Chelonian Conservation and Biology, 2000, 3(4):751–753

Predation of Green (*Chelonia mydas*) and Leatherback (*Dermochelys coriacea*) Turtles by Jaguars (*Panthera onca*) at Tortuguero National Park, Costa Rica

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The black sand beach of Tortuguero National Park on the Caribbean coast of Costa Rica hosts the largest green turtle (*Chelonia mydas*) breeding colony in the Western Hemisphere and in the Atlantic (Carr et al., 1978; Hirth, 1997; Bjorndal et al., 1999). Monitoring of green turtle nesting was initiated there in 1955 (Carr et al., 1978). Tortuguero also supports a leatherback (*Dermochelys coriacea*) nesting population, monitored since 1995 (Campbell et al., 1996).

Sea turtles are subjected to considerable predation during their early years by a wide variety of predators (Hirth, 1997). However, only sharks, crocodiles, killer whales (*Orca*), and jaguars are known to be able to kill adult sea turtles (Hirth, 1997; Ortiz et al., 1997). Other large neotropical cats such as pumas may not have sufficient bite power to prey on large chelonians (Emmons, 1989). Autar (1994) reported that 82 green turtles were killed by jaguars in Suriname between 1963 and 1973. In 1980, a single jaguar killed 13 green turtles within the span of a few days, and jaguars were still killing green turtles in Suriname in 1994 (Autar, 1994). Autar (1994) also reported that a male and female jaguar were shot in 1981 after killing captive-reared green turtles. In Costa Rica, jaguars prey upon olive ridleys (*Lepidochelys olivacea*), black (*Chelonia agassizii*), and hawksbill (*Eretmochelys imbricata*) turtles that nest on the Pacific coast (Carrillo et al., 1994; Chinchilla, 1997; E. Carrillo, *pers. comm.*). Jaguars are also known to kill olive ridleys and leatherback turtles in French Guiana (J. Chevalier, *pers. comm.*).

Although sea turtle researchers working at Tortuguero from 1956–95 occasionally have seen jaguar tracks on the beach and in the adjacent forest (A. Carr III, E. Chamorro, K. Horikoshi, A. Meylan, and L. Ogren, *pers. comm.*), there are only two reports of sea turtles killed by jaguars at Tortuguero; a green turtle in 1981 (Carrillo et al., 1994) and a green turtle in 1984 (J. Mortimer, *pers. comm.*). Considering the large number of sea turtle researchers present on the Tortuguero beach over the last decades, it appears that sea turtle predation by jaguars was rare, up until the time of the present study.

During regular track surveys to determine nesting activity of sea turtles in Tortuguero National Park, notes were taken on the number of sea turtles killed by jaguars (Troëng, 1997; Troëng et al., 1999). This article summarizes the observations of sea turtle predation by jaguars (*Panthera onca*) on the Tortuguero nesting beach.

Methods. — Evidence of jaguar predation was recorded during approximately weekly track surveys from 6 July 1997 to 7 November 1999. All track surveys commenced at dawn (0500 hrs) and were completed before 1230 hrs the same day. Track surveys were conducted from the Tortuguero River mouth to Jalova Lagoon, 29 km to the south. Dead sea turtles were considered killed by jaguars if they were surrounded by jaguar tracks or showed characteristic jaguar injuries (Aranda-Sánchez, 1981). All sea turtles killed by jaguars were recorded in 1997. However, the longer the time a sea turtle has been dead, the more difficult it is to determine when it was killed. Jaguars often drag their prey a considerable distance from the site of the kill (*pers. obs.*). Therefore, only those sea turtles freshly killed in the previous 24 hours were recorded during the 1998 and 1999 track surveys to avoid counting the same turtle during subsequent surveys.

