Herpetofaunal Diversity and Seasonality from a Remnant Coastal Chenier Forest in Southwestern Louisiana

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Abstract - Cheniers are ancient beach ridges in southwestern Louisiana that are often characterized by coastal forest surrounded by marshland. Coastal chenier forests (CCFs) are considered an imperiled habitat in Louisiana because many forest remnants are considerably impacted due to human activities and recent hurricanes. Because little is known about the herpetofaunal community of CCFs, I initiated a seasonal herpetofaunal diversity and abundance study on a privately-owned, remnant CCF in eastern Cameron Parish, Louisiana. Utilizing coverboards and drift fence arrays with pitfall and funnel traps, I documented 12 species (4 anuran, 4 snake, 3 lizard, and 1 turtle) comprising CCF obligate and facultative species, as well as one marsh transient species. Species-accumulation curves indicate the sample was representative of the small herpetofaunal community. Three amphibian (*Incilius nebulifer* [Gulf Coast Toad], *Lithobates sphenocephalus utricularius* [Coastal Plains Leopard Frog], and *Gastrophryne carolinensis* [Eastern Narrow-mouthed Toad]) and 2 reptile (*Scincella lateralis* [Little Brown Skink] and *Thamnophis p. proximus* [Orange-striped Ribbonsnake]) species comprised 94% of the captures. Diversity was highest during the spring, with 3 months (March–May) of sampling detecting 92% of the total diversity observed. Sampling during single months only yielded 42–75% of the diversity. Amphibian abundance varied by month (highest June to September) and with the presence of rain, whereas reptile abundance only varied by month (highest in March). Funnel traps were more effective and quantified diversity better than pitfall traps or coverboards. The herpetofaunal diversity at the site was low and comprised of mostly generalist species; regional specimen records also exhibit a modest herpetofaunal community. This data will provide baseline information to determine the impacts of future hurricanes on the herpetofaunal community, analyze recolonization dynamics following hurricanes, and make comparisons to other CCF remnants in the region. I also provide recommendations for improving herpetofauna sampling methodology in coastal settings.

Introduction

The Chenier Plain of southwestern Louisiana is a band of coastal wetlands with interspersed narrow sand and shell ridges called cheniers. Cheniers are relict beach ridges of late Holocene origin (≤2800 years old; McBride et al. 2007) that have been shaped and formed via the shifting delta of the Mississippi River and by ocean wave energy (Hoyt 1969, McBride et al. 2007). The chenier system of southwestern Louisiana is extensive and occurs across ~164 km in Cameron and Vermilion parishes (Fig. 1). The system is very dynamic in both longer and shorter time scales due to the shifting sediments of the wandering Mississippi River (i.e., the river shifts every ~1000–1500 years; McBride et al.

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Manuscript Editor: John Placyk

2007) and periodic intense hurricanes (approximately every 130–450 years; Liu and Fearn 2000), respectively.

Quercus virginiana Mill. (Southern Live Oak) and *Celtis laevigata* Willdenow (Sugarberry) trees dominate coastal chenier forests (CCFs; Neyland and Meyer 1997), with elevations of cheniers slightly higher (1–4 m; McBride et al. 2007) than surrounding low-lying coastal marsh. Prior to European settlement in the early 1800s (Midkiff et al. 1995), it is estimated that ~40,470 ha of CCFs occurred along chenier ridges in southwestern Louisiana (Lester et al. 2005). However, only ~809 to 4047 ha of this CCF habitat remain (2–10%; Lester et al. 2005), with far fewer intact forest remnants (i.e., full complement of understory, midstory, and canopy) still in existence (Neyland and Meyer 1997). Consequently, CCFs are considered imperiled in Louisiana primarily due to human development (i.e., community development, oil and gas facility development) or alternative land uses (i.e., pasture land, pit mining; Lester et al. 2005).

Coastal chenier forests are also prone to periodic hurricanes, including high winds and prolonged stormwater-inundation events. Recently, 2 major hurricanes—Rita in 2005 and Ike in 2008—made landfall along the southwestern Louisiana coastline, with wind and storm surges (~3–4.6 m; NOAA 2014) causing major damage to human infrastructure as well as CCFs in the area. Because many herpetofauna are not adapted to deal with major flooding and salinity increases associated with large hurricane storm surges, CCFs likely undergo significant faunal change and turnover following these major tropical events.

