

Maximum body size in Central American River Turtles, *Dermatemys mawii* Gray, 1847

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The Central American River Turtle (*Dermatemys mawii*; known locally as *Hicatee* or *Tortuga Blanca*) is the largest freshwater turtle in Central America. Tragically, this species has experienced dramatic declines due to overharvesting for human consumption, and it is currently listed as Critically Endangered (Vogt et al., 2016). Many populations have disappeared or declined sharply, and most remaining populations are heavily shifted toward juveniles and small adults, because most large adults, which are prized for their meat, have been consumed (Legler and Vogt, 2013; Ligon et al., 2019). This absence of large adults makes it important to understand the true historic maximum size of this species to better assess existing populations and evaluate their demographic structure. Hence, we briefly review the literature on the maximum size for *D. mawii* and present evidence suggesting that the commonly cited maximum sizes (600–650 mm) are, in fact, curved carapace lengths (CCL), and 558 mm is a more realistic maximum straight midline carapace length (SCL).

We report here on the "maximum size" or "maximum carapace length" in the literature. Unfortunately, none of these sources specified whether the measurements were straight midline carapace lengths (SCL) or curved carapace lengths (CCL). These numbers are often repeated as if they were SCL, but CCL is commonly measured for large turtles due to the unwieldy size of the requisite callipers for SCL. *Dermatemys mawii* varies in size by habitat type, with larger individuals in lagoons than rivers (Polisar 1996). Reports of maximum carapace lengths include 600, 610, 650, and 660 mm (see below). However, in several cases, we were unable to trace a claim back to a primary source. The claim of 660 mm appears to have originated in a review by

Briggs-Gonzalez et al. (2019), which cited Lee (1969), but Lee (1969) reported a maximum size of 24 inches (610 mm), not 660 mm. Similarly, the claim of 650 mm originated in a review by Smith and Smith (1979) and has been repeated by authors such as Legler and Vogt (2013). However, Smith and Smith (1979) cited Boulenger (1889) and Alvarez del Toro (1973) who reported sizes up to 380 and 600 mm, respectively. Thus, the largest measurements we have found in primary sources were 610 mm (Lee, 1969 originally reported 24 inches, without an associated weight) and 600 mm, 22 kg (Alvarez del Toro, 1973; Alvarez del Toro et al., 1979), with the latter often cited as the maximum size for *D. mawii* (Iverson and Mittermeier, 1980; Vogt et al., 2011). Because these sources did not specify whether they measured SCL or CCL, we collected data on current *D. mawii* populations and used regressions to determine whether the historical records were most likely SCL or CCL.

Materials and Methods

We collected data from 58 wild *Dermatemys mawii* from lagoons in central Belize. We recorded SCL using tree callipers, CCL using a flexible "sewing" tape measure, and weight using Pesola Spring scales. The largest individual had the following measurements: CCL = 510 mm, SCL = 479 mm, and weight = 13.8 kg. We also included an old shell that was shown to us by a local fisher (CCL = 549 mm, SCL = 502 mm) and the largest individual reported in Legler and Vogt (2013; SCL = 512, weight = 17.2 kg).

We used a series of least-squares regressions to calculate the relationships among shell metrics and to test whether the reported maximum size was an SCL or CCL measurement. First, we regressed weight (kg) against SCL (mm) and CCL (mm) and plotted the maximum reported *D. mawii* size (600 mm, 22 kg) to see which regression line it matched (Fig. 1A). Second, we \log_{10} transformed the data and used the least-squares regression equations (Fig. 1B) to calculate the expected weight for a 600 mm SCL turtle and a 600 mm CCL

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turtle, as well as the differences (residuals) between those weights and the reported maximum weight (22 kg). We then compared those residuals with the residuals from the \log_{10} regressions (Fig. 1C). Finally, we regressed SCL against CCL (both \log_{10} transformed) and used the equation of a line to calculate the expected SCL for a 600 mm CCL individual (Fig. 1D).

Results and Discussion

All regressions had high R^2 values (>0.99) and narrow confidence intervals that fit closely around the central trendline (Fig. 1). A visual inspection of the regression lines suggested that the maximum reported length (600 mm) is a CCL metric, not SCL (see the black square with a white star in Fig. 1A). Indeed, based on our regressions (Fig. 1B), a 600 mm SCL *Dermatemys mawii* would be

