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Editorial Introduction

The Map Turtles and Sawbacks (Testudines: Emydidae: *Graptemys*): Two Centuries of Study and the Conservation Imperative

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It was just over 2 centuries ago that the first species of *Graptemys* (*G. geographica*) was described by the French naturalist Charles Alexandre LeSueur (1817; see also Lindeman 2009) under the "catch-all" turtle genus of the time, *Testudo*. The first use of the name *Graptemys*, applied by the Swiss-American naturalist Louis Agassiz, came 4 decades later (Agassiz 1857; etymology: *Graptos*—inscribed, painted; *emys*—turtle; named in reference to the distinctive map-like markings on the carapace). Aside from mostly taxonomic publications, literature on the natural history of the genus accumulated slowly for the next 130+ yrs after LeSueur's description. It was not until the 1950s that information about the genus started to increase rapidly, with the pioneering research of one of the co-founders of modern turtle ecology: Fred Cagle (Gibbons and Lovich 2019).

At Tulane University, Cagle was perfectly located near the center of *Graptemys* diversity along the northern Gulf of Mexico in New Orleans, Louisiana. Cagle and his research crews scoured the rivers of the southeastern United States looking for turtles, especially *Graptemys* (Lindeman 2013). The discovery of taxidermic mounts of 4 little-known species in a dusty back room at the university—display specimens collected in the late 1800s that had become forlorn remnants of a by-then long-defunct public museum—was the catalyst to investigate the group (Fig. 1). Cagle and his students were responsible for describing several new species, obtaining novel information on life history and ecology, and documenting the species' native river drainages. Up until that point, the provenance of most museum specimens was unknown or geographically dubious. For example, Baur (1890) had described *G. oculifera* from Mandeville, Louisiana, and Pensacola, Florida, but Cagle (1953) later found the species to be located only in the Pearl River system, ~33 km east of Mandeville and ~230 km west of Pensacola. Cagle was also the first to recognize the phenomenon of river endemicity in the genus and knew that "the evolutionary history of this complex is substantially different from that of other turtle species of the Gulf Coast" (Cagle 1954).

We now know that the evolutionary history of the genus was likely shaped by historical sea-level changes and/or stream piracy events that drove dispersal and vicariant speciation events (Lamb et al. 1994). We also know that evolutionary diversification has occurred rapidly in the genus over the last 2 million yrs (Thomson et al. 2018). Now there are 14 recognized species of *Graptemys* (Lindeman 2013), making it the most speciose genus of turtles in the United States and one of the most diverse turtle genera in the world (Turtle Taxonomy Working Group 2017). Recognition of this diversity came relatively recently. Nine species were described in the 20th century, including *G. ernsti* and *G. gibbonsi* in 1992 (Lovich and McCoy 1992). Another, *G. pearlensis*, was described in 2010 (Ennen et al. 2010) and *G. sabinensis* was formally elevated to a full species in 2013 (Lindeman 2013), following the suggestions of earlier researchers. Clearly, our knowledge of the diversity of this genus is still evolving and new species or distinct evolutionary lineages may yet be discovered and recognized.

As measured by the number of peer-reviewed scientific publications concerning individual species, *Graptemys* are relatively poorly studied compared with the species of other turtle genera in the United States and Canada. The species with the largest number of peer-reviewed scientific publications in the genus, *G. geographica*, is not only the earliest described species, but also the widest-ranging species, and wide-ranging turtle species are typically the best studied in any genus (Lovich and Ennen 2013). Limited research attention likely stems from the difficulty *Graptemys* species present from a sampling and habitat perspective. As consumers of aquatic insect larvae, mollusks, sponges, and algae, they show little affinity for the traditional fish or fowl baits used in 3-hoop turtle nets, so alternative methods of catching them in order to record their data have had to be sought, such as fykenets, basking traps, and driving them into trammel nets with the use of a carphorn (Vogt 1980; Jones and Hartfield 1995; Lindeman 2014). These alternative traps capitalize upon map turtle and sawback movements throughout the water column and their drive, seemingly unmatched by other turtles, to climb out of the water and bask in the sun. Because of the turtles' basking proclivity, researchers have also benefitted enormously from the development of relatively inexpensive, high-power optical devices (e.g., image-stabilized binoculars, spotting scopes, and high-zoom cameras) that facilitate studies of relative

