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Carapacial scute variation in green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) hatchlings in Alata, Mersin, Turkey

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Abstract: In recent years, Alata beach has been considered to be among 20 important sea turtle nesting areas in Turkey. In the 2003 nesting season, the carapacial scute variation of 1086 *Chelonia mydas* hatchlings (169 dead and 917 live) and 394 *Caretta caretta* hatchlings (74 dead and 320 live) from Alata beach in Mersin, Turkey, were examined within carapacial scute series and in carapacial scute pattern.

The most frequent scute pattern observed for *Ch. mydas* hatchlings was 1 nuchal, 5 vertebrals, 1 pair of supracaudals, 4 pairs of costals, and 11 pairs of marginals. The pattern of 1 nuchal, 5 vertebrals, 1 pair of supracaudals, 5 pairs of costals, and 12 pairs of marginals was the most frequent pattern for loggerhead hatchlings. Using the Minitab 13.0 Z test for 2 proportions, the numbers of variations on the carapacial scutes of dead and live hatchlings of *Ch. mydas* and *C. caretta* were examined to see whether there was a relation between the rate of dead hatchlings and the number of variations on the carapacial scute. It was found that there was no relation between the changes in variation numbers and the mortality rates in *Ch. mydas* and *C. caretta* hatchlings.

Key words: Carapace, scute variation, *Chelonia mydas*, *Caretta caretta*, Alata

Alata, Mersin – Türkiye'deki yeşil deniz kaplumbağası (*Chelonia mydas*) ve iribaş kaplumbağa (*Caretta caretta*) yavrularının karapas kabuğundaki farklılaşmalar

Özet: Son yıllarda, Alata kumsalı Türkiye'deki 20 önemli deniz kaplumbağası yuvalama alanlarından biri olarak değerlendirilmektedir. Mersin'deki Alata kumsalında, 2003 üreme sezonunda, 1086 *Chelonia mydas*, (169 ölü ve 917 canlı) ve 394 *Caretta caretta*, (74 ölü ve 320 canlı) yavrularının karapas kabuğundaki farklılaşma karapas plak serileri ve plak sıralanması bakımından incelenmiştir.

Ch. mydas yavrularında en çok gözlemlenen kabuk serisi 1 nukal, 5 vertebral, 1 çift suprakaudal, 4 çift kostal ve 11 çift marginal şeklindedir. İribaş kaplumbağa için en çok tekrar eden kabuk serisi ise 1 nukal, 5 vertebral, 1 çift suprakaudal, 5 çift kostal ve 12 çift marginal şeklindedir. Minitab 13.0 ikili oran için Z testi kullanılarak, *Ch. mydas* ve *C. caretta* ölü ve canlı yavrularının karapas kabuklarındaki farklılaşma, ölü yavruların oranı ile karapas kabuğundaki plak farklılaşması arasında bir ilişki olup olmadığını görmek için incelenmiştir. *Ch. mydas* ve *C. caretta* yavrularında varyasyon sayısındaki değişiklikler ve ölüm oranları arasında herhangi bir ilişki bulunamamıştır.

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Introduction

Two sea turtle species, *Caretta caretta* and *Chelonia mydas*, nest regularly on the Turkish coast of the Mediterranean (Geldiay et al., 1982; Baran and Kasparek, 1989; Türkozan et al., 2003; Canbolat, 2004). Leatherback turtles (*Dermochelys coriacea*) have also been reported on the Turkish coast (Oruç et al., 1997; Baran et al., 1998; Taşkavak et al., 1998; Sönmez et al., 2008). In Turkey, 20 important nesting beaches for sea turtles were determined in various studies (Baran and Kasparek, 1989; Baran, 1990; Baran et al., 1992; T.Ç.O.B., 2005; Aymak et al., 2005; Ergene et al., 2006a, Ergene et al., 2006b) (Figure 1).

Many scientists state that although the arrangement and the number of scutes in turtles are stable individual differences can be observed in many turtle species (Gadow, 1899; Newman, 1906; Hewavisenthi and Kotagama, 1989; Mast and Carr, 1989). Deraniyagala (1939) states that vertebral scutes form carapace scutellation of a turtle. Vertebral scutes are a series of unpaired pieces in the median line, costal scutes are a bilateral series of paired scutes on each side of the vertebral scutes, and marginal scutes are a bilateral series of paired scutes encircling the outer side of costal scutes. There is a pair of supracaudal scutes between the last pair of marginal scutes. A nuchal scute is located anteriorly between the first pair of marginals (Figure 2).

In his study on *C. caretta,* Gadow (1899) concludes that the proportion of variation in adults is less than that of hatchlings. Starting from this fact, Gadow (1899) puts forward the idea of orthogenetic variation. According to this idea, in young turtles having different combinations than normal components, scutes undergo fusion during ontogeny so that the adult stage shows the normal reduced scute pattern. On the other hand, Newman (1906) argues that supernumerary scutes are the atavistic reappearance of scutes lost during phylogeny (Türkozan et al., 2001). Özdemir and Türkozan (2006) explain the absence of adults with deviant numbers of costal, vertebral, nuchal, or supracaudal scutes in 2 ways: the hatchlings with deviant scutes die before they mature, or the scutes change to the normal number with growth. According to Zangerl and Johnson (1957), carapaces of turtles, while forming, remain stable during chelonian evolution.

