Herpetology Notes, volume 15: 609-613 (2022) (published online on 11 August 2022)

Where are the turtles? Looking for the Western Chicken Turtle, *Deirochelys reticularia miaria*, in Mississippi

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Turtles are among the world's most threatened vertebrates, with roughly two-thirds of species listed as threatened or endangered (Buhlmann et al., 2009). Factors such as habitat loss, overharvesting, poaching, disease, and climate change are driving these declines (Stanford et al., 2020), and it is imperative that we carefully monitor turtle populations to determine the extent of declines and prioritize conservation actions for threatened species.

Western Chicken Turtles (*Deirochelys reticularia miaria* Schwartz, 1956) are among the turtles that appear to be experiencing rapid declines. This subspecies is distinct from the other subspecies in morphology (Schwartz, 1956), diet (McKnight et al., 2015c), nesting season (McKnight et al., 2015a, 2018; Carr and Tolson, 2018), and activity season (McKnight et al., 2015a; Bowers 2020). Genetic comparisons are currently limited, but available data also suggest a deep phylogenetic split between the Eastern Chicken Turtle, *D. r. reticularia*, (Latreille, 1801) and *D. r. miaria* Schwart, 1956 (Walker and Avise 1998; Hilzinger 2009). Historically, *D. r. miaria* occurs in Missouri, Oklahoma, Arkansas, Louisiana, Texas, and a small portion of western Mississippi, and the ranges of *D. r. miaria* and *D. r. reticularia* are primarily divided by the Mississippi River, which likely acts as a strong barrier to interbreeding.

Our understanding of the extent of *D. r. miaria* declines is limited by a lack of systematic historical surveys, but few extant populations are currently known (Ryberg et al., 2017), and many of those are small (Dinkelacker and Hilzinger, 2014; McKnight, 2014) and sometimes have high rates of developmental abnormalities (McKnight and Ligon, 2014). Continuing to search for *D. r. miaria* at historical locations is imperative to properly assess their conservation status and implement appropriate management actions.

The Mississippi populations of *D. r. miaria* are of particular interest. They historically occurred in northwestern Mississippi, in the "Mississippi Delta" region of the Mississippi Alluvial Valley (disjunct from the *D. r. reticularia* in southern Mississippi; Landreth and Finley, 1968) and are the only known populations of *D. r. miaria* east of the Mississippi River. Records of these populations are extremely limited. Two individuals were collected from unknown locations in the 1930s (B. Jones pers. comm.), six individuals were captured in 1966–1967 in a ditch near Belzoni, Humphrey's County (Landreth and Finley 1968) and one individual was collected in 1969 in Warren County (B. Jones pers. comm). To the best of our knowledge, there are no other formal records of *D. r. miaria* in Mississippi, and their current status is unknown. A 1983 survey of turtles at Coldwater River National Wildlife Refuge in the Mississippi Delta (Nickerson et al., 2019) failed to find *D. m. miaria*; however, that survey was conducted from 13 July to 16 September, and *D. r. miaria* are often estivating in terrestrial refugia by mid-July (McKnight et al., 2015a; Bowers, 2020; McKnight and Ligon, 2020).

In 2018, we attempted to locate *D. r. miaria* in the Mississippi Delta. The reliability of species-detection surveys can be greatly affected by the species-specific experience of the researchers conducting the surveys (e.g., Farmer et al., 2012); therefore, we used well-established trapping methods that we have implemented with success at sites in Oklahoma and Arkansas. *Deirochelys r. miaria* generally occupy shallow bodies of water with extensive emergent vegetation interspersed with slightly deeper (~1–1.5m) sections of open water. In our experience, they can be readily trapped using either single hoop nets baited with sardines or pairs of hoop nets (baited or

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unbaited) with a lead ("wing") spanning the water column between them to guide turtles toward the throats of the traps (sometimes referred to as a type of fyke net). Paired traps with leads are generally most effective (Bowers et al., 2021). A given body of water can be rapidly surveyed by using a "saturation" strategy in which numerous traps are deployed simultaneously across all micro-habitats frequented by *D. r. maria*, with a particular focus on channels in sections of shallow, emergent vegetation, and transition zones between emergent vegetation and open water. To accomplish this, we used a variety of hoop net designs ranging in size from 0.51–0.91m diameter, including both standard round nets and flat-bottomed D-shaped nets (McKnight et al., 2015b). We also used smaller minnow traps and crawfish traps (McKnight et al., 2015b; Howell et al., 2016), which are particularly effective for juveniles, but also capture adults in areas that are too shallow for standard hoop nets.

