Turk J Zool
30 (2006) 141-146
© TÜBİTAK

Carapacial Scute Variation in Green Turtle, *Chelonia mydas* Hatchlings in Northern Cyprus

Burcu ÖZDEMİR, Oğuz TÜRKOZAN*

Adnan Menderes University, Faculty of Science and Arts, Department of Biology, Aydın, 09010 - TURKEY

Received: 17.05.2005

Abstract: The carapacial scutes of 718 green turtle hatchlings, *Chelonia mydas* (Linnaeus, 1758), from 2 different nesting beaches in Northern Cyprus were examined. Scutes were examined with regard to variation within carapacial scute series and variation in carapacial scute pattern. The vertebral, costal and marginal series were the most variable and the supracaudal scutes were almost stable for the hatchlings. The most common scute pattern observed was 11 pairs of marginals, 4 pairs of costals, 5 vertebrals, 2 supracaudals and a single nuchal. The straight carapace length (SCL) of the hatchlings ranged from 39 to 51 mm with a weight that varied between 13 and 26 g. Negative allometric growth was reported between straight carapace length and weight.

Key Words: Scute variation, carapace, green turtle, hatchlings, Northern Cyprus

Kuzey Kıbrıs Yeşil Deniz Kaplumbağası, *Chelonia mydas*, Yavrularının Karapas Kabuğundaki Farklılaşmalar

Özet: Kuzey Kıbrıs'taki iki farklı yuvalama kumsallarındaki 718 yeşil deniz kaplumbağası *Chelonia mydas* (Linnaeus, 1758) yavrusunun karapasındaki plaklar incelenmiştir. Plaklar, karapas plaklarındaki sıralanma ve seri farklılıkları açısından incelenmiştir. Yavrularda vertebral, kostal ve marginal plak serileri en fazla varyasyon gösteren seriler olurken suprakaudal plaklar hemen hemen sabit kalmıştır. Tespit edilen en fazla tekrar eden kabuk serisi 11 çift marginal, 4 çift kostal, 5 vertebral, 2 suprakaudal ve tek nukal plak şeklindedir. Yavruların düz karapas boyu 39 ile 51 mm arasında, ağırlığı ise 13 ile 26 gr arasında değişmiştir. Düz karapas boyu ve ağırlık arasında negatif allometrik büyüme kaydedilmiştir.

Anahtar Sözcükler: Plak farklılaşması, karapas, yeşil deniz kaplumbağası, yavrular, Kuzey Kıbrıs

Introduction

Although a great deal of stability has been observed in the number and arrangement of scutes in turtles, individual variation has also been observed for nearly all species of turtles that possess scutes (Mast and Carr, 1989). The typical chelonian carapacial scutation (a term introduced by Deraniyagala (1939)) consists of a median longitudinal series of unpaired elements, the vertebral scutes, flanked on each side by a series of bilaterally paired scutes (the costals), which are bordered exteriorly by another series of bilaterally paired scutes, the marginals. Situated anteriorly between the first pair of marginals is a nuchal. Situated posteriorly between the last pair of marginals is a pair of supracaudals. However, some researchers consider the supracaudals as part of the marginal series, but we have considered these scutes as separate from the marginals. Supernumerary and subnumerary scute counts have been observed for nearly all species of turtles that possess scutes (Newman, 1906; Hewavisenthi and Kotagama, 1989; Mast and Carr, 1989). Among the sea turtles, the most deviance from the scute pattern is found in the genus *Lepidochelys* (Mast and Carr, 1989).

Gadow (1899), in his study with loggerhead turtles, *Caretta caretta*, noted that adults appear to have far less variation than do hatchlings of the same species. He proposed the idea of "orthogenetic variation" theorizing that young turtles that possess more than the normal complement of scutes undergo fusion of scutes during ontogeny such that the adult stage exhibits the normal reduced scute pattern. Newman (1906) opposed this view and suggested that supernumerary scutes were an

---

*E-mail: turkozan@adu.edu.tr

atavistic reappearance of scutes that had been lost during phylogeny.

