BODY TEMPERATURE OF THE LOGGERHEAD SEA TURTLE *CARETTA CARETTA* AND THE LEATHERBACK SEA TURTLE *DERMOCHELYS CORIACEA* DURING NESTING

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ABSTRACT

Body temperatures of loggerhead and leatherback turtles recorded during nesting excursions were found to be greater than sea temperatures. Leatherback turtles exhibited greater temperature differentials (5,3 - 6,25°C) than loggerhead turtles (1,9 - 3,22°C).

The possibility that leatherback turtles may have a preferred temperature range (30 - 32°C) as is the case in terrestrial chelonians is discussed. Recordings of exhaled air temperatures suggest that leatherback turtles may employ a countercurrent heat exchange system in the nares in order to conserve body heat.

INTRODUCTION

The thermal relations of marine turtles are of interest, since only the adult females emerge from the sea during the nesting season. Despite this, records of body temperatures obtained at these times reflect considerable temperature differentials between the turtles and their environment. Although terrestrial 'basking' has been reported for juvenile green turtles (Balazs & Ross 1974), the other species appear to be totally aquatic.

Mean body temperatures of 30,6; 29,7 and 28,7°C have been reported for the leatherback turtle, *Dermochelys coriacea L.*, the green turtle, *Chelonia mydas L.* and the olive ridley *Lepidochelys olivacea L.* respectively, after emerging from water of 27,5°C to nest (Mrosovsky & Pritchard 1971). Smaller but significant temperature differentials have been reported for green and hawksbill turtles by Hirth (1962).

Records of body temperatures of free-ranging animals are scarce; the only record being that of Friar *et al.* (1972), who reported a body temperature of 25,5°C from a 417 kg leatherback turtle removed from water of 7,5°C.

Leatherback turtles possess both countercurrent heat exchange retia at the base of the flippers and a subepidermal fat layer (Greer *et al.* 1973). Adaptations of this nature suggest an ability to retard heat loss to a cold aquatic environment.

In view of the large temperature differentials observed between T_b and T_a in leatherback turtles, Pritchard (1969) suggested that they may be endothermic. Mrosovsky & Pritchard

(1971), on the other hand, suggested that the large mass and relatively small surface area of these animals might favour the retention of body heat without necessarily invoking endothermy and the implied increased metabolism associated with this state.

Hirth (1962) has further suggested that the elevated body temperatures of sea turtles observed during nesting, may be due to metabolic heat production in response to muscular activity associated with hauling out onto the beach and nest-digging.

The present study reports on body temperature of the leatherback turtle *Dermochelys coriacea* and the loggerhead turtle *Caretta caretta L.* during nesting, after emerging from sea water of a temperature 3 to 4° C below that previously reported for the leatherback and other species (Mrosovsky & Pritchard 1971).

MATERIALS AND METHODS

Data obtained in this study were collected during two field excursions to the Tongoland turtle nesting beaches in northern Zululand during early December and early January 1974/75 (for location, see Hughes 1974).

Body temperatures of adult leatherback and loggerhead females were recorded with the aid of a thermistor probe inserted through the cloaca. By applying gentle pressure, it was possible to insert the probe into the large intestine to a depth of 42,0 $\pm$ 8,8 cm in the leatherback turtles and 34,7 $\pm$ 9,2 cm in the loggerhead turtles. In most cases, once the tip of the probe had negotiated the cloacal sphincter, little difficulty was experienced in inserting it to greater depths.

The probe consisted of a thermistor bead (Victory model 35A18) mounted in the aperture of an 80 cm length of stiff yet flexible polythene piping, 1,7 cm in diameter. The thermistor bead was mounted in position using a plug of silastic aquarium sealer (Dow Corning), in such a way that the bead protruded. The thermistor lead was run through the centre of the piping and connected to a portable, laboratory-constructed, Wheatstone bridge circuit. Deflections of an ammeter indicated changes in thermistor resistance with temperature. The readings were transposed to temperature by reference to a previously prepared calibration curve. Calibration checks were carried out against sea water samples of known temperature at the end of each set of body temperature recordings. In this way, recorded temperatures were accurate to within 0,5° C.

Due to the large bulk of the leatherback turtles, the probe was inserted while the animals were upright by grasping the tail and lifting it. In the case of the loggerhead turtles, the animals were flipped over onto the carapace before inserting the probe.

Sea temperatures were recorded in the immediate vicinity of beaching, together with sheltered air temperatures. No wet bulb temperatures were recorded. Skin temperatures at the base of the fore-flippers were recorded on most occasions. On three occasions, egg temperatures were recorded by catching the eggs as they dropped from the cloaca and immediately inserting the probe into the egg substance by rupturing the egg shell. In these cases, eggs were collected towards the end of a laying bout. Three rough measurements of exhaled air temperatures were recorded by holding the probe tip just in front of the nostril during exhalation.

