Scalation Patterns of Loggerhead Turtles Nesting in Laganas Bay, Zakynthos Island, Greece

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In turtle, scalation patterns (including scales on the head and scutes on the carapace) provide taxonomic information. Nevertheless, in loggerhead turtles variation in scalation is rather common (Carr 1952 and references therein). Variation in the number of marginal scutes has caused in the past some taxonomic confusion. Specifically, the dissimilar marginal count observed by Deraniyagala (1933), among Atlantic and Indo-Pacific loggerheads, led him to declare the Indo-Pacific loggerhead a separate species (*Caretta gigas*) and later a subspecies of *Caretta caretta* (Deraniyagala 1939). This differentiation between Atlantic-Mediterranean and Indo-Pacific loggerheads on the basis of the marginal count was adopted also by Carr (1952). Brongersma (1961) examining marginal scutes in loggerhead specimens from Atlantic, Mediterranean, and Indo-Pacific found little variation among them and concluded that the marginal count is of no value in distinguishing subspecies. Similarly, Hughes & Mentis (1967) and Hughes (1974) working on loggerheads in Tongaland (South Africa) concluded that the Indian Ocean stock differs little in scalation patterns from the Atlantic stock, and because of the wide variation observed they rejected the use of the marginal count alone as a sound taxonomic character. Eventually, after the work of Pritchard (1979) and Pritchard & Trebbau (1984), the subspecies *Caretta caretta gigas* was rejected.

Hughes & Mentis (1967) noted discrepancies in the marginal counts between loggerhead hatchlings and adults. Brongresma (1975) stated that scute variations are more pronounced in hatchlings because of adverse environmental conditions during incubation, and these hatchlings usually do not survive to adulthood. This has been confirmed by subsequent authors (e.g. Yntema & Mrosovsky 1980).

In the Mediterranean Sea there is a paucity of data concerning scalation patterns, especially of adult loggerheads. Capocaccia (1966) studied scalation patterns of loggerhead specimens, mostly juveniles, found in Italian museums or aquaria and thus it is not known whether these specimens belong to the Mediterranean or to the Atlantic stock. As far as can be ascertained, the only work on the variation of carapacial scutes on loggerheads nesting in the Mediterranean was done in Turkey (Turkozan *et al.* 2001).

Laganas Bay at the southern coast of Zakynthos Island, Greece, holds the largest nesting concentration of loggerheads in the Mediterranean. Since 1982 ARCHELON has conducted a long-term tagging project in Laganas Bay, which provided the opportunity to approach nesting females and observe their scalation patterns over a number of seasons. These observations are presented herein.

Scale and scute counts on nesting loggerheads were done, in varying intensity, over 8 nesting seasons (1983 - 1990) in the course of the routine tagging work at night. Nesting turtles were approached from behind, and after egg-laying they were measured and examined for tags or tagging scars; if they did not bear tags they were tagged. During or shortly after tagging an observer counted all or some, depending on the available time and the state of the turtle, of the following scalation sets: nuchal, vertebrals, supracaudals, costals, marginals, postoculars, and prefrontals. It was not always possible to count all scalation sets on the same individual as the carapace was often covered with sand and/or epibionts (e.g. barnacles, algae) and we generally did not want to further stress nesting turtles by attempting to clean them. Scalation counts on the same turtles, done repeatedly within the same season or among seasons, were combined to avoid pseudoreplication, i.e. to count the same scalation set two or more times for the same individual. To further reinforce this precaution, all counts on "scarred" turtles (i.e. bearing scars attributed to lost flipper tags) were excluded from the analysis.

In total 767 observations of various scalation sets were made over the seasons. These are distributed per season as follows 1983: 191, 1984: 139, 1985: 122, 1986: 31, 1987: 162, 1988: 59, 1989: 50, 1990: 13. By combining the observations of the same individuals and excluding all observations of "scarred" turtles, the total number of observations is reduced to 585 individual turtles. The patterns of the observed scalation sets appear below (see also Table 1).

Nuchals. The recorded number of nuchal scutes was 1 or 2. The most common pattern was 1 nuchal, which was recorded in 98.7% of all observed individuals (n=319).

Vertebrals. The recorded number of vertebral scutes ranged from 4 to 7. The highest frequency was 5 scutes, observed in 97.7% of all observed individuals (n=311).

Supracaudals. The highest frequency was 2 (1 pair), recorded in 97.7% of the observed turtles (n=86). There was one case with 1 merged scute and another case where each supracaudal was fragmented in 2 (see Table 1).

