ARTICLES

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Terrestrial Movements of the Red-bellied Mudsnake (*Farancia abacura*) and Rainbow Snake (*F. erytrogramma*)

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Red-bellied Mudsnakes (*Farancia abacura*; Fig. 1A) and Rainbow Snakes (*Farancia erytrogramma*; Fig. 1B) are relatively large species with geographic distributions restricted to the southeastern United States. Both species are highly associated with aquatic habitats, to the extent that at least one, the Red-bellied Mudsnake, has been described as "fully aquatic" (Lutterschmidt et al. 2006). Adults of both species have highly specialized diets: Red-bellied Mudsnakes feed primarily on aquatic, elongate, eel-like salamanders (Sirens [*Siren* spp., *Pseudobranchus* spp.] and Amphiumas [*Amphiuma* spp.]), while adult Rainbow Snakes feed almost exclusively on a stream-dwelling, catadromous fish, the American Eel (*Anguilla rostrata*; Neill 1964).

Because *Farancia* are difficult to observe or study, we know little about their ecology and natural history; however, both species are known to undertake terrestrial movements. Our knowledge regarding terrestrial activity of these snakes is based largely on captures from drift fences surrounding Carolina bays (e.g., Semlitsch et al. 1988); although data derived from these captures have expanded our understanding of the species, the spatial extent of terrestrial movements has not been reported. This information, however, is of relevance to the conservation of wetland-associated organisms (Semlitsch and Bodie 2003).

Farancia may undertake terrestrial movements for several reasons. Both species are generally thought to hibernate below ground or under woody debris adjacent to their aquatic habitats (Ernst and Ernst 2003; Gibbons et al. 1977; Neill 1948; Young and Gibbons 2008). Richmond (1945) suggested Rainbow Snakes were the most abundant snake in the sandy fields of New Kent County, Virginia, based on his observations that specimens were frequently discovered by plowing fields. In this region, snakes were observed more often on land than in the neighboring wetlands.

Farancia may emigrate from wetlands during drought (Seigel et al. 1995; Willson et al. 2006) but sample sizes from past studies have generally been small. In the only published radio-telemetry study of the genus, Martin (1998) noted that Red-bellied Mudsnakes (N = 3) had small home ranges and were highly aquatic, making only small movements overland to neighboring wetlands during drying conditions. Red-bellied Mudsnakes may move overland in response to significant rainfall events, based on a mass movement of juveniles across a two-lane highway through a freshwater marsh in Florida (Hellman and Telford 1956).

Both species nest on land and their nests are generally thought to be located close to wetlands (e.g., Neill 1964; Hall and Meier 1993). However, Red-bellied Mudsnake nests have been found 15 m and 46 m from lakes in Alachua Co., Florida (Auth

1992; Riemer 1957) and 91 m from a lake in Aiken Co., South Carolina (Neil 1964). Neil (1964) also noted a Rainbow Snake approximately 64 m from a lake in Richmond Co., Georgia, but the impetus for this movement is not known.

Methods.—Herein, we review our previously unpublished data on Red-bellied Mudsnakes and Rainbow Snakes found in terrestrial habitats >25 m from the nearest body of water. For Rainbow Snake captures, we also report the distance to the nearest body of water known to be inhabited by American Eels (when available). Distances were estimated through use of Geographic Information Systems, topographical maps, or Google Earth. Because water levels may fluctuate, the distances we report should be considered approximations, but they correspond to our impressions in the field.

To determine whether our observations of *Farancia* away from water were unusual events, we reviewed location data compiled by the Carolina Herp Atlas (CHA), an online database maintained by Davidson College and generated by voluntary submissions of amphibian and reptile observations in North and South Carolina (Price and Dorcas 2011). We first removed data from Aiken or Barnwell Counties, South Carolina, because many of the observations from these counties were not generated from incidental observations, but rather resulted from controlled trapping efforts for semi-aquatic snakes on the Savannah River Site (e.g., Durso et al. 2011). We also removed any remaining observations generated from trapping elsewhere, as indicated in the "Remarks" section of the data input form. Finally, we removed observations collected prior to 2000 to ensure currently available wetland boundaries were relevant to snake observations. Then, we used ESRI ArcMap 9.3.1 to measure the distance between each *Farancia* location and the nearest wetland boundary, as delineated by the National Wetland Inventory (U.S. Fish and Wildlife Service 2011). A value of zero was recorded if the observation was within a wetland boundary.