RESULTS

Data obtained for the two species during the December and January excursions are shown in Tables 1 and 2. Leatherback turtles were clearly able to maintain larger temperature differentials between the body and the surroundings than were loggerhead turtles.

For both species, mean body temperatures during December were found to be greater than the mean values recorded during January. For *D. coriacea*, the difference in means was

TABLE 1

Data obtained during nesting of the leatherback turtle, *D. coriacea*.
JE, just emerged; -, emerged but had not nested; +, excavating nest or laying eggs; △ T, body temperature minus sea temperature

Month	No.	Nest	Time in hours	Recording depth (cm)	Body temp. (°C)	Sea temp. (°C)	△T°C.
DECEMBER 1974	E. 134/135	-	0030	31,0	33,0	25,75	7,25
	—	+	0215	30,5	31,25	25,0	6,25
	E. 139/140	+	0245	41,0	31,75	25,0	6,75
	D. 73/74	+	0200	45,5	31,25	25,25	6,0
	E. 145/146	+	0400	43,0	30,00	25,0	5,0
	MEAN ± SD			38,0 ± 6,70	31,45 ± 1,08	25,2 ± 0,33	6,25 ± 0,85
JANUARY 1975	E. 139/140	+	0130	52,5	30,60	23,25	7,35
	E. 322/323	+	0115	46,0	27,00	24,00	3,0
	A. 925/E. 237	+	0200	44,0	29,00	24,00	5,0
	E. 159/160	+	0110	55,0	29,25	24,75	4,5
	E. 97/ 98	+	0130	52,0	29,50	24,75	4,75
	E.332/333	+	0145	44,0	29,50	24,75	5,25
	E.334/335	-	0225	52,0	30,00	24,50	5,50
	E. 53/ 54	JE	0345	32,0	30,50	24,75	5,75
	E.286/287	+	0300	31,5	30,50	24,50	6,00
	E.336/337	+	0315	31,5	30,25	24,50	5,75
	MEAN ± SD			44,05 ± 9,32	29,60 ± 1,08	24,3 ± 0,47	5,3 ± 1,12

1,85°C, while for *C. caretta* this value was 2,75°C. Sea temperatures during January 1975 were 0,9 to 1,3°C lower than those recorded during December 1974. Body temperature increased with increasing depth of insertion of the probe. For the leatherbacks, a constant temperature was reached at a mean depth of 15,9 ± 6,0 cm (n=7), while this depth for a single observation on a loggerhead was 16,0 cm.

Egg temperatures were found to be 1,25 and 1,5°C lower than body temperatures of the respective loggerhead females, while the single egg temperature recorded for the leatherback turtle was 1,3°C below that of the body.

Skin temperature at the base of the fore-flippers in all cases exceeded air temperature. However, the observations during December showed that for leatherback turtles, mean skin temperature was 1,55 ± 1,05°C (n=5) above that of seawater, while for loggerheads this value was 1,0 ± 0,5°C (n=2). In January these values were 0,94 ± 0,96 (n=9) and 2,0°C (n=2) below water temperature respectively.

Mean body temperature was 4,7 ± 0,27°C (n=5) higher than skin temperature for leatherbacks during December and 6,3 ± 1,77°C (n=9) during January. Equivalent values

TABLE 2

Data obtained during nesting of the loggerhead turtle, *C. carreta*.
JE, just emerged; –, emerged but had not nested; +, excavating nest or laying eggs; △T, body temperature minus sea temperature

Month	No.	Nest	Time in hours	Recording depth (cm)	Body temp. (°C)	Sea temp. (°C)	△T°C.
DECEMBER 1974	E. 100	–	2330	28,0	26,75	25,00	1,75
	E. 63	+	2400	27,0	29,50	25,00	4,50
	E. 136		0045	30,5	27,75	25,00	2,75
	E. 141	–	0335	30,0	28,25	25,00	3,25
	E. 142	+	0105	40,0	28,50	25,00	3,50
	E. 143	–	0130	36,5	27,25	25,25	2,00
	E. 16	JE	0235	34,5	29,00	25,00	4,00
	E. 144		0315	26,5	29,00	25,00	4,00
	MEAN ± SD			31,62 ± 4,88	28,25 ± 0,95	25,0 ± 0,09	3,22 ± 0,99
JANUARY 1975	E. 283		0035	31,50	24,6	23,5	1,1
	E. 114		0215	59,00	25,0	23,0	2,0
	A. 721		0010	38,00	27,0	24,5	2,5
	MEAN ± SD			42,8 ± 14,37	25,5 ± 1,29	23,7 ± 0,76	1,9 ± 0,71

for loggerheads were 3,0 $\pm$ 0,71 (n=5) and 3,8 $\pm$ 0,99 (n=2) respectively.

On the two occasions that exhaled air temperatures were recorded from leatherback turtles, the temperatures were 4,5 and 5,0°C lower than body temperature and 4,8 and 2,25°C above air temperature respectively. A single record from a loggerhead turtle showed exhaled air temperature to be 4,0°C below body temperature and 2,0°C above that of the air.

