Cloacal temperature change in loggerhead (*Caretta caretta*) sea turtles in response to changes in ambient temperature

by

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Abstract. — Cloacal temperatures of juvenile loggerhead sea turtles (*Caretta caretta*) were recorded before and after the turtles were transported out of water on two separate occasions. Ambient temperatures were monitored and analyzed for each transportation period. Mean ambient temperature of the transportation period was significantly different ($P < 0.05$) between the two transports. A statistically significant ($P < 0.05$) mean change in cloacal temperature was observed for each transportation (-0.2 °C and -1.8 °C).

INTRODUCTION

Annually, the National Marine Fisheries Service (NMFS) Galveston Laboratory transfers sea turtles from Galveston, Texas to Panama City, Florida by United States Coast Guard (USCG) aircraft to be used in turtle excluder device (TED) certification trials (Robertson and Cannon, 1997). During this transfer, the ambient temperature aboard the aircraft can be lower than the ambient temperature the turtles are exposed to prior to and after the flight. There was concern that the turtles' body temperatures might fall during transfer and stress the turtles. We examined cloacal temperatures of

loggerhead (*Caretta caretta*) sea turtles before and after the flight to determine whether or not cloacal temperature changed.

METHODS

Captive-reared, 21 month old loggerhead sea turtles obtained in August 1995 as hatchlings from Clearwater Marine Science Center, Clearwater, Florida were used for this study. Five turtles were randomly selected for the 23 May 1997 transportation period and 7 turtles were randomly selected for the 20 June 1997 transportation period (Tables 1 and 2). Straight carapace lengths and body weights were recorded prior to transfer for all test turtles (Tables 1 and 2).

The transportation period consisted of three phases: packing and loading, flight, and unpacking. The amounts of time required for each phase and for the entire transport period were recorded (Table 3). The packing and loading phase involved taking turtles out of the rearing tanks and placing them into plastic shipping containers lined at the bottom with wet polyurethane foam. The shipping containers were 81cm X 48cm X 41cm and had holes for ventilation. The containers were then loaded onto trucks and transported to Scholes Field, Galveston, Texas. A USCG C-130 aircraft, stationed at Clearwater, Florida, flew the turtles from Galveston to Panama City International Airport, Panama City, Florida. After the flight phase, the turtles were unloaded onto trucks and driven to the NMFS Panama City Laboratory where they were placed into holding tanks filled with sea water.

Fast-reading, cloacal, mercury thermometers (Miller and Webber™, accuracy ± 0.2 °C) were inserted only 5 cm (due to the small size of the turtles) into the cloaca of each turtle to measure its body temperature. For the 23 May transfer, the cloacal temperatures were measured as soon as the turtles were removed from the holding tanks, and for the 20 June transfer, 40 minutes after the turtles were removed from the holding tanks. At the end of the transfers and prior to being placed into the holding tanks at the NMFS Panama City Laboratory, cloacal temperature was again measured in each turtle. Cloacal temperatures were not measured during the flight. The changes in cloacal temperatures of the turtles were calculated and tested for normality and were found to be normally distributed (Tables 1 and 2). The mean difference in cloacal temperatures was then determined, and a paired t-test was performed to determine if it was significantly different ($P < 0.05$) from zero.

Three StowAway® XTI temperature loggers (accuracy ± 0.01 °C) were programmed to record ambient temperatures every 10 minutes during the transportation. The temperature loggers were first placed in the rearing tanks so that water temperature could be measured and were removed with the turtles. Each temperature logger was then placed in a shipping container with a turtle. Ambient temperatures included the water temperatures of the rearing tanks when the turtles were removed and the air temperatures of the trucks and aircraft during transfer. A mean ambient temperature was calculated from the three temperature loggers for each 10 minute recording interval. A comparison of the ambient temperatures during the two

transportation periods was conducted to determine if they differed significantly, using analysis of variance.

A comparison between temperatures measured by the cloacal thermometers and temperature loggers was made. The cloacal thermometers and the temperature loggers were placed in a bucket of water and temperature readings compared. The thermometers and the temperature loggers recorded the same temperatures.