From 18–24 May 2018, during the peak *D. r. miaria* activity season, (McKnight et al., 2015a), we employed these methods at three sites in the Mississippi Delta. The location of the six turtles captured in 1966–1967 was reported simply as a "drainage ditch near Belzoni." Therefore, we deployed traps in two bodies of water around Belzoni, as well as multiple bodies of water at the Panther Swamp National Wildlife Refuge (NWR; between Belzoni and the 1969 record), and Morgan Brake NWR (east of Belzoni; Fig. 1). Although the duration of the survey was short, we deployed many traps, resulting in a total of 269 trap-nights (Table 1). This level of effort exceeds the level required to detect *D. r. miaria* in our Oklahoma and Arkansas surveys. For example, during standardized surveys in May 2012 and May 2013 at two Oklahoma beaver ponds (2.05 and 2.82 ha) with known populations of nine and six *D. r. miaria*, we achieved capture rates of 0.056–0.065 *D. r. miaria* per trap night (for hoop nets), and in all four cases (two ponds × two years), we captured at least one *D. r. miaria* within the first two days of checking traps (i.e., within 24 trap nights; data from: McKnight et al., 2015b).

We were able to survey a wide range of habitats, including cypress swamps, cut-off river channels and oxbows, flooded ditches, large shallow wetlands, and retired catfish ponds with varying levels of aquatic vegetation (Fig. 2). Many of the wetlands on the NWRs appeared well suited to *D. r. miaria*, particularly at Morgan Brake NWR (e.g., Fig. 2A–D). They were often shallow with large areas of emergent vegetation and appeared similar to *D. r. miaria* sites we have surveyed elsewhere. They also contained abundant populations of crawfish (*Procambarus* sp.) which are the primary food source of *D. r. miaria* (McKnight et al., 2015c). Additionally, at both NWRs, we documented Three-toed Amphiuma (*Amphiuma tridactylum* Cuvier, 1827) and Bowfin (*Amia calva*), two species with similar habitat preferences to *D. r. miaria*.

In contrast, we found little suitable habitat outside of the NWRs. The region historically had numerous catfish farms, but most have been converted to agricultural fields, which dominate the landscape (B. Jones pers. comm.). The remaining water bodies that we were able to see had little emergent vegetation and generally appeared poorly suited for *D. r. miaria.*

We documented eight species of turtle (Table 1) representing four families (Trionychidae, Chelydridae, Kinosternidae, and Emydidae), but we were unable to document *D. r. miaria* at any site. Unsurprisingly, Red-eared Sliders, *Trachemys scripta elegans* (Wied-Neuwied, 1839) were the most abundant species at all sites.

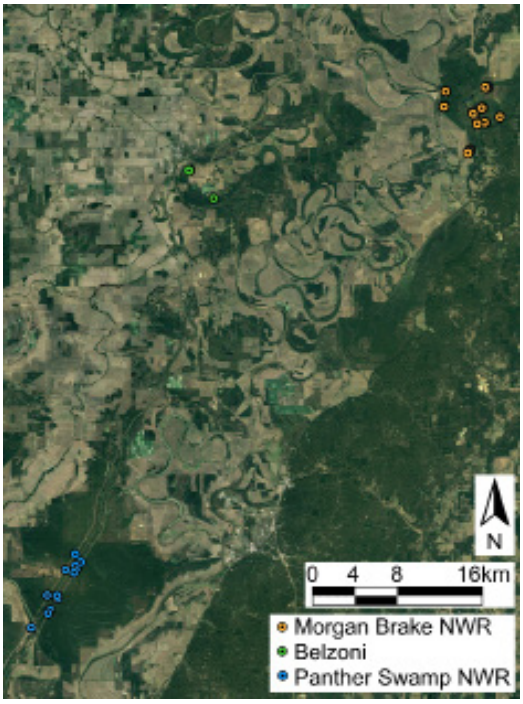

Figure 1. Sites we sampled (Google Earth, 2021, Landsat/ Copernicus). Each point indicates a location where traps were placed (one point often represents multiple traps). The "Mississippi Delta" region of the Mississippi Alluvial Valley can distinctly be seen in the top left two-thirds of the map. This area is flat, contains numerous old river channels, and has largely been converted to agricultural fields.

Table 1. Turtle captures, trapping effort, and capture rates.

