

## ARTICLES

### THE DISPERSAL OF THE GREENHOUSE FROG, *ELEUTHERODACTYLUS PLANIROSTRIS* (ANURA: ELEUTHERODACTYLIDAE), IN LOUISIANA, WITH PRELIMINARY OBSERVATIONS ON SEVERAL POTENTIAL EXOTIC COLONIZING SPECIES

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**Abstract:** We used literature records, unpublished museum records, and observations, to evaluate the status and ecology of the Greenhouse Frog (*Eleutherodactylus planirostris*), an exotic species in Louisiana. During 1976–2008, 56 specimens and an egg clutch were collected from 10 parishes in southern Louisiana. Human disturbance was common to all sites. Most individuals were mottled in dorsal pattern. Captures occurred in all months except December, and most captures occurred in June and October. Calling was heard during May–October, and nesting and parturition occurred during May–July. Attributes associated with its success in Louisiana mirrored those of the Mediterranean Gecko (*Hemidactylus turcicus*), also well-established in Louisiana. Human-mediated dispersal, association with humans, and climatic compatibility lead us to predict eventual colonization of larger areas of the state. Those attributes, also found in other range-expanding exotic amphibian and reptile populations in Florida, lead us to predict an inevitable dispersal of, and high likelihood of colonization by, several other exotic species to Louisiana.

#### Introduction

The Greenhouse Frog (*Eleutherodactylus planirostris*) is a small-bodied West Indian frog that is found in Cuba, the Bahamas, and the Cayman Islands (Schwartz and Henderson, 1991). In the United States, this non-native species is established in Alabama, Florida, Georgia, Hawaii, Louisiana, Mississippi, and Texas, and it represents one of seven anuran species that are exotic to the United States (Meshaka, 2008). In the southeastern United States, the Greenhouse Frog is most widespread in Florida (Meshaka et al., 2004) where it was first reported from Key West (Cope, 1863). Its appearance elsewhere in the southeastern United States is much more recent, with fewer documented colonies (Meshaka, 2008). In Louisiana, the Greenhouse Frog was first detected from Audubon Park in New Orleans, where it has been established since 1975 (Plotkin and Atkinson, 1979; Dundee and Rossman, 1989). In light of a recent increase in published records of this species in southern Louisiana, we undertook this study to examine the status of this species in Louisiana with respect to its spatial and temporal colonization pattern. We also summarize its natural history from published and unpublished accounts to ascertain the degree to which life history traits may be responding to its geographic expansion.

#### Materials and Methods

We examined published records, unpublished reports, and museum specimens from Louisiana State University Museum of Zoology, LSU-Eunice, and Tulane University to determine the spatial and temporal colonization patterns of the Greenhouse Frog in Louisiana. Records also provided us with seasonal activity data, and specimens provided us with data relating to body size and reproductive condition. Body size was measured in mm snout–urostyle length (SUL). Means are followed by  $\pm 2$  standard deviations.

#### Results

During 1976–2008, the Greenhouse Frog was detected in 10 Louisiana parishes: Calcasieu (Williams and Wygoda, 1997), East Baton Rouge (Platt and Fontenot, 1995), Jefferson (Dundee and Rossman, 1989), Lafayette (Boundy, 2004), Orleans (Plotkin and Atkinson, 1979), Plaquemines (Dundee, 1994; Boundy, 2004), St. Bernard (Boundy, 1998), St. John the Baptist (Boundy, 1998), St. Tammany (Elbers, 2007), and Terrebonne (Liner, 2007) parishes. All of these parishes are within the southern one half of the state (Figure 1), sites are disturbed, and the rate at which the species has been detected has remained on the rise since a spike in detection beginning in the 1990s (Figure 2).

