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Predation upon Olive Ridley Sea Turtles (*Lepidochelys olivacea*) by the American Crocodile (*Crocodylus acutus*) at Playa Nancite, Costa Rica

RUDY M. ORTIZ^{1,3}, PAMELA T. PLOTKIN²,
AND DAVID WM. OWENS¹

¹Department of Biology, Texas A&M University, College Station, Texas 77843 USA; ²Department of Bioscience and Biotechnology, Drexel University, Philadelphia, Pennsylvania 19104 USA; ³Present Address: NASA Ames Research Center, MS 239-7, Moffett Field, California 94035 USA [Fax: 415-604-3954; E-mail: rortiz@mail.arc.nasa.gov]

The large size and hard shell of a sea turtle acts as a defense mechanism and it has been assumed that few predators other than killer whales (*Orcinus orca*) and large sharks actively prey upon adult sea turtles (Cornelius, 1986). The ability of American crocodiles (*Crocodylus acutus*) and saltwater crocodiles (*C. porosus*) to tolerate a marine habitat (Mazotti and Dunson, 1984; Taplin, 1988) provides these predators the opportunity to exploit marine prey such as sea turtles. However, published accounts of crocodile predation on or consumption of sea turtles are few

(Allen, 1974; Limpus et al., 1983; Pérez Higuera et al., 1989; Hirth et al., 1993).

Turtles of the genus *Lepidochelys* sometimes display a unique nesting behavior termed *arribada* (Spanish for “arrival”) in which thousands of females synchronously ascend a single beach on one or a few successive nights (or days) to lay their eggs (Richard and Hughes, 1972; Cornelius, 1986). *Arribadas* typically occur once a month during the nesting season, while some solitary nesters may nest every night. Pritchard (1969) and Eckrich and Owens (1995) hypothesized that *arribada* behavior evolved as a predator satiation mechanism in which the probability of individual predation is reduced.

During the *arribada* season between July and November of 1990, we observed and recorded evidence of predatory activity of the American crocodile (*C. acutus*) upon olive ridley sea turtles (*L. olivacea*) during the turtle’s nesting season at Playa Nancite, Santa Rosa National Park, Gulf of Papagayo, Pacific coast of Costa Rica. We documented: 1) the date crocodiles, their tracks, and depredated turtle carcasses appeared, 2) direction of crocodile tracks (leaving from or returning to the estuary), and 3) condition of turtle carcasses.

American crocodiles inhabit the estuary behind the turtle nesting beach at Playa Nancite. The ca. 1.1 km stretch of beach is bordered by two rocky headlands, isolating the estuary, therefore making the beach the only access to the ocean for the crocodiles. The estuary is roughly divided into two separate pools of approximately equal size that often join during the wet season. A larger estuary is present at Playa Naranjo approximately 1.5 km to the south and a smaller estuary and beach, Playa Tule, is ca. 2 km to the north. The crocodiles inhabiting the estuary system of Playa Naranjo occasionally visit Playa Nancite (Cornelius, 1986).

Crocodiles were observed in nearshore waters, in the estuary, and on the beach. Although none of the crocodiles were marked or tagged for subsequent identification, we estimated that approximately 15 individuals frequented Playa Nancite. One large animal (ca. 3 m total length (TL), gender undetermined), 2–3 subadults (1.5–2 m TL), and the remainder juveniles (0.5–0.9 m TL) and hatchlings (< 30 cm TL), inhabited the estuary behind the beach during the *arribada* season. Size classes defined here follow those described by Mendez and Casas Andreu (1992).

During the 5 month study period, four *arribadas* occurred with each involving approximately 1000 to 20,000 turtles. The presence of crocodile tracks on the beach during *arribadas* was difficult to determine due to the large number of turtles using the beach. Also the high tide sometimes eroded crocodile tracks making them indistinct. When crocodile tracks were identified we observed that 1) tracks indicating seaward or landward movement did not always have a complementary set of tracks in the opposite direction, and 2) the single large crocodile’s exit to sea and subsequent return did not always coincide with the presence of a turtle carcass on the beach.

Turtle carcasses were usually found either 3–4 days prior to an *arribada* or a week following an *arribada*. No turtle carcasses were discovered during an *arribada*. During the 5

month observation period, a total of 11 turtle carcasses were found of which 9 were attributed to crocodile predation. Because carcasses were always found on the beach we assumed that the crocodile’s attack occurred on land. However, we can not rule out the possibility that the crocodile killed the turtles at sea and the carcasses washed up on shore. The observation of a crocodile stalking a nesting turtle suggests that crocodiles capture and kill turtles in nearshore waters. The second author observed a solitary turtle emerge on the beach in the late afternoon to lay eggs, while a large crocodile (ca. 3 m TL) remained offshore (ca. 25 m) observing the turtle from shallow water (< 1 m). When the turtle completed nesting and began her return to the water, the crocodile moved towards her, remaining concealed in the water. As the turtle reached the water’s edge, two volunteers came running down the beach, sending the crocodile off to deeper water and abandoning what appeared to be an impending attack on the turtle.

