distribution of Amphibians: A Global Perspective. Johns Hopkins Univ. Press, Baltimore, Maryland.
 - , C.A. Hass, and L.R. Maxson. 1992. Caribbean biogeography: Molecular evidence for dispersal in West Indian terrestrial vertebrates. Proc. Natl. Acad. Sci. (USA) 89:1909–1913.
 - , R. Joglar, and R. Thomas. 2004. *Bufo lemur*. In IUCN 2006. 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>.
 - Henderson, R.W. and R. Powell. 1999. West Indian herpetoecology, p. 223–268. In B.I. Crother (ed.), Caribbean Amphibians and Reptiles. Academic Press, San Diego, California.
 - and –. 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Press Florida, Gainesville.
 - Joglar, R.L. 1998. Los Coquies de Puerto Rico: Su historia natural y conservación. Edit. Univ. Puerto Rico, San Juan.
 - . 1999. ¡Que Cante el Coquí! Ensayos, Cartas y Otros Documentos Sobre la Protección de la Biodiversidad en Puerto Rico (1987–1999). Proyecto Coquí, San Juan, Puerto Rico.
 - . 2003. An island enchanted by frogs, p. 203–211. In R.W. Henderson and R. Powell (eds.), Islands and the Sea: Essays on Herpetological Exploration in the West Indies. Contrib. Herpetol., vol. 20. SSAR, Ithaca, New York.
 - (ed.). 2005. Biodiversidad de Puerto Rico: Vertebrados Terrestres y Ecosistemas, Serie de Historia Natural. Edit. Inst. Cult. Puertorriquena, Univ. Interamer. Puerto Rico, and El Proyecto Coquí, San Juan.
 - , A.O. Álvarez, T.M. Aide, D. Barber, P.A. Burrowes, M.A. García, A. León-Cardona, A.V. Longo, N. Pérez Buitrago, A. Puente, N. Ríos-López, and P.J. Tolson. 2007. Conserving the Puerto Rican herpetofauna. Appl. Herpetol. 4:327–345.
 - and P.A. Burrowes. 1996. Declining amphibian population in Puerto Rico, p. 371–380. In R. Powell and R.W. Henderson (eds.), Contributions to West Indian Herpetology: A Tribute to Albert Schwartz. Contrib. Herpetol., vol. 12. SSAR, Ithaca, New York.
 - Johnson, R.R. 1990. Release and translocation strategies for the Puerto Rican Crested Toad, *Peltophryne lemur*. End. Spec. Update 8(1):54–57.
 - . 1994. Model programs for reproduction and management: Ex situ and in situ conservation of toads of the family Bufonidae, p. 243–254. In J.B. Murphy, K. Adler, and J.T. Collins (eds.), Captive Management and Conservation of Amphibians and Reptiles. Contrib. Herpetol., vol. 11. SSAR, Ithaca, New York.
 - . 1999. Recovery of the Puerto Rican Crested Toad. End. Spec. Bull. 24(3):8–9.
 - and D. Barber. 2008. Re-introduction of Puerto Rican Crested Toad to historic range in Puerto Rico, p. 50–53. In P.S. Soorae (ed.), Global Re-introduction Perspectives: Re-introduction Case studies from Around the Globe. IUCN/SSC Re-introduction Specialist Group, Abu Dhabi, UAE.
 - and F. Paine. 1989a. The release of captive bred Puerto Rican Crested Toads: Captive management implications and the cactus connection. AAZPA Reg. Conf. Proc. 1989:962–967.
 - and –. 1989b. Puerto Rican Crested Toad, SSP Report. AAZPA Newsl. 30(12):7–9.
 - Johnson, T.H. 1988. Biodiversity and conservation in the Caribbean: Profiles of selected islands. Intl. Council Bird Preserv. Monogr. (1):xvii + 144 p.
 - Lazell, J.D. 1983. Biogeography of the herpetofauna of the British Virgin Islands, with description of a new anole (Sauria: Iguanidae), p. 99–117. In A.G.J. Rhodin and K. Miyata (eds.), Advances in Herpetology and Evolutionary Biology. Mus. Comp. Zool., Cambridge, Massachusetts.
 - Lee, G. 1992. Recovery Plan for the Puerto Rican Crested Toad (*Peltophryne lemur*). USDI, Fish Wildl. Serv., Carib. Field. Off., Boqueron, Puerto Rico.