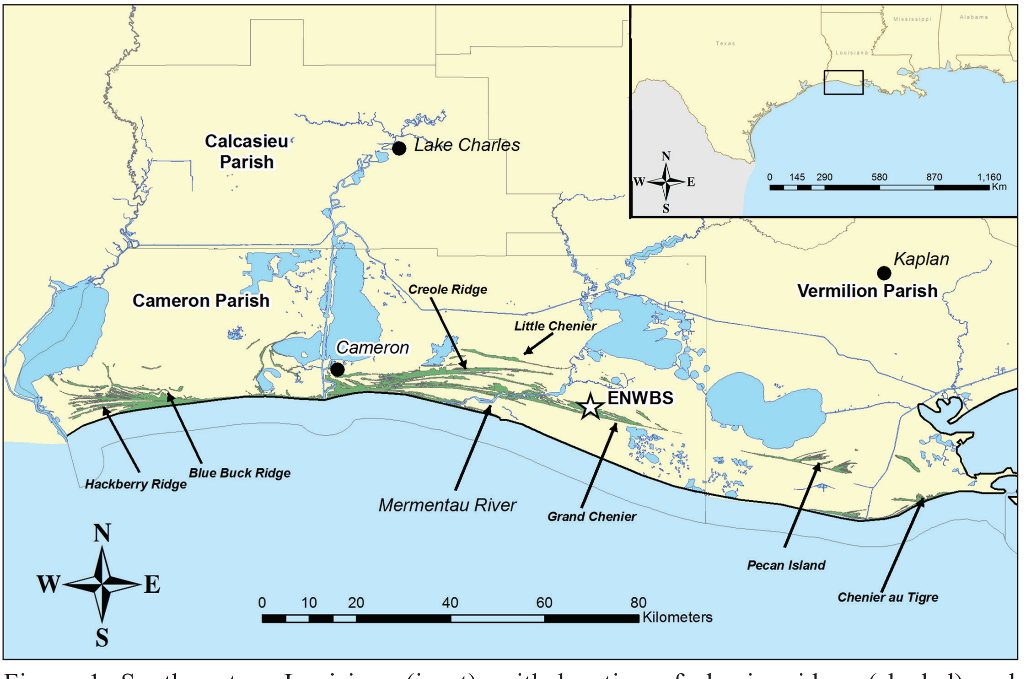

Figure 1. Southwestern Louisiana (inset), with location of chenier ridges (shaded) and Evariste Nunez Woods and Bird Sanctuary (ENWBS; bottom). Major ridges and ridge complexes are labeled, as is the Mermentau River which separates eastern and western cheniers.

Other than anecdotal and opportunistic specimen records (e.g., from road cruising), little data exist on the diversity and abundance of herpetofaunal species that inhabit CCF remnants. In this study, I sought to determine herpetofaunal diversity and abundance on a remnant CCF property. Along with this primary goal, I also wanted to determine the correlates that drive seasonal herpetofaunal diversity and abundance throughout the annual cycle, as well as determine effective sampling methodology in this coastal forest habitat type. The information gained will provide a "baseline" for the herpetological community for the area, enable a comparison of the current community to historical records for the area, and develop a sampling methodology for assessing CCF herpetofaunal communities.

Study Area

The study was conducted at Evariste Nunez Woods and Bird Sanctuary (ENWBS; 29.738794°N, 92.836653°W), a privately owned CCF remnant (34.9 ha) located on the Grand Chenier Ridge in eastern Cameron Parish, LA (Fig. 1). Within the CCF remnant, the site formerly included a private airstrip (4.8 ha) that was routinely used by Louisiana Department of Wildlife and Fisheries (LDWF) pilots from the early 1960s until 1998 (G. Perry, LDWF, Grand Chenier, LA, pers. comm.; Fig 2). Following cessation of flights, the former airstrip has been intermittently cut for hay and used as a wildlife food plot, while the area surrounding the airstrip has remained relatively undisturbed as a CCF (30.1 ha).

Hurricanes Rita and Ike changed the structure of the ENWBS, with many large trees dying, particularly on the northern side of the property (Fig. 2); this massive tree death was likely associated with long-term stress associated with the 2 hurricanes, subsequent extended droughts, prolonged water ponding of roots, and salt inundation. The remaining woods (16.8 ha; 56% of pre-hurricane forest) are dominated in the overstory by Live Oak and Sugarberry, in the midstory by *Ilex decidua* Walter (Deciduous Holly) and *Ulmus americanus* L. (American Elm) and in the understory by *Sabal minor* (Jacq.) Pers. (Dwarf Palmetto) and *Rubus* sp. (briars). Even with the loss of some of the mature forest on the property, ENWBS remains one of the few relatively intact CCF properties in southwestern Louisiana.

Methods

Sampling methodology

I surveyed herpetofauna at ENWBS from July to September 2012 and February to June 2013; months inclusive between October 2012 and January 2013 could not be sampled due to an agreement with the landowners to not access the property during hunting season. I used standard herpetological sampling techniques including a combination of drift fences with pitfall and funnel traps, as well as coverboards (Wilson and Gibbons 2010). Five drift fences were set at ENWBS, with each 30.5-m drift fence (i.e., silt fencing material with wooden stakes) containing 2 funnel traps placed on each side and each end of the fence (n = 4 traps per array), as well as 4 pitfall traps (for schematic design, see Baxley and Qualls [2009]).