Parker (1901), Hildebrend (1930), and Zangerl (1969) claim that this abnormal situation occurs accidentally or because of a disorder during ontogenetic development. Hildebrend (1938) says that the abnormal scutes of Diamondback terrapins are formed as a result of fluctuations in oxygen levels during incubation. In addition, Kazmaier and Robel (2001) report that the greater number of scute anomalies in *Terrapene ornata* in central Kansas may be the result of variations in temperature or moisture that cause stress during egg development or incubation, or the mutagenic effects of excess salinity during those periods. Deviations from the normal scute formulae of turtles may also result from embryonic mutations, specific causes of which are unknown (Kazmaier and Robel, 2001).

Yntema (1976) and Yntema and Mrosovsky (1980) indicate that, regarding temperature-

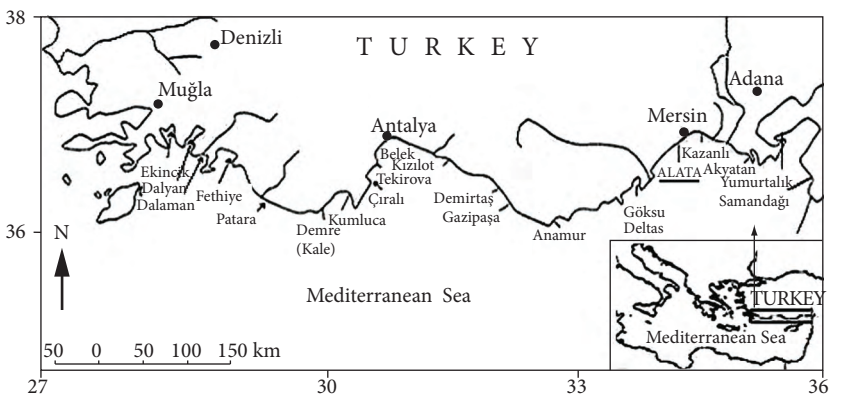

Figure 1. The location of Alata in Turkey.

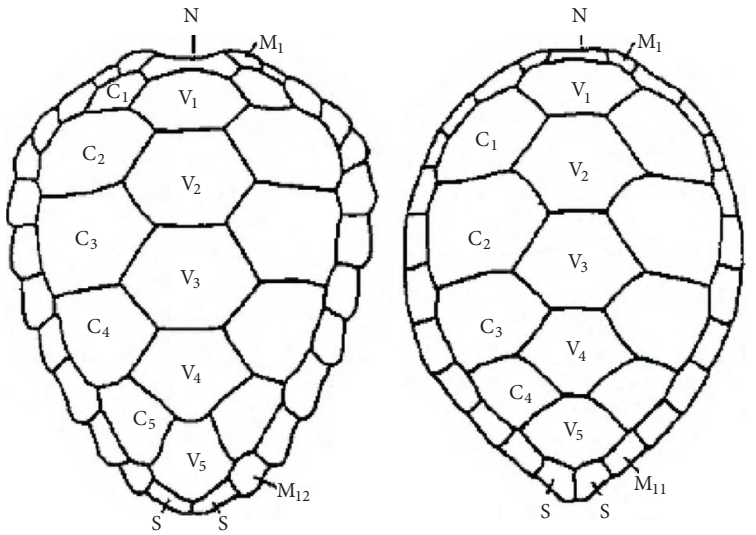

Figure 2. Carapace in sea turtles A: *Caretta caretta* (Left) B: *Chelonia mydas* (Right).
(**N:** Nuchal, **M:** Marginal, **S:** Supracaudal, **V:** Vertebral, **C:** Costal) (Başoğlu and Baran, 1977).

dependent sex determination, morphogenetic effects can be observed in turtles as a result of changes in temperature during incubation. As Mast and Carr (1989) state, among sea turtles, *Lepidochelys* has the highest rate of deviation in scutes. Furthermore, handling the eggs during the development phase increases scute variation in *Lepidochelys olivacea* (Hill, 1971) and causes the mortality rate of embryos to rise (Limpus et al., 1979). The above-mentioned evidence demonstrates the effects of different kinds of environmental factors on scute variation during incubation.

The main aims of this study were to provide information about carapacial scute variation of *C. caretta* and *Ch. mydas* hatchlings and to detect whether there is a relationship between variation in scute numbers and the mortality rate of hatchlings of 2 species.

Materials and methods

Alata beach is located inside the borders of Alata Horticultural Research Institute, which is one of the 1st degree natural sites. It is 3 km east of Erdemli and 30 km west of Mersin, and the nesting area is a 3-km-long beach in front of the institute.

