This paper should be cited as:

Margaritoulis, D. (1983). The Inter-nesting Interval of Zakynthos Loggerheads. Pages 135-144 in Adaptations to Terrestrial Environments (eds. N. S. Margaris, M. Arianoutsou-Faraggitaki, R. J. Reiter), Plenum Press, New York.

THE INTER-NESTING INTERVAL OF ZAKYNTHOS LOGGERHEADS

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INTRODUCTION

Although sea turtles live almost all their lives in the sea, they depend on the terrestrial habitat for reproduction. Female turtles come on land for short periods to lay their eggs and hatchlings emerging from nests in the sand walk briefly on land before entering (probably forever if they are males) the marine habitat. Nesting occurs on specific beaches, the "nesting beaches" or "rookeries", where the majority of the female population converges during the nesting season.

The loggerhead sea turtle *Caretta caretta* (L.) nests in various beaches along the southern and western coasts of Greece, but the most important rookery seems to be on the island of Zakynthos. Nesting in Zakynthos concentrates on Sekania, a small beach on the southern coast (Margaritoulis, 1982). This is perhaps the last active rookery on the island, for the other beaches suffer high pressures from development and tourism. During the nesting season (June until August) female loggerheads come ashore at night and, following a stereo-typed behavior, excavate a nest in the sand where they deposit about 100 eggs.

Despite the fact that emerging females leave conspicuous tracks on beaches, it is not feasible to estimate exactly the size of the nesting population by counting tracks for two reasons. First, sea turtles quite often come ashore without laying, and second, they may nest more than once in the same season.

Non-nesting emergences vary from a simple walk on the beach with no excavation to a series of nearly completed nests. The reason

for a non-nesting emergence is not always clear. Sometimes, various obstructions may hinder nesting,but often the turtle returns to the water for no apparent cause. However, it is not always easy to distinguish a non-nesting emergence from a nesting one by inspecting the spoor. This is mainly caused by the number of superficial excavations a turtle may make in the course of an emergence, regardless of whether she is going to lay or not. As a matter of fact, even a seemingly straightforward nesting spoor does not provide one hundred per cent evidence that the turtle has laid.

It seems that fishermen and other people associated with sea turtles knew long ago that loggerheads, as all other species of sea turtles, may nest more than once in the same season (Mast, 1911; Carr, 1952). Multiple nesting in loggerheads, first verified by Caldwell et al. (1959) in Georgia, has been widely documented in most loggerhead rookeries around the world. As far as can be ascertained, in the Mediterranean region such work has been presented only for the southern coast of Turkey (Geldiay, 1980).

In Zakynthos the first evidence of multiple nesting was groups of unlaid eggs of several distinct sizes seen in the dissection of a turtle found dead on a nesting beach in 1978 (Margaritoulis, in press).

A long-term tagging program was initiated in the summer of 1982 to assess various parameters of Zakynthos loggerhead population. This paper presents mainly a preliminary result of the tagging effort: an estimation of the inter-nesting interval; i.e., the elapsed time between successive nestings of an individual during the same season.

METHODS

Tagging of the turtles started on 25 June and continued until the end of August when the number of emergences had decreased considerably. During this period patrolling was done on parts of the Western Peloponnesus coast in order to detect whether a turtle, tagged in Zakynthos, would appear on the Peloponnesus. Tagging and patrolling was done mostly by students working singly or in teams.

The tags used were monel self-piercing tags purchased from the National Band and Tag Company by the Hellenic Society for the Protection of Nature. Each tag bears a serial number and the Society's address to facilitate return.

Great care was taken to avoid disturbing the nesting females. For this reason tags were usually applied during or after oviposition when turtles exhibit the least sensitivity to disturbance. The tags were applied to the posterior edge of the left front

flipper and subsequently were carefully inspected to check whether the locking mechanism had properly clipped.

A nesting emergence was scored as successful only if eggs were actually seen. Turtles encountered during nest covering or during their return to the sea were recorded as "no data", although they might have nested.

To avoid confusion, dates during the study period were not changed after 24.00 h but were kept the same until dawn (06.00 h).

RESULTS AND DISCUSSION

One hundred forty-eight females were tagged on Zakynthos, 97% of them on Sekania beach. Twenty-five individuals from the group tagged on Sekania were seen again from 1 to 6 times (38 recaptures) on the same beach (Table 1). Eleven additional females were tagged during patrols of the Western Peloponnesus coast, but these animals, were never seen again. No turtles tagged on Zakynthos were encountered on the Western Peloponnesus coast.