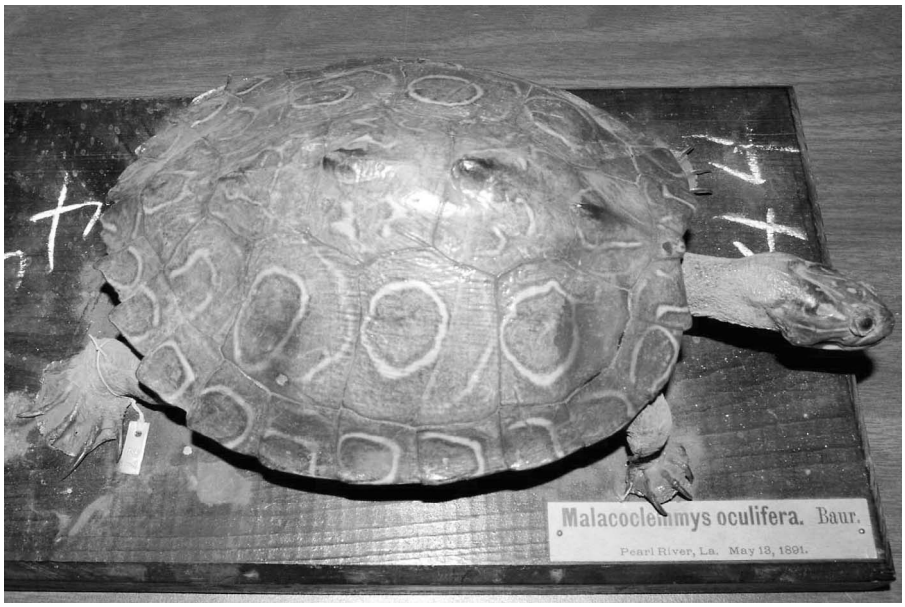

Figure 1. A taxidermic mount of a ringed sawback, *Graptemys oculifera*, from the Tulane University Museum collection (TU 27), collected in 1891 and on public display for several years thereafter. Rediscovery of specimens of *G. oculifera*, *G. pearlensis*, *G. sabinensis*, and *G. pseudogeographica* collected by Baur in the late 1800s catalyzed work on *Graptemys* of the Gulf Coast states by Cagle and his students in the late 1940s and 1950s. (Photo by P.V.L.)

abundance and vouchering of new locality records (e.g., McCoy and Vogt 1979; Lindeman 1999, 2013, 2019; Selman and Qualls 2009; Ilgen et al. 2014; Fig. 2). The medium to large rivers the species inhabit are also a challenge, requiring a boat with a motor and frequently consulting weather forecasts to avoid storms that may send river levels spiking one or more meters overnight, rendering trap retrieval nearly impossible.

In contrast to catching adults, finding nests for reproductive studies is relatively easier. In the northern United States, thousands of nests of 3 sympatric species were often encountered in a single day on the sandbar islands in the Mississippi River, leading to landmark studies of temperature-dependent sex determination in turtles (Bull and Vogt 1979, 1981; Vogt and Bull 1984). These incubation experiments also led to the discovery

Figure 2. Photo taken with a Nikon CoolPix zoom lens; first county record of *Graptemys geographica* in Susquehanna County, Pennsylvania, representing an upstream range extension of 84.8 river km over previously vouchered localities in the upper Susquehanna River (University of Flordia Museum of Natural History digital collection, UF 181006; Lindeman 2017). (Color version is available online.)

that incubation temperatures affect head patterns in these species, helping to unravel the speciation problem in the *Graptemys pseudogeographica* complex (Vogt 1993).

Conservation interest in map turtles and sawbacks has increased greatly over the past 30 yrs. Two species, *G. oculifera* and *G. flavimaculata*, were federally listed as threatened under the Endangered Species Act (ESA) in 1986 and 1990, respectively. Since then, many other *Graptemys* have been considered for either state or federal protection status (reviewed in Lindeman 2013), including two species that are currently petitioned for federal ESA protection status (*G. gibbonsi* and *G. pearlensis*). From a conservation perspective, *Graptemys* is likely one of the most imperiled turtle groups in the United States. Declines have been documented for some species of *Graptemys*, and they all face continued threats to their survival, including human alterations to river systems (especially riverine impoundments, river regulation, and channelization), declines in water quality, and direct take for the pet trade.

Slowly, the species of *Graptemys* are getting their due, a transition that this special issue of *Chelonian Conservation and Biology* is meant to further catalyze. This issue reflects expanding interest in the genus among turtle biologists and makes an important contribution to our knowledge base, with topics focused on conservation, ecological research, and education. The 17 articles include new studies focused on 10 of the 14 recognized species of *Graptemys*, leaving out only *G. caglei*, *G. ernsti*, *G. sabinensis*, and *G. versa*.

Research topics in this issue run a wide gamut that covers both basic biology and conservation concerns. There are studies of various aspects of reproduction in *Graptemys*, including reproductive output and life-history strategies (Coleman, Lindeman), nest-site fidelity (Freedberg, Nagle and Russell), and hatchling emergence (2 articles by Geller et al.). Dietary studies of half the species in the genus are included (the 3 sawbacks and their sympatric megacephalic congeners, McCoy et al.; *G. barbouri*, Sterrett et al.). One of the 5 turtle species included in a long-term data set for a lake in Indiana, investigated here for scute anomalies (G. Smith et al.), is a *Graptemys* species. A focus on geographic distribution is included with regard to new discoveries regarding natural range limits of 5 species in Mississippi (Brown et al., Lindeman et al.), anthropogenic impacts on waterways that appear to be allowing range expansion in 2 others (Berry et al.), and a *Graptemys* species acting as an introduced species (H. Smith et al.). The conservation focus includes a study of boating as a source of disturbance (Bulté et al.) and 3 articles involving extensive visual and/or trapping surveys (Lindeman et al., Mays and Hill, Selman), with 2 of these studies focusing on *G. pearlensis* and *G. gibbonsi*, which are currently candidates for federal listing. Finally, the interaction of *Graptemys* species with human communities is highlighted in an article using community scientists for data collection (Coleman) and an article examining the phenomenon of turtle watching in an urban park (Lindeman).

If the information reported in the articles included in this volume could be translated into concentrated education efforts, it could lead to increased local awareness and appreciation of these unique animals. Ultimately, we hope that research and education efforts in the coming decades lead to effective conservation of this truly unique group of North American turtles.

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