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Nesting and hatching success of the sea turtle *Caretta caretta* on Marathonissi island (Zakynthos, Ionian Sea, Greece)

George Skoufas

Technological Educational Institute, Department of Fisheries Technology and Aquacultures, N. Miltiadi 1, GR- 63200, N. Moudania, Greece

Corresponding author : Georges Skoufas, e-mail : gskoufas@hotmail.com

ABSTRACT. Nesting behaviour and hatching success of the sea turtle *Caretta caretta* (loggerhead) were studied on Marathonissi island in Zakynthos (Ionian Sea, Greece) during the summer of 1995. On this island there exist two discrete nesting areas : the North sector and the West sector. Nesting activity was greatest in both sectors during July. The number of nests was significantly higher in the North sector, whereas remarkably more attempts were observed in the West sector. Hatching success was also greater in the North sector where there were significantly more empty eggshells, mark of successful hatching, than in the West sector. Moreover, the number of dead embryos was significant in the West sector. The current study demonstrates a correlation between the choice of nesting area and hatching success.

KEY WORDS : *Caretta caretta*, loggerhead, hatching success, nesting behaviour, sea turtle.

INTRODUCTION

Caretta caretta (loggerhead or caouanne in French) is one of the two common sea turtle species in the East Mediterranean Sea. The other one is the green turtle, *Chelonia mydas*. The reproductive behaviour of loggerhead is not so clear while most of the existing data concern its nesting behaviour. *C. caretta* displays a wide geographical distribution, encompassing Mexico, Australia and the Mediterranean Sea. A typical characteristic of the loggerhead's nesting behaviour is migration (MEYLAN et al., 1983; HUGHES, 1989; LIMPUS et al., 1992). Scientific data obtained via tagging of the females during nidification (MARGARITOULIS, 1988a) as well as by examination of the mitochondrial DNA (BOWEN et al., 1994; LAURENT et al., 1993) enhance the hypothesis of the existence of different populations of *C. caretta*. The age of reproductive maturity is 22-26 years for the West Atlantic population (KLINGER & MUSIK, 1995) and more than 30 years for the Australian loggerhead population (BOWEN et al., 1994; LAURENT et al., 1993). Regarding the present study, the population nesting on the Greek beaches passes the winter months in Tunisia (LAURENT & LESCURE 1994). Only the adult females leave the sea so as to nest and their corresponding behavioural patterns have been described (HAILMAN & ELOWSON, 1992). During the same reproductive period the females nest more than once (HUGHES et al., 1967; WORTH & SMITH, 1976). Several studies have examined the factors implicated in juvenile mortality (PRITCHARD 1980; YNTEMA & MROSOVSKY, 1980; BLANCK & SAWYER, 1981; YNTEMA & MROSOVSKY, 1982; WYNKEN et al., 1988; HAYS & SPEAKMAN, 1993). The aim of the current study is to investigate whether a correlation exists between the females' choice of nesting site and the hatching success.

MATERIAL AND METHODS

Laganas bay in Zakynthos is one of the most important nesting places of the loggerhead *C. caretta*. The sites of the present study are located on the beaches of Marathonissi island. Seven discrete nesting beaches occur in Laganas bay : Laganas, Kalamaki, Theiafi, Sekania, Daphni, Gerakas and Marathonissi. Marathonissi is a small, uninhabited island in Laganas Bay, allowing all field observations to be carried without interference from anthropogenic activities (i.e. tourism). The nesting area of Marathonissi is dense and for the needs of this study was subdivided into two sectors : West sector and North sector (Fig. 1).

One nesting area, that of the North sector, was 200 m long and closer to the sea, comprising rocks and stones. Halophytic vegetation began at a distance of 150 m from the beach. The slope of the infralittoral zone was steep. A dense meadow of the phanerogam *Posidonia oceanica* was located close to the beach. The other area, that of the West sector, was 150 m long and narrower than that of the North sector. A dense meadow of the phanerogam *Cymodocea nodosa* at 0-2 m, as well as a deeper meadow of *P. oceanica* characterized the infralittoral zone. All field observations and consequent data collections were conducted between 28 May and 25 September 1995.

The first part of the study involved observation of the adult females, coming out to the beach so as to nest. The term "nest" was utilized to characterize the successful oviposition along with all the distinctive behavioural patterns. Occasionally, exit of the females from the sea was

followed by unsuccessful oviposition, attributed to various reasons. In this case, the term "attempt" was used to characterize such a behaviour. Observations were direct during the night watch, when animals were tagged, and indirect every morning via examination of tracks on the beach.