Funnel traps made of window screen were covered with Dwarf Palmetto fronds both for trap concealment and to prevent overheating of trapped individuals. For pitfall traps, two 18.9-L buckets were recessed at ground level on each side of the drift fence and equally spaced along the fence at 10.1 m and 20.2 m; holes were punctured in the bottom of the bucket to promote draining following heavy rains. A sponge was included in each bucket, and I added small amounts of water on hot days to prevent overheating and desiccation of trapped individuals. These sponges also served as floating platforms for trapped individuals during high rain/water events. During 2013 months (February–June), I utilized plywood coverboards (91 cm x 91 cm x 1.9 cm, $n = 4$ per array) spaced equally and perpendicular to the fence (~5 m away). Each month I attempted to survey the site for 7 consecutive days, checking the drift-fence arrays (including funnel traps, pitfalls, and coverboards) once per day during most months, but checking traps twice per day in July and August 2013 because of warmer temperatures (maximum daily temperature >30°C).

Figure 2. Aerial imagery of Evariste Nunez Woods and Bird Sanctuary in 1998 (top) and in 2012 (bottom). For the latter, note the location of drift fences (white lines) and the dramatic loss of trees on the northern side of the property (light-colored polygon).

I did not choose to utilize Anuran call surveys during the study due to the narrow strip of CCF (maximum width = 200 m) and the inability to differentiate between anurans calling from the CCF and the surrounding marshland.

I removed all captured individuals from traps and recorded the species, drift fence and trap number, and date captured for each individual; individual length and mass were recorded for a related study. Following processing of each individual, I immediately released them at the site of capture. I collected meteorological data (mean, maximum, minimum daily temperatures, and rainfall) from a VantageVue Weather Station (Davis Instruments, Hayward, CA) located at Rockefeller Wildlife Refuge (RWR; 29.72847°N, 92.81850°W), ~2.0 km ESE of the center of the ENWBS site.

Statistical analysis

In order to determine the effectiveness of sampling the herpetofaunal community as well as the efficiency of trap effort across months, I created species accumulation curves for sampling beginning at 4 spring–summer sampling months (February–May). One species, *Nerodia erythrogaster* (Plain-bellied Watersnake), was not included because it is considered a marsh-transient species and only a single individual was captured. Sampling was not continuous (only 5–7 days each month), and therefore, cumulative days are presented in accumulation curves with the understanding that gaps occurred between sampling months.

I used 2 separate two-factor ANOVAs to determine if amphibian and reptile abundance (i.e., daily total captures) was equal by month (February–September) and by the presence of rainfall recorded (yes or no), and a month × rain presence interaction. For total anuran captures and for the 3 most-common species captured (*Gastrophryne carolinensis* [Eastern Narrow-mouthed Toad], *Incilius nebulifer* [Gulf Coast Toad], and *Lithobates sphenocephalus utricularius* [Coastal Plains Leopard Frog]), I used linear regressions to determine if the amount of rainfall (cm) corresponded to daily captures.

Results

Survey data

Throughout the study period at ENWBS, I sampled herpetofauna on 53 days across 8 months (mean = 6.6 days per month) for a total of 1013 funnel trap days (mean = 126.6/month), 794 pitfall trap days (mean = 99.3/month), and 677 coverboard days (mean = 135.4/month) (Table 1). Values were less than the maximum possible throughout the study (funnel and pitfall: 1120, coverboard: 700) due to excessive water accumulation within pitfall traps and under coverboards, rodent holes in funnel traps (i.e., may have facilitated escapes), and *Solenopsis invicta* Buren (Red Imported Fire Ant) colonies around funnel traps or coverboards.

A total of 908 individuals of 12 species were captured throughout the study, including 4 anuran, 4 snake, 3 lizard, and 1 turtle species (Tables 2, 3). Three amphibian species—Gulf Coast Toad (relative abundance [RA]: 0.37), Coastal Plains Leopard Frog (RA: 0.21), and Eastern Narrow-mouthed Toad (RA: 0.14)—and 2 reptile species—*Scincella lateralis* (Little Brown Skink; RA: 0.12) and *Thamnophis p. proximus* (Orange-striped Ribbonsnake; RA: 0.10)—comprised 94% of the herpetofaunal community. All other species had RA values ≤ 0.03, with 5 of the species represented by 3 or fewer captures (Table 3).

Overall, funnel traps captured all 12 species encountered during the study, while pitfall traps and coverboards captured only 5 (42%) and 4 (33%) species, respectively. Funnel traps also had a higher overall herpetofaunal capture rate (0.90 individuals/trap day) compared to pitfall traps (0.37) or coverboards (0.06)

Table 1. Summary table for environmental data at ENWBS, Cameron Parish, LA. Abbreviations : Trap = funnel trap, Pit = pitfall trap, and CB = coverboard.