Throughout the study, the whole beach was monitored both night and day. During the night studies, the sea turtles coming out of the sea to the beach to nest were observed without interference. Eight live female *Ch. mydas* that were found laying eggs on the beach in 2003 and 5 *Ch. mydas* (sex unknown) that were found dead on the beach (3 in 2002 and 2 in 2003) were measured and the scutes of 13 adult individuals in total were counted. The 5 stranded dead individuals were so badly decomposed that it was not possible to determine their sex. When the variation numbers on the carapacial scutes of the adult *Ch. mydas* were evaluated, the sex of the adults and their being dead or alive were not taken into consideration. Only an assessment of the general situation of the 13 adults in total was made.

Emergences from the natural nests were recorded during the hatchling season. Furthermore, 5-10 days after the first emergence of hatchlings, openings were made in the nests to gather nest and egg data, count dead embryos, and check the number of hatchlings. In this study, all of the hatchlings found were grouped

as dead or alive and their scutes were counted. Both live and dead hatchlings were found in the nests at nest excavation. Also, they were encountered both in the nests and between the nests and the sea when they naturally emerged to orient toward the sea. Most of the live hatchlings found at nest excavation were in apparent good health with vigorous movements. After examination, they found their way to the sea by crawling towards the coastline.

In the 2003 nesting season, the carapacial scute variation of 1086 *Ch. mydas* hatchlings in 81 total nests (43 nests with 169 dead and 74 nests with 917 live) and 394 *C. caretta* hatchlings in 25 total nests (16 nests with 74 dead and 22 nests with 320 live) from Alata beach in Mersin, Turkey were examined within carapacial scute series and in carapacial scute pattern.

The most frequent scute pattern observed on Alata beach was accepted as the normal scute pattern and these frequencies were similar to the ones in Canbolat (1991), Türkozan et al. (2001), Türkozan et al. (2006), and Türkozan and Yılmaz (2007). The normal scute pattern was 1 nuchal, 5 vertebrals, 1 pair of supracaudals, 4 pairs of costals, and 11 pairs of marginals for *Ch. mydas* hatchlings and 1 nuchal, 5 vertebrals, 1 pair of supracaudals, 5 pairs of costals, and 12 pairs of marginals for *C. caretta* hatchlings. The patterns that were different from the normal scute patterns were accepted as abnormal scute patterns.

All data were analysed using SPSS 11.5 in order to evaluate the number, distribution, and frequency (%) of carapace scutes and the occurrence of carapacial scute variation in *Ch. mydas* and *C. caretta* hatchlings and adult individuals of *Ch. mydas*. The number of variations on the carapacial scutes of dead and live hatchlings of *Ch. mydas* and *C. caretta* were examined as to whether there was a relation between the mortality rate of hatchlings and number of variations on the carapacial scute using the Z test for comparison of 2 proportions in Minitab 13.0.

For *Ch. mydas* and *C. caretta* hatchlings, it was not possible to analyze the variation within each species statistically because the number of *Ch. mydas* individuals with 4, 5, or 6 variations and the number of *C. caretta* individuals with 3, 4, or 5 variations were low. Therefore, the mortality rates of *Ch. mydas* individuals with 0, 1, 2, or 3 variations and *C. caretta* individuals with 0, 1, or 2 variations were compared in pairs.

Results

Chelonia mydas

The scutes of 917 live *Ch. mydas* hatchlings were counted. The number of vertebral scutes was 5 (90%). The number of nuchal plates was 1 (95%). The number of supracaudal scutes was 2 (100%). The numbers of right and left costal scutes were 4-4 (88.1%), and the numbers of right and left marginal scutes were 11-11 (95.7%). The scutes of 169 dead *Ch. mydas* hatchlings were also counted. The number of vertebral scutes was 5 (87%). The number of nuchal plates was 1 (94.7%). The number of supracaudal scutes was 2 (100%). The numbers of right and left costal scutes were 4-4 (88.8%), and the numbers of right and left marginal scutes were 11-11 (92.9%) (Table 1).

Of 169 dead *Ch. mydas* hatchlings, 39 hatchlings (23.1%) had carapacial scute variation. Only 1 of them (0.6%) had at most 5 separate variations in carapacial scute pattern and 23 hatchlings (13.6%) had at least 1 carapacial scute variation. Of 917 live *Ch. mydas* hatchlings, 201 hatchlings (21.9%) had carapacial scute variation. Only 1 of them (0.1%) had at most 6 separate variations in carapacial scute pattern and 119 hatchlings (13%) had at least 1 carapacial scute variation (Table 2).

The mortality rates of individuals with 0, 1, 2, or 3 variations were compared in pairs. In these comparisons, there are no significant differences with respect to the mortality rate of hatchlings between the individuals with 0 and 1 variation ($P = 0.803$), 0 and 2 variations ($P = 0.479$), 0 and 3 variations ($P = 0.418$), 1 and 2 variations ($P = 0.449$), 1 and 3 variations ($P = 0.518$), and 2 and 3 variations ($P = 0.277$).

On Alata beach, the scutes of 13 adult *Ch. mydas* were counted. The most observed numbers of scutes were 5 for vertebral, 1 for nuchal, 2 for supracaudals, 4-4 for costal, and 11-11 for marginals (Table 3).