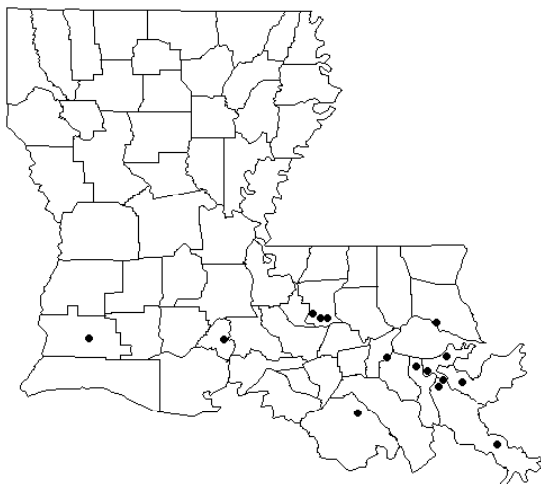


Figure 1. Geographic distribution of the Greenhouse Frog (*Eleutherodactylus planirostris*) in Louisiana.

Greenhouse Frogs display two body patterns, mottled and striped. The mottled morph was found in 74.5% of all Greenhouse frogs, including those of unknown sex. With only two exceptions, the mottled morph occurred at a greater frequency than the striped morph, respectively, in nine parishes: East Baton Rouge (2, 4), Jefferson (2, 0), Lafayette (4, 0), Orleans (16, 0), Plaquemines (9, 1), St. Bernard (1, 0), St. John the Baptist (1, 0), St. Tammany (1, 0), and Terrebonne (2, 8) parishes. Likewise, the mottled morph was dominant in each sex and among juveniles (Figure 3). Adult males (mean = 19.8 ± 2.8 mm SUL; range = 16–25; n = 26) were significantly smaller in mean body size (t = -4.777; df = 38; p < 0.000) than adult females (mean = 24.1 ± 2.6 mm SUL; range = 18–29; n = 14). Most Greenhouse Frogs were captured in June and October (Figure 4). Most captures of males occurred in June and October, whereas all captures of females occurred primarily during May–June and less so during October–November (Figure 5). Juveniles were detected

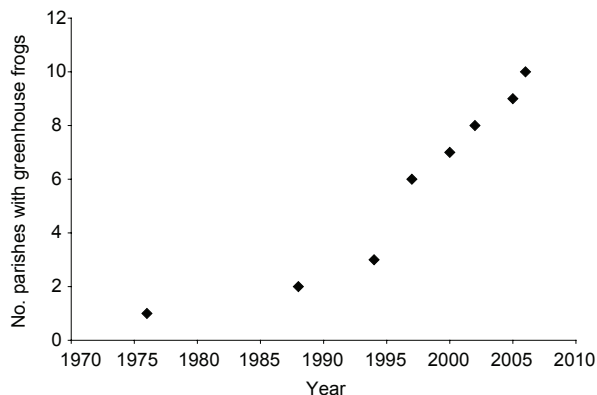


Figure 2. An accumulation curve of the number of parishes in which the Greenhouse Frog (*Eleutherodactylus planirostris*) was recorded in Louisiana during 1976-2008.

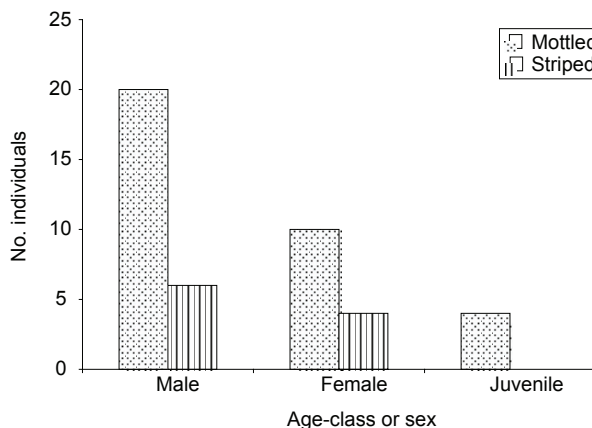


Figure 3. Distribution by sex and age-class of mottled and striped morph of the Greenhouse Frog (*Eleutherodactylus planirostris*) in Louisiana.

in July (Figure 5). The seasonal distribution of body sizes among the juveniles (Figure 6) suggested parturition in June and at least in May. In this connection, spent females were collected in May (n = 1) and June (n = 2). A nine-egg clutch was discovered in Houma, Terrebonne Parish, on 6 June 2005 (LSUMZ 89730) by Ernie Linder.

