BEHAVIORAL AND TOLERANCE RESPONSES TO COLD WATER TEMPERATURES BY THREE SPECIES OF SEA TURTLES (REPTILIA, CHELONIIDAE) IN NORTH CAROLINA

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ABSTRACT

Three species of sea turtles, held in large outdoor tanks, were exposed to cold water. Behavioral and tolerance responses were recorded over eight observation periods (November-March, 1968-1976). All responded to cold water temperatures by bobbing to the surface tail first, then horizontally once temperatures fell below 10.0°C. Lethal temperatures were between 5.0 and 6.5° C. Young or hatchlings of each species were able to tolerate cold water longer than large adults. Survival in lethal cold water was longest for ridley turtles, approximately 20-24 h. Loggerhead and green turtles died after 9-12 h exposure. Based on these observed physiological and behavioral responses, survival of turtles seems unlikely during long exposures to winter water of northern latitudes.

INTRODUCTION

Faulkner and Binger (1927) showed a temperature of 37.5°C caused sea turtles to lose appetite, breathe rapidly, lose immunity to oxygen poisoning, and die after chronic exposure. An upper lethal temperature for leatherback and green turtle hatchlings crawling over hot beach sands was 33°C (Hendrickson, 1958; Bustard, 1970). Body temperatures may range from near ambient water temperature to 20°C above ambient (Hirth, 1962; Mrosovsky and Pritchard, 1971; Frair et al., 1972). Internal differences between head and cloacal temperatures also exist; head temperatures are higher and more variable than cloacal temperatures.

Sea turtles frequent northern Atlantic latitudes (Bleakney, 1955; Brongersma, 1972), sometimes active at 13-18°C in Canadian waters (Bleakney, 1965). Fifty-nine lethargic loggerheads (carapace lengths = 0.3-0.9 m) were observed on the surface 57 km SSW of Beaufort Inlet, N. C. (12.8°C, 25 February 1976). Hughes (1970) reported that loggerhead sea turtles can withstand an unacclimated temperature drop from 22 to 10°C. He further noted (1974) that loggerhead hatchlings were stressed and lost weight if maintained at 14°C for 14 days. This paper helps define critically low temperatures in which sea turtles may survive.

METHODS AND MATERIALS

Kemp's ridley (*Lepidochelys kempii*), loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) turtles were captured primarily in the bight of Cape Lookout, 12.9 km east of Morehead City, North Carolina. Tests were conducted between November and April from 1968 through spring 1976. Turtles were captured in 12.1 m semi-balloon otter trawls towed for varying times and distances. Surface water temperatures were recorded during each tow. Salinities were determined with A/O refractometers. Turtles were transported by boat to the Institute of Marine Sciences (Morehead City, North Carolina). Hatchling loggerhead turtles were obtained from local nests or from eggs incubated in styrofoam box nests.

All turtles were placed in outdoor 125,070 l concrete tanks (0.8 m deep). Tanks could be partitioned to keep various groups separated. Except for an accumulated veneer of mud, no substrate covered holding tank bottoms. Hatchlings were kept in floating wire baskets (1.0 x 1.5 x 0.5 m depth). A Bristol thermograph monitored air and water temperatures. Water was pumped continuously from adjacent Bogue Sound where annual salinities, except during heavy rains, varied between 28-32 ‰. No shade was provided.

All turtles were fed fishes, crabs, shrimp, scallops, or other available food. Food rations were increased during summer and decreased during winter or after turtles stopped eating. No effort was made to remove the natural tank growths of green algae (*Enteromorpha codium*), red algae, and oysters.

Similarly sized turtles of each species were simultaneously tested as controls. Controls were kept outdoors until critical low water temperatures were reached for each species or until they began bobbing to the surface (floaters). When either condition occurred, turtles were moved into 2.4 m indoor circular tanks (1 m deep) subject to ambient air temperatures. Most indoor fatalities were hatchling loggerhead turtles afflicted by fungal diseases similar to those reported by Witham (1973). Treatment was with potassium permanganate plus boric acid, a modification of the Witham (1973) formula. Control turtles resumed normal behavior when indoor water temperatures became 10.0°C or warmer.