Considering all the observations of dead and live hatchlings and adult individuals of *Ch. mydas*, the general scute pattern was 1 nuchal (in all hatchlings 94.9%; in adult individuals 84.6%), 5 vertebrals (in

Table 1. The number, distribution, and frequency (%) of carapacial scutes of *Chelonia mydas* hatchlings in the 2003 nesting season at Alata beach. L: Left R: Right N: Sample size.

Chelonia mydas	Live hatchlings			Dead hatchlings		
	L-R	N = 917	%	L-R	N = 169	%
Nuchal	1	871	95	1	160	94.7
	2	46	5	2	9	5.3
Vertebrals	3	1	0.1	-	-	-
	4	1	0.1	-	-	-
	5	825	90	5	147	87
	6	69	7.5	6	19	11.2
	7	15	1.6	7	1	0.6
	8	5	0.5	8	1	0.6
	9	1	0.1	9	1	0.6
Supracaudals	2	917	100	2	169	100
Costals	2-2	1	0.1	-	-	-
	3-3	1	0.1	-	-	-
	4-4	808	88.1	4-4	150	88.8
	4-5	22	2.4	4-5	6	3.6
	4-6	5	0.5	4-6	1	0.6
	5-4	39	4.3	5-4	7	4.1
	5-5	13	1.4	5-5	5	3.0
	5-6	9	1.0	-	-	-
	5-7	2	0.2	-	-	-
	6-4	4	0.4	-	-	-
	6-5	4	0.4	-	-	-
	6-6	5	0.5	-	-	-
	6-7	1	0.1	-	-	-
	7-7	3	0.3	-	-	-
Marginals	9-8	1	0.1	-	-	-
	10-10	6	0.7	10-10	1	0.6
	10-11	8	0.9	10-11	1	0.6
	11-10	3	0.3	-	-	-
	11-11	878	95.7	11-11	157	92.9
	11-12	8	0.9	11-12	6	3.6
	12-11	8	0.9	12-11	3	1.8
	12-12	5	0.5	12-12	1	0.6

all hatchlings 88.5%; in adult individuals 92.3%), 2 supracaudals (in all hatchlings 100%; in adult individuals 100%), 4-4 costals (in all hatchlings 88.5%; in adult individuals 84.6%), and 11-11 marginals (in all hatchlings 94.3%; in adult individuals 100%).

No variation was observed in 69.2% of 13 adults in total. Of the 13 adults, 8 were live females found laying eggs on the beach, and 5, with sex unknown, were dead (Table 4). The individuals with variations had 2 variations at most (Table 4).

Table 2. The variation numbers of the carapacial scutes of *Chelonia mydas* hatchlings.

		No variation	Variation						Total
	Valid	0	1	2	3	4	5	6	
Dead	Frequency	130	23	6	7	2	1	-	169
	The percentage in the dead samples (%)	76.9	13.6	3.6	4.1	1.2	0.6	-	100
	The percentage in 1086 samples total (%)	12	2.1	0.6	0.6	0.2	0.1	-	15.6
Live	Frequency	716	119	44	26	8	3	1	917
	The percentage in the live samples (%)	78.1	13	4.8	2.8	0.9	0.3	0.1	100
	The percentage in 1086 samples total (%)	65.9	11	4.1	2.4	0.7	0.3	0.1	84.4
Total	Frequency	846	142	50	33	10	4	1	1086
	The percentage in 1086 samples total (%)	77.9	13.1	4.6	3	0.9	0.4	0.1	100

Table 3. The number, distribution, and frequency (%) of carapacial scutes of adult individuals of *Chelonia mydas* in the 2003 nesting season. L: Left R: Right N: Sample size.

	L-R	N = 13	%
Nuchal	1	11	84.6
	2	2	15.4
Vertebrals	5	12	92.3
	6	1	7.7
Supracaudals	2	13	100
Costals	4-4	11	84.6
	5-4	1	7.7
	6-4	1	7.7
Marginals	11-11	13	100

Caretta caretta

In 320 live *C. caretta* hatchlings, the number of vertebral scutes was 5 (87.2%), the number of nuchal plates was 1 (90.9%), the number of supracaudal scutes was 2 (100%), the numbers of right and left costal scutes were 5-5 (96.3%), and the numbers of right and left marginal scutes were 12-12 (41.3%). In 74 dead *C. caretta* hatchlings, the number of vertebral scutes was 5 (93.2%), the number of nuchal plates was 1 (100%), the number of supracaudal scutes was 2 (100%), the numbers of right and left costal scutes were 5-5 (95.9%), and the numbers of right and left marginal scutes were 12-12 (63.5%) (Table 5). There were no data available for the adult female *C. caretta*.

Considering the observations of dead and live hatchlings, the general scute pattern was 1 for nuchal (95.5%), 5 for vertebral (90.2%), 2 for supracaudals (100%), 5-5 for costal (96.1%), and 12-12 for marginals (52.4%).

Of 74 dead *C. caretta* hatchlings, 31 hatchlings (41.9%) had carapacial scute variation. Only 1 of them (1.4%) had at most 4 separate variations in carapacial scute pattern and 16 hatchlings (21.6%) had at least 1 carapacial scute variation. Of 320 live *C. caretta* hatchlings, 211 hatchlings (65.9%) had carapacial

Table 4. The variation numbers of the carapacial scutes of adult *Chelonia mydas*.