RESULTS

23 May transportation period. — Prior to the flight, the mean cloacal temperature was 26.0 °C with a range of 25.8 - 26.2 °C (Table 1, Fig. 1). The mean cloacal temperature after the flight was 25.8 °C with a range of 25.4 - 26.0 °C (Table 1, Fig. 1). The mean difference in cloacal temperatures (-0.2 °C) of the turtles prior to and after the flight was significantly different from zero ($P = 0.022$). The elapsed time between cloacal temperature readings before and after the flight was 420 minutes.

The range in ambient temperatures illustrates the wide fluctuations experienced during the 23 May transfer (Fig. 1). The flight phase produced the lowest ambient temperatures, and was immediately followed by the highest temperatures which were observed during the unpacking phase (Fig. 1). Between these two phases a change in ambient temperature from 19.39 °C to 28.44 °C occurred within 80 minutes (Fig. 1). Overall, the mean ambient temperature for this entire transportation period was 25.06 °C, with a range of 19.39 - 28.99 °C (Table 3).

20 June transportation period. — Prior to the flight, the mean cloacal temperature was 26.4 °C, with a range of 25.6 - 27.0 °C (Table 2, Fig. 2). The mean cloacal temperature after the flight was 24.6 °C, with a range of 24.0 - 26.0 °C (Table 2, Fig. 2). The mean difference in cloacal temperatures (-1.8 °C) of the turtles prior to and after the flight was significantly different from zero (P = 0.0001). The elapsed time between cloacal temperature readings before and after the flight was 420 minutes.

The 20 June transfer experienced a large fluctuation in ambient temperatures throughout the transport (Fig. 2). The lowest temperatures were during the flight phase, and the highest immediately followed during the unpacking phase (Fig. 2). This change (18.74 °C to 28.99 °C) occurred within 160 minutes (Fig. 2). The mean ambient temperature for this entire transportation period was 24.04 °C, with a range of 18.74 to 29.54 °C (Table 3).

Comparisons between the transportation periods. — The mean difference in cloacal temperatures (-0.2 °C and -1.8 °C) was significantly different (P = 0.0001) between the two transportation periods. Therefore, a comparison of ambient temperatures in the two transportation periods was performed. Significant differences in mean ambient temperatures were observed between the two transportation periods for the packing and loading phase, for the flight, and for the entire transport period (Table 4). A significant difference was not observed for the unpacking phase of the two transports (Table 4). The 20 June transport experienced significantly lower temperatures for the first 390 minutes of the transfer than in the 23 May transport. The

lower temperatures during this period may have accounted for the difference in mean cloacal temperature change that was observed between the two transports.

DISCUSSION

In previous studies, sea turtles have been observed maintaining body temperatures several degrees higher than surrounding ambient water and air temperatures (Mrosovsky and Pritchard, 1971; Frair et al., 1972; Spotila et al., 1979; Heath and McGinnis, 1980; Mrosovsky, 1980; Sato et al., 1994). Friar et al. (1972) concluded that leatherback sea turtles (*Dermochelys coriacea*) due to their large size retain heat from muscular activity. Mrosovsky and Pritchard (1971) measured body temperature of olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*) and leatherback sea turtles at a nesting beach and found that all three had body temperatures above ambient temperatures, with the leatherback having the greatest difference. Heath and McGinnis (1980) found that body temperatures above ambient temperatures were similar for juvenile (2-4 kg) and adult (50-60 kg) green sea turtles. Sea turtles can also maintain body temperatures above ambient temperatures during periods of inactivity (Heath and McGinnins, 1980).

In our study, the turtles were exposed to a wide range in ambient temperatures in a relatively short period of time while being transported out of water. Sea turtles in the wild might experience such dramatic fluctuations in ambient temperatures when

making deep dives in waters that are thermally stratified or when coming onto a beach to nest.

A significant cloacal temperature change was observed for each transport. The change in cloacal temperature was more pronounced for the transportation period on 20 June (-1.8 °C compared to -0.2 °C), and there are several explanations. The packing and loading phase had a significantly lower mean ambient temperature (25.34°C; Table 4). The flight was 40 minutes longer, and the mean ambient air temperature (21.60 °C) was significantly lower during the flight (Table 4). The mean ambient temperature (24.04 °C) for the entire transportation period was significantly lower (Table 4).