Only successful nestings are taken into account in calculating the inter-nesting interval. Figure 1 shows the distribution of intervals preceding each of the fourteen recorded successful returns. The prominent group, including intervals from 13 to 20 days, has an arithmetic mean of 14.6 days and apparently represents the turtles which nested successfully for a second (observed) time. Inclusion in this group of turtle Z-719 which renested after 20 days is justified by its history (Table 1).

Turtles Z-274 and Z-859 were observed nesting three successive times at intervals of 14-15 days and 13-14 days respectively (Table 1). The two individuals which nested after 29 and 33 days of their previous observed nesting (Fig. 1) may also represent 3-time nesters, their intermediate nesting having been missed by the observers. Behavior of the individual which renested after an interval of 3 days (Fig. 1) will be explained below.

Apart from helping estimate the inter-nesting interval, tagging can provide valuable information on other aspects of turtle behavior. Although the observers were instructed to avoid approaching turtles during the initial stages of nesting (when the animals are most sensitive), it seems that some females were disturbed and returned to the sea without laying. Unfortunately, no record was kept of turtles that were clearly disturbed by people, and therefore, non-nesting emergences resulting from human disturbance cannot be distinguished from the others,sea turtles often make. In any case, from Table 1 it is seen that turtles which have returned to the sea without laying, usually come back to nest either the same night

Table 1. In-season recovery data of loggerheads tagged in Zakynthos

First tagged			Recaptures		
Tag No	Date tagged	Nest	Date	Days*	Nest
Z-251[a]	10.7.82	Yes	12.8.82	33	Yes
Z-255	10.7.82	Yes	10.8.82	31	No
Z-256	10.7.82	No	26.7.82	16	Yes
Z-261	11.7.82	Yes	30.7.82	19	?
Z-262	11.7.82	Yes	14.7.82	3	Yes
Z-267	11.7.82	Yes	28.7.82	17	?
Z-268	12.7.82	?	28.7.82	16	Yes
Z-274	12.7.82	Yes	26.7.82	14	Yes
			10.8.82	15	No
			10.8.82	0	Yes
Z-275	12.7.82	?	16.7.82	4	?
Z-279	13.7.82	Yes	11.8.82	29	No
			11.8.82	0	Yes
Z-282[b]	14.7.82	Yes	28.7.82	14	Yes
Z-286	16.7.82	?	23.8.82	38	Yes
Z-293	18.7.82	?	4.8.82	17	Yes
Z-300	22.7.82	Yes	5.8.82	14	Yes
Z-715	25.7.82	Yes	10.8.82	16	Yes
Z-719	25.7.82	Yes	11.8.82	17	No
			12.8.82	1	No
			12.8.82	0	No
			14.8.82	2	No
			14.8.82	0	No
			14.8.82	0	Yes
Z-790	3.8.82	Yes	5.8.82	2	?
			21.8.82	16	No
Z-814	5.8.82	No	5.8.82	0	No
			6.8.82	1	No
			6.8.82	0	Yes
Z-821	7.8.82	No	8.8.82	1	No
			8.8.82	0	No
Z-833	9.8.82	No	9.8.82	0	Yes
Z-851	12.7.82	Yes	26.7.82	14	Yes
Z-857	12.7.82	Yes	26.7.82	14	Yes
Z-859	13.7.82	Yes	26.7.82	13	Yes
			9.8.82	14	Yes
Z-869	15.7.82	Yes	28.7.82	13	Yes
Z-870	17.7.82	?	2.8.82	16	Yes

(*)days elapsed between emergences, (?)no data, (a)retagged with Z-838, (b)double tagged with Z-283 on the right front flipper.