Costals. Six combinations of costal scutes were observed with the combination 5–5 being the most frequent, seen in 96.7% of the observed turtles (n=334).

Marginals. The two most commonly recorded combinations were 11–11 (42%) and 12–12 (36.8%) in all observed turtles (n=76). It is interesting to note that while the asymmetrical combination 12-11 had a frequency of 9.0%, the opposite combination 11-12 has a frequency of only 1.0%.

Postoculars. All observations on postocular scales revealed the same 3–3 combination (n=284 turtles). In a small number of turtles, one or two postoculars (always on both sides) were divided vertically in two, but this does not change the 3-3 combination as the posterior part of the divided scale did not border the eye orbit, and thus by definition it is not considered a true postocular.

Prefrontals. The observed combinations of prefrontal scales appear in Table 1. The digit after the addition mark refers to the number of small scales, called inter-prefrontals by Kamezaki (2003), found in the middle of the usually two pairs of main prefrontal scales. The most commonly recorded prefrontal scale combinations were 4 (38.3%) and 4+1 (33.3%) in the observed individuals (n=141). Cases listed as having 5 or 6 as main prefrontals refer to 1 or 2 azygous

Scalation set	L - R	n	Frequency (%)
Nuchals (n=319)	1	315	98.7
	2	4	1.3
Vertebrals (n=311)	4	1	0.3
	5	304	97.7
	6	4	1.3
	7	2	0.6
Supracaudals (n=86)	1	1	1.2
	1+1	84	97.7
	2+2	1	1.2
Costals (n=334)	4 - 4	2	0.6
	4 - 5	1	0.3
	5 - 5	323	96.7
	5 - 6	3	0.9
	6 - 6	1	0.3
	6 - 5	4	1.2
Marginals (n=76)	10 - 10	2	2.6
	10 - 11	1	1.3
	11 - 11	32	42.1
	11 - 12	1	1.3
	12 - 11	9	11.8
	12 - 12	28	36.8
	12 - 13	1	1.3
	13 - 12	1	1.3
	13 - 13	1	1.3
Postoculars (n=284)	3 - 3	284	100
Prefrontals (n=141)	4	54	38.3
	5	6	4.3
	4+1	47	33.3
	4+2	21	14.9
	4+3	3	2.1
	5+1	6	4.3
	5+2	1	0.7
	6+1	1	0.7
	7?	2	1.4

Table 1. Recorded patterns of scalation sets, number of cases and their frequencies (%) on adult female loggerhead turtles nesting in Zakynthos (L: left; R: Right; n: number of turtles). See text for explanations on supracaudals and prefrontals.

(supernumerary) scales, usually found between the posterior pair of main prefrontals and completely separating them, thus making the total number of main prefrontals 5 or 6 (see also Brongersma 1961). The observation of 7 prefrontals was recorded in 2 cases but it was not possible to define in detail the exact arrangement.

LC-V-RC	n	%
4 - 4 - 4	1	0.3
4 - 5 - 4	1	0.3
4 - 5 - 5	1	0.3
5 - 5 - 5	277	95.5
5 - 6 - 5	3	1.0
5 - 5 - 6	2	0.7
6 - 5 - 5	2	0.7
6 - 6 - 5	1	0.3
5 - 7 - 5	2	0.7

Table 2. Patterns of vertebral and costal scutes, sample size and frequency in 290 individual turtles nesting at Zakynthos (LC: left costal; V: vertebral; RC: right costal).

LM-LC-V-RC-RM	n	%
10 - 5 - 5 - 5 - 10	1	1.7
10 - 5 - 5 - 5 - 11	1	1.7
11 - 4 - 4 - 4 - 11	1	1.7
11 - 5 - 5 - 5 - 11	19	31.7
11 - 5 - 5 - 5 - 12	1	1.7
11 - 5 - 5 - 6 - 11	1	1.7
11 - 6 - 6 - 5 - 11	1	1.7
11 - 5 - 6 - 5 - 11	1	1.7
12 - 5 - 5 - 5 - 11	8	13.3
12 - 5 - 5 - 5 - 12	24	40.0
12 - 5 - 7 - 5 - 12	1	1.7
13 - 5 - 5 - 5 - 13	1	1.7

Table 3. Patterns of vertebral, costal and marginal scutes, sample size and frequency in 60 individual turtles nesting at Zakynthos (LM: left marginal; LC: left costal; V: vertebral; RC: right costal; RM: right marginal).

