



Observations of Non-Nesting Emergence by Green Turtles in the Gulf of Carpentaria

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OBSERVATIONS OF NON-NESTING EMERGENCE BY GREEN TURTLES IN THE GULF OF CARPENTARIA.—The green turtle (*Chelonia mydas*) is the only marine turtle known to emerge from the water regularly when not nesting. Behavior of this type has been observed along the northern Australian coast and in the Pacific, and is usually considered to be intentional or voluntary. Detailed descriptions of non-nesting emergence have been made in the Northwestern Hawaiian Islands (Balazs, 1980; Whittow and Balazs, 1982) and in the Galapagos Islands (Fritts, 1981; Snell and Fritts, 1983) but the only Australian evidence is from Bustard (1974) who reported that females allow themselves to be stranded by the falling tide on Bountiful Island of the Wellesley Group in the Gulf of Carpentaria.

We made observations of turtles emerging when not nesting in the Wellesley Islands during a survey of the biological resources of Rocky Island (16°20'S, 139°18'W). A photograph of nesting tracks on Rocky Island was included by Bustard (1974) but the island was not labelled on his map of major rookeries in the area. On aerial surveys during Dec. 1981 and Feb., July and Sept. 1982 we observed a peak of turtle nesting on Rocky Island during the winter

months while on nearby Bountiful Island turtle nesting was seen throughout the year. The visit to Rocky Island was made between 9 and 12 July 1982.

Rocky Island is a sedimentary island of 14 ha with 1,200 m of beach along the northern and eastern coasts. Adjacent to these beaches are shallow rocky reef flats up to 200 m wide which are exposed during low tide. In the Gulf of Carpentaria only one tide cycle occurs each day, the tidal variation at Rocky Island being about 2 m. At the time of the survey low tide occurred at 2200 hrs and the reef flat was exposed between 1700 hrs and 0300 hrs.

On our arrival at 1600 hrs, we saw the partially exposed carapaces of 50 turtles on the reef flats to the north of the island. Two of the turtles were completely exposed on dry sand but below the high tide mark; two pairs were copulating in the shallow water. As the water receded more turtles became completely exposed and copulation ceased. The following day, we saw turtles swimming or floating above both the northern and eastern reef flats and we saw three more pairs copulating. On the second evening, we attached numbered monel tags to the flippers of most turtles. Only one of the 40 exposed turtles tagged was a male, although another male had escaped to deeper water. All turtles were adults with a curved carapace length in excess of 85 cm. Three were among 19 that had been tagged while nesting, or attempting to nest, on the adjacent beach during the early hours of the same morning. Another six of the tagged, exposed turtles attempted to nest the following morning. The air temperature above the exposed turtles at 1800 hrs was 19.8 C; the temperature in the water beside them was 20.5 C. Although no other air temperatures were taken in the vicinity of the turtles, we felt the air temperature decline throughout the night until it was considerably cooler than the water temperature.

There are several differences between our observations of non-nesting emergence by green turtles and those described elsewhere. First, emergence from the water was a passive rather than an active event. This has been reported in the Galapagos (Fritts, 1981; Snell and Fritts, 1983) but not in Hawaii (Whittow and Balazs, 1982). Turtles became exposed and settled onto the substrate as the tide receded. Second, in neither Hawaii nor the Galapagos were non-nesting emergence and nesting consecutive (Balazs, 1980; Snell and Fritts, 1983), but on

Rocky Island some turtles lay exposed on the reef flat either immediately before or immediately after nesting without reentering the water between activities. Active emergence was always associated with an attempt at nesting. Third, although most observations of non-nesting emergence have been during the day (Bustard, 1974; Whittow and Balazs, 1982; Snell and Fritts, 1983), at Rocky Island emergence began 2 hrs before dark and the turtles remained exposed through most of the night. This difference may have been partly an artefact of tidal cycle although nocturnal emergence elsewhere may have gone undetected. Nocturnal non-nesting emergence has been reported from Hawaii (Balazs, 1980) but later workers have only been able to study the activity during the day (Whittow and Balazs, 1982; Snell and Fritts, 1983).

Several reasons have been proposed for non-nesting emergence by green turtles. These include synthesis of vitamin D (Pritchard and Greenwood, 1968), acceleration of digestion (Boyer, 1965; Snell and Fritts, 1983) and egg maturation (Snell and Fritts, 1983), avoidance of courting males by females (Bustard, 1974), avoidance of predation by sharks in deep water (Whittow and Balazs, 1982), absence of suitable deep water resting sites and energy conservation while resting (Balazs, 1980).