		No variation	Variation						Total
	Valid	0	1	2	3	4	5	6	Total
5 stranded dead adults whose sex were unknown	Frequency	4	1	-	-	-	-		5
	Percent (%)	80	20	-	-	-	-	-	100
8 live adult females	Frequency	5	2	1	-	-	-	-	8
	Percent (%)	62.5	25	12.5	-	-	-	-	100
Total	Frequency	9	3	1	-	-	-	-	13
	Percent (%)	69.2	23.1	7.7	-	-	-	-	100

scute variation. Only 1 of them (0.3%) had at most 5 separate variations in carapacial scute pattern and 69 hatchlings (21.6%) had at least 1 carapacial scute variation (Table 6).

Regarding the mortality of individuals with 0, 1, or 2 variations, some results suggested that the mortality rate decreased as the number of variations increased. Although there was a clear decrease in the mortality rates as the number of variations increased, there was a statistically significant difference only between the individuals with 0 and 2 variations (P = 0.001). There was no statistically significant difference between the individuals with 0 and 1 variations (P = 0.091) or 1 and 2 variations (P = 0.139).

Discussion

Chelonia mydas

The examination of carapacial scute variations of 1086 specimens of *Ch. mydas* hatchlings in total showed that there was no statistically significant difference (P = 0.742) between the dead (39; 23.1%) and live (201; 21.9%) hatchlings with respect to variation values.

Regarding *Ch. mydas*, only the individuals with 0, 1, 2, or 3 variations could be compared in pairs, but the results were not statistically significant. In conclusion, no relation between the changes in variation numbers and the mortality rates were found in *Ch. mydas* hatchlings. It was not possible to compare the proportion of carapacial scute variation of the 1086 dead and live *Ch. mydas* hatchlings to the 13 adult individuals since the number of adult specimens was not sufficient for statistical analysis.

The variation numbers of the carapacial scutes; the range of variations of vertebral, costal, and marginal plates; and the number of combinations of costals and marginals in *Ch. mydas* hatchlings are higher than those of adults at Alata beach. Özdemir and Türkozan (2006) offer 2 explanations for the absence of adults with deviant numbers of costal, vertebral, nuchal, or supracaudal scutes. They argue that the hatchlings with deviant scutes die before they mature, or the scutes change to the normal number with growth.

Türkozan et al. (2006) concluded that there were no big differences among 1164 hatchlings of *Ch. mydas* in natural and relocated nests at Kazanlı beach in the 2002 nesting season with respect to the numbers of plates in their carapaces. However, they stated that the numbers of plate combinations changed, and added that the number of nuchal scutes is 1 or 2 in hatchlings from natural nests at Kazanlı beach. The most common individuals were those with 1 nuchal scute, with a rate of 89.2%, lower than that of Alata beach. The total number of nuchal scutes changed between 1 and 2 for *Ch. mydas* at Alata beach. Among the hatchlings of *Ch. mydas* examined, the most common number of nuchal plates was 1, found on average in 94.9% of hatchlings.

Table 5. The number, distribution, and frequency (%) of carapacial scutes of *Caretta caretta* hatchlings in the 2003 nesting season at Alata beach. L: Left R: Right N: Sample size.

Caretta caretta	Live hatchlings			Dead hatchlings		
	L-R	N = 320	%	L-R	N = 74	%
Nuchal	1	291	90.9	1	74	100
	2	29	9.1	-	-	-
Vertebrals	5	279	87.2	5	69	93.2
	6	32	10	6	4	5.4
	7	7	2.2	7	1	1.4
	8	2	0.6	-	-	-
Supracaudals	2	320	100	2	74	100
Costals	4-5	2	0.6	-	-	-
	5-4	1	0.3	-	-	-
	5-5	308	96.3	5-5	71	95.9
	5-6	4	1.3	5-7	1	1.4
	6-5	2	0.6	-	-	-
	6-6	1	0.3	6-6	2	2.7
	7-5	1	0.3	-	-	-
	8-7	1	0.3	-	-	-
Marginals	11-10	1	0.3			
	11-11	120	37.5	11-11	10	13.5
	11-12	20	6.3	11-12	6	8.1
	12-11	28	8.8	12-11	6	8.1
	12-12	132	41.3	12-12	47	63.5
	12-13	9	2.8	12-13	2	2.7
	13-11	1	0.3	-	-	-
	13-12	4	1.3	13-12	1	1.4
	13-13	4	1.3	13-13	2	2.7
	13-14	1	0.3	-	-	-

At Kazanlı beach, the number of vertebrals varied from 5 to 8 with the most common pattern being 5 vertebrals (91.9%). This rate was higher than that of Alata beach. At Alata beach, the number of vertebral scutes varied between 3 and 9, and the most observed number of vertebral scutes was 5, found on average in 88.5% of hatchlings. The range of variation at Alata beach was more than that of Kazanlı beach.

At Kazanlı beach, the number of costals varied from 4 to 7 on both sides, and 10 combinations were noted. The number of combinations was lower than that of Alata beach. The most common individuals

Table 6. The variation numbers of the carapacial scutes of *Caretta caretta* hatchlings.

