

SHORT PAPERS

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WEIGHT AND LENGTH RELATIONSHIPS
OF SOME ADULT MARINE TURTLES

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ABSTRACT—The weights and lengths of marine turtles were analyzed. Significant weight-carapace length relationships were found in 17 of 19 populations of adult sea turtles, representing six species. The sizes of nesting green turtles (*Chelonia mydas*) at Ascension Island, Europa Island and Scilly Atoll are somewhat distinctive. No significant weight-length differences were uncovered between male and female green turtles within a feeding population, but there were significant differences between males in different feeding populations and between females in different feeding aggregations. Significant weight-length relationships were also found in hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*) and Kemp's ridley (*Lepidochelys kempii*) nesting populations and among a worldwide sample of leatherback turtles (*Dermochelys coriacea*).

There is a great deal of interest in the behavior and ecology of marine turtles and, no doubt, much of this concern is generated by the fact that the survival of some populations is now threatened. Linked with this is a growing interest in the zoogeography and systematics of sea turtles. Especially interesting are such questions as, how different are neighboring and widely distant breeding populations from each other, and which populations constitute a species or subspecies?

If, as commonly believed, growth in wild and captive marine turtles is negligible or sharply reduced once sexual maturity is reached (Bjorndal, 1980; Wood and Wood, 1980), and if, as assumed by most sea turtle biologists, breeding populations are reproductively isolated from each other, then an analysis of morphometric characters can be useful in determining the degree of differentiation among nesting demes. The feeding populations of sea turtles are less isolated but morphometric traits can justifiably be compared between widely distant populations or between feeding aggregations isolated by land bridges.

The purposes of this study were to analyze the weight-carapace length relationships among breeding populations of sea turtles and among some feeding aggregations and to determine the degree of size differentiation. The results, when combined with other traits, may prove useful in unraveling the systematics and biogeography of these circumglobal reptiles.

All individuals analyzed in this paper were sexually mature and carapace lengths were straight-line distances unless otherwise indicated. Statistical procedure follows Snedecor and Cochran (1967) and statistical significance is set at the 5% level unless otherwise noted. All calculations were done on log transformed data. I thank Dr. John Endler for his helpful statistical advice.

RESULTS

Green Turtle (*Chelonia mydas*)

The relationships between weight and carapace length in mature green turtles are highly significant (i.e. slopes are significantly different from zero) in five of six nesting colonies sampled (Table 1). The regression of the Scilly Atoll population is based on a sample of 20 measurements selected at random from a table of 244 measurements in Anon. (1979). With a larger sample size the females on

Table 1. Regressions of log weight (Y) in kg on log carapace length (X) in cm, in mature sea turtles; $\log Y = a + b \log X$, where a is the intercept and b is the slope. * = $P < .05$; ** = $P < .01$

Locality	N	Sex	Range of Carapace Lengths (cm)	Slope	Intercept	t	Source of Data
Green turtles on the nesting beach							
Scilly Atoll, South Pacific	20	♀	80-102	2.084	-2.055	4.87**	Anon., 1979
Talang Is., Malaysia	10	♀	88-100	2.503	-2.908	7.14**	Hendrickson, 1958
Europa Is., Mozambique Channel	19	♀	101-119	4.011	-5.946	5.44**	Servan, 1976
Ascension Is., South Atlantic	9	♀	99-132	1.636	-1.079	4.20**	Carr and Hirth, 1962
Aves Is., Caribbean Sea	16	♀	100-119	2.914	-3.689	6.22**	Rainey, 1971
Tortuguero, Costa Rica	6	♀	98-107	2.109	-2.115	1.93	Carr and Hirth, 1962
Green turtles on the feeding pasture							
Gulf of California	45	♀	61-98	2.818	-3.586	31.34**	Caldwell, 1962
Gulf of California	26	♂	62-90	2.744	-3.457	16.09**	Caldwell, 1962
Gulf of Aden	16	♀	80-109	2.834	-3.542	9.07**	Hirth and Carr, 1970; F.A.O., 1973
Gulf of Aden	10	♂	79-100	2.636	-3.159	6.25**	Hirth and Carr, 1970; F.A.O., 1973
Caribbean	70	♀	72-109	3.231	-4.447	37.45**	Ingle, 1972
Caribbean	55	♂	80-105	2.924	-3.845	16.11**	Ingle, 1972
Hawksbill turtles on the nesting beach							
Jabal Azaz Is., South Yemen	14	♀	63-72	1.864	-1.802	2.32*	Hirth and Carr, 1970
Shell Beach, Guyana	10	♀	81-89	2.262	-2.568	1.30	Pritchard, 1969
Loggerhead turtles on the nesting beach							
Tongaland, South Africa	33	♀	84-105	1.642	-1.233	6.49**	Hughes, et al., 1967
Merritt Is., Florida	33	♀	87-114	2.341	-2.613	10.54**	Ehrhart, 1978
Kemp's ridley turtles on the nesting beach							
Rancho Nuevo, Mexico	17	♀	63-69	1.610	-1.279	3.19**	Chávez, et al., 1967
Olive ridley turtles on the nesting beach							
Surinam	14	♀	64-72	1.791	-1.735	2.19*	Pritchard, 1969
Leatherback turtles							
Worldwide	22	combined	119-183	3.121	-4.276	8.02**	Deraniyagala, 1939; Carr, 1952; Lowe and Norris, 1955; Ray and Coates, 1958; Pritchard, 1969, 1971; Brongersma, 1972; Glüsing, 1973; and Hughes, 1974