### Discussion

The original source of the Louisiana population of Greenhouse Frogs was thought most likely to have been derived from large nurseries (Dundee and Rossman, 1989). Likewise, the colonies in Calcasieu have all but certainly been traced to a nursery (AAW). This species disperses well in the agency of humans, and the temporal and spatial scattershot pattern to its colonization in Florida (Goin, 1947; Meshaka et al., 2004) and elsewhere in the United States (Meshaka, 2008) is true of Louisiana as well. In much of Florida, the Greenhouse Frog is not restricted to human-disturbed habitats but it does succeed in them (Meshaka, 2001; Meshaka et al., 2004; Meshaka and Layne, 2005). In the Florida panhandle, the Greenhouse Frog is known only

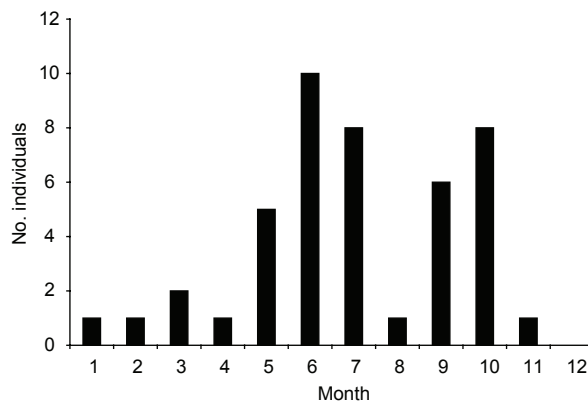


Figure 4. Seasonal distribution of opportunistic captures of the Greenhouse Frog (*Eleutherodactylus planirostris*) in Louisiana. This figure includes individuals of known and unknown sex.

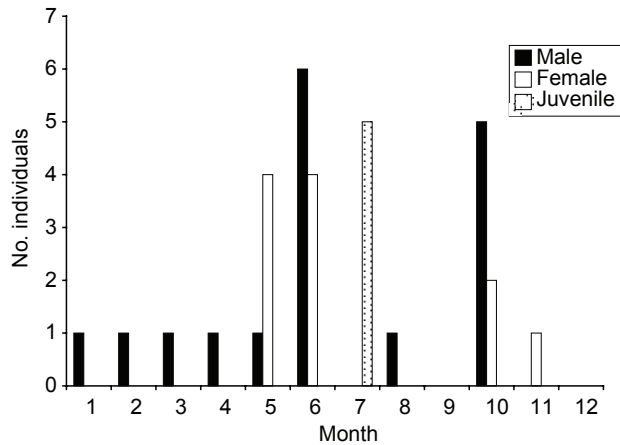


Figure 5. Seasonal distribution of opportunistic captures of male, female, and juvenile Greenhouse Frogs (*Eleutherodactylus planirostris*) in Louisiana.

from disturbed sites (B. Means, pers. comm.), and in Louisiana, this species does not yet appear to have invaded natural habitat. However, the climate of northern peninsular Florida (exclusive of the panhandle) and extreme southern Louisiana are similar and these two regions are divided climatically by colder climate in the Florida panhandle and coastal zones of Alabama and Mississippi. Consequently, what appears to us to be inevitable human-mediated dispersal along the coast westward to Louisiana could depend heavily on disturbed systems for natural dispersal.

Greenhouse Frogs from Audubon Park, Orleans Parish, were of the mottled morph, but a striped individual was found near the Audubon Park colony (Dundee and Rossman, 1989). Most animals from a nursery located 11.3 km (7 miles) northeast of the Audubon Park were striped (Dundee and Rossman, 1989). The suggestion that future dispersal of this species in Louisiana would include mixed-pattern populations was corroborated by our findings.