		No variation	Variation					Total
	Valid	0	1	2	3	4	5	
Dead	Frequency	43	16	13	1	1	0	74
	The percentage in the dead samples (%)	58.1	21.6	17.6	1.4	1.4	0	100
	The percentage in 394 samples total (%)	10.9	4.1	3.3	0.3	0.3	0	18.8
Live	Frequency	109	69	103	33	5	1	320
	The percentage in the dead samples (%)	34.1	21.6	32.2	10.3	1.6	0.3	100
	The percentage in 394 samples total (%)	27.7	17.5	26.1	8.4	1.3	0.3	81.2
Total	Frequency	152	85	116	34	6	1	394
	The percentage in 394 samples total (%)	38.6	21.6	29.4	8.6	1.5	0.3	100

were those with the 4-4 pattern of costals (93.8%). The rate of this pattern was higher than that of Alata beach. The number of costal scutes varied between 2 and 7, and 14 combinations existed at Alata beach. The pattern 4-4 was observed on average in 88.5% of hatchlings at Alata beach.

Finally, at Kazanlı beach the total number of marginals ranged from 10 to 13 on both sides and 9 combinations were noted. The most common individuals were those with the 11-11 pattern of marginals (96.3%). The number of combinations at Kazanlı beach was only 1 more than those of Alata beach. In marginal scutes, the numbers were between 9 and 12, and there were 8 combinations at Alata beach. Among the individuals, the most observed ones were 11-11, found on average in 94.3% of hatchlings. The number of supracaudals (2) was constant (100%) at Kazanlı beach. This result is the same as that for Alata beach.

Özdemir and Türkozan (2006) analyzed the scutes in carapaces of *Ch. mydas* hatchlings from the relocated nests at 2 different nesting beaches in Northern Cyprus (Ronas beach and Golden beach I). Since we have no data available from the relocated *Ch. mydas* nests, we are not able to compare the variations of hatchlings in natural and relocated nests.

In conclusion, the most common carapace plate frequency of *Ch. mydas* in our study on Alata beach is similar to the ones in the study conducted by Türkozan et al. (2006) (the most frequent scute combination in the carapaces of hatchlings in both natural and relocated nests) and Özdemir and Türkozan (2006) (the most frequent scute combination in the carapaces of hatchlings in relocated nests). This frequency is 1 nuchal, 1 pair of supracaudals, 5 vertebrals, 4 pairs of costals, and 11 pairs of marginals.

Özdemir and Türkozan (2006) stated that they were not able to comment on whether hatchlings in their relocated nests had a higher variation than those of natural ones since they had no data available from the natural *Ch. mydas* nests. Unlike Özdemir and Türkozan (2006), we had data from natural nests, not from relocated ones. Therefore, we were not able to compare the variations of hatchlings in natural and relocated nests. Hence, we compared the scute variations of the hatchlings of natural nests at Alata in Mersin to those of relocated nests in Northern Cyprus (Ronas beach and Golden beach I) (Table 7).

In their study of the population of *Ch. mydas* hatchlings in Northern Cyprus (Golden Beach I and Ronas Beach), Özdemir and Türkozan (2006) stated that, out of 718 hatchlings, 290 (40.4%) had carapacial scute variation. According to Özdemir and Türkozan (2006), the rate of hatchlings in relocated nests with no carapacial scute variation (59.6%) was approximately 1.5 times higher than the rate of hatchlings in relocated nests in which carapacial

Table 7. Comparison between the carapacial scute variation of *Chelonia mydas* hatchlings in natural nests of Alata Beach and *Chelonia mydas* hatchlings in relocated nests of Northern Cyprus.

Chelonia mydas		Natural nests of Alata Beach (This study)	Relocated nests of Northern Cyprus (Ronas beach and Golden beach I) *
Variation	Frequency	240	290
	Percent (%)	22.1	40.4
No variation	Frequency	846	428
	Percent (%)	77.9	59.6
Total	Frequency	1086	718

* According to Özdemir and Türkozan (2006).

scute variation was seen (40.4%) in Northern Cyprus (Golden Beach I and Ronas Beach). According to the current study at Alata beach, out of 1086 hatchlings that were examined from the natural *Ch. mydas* nests, 240 hatchlings (22.1%) had carapacial scute variation. As Table 7 indicates, the rate of hatchlings with no carapacial scute variation (77.9%) is approximately 3.5 times higher than the rate of hatchlings with carapacial scute variation (22.1%) in natural nests at Alata Beach. As shown in Table 7, the rate of hatchlings with carapacial scute variation of relocated nests of Northern Cyprus (Golden Beach I and Ronas Beach) (40.4%) (Özdemir and Türkozan, 2006) is almost 2 times higher than the rate of hatchlings of natural ones (22.1%) at Alata beach. Futhermore, in the natural nests at Alata beach, a total of 1086 *Ch. mydas* hatchlings have at most 6 variations on their carapacial scutes, and in the relocated nests in Northern Cyprus, a total of 718 *Ch. mydas* hatchlings have at most 6 variations on their carapacial scutes (Özdemir and Türkozan, 2006). In short, the results are the same in the 2 studies.

