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The Fossil Record of the Diamond-backed Terrapin, *Malaclemys terrapin* (Testudines: Emydidae)

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ABSTRACT.—New fossil materials of the Diamond-backed Terrapin (*Malaclemys terrapin*) are described from Late Pleistocene coastal deposits of South Carolina, Georgia, and Florida. Specimens represent isolated carapacial bones from a number of different individuals. The fossils are identified as *Malaclemys* based on the features of scute sulci and the presence of annuli scars on most specimens. These new fossil records provide evidence that *Malaclemys* was distributed throughout the southeastern United States during the Late Pleistocene.

The fossil record of the Diamond-backed Terrapin (*Malaclemys terrapin*) is scant. Prior to this contribution, the only published records for the genus included two Late Pleistocene carapace fragments recovered from South Carolina (Dobie and Jackson, 1979), an inclusion in a Late Pleistocene faunal list from the Page-Ladson locality in the Aucilla River of Florida (Webb and Simons, 2006), and a Holocene shell and postcranial elements from Bermuda (Parham et al., 2008). Extant Diamond-backed Terrapins occur along the Atlantic and Gulf coasts of the United States from Cape Cod, Massachusetts to Texas (Ernst and Lovich, 2009). Additionally, a disjunct population of curious origin exists in Bermuda (Parham et al., 2008). Unlike any other emydid, *Malaclemys* is specifically adapted to salt marshes, estuaries, tidal creeks, and mangroves along the North American coast (Wood, 1977; Parham et al., 2008; Ernst and Lovich, 2009). This study reports and describes new materials recovered from Edisto Beach, South Carolina, Andrews Island/South Brunswick River, Georgia, and the Aucilla and Wekiva Rivers, Florida. These additions fill out the range for the genus in the southeastern United States during the Late Pleistocene.

MATERIALS AND METHODS

Fossils were collected by a combination of surface prospecting, snorkeling, diving, and river dredging. Specimens from Edisto Beach, Colleton County, SC were surface collected along the shoreline and likely washed in from the Atlantic Ocean (Fig. 1; Dobie and Jackson, 1979; Roth and Laerm, 1980). Materials recovered from Andrews Island, Glynn County, Georgia were found in dredge spoil piles from the South Brunswick River, Georgia. One specimen, UF 256391, was hand collected on the river bottom while snorkeling the Wekiva River, Levy County, Florida. Materials from the Aucilla River, Taylor County, Florida were recovered while scuba diving by the Aucilla River Project at the Florida Museum of Natural History (FLMNH) from 1984 to 1997.

Materials are deposited in the Division of Vertebrate Paleontology at the Florida Museum of Natural History (UF), Gainesville, Florida and the Chelonian Research Institute (PCHP), Oviedo, Florida. Anatomical abbreviations include: C, costal bone (e.g., C1 = first costal bone); N, neural bone; P, peripheral bone; V, vertebral scute; Pl, pleural scute, and M, marginal scute.

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Description:

Family Emydidae Bell, 1825

Subfamily Deirochelyinae Agassiz, 1857

Genus *Malaclemys* Schoepff, 1793

Malaclemys terrapin

Figures 2–3.

Referred Material.—UF 92451, nuchal bone; UF 247192, nuchal bone; UF 256391, first left costal bone; UF 256392, first left costal bone; PCHP 12754, first right costal bone; UF 131346, second left costal bone; UF 132617, partial second right costal bone; UF 227628, fourth left costal bone; UF 227629, fifth left costal bone; UF 256393, fifth left costal bone; UF 227627, fifth right costal bone; PCHP 12753, fifth right costal bone fragment; UF 256394, sixth left costal bone; UF 256395 seventh right costal bone; UF 256396, two costal bone fragments.

Localities and Age.—Specimens were collected from four different localities: the Aucilla River, Taylor County, Florida; the Wekiva River, Levy County, Florida; South Brunswick River, Glynn County, Georgia; and Edisto Beach, Colleton County, South Carolina (Fig. 1). Most of these specimens are from river or dredge spoil deposits in near-shore coastal areas along the Atlantic and Gulf coasts of the United States.

All fossil specimens are considered to be Rancholabrean (Late Pleistocene) in age. Previous work on the Edisto Beach, South Carolina and Aucilla River, Florida localities have indicated Rancholabrean ages based on associated mammalian fossil materials (Dobie and Jackson, 1979; Roth and Laerm, 1980; Webb and Simons, 2006). The specimen from the Wekiva River is assigned to the Late Pleistocene based on other fossil taxa that have been collected from multiple localities in the river. These species include: *Holmesina septentrionalis* (Giant Armadillo), *Tapirus veroensis* (Tapir), and *Mammot americanum* (American Mastodon), all of which are indicative of a Rancholabrean age. Recent fossil discoveries from the Waccasassa River, a tributary of the Wekiva, also indicate a Rancholabrean age (Ehret and Bourque, 2011).