Generally speaking, the striped morph was most prevalent in northern Florida (exclusive of the panhandle), the mottled morph was predominant in southern Florida, and the ratios varied among sites in central Florida (Goin, 1947). Even with a larger sample from extreme southern Florida, mottled individuals still outnumbered those of the striped morph in Miami, Upper Keys, and Lower Keys (Duellman and Schwartz, 1958).

Most captures of Greenhouse Frogs occurred during May–October when average highs are at least 26.7°C (80°F) in Baton Rouge, Houma, Lafayette, Metairie, and New Orleans. In south-central Florida, most captures using systematic trapping occurred during September–December and were represented by rapidly maturing juveniles from a summer peak in reproduction (Meshaka and Layne, 2005).

Male Greenhouse Frogs were heard calling on 21 May 1997 at a site in Lake Charles, Calcasieu Parish (Williams and Wygoda, 1997) and choruses have been heard there from during May to September (AAW pers. obs.). In Baton Rouge, males were heard calling on 9 October 2007 and beginning 4 May 2008 (JB, pers. observ.). Calling occurred during April–September in extreme southern, south-central, and northern Florida (Goin, 1947; Meshaka and Layne, 2005); however, in a residential area in extreme southern

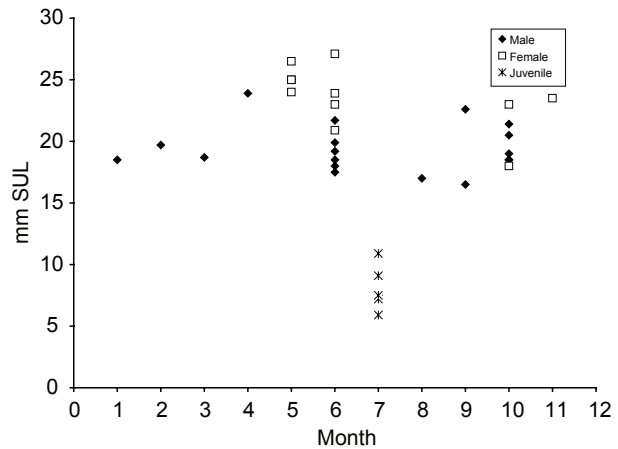


Figure 6. Seasonal distribution of body sizes of the Greenhouse Frog (*Eleutherodactylus planirostris*) in Louisiana.

Florida, calling was heard during February–November (Meshaka et al., 2004). Calling was possible when average monthly temperature lows were at least 15.8°C (60.4°F) and monthly rainfall volumes were at least 6.9 cm (2.72 inches) (Meshaka and Layne, 2005). Using these threshold values, the predicted seasons during which calling should occur by the Greenhouse Frog in selected sites in southern Louisiana are May–October (Houma, Metairie, New Orleans) and May–September (Baton Rouge, Lafayette, Lake Charles).

Based on the hatchling body sizes of Greenhouse Frogs reported in northern Florida of up to 5.7 mm (Goin, 1947), the distribution of July hatchling body sizes from our data set suggested that hatching was possible at least one month prior (in June) in southern Louisiana. Hatchlings were also found in a garden 0.8 km (0.5 miles) from Audubon Park in Orleans Parish in July 1980, and juveniles were found 11.3 km (7 miles) from Audubon Park in early August in 1981 (Dundee and Rossman, 1989). A gravid female was collected on 13 July 1997 at a site in Lake Charles, Calcasieu Parish (Williams and Wygoda, 1997), and eggs with developed froglets were found 11.3 km (7 miles) from Audubon Park in mid-June 1981 (Dundee and Rossman, 1989). These findings suggested a nesting season of at least June–July in southern Louisiana, although in light of a 13–20 day incubation period (Goin, 1947), the mid-June developed clutch found by Dundee and Rossman (1989) could certainly have been deposited in late May. In north-central Florida, eggs were laid during May–September with first hatchlings appearing in mid-June (Goin, 1947). Based on seasonal distribution of body sizes, it appeared that the nesting season in north-central Florida was similar to that of south-central Florida (Meshaka and Layne, 2005). In extreme southern Florida, eggs (Deckert, 1921) and neonates (Lazell, 1989) were found in May. It remains to be seen how long the nesting season extends in southern Louisiana, although it appears to begin at about the same time as in Florida. If calling ends in September, then it would appear likely that nesting occurred in southern Louisiana during a season that did not exceed May–September.