For the change in cloacal temperatures observed in this study, there are several explanations. The longer period of time exposed to lower ambient temperatures than to higher ambient temperatures. The turtles were inactive during the transportation period, so they probably did not generate much metabolic heat. The wet polyurethane foam that the turtles were shipped on cooled as the ambient air temperature dropped and may have encouraged heat loss in the turtles in contact with it. Heath and McGinnis (1980) measured heat loss of green sea turtles and discovered that the greatest loss of heat is around the soft white skin of the neck, the proximal area of the flippers, and the plastron. The wet polyurethane foam that lines the shipping container was in direct contact with these body regions.

Mrosovsky (1980) indicated that a probe inserted only 6 cm into a cloaca of an adult sea turtle does not record deep body temperature. We do not know if the cloacal

temperatures recorded at a 5 cm depth in this study was an accurate measurement of deep body temperature in small juvenile loggerheads. However, we believe that at a 5 cm depth the cloacal temperature can reflect the effects of ambient temperature on juvenile loggerhead sea turtles, and we assume that deep body temperature change would lag behind cloacal temperature change. We also would assume that, at a depth less than 5 cm, the cloacal temperature would be influenced more by ambient temperature than at a greater than 5 cm depth.

The results of this study indicate that a change in cloacal temperature of juvenile loggerhead sea turtles occurred during changes in ambient air temperatures associated with various phases of transport. We feel that the cloacal temperature change observed in this study was not stressful to the turtles even though a wide range in ambient temperatures was observed during this short period of time.

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Table 1. Cloacal temperatures (°C) before and after the flight and mean difference in cloacal temperature, for the transportation period on 23 May 1997. Straight carapace length and weight were recorded prior to transfer.

Tag code	Straight carapace length (cm)	Weight (kg)	Cloacal temp. before flight	Cloacal temp. after flight	Cloacal temp. change
SSS239	33.3	5.5	26.0	25.9	-0.1
SSS210	32.6	4.9	25.8	25.7	-0.1
SSS203	33.0	5.1	25.8	25.4	-0.4
SSS208	34.4	5.4	26.0	25.8	-0.2
SSS206	32.3	4.7	26.2	26.0	-0.2
Mean	33.1	5.1	26.0	25.8	-0.2

Table 2. Cloacal temperatures (°C) before and after the flight and mean difference in cloacal temperature, for the transportation period on 20 June 1997. Straight carapace length and weight were recorded prior to transfer.

Tag code	Straight carapace length (cm)	Weight (kg)	Cloacal temp. before flight	Cloacal temp. after flight	Cloacal temp. change
SSS308	33.9	5.5	26.1	24.2	-1.9
SSS245	35.4	5.7	25.6	24.2	-1.4
SSS259	33.9	5.3	25.9	24.4	-1.5
SSS215	34.4	5.5	26.2	24.0	-2.2
SSS242	32.9	5.0	26.9	25.2	-1.7
SSS340	32.8	5.0	27.0	26.0	-1.0
SSS296	33.9	5.3	27.0	24.4	-2.6
Mean	33.9	5.3	26.4	24.6	-1.8

Table 3. Mean, minimum and maximum of ambient temperatures, and duration of each phase of the transportation periods.

Transport phase	Duration (min)	Mean ambient temp. °C	Min. ambient temp. °C	Max. ambient temp. °C
23 May 1997:				
Packing and loading	260	25.93	25.08	27.18
Flight	130	22.70	19.39	26.83
Unpacking	80	26.39	21.18	28.99
Combined	470	25.06	19.39	28.99
20 June 1997:				
Packing and loading	220	25.34	23.87	28.26
Flight	170	21.60	18.74	26.30
Unpacking	80	25.96	23.02	29.54
Combined	470	24.04	18.74	29.54

Table 4. Mean ambient temperature comparisons (ANOVA) for each phase of the transportation periods and for the combined phases.

Transport phase	23 May mean temp. °C	20 June mean temp. °C	P-Value
Packing and loading	25.93	25.34	0.006
Flight	22.70	21.60	0.0129
Unpacking	26.39	25.96	0.4436
Combined	25.06	24.04	0.0003

Figure 1. Ambient temperatures recorded from three temperature loggers (TL1, TL2 and TL3), their mean ambient temperature (TLM), and cloacal temperatures (CT1-CT5) recorded during the 23 May 1997 transportation period.