Month	Days	Trap days	Pit days	CB days	Rainfall (cm)	Mean temp. (°C) (range)
February 2013	7	132	112	140	0.6	14.4 (10.3–17.6)
March 2013	5	132	112	140	0.4	18.6 (14.6–22.2)
April 2013	6	119	80	120	6.0	20.2 (16.2–23.6)
May 2013	7	132	126	137	3.3	19.2 (14.9–22.7)
June 2013	7	140	140	140	0.6	28.3 (24.5–31.5)
July 2012	7	140	63	n/a	14.2	26.4 (22.8–29.0)
August 2012	5	98	65	n/a	1.7	26.6 (23.4–30.5
September 2012	6	120	96	n/a	3.5	26.8 (23.2–31.6)
Sum total	53	1013	794	677	30.3	-
Mean	6.6	126.6	99.2	135.4	3.8	22.6

Table 2. Number of captures and capture rates for each species by trap type. Species abbreviations are as follows: Ac = *Anolis c. carolinensis*, Cc = *Coluber constrictor flaviventris*, Gc = *Gastrophryne carolinensis*, Hc = *Hyla cinerea*, In = *Incilius nebuliber*, Ks = *Kinosternon subrubrum hippocrepis*, Lh = *Lampropeltis holbrooki*, Ls = *Lithobates s. utricularius*, Ne = *Nerodia erythrogaster*, Pf = *Plestiodon fasciatus*, Sl = *Scincella lateralis*, and Tp = *Thamnophis p. proximus*.

Method	Ac	Cc	Gc	Hc	In	Ks	Lh
Number of captures							
Pitfall	1	0	66	0	182	0	0
Coverboard	0	0	0	0	5	0	0
Funnel trap	2	2	63	3	149	2	7
Capture rates							
Pitfall	0.014	0.000	0.083	0.000	0.229	0.000	0.000
Coverboard	0.000	0.000	0.000	0.000	0.007	0.000	0.000
Funnel trap	0.002	0.002	0.127	0.003	0.147	0.002	0.007

Method	Ls	Ne	Pf	Sl	Tp	Total
Number of captures						
Pitfall	10	0	15	17	0	291
Coverboard	0	0	6	27	3	41
Funnel trap	177	1	10	68	92	576
Capture rates						
Pitfall	0.013	0.000	0.019	0.021	0.000	0.366
Coverboard	0.000	0.000	0.009	0.040	0.004	0.061
Funnel trap	0.175	0.001	0.010	0.067	0.091	0.896

Table 3. Summary table for capture data for ENWBS, Cameron Parish, LA. Abbreviations : Trap = funnel trap, Pit = pitfall trap, and CB = coverboard. Species abbreviations follow those presented in Table 2. RA. = species relative abundance. TA = total anurans, TR = total reptiles, and TC = total captures.

Month	Ac	Cc	Gc	Hc	In	Ks	Lh	Ls	Ne	Pf	Sl	Tp	Diversity	TA	TR	TC
February 2013	1	0	0	1	2	0	0	0	0	0	6	3	5	3	10	13
March 2013	1	0	12	0	2	0	1	0	0	1	34	53	7	14	90	104
April 2013	0	0	1	0	4	0	0	0	1	1	12	14	6	5	28	33
May 2013	0	2	2	0	6	1	4	3	0	5	12	7	9	11	31	42
June 2013	0	0	16	0	19	1	0	78	0	13	17	3	7	113	34	147
July 2012	0	0	30	2	162	0	1	94	0	1	14	1	8	288	17	305
August 2012	0	0	45	0	98	0	0	10	0	6	5	4	6	153	15	168
September 2012	1	0	23	0	43	0	1	2	0	4	12	10	8	68	28	96
Sum total	3	2	129	3	336	2	7	187	1	31	112	95	-	655	253	908
Mean	0.38	0.25	16.13	0.38	42.00	0.25	0.88	23.38	0.13	3.88	14.00	11.88	7	81.88	31.63	113.50
RA	<0.01	<0.01	0.142	<0.01	0.370	<0.01	<0.01	0.21	<0.01	0.03	0.12	0.11				

(Table 2). Funnel traps also outperformed the other 2 capture methods with all species pairwise comparisons except Gulf Coast Toad, *Anolis c. carolinensis* (Northern Green Anole), and *Plestiodon fasciatus* (Common Five-lined Skink), which were captured in marginally higher rates in pitfall traps relative to funnel traps (Table 2).

Even though traps were checked regularly during the study, overall mortality was high (10.5%; 95 of 908) due to desiccation of anurans and predation of herpetofauna by fire ants. Mortality rates were higher for moist-skinned anurans (Coastal Plains Leopard Frog: 39 of 187 [21%], Eastern Narrow-mouthed Toad: 35 of 129 [27%]) relative to Gulf Coast Toad (16 of 336; 4.8%) and two lizard species (Little Brown Skink: 2 of 112 [1.7%]; Common Five-lined Skink: 3 of 31 [9.6%]). No mortality was observed for any of the other species captured.