Other authors have suggested that abnormalities of scutation arise from accidents or disturbances during ontogenetic development (Parker, 1901; Hildebrend, 1930; Zangerl, 1969). Hildebrend (1938) suggested that scute anomalies in Diamondback Terrapins (*Malaclemys terrapin*) result from changes in available oxygen supply during incubation. Temperature variation during incubation may also account for scute abnormalities. Studies by Yntema (1976), Yntema and Mrosovsky (1980), and others concerning temperature-dependent sex determination indicate that morphogenetic effects can occur in turtles as a result of varied incubation temperature. Furthermore, handling of eggs at certain stages of development has been cited as a source of increased scute variation in Olive Ridley (*Lepidochelys olivacea*) (Hill, 1971), and has been shown to induce mortality in embryos (Limpus et al., 1979). Thus there is evidence to suggest that several different environmental factors may influence scute pattern variation during incubation. Suganuma et al. (1994) studied scute deviation in green turtle hatchlings from a hatchery in Japan and concluded that the scute deviation rate of hatchlings from the hatchery was significantly higher than those from the natural beaches. Türkozan et al. (2001) reported on the carapacial scute variation of loggerhead turtle hatchlings and adults in Turkey and Northern Cyprus. They noted that adults have far less variation than do hatchlings.

This study aims to close the information gap on the carapacial scute variation of hatchlings of *Chelonia mydas* from Northern Cyprus, since there is no information available from the eastern Mediterranean on this subject.

Materials and Methods

The carapacial scutes of 718 green turtle hatchlings were examined from translocated nests of 2 different beaches (Golden Beach I and Ronas) in Northern Cyprus (Figure 1). All the observations were carried out during the hatchling emergence (2.8.2002 to 6.9.2002) season from the relocated nests. Furthermore, straight carapace length (SCL) and width (SCW) measurements were taken by means of dial calipers with an accuracy of ±0.02 mm. The weights of hatchlings were also measured with a digital scale (accuracy ±0.1 g). The length-weight relationship was tested with the formula $W = a * L^b$, where $L = SCL$. The beaches were compared in terms of carapacial scute variation and number of variations by means of Mann-Whitney U test. All statistical applications were carried out using STATISTICA version 6.0.

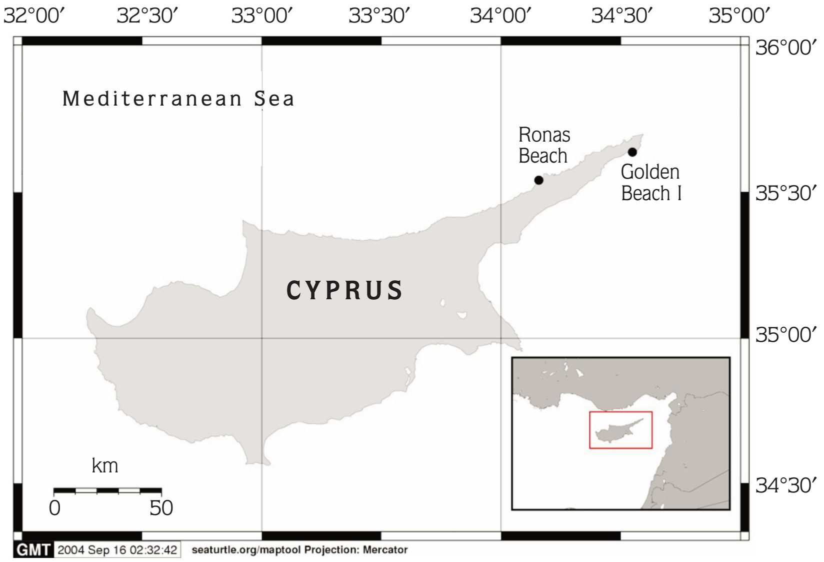

Figure 1. Map of localities (Seaturtle.org Map tool).

Results

The results were presented with respect to beaches for the hatchlings (Table 1).

Ronas

A total of 673 hatchlings were examined in 45 nests. The number of nuchal scutes was 1 or 2. The most common individuals were those with 1 nuchal scutes, with a frequency of 83.8%. The number of vertebrals varied from 5 to 9. The most common pattern was those with 5 vertebrals (90.04%). The number of costals varied from 4 to 8 on either side and 16 combinations of these were noted. The most common individuals were those with the 4-4 pattern, with a frequency of 85.88%. The number of marginals varied from 10 to 12 on either side and 8 combinations of these were noted. The most common individuals were those with the 11-11 pattern, with a frequency of 94.21%. The number of supracaudals was always constant (2) except in 1 individual (0.15%).