Accordingly, turtles were usually placed outdoors by mid-April when water temperatures rose above 10.0°C and restudied during the following winter season(s).

The turtle was determined dead when it did not respond to a tap on the nape. If alive, the turtle would try to retract further the already tightly constricted neck, or the turtle would attempt to breathe. Eyes of moribund turtles remained closed.

RESULTS

Each species passed through the floater stage near death many times during each year's November-March test period. Floating consisted of a posterior carapace emerging so that the body was inclined head downward about 35°. Diving was difficult or impossible. The floater condition suggested that large amounts of gas were forming or accumulating posteriorly as a physiological result of lower water temperatures (Parker, 1925). Gulping of cold air may also have caused this condition. The front flippers were usually extended outward, used in slow swimming or in balancing. Breathing was difficult; turtles had either to swim vigorously to attain a horizontal position or the head had to be cocked sharply upward to gulp air. Sudden or prolonged cold snaps which lowered water temperatures (acute changes) would kill just as readily as slower seasonal lowering of water temperatures (chronic).

All turtle carapaces became covered with algae *(Ectocarpus subcorymbus)* during cold periods; growths of *Bryopis hypnoides* occurred in 1971. Little is known about these algae and their biotic relationships to turtles. Marquez (personal communication) noted algae on some wild black sea turtles in Mexico. Cold water temperatures usually killed barnacles which festoon sea turtles (Hughes, 1974; Schwartz, 1960) and likewise prevented epizootic outbreaks of the leech, *Ozobranchus margoi* (Schwartz, 1974).

All three species stopped feeding when outdoor tank water temperatures fell below 10.0°C and feeding resumed when temperatures rose above this level.

LOGGERHEAD

Swimming activities of loggerheads at temperatures above 9.5°C were natural. At or near 9.5°C some adults would become floaters while others did not until 9.0°C was attained. Young loggerheads were affected between 5.0 and 9.0°C; hatchlings reacted naturally until water temperatures fell to 3.5 or 4.5°C.

Death occurred in less than 24 h for large turtles greater than 600 cm carapace length (CL) at 5.0°C. Time to death at 4.0°C was between 9-12 h. Young or hatchling loggerheads survived up to 12 h at 4.0°C or less; all died before temperatures reached 1.0°C.

When water temperatures reached 5.0°C (larger turtles) and 3.5°C (smaller ones) turtles assumed a horizontal floating position. Swimming was labored or non-existent. Hind flippers, originally held at a horizontal or 45° angle to the body, gradually attained a vertical position with the flat surfaces coming together as death approached. Front flippers moved slowly from a laterally held outward balance position to a drooped one as lethal temperatures were approached. The head relaxed and drooped downward at death; the body continued to remain horizontal at the water surface. During winter all loggerheads passed through all floating and associated behavior patterns as long as lethal temperature was not reached or sustained.

KEMP'S RIDLEY

As water temperatures fell below 13.0°C, ridleys began exhibiting a sluggish floating behavior. Some floated, swimming laboriously and reacting as noted for loggerheads; others, depending on size, swam and dove naturally until about 10.0°C was reached. Specimens greater than 300 cm CL died at 6.5°C within 20-24 h. Smaller specimens tolerated 5.0°C before death.

The typical ridley initially floated head downward at an angle of about 30°. Turtles were able to gulp air by laterally extending fore flippers for balance. Breathing was labored and more effort was required to raise the head, which was less retracted than noted for loggerheads. Less swimming was necessary to maintain position than for loggerhead turtles. Death reactions were similar to that of loggerheads.

GREEN TURTLE

Green turtles floated at 9.0°C. Death usually occurred at 6.0°C. Some specimens greater than 56.0 cm CL died at 6.5°C. All turtles died by 5.0°C.

Floating green turtles behaved like loggerheads and ridleys except that necks were extended; breathing was also laborious.

CONCLUSIONS

Studies into the actual gas exchange within sea turtles would help explain when and how floating oc-

curs and what regulates its onset or dissipation.

Loggerhead, green and Kemp's ridley sea turtles exposed to 10°C water initially react by bobbing to the surface and die between 5.0 and 6.5°C. These data should help our understanding of geographic and bathymetric distributions of these turtles.

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