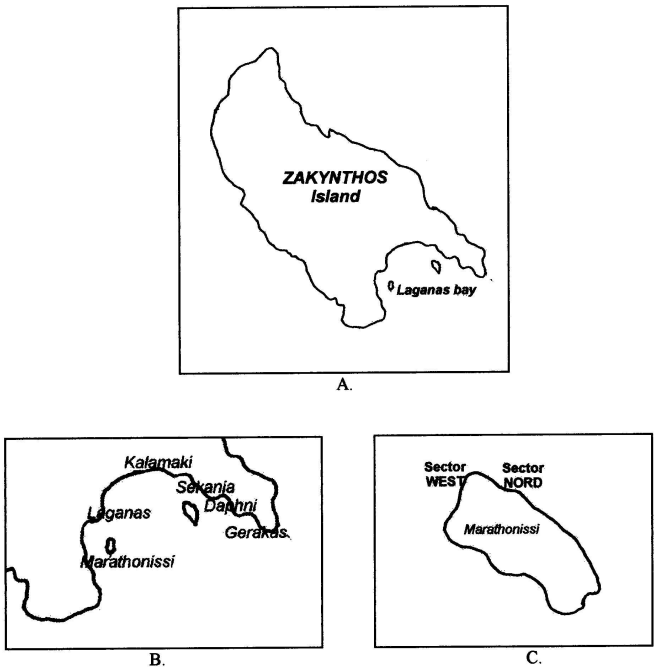

Fig. 1. – Map of the nesting areas on Marathonissi island in Zakynthos (A), Laganas bay with the potential nesting beaches (B) and Marathonissi nesting beaches (C).

Similar methods were applied during the second part of the study to estimate the hatching success, including indirect observations of the tracks of hatchlings and direct observations after excavation of the nests. Each nest excavation was carried out five days after the last tracks. Empty eggshells were characterized as successful hatching.

RESULTS

Nests and attempts were observed in both sectors. One of the factors influencing the hatching success was the distance of the nest from the sea. This distance was significantly greater in the North sector (24.6±7.6 m; n : 131) than in the West sector (20.9±7.5m; n : 97) (t-impaired : t=3.582, d.f. =226, $p<0.001$). As shown in Fig. 2, more nests were present in both sectors during July. However, the number of nests was significantly higher in the North sector than in the West sector during July (t-impaired : t=1.935, d.f. =73, $p<0.05$). Based on Fig. 3, the number of attempts was also greater in both sectors during July. In contrast to nests, significantly more attempts were observed in the West sector than in the North sector during July (t-impaired: t=3.426, d.f. =, $p<0.05$). As a general remark the percentage of nests was higher in the North sector (39% nests/61% attempts) than in the West sector (27% nests/73% attempts) during the nesting phase.

The second phase of the current study focused on hatching. The data demonstrated in Table 1 were collected via excavation of the nests five days after the last hatchlings' tracks. The time of the incubation period was practically the same in both sectors (t-impaired : t=1.1, d.f.=16, $p>0.05$). The mean incubation period was 72.0±8.4 days (n: 8) in the North sector and 66.0±13.4 days (n: 10) in the West sector. Another parameter not significantly different in the two sectors was the depth of the nest (t-impaired : t=-0.293, d.f. =37, $p>0.05$). The mean depth of the nest was 48.2±7.2 cm in the North sector and 48.8±5.3 cm in the West sector. As observed, all the hatchlings did not leave the nest at the same time. The period between the first and the last tracks was similar in the two sectors (t-impaired : t=-0.251, d.f.=37, $p>0.05$). Mean time of the hatchlings' exit from the nest was 5.2±1.8 days in the North sector and 5.4±3.8 days in the West sector.

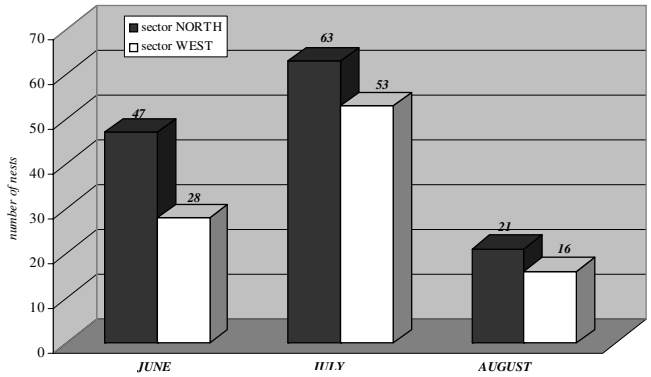

Fig. 2. – Number of nests in the North and West sectors on Marathonissi island (Zakynthos, Greece) during the summer of 1995.

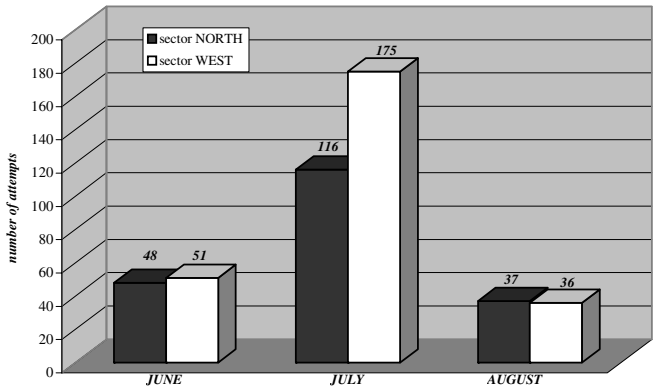

Fig. 3. – Number of attempts in the North and West sectors on Marathonissi island (Zakynthos, Greece) during the summer of 1995.