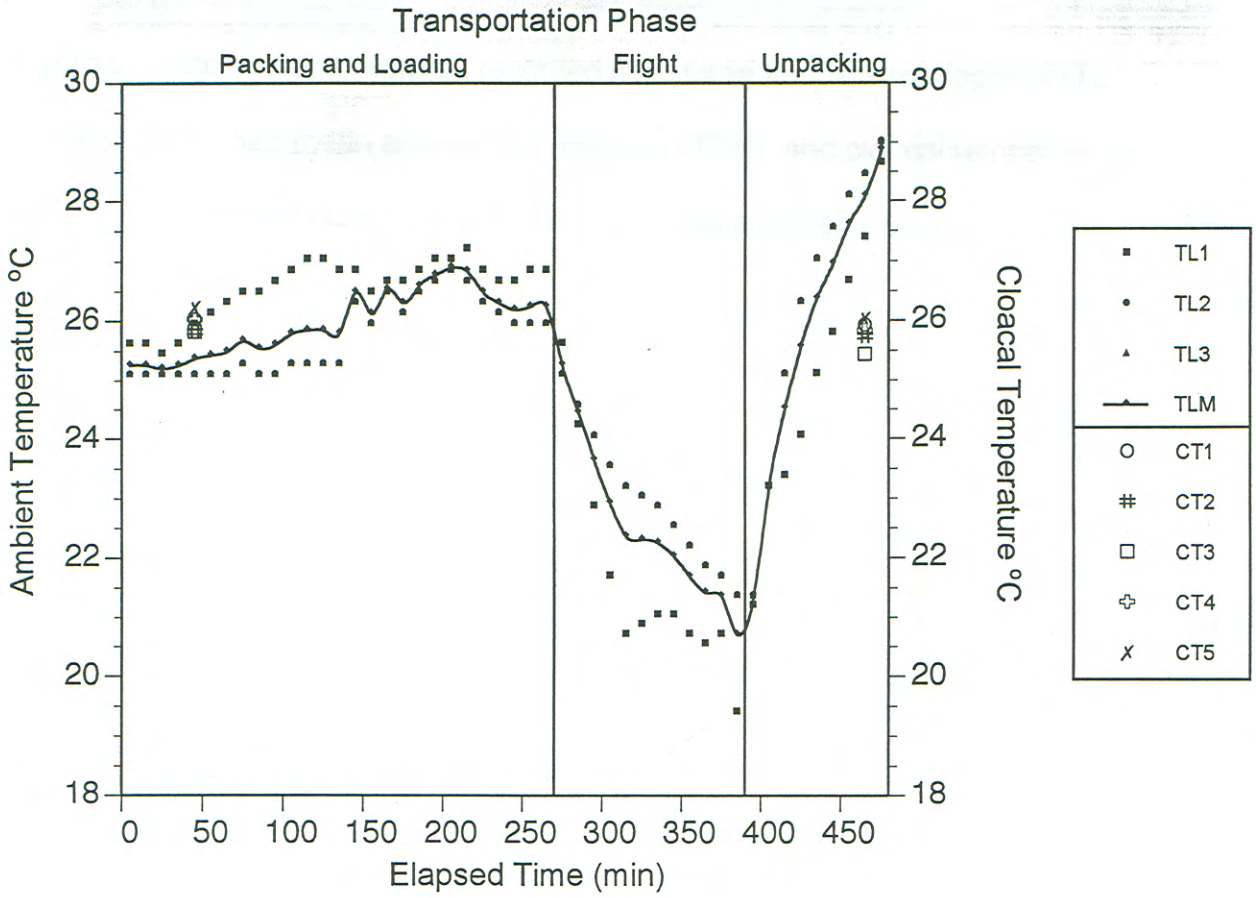
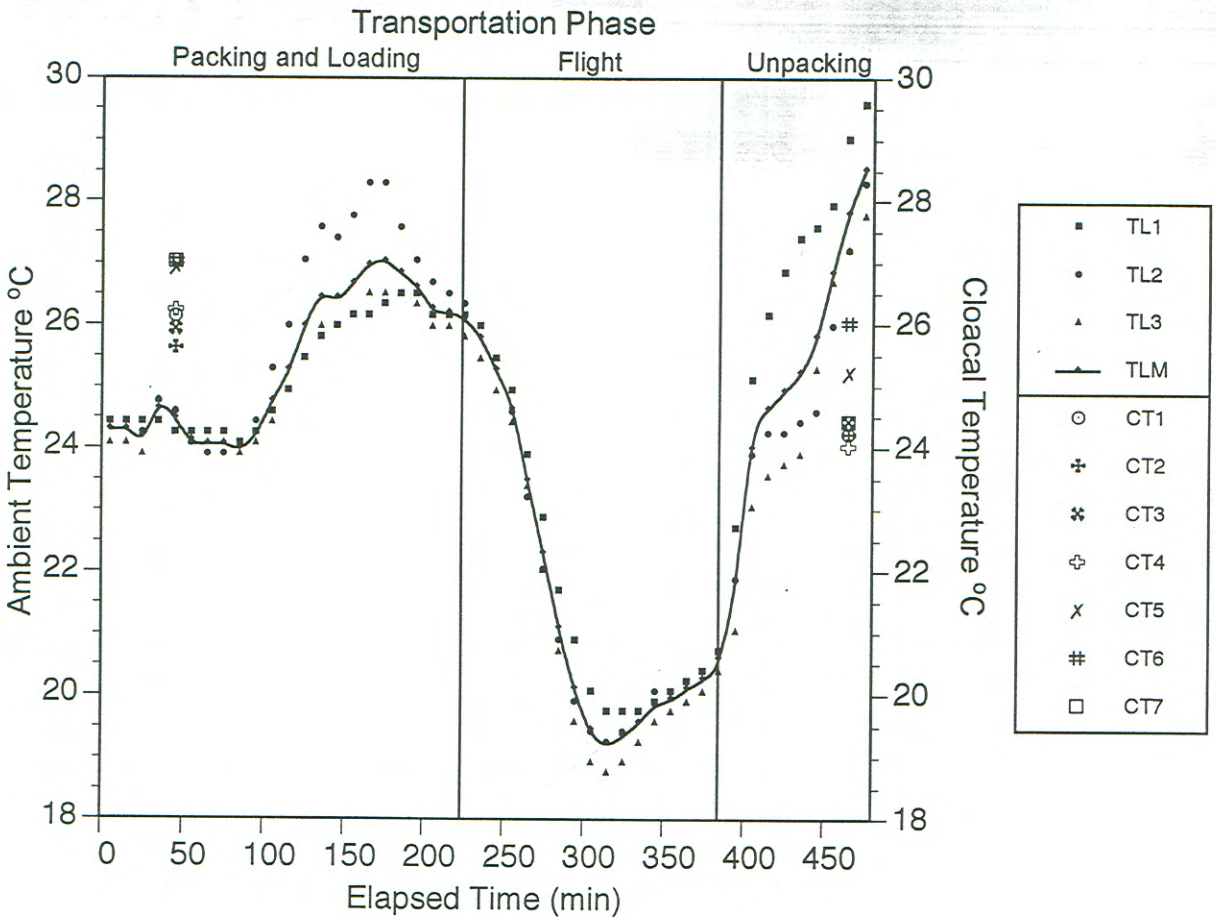

Transportation Phase
Packing and Loading
Flight
Unpacking
Ambient Temperature °C
Cloacal Temperature °C
Elapsed Time (min)
30
28
26
24
22
20
18
0
50
100
150
200
250
300
350
400
450
TL1
TL2
TL3
TLM
CT1
CT2
CT3
CT4
CT5

Figure 2. Ambient temperatures recorded from three temperature loggers (TL1, TL2 and TL3), their mean ambient temperature (TLM), and cloacal temperatures (CT1-CT7) recorded during the 20 June 1997 transportation period.


Transportation Phase
Packing and Loading
Flight
Unpacking
Ambient Temperature °C
Cloacal Temperature °C
Elapsed Time (min)
30
28
26
24
22
20
18
0
50
100
150
200
250
300
350
400
450
TL1
TL2
TL3
TLM
CT1
CT2
CT3
CT4
CT5
CT6
CT7