Combinations of vertebrals and costals. In 290 turtles it was possible to observe, on the same individual turtle, the pattern of both vertebral and costal scutes. The most frequently observed combination was 5-5-5, recorded in 95.5% of the sample (Table 2).

Combinations of vertebrals, costals and marginals. In 60 turtles it was possible to observe, on the same individual, the pattern of vertebral, costal and marginal scutes. The most frequent combinations observed were 12-5-5-5-12 (40.0%) and 11-5-5-5-11 (31.7%, Table 3). The asymmetrical combination 12-5-5-5-11 had a frequency of 13.3%, while the opposite combination 11-5-5-5-12 has a frequency of only 1.7% (Table 3).

Combinations of nuchals, vertebrals, costals, marginals and supracaudals. In 55 turtles it was possible to observe, on the same individual, the pattern of all carapacial scutes: nuchal, vertebral, costal, marginal and supracaudal scutes (Table 4). The most frequent combinations observed were 1-12-5-5-5-12-2 (38.2%) and 1-11-5-5-5-11-2 (29.1%). The asymmetrical combination 1-12-5-5-5-11-2 appeared in 14.5% of the observed turtles, while the opposite combination 1-11-5-5-5-12-2 appeared only once (Table 4).

Scalation data of nesting loggerheads in Zakynthos over 8 seasons have shown that the most frequent pattern of carapacial scutes was 1 nuchal, 5 vertebrals, 5 pairs of costals, and 2 supracaudals. This pattern conforms, as expected, to similar studies on loggerheads around the world.

The most frequent combinations in marginal scutes, observed in a sample of 76 turtles, were 11-11 and 12-12. Nevertheless, in the samples of 60 and 55 turtles (Tables 3 and 4) where observations of multiple sets of carapacial scutes were performed on the same individuals, the most frequent marginal patterns were 12-12 (40.0% and 38.2% respectively) and 11-11 (31.7% and 29.1% respectively).

N-LM-LC-V-RC-RM-S	n	%
1-11-4-4-4-11-2	1	1.8
1-10-5-5-5-10-2	1	1.8
1-10-5-5-5-11-2	1	1.8
1-11-5-5-5-11-2	16	29.1
1-11-5-5-5-12-2	1	1.8
1-12-5-5-5-11-2	8	14.5
1-12-5-5-5-12-2	21	38.2
1-13-5-5-5-13-2	1	1.8
2-11-5-5-5-11-2	1	1.8
1-12-5-7-5-13-2	1	1.8
1-11-6-6-5-11-2	1	1.8
1-11-5-6-5-11-2	1	1.8
1-11-5-5-6-11-2	1	1.8

Table 4. Patterns of carapacial scutes, sample size and frequency in 55 individual turtles nesting at Zakynthos (N: nuchal; LM: left marginal; LC: left costal; V: vertebral; RC: right costal; RM: right marginal; S: supracaudal).

These observed patterns are similar to the observations of Turkozan *et al*. (2001), albeit at much lower frequencies. Indeed, those authors found 12-12 as the predominant marginal count with a frequency of 61.3% over four nesting beaches in Turkey. The above differences indicate once more the instability of the marginal count as a firm morphological character. Although the noted large variation in marginal scutes led several authors (Hughes 1974, Kamezaki 2003) to suggest that the marginal count should not be used as a criterion for classification, it would be interesting to continue or start such long-term observations in various loggerhead rookeries in the Mediterranean and compare the relevant nesting populations.

The number of postocular scales was stable with a 3-3 pattern on all examined individuals (n=284). The 100% stability of the postocular count in the present study has not been observed elsewhere. Deraniyagala (1939) and Kamezaki (2003) state that postoculars in *Caretta caretta* are 3 or 4, and Hughes (1974) reports a 3-3 postocular count in 91.5% of 47 nesting loggerheads in Tongaland and Natal. This morphological character, apparently not studied adequately worldwide, deserves more examination as it may prove a more stable criterion for classification.

Prefrontal scales showed a wide variation with 38.3% of the observed individuals having 4 scales (2 pairs), 33.3% featuring a pattern 4+1 (2 pairs of main prefrontals incorporating one azygous scale in the middle), and 14.9% with a pattern 4+2 (2 pairs of main prefrontals incorporating two smaller scales in the middle). This generally complies with the typical loggerhead pattern given by Kamezaki (2003).

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