Table 2. Comparison of adult, female green turtle regression lines. Samples are from nesting beaches. The upper values are the tests comparing slopes and the lower values are the tests comparing elevations. The elevation test is not given when the slopes are statistically different. Degrees of freedom given in parentheses. Calculations are omitted in two cases where residual variances are heterogeneous

	Scilly	Talang	Europa	Aves
Ascension	F = 0.55 (1, 25) n.s. F = 5.32 (1, 26) P < .05	F = 1.91 (1, 15) n.s. F = 16.06 (1, 16) P < .01	F = 8.10 (1, 24) P < .01	F = 4.38 (1, 21) P < .05
Aves	F = 1.36 (1, 32) n.s. F = 2.02 (1, 33) n.s.	F = 0.40 (1, 22) n.s. F = 3.67 (1, 23) n.s.	F = 1.55 (1, 31) n.s. F = 2.18 (1, 32) n.s.	
Europa	F = 5.17 (1, 35) P < .05	—		
Talang	—			

the Tortuguero chelonery will also probably exhibit a significant weight-length relationship. It would be interesting to compare the sizes of breeding males with the females at these specific breeding beaches, and to determine if males are smaller than females as proclaimed by some knowledgeable fishermen.

The five statistically significant regression lines are compared in Table 2. The residual variances in all pairs were homogeneous in a two-tailed F test (P ranged from 0.07 to >0.50) except in the tests between Talang Talang Besar Island vs. Scilly Atoll and Talang vs. Europa Island where the significance levels were between 0.05 and 0.01. Statistically significant differences in slope were found between Ascension and Europa, Ascension and Aves, and between Europa and Scilly. Significant differences in elevation were uncovered between Ascension and Talang and between Ascension and Scilly. Different elevations indicate that pre-adult growth relationships are different. This could be a reflection of genetic constraints, feeding behavior, length of remigration, fecundity or any combination of these factors. Based upon the available morphometric data it appears that the Ascension population is the most distinctive of the five populations compared here and the Europa and Scilly nesting populations are also somewhat unique in body weight-carapace length traits. These results may prove useful in the inevitable taxonomic revision of the *Chelonia mydas* complex.

The relationships between weight and carapace length of females and males captured on their feeding pastures are given in Table 1. Because individual weights of turtles in the Gulf of California are not reported, means representing from 1 to 13 individuals were used as data points. Since Márquez and Doi (1973) estimated that this feeding population of green turtles reaches sexual maturity at carapace lengths of between 55 and 65 cm, I selected 60 cm as the minimal size of breeding turtles in my computations. Regression lines for both sexes are highly significant. A comparison of regression lines indicated homogeneity of slope ($F = 0.15$; d.f. = 1, 67; n.s.) and homogeneity of elevation ($F = 1.31$; d.f. = 1, 68; n.s.). In this and in the following statistical tests between male and female green turtles, the homogeneity of residual variances was confirmed. Although the regression lines of males and females are statistically similar, Caldwell (1962) noted a tendency for males to weigh less than females of the same carapace length after a shell length of about 76 cm is attained.