Results.—We compiled 60 and 18 observations of Red-bellied Mudsnakes and Rainbow Snakes, respectively, from our unpublished field notes and trap capture data (Table 1). Individuals of both species were observed considerable distances from the nearest body of water (up to 1288 and approximately 2000 m for Red-bellied Mudsnakes and Rainbow Snakes, respectively). We included 17 Red-bellied Mudsnake and six Rainbow Snake observations from the CHA (Fig. 2). On average, Red-bellied Mudsnakes submitted to the CHA were observed 62 m from the nearest wetland boundary (SD = 72.07 m, range 0–264 m) and Rainbow Snakes were observed 44 m from the nearest wetland boundary (SD= 44.91 m, range 0–117 m).

Discussion.—We demonstrate that both Red-bellied Mudsnakes and Rainbow Snakes undertake considerable terrestrial movements and these movements may not be unusual events. This information supplements similar and recent information on terrestrial movements of other snakes considered highly aquatic (Steen et al. 2011), and further emphasizes the important role of the terrestrial landscape to species that spend the majority of their time in wetlands. We are unable to determine why the snakes we observed were traveling overland. However, many of the small individuals captured in the spring were likely immature (Gibbons et al. 1977; Lutterschmidt et al. 2006) and dispersing to wetlands after overwintering and emerging from their nests (Gibbons et al. 1977). For example, our spring observations of four hatchling-sized Rainbow Snakes (captured in a large area of xeric sandhill habitat adjacent to the Canoochee River on Fort Stewart, Georgia [Table 1]) suggest that the coarse sandy soils of xeric sand ridges adjacent to perennial blackwater streams may be important nesting habitat, when available.

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND PHOTOS BY D. STEVENSON

FIG. 1. A) Western Mudsnake (*Farancia abacura reinwardtii*), Cache River bottomlands, Johnson Co., Illinois, USA. B) Rainbow Snake (*Farancia e. erytrogramma*), Canoochee River, Liberty Co., Georgia, USA.

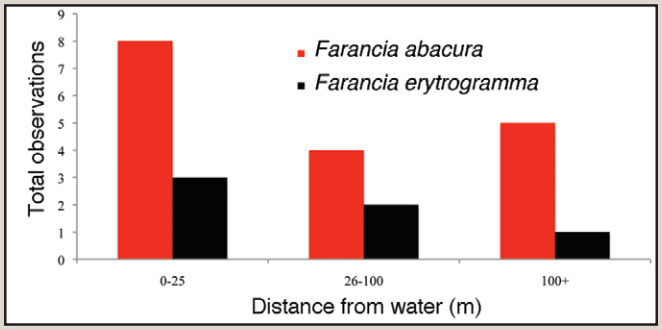

FIG 2. Distance to nearest body of water for Red-bellied Mudsnake (*Farancia abacura*) and Rainbow Snake, (*F. erytrogramma*) observations submitted to the Carolina Herp Atlas since 2000.

Sexually mature individuals were likely undertaking a nesting migration, dispersing to wetlands, or moving to a terrestrial overwintering site. Observations from Baker Co., Georgia (Table 1) suggest these animals may also travel overland in response to flooding events, as suggested by Hellman and Telford (1956). Only two captures from this site were recorded in seven years of trapping in a Longleaf Pine forest and both were in months of unusually high

TABLE 1. Information related to observations of Red-bellied Mudsnake (*Farancia abacura*) or Rainbow Snake (*F. erytrogramma*) located far (>25 m) from the nearest body of water. When the sex of a snake is known, it is indicated by M (male) or F (female). If no size data were available, but it is known whether the individual was an adult or juvenile, this is indicated by an A, or J, respectively. DOR = Dead on Road, AOR = Alive on Road.