Specimens from the South Brunswick River, Georgia were found in dredge spoil piles. Due to the imprecise nature of the collection, the age range of the fossil materials is Late Miocene through Late Pleistocene. However, we are fairly confident these *Malaclemys terrapin* specimens are Rancholabrean, based on other associated turtle species which include *Trachemys* cf. *scripta*, *Chelydra* cf. *serpentina*, Cheloniidae indet., and *Geochelone crassiscutata*.

Description.—The fossils we report on here represent an assortment of carapacial bones from numerous individuals.

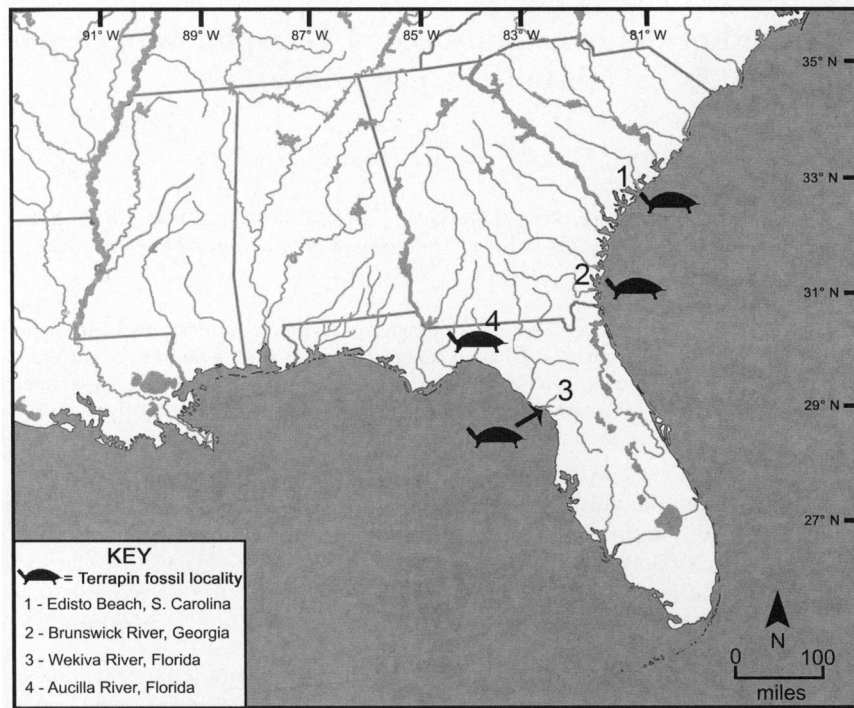


FIG. 1. Geographic map indicating *Malaclemys terrapin* fossil localities.

Malaclemys specimens were distinguished from other emyids based on the following criteria: relative thinness of the shell elements with respect to overall size, the presence of well-defined concentric annuli, and scute sulci patterns. Two complete nuchal bones were recovered from the Aucilla River. Specimen UF 92451 was collected by the Aucilla River Project and is nearly complete, missing only a small portion of bone along the posterior suture (Fig. 2A). The maximum width and length of the bone are 39.0 mm and 41.8 mm, respectively. The sulci are visible for the

cervical scute, M1, V1, and P1. The cervical scute is rectangular and is slightly longer than it is wide. The opposite is true of the underlap on the ventral side of the bone, which is much wider than it is long, a feature also noted by Dobie and Jackson (1979) and Dobie (1981). The maximum width of the cervical scute is 7.4 mm and the maximum length is 10.4 mm. Both left and right P1 sulci overlap onto the nuchal bone and contact V1 and M1. This feature is partially present in UF 228492 (Fig. 2C), with the P1 sulci in contact with V1 but not with M1 (Dobie and Jackson, 1979). The bone gets progressively thinner posteriorly, measuring only 1 mm in thickness along the posterior suture. Numerous concentric annuli are visible on the dorsal surface of the bone in the area occupied by V1, a feature also observed on UF 228492 by Dobie and Jackson (1979). In ventral view, the suture for the articulation with the N1 is preserved along the posterior edge of the bone. The posterolateral borders of the nuchal posterior to the P1 sulci are straight and un-notched (see Dobie and Jackson, 1979).