Predation on adult turtles was characterized by frontal attacks, with usually one fresh turtle carcass on the beach at a time. Frontal attacks by *C. acutus* and Morelet’s crocodile (*C. moreleti*) on prey have been reported in Mexico (Casas Andreu and Guzmán Arroyo, 1970; Pérez Higuera et al., 1989). In Papua New Guinea, the occurrence of a frontal attack by a crocodile (presumably *C. porosus*; species not mentioned) on a leatherback sea turtle (*Dermochelys coriacea*) has been documented (Hirth et al., 1993). Although we never observed an actual attack, “predatory events” were reported by other research personnel. They reported on one occasion a large crocodile emerging quickly from the surf and attacking a female turtle on the beach. The frontal attack was initiated at the left forelimb, which was ripped completely off by the aggressive rolling which ensued, exposing the turtle’s viscera. Aside from this one report, the condition of the turtle carcasses sometimes made it difficult to positively determine their gender, but most were presumed to be females.

Bite widths, the shape of teeth holes, and the presence of teeth scrapes on the turtle’s shell as well as the direction of the attack helped to differentiate between either a shark or a crocodile attack. An attack by *C. acutus* was characterized by a narrow bite width with conical teeth holes anteriorly in the carapace in a definite pattern, and usually without teeth scrapes. Turtle carcasses were always gutted and lacked the front flippers and usually the head. A volunteer reported observing a large crocodile with its head inside the turtle’s body cavity, consuming the viscera.

American and Morelet’s crocodiles in Mexico have been reported to allow their prey to decompose in order to facilitate dismemberment for consumption (Casas Andreu and Guzmán Arroyo, 1970; Pérez Higuera et al., 1989), but we did not observe this behavior at Nancite. Turtle carcasses were found on the beach or in the nearshore vegetation. They were not found in or near the estuary, suggesting that they had been consumed shortly after being attacked.

In addition to crocodile predation on adult turtles, subadult and juvenile crocodiles were seen consuming turtle hatchlings. One subadult crocodile (ca. 1.5 m TL) was observed at the edge of the shore eating hatchling turtles as they

entered the sea. Juvenile crocodiles were most evident when hatchling turtles were emerging from their nests on the beach and during periods of heavy rain.

The successful attacks on solitary turtles and the absence of predation on *arribada* turtles suggests that *arribada* behavior may deter predation by crocodiles. Observations from the present study make it difficult to accurately assess the predatory pressures American crocodiles impose on the olive ridley sea turtle population at Playa Nancite. However, the depredation of 1 or 2 sea turtles by American crocodiles between *arribadas* ranging from 1000 to 20,000 turtles is at a low level, having little or no effect on the nesting population of olive ridleys at Playa Nancite. Instead, predation of crocodiles upon turtles at Playa Nancite may actually enhance the survival of this population of crocodiles which persists as a small, fragmented remnant of the original population on the Pacific coast.

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Growth and Reproductive Estimates from Alligator Snapping Turtles, *Macrolemys temminckii*, taken by Commercial Harvest in Louisiana

ANTON D. TUCKER¹ AND KEVIN N. SLOAN^{2,3}

¹Zoology Department, University of Queensland, Brisbane, Queensland 4072 Australia; ²U.S. Department of the Interior, Fish and Wildlife Service, 1500 North Decatur Boulevard #01, Las Vegas, Nevada 89108 USA
[Fax: 702-646-1554; E-mail: kevin_sloan@mail.fws.gov];
³Corresponding Author for Reprint Requests

The alligator snapping turtle (*Macrolemys temminckii*) is a large freshwater chelydrid restricted to drainages of the Gulf Coastal Plain and the Mississippi River Valley of the USA (Lovich, 1993). In comparison to other North American turtles, many aspects of its biology remain poorly known (Ernst et al., 1994) even though the species has been exploited heavily by the soup industry for decades (Pritchard, 1989). Populations of *Macrolemys* are considered low or depleted because of overharvesting, yet the actual status is poorly known (George, 1987).

Many biological details about *Macrolemys* have been learned by analyzing specimens gathered by commercial turtle trappers (Dobie, 1971; Pritchard, 1989; Sloan and Lovich, 1995; Sloan et al., 1996). Ancillary information gleaned from commercial harvesting provides useful, albeit fragmentary data, in situations analogous to salvage archeology. There are compelling reasons to collect and report salvage biology whenever a harvested species is incompletely known or of conservation concern.

In this paper we summarize reproductive and growth data gathered from a large sample of *Macrolemys* that were processed at a commercial facility in Louisiana in 1986. The data were compared to a similar study conducted two decades earlier in the same region (Dobie, 1971). Because growth and reproductive parameters are vital elements in the recovery plans for *Macrolemys*, the information has implications for the proposed size limits in commercial harvesting of the species.

Methods. — A processing facility in Jonesville, Louisiana, saved *Macrolemys* viscera and carapaces which were bagged, labelled, and frozen for later analysis. Both sexes were collected initially in March and April, but from May to October, only females were saved by the processor because of limited freezer space, even though both sexes were still processed. Sample sizes varied because some individual samples were incomplete, e.g., the carapace was salvaged but not the viscera.

Midline carapace length (ML, straightline measurement to the nearest 0.1 cm) was used for analyses of body