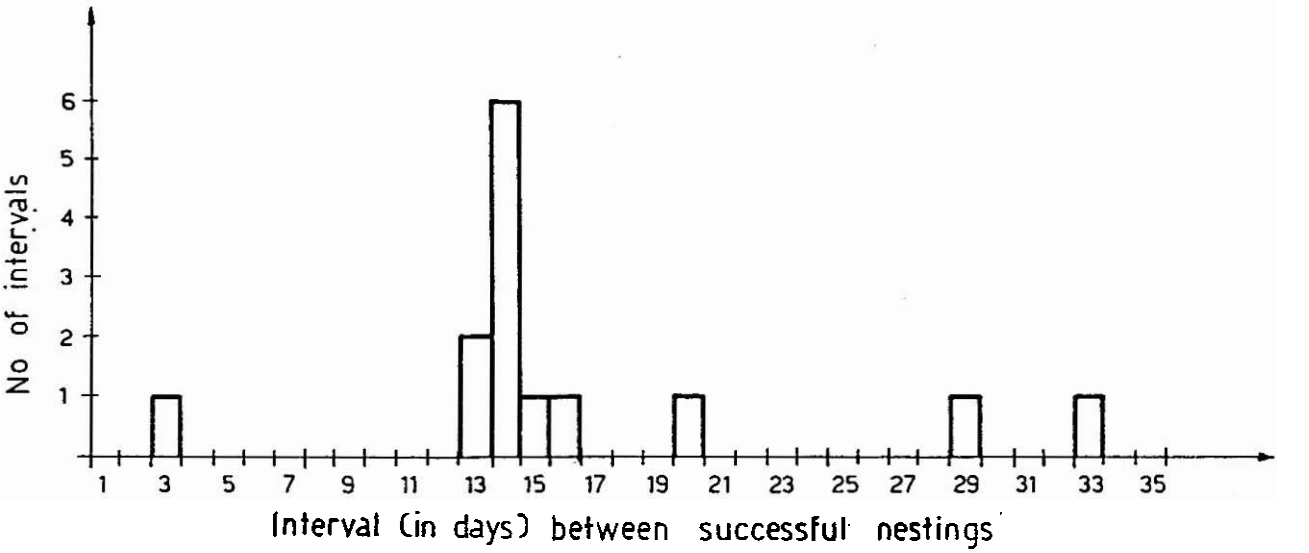

Fig. 1. Distribution of intervals preceding a successful nesting.

(3 cases) or on following nights (2 cases). The longest recorded interval between a non-nesting emergence and a nesting one was 3 days for turtle Z-719. This individual, tagged after egg-laying on 25 July, was observed in non-nesting emergences once on 11 August, twice on 12 August, and twice on 14 August, to nest again only after a third emergence on 14 August (Table 1). Turtle Z-275 might have exceeded this interval, emerging again after 4 days; but in both emergences there are no data to determine whether the individual nested or not. Hughes et al. (1967) have repeatedly disturbed an individual loggerhead which finally nested 11 days after the first observed non-nesting emergence.

Tag application greatly disturbed a number of turtles (N≈15), especially when done during oviposition. The usual reaction of the disturbed animals was an immediate interruption of egg-laying; oviposition usually resumed after a while. Some individuals, however, stopped laying and immediately covered the nest (although only superficially) and returned to the sea, presumably without having laid the full clutch. One of these turtles (Z-262) emerged again 3 days after the interrupted nesting and laid a small number of eggs, apparently the remainder of her clutch. Turtle Z-790 was tagged during oviposition and was disturbed to the point that she returned to the water so hastily the observers had to cover her nest. Her emergence 2 days later (although with an undetermined result) represents a probable continuation of the previously interrupted nesting. For this reason the recorded 3-day interval (Fig. 1) of the individual Z-262 was not included in the calculation. In the literature there are examples of loggerheads in Florida (2 cases) nesting twice in 2 days (Davis and Whiting, 1977; Worth and Smith, 1976) and in Georgia (1 case) in a non-nesting emergence 6 days

after a previous nesting (Caldwell et al., 1959). Although these authors do not state whether the animals were disturbed during the previously recorded egg-laying, it is thought that a second emergence after such a short interval might be a result of disturbance.

The calculated inter-nesting interval for Zakynthos loggerheads is comparable with those for other loggerhead rookeries with the exception of Turkey (Table 2). Existing data from Zakynthos are not enough to determine if the inter-nesting interval changes during the laying season. Hughes and Brent (1972) have suggested that sea temperature may affect egg ripening and therefore the inter-nesting interval of loggerheads in Tongaland, South Africa.

Considering that a non-nesting emergence is an indication of an imminent nesting, the observed total number of nests per female is as much as these: two individuals (Z-274 and Z-859) were recorded nesting three successive times and it is possible that four others (Z-251, Z-255, Z-286 and Z-279) were also 3-time nesters (4% of the tagged animals), fourteen turtles (9.5%) deposited probably two clutches each, and the remaining 128 individuals (86.5%) laid probably one clutch each.