UF 247192 was collected from a different locality within the Aucilla River (Fig. 2B). The specimen is complete, and slightly larger than UF 92451, with a maximum width of 40.3 mm and a maximum length of 43.5 mm. Scute sulci for the cervical, left and right P1, and V1 are visible on the dorsal surface of the bone. The cervical scute is rectangular with a maximum width of 9.5 mm and a maximum length of 9.8 mm. P1, V1, and M1 sulci meet on the nuchal bone; however, they do not overlap onto the bone as much as is seen in UF 92451 but more than in UF 228492. The bone also gets progressively thinner posteriorly with a maximum thickness of 2.5 mm along the posterior suture. The specimen is polished smooth with no definitive annuli visible.

Three new C1 specimens have been recovered from the Wekiva River, Florida (UF 256391), South Brunswick River, Georgia (UF 256392), and Edisto Beach, South Carolina (PCHP 12754; Fig. 3A–C). UF 256391 represents a left C1 with a maximum width of 28.1 mm and a maximum length of 38.2

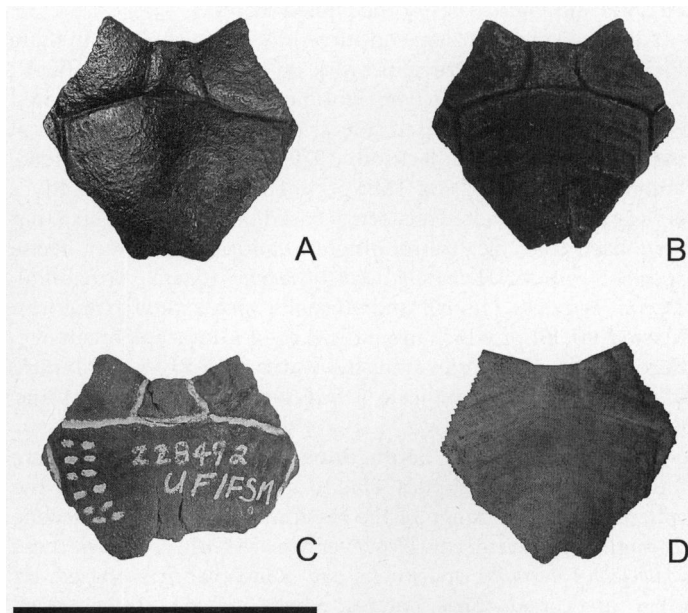


FIG. 2. *Malaclemys terrapin* nuchal bones: (A) UF 247192, Aucilla River, Florida; (B) UF 92451, Aucilla River, Florida; (C) UF 228496, Edisto Beach, South Carolina; and (D) UF 137319, Pinellas County, Florida (extant). Scale bar = 5 cm.