DISCUSSION

It is clear from the results obtained that both leatherback and loggerhead turtles are able to maintain body temperatures considerably greater than the temperature of the water in which they occur. This is particularly evident in the case of the leatherback turtle in which the maximum temperature differential observed was 7,35°C, while in the loggerhead, the value was 4,50°C.

Mrosovsky & Pritchard (1971) reported a mean temperature differential of 3°C for leatherback turtles emerging from water of 27,5°C. Mean body temperature was 30,6°C while the maximum body temperature was 31,25°C. These results are in close agreement with the present data, although body temperatures recorded during December were higher, with a maximum of 33,0°C, while those recorded during January were lower on average (Table 1).

In the present study, water temperatures were 2 to 3°C below those recorded by Mrosovsky & Pritchard (1971), yet mean body temperatures were similar. This suggests that the leatherback turtle may have a preferred body temperature or temperature range in the region of 30 to 32°C, and that these animals are able to maintain this level despite small fluctuations in water temperature. It is of interest here, that these values are similar to the preferred body temperatures of many semi-aquatic and terrestrial Chelonia (Cloudsley-Thompson 1971). The report of a body temperature of 25,5°C in a leatherback turtle removed from water at 7,5°C suggests that this ability may decrease with greater decreases in water temperature.

That body temperature in sea turtles may be elevated in response to muscular activity associated with hauling out onto the beach and nesting (Hirth 1962), was not supported by the present observations. Reference to Tables 1 and 2 shows that body temperatures recorded from animals which had just emerged from the water were at least as great as those recorded from animals in the process of nest digging. In this respect, the highest body temperature recorded for a leatherback turtle (E 134/135) was from an animal that had emerged, but was still close to the water's edge, and had not yet nested.

It has been demonstrated in this laboratory that juvenile loggerhead, hawksbill and green turtles are able to absorb infra-red radiation through the carapace while partially immersed in water (Sapsford, unpublished data). It has further been shown that a loggerhead turtle (42 kg) was able to raise its body temperature 4°C above water temperature utilizing solar radiation while voluntarily floating at the surface of a large outdoor marine aquarium

(Sapsford & Van der Riet, unpublished data). In this respect, the present observations on the loggerhead and leatherback turtles during the two excursions are of interest. During December, the weather was warm and sunny and the sea surface calm, while during January, fairly heavy seas were encountered, the weather was overcast for most of the time and air temperatures considerably lower. Sea temperatures recorded during this time were approximately 1°C lower on average than those recorded in December, yet mean body temperature for leatherback turtles was 1,85°C below that for December. For the loggerhead, this value was 2,78°C.

It seems unlikely that decreases in body temperature of this magnitude would have resulted from a difference in sea temperature of 1°C and it may be suggested that if adult sea turtles are capable of utilizing solar radiation as a heat source by basking at the surface (Sapsford & Van der Riet, unpublished data), then choppy seas would reduce the efficiency of basking and body temperatures might decrease as a result. If this is valid, then the greater decrease in loggerhead mean body temperature during January when compared with that for leatherbacks suggests that turtles of small bulk, such as the former, may be affected to a greater degree. In this respect it is of interest to note that the nesting incidence of loggerhead turtles during the January excursion was greatly reduced relative to the December excursion, despite the fact that the breeding season extends into February (Hughes 1974).

The observation that skin temperatures at the base of the fore-flippers were higher than the temperature of the water for both species during December and lower than the water during January, probably reflects the evaporative cooling effect of wind encountered on the second excursion. This decrease is reflected in the greater body : skin temperature gradients exhibited during January.

Since the surface area to mass ratio of the leatherback turtle is considerably smaller than for the loggerhead turtle, and in view of the length of time spent on the beach during nesting, it is conceivable that cool windy conditions may reduce body temperature and result in greater temperature decreases in loggerheads than in leatherbacks. It is, however, clear that during January body temperature in both species was consistently lower than during December, even in animals that had just emerged from the sea. In this light, evaporative cooling effects on land may not be of great importance as a determinant of core body temperature.

It has been reported that in some lizards, a countercurrent heat exchange principle is employed in the nasal sinuses for purposes of water economy (Murrish & Schmidt-Nielsen 1970). On the strength of the observations for leatherback and loggerhead turtles in which exhaled air temperature was considerably lower (4 and 5°C respectively) than body temperature and higher than air temperature, it may be tentatively suggested that sea turtles employ a similar mechanism for heat conservation, and that heat exchange in the nares during respiratory activity may contribute further to the adaptations of animals with a chronic heat conservation problem.

Egg temperatures recorded for both species were found to be lower than body temperatures and in this respect the results differ from those of Mrosovsky & Pritchard (1971) who showed that egg temperature was a good reflection of deep core temperature in various species, including the leatherback turtle. The thermistor probe used in this present study, however, exhibited a fairly long time constant for equilibration and it is possible that the eggs had cooled to some degree before stabilization of the probe.

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