Peak nesting of the Greenhouse Frog in northern Florida was July, and the breeding season overlapped the rainy sea-

son (Goin, 1947). The greatest intensity of calling in extreme southern Florida occurred during May–June and was followed by a much smaller peak in September, which was associated with the bimodal rainfall pattern during May–October of extreme southern Florida, and perhaps reflected seasonal frequency of nesting (Meshaka and Layne, 2005). Peak rainfall in southern Louisiana occurs approximately during June–September; however, peak months vary among sites.

Thus, it appears that southern Louisiana populations of the Greenhouse Frog shared similar colonization, morphological, ecological, and life history traits as those of Florida. Human-mediated dispersal, an association with human-disturbed habitat, a preponderance of the mottled pattern morph, calling seasons, and initiation of nesting activities as well as probable termination of those activities were similar to those of Florida populations.

Among the exotic amphibian and reptile species of the United States, three other exotic taxa, the Mediterranean Gecko (*Hemidactylus turcicus*), Brown Anole (*Anolis sagrei*), and Brahminy Blind Snake (*Ramphotyphlops braminus*) are common to Louisiana and Florida (Meshaka, 2008). In Louisiana, the Brahminy Blind Snake is known from Orleans Parish (Thomas, 1994), and the Brown Anole is known from six parishes: Calcasieu (Williams and Comeaux, 2008), East Baton Rouge (Platt and Fontenot, 1994; Boundy, 2004), Jefferson (Boundy, 2004), Lafourche (Wiley et al., 2007), Orleans (Boundy, 2004), and Terrebonne (Wiley et al., 2007) parishes. The Mediterranean Gecko is, however, widespread in Louisiana and has been studied to a greater extent. As exotic species in Florida and Louisiana, all three species share several ecological traits with those of the Greenhouse Frog. First, all but the Brahminy Blind Snake are among the oldest colonizing species of their respective states. Second, all four species first colonized the warmest regions of their respective states. Third, all four species have extensive geographic ranges in Florida, whose northern climate is similar to the interior of Louisiana. Fourth, all four species dispersed well in the agency of humans and succeeded in many human-disturbed habitats. Fifth, exclusive of the Brown Anole and Brahminy Blind Snake, for which comparable data do not exist, the reproductive seasons of the Mediterranean Gecko and the Greenhouse Frog are similar in southern Louisiana and Florida.

From our findings and comparisons, it seems not too surprising that Louisiana should expect to see the Greenhouse Frog in disjunct locations farther north as the species begins to attain a statewide distribution. Louisiana cities in more northerly locales, such as Natchitoches, Alexandria, and Shreveport would be among the likely initial sites of introduction from Florida or southern Louisiana nurseries that supply those cities with retail ornamental plants.

Likewise, other human commensal species of exotic amphibians and reptiles that have reached northern peninsular Florida, exclusive of the panhandle, will presumably be accompanied by a greater likelihood of human-mediated dispersal by those species to coastal Louisiana, most notably through disturbed systems that could serve as intermediate colonies. In this connection, one can expect an inevitable dispersal to Louisiana by Florida hemidactyline geckos (Meshaka et al., 2006) and by the Cuban Treefrog (*Osteopilus septentrionalis*), whose colonization is likely to take it around the entire gulf coast (Meshaka, 2001). To this list, we add the

Tokay Gecko (*Gekko gecko*) and the Cane Toad (*Rhinella marina*), which meet the aforementioned third and fourth shared traits such that dispersal to Louisiana seems inevitable and establishment has a high likelihood of success.

*Acknowledgments:* We heartily thank D. Bruce Means for his constructive comments on this manuscript.