Date	Location	Sex	SVL[a](mm)	TL[b]	Mass (g)	Distance[c] (m)	Wetland Type	Distance Eel[d]	Observation
Farancia abacura									
5/16/1987	Scotland Co., NC	J				423	Stream		Incidental, AOR
6/14/1987	Scotland Co., NC					341	Stream		Incidental, DOR
7/19/1987	Scotland Co., NC					570	Lake		Incidental, DOR
8/9/1987	Montgomery Co., NC					720	Pond		Incidental, DOR
6/18/1989	Scotland Co., NC					360	Headwater stream		Incidental, DOR
4/12/1992	Scotland Co., NC	F	205	233		120	Headwater stream		Incidental, DOR
9/5/1992	Bladen Co., NC					270	Carolina bay lake		Incidental, DOR
5/9/1993	Scotland Co., NC					710	Headwater stream		Incidental, DOR
9/5/1994	Bulloch Co., GA		~225	~250		90	Forested swamp		Incidental, AOR
5/15/1997	Scotland Co., NC	F	202	230		625	Stream		Incidental, DOR
10/8/1997	Bryan Co., GA		225	251		26	Cypress-gum pond,		Trap
4/8/1999	Bryan Co., GA	F	235			130	Cypress-gum swamp		Trap
9/5/2000	Bryan Co., GA		225	253	6	65	Cypress-gum swamp		Trap
7/20/2001	Barnwell Co., SC	M				183	Pond		Incidental, DOR
5/13/2002	Aiken Co., SC					~200	Stream		Incidental, DOR
7/6/2002	Aiken Co., SC			471		38	Pond		Incidental, DOR
8/16/2002	Barnwell Co., SC					290	Forested wetland		Incidental, DOR
9/11/2002	Orangeburg Co., SC					~170	Forested wetland		Incidental, DOR
5/5/2003	Aiken Co., SC	M		~980		~100	Stream		Incidental, DOR
5/11/2003	Aiken Co., SC			~850		~750	Beaver pond/stream		Incidental, DOR
5/20/2003	Aiken Co., SC	M		1021	208	390	Beaver pond/stream		Incidental, AOR
5/24/2003	Aiken Co., SC	F		1072	242	1086	Barrow pit		Incidental, AOR
6/12/2003	Aiken Co., SC			~1000		317	Carolina bay		Incidental, DOR
6/17/2003	Barnwell Co., SC	J		260	5.2	461	Stream		Incidental, DOR
6/21/2003	Bulloch Co, GA					138	Stream		Incidental, DOR
6/21/2003	Bulloch Co., GA					~600	Pond		Incidental, DOR
6/23/2003	Effingham Co., GA	F				79	Stream		Incidental, DOR
10/13/2003	Walton Co, GA					557	Farm pond		Incidental, DOR
4/25/2004	Covington Co., AL	J				150	Cattle pond		Trap
5/13/2004	Covington Co., AL		235	266	5.5	115	Creek		Trap
5/18/2004	Aiken Co., SC					77	Carolina bay		Incidental, DOR
5/27/2004	Covington Co., AL		218	260	6.5	62	Beaver pond		Trap
6/22/2004	Vernon Parish, LA			1000		160	Stream		Trap
6/29/2004	Aiken Co., SC	F	774	859	176	363	Carolina bay		Incidental, AOR

Table 1. Continued.