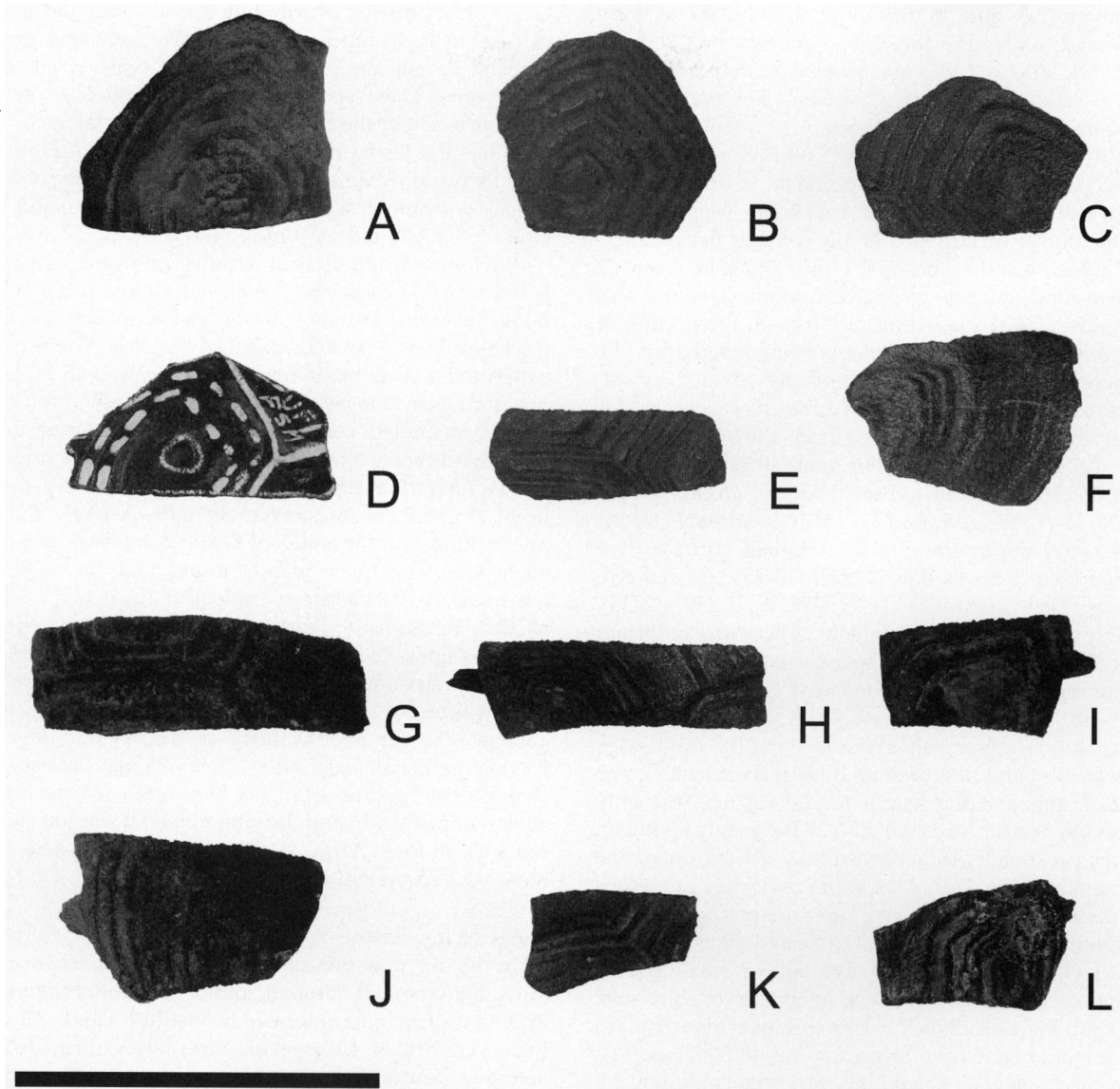


FIG. 3. *Malaclemys terrapin* specimens from the Late Pleistocene: (A) UF 256392, left first costal; (B) UF 256391, left first costal; (C) PCHP 12754, right first costal; (D) UF 22849, left first costal; (E) UF 131346, left second costal; (F) PCHP 12753, right fifth costal; (G) UF 227628, left fourth costal; (H) UF 227629, left fifth costal; (I) UF 227627, right fifth costal; (J) UF 256393, left fifth costal; (K) UF 256395, left sixth costal; (L) UF 256395, right seventh costal. Scale bar = 5 cm.

mm. The bone is fragmentary and is missing both the medial and distal edges. However, sutures along the P1 and C2 boundaries are preserved. Seven concentric annuli are visible on the dorsal surface of the bone with a semicircular depression in the center.

UF 256392 represents a large left C1 with a maximum width of 34.2 mm and a maximum length of 29.3 mm. The specimen is broken mesially but preserves anterior, posterior, and dorsal sutures. The anterior suture contains the contact with the nuchal bone. Distal sutures include contacts with P1, P2, and P3 with the largest suture belonging to the contact with P2. The posterior suture is straight and contacts C2. Four concentric scute annuli are visible on the dorsal surface of the bone with numerous small pitted erosions in the center. Along the anterior suture of the bone, the V1 sulcus overlaps slightly onto the dorsal surface of the bone. This sulcus would continue along the mesial side of the bone; however, it is broken.

PCHP 12754 represents a right C1 with a maximum width of 31.8 mm and a maximum length of 22.1 mm. The bone is fragmentary, preserving portions of the anterior suture which contacts the nuchal bone, and the posterior suture which would contact C2. The dorsal surface of the bone preserves the V1 and V2 sulci. Concentric annuli are preserved on the dorsal surface. There are three preserved rings on the portion of bone originally covered by V1 and four preserved on the section covered by V2.

Two C2 were recovered from the Aucilla River, Florida (UF 131346 and UF 132617). UF131346 is a complete left costal from a small individual (Fig. 3E). The maximum width of the bone is 12.6 mm and the maximum length is 32.0 mm. All sutures are preserved and the distal edge of the bone has not finished calcifying, suggesting that the individual was still growing. Scute sulci are present on the dorsal surface with contacts including V2, P11, and P12. Concentric scute annuli are also present on the dorsal surface with three present in the area occupied by P11, three present in the area occupied by P12, and four present in the area occupied by V1. The bone is quite thin,

averaging about 2.3 mm in thickness. UF 132617 is very fragmentary and represents the mesial portion of C2. Sulci representing V2, P11, and P12 are preserved and resemble a sharp v-shape halfway down the specimen. The bone is also very thin, averaging 2.4 mm in thickness.