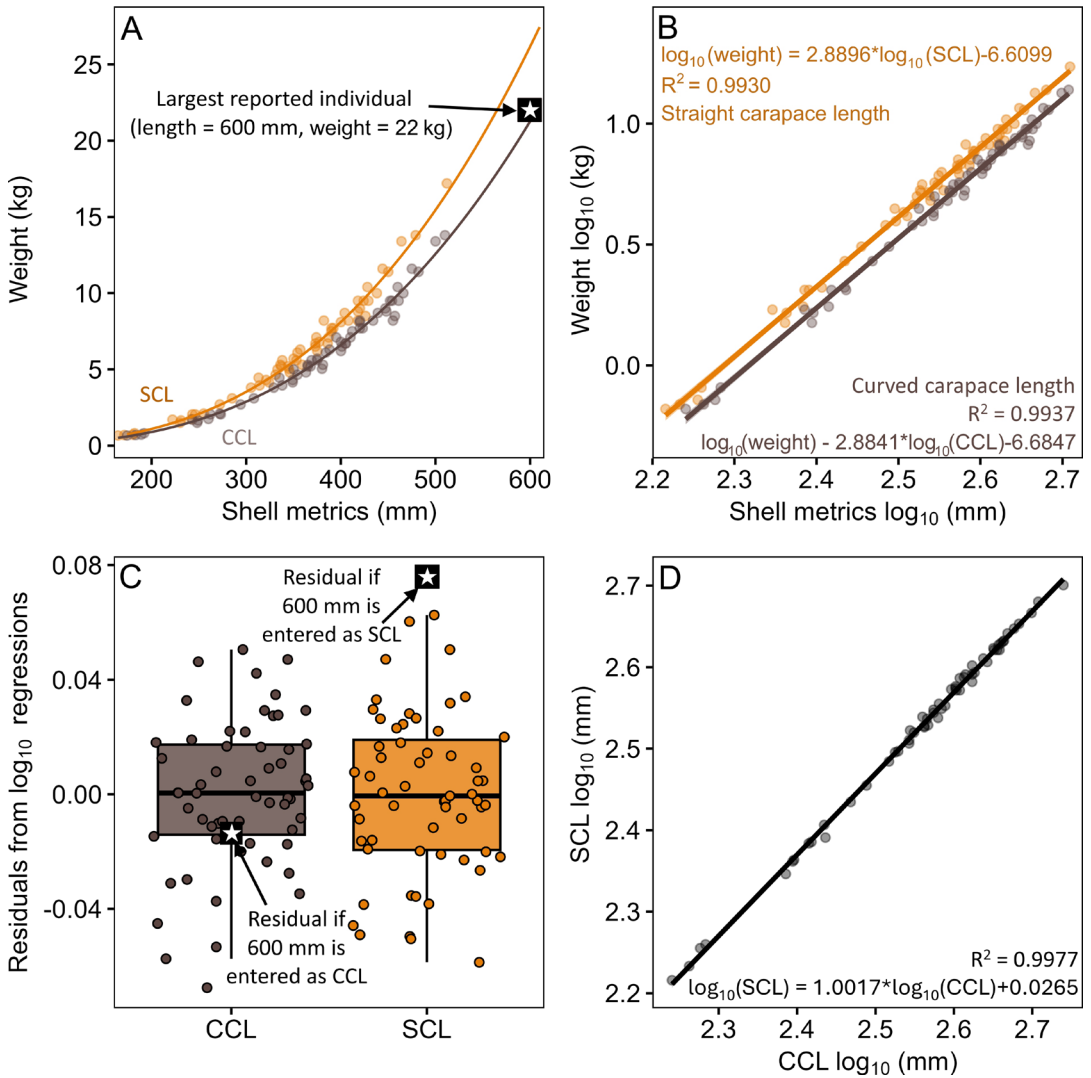


Figure 1. Body metric regressions for Central American River Turtles (*Dermatemys mawii*). (A). Regressions of weight against straight midline carapace lengths (SCL) and curved carapace lengths (CCL), with the largest reported individual (black square with a white star) added to the plot (but not included in the regression calculations). (B). \log_{10} regressions of weight against SCL and CCL. (C). Residuals of weight from \log_{10} regressions (from B) with the residuals for the maximum reported weight (22 kg) if the maximum reported length (600 mm) is entered into the line equations for CCL and SCL. (D). \log_{10} regression of SCL against CCL. Note that 95% confidence intervals are shown for B and D, but they are so tight to the line that they are barely visible.

expected to have a weight of 26.2 kg (a 19% difference from the reported weight of 22 kg), whereas a 600 mm CCL *D. mawii* would be expected to have a weight of 21.3 kg (a 3.2% difference from the reported weight of 22 kg). Additionally, the residual from entering 600 mm in the SCL regression was greater than any observed residual, whereas the residual from entering 600 mm into the CCL regression was well within the range of recorded residuals (Fig. 1C).

In conclusion, while it is impossible to know definitively how the largest reported *Dermatemys mawii* was measured, based on our results, the reported maximum size likely represents a measurement of CCL, not SCL. Further, based on our regressions of SCL by CCL, a 600 mm CCL *D. mawii* would be expected to have a ~558 SCL (Fig. 1D). Alternatively, if the report of 610 mm by Lee (1969) is used, then the true maximum SCL is 567 mm; however, the conversion from inches (with no decimals specified) and lack of associated weight make that number less reliable, and we argue that 558 mm should be treated as the most likely maximum SCL pending additional evidence.

Acknowledgements. This work was conducted under Belize Fisheries Permit #001-25 and with the approval of Missouri State University Institutional Animal Care and Use Committee #2024-05. We would like to thank the Wildlife Society of Belize, particularly Curt Reyes for their help collecting these data.

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