The weight and length relationships of mature males and females caught on their feeding grounds off the coast of the People's Democratic Republic of Yemen in the Gulf of Aden are also highly significant. In these calculations I used the

Table 3. Comparisons of adult, female and adult, male green turtle regression lines. Samples are from feeding pastures. The upper values are the tests comparing slopes and the lower values are the tests comparing elevations. The elevation test is not given when the slopes are statistically different. Degrees of freedom given in parentheses

	Gulf of California	Gulf of Aden
FEMALES		
Caribbean	$F = 11.18 (1, 111) P < .01$	$F = 2.52 (1, 82) \text{ n.s.}$ $F = 119.06 (1, 83) P < .01$
Gulf of Aden	$F = 0.01 (1, 57) \text{ n.s.}$ $F = 24.87 (1, 58) P < .01$	
MALES		
Caribbean	$F = 0.52 (1, 77) \text{ n.s.}$ $F = 7.74 (1, 78) P < .01$	$F = 0.39 (1, 61) \text{ n.s.}$ $F = 110.88 (1, 62) P < .01$
Gulf of Aden	$F = 0.06 (1, 32) \text{ n.s.}$ $F = 22.06 (1, 33) P < .01$	

carapace length of the smallest female found nesting in Yemen (i.e., 77 cm) as the size of sexual maturity for both sexes. A comparison of male and female regression lines revealed no statistically significant differences in slope ($F = 0.11$; d.f. = 1, 22; n.s.) nor in elevation ($F = 0.08$; d.f. = 1, 23; n.s.).

The data points of the Caribbean sample were extracted from a graph, and although the exact feeding localities are unknown, most of the individuals were probably caught on the Central American feeding grounds. In this sample I selected 70 cm carapace length as the threshold for maturity for both sexes because this is the carapace length of the smallest nesting female recorded on the Tortuguero, Costa Rica, breeding beach. As in the other two samples, the relationships between weight and shell length are highly significant, and a comparison of the male and female regression lines indicated similarity of slope ($F = 2.48$; d.f. = 1, 121; n.s.) and elevation ($F = 0.01$; d.f. = 1, 122; n.s.).

These results indicate that within the three different feeding populations there is no statistically significant sexual dimorphism with respect to weight and length relationships.

The three regression lines of each sex are compared in Table 3. Female regression lines based upon samples from the Caribbean and the Gulf of California differ significantly in slope. The three male regression lines do not differ significantly with respect to slope but do differ in elevation. These data from the three feeding populations suggest that males vary less in weight/length proportions than do females.

These results should be viewed with the conditions that the sample sizes in a few comparative tests varied widely; and that it is possible that individuals from several different breeding populations mix in and are included in the samples from the three feeding aggregations.

Other Sea Turtles

There is a statistically significant relationship between log weight and log carapace length in hawksbill turtles (*Eretmochelys imbricata*) from Jabal Aziz Island but, based on available data, no such relationship is evident in the Guyana population (Table 1).

The regressions of the two smallest sea turtles, Kemp's ridley (*Lepidochelys kempi*) and the olive ridley (*Lepidochelys olivacea*) are significant. Márquez et

al. (1976) found that adult, female *L. olivacea* captured in January in Oaxaca, Mexico, are slightly heavier than males of the same carapace length. Pritchard and Márquez (1973) state that there is no demonstrable difference in the average size of male and female *L. kemp*i at maturity.

Data in Table 1 indicate that the regression of weight on carapace length (measured over-the-curve) of mature loggerhead turtles (*Caretta caretta*) from Tongaland is highly significant. The data points were extracted from a graph in Hughes et al. (1967). Ehrhart and Yoder (1978) found a highly significant relationship between weight and shell length of Florida loggerheads and results given in Table 1 based on a random sample of more recent over-the-curve measurements further support their findings. A comparison of regression lines based on the 33 from Tongaland and 33 from Merritt Island, Florida, showed homogeneity of residual variances and statistically different slopes ($F = 4.30$; d.f. = 1, 62; $P < 0.05$).

The weights of leatherback turtles (*Dermochelys coriacea*), the largest of the marine turtles, are difficult to obtain and sample sizes from specific localities are very small. Therefore, I have combined all the reliable weights and carapace lengths (measured over-the-curve in most cases), and the result is a highly significant regression (Table 1). This sample includes 6 adult males, 11 adult females, and 5 unsexed adults. Nine are from the northern Atlantic Ocean, one from the Caribbean Sea, nine from the Indian Ocean and three from the eastern Pacific Ocean. While the robustness of this combined regression awaits more measurements, the available data do suggest that *Dermochelys coriacea* has not differentiated in size to the degree that *Chelonia mydas* has.

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PREDATION BY RUDDY TURNSTONES (*ARENARIA INTERPRES*) ON A POLYMORPHIC CLAM (*DONAX VARIABILIS*) AT SANIBEL ISLAND, FLORIDA

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Several clams of the genus *Donax* show a remarkable color polymorphism, which Smith (1975) has attributed to frequency dependent predation. Smith examined the selectivity of a nocturnal predator (crabs), but did not look at shore-bird predation, which occurs during the day. In this paper I report a comparison of the shell colors of *Donax* eaten by Ruddy Turnstones to the shell colors of a random sample of *Donax* collected in the area where the birds had captured the clams.