Species-accumulation curves indicate that an asymptote was reached for herpetofaunal diversity at this site and that sample efforts accurately represent the site herpetofaunal community (Fig. 3). Sampling beginning in May appears to best fit an asymptotic curve for species accumulation, with 10 of the 11 species (91%) obtained in 15 sample days (7 days in May and June, 1 day in July). To reach a similar diversity, it took 20, 22, and 25 days for sampling begun in March, April, and February, respectively. To reach full diversity without marsh species (11 species), it took between 27 and 36 days, with sampling begun in February needing the fewest sampling days (27 days, February–May), while sampling begun in April needing the most sampling days (36 days, April–September).

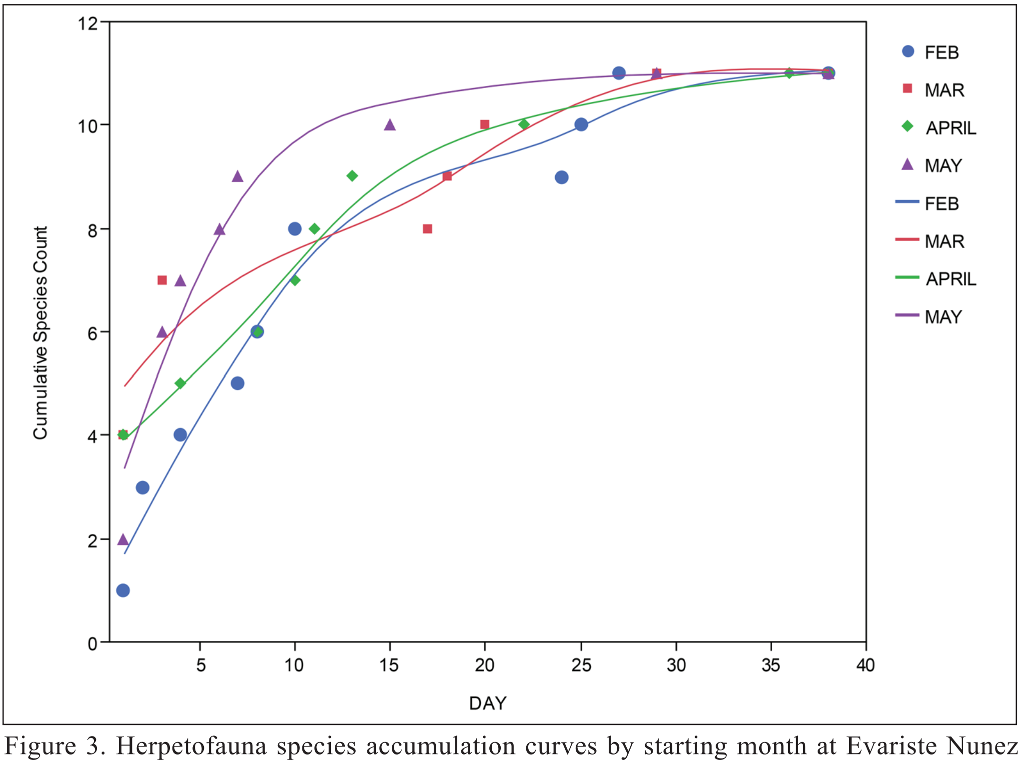

Figure 3. Herpetofauna species accumulation curves by starting month at Evariste Nunez Woods and Bird Sanctuary, Cameron Parish, LA.

Monthly diversity and abundance

Monthly herpetofaunal diversity averaged 7 species, with the greatest species diversity observed during May 2013 (n = 9) and the lowest during February 2013 (n = 5). Total amphibian captures differed significantly by month ($F_{7,53}$ = 12.95, P < 0.0001) and by the presence of rain ($F_{1,53}$ = 4.07, P = 0.05), but there was no month × rain presence interaction ($F_{7,53}$ = 1.74, P = 0.13). Summer months (June–September) had significantly higher amphibian capture rates than winter (February) or spring (March–May) months, while days with rain had significantly higher amphibian capture rates than days without rain. Reptile daily capture rates also differed significantly ($F_{7,53}$ = 2.27, P = 0.05) by month, but there was no difference by the presence of rain ($F_{1,53}$ = 2.69, P = 0.11) and no month × rain presence interaction ($F_{7,53}$ = 1.01, P = 0.43). The month of March had significantly higher daily capture rates of reptile species than all other sample months.

Rainfall amount was a significant predictor in captures of total amphibians ($F_{1,53}$ = 14.49, R^2 = 0.22, P = 0.0004) and captures of Gulf Coast Toad ($F_{1,29}$ = 9.30, R^2 = 0.26, P = 0.005), but was not a significant predictor of captures of Eastern Narrow-mouthed Toad ($F_{1,30}$ = 9.30, R^2 = 0.0004, P = 0.92) or Coastal Plains Leopard Frog ($F_{1,22}$ = 1.86, R^2 = 0.09, P = 0.19).