The SCL of the hatchlings ranged from 39 to 51 with a mean of 46.1 ± 1.83 mm. The SCW of the hatchlings varied between 29.9 and 43.8 with a mean of 35.09 ±

Table 1. The number and distribution of carapace scutes of *Chelonia mydas* hatchlings and their frequency (%). R-L = distribution right - left.

	Ronas			Golden beach I	
	R-L	n	%	n	%
Nuchal	1	564	83.8	36	80
	2	109	16.2	9	20
	5	606	90.04	39	86.62
Vertebral	6	50	7.43	5	11.11
	7	15	2.23	-	-
	8	1	0.15	1	2.22
	9	1	0.15	-	-
Supracaudal	2	672	99.85	45	100
	3	1	0.15		
	4-4	578	85.88	42	93.33
	4-5	27	4.01	1	2.22
	5-4	22	3.69	1	2.22
	5-5	19	2.82	-	-
	4-6	6	0.89	-	-
	5-6	4	0.59	-	-
	6-6	4	0.59	-	-
Costal	4-7	2	0.3	-	-
	6-4	2	0.3	-	-
	6-5	2	0.3	-	-
	8-8	2	0.3	-	-
	5-7	1	0.15	1	2.22
	6-7	1	0.15	-	-
	7-6	1	0.15	-	-
	7-7	1	0.15	-	-
	8-7	1	0.15	-	-
	11-11	634	94.21	40	88.89
	10-10	21	3.12	-	-
	11-12	6	0.89	-	-
Marginal	12-11	5	0.74	1	2.22
	12-12	4	0.59	2	4.44
	11-10	1	0.15	1	2.22
	12-10	1	0.15	-	-
	10-11	1	0.15	1	2.22

1.81 mm. The weight of the hatchlings ranged from 13 to 26 with a mean of 19.84 ± 2.02 g.

Golden Beach I

A total of 45 hatchlings were examined in 3 nests. The number of nuchal scutes was 1 or 2. The most common individuals were those with 1 nuchal scute, with a frequency of 80%. The number of vertebrals varied from 5 to 8. The most common pattern was those with 5 vertebrals (86.6%). The number of costals varied from 4 to 7 on either side and 4 combinations of these were noted. The most common individuals were those with the 4-4 pattern, with a frequency of 93.3%. The number of marginals varied from 10 to 12 on either side and 5 combinations of these were noted. The most common individuals were those with the 11-11 pattern, with a frequency of 88.9%. The number of supracaudals was always constant (2).

The SCL of the hatchlings ranged from 42.9 to 50.5 with a mean of 46.1 ± 1.60 mm. The SCW of the hatchlings varied between 31.3 and 38.1 with a mean of 34.6 ± 1.73 mm. The weight of hatchlings ranged from 17.8 to 23.5 with a mean of 19.97 ± 1.40 g.

Out of 718 hatchlings, 290 (40.4%) had carapacial scute variation (Table 2). Since we have no data available from the natural green turtle nests we are not able to comment on whether our relocated nests had a higher variation than those of natural ones. A total of 183 (25.49%) hatchlings had at least one carapacial scute variation (Table 3).

When the length-weight relationship was tested with the formula $W = a * L^b$, where L = SCL, for the whole data negative allometric growth ($W = 0.0493 * L^{1.5643}$, $R^2 = 0.3482$) was recorded in the green turtle hatchlings (Figure 2).

Table 2. The occurrence of carapacial scute variation with respect to beaches.

Locality	No variation	Variation	Total
Golden Beach I	29	16	45
Percent (%)	64.44	35.56	100.00
Ronas	399	274	673
Percent (%)	59.29	40.71	100.00
Total	428	290	718
Percent (%)	59.61	40.39	100.00

Discussion and Conclusion

No difference was detected between the beaches in terms of carapacial scute variation (Mann-Whitney U test U =14,339, Z = -0.596, $P < 0.05$) and number of deviations (Mann-Whitney U test U = 14,415, Z = -0.540, $P < 0.05$). Considering all hatchlings from the beaches, the general scute pattern can be summarized as follows. The number of nuchal scutes was 1 or 2. The most common individuals were those with 1 nuchal scute, with a frequency of 83.6%. The number of vertebrals varied from 5 to 9 with the most common pattern of 5 vertebrals (89.8%). The number of costals varied from 4 to 8 on either side and 16 combinations of these were noted. The most common individuals were those with the 4-4 pattern (86.4%). The total number of marginals ranged from 10 to 12 on either side and 8 combinations of these were noted. The most common individuals were those with the 11-11 pattern (93.9%). The number of supracaudals (2) was almost constant (99.9%).