Although the laying season in Zakynthos lasts for about 90 days which could accommodate as many as 6 nestings of one female it is improbable that this number of nests was made by any individual. Nesting activity in Zakynthos increases during June, reaches a maximum in the first two weeks of July, and then falls off gradually to end in August (Margaritoulis, unpublished data). This nesting pattern and the above findings suggests that most turtles do not nest throughout the entire season but for only a part of it. Further evidence is provided by the declining probability of recaptures as the nesting season progresses. Intense tagging on Zakynthos began on July 10th; i.e., during the second half of the nesting season. It is seen from Table 3 that the majority of recaptures (37%) are individuals tagged at Sekania during the interval 10-14 July which coincides with the peak in nesting activity. Thereafter, the percentage of recaptures decreases rapidly, presumably as the turtles depart from the breeding area.

The overall recapture rate of the present study (≃17%) compared to similar investigations in other localities (Hughes and Brent, 1972; Talbert et al., 1980) is considered low. This cannot be attributed to relocation of in-season nesting on Zakynthos since the other available beaches on the island are subject to heavy disturbances which discourage most nesting activity. Relocation of nesting in areas outside Zakynthos seems also unlikely according to the evidence provided by the patrols on the Western Peloponnesus coast. Assuming that Zakynthos loggerheads nest as many times per season as logger-

Table 2. Inter-nesting intervals of loggerhead populations in Zakynthos and in other localities

Locality	Source	Inter-nesting interval (in days)	
		Mean	Range
Zakynthos, Greece	present study	14.6	13-20
Köycegiz, Turkey	Geldiay, 1980	23.4	18-28
South Carolina, USA	Talbert et al., 1980	13.0	
Georgia, USA	Caldwell et al., 1959		12-15
Hutchinson, Florida, USA	Worth and Smith, 1976	14.0	11-17
Everglades, Florida, USA	Davis and Whiting, 1977	12.0	
Buritaca, Colombia	Kaufmann, 1975	15.0	13-20
Tongaland, S. Africa	Hughes and Brent, 1972	15.2*	
Queensland, Australia	Bustard, 1972	15.0	12-17

*Arithmetic mean calculated from values given by the authors for the seasons 1969/70-1970/71-1971/72.

Table 3. Numbers of turtles tagged during 5-day intervals and numbers (and percentages) recaptured subsequently during the 1982 nesting season at Sekania, Zakynthos

Dates	Turtles tagged	Turtles subsequently recaptured during the season (%)
10.7-14.7	38	14 (37%)
15.7-19.7	19	4 (21%)
20.7-24.7	9	1 (11%)
25.7-29.7	22	2 (9.1%)
30.7- 3.8	10	1 (10%)
4.8- 8.8	27	2 (7.4%)
9.8-13.8	13	1 (7.6%)
14.8-18.8	5	0
19.8-23.8	1	0
24.8-28.8	0	0
Total	144	25 (17%)

heads in other localities, the observed low recapture rate is probably an articraft due to the late beginning of tagging.

Multiple nesting represents a tremendous metabolic and physiological effort to the turtle (Ulrich and Parkes, 1978). Assuming that a loggerhead makes 4 nests of 100 eggs each and each egg weighs 40 g, over a period of 60 days a medium-sized loggerhead could deposit the equivalent of 1/6 of her body weight in the form of eggs. The survival value of such an effort is evident considering that loggerheads, as other sea turtles, may migrate thousands of miles between their rookery and feeding grounds (Bustard and Limpus, 1970; Bustard and Limpus, 1971; Hughes, 1974). The risk involved in such long travels is probably manifested by the irregular remigration patterns and by the fact that a great percentage (40-50%) of loggerheads may nest only during one season in their lifetime (Hughes, 1976).

ACKNOWLEDGEMENTS

Financial assistance for the program was provided by the Greek Ministry of Physical Planning, Housing and the Environment. The Hellenic Society for the Protection of Nature bought the tagging equipment.

Especial thanks are due to Dr. Jack Frazier of the Smithsonian Institution who provided his expert "know-how" in solving various problems and who with S. Salas tagged many turtles. Dr. J. Frazier

made also many valuable comments on the manuscript.

I am grateful to Prof. N.S. Margaris of the Laboratory of Ecology, University of Thessaloniki for his continued encouragement.

My personal thanks to the dedicated students who did most of the tagging and patrolling of the beaches: D. Botsea, M. Gaethlich, K. Kalogirou, P. Kanellopoulos, E. Karanatsidis, A. Kotitsas, L. Loukas, K. Moraitis, M. Papoutsa, E. Roidou and A. Tselepidis.

The work at Zakynthos received the friendly and helpful interest of the Prefecture of Zakynthos and of many local citizens to whom I am grateful.

Finally, I am indebted to Helen O'Keefe for her editorial assistance.

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