Caretta caretta

The examination of carapacial scute variation of 394 total specimens (74 dead and 320 live) of *C. caretta* hatchlings showed that the proportion of 211 live hatchlings with scute variation (65.9%) was higher than the proportion of 31 dead hatchlings (41.9%) ($P < 0.001$). Regarding *C. caretta*, some results suggest that the mortality rate decreased as the number of variations increased in individuals with 0, 1, or 2 variations. Although there was a clear decrease in the mortality rate as the number of variations increased, there was a statistically significant difference only between the individuals with 0 and 2 variations ($P = 0.001$). However, it was not possible to conclude that the mortality rate decreased as the number of variations increased because the difference between the individuals with other variation numbers was not statistically significant. If the mortality rates decreased as the number of variation increased, the percentage of adults with deviant scutes would be very high. However, in adults the proportion of variation is less than that of hatchlings (Gadow, 1899). As a result, there was no relation between the changes of variation numbers and the mortality rate.

In his study on the population of *C. caretta* at Dalyan beach, Canbolat (1991) examined the carapacial scute variation of 71 adults and 497 hatchlings. Türkozan et al. (2001) analyzed the scutes of the carapaces of adult female and hatchling *C. caretta* in 5 nesting beaches in Turkey (Dalyan, Fethiye, Belek, and Kızılot) and Northern Cyprus (Karpaz). They studied all the hatchlings from 5

beaches and determined a general scute pattern. Türkozan et al. (2006) determined that the numbers of scutes of 1052 hatchlings of *C. caretta* in natural and relocated nests at Fethiye beach in the 2003 nesting season did not show big differences; however, they stated that scute combinations varied. In their study at Dalyan beach in Turkey in the 2004 season (June to early August), Türkozan and Yılmaz (2007) examined differences in carapacial scute patterns, and sizes and weights of 734 hatchlings from 34 in situ nests and 1188 hatchlings from 49 hatchery-relocated nests. They found that the vertebral, costal, and marginal series were the most variable and the supracaudal scutes were extremely stable.

In this study, we compared the scute variation patterns of hatchlings in natural nests of Alata beach to those of hatchlings in natural nests of the above mentioned beaches studied by other researchers. The total number of nuchal scutes varied between 1 and 2 for *C. caretta* at Alata beach. The most observed number of nuchals among hatchlings was 1, found on average in 95.5% of hatchlings. In Canbolat's (1991) study, the numbers of nuchal scutes were observed as 1, 2, or 3 and the most observed number was 1 (95.6%). In the studies by Türkozan et al. (2001), Türkozan et al. (2006), and Türkozan and Yılmaz (2007), the total number of nuchal scutes varied between 1 and 2 and the most observed structure was 1. The rates were 97.5%, 93.2%, and 95.2%, respectively.

The numbers of vertebrals varied between 5 and 8 at Alata beach. The most observed number of vertebrals was 5, found on average in 90.2% of hatchlings. These numbers were between 5 and 8 in Canbolat's (1991) study, and the most observed numbers of vertebrals were at the rate of 94.6%. In Türkozan et al. (2001), the numbers of vertebrals changed between 4 and 9, and the most observed number of vertebral scutes was 5 (89.9%) The numbers of vertebrals varied between 4 and 8 and the most observed number of vertebral scutes was 5 (81.59%) (Türkozan et al., 2006). In Türkozan and Yılmaz (2007), the number of vertebral scutes varied between 5 and 8. The most observed number was 5 with a rate of 92%.

At Alata beach, the numbers of costals varied between 4 and 8, and there were 8 combinations. Among the individuals, 5-5 was the most common pattern, found on average in 96.1% of hatchlings. In Canbolat (1991), the numbers of costals were between 3 and 7, and there were 10 combinations. The most common pattern was 5-5, and the average rate was 95.2%.

In Türkozan et al. (2001), the numbers of costal scutes varied between 4 and 8 on either side, and there were 14 combinations. Among the individuals 5-5 was most frequently observed (93.3%). In Türkozan et al. (2006), the numbers of costal scutes varied between 4 and 8 and there were 18 combinations. A 5-5 pattern was the most common (85.4%). In Türkozan and Yılmaz (2007), the numbers of costal scutes varied between 4 and 7, and there were 11 combinations. A 5-5 pattern was the most commonly seen at a rate of 92.1%.

At Alata beach, the marginal scutes varied between 10 and 14 and there were 10 combinations. The most common individuals were those with the 12-12 pattern, which was found on average in 52.4% of hatchlings. The marginal scutes varied between 10 and 13 and there were 10 combinations in Canbolat (1991). A 12-12 pattern was most frequently observed with a rate of 42.5%. In Türkozan et al. (2001), there were variations between 9 and 13 on each side in the total number of marginals. There were 14 combinations, and among the individuals, 12-12 was most often seen (63.3%). In Türkozan et al. (2006), the numbers of marginal scutes were between 11 and 13, and there were 6 combinations. A 12-12 pattern was most often seen (55.7%). The numbers of marginal scutes varied between 10 and 14 and there were 11 combinations in Türkozan and Yılmaz (2007). A 12-12 pattern was most commonly seen (62.5%).