Table 3. The number of variations on the carapacial scute of green turtle hatchlings with respect to beaches.

Variations/ Locality	0	1	2	3	4	5	6	Total
Golden Beach I	29	9	5	2	0	0	0	45
%	64.44	20	11.11	4.44	-	-	-	100
Ronas	398	174	53	36	8	3	1	673
%	59.14	25.85	7.88	5.35	1.19	0.45	0.15	100
Total	427	183	58	38	8	3	1	718
%	59.47	25.49	8.08	5.29	1.11	0.42	0.14	100

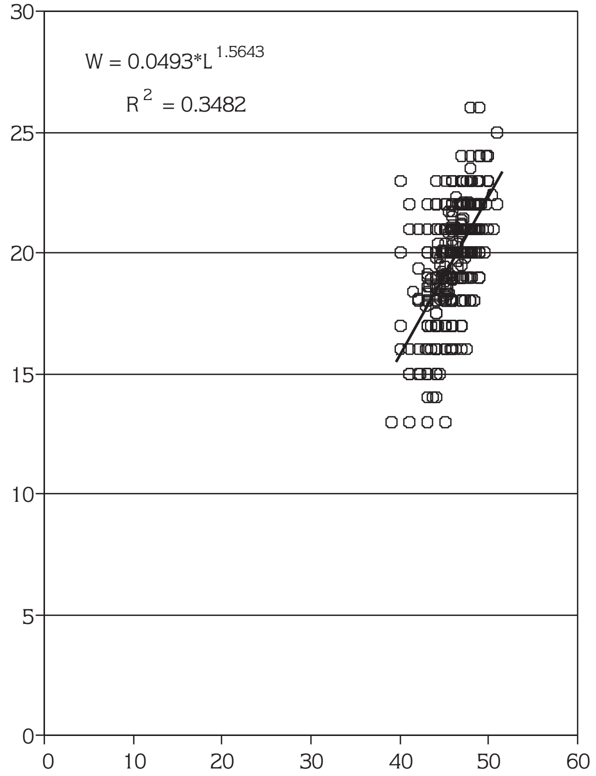

Figure 2. The length-weight relationship of green turtle hatchlings ($W = a * L^b$) according to L = SCL.

Consequently, the most frequent scute combination was that with 1 nuchal, 5 vertebrals, a pair of supracaudals, 4 pairs of costals and 11 pairs of marginals. The absence of adults with deviant numbers of costal, vertebral, nuchal or supracaudal scutes could be explained in 2 ways: the hatchlings with deviant counts die before they mature, or the plates change to the normal number with growth. According to Gadow (1899), scutes may undergo fusion during ontogeny such that the adult stage exhibits the normal reduced scute pattern. Newman (1906) opposed this view and suggested that supernumerary scutes were an atavistic reappearance of scutes that had been lost during phylogeny. According to Zangerl and Johnson (1957), there has been great stability in scutation of the carapace during chelonian evolution. According to Suganuma et al. (1994), the scute deviation rate of hatchlings from a hatchery was significantly higher than that of hatchlings from natural beaches. They also recorded that 5% of the adult females and 3.3% of the males showed scute variation. Türkozan et al. (2001) studied adult female loggerhead turtles and they recorded variations only in the marginal scutes. As seen, the fate of hatchlings with a deviant scute number is unclear. However, the appearance of scute variation in hatchlings has been based on different factors.

Mast and Carr (1989) stated that handling of the eggs after ovoposition has a marked effect on carapacial scute variability. Therefore, transplantation, translocation and artificial incubation of sea turtle eggs should be evaluated with concern for their possible effects on viability of hatchlings. According to Ewert (1979), the carapacial scute pattern must also have a critical period for differentiation as gonadal differentiation in turtles is the middle third of incubation (Yntema and Mrosovsky, 1982). When the mechanism of scute abnormality is better understood, it could help conservation biologists in making choices to move eggs. However, we recommend the in situ protection of nests not only because of high percentages of scute deviation but also because of high percentages of nest success obtained (Carretero-Montes and Trejo-Robles, 2000), and the natural sex ratio of hatchlings is maintained (Boulon, 1999).

Acknowledgment

This study is part of a UNEP project coordinated by the Department of Environmental Protection of Northern Cyprus. The authors would like to thank Asaf Şenol, Hakan Efendi, Hasibe Kusetoğullları and biology students from Adnan Menderes University for their contributions during the field study.