Discussion

Sampling methodology

Because some of the CCF obligate (CCF-O) and facultative (CCF-F) species previously documented in the area (Table 4) were not captured during our sampling, it is possible that some species may not have been detected, whereas others may actually not occur in this remnant CCF or are only transient marsh species (e.g., *Nerodia,* spp. [watersnakes]). For example, the method of using

Table 4. Herpetofauna of lower Cameron/Vermilion parishes and coastal chenier forests based on Dundee and Rossman (1989) and specimen records. Under ENWBS, species with a "X*" have been observed or reported to the author outside of this study. Codes under presence on cheniers (Presence) represent a presumed chenier obligate species (O), facultative chenier-marsh species (F), and marsh species (M). EC = eastern cheniers, WC = western cheniers. Continued on the following page.

All species observed on cheniers by clade	Presence	ENWBS	EC	WC
Anura				
Acris blanchardi Harper (Blanchard's Cricket Frog)	F			X
Anaxyrus fowleri Hinckley (Fowler's Toad)	O		X	X
Gastrophryne carolinensis Holbrook (Eastern Narrow-mouthed Toad)	F	X	X	X
Hyla cinerea Schneider (Green Treefrog)	F	X	X	X
Hyla squirella Bosc (Squirrel Treefrog)	F		X	X
Incilius nebulifer Girard (Gulf Coast Toad)	F	X	X	X
Lithobates catesbeianus Shaw (American Bullfrog)	M		X	X
Lithobates clamitans Latreille (Green Frog)	M		X	X
Lithobates grylio Stejneger (Pig Frog)	M		X	X
Lithobates sphenocephalus utricularius Harlan (Coastal Plains Leopard Frog)	F	X	X	X
Pseudacris fouquettei Lemmon et al. (Cajun Chorus Frog)	F			X

drift-fence arrays poorly detects arboreal species (e.g., Hylid treefrogs). This limitation is evident because only 3 Northern Green Anoles were detected, and *Pantherophis obsoletus* (Sya in James) (Western Ratsnake) or *Opheodrys a. aestivus* (L.) (Northern Rough Greensnake) were not detected. However, both of the latter species have been documented at ENWBS outside of this sampling effort (W. Selman, pers. observ.).

Table 4, continued.

All species observed on cheniers by clade	Presence	ENWBS	EC	WC
Caudata				
Siren intermedia nettingi Barnes (Lesser Siren)	M		X	
Crocodylia				
Alligator mississipiensis Daudin (American Alligator)	M		X	X
Squamata				
Agkistrodon piscivorus leucostoma Troost (Western Cottonmouth)	M		X	X
Anolis c. carolinensis Voigt (Green Anole)	O	X	X	
Aspidoscelis s. sexlineata L. (Eastern Six-lined Racerunner)	O		X	X
Coluber constrictor flaviventris Say (Eastern Yellow-bellied Racer)	O	X	X	X
Farancia abacura reinwardtii Schlegel (Western Mud Snake)	M		X	X
Heterodon platirhinos Latreille (Eastern Hog-nosed Snake)	O		X	X
Lampropeltis holbrooki Stejneger (Speckled Kingsnake)	F	X	X	X
Lampropeltis triangulum amaura Cope (Louisiana Milksnake)	O			X
Nerodia c. clarkii Baird and Girard (Gulf Saltmarsh Watersnake)	M		X	X
Nerodia cyclopion Duméril et al. (Mississippi Green Watersnake)	M		X	X
Nerodia erythrogaster Forster (Plain-bellied Watersnake)	M	X	X	
Nerodia fasciata confluens Blanchard (Broad-banded Watersnake)	M		X	X
Nerodia r. rhombifer Hallowell (Northern Diamond-backed Watersnake)	M		X	X
Opheodrys a. aestivus L. (Northern Rough Greensnake)	O	X*	X	X
Ophisaurus a. attenuatus Cope (Western Slender Glass Lizard)	O			X
Pantherophis obsoletus Say (Western Ratsnake)	O	X*	X	X
Plestiodon fasciatus L. (Common Five-lined Skink)	O	X	X	
Regina grahamii Baird and Girard (Graham's Crayfish Snake)	M		X	X
Regina rigida sinicola Huheey (Gulf Crayfish Snake)	M		X	X
Scincella lateralis Say in James (Little Brown Skink)	F	X	X	X
Storeria dekayi limnetes Anderson (Marsh Brownsnake)	O		X	X
Thamnophis p. proximus Say (Orange-striped Ribbonsnake)	F	X	X	X
Testudines				
Apalone spinifera pallida Webb (Pallid Spiny Softshell)	M		X	X
Chelydra serpentina L. (Snapping Turtle)	M	X*	X	X
Deirochelys reticularia miaria Schwartz (Western Chicken Turtle)	F			X
Kinosternon subrubrum hippocrepis Gray (Mississippi Mud Turtle)	F	X	X	X
Malaclemys terrapin pileata Wied-Neuwied (Mississippi Diamond-backed Terrapin)	M		X	X
Pseudemys c. concinna LeConte (Eastern River Cooter)	M		X	X
Terrapene carolina triunguis Agassiz (Three-toed Box Turtle)	O		X	X
Terrapene o. ornata Agassiz (Plains Box Turtle)	O			X
Trachemys scripta elegans Wied-Neuwied (Red-eared Slider)	M		X	X
Total species	44	15	38	40