 - Lentini, A. 2000. Puerto Rican Crested Toad (*Peltophryne lemur*) SSP Husbandry Manual. Keeper and Curator Edition. Toronto Zoo, Scarborough, Ontario, Canada.
 - . 2003. A case study: Keeper involvement in husbandry and *in situ* conservation of a threatened amphibian, Puerto Rican Crested Toad (*Peltophryne lemur*). Toronto Zoo, Ontario, Canada. In CBSG, Puerto Rican Crested Toad Population and Habitat Viability Assessment: Briefing Book. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.
 - . 2006. Puerto Rican Crested Toad captive population. In CBSG, Population and Habitat Viability Analysis for the Puerto Rican Crested Toad. Final Report. IUCN/SSC Conservation Breeding Spe-

- cialist Group, Apple Valley, Minnesota.
- MacLean, W.P. 1982. Reptiles and Amphibians of the Virgin Islands. MacMillan Caribbean, London.
- , R. Kellner, and H. Dennis. 1977. Island lists of West Indian amphibians and reptiles. *Smithson. Herpetol. Info. Serv.* (40):1–47.
- Maldonado-Arrigoitia, W. 2006. Proyecto para salvarlos de la extincion, renacuajos ya son Sapitos Conchos. *Periodico Primera Hora*. 31 de Mayo de 2006:4.
- Marcellini, D.L. 1994. Collection-management, captive-breeding, and conservation programs in zoo herpetological collections, p. 397–400. *In* J.B. Murphy, K. Adler, and J.T. Collins (eds.), *Captive Management and Conservation of Amphibians and Reptiles*. *Contrib. Herpetol.*, vol. 11. SSAR, Ithaca, New York.
- Matos-Torres, J.J. 2006. Habitat characterization of the Puerto Rican Crested Toad (*Peltophryne* [*Bufo*] *lemur*) at Guanica State Forest. M.S. Thesis, Univ. Puerto Rico, Mayagüez.
- Milmoe, J. 2008. Partnerships to conserve amphibian habitat. *End. Spec. Bull.* 32(2):36–37.
- Miller, T. 1985. Husbandry and breeding of Puerto Rican toad (*Peltophryne lemur*) with comments on its natural history. *Zoo. Biol.* 4:21–26.
- Moreno, J.A. 1985. Unpublished notes on *Peltophryne lemur* Cope. Internal document for the Puerto Rico Department of Natural Resources. San Juan.
- , 1989. Apuntes sobre el *Peltophryne lemur*, Cope. *Chelonia* 7:5–7.
- , 1991. Appendix II. Status recommendations/recomendaciones de designation. *In* J.A. Moreno (ed.), *Status y Distribución de los Reptiles y Anfibios de la Región de Puerto Rico*, p. 65–67. *In* Publ. Cien. Misc. (1), Depto. Rec. Nat. Puerto Rico, San Juan.
- Norton, R.L. 1997. First report of *Peltophryne lemur* from St. John, U.S. Virgin Islands. *Bull. Chicago Herpetol. Soc.* 32:106–107.
- , 1998. Comments on habitat and threats to populations of the Puerto Rican Crested Toad (*Peltophryne lemur*) in the Virgin Islands. *Brit. Herpetol. Soc. Bull.* (62):20–22.
- Olsen, R. 1984. Tiny crested toads returned to habitat. *The San Juan Star*, 7 May:2.
- Paine, F.L., J.D. Miller, G. Crawshaw, B. Johnson, R. Lacy, C.F. Smith, and P.J. Tolson. 1989. Status of the Puerto Rican Crested Toad *Peltophryne lemur*. *Intl. Zoo Yrbk.* 28:53–58.
- and W.T. Neill. 1958. The occurrence of amphibians and reptiles in saltwater areas and a bibliography. *Bull. Marine Sci. Gulf Carib.* 8:1–97.
- Paine, F.L. 1984. The husbandry, management & reproduction of the Puerto Rican Crested Toad (*Bufo lemur*). *In* R. Hahn (ed.), *Proceedings of the 8th International Symposium on Captive Propagation and Husbandry*, p. 59–73. Zool. Consor., Thurmont, Maryland.
- , 1987. Puerto Rican Crested Toad. *AAZPA Newsl.* 28(12):10–11.
- and J.J. Duval. 1985. The resurrected toad. *Anim. King.* 88(5):33–38.