	Private property	Panther Swamp NWR	Morgan Brake NWR
Turtle captures			
Apalone spinifera	17	0	2
Chelydra serpentina	1[a]	0	0
Chrysemys dorsalis	1	0	0
Kinosternon subrubrum hippocrepis	0	3	2[b]
Macrochelys temminckii	1	0	1
Pseudemys concinna concinna	1[a]	0	0
Sternotherus odoratus	0	3	2[b]
Trachemys scripta elegans	128	7	3[b]
All turtles	149	13	10
Trapping effort (trap nights)			
All traps	27	103	139
Hoop nets	27	89	137
Hoop net on leads	25	58	74
Capture rates (total number in traps/trap nights)			
All traps	5.44	0.13	0.04
Hoop nets	5.44	0.15	0.04

[a] Found dead on road near Morgan Brake NWR
[b] One *S. odoratus*, two *K. s. hippocrepis*, and one *T. s. elegans* were captured on land (not in a trap; not included in capture rates)

Capture rates of turtles were substantially higher on private property than on NWRs, and species richness was slightly higher on private property (Table 1). Indeed, for the two most abundant species, *T. s. elegans* and Spiny Softshell Turtles, *Apalone spinifera* (Le Sueur, 1827), the wetlands on private property had robust populations, with capture rates of 4.74 and 0.63 turtles per trap night, respectively (for hoop nets, with or without leads), compared to rates of 0.01–0.08 *T. s. elegans* and 0–0.01 *A. spinifera* per trap night on the NWRs. Further, we frequently saw numerous *T. s. elegans* basking just outside of Panther Swamp NWR, but rarely saw them basking on the NWRs. Given that *T. s. elegans* is a generalist that likely could inhabit any of the bodies of water we trapped, habitat differences are unlikely to explain such a strong difference between sites.

An alternative explanation relates to a high abundance of American Alligators, *Alligator mississippiensis* Daudin, 1802 on the NWRs. Many *A. mississippiensis* were frequently sighted in every body of water at both NWRs, and they repeatedly repositioned or damaged our traps. One *A. mississippiensis* was captured at Panther Swamp NWR and five were captured at Morgan Brake NWR (all released unharmed). In contrast, we saw no *A. mississippiensis* on private property, nor was there any evidence of them disturbing our traps, and from conversations with local residents, it appears that *A. mississippiensis* are frequently persecuted when found off the NWRs.

Turtles are a common food source for *A. mississippiensis* (Delany and Abercrombie, 1986), and predation rates on turtles can be high enough to strongly influence food webs and benefit species that turtles consume, such as crayfish (Bondavalli and Ulanowicz, 1999). Thus, while admittedly speculative, it is plausible that the high abundance of *A. mississippiensis* at the NWRs suppressed turtle populations. This may be particularly important with regards to our target species, because *D. r. miaria* are relatively small and have unusually thin shells for an emydid, which likely make them particularly vulnerable to predation by *A. mississippiensis* (Ewert et al., 2006). Thus, although the habitat on the NWRs appeared suitable for *D. r. miaria*, the high abundance of *A. mississippiensis* may preclude their presence, whereas off the NWRs, there was little pressure from *A. mississippiensis*, but also little suitable habitat.

In conclusion, this survey further highlights the pressing need for serious conservation action for *D. r. miaria*. Documenting the absence of a species is an inherently dubious undertaking, and it is possible that remnant populations of *D. r. miaria* continue to exist in the Mississippi Delta. However, we searched for them using

methods and intensities of trapping effort that reliably document *D. r. miaria* in other parts of the subspecies' range, and, based on our inability to document *D. r. miaria* in this survey, the high abundance of *A. mississippiensis*