Based on the diversity of species captured and CPUE, funnel traps were the most effective trap for almost every species encountered. They sampled the entire herpetofaunal community observed during the study. Interestingly, funnel traps also captured 2 adult *Kinosternon subrubrum hippocrepis* (Mississippi Mud Turtle) of 9.3 and 9.4 cm carapace length, respectively. However, funnel traps were prone to "chew outs" by rodents (i.e., rodents chewing through the window screen trap to escape) and had high rates of mortality via fire ants and desiccation. For the former, a stronger gauge wire mesh would be preferred for trapping in similar rodent-prone areas. Fire ant mortality may be abated through targeted ant-bait application around traps (Allen et al. 2004). Apparently the palmetto fronds covering the traps did not provide enough protection from dessication, so that source of mortality may be harder to relieve. It is likely exacerbated by the relatively constant sea breeze in coastal habitats, which may therefore warrant the checking of traps twice per day during windy days (>16 km/h).

Pitfall traps and coverboards were less effective at sampling the herpetofaunal community and were not complementary to funnel traps as found by Todd et al. (2007). Pitfall traps often filled with water following heavy rains even though drainage holes were drilled in the bottom bucket. Buckets did not drain effectively, likely due to a high water table and poor drainage in the low-lying coastal setting. Coverboards were relatively new when deployed in February 2013, with some authors suggesting that time since deployment is important for coverboard effectiveness (Willson and Gibbons 2010); conversely, others suggest that time since deployment is not a determinant in coverboard effectiveness (Houze and Chandler 2002). However, abundant natural debris cover was present at ENWBS due to long-term dead or dying trees from recent hurricanes, possibly leaving coverboards less desirable than natural cover objects (Houze and Chandler 2002). Also, the type of coverboard material may have influenced their effectiveness (Hesed 2012), and thus, experiments using different materials may be needed to optimize coverboard efforts. Thus, based on these findings in a coastal forest setting, there are several recommendations that may improve drift-fence sampling design in these habitats including (1) sampling with stronger mesh screen funnel traps, (2) not using coverboards or pitfall traps due to ineffectiveness, (3) checking funnel traps twice per day in windy conditions, regardless of ambient temperature, and (4) augmenting drift-fence arrays with line-transects or timed manual searching to better detect arboreal species (Marsh and Haywood 2010). Collectively, implementing these measures would improve sampling effectiveness, reduce time installing/checking traps, reduce trap mortality, and better detect arboreal species.

Based on species-accumulation curves, it appears that my sampling efforts adequately characterized the herpetofaunal community at ENWBS. The number of sampling days needed to reach 90% (15–25 days) and 100% (27–36 days) community accumulation varied ~10 days depending on the month in which the sample counting began. Monthly curve comparisons indicate that starting sampling earlier in the spring (from mid-February to March) is the most efficient time to accurately sample herpetofauna in CCF habitats; initiating studies during this period would likely be beneficial for surveys in other southern Louisiana coastal habitats.

Southwestern Louisiana herpetofaunal diversity

Considering specimen records, there are 44 reptile and amphibian species that have been reported from lower Cameron and Vermilion parishes in southwestern Louisiana (Table 4). Based on the distribution of these records and because roads occur along most of the cheniers (due to the fact that they are the only high ground within surrounding marsh), it is likely that the majority are representative of individuals encountered on roads (as described by LaDuc and Bell 2010). Of those 44 species, Dundee and Rossman (1989) and this study consider 13 species (29.5%) tightly associated with CCF habitats (i.e., obligate to CCFs; CCF-O), 13 species (29.5%) inhabit both CCFs and the surrounding marshlands (i.e., facultative; CCF-F), and 18 species (41%) are mostly associated with marsh habitats (Table 4). For the latter, many of these species are considered marsh transients moving across chenier habitats to other marsh habitat (e.g., *Alligator mississippiensis* [American Alligator]). Further delineation of the 44 species recorded indicates that 38 species (86%) have been documented in eastern cheniers (east of the Mermentau River) and 40 (91%) in western cheniers (Table 4). However, even though a similar percentage is observed in eastern and western cheniers, species are not equally represented along the longitudinal gradient even within this relatively small geographic range. Western cheniers are more representative of scrub-shrub habitats and have some species more characteristic of herpetofauna from Texas (e.g., *Terrapene o. ornata* [Plains Box Turtle]).