- Peters, W. 1876. Über eine von Hrn. Viceconsul L. Krug und Dr. J. Gundlach auf der Insel Puertorico gemachte Sammlung von Säugethieren, so wie über die Entwicklung eines Batrachiers, *Hylodes martinicensis* Dum. Bibr., ohne Metamorphose. *Monatsber. Königl. Akad. Wiss. Berlin* 1876:703–714.
- Platenberg, R.J. and R.H. Boulon, Jr. 2006. Conservation status of reptiles and amphibians in the U.S. Virgin Islands. *Appl. Herpetol.* 3:215–235.
- Pough, F.H. 1992. Recommendations for the Care of Amphibians and Reptiles in Academic Institutions. *Natl. Acad. Press*, Washington, D.C.
- Pramuk, J. 1999. The Systematics of West Indian Toads (Anura: Bufonidae). M.S. Thesis, Univ. Kansas, Lawrence.
- , 2000. Prenasal bone and snout morphology in West Indian bufonids and the *Bufo granulosus* species group. *J. Herpetol.* 34:334–340.
- , 2002. Combined evidence and cladistic relationships of West Indian toads (Anura: Bufonidae). *Herpetol. Monogr.* 16:121–151.
- , C.A. Hass, and S.B. Hedges. 2001. Molecular phylogeny and biogeography of the West Indian toads (Anura: Bufonidae). *Mol. Phylo. Evol.* 20: 294–301.
- Pregill, G.K. 1981a. Cranial morphology and the evolution of West Indian toads (Salientia: Bufonidae): resurrection of the genus *Peltophryne* Fitzinger. *Copeia* 1981:273–285.
- , 1981b. Late Pleistocene herpetofaunas from Puerto Rico. *Univ. Kansas Mus. Nat. Hist. Misc. Publ.* (71):1–72.
- and S.L. Olson. 1981. Zoogeography of West Indian vertebrates in relation to Pleistocene climate cycles. *Ann. Rev. Ecol. Syst.* 12:75–98.
- Powell, R., R.W. Henderson, K. Adler, and H.A. Dundee. 1996. An annotated checklist of West Indian amphibians and reptiles, p. 51–93 + 8 pl. *In* R. Powell and R.W. Henderson (eds.), *Contributions to West Indian Herpetology: A Tribute to Albert Schwartz*. *Contrib. Herpetol.*, vol. 12. SSAR, Ithaca, New York.
- Raffaele, H. 1973. Rare and endangered animal species of Puerto Rico: A committee report. *USDA Soil Conserv. Serv. and Dept. Nat. Res.*, San Juan, Puerto Rico.
- Restani, M. and J.M. Marzluff. 2002. Funding extinction? Biological needs and political realities in the allocation of resources to endangered species recovery. *Bioscience* 52:169–177.
- Rivero, J.A. 1978. Los Anfibios y Reptiles de Puerto Rico. *The Amphibians and Reptiles of Puerto Rico*. Univ. Puerto Rico, San Juan.
- , 1998. Los Anfibios y Reptiles de Puerto Rico, segunda edición revisada. *The Amphibians and Reptiles of Puerto Rico*, second edition revised. Univ. Puerto Rico, San Juan.
- , H. Mayorga, E. Estremera, and I. Izquierdo. 1980. Sobre el *Bufo lemur* (Cope). *Carib. J. Sci.* 15:33–40.
- and D. Seguí Crespo. 1992. Anfibios y Reptiles en

- Nuestro Folklore. Imprenta San Rafael, Quebradillas, Puerto Rico.
- Ross, G.S. 2007. Biotic and abiotic factors affecting calling activity at traditional breeding ponds of Puerto Rican Crested Toads (*Bufo [Peltophryne] lemur*) in Quebradillas, Puerto Rico. M.S. Thesis, Univ. Puerto Rico, Mayagüez.
- Schmidt, K.P. 1920. Contributions to the herpetology of Porto Rico. Ann. New York Acad. Sci. 28:167–200.
- . 1928. Amphibians and land reptiles of Porto Rico, with a list of those reported from the Virgin Islands. Scientific Survey of Porto Rico and the Virgin Islands. New York Acad. Sci. (10):1–160.
- Schwartz, A. 1978. Some aspects of the herpetogeography of the West Indies. Acad. Nat. Sci. Philadelphia Spec. Publ. (13):31–51.
- and R.W. Henderson. 1985. A Guide to the Identification of the Amphibians and Reptiles of the West Indies Exclusive of Hispaniola. Milwaukee Pub. Mus., Milwaukee, Wisconsin.