UF 227628 from the Aucilla River, Florida represents a complete left C4 (Fig. 3G). The specimen is 16.1 mm at maximum width and 47.4 mm at maximum length. Sulci present on the dorsal surface include the contacts between V3, P12, and P13. Much like the sulci on C2, the contact between V2 and the two pleural scutes is v-shaped. Concentric annuli also preserved on the dorsal surface include two on the portion of the bone covered by P12, three on the portion covered by P13, and two preserved on the portion originally covered by V2. Overall thickness of the bone averages 2.5 mm.

Four C5 specimens were recovered from the Aucilla River, Florida (UF 227627 and UF 227629), South Brunswick River, Georgia (UF 256393), and Edisto Beach, South Carolina (PCHP 12753; Fig. 3F, H–J). C5 specimens are easily identifiable by the distinctive scar for the insertion of the inguinal buttress. Two specimens represent left C5s (UF 227629, UF 256393) and two specimens represent right C5s (UF 227627, PCHP 12753), although only UF 227629 is complete. There is significant variation in size, with two small specimens (UF 227627, UF 227629) likely representing subadults based on the presence of large distal rib ends which are typically lacking in these elements on adult terrapin shells. Widths along the distal edge of the bones (widest and best preserved in all specimens) range from 13.3–24.6 mm and the length for UF 227629 (the only complete specimen) is 43.7 mm. UF 227629 is the only specimen preserving the proximal portion of the bone, which exhibits the sulcus between the V3 and V4. All specimens display numerous concentric annuli which would have been present on the P13.

One C6 specimen (UF 256394) was recovered from the South Brunswick River, Georgia (Fig. 3K). The bone is missing both proximal and distal ends; however, it preserves the sulci between P13 and P14 as well as V4. This specimen also displays annuli which would have been present on the V4, P13, and P14. The delicate specimen is 23.1 mm long, 14.2 wide, and only 2.0 mm thick.

One right C7 specimen (UF 256395) was collected from the South Brunswick River, Georgia (Fig. 3L). It is 17.8 mm wide at the distal margin and 28.0 mm in length; the proximal portion of the bone is missing. The specimen exhibits at least four visible concentric annuli that would have been present on the P14. The surface of the bone also appears to have some pitting or damage commonly seen in extant turtles with fungal, algal, bacterial, or parasite conditions (Garner et al., 1997). The thickness of the specimen is similar to other specimens and averages 2.5 mm. A small portion of the distal rib end is also incompletely preserved.

DISCUSSION

The fossil record for the genus *Malaclemys* has been increased substantially by the addition of these newly described materials. These records provide evidence that terrapins were established in the Atlantic coastal areas of South Carolina and Georgia and in the Gulf coast of Florida by the Late Pleistocene. The South Brunswick River locality in Georgia has provided the majority of new specimens and should be targeted for future collecting. The lack of an ancestral *Malaclemys* at the present time does not allow us to infer the geographic origins of the taxon. However,

based on its current distribution and the size and morphology of the fossils, it appears that *Malaclemys terrapin* evolved and dispersed along the Atlantic and Gulf coasts prior to the Late Pleistocene. These specimens provide evidence that terrapins had been established in the Atlantic coastal areas of South Carolina and Georgia, and in the Gulf coast of Florida, by the Late Pleistocene. Unfortunately, due to the rarity of *Malaclemys* fossils, we cannot ascertain if the genus originated along the Gulf or the Atlantic coastline.

Previous morphological studies indicate close affinities between *Malaclemys* and *Graptemys*, suggesting a close taxonomic relationship and evolutionary history between the genera (McDowell, 1964; Wood, 1977; Dobie, 1981). Wiens et al. (2010) supported a sister taxon relationship using both molecular and nuclear DNA analyses. Unfortunately, fossil records for both genera are limited, confined to the Late Pleistocene, and are not yet helpful when considering their evolutionary origins (Dobie and Jackson, 1979; Ehret and Bourque, 2011). The general lack of fossil material for *Malaclemys* to date is likely the result of misidentification (or nonidentification), inadequate collecting in areas where specimens may be found, and the fragile nature of the material. Furthermore, ecological restriction of Diamond-backed Terrapins to coastal salt marshes, mangroves, and estuaries limits the potential for fossilization. This restriction is further compounded by changes in sea level through time. During times of lower Pleistocene sea level stands, the littoral zone was as far as 100 m off of the present day shoreline, leaving potential fossil sites offshore today (Webb, 1990). In contrast, during times of higher Pleistocene sea level stands, this zone was pushed inland, leaving potential sites onshore. Future research on fossil *Malaclemys* should target deposits that cover these past ecosystem localities.

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