The implications of adult morphology for clutch size
in the flatback turtle (*Natator depressa*)

Graeme C. Hays

School of Biological Sciences, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP
E-mail: g.hays@swan.ac.uk

When the mean adult length and mean clutch volume of marine turtles are examined, a clear pattern for larger species to lay larger clutches is evident, in accord with predictions that female size constrains the available space for carrying eggs. However, when compared with this general trend, the volume of clutches laid by flatback turtles (*Natator depressa*) are smaller than expected. The implication is that the unusually flat morphology of flatback turtles, provides an additional constraint on their egg carrying capacity.

The size of clutches is a fundamental component of the reproductive output of oviparous species and factors that influence clutch size will have important life history consequences. For both freshwater and marine chelonians, clutch size generally increases with body length (Elgar & Heaphy, 1989; Hays & Speakman, 1991; Van Buskirk & Crowder, 1994) and for marine turtles this pattern has a clear functional explanation. Since the energy spent in nest construction is large, females can minimize the nest construction costs per egg by maximizing clutch size (Hays & Speakman, 1991). In other words, turtles would be expected to lay a few large clutches, rather than many smaller clutches and, since large females would be expected to have a greater egg carrying capacity than smaller individuals, clutch size would therefore be expected to increase with female size.

For thcale marine turtles (i.e., members of the Family Chelonidae) there is a fairly uniform body morphology and so when comparing different species, simple linear measurements of female length (e.g., carapace length) probably provide a comparative measure of egg carrying capacity. The one clear exception to this general pattern of similar morphology is the flatback turtle (*Natator depressa*), which, as its name suggests, has a flatter morphology compared with other species. Therefore, when comparing species of the same length, it would be predicted that flatback turtles would have a smaller body volume and so a smaller egg carrying capacity. Ehrhart (1992) has considered this possibility by using number of eggs per clutch as a measure of clutch size and concluded that flatbacks laid very small clutches and so this species was ‘very aberrant’. However, a more appropriate measure of clutch size is the volume of eggs laid, as it is clutch volume, rather than number of eggs, that would be expected to be constrained by female size. This paper examines how clutch volume scales with female length across different species of thcale marine turtles to assess whether adult morphology constrains clutch volume in flatback turtles.

For different populations and species of turtle, the mean female length, mean number of eggs per clutch and mean egg diameter were obtained from the comprehensive literature review detailed in Van Buskirk & Crowder (1994). The mean egg diameter reported for green turtles (*Chelonia mydas*) at Ascension Island (34.6 mm, Carr & Hirth, 1962), was substituted with my own measurements which showed a mean egg size of 45.5 mm, similar to all other populations of this species (Hays et al., 1995). The value reported by Carr & Hirth (1962) is most probably a typographical error where 45.6 mm was incorrectly printed as 34.6 mm. Clutch volume was calculated as mean egg volume (assuming eggs are spherical) multiplied by the mean number of eggs laid. The length of marine turtles is reported as either straight carapace length (SCL) or curved carapace length (CCL). To establish a general relationship between SCL and CCL, I compared these two parameters for loggerhead turtles (*Caretta caretta*) in Greece (data originally presented in Hays & Speakman, 1992) and for green turtles at Ascension Island (data originally presented in Hays et al., 1993).

Data for loggerhead and green turtles show a very similar correlation between SCL and CCL (Figure 1) consistent with the broadly similar morphology of these two species. I used the equation listed in the legend to Figure 1 to convert all measurements for loggerhead, green, hawksbill (*Eretmochelys imbricata*), Kemp’s Ridley (*Lepidochelys kempii*) and Olive Ridley turtles (*L. olivacea*) into units of CCL. Data for the length of flatback turtles were already reported in CCL units, so were left

Figure 1. For loggerhead turtles in Greece (open circles) and green turtles at Ascension Island (filled circles) the relationship between curved carapace length (CCL) and straight carapace length (SCL). A single least squares linear regression equation explained 99.6% of the variation: CCL=1.11 SCL -4.5 (F1,35=150.56, P<0.001).
flatback turtles is less than for an equivalent sized turtle from the other thecate species. For example, while the mean CCL values of loggerhead and flatback turtles are about the same, the mean clutch volume for flatbacks is about 7% less.

In short, while flatbacks lay fewer eggs this is at least partly compensated for by the eggs’ larger size. However, when superimposed on the general pattern of increasing clutch volume in larger species, it was still evident that flatbacks lay slightly smaller clutches than predicted by their length. The implication is that the unusual body morphology does limit clutch volume of flatback turtles, but only slightly. As a corollary to this finding we would predict that the flatback turtle might lay relatively more clutches in a season as each clutch is relatively small. However, establishing the clutch frequency for marine turtles is problematic because it is logistically challenging to identify females every time they nest during a season.

The results presented here provide evidence that both adult size and morphology influence clutch volume in marine turtles by determining the available space in the animal for carrying eggs.

REFERENCES