#### Literature Cited

- Boundy, J. 1998. Distributional records for Louisiana amphibians. *Herpetol. Rev.* 29: 251–252.
- Boundy, J. 2004. Amphibians and reptile distribution records for Louisiana. *Herpetol. Rev.* 35: 194–196.
- Cope, E. D. 1863. On *Trachycephalus*, *Scaphiopus* and other American Batrachia. *Proc. Acad. Nat. Sci., Philadelphia* 15: 43–54.
- Deckert, R. F. 1921. Amphibian notes from Dade Co., Florida. *Copeia* 1921: 20–23.
- Dundee, H. A. 1994. Geographic distribution: *Eleutherodactylus planirostris* (Greenhouse Frog). *Herpetol. Rev.* 25: 60.
- Dundee, H. A. and D. A. Rossman. 1989. *The Amphibians and Reptiles of Louisiana*. Louisiana State University Press. 300 pp.
- Duellman, W. E., and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. *Bulletin of the Florida State Museum, Biological Sciences* 3: 181–324.
- Elbers, J. B. 2007. Geographic distribution: *Eleutherodactylus planirostris* (Greenhouse Frog). *Herpetol. Rev.* 38: 474.
- Goin, C. B. 1947. *Studies on the life history of Eleutherodactylus ricordii planirostris* (Cope) in Florida. *University of Florida Studies in Biological Science Series* 4: 1–66.
- Lazell, J. D., Jr. 1989. *Wildlife of the Florida Keys: A Natural History*. Island Press, Covelo, California, USA. 254 pp.
- Liner, E. A. 2007. Geographic distribution: *Euhyas planirostris* (Greenhouse Frog). *Herpetol. Rev.* 38: 214.
- Meshaka, W. E., Jr. 2008. The exotic amphibians and reptiles of the United States. In *Graeter, Gabrielle J., Kurt A. Buhlmann, Susan C. Walls, Charles R. Peterson, Lucas R. Wilkinson, and J. Whitfield Gibbons (Editors). Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians, with application to the United States and Canada*. PARC Technical Report. Aiken, South Carolina. *In press*.
- Meshaka, W. E., Jr., B. P. Butterfield, and J. B. Hauge. 2004. *The Exotic Amphibians and Reptiles of Florida*. Krieger, Melbourne, Florida. 166 pp.
- Meshaka, W. E., Jr., and J. N. Layne. 2005. Habitat relationships and seasonal activity of the Greenhouse Frog (*Eleutherodactylus planirostris*) in southern Florida. *Florida Scientist* 68: 35–43.
- Meshaka, W. E., Jr., S. D. Marshall, J. Boundy, and A. A. Williams. 2006. Status and geographic expansion of the Mediterranean Gecko, *Hemidactylus turcicus*, in Louisiana: Implications for the Southeastern United States. *Herpetol. Conserv. Biol.* 1: 45–50.
- Platt, S. G. and L. W. Fontenot. 1994. Geographic distribution: *Anolis sagrei*. *Herpetol. Rev.* 25: 33.
- Platt, S. G. and L. W. Fontenot. 1995. Geographic distribution: *Eleutherodactylus planirostris* (Greenhouse Frog). *Herpetol. Rev.* 26: 207.
- Plotkin, M. and R. Atkinson. 1979. Geographic distribution: *Eleutherodactylus planirostris planirostris*. *Herpetol. Rev.* 10: 59.
- Schwartz, A., and R. W. Henderson. 1991. *Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History*. University of Florida Press, Gainesville, Florida. 720 pp.
- Thomas, R. 1994. Geographic distribution: *Ramphotyphlops braminus*. *Herpetol. Rev.* 25: 34.
- Wiley, M., A. Ferrara and Q. Fontenot. 2007. Geographic Distribution: *Anolis sagrei* (Brown Anole). *Herpetol. Rev.* 38: 217.
- Williams, A. A. and J. Comeaux. 2008. Geographic Distribution: *Anolis (= Norops) sagrei* (Brown Anole). *Herpetol. Rev.* 39: 366.
- Williams, A. A. and M. L. Wygoda. 1997. Geographic distribution: *Eleutherodactylus planirostris* (Greenhouse Frog). *Herpetol. Rev.* 28: 207.