Date	Location	Sex	SVL[a](mm)	TL[b]	Mass (g)	Distance[c] (m)	Wetland Type	Distance Eel[d]	Observation
7/12/2004	Covington Co., AL		231	278	7	72	Beaver pond		Trap
8/31/2004	Aiken Co., SC	J	192	226	5.33	91	Carolina bay wetland		Coverboard
4/11/2005	Baker Co., GA	F	709	856	227	457	Creek		Trap
5/14/2005	Moore Co., NC	F	222	249		446	Beaver swamp		Incidental, DOR
5/21/2005	Aiken Co., SC	F	930	1046		520	Stream		Incidental, DOR
6/11/2005	Jasper Co., Texas			720		180	Stream		Trap
6/13/2005	Perry Co., MS	F	323	384	18	181	Gum swamp		Trap
9/3/2005	Liberty Co., GA	A		914		265	Canal		Incidental
7/2/2006	Barnwell Co., SC	F	~680	~780	117	125	Pond		Incidental, DOR
7/3/2006	Barnwell Co., SC	M	~645	~745		730	Beaver pond/stream		Incidental, DOR
7/14/2006	Montgomery Co., NC	F				80	Stream		Incidental, AOR
8/2/2006	Scotland Co., NC	F	816	913		325	Stream		Incidental, DOR
5/23/2007	Moore Co., NC	M	714	853		415	Stream		Incidental, AOR
5/28/2007	Moore Co., NC	F	696	778		1288	Stream		Incidental, DOR
June, 2007	Liberty Co., GA	A		1270		150	Cypress swamp		Incidental, DOR
6/18/2007	Sabine Co., TX			880		140	Stream		Trap
6/20/2007	Moore Co., NC	F	745	833		1100	Stream		Incidental, DOR
6/20/2007	Richmond Co., NC	M	584	690		534	Stream		Incidental, DOR
6/22/2007	Walton Co., FL	A				54			Incidental, DOR
7/12/2007	Beinville Parish, LA					200	Stream		Trap
5/14/2008	Macon Co., AL	F	580	712	175	35	Oxbow lake		Incidental
7/22/2009	Walton Co., FL	F		1905		32			Incidental, DOR
6/20/2010	Walton Co., FL	F				75			Incidental, DOR
8/17/2010	Walton Co., FL	A				30			Incidental, DOR
7/8/2011	Scotland Co., NC	F				788	Lake		Incidental, AOR
7/17/2011	Elmore Co., AL	F	1425	1580	1440	148	Stream		Incidental
Farancia erytrogramma									
5/9/1993	Bulloch Co., GA			~864		210	Forested Swamp	460	Incidental, AOR
1/6/1994	Washington Parish, LA				120	River	Same		Incidental, plowed
1/6/1994	Washington Parish, LA	A				120	River	Same	Incidental, plowed
5/19/1996	Bladen Co., NC	M				480	Stream	Same	Incidental, AOR
4/2/1999	Bryan Co., GA	M	~200	~220		65	Cypress-gum swamp	470	Trap
4/7/1999	Bryan Co., GA	F	200	220		210	Cypress-gum swamp	590	Trap
4/16/1999	Bryan Co., GA	M	229	279		210	Cypress-gum swamp	590	Trap
5/5/2000	Bryan Co., GA	F	216	248	6	185	Cypress-gum swamp	575	Trap
5/7/2003	Liberty Co., GA	F		1070		150	Cypress-gum swamp	365	Incidental, DOR

Table 1. Continued.

Date	Location	Sex	SVL[a](mm)	TL[b]	Mass (g)	Distance[c] (m)	Wetland Type	Distance Eel[d]	Observation
6/8/2003	Bladen Co., NC	J				625	Pond	1329	Incidental, DOR
6/23/2003	Candler Co., GA					~200	Stream/river	same	Incidental, DOR
6/27/2003	Aiken Co., SC	F - gravid				230	Stream	same	Incidental, DOR
7/20/2003	Liberty Co., GA	F		356		45	Cypress-gum swamp	2590	Incidental, DOR
2004	Pulaski Co., GA	F		<1700		140	River	255	Incidental, plowed
5/21/2005	Aiken Co., SC	M	670	814		~2000	Stream	same	Incidental, DOR
7/18/2005	Baker Co., GA	F	820	949	326	457	Creek	457	Trap
6/1/2007	Liberty Co., GA			345		26	Cypress-gum swamp	505	Incidental, DOR
3/29/2008	Emanuel Co., GA			~200		70	Stream		Incidental, under log

[a] Snout–vent length
[b] Total length
[c] Distance from the snake to the nearest body of water
[d] Distance from the snake to the nearest body of water known to contain a population of American Eels, *Anguilla rostrata*

flow rates for Ichawaynochaway Creek, the nearest body of water at this site (U.S.G.S. Water-Data Report GA-2005).

Results presented herein demonstrate that both Red-bellied Mudsnakes and Rainbow Snakes undertake long movements overland. We are unable to determine the cause or extent of these movements, or the frequency with which these snakes move onto or across the terrestrial landscape. Radio-telemetry studies of other aquatic snakes (e.g., *Nerodia* spp.) have demonstrated that they undertake regular terrestrial movements and terrestrial landscapes were identified as an important component of their life history (e.g., Camper 2009; Roe et al. 2003). The distances we report are well beyond the mean distances traveled overland by these other species (Camper 2009; Roe et al. 2003). Given the biology of *Farancia*, generating robust sample sizes for comparable radio-telemetry studies might be difficult; however, studies of this type are warranted, as they will likely generate novel natural history information related to aquatic home range size or the degree to which terrestrial habitats are used. An intact landscape to accommodate terrestrial movements is likely an important component to the life history of these wetland-associated snakes.

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