In all specimens, supracaudals were determined to be 2 at Alata beach. Both at Alata beach and in other studies (Canbolat, 1991; Türkozan et al., 2001; Türkozan et al., 2006; Türkozan and Yılmaz, 2007), the numbers of supracaudals were also exclusively 2.

In conclusion, the most commonly seen carapace scute frequency of *C. caretta* in our study on Alata beach is similar to the ones in Canbolat (1991), Türkozan et al. (2001), Türkozan et al. (2006) (the most frequent scute combination in the carapaces of hatchlings in both natural and relocated nests), and Türkozan and Yılmaz (2007) (the most frequent scute combination in the carapaces of hatchlings in

both natural and relocated nests). This frequency is 1 nuchal, 1 pair of supracaudals, 5 vertebrals, 5 pairs of costals, and 12 pairs of marginals.

Since our data were limited to only the natural nests, not from relocated ones, we were not able to compare the variations of hatchlings in natural and relocated nests. When the scute variations of the hatchlings of natural nests of Alata beach and those of natural and relocated nests of Dalyan beach (Türkozan and Yılmaz, 2007) were compared, the rate of carapacial scute variation of natural nests of Alata beach (61.2%) was higher than the rate of natural (44.4%) and relocated (46.0%) nests of Dalyan beach (Table 8).

Scute variation is common in hatchlings. Scute deviation is significantly higher in *Ch. mydas* hatchlings from a hatchery than in the hatchlings from natural nests (Suganuma et al., 1994). This is also true for the *C. caretta* nests in Turkey (Türkozan and Yılmaz, 2007). Accordingly, the variation of hatchlings from potential relocated nests is likely to be higher than that of hatchlings from natural nests on Alata beach.

Some scientists have tried to explain the factors which cause variation of scutes in hatchlings. Mast and Carr (1989) state that handling of the eggs after a turtle's ovoposition has a significant effect on the variation of the structures in the hatchling's carapace. Hill (1971) reports that in Olive Ridley (*Lepidochelys olivacea*), handling eggs at certain stages of development has increased scute variation. Transplantation, translocation and artificial incubation of sea turtle eggs possibly have effects on the viability of hatchlings (Mast and Carr, 1989). Therefore, the in situ protection must be preferred not only because of low percentages of scute deviation but also because of high percentages of nest success obtained (Carretero-Montes and Trejo-Robles, 2000). Also, with the in situ protection the natural sex ratio of hatchlings is maintained (Boulon, 1999). According to Ewert (1979), the structure of the carapace in specimens has a certain period for change. It is stated that in the middle third of the incubation period, gonadal differentiation in turtles occurs (Yntema and Mrosovsky, 1982).

On the other hand, Başkale and Kaska (2003) state that relocating nests that are at risk of predation and flood can be useful in terms of increasing the percentage of successful hatchling emergence. It is crucial to obey the rules for relocating nests in order to ensure continuity of marine turtle generations. Whether the method applied is trustworthy or not would be clear when the percentages of nest success and percentages of scute deviations in relocated nests are compared to those in natural nests. Variation of numbers of scutes in hatchlings may depend on different factors. Understanding several different environmental factors that might influence the variations seen in carapaces in natural and relocated nests may contribute to scientists making choices to move clutches to protect marine turtles (Özdemir and Türkozan, 2006).

Table 8. Comparison between the carapacial scute variation of *Caretta caretta* hatchlings in natural nests of Alata Beach and *Caretta caretta* hatchlings in relocated nests of Dalyan Beach.

Caretta caretta		Natural nests of Alata Beach (This study)	Natural and relocated nests of Dalyan Beach **	
			Natural Nests	Relocated Nests
Variation	Frequency	241	326	546
	Percent (%)	61.2	44.4	46.0
No variation	Frequency	153	408	642
	Percent (%)	38.8	55.6	54.0
Total	Frequency	394	734	1188

** According to Türkozan and Yılmaz (2007).

Since the data compared were obtained from different beaches (Alata beach in Mersin, Golden beach I and Ronas beach in Northern Cyprus, and Dalyan beach in Muğla), the different properties of the beaches must be taken into consideration. If the nests of *C. caretta* and *Ch. mydas* in Alata beach need relocating in subsequent years, a comparison of the variations of hatchlings to be examined in the natural and relocated nests will reveal to what extent the relocation of nests will change the variations. We also think that in situ protection must be preferred unless the relocation is needed for nest success and the evolution and the survival of the hatchlings. While the carapacial scute variation of hatchlings is determined from both the dead and live hatchlings whose sex are unknown, the carapacial scute variation of adults is determined mostly from the mature females emerging from the sea for nesting. We think that the carapacial scute variation should be determined from the dead hatchlings whose sex ratio is estimated by histological analysis of gonads (Yntema and Mrosovsky, 1980). Also, in the studies determining carapacial scute variation of adults, the number of male individuals should be increased. This will ensure that the comments on the carapacial scute variation of marine turtle populations will be more reliable.

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