After nest excavation it was found that the number of eggs per nest was also not significantly different (t-impaired : t=-0.541, d.f. =37, $p>0.05$) in the two sectors. The mean number of eggs per nest was 127.4±19.8 in the North sector and 122.6±33.7 in the West sector. Nevertheless the number of empty eggshells, mark of successful hatching, was greater in the North sector than in the West sector (t-impaired : t=-2.498, d.f. =37, $p<0.05$). Moreover

there were more dead embryos in the West sector than in the North sector (t-impaired : t=-2.828, d.f. =37, p<0.05). Finally, the numbers of unfertilized eggs (t-impaired : t=-1.532, d.f. =37, p>0.05), of live embryos (only one, found in the West sector), of live hatchlings (t-impaired : t=0.082, d.f. =37, p>0.05) and of dead hatchlings (t-impaired : t=-1.544, d.f. =37, p>0.05) did not show significant differences between the two sectors.

TABLE 1

Hatching parameters in the North and West sectors on Marathonissi island (Zakynthos, Greece) during the summer of 1995.

	Sector NORTH (n :19)		Sector WEST (n :20)	
	mean±SD	min-max	mean±SD	min-max
Number of eggs per nest	127.4±19.8	88-172	122.6±33.7	76-238
Empty eggshells	97.7±33.6	13-143	70.9±33.3	14-120
Unfertilised eggs	24.3±24.0	0-86	39.3±36.0	0-125
Dead embryos	2.3±2.9	0-10	6.5±7.6	0-28
Dead hatchlings	1.6±2.1	0-7	4.3±7.2	0-26
Live hatchlings	1.5±2.7	0-11	1.4±2.9	0-11

DISCUSSION

Marathonissi island is one of the most important nesting beaches of Zakynthos, where, during the summer of 1995, 228 nests on 350 meters of beach length were observed. During this study the curve length of the adult females *C. caretta* was measured. Such results confirm the hypothesis of the presence of different loggerhead populations in the East Mediterranean Sea. The females of the loggerhead's Cyprus population are larger in size than the Greek ones (Broderick & Godley, 1996). In support of the morphological parameters the same hypothesis was confirmed by the examination of mitochondrial DNA (Bowen et al., 1994; Laurent et al., 1993).

The observations of the present study have shown that the period with the greatest nesting activity was July. Similar data were collected in Cyprus (Demetropoulos & Hadjichristophorou, 1989). However, respective observations on Turkish beaches in Mugla (Erk'akan, 1993) and in Fetihye (Baran & Türkozan, 1996) have demonstrated that the month with the highest nesting activity is June.

The mean number of eggs per nest observed in Marathonissi was 127.4 in the North sector and 122.6 in the West sector. These values were higher than those measured in Kyparisisa (Greece) 117.7 eggs/nest, (Margaritoulis, 1988b), in Israel 82 eggs/nest (Silbersetein & Dmi'el, 1991), in Turkey 82.9 eggs/nest (Baran & Türkozan, 1996) and in Cyprus 61.0 eggs /nest (Broderick & Godley, 1994). Based on bibliographic data, hatchlings show high mortality and it is estimated only 1/1,000 survives to adulthood (Frazer, 1986). It can be assumed that the increased number of eggs/nest in Marathonissi demonstrates a reproductive strategy. Such a hypothesis is enhanced by the percentage of successful hatching in both sectors of Marathonissi (empty eggshells/total of number eggs), being only 65.1%.

Sand temperature is one of the factors that influence the sex ratio and probably the hatchlings' mortality (Mrosovsky & Yntema, 1980). Temperature is also the major factor that affects the incubation period. The two nesting sectors in Marathonissi did not exhibit remarkable differences in the incubation time (Hays et al., 1992). Hatchling emergence, as has been observed in Cephalonia, is an asynchronous phenomenon (Houghton & Hays, 2001). In other nesting areas shorter incubation periods than that in Marathonissi have been observed, such as 55 days in Kiparissia (Greece) (Margaritoulis, 1988), 47.9 days in Cyprus (Broderick & Godley, 1994; Godley et al., 2001), 54 days in Israel (Silbersetein & Dmi'el, 1991) and 55.0 in Turkey (Baran & Turkozan, 1996).

Other studies on the neighboring island of Cephalonia demonstrate a positive linear relationship between the number of clutches into which eggs could be divided and the total time spent by nesting turtles on the beach, and hence a negative relationship between the time invested on the beach per egg and clutch size (Hays & Speakman, 1991). Body size of females was also positively related to the number of eggs laid and clutch volume (Hays & Speakman, 1992).

The current study showed that in both nesting areas in Marathonissi a correlation existed between the number of nests, the number of hatchlings and their mortality. Most likely factors, such as sand granulometry, humidity, presence of rocks and stones e.t.c. influence both nesting choice and successful incubation. Nevertheless, further investigation is required to establish the significance of this correlation, as well as to demonstrate the factors affecting nesting choice and hatching success.

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