The sampling site at ENWBS is situated within an eastern chenier complex, and based on specimen records reported (Dundee and Rossman 1989, Herpnet 2014), there are 10 CCF-O and 9 CCF-F species that have been recorded in the surrounding area. Sampling at ENWBS documented 3 CCF-O species (33%), 8 CCF-F species (89%), and 1 marsh species. Previously documented eastern CCF-O species that were not documented at ENWBS include *Anaxyrus fowleri* Hinckley (Fowler's Toad), *Terrapene carolina triunguis* (Agassiz) (Three-toed Box Turtle), *Aspidoscelis s. sexlineata* (L.) (Eastern Six-lined Racerunner), *Heterodon platirhinos* Latreille in Sonnini & Latreille (Eastern Hog-nosed Snake), *Storeria dekayi limnetes* Anderson (Marsh Brown Snake), Northern Rough Greensnake, and Western Ratsnake. The latter two have been documented by the author at ENWBS outside of the study period. Marsh Brown Snakes have been observed < 2 km away at RWR (W. Selman, pers. observ.), and it is not likely that Eastern Six-lined Racerunner would have been encountered because regional records appear to be from beach and dune habitats. The only CCF-F species not encountered at the site was *Hyla squirella* Bosc in Daudin (Squirrel Treefrog), but this species has been readily heard calling ~0.5 km away at RWR (W. Selman, pers. observ.).

Thus, the only species lacking from the sample at ENWBS that had been documented previously at the site but are lacking recent records or observations in the area are Fowler's Toad, Three-toed Box Turtle, and Eastern Hog-nosed Snake.

Specimen records indicate that the most recent collections for these 3 species date from the 1960s–1970s (Herpnet database search 3 December 2014), with a personal observation of the Eastern Hog-nosed Snake ~3.5 km east of ENWBS in the early 2000s (P. Trosclair, LDWF, Grand Chenier, LA, pers. comm.). Because these species were observed prior to Hurricanes Rita and Ike, it is possible that their populations were diminished or were extirpated from the region due to the impacts of those 2 major storms. Other studies along the Gulf Coast have documented changes to herpetofaunal communities following hurricanes (Nicoletto 2013, Schriever et al. 2009). However, because the sampling in this study was limited to a single CCF remnant, it is possible that these species still occur in the area. Additional sample sites and effort may reveal these species to be extant in the eastern chenier region.

In summary, this study indicates that the herpetofaunal community of ENWBS is relatively small, but in general it is similar to previously documented species in the area (including CCF-O and CCF-F species). Further, regional specimen records from southwestern Louisiana indicate that CCF habitats are represented by 13 CCF-O and 13 CCF-F species, indicating a relatively modest herpetofaunal community compared to other studies in the southeastern United States (e.g., 54 species at 24 sites in south Mississippi [Baxley and Qualls 2009], 59 species at a single site in South Carolina [Todd et al. 2007]). Almost all species documented in CCFs would be considered "generalist" species.

Effect of season and environmental conditions

There have been few studies that assess herpetofaunal communities across the annual cycle (Todd et al. 2007). This study found that spring sampling (March–May) yielded the highest species diversity. During the summer (June–September), the community remained diverse, but was dominated by 3 anuran species (Gulf Coast Toad, Eastern Narrow-mouthed Toad, and Coastal Plains Leopard Frog); however, abundance of only 1 of these species (Gulf Coast Toad) appeared to be driven by rainfall amounts, whereas patterns of abundance for the other 2 species may have been most affected by movement between marsh habitats on either side of the chenier for breeding. I conducted no fall sampling due to stipulations by the landowner, but it is likely that diversity declines during the period leading into the winter. Even though the only winter sampling month was February, monthly diversity was lowest during this month, probably driven by dormancy during cooler temperatures (Todd et al. 2007, Vitt and Caldwell 2014).

This study indicates that sampling across multiple spring months (March–May) is needed to characterize most of the community diversity. Sampling a single week per month from March through May yielded 92% of species (only excluding *H. cinerea* [Green Treefrogs]), while sampling for just a single week of a single month yielded 42–75% of the community. Because little information is known about CCF herpetofauna, these data can be used for future comparisons following periodic hurricanes and to determine the dynamics of recolonization events.

Acknowledgments

LDWF's Rockefeller Trust Funds financially supported this research project. I would like to thank J. Landry, A. Toepfer, and C. Reeves for assistance with constructing the drift-fence arrays, as well as C. Reeves, D. Brown, R. Elsey, and R. King for assisting with checking traps in 2013. The author also appreciates the Nunez family for permitting access to sample on their property during the study. Former RWR Program Manager T. Hess and LDWF administrator B. Baker also supported the implementation of this project. R. Elsey, J. Boundy, and 2 anonymous reviewers provided helpful comments on an earlier draft of this manuscript. LDWF approved of this project, and I complied with all applicable animal care guidelines as outlined by Society for the Study of Amphibians and Reptiles.

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