The first four theories do not explain adequately the behavior observed on Rocky Island. It is probable that green turtles require sunlight to meet vitamin D requirements since the turtles select the growing parts of seagrass (Bjorndal, 1980) while vitamin D is concentrated in the dead parts of plants (McDonald et al., 1973). However, this feeding preference of green turtles (Bjorndal, 1980) was observed in a population that emerges from the water only when nesting. It seems unlikely that non-nesting emergence should occur in a few populations to meet a nutritional requirement that is met in other areas by routine behavior. Furthermore most of the non-nesting emergence seen at Rocky Island was during the night.

If the function of non-nesting emergence by turtles is to accelerate digestion or egg maturation, it would be expected that the emergent turtles would be warmer than when submerged. However, by the middle of the night at Rocky Island, the air to which the turtles were exposed was cooler than the shallow water. The deeper water, better buffered against variations in air temperature, would have remained warmer still.

Therefore digestion during the time the turtles were exposed was probably retarded (Bjorndal, 1980). In any case, it is unlikely that the emergent turtles at Rocky Island were digesting food. The island is surrounded by relatively deep water and is 15 km from the nearest shallow feeding grounds. It is possible to calculate, from the figures provided by Bjorndal (1982), that the energetic cost of swimming there and back would necessitate a feeding period of at least 15 days before a net increment in energy intake would occur, which would be an excessively long internesting interval. Acceleration of digestion or egg maturation is consistent with observations made in Hawaii (Whittow and Balazs, 1982) and Galapagos (Snell and Fritts, 1983) but does not explain non-nesting emergence on Rocky Island.

We obtained no evidence in support of the theory that females in the Wellesley Islands emerge on land deliberately to avoid courting males, as has been suggested by Bustard (1974). Contrary to the observations of Bustard (1974) on Bountiful Island, the females at Rocky Island were all equally torpid regardless of the proximity of males. Mating in shallow water would appear to be a regular event (Bustard, 1974; Snell and Fritts, 1983) that stops when the tide becomes limiting.

Nevertheless, although both sexes were found exposed, the ratio of males to females was extremely low (2:48). This may be an artefact of the time at which Rocky Island was visited; by July the nesting season was probably past its peak. Most mating takes place before nesting starts and once females have nested they are not mated again (Booth and Peters, 1972). Therefore, by July, most females would have been mated and the majority of those lying in the shallows would have nested at least once. If this assumption is correct, the situation is similar to that in the Northwestern Hawaiian Islands where the proportion of males emerging declined as the nesting season progressed (Balazs, 1980), although it differs from the Galapagos where females predominated both before and after the nesting season (Snell and Fritts, 1983). The observations made by Bustard (1974) may also have been towards the end of a nesting peak.

We have no information on the local density of turtle predators or the availability of deep water resting sites. However, optimization of energy use seems to us to be the most likely explanation of non-nesting emergence by green

turtles on Rocky Island. The conservation of energy reserves which may take years to accumulate (Parmenter, 1980) would be paramount for a nesting turtle. It has already been argued on energetic grounds that feeding between nesting attempts by turtles at Rocky Island is unlikely. It is probable, therefore, that during the interesting period, the ratio of activity to inactivity mentioned by Bjorndal (1982) will be further shifted towards inactivity, a shift that would save up to 40% of the interesting energy use she postulated. In areas where ambient air temperatures are low, such as in the Gulf of Carpentaria during winter, exposure in the shallows between consecutive nesting attempts would not only reduce the amount of energy used moving to and from the nesting beach and in coming to the surface to breathe, but, because of the lower temperatures, would also result in a lower metabolic rate (Davenport et al., 1982). Where air temperatures are high during the nesting season, the interesting rest areas are likely to be in deeper water such as the "female reserve" described by Booth and Peters (1972). The high proportion of females exposed on the reef flats is consistent with the theory that this area on Rocky Island is the equivalent of the "female reserve." Since energy conservation, while desirable, is not essential for the survival of the turtle except under extreme circumstances, it is a behavioral pattern that can be forsaken in populations vulnerable to extensive hunting. This would explain why non-nesting emergence occurs only on islands lacking large predators (Whittow and Balazs, 1982; Snell and Fritts, 1983).

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SIREN (CAUDATA: SIRENIDAE) FROM THE BARSTOVIAN MIOCENE OF NEBRASKA.—Recent species of *Siren* characteristically occur in warm, shallow lakes and swamps in the SE United States. The recovery of *Siren* fossils from the Miocene deposits of northern Nebraska is thus of paleoecological interest. The fossils were collected by a University of Nebraska field party under the direction of MRV in 1981. The site is University of Nebraska Collecting Locality BW106, Brown County, Nebraska, well known in the paleontological lit-