- and –. 1988. West Indian amphibians and reptiles: A check-list. Milwaukee Pub. Mus. Contrib. Biol. Geol. (74):1–264.
- and –. 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville.
- and R. Thomas. 1975. A Check-list of West Indian amphibians and reptiles. Carnegie Mus. Nat. Hist. Spec. Publ. (1):1–216.
- , R. Thomas, and L.D. Ober. 1978. First supplement to a check-list of the West Indian amphibians and reptiles. Carnegie Mus. Nat. Hist. Spec. Publ. (5): 1–35.
- Seoane, V.L. 1881. Neue Boiden-Gattung und Art von den Philippinen. Abh. Senckenberg. Natur. Ges. 12:217–224.
- Slavens, F. and K. Slavens. 2003. Reptiles and amphibians in captivity—longevity—home page. <<http://www.pondturtle.com/longev.html>>.
- Smith, C.F. and F.L. Paine. 1989. A system for rearing tadpoles at the Buffalo Zoological Gardens. Intl. Zoo Yrbk. 28:58–59.
- Stejneger, L. 1904. The herpetology of Porto Rico. Rep. U.S. Natl. Mus. 1902:551–724.
- Taylor, E.H. 1920. Philippine Amphibia. Philip. J. Sci. 16:213–259 + 10 pls.
- Thomas, R. 1999. The Puerto Rico area, p. 169–179. In B.I. Crother (ed.), Caribbean Amphibians and Reptiles. Academic Press, San Diego, California.
- and R. Joglar. 1995. The herpetology of Puerto Rico: Past, present, and future. Publ. New York Acad. Sci. (776):181–200.
- and K.R. Thomas. 1977. Distributional records of amphibians and reptiles from Puerto Rico. Herpetol. Rev. 8:40.
- Tuffly, M.F. and P.J. Come. 2005. Generating Conservation Scenarios for Puerto Rico. Nature Serve, Boulder, Colorado.
- USFWS. 1987. Endangered and threatened wildlife and plants; determination of threatened status for the Puerto Rican Crested Toad. Fed. Reg. 52: 28828–28831.
- . 1992. Recovery Plan for the Puerto Rican Crested Toad, (*Peltophryne lemur*). U.S. Fish Wildl. Serv., Atlanta, Georgia.
- . 2008. Species Information. Threatened and Endangered Animals and Plants. <<http://www.fws.gov/endangered/wildlife.html>>.
- Valdes, E., A. Owen, G. Chawshaw, A. Lentini, and L. Lambrakis. 1999. The effect of diet on growth and development of Puerto Rican Crested Toad (*Peltophryne lemur*) tadpoles, p. 136–137. In NAG 3rd Conf. Proc., Columbus, Ohio.
- Vitt, L.J. and J.P. Caldwell. 2009. Herpetology: An Introductory Biology of Amphibians and Reptiles. 3rd ed. Academic Press, San Diego, California.
- Wiese, R.J. 1994. Species Survival Plans: Strategies for wildlife conservation. Amer. Zoo Aquar. Assoc. (AZA), Silver Spring, Maryland.
- and M. Hutchins. 1994. The role of zoos and aquariums in amphibian and reptilian conservation, p. 37–45. In J.B. Murphy, K. Adler, and J.T. Collins (eds.), Captive Management and Conservation of Amphibians and Reptiles. Contrib. Herpetol., vol. 11. SSAR, Ithaca, New York.
- Zippel, K.C. 2009. Zoos play a vital role in amphibian conservation. <<http://amphibiaweb.org/declines/zoo/index.html>>.

Alondra M. Díaz-Lameiro, Department of Biology, University of Puerto Rico, Mayagüez, PR 00682 (a_diazlameiro@yahoo.com), **José Luis Herrera**, Department of Biology, University of Puerto Rico, Mayagüez, PR 00682 (caliaji@gmail.com), **Diane Barber**, Fort Worth Zoo, 1989 Colonial Parkway, Fort Worth, Texas 76110, USA (dbarber@fortworthzoo.org), **Robert Powell**, Department of Biology, Avila University, Kansas City, MO 64145, USA (robert.powell@avila.edu), and **Fernando Bird-Pico**, Department of Biology, University of Puerto Rico, Mayagüez, PR 00682 (fbird@uprm.edu).

Primary editor for this account, Andrew H. Price.

Published 15 January 2010 and Copyright © 2010 by the Society for the Study of Amphibians and Reptiles.