References

Boulon, R.H. Jr. 1999. Reducing threats to eggs and hatchlings: in situ protection. In: Research and Management Techniques for the Conservation of Sea Turtles (ed. K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donelly), IUCN/SSC Marine Turtle Specialist Group, Publ. No. 4, pp. 169-174.

Carretero-Montes, R.E. and Trejo-Robles, J.A. 2000. Hatching and emergence of *Lepidochelys olivacea* from protected and unprotected nests in La Gloria (Playón de Mismaloya), Jalisco, México: 1991-1994. In: Proceedings of the 8th International sea turtle symposium (Eds. F.A. Abreu-Grobois, R. Briseño -Dueňas, R. Márquez and L. Sarti) NOAA Tech Memo NMFS 436: 1-184.

Deraniyagala, P.E.P. 1939. The tetrapod reptiles of Ceylon, I. Testudinates and Crocodilians. Colombo Museum, Colombo, Ceylon.

Ewert, M.A. 1979. The embryo and its egg: development and natural history, In: Turtles: Perspectives and Research (ed. M. Harless and H. Morlock), New York, pp. 333–413.

Gadow, H. 1899. Orthogenetic variation in the shells of Chelonia. In: Zoological results based on material from New Britain, New Guinea, Loyalty islands and elsewhere, collected during the years 1895, 1896, and 1897 (ed. A. Willey), part 3. p. 207-222.

Hewavisenthi, S. and Kotagama, S.W. 1989. Carapace scute variation in Olive Ridley (*Lepidochelys olivacea*) hatchlings from a Turtle Hatchery in Sri Lanka. Proceedings Sri Lanka Assoc. Adumt. Sci. 45: 75–76.

Hildebrend, S.F. 1930. Duplicity and other abnormalities in diamond-back terrapins. Journal of the Elisha Mitchell Scientific Society 46: 41–53.

Hildebrend, S.F. 1938. Twinning in Turtles. Journal of Heredity 29: 243–253.

Hill, R.L. 1971. Surinam turtle notes- 1. Polymorphism of costal and vertebral laminae in the sea turtle *Lepidochelys olivacea*. Stichting Natuurbehoud Suriname (Stinasu), Mededelingen 2: 1–9.

Limpus, C.J., Baker, V. and Miller, J.D. 1979. Movement induced mortality of loggerhead eggs. Herpetologica 35: 335–338.

Mast, B.R. and Carr, J.L. 1989. Carapacial scute variation in Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) hatchlings and juveniles. In: Proceeding of the First International Symposium on Kemp's Ridley Sea Turtle Biology. Conservation and Management. Texas A & M University Sea Grant College Program Galveston, p. 202-219.

Newman, H.H. 1906. The significance of scute and plate 'abnormalities' in *Chelonia*. Biological Bulletin 10: 68–114.

Parker, G.H. 1901. Correlated abnormalities in the scutes any bony plates of the carapace of the sculptured tortoise. American Naturalist 35: 17–24.

Seaturtle.org. Maptool. 2002. SEATURTLE.ORG, Inc. http://www.seaturtle.org/maptool

Suganuma, H., Horikoshi, K. and Tachikawa, H. 1994. Scute deviation of green turtle hatchlings from a hatchery in Ogasawara Islands, Japan. In Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, p. 148. NOAA Technical Memorandum NMFS-SEFSC-351.

Türkozan, O., Ilgaz, Ç. and Sak, S. 2001. Carapacial scute variation in loggerhead turtles, *Caretta caretta*. Zoology in the Middle East. 24:137-142

Yntema, C.L. 1976. Effects of incubation temperatures on sexual differentiation in hatchling loggerhead (*Caretta caretta*) incubated at different controlled temperatures. Herpetologica 36: 33–36.

Yntema, C.L. and Mrosovsky, N. 1980. Sexual differentiation in hatchling loggerhead (*Caretta caretta*) incubated at different controlled temperatures. Herpetologica, 36: 33-36.

Yntema, C.L. and Mrosovsky, N. 1982. Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. Canadian Journal of Zoology 60: 1012–1016.

Zangerl, R. 1969. The turtle shell, In: Biology of Reptilia. (ed. C. Gans), Volume 1: Morphology. London, pp. 311–339.

Zangerl, R and Johnson, R.G. 1957. The nature of shield abnormalities in the turtle shell. – Fieldiana, Geology, 341–362.