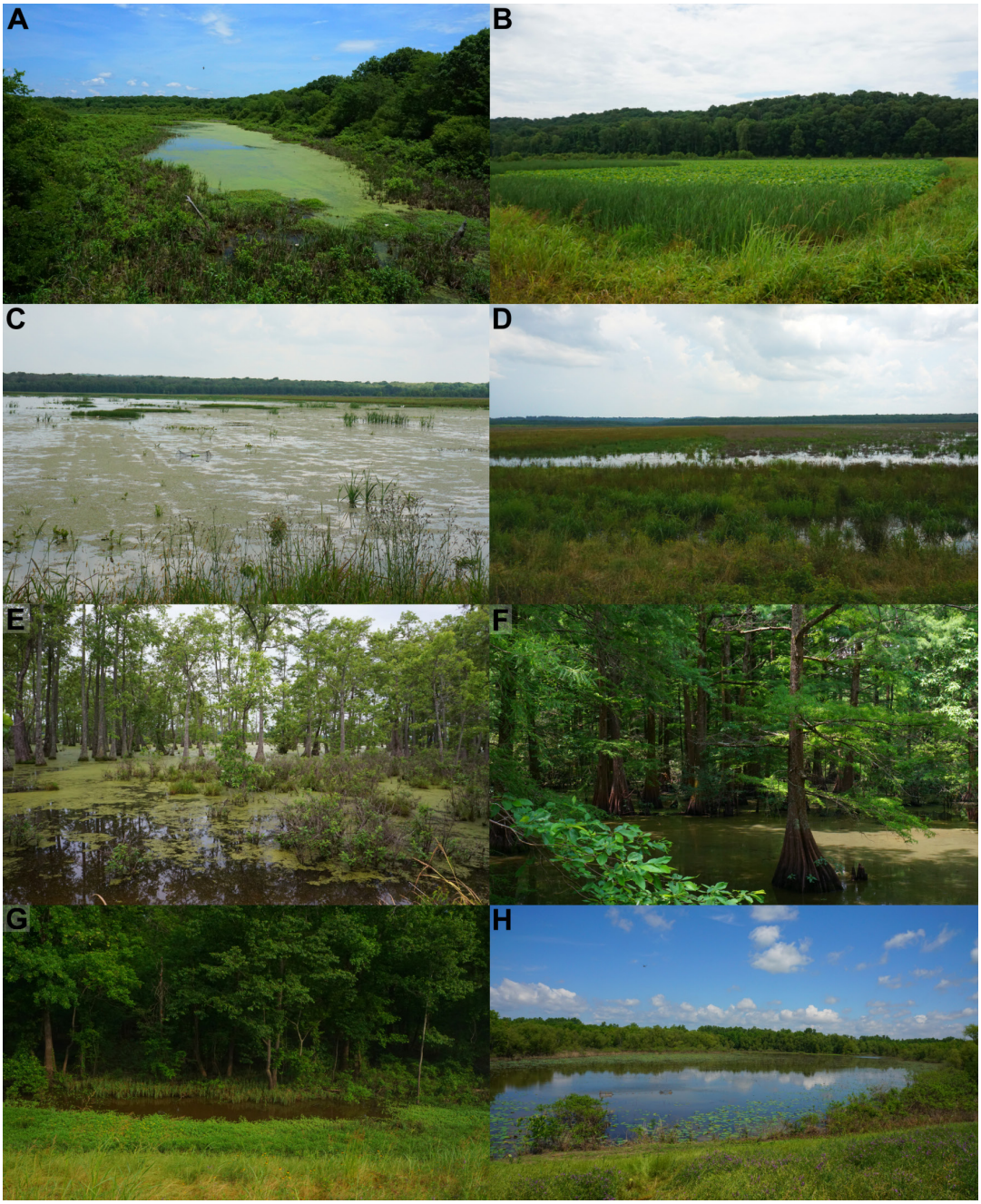

Figure 2. Photos of sites we trapped representing several of the major habitat types. (A–E) Morgan Brake NWR. (A) A large body of water with extensive emergent vegetation (predominantly *Zizaniopsis miliacea*) and large open area. (B) An old aquiculture pond covered in *Nelumbo nucifera* with emergent vegetation around the edges. (C) An old aquiculture pond with scattered emergent vegetation. (D) An old aquiculture pond with large amounts of emergent vegetation and interspersed open areas. (E) A cypress swamp. (F) A cypress swamp in Belzoni. (G–H) Panther Swamp NWR. (G) A flooded ditch with emergent vegetation. (H) A large pond with lilies and open water in the middle and emergent vegetation along the edges, backing into the forest.

on the NWRs, and the general dearth of suitable habitat outside of the NWRs, we, regrettably, think it is unlikely that *D. r. miaria* has persisted in this area. Furthermore, if any remnant populations remain, they are likely isolated and therefore unlikely to persist long term unless they can quickly be identified and protected. Nevertheless, it would be useful to survey additional patches of suitable habitat in the Mississippi Delta, conduct eDNA surveys (Siler et al., 2021), or use trained canines to search terrestrial habitats during the *D. r. miaria* terrestrial estivation season.

Acknowledgements. We are indebted to B. Jones, L. Dorris, and S. Swafford for their advice and assistance with this work. This research was conducted under Mississippi Scientific Collecting Permit #0301181, Theodore Roosevelt National Wildlife Refuge Complex Research and Monitoring Special Use Permit #43680-2018, and with the approval of Missouri State University IACUC #18-027.

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Accepted by Eric Munscher