Results. — Predation of nesting green turtles by jaguars increased from 4 in 1997 to a minimum of 25 in 1998 and a minimum of 22 in 1999 (Fig. 1). Two killed leatherbacks were encountered in 1999 (Fig. 1). Turtles were killed at

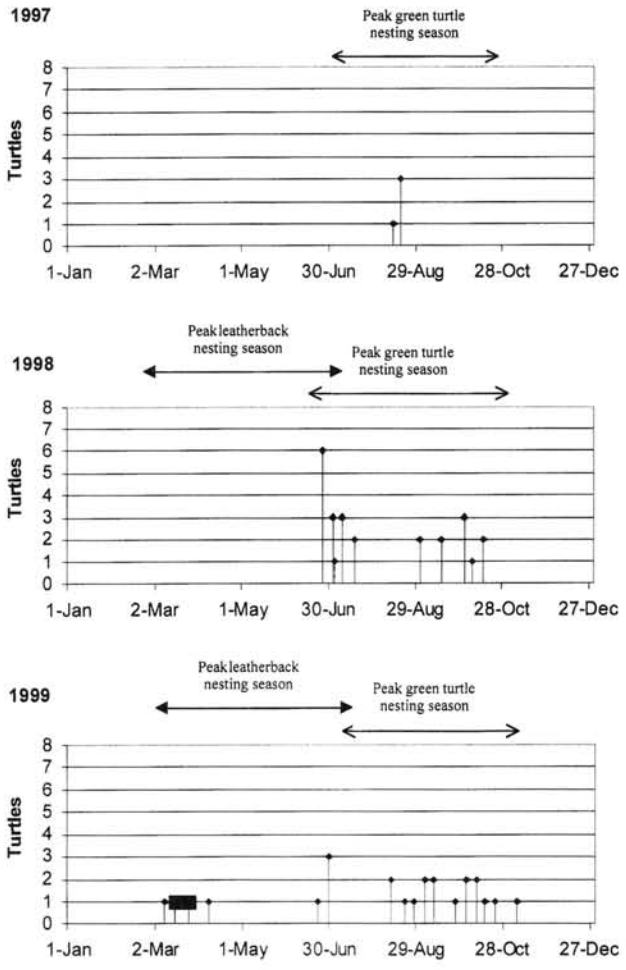

Figure 1. Sea turtles killed by jaguars at Tortuguero National Park, 1997–99; ■ = leatherback turtle, ◆ = green turtle.

different stages of the nesting process, most likely at the time when the jaguar first encountered the turtle. Jaguars ate only the neck muscle of the turtles and left the remainder to be consumed by black vultures (*Coragyps atratus*). Jaguars ate the flippers of a turtle only on one occasion. Turtles were killed and left on the open beach in most cases, although jaguar-killed turtles were also encountered in the vegetation behind the beach. Park rangers reported finding a jaguar-killed green turtle that had been dragged from the beach approximately 100 m into the forest (E. Moreno, *pers. comm.*).

In 1997, the track surveyor encountered a female jaguar with two cubs on the beach next to a freshly killed green turtle (A. Rankin, *pers. comm.*). A juvenile jaguar was encountered on the beach early in the morning of 2 August 1998 (A. Polo, *pers. comm.*). Later in August 1998, very fresh jaguar tracks were found at night by a turtle tagging team (*pers. obs.*). The team had patrolled their section and were returning along the same stretch of beach when they noticed the jaguar tracks in the sand. The jaguar had passed several nesting turtles without attacking any of them. From the tracks it appeared that in some instances the jaguar had walked up to a nesting turtle, only to return to the mid-beach platform and continue walking along the beach.

In 1998 and 1999, natural predation of green turtles by jaguars was observed throughout the green turtle nesting season, with up to 6 green turtles killed in a single night (Fig. 1). In 1998 and 1999, jaguar tracks were also often seen on the beach when no freshly killed turtles were encountered. The tracks were observed on the ca. 23 km long beach between Tortuguero village (5.5 km south of Tortuguero River mouth) and Jalova Lagoon. In 1999, park rangers encountered a female jaguar with two cubs feeding on a freshly killed green turtle (E. Chamorro, *pers. comm.*).

Discussion. — The green turtle population that nests in Tortuguero is not significantly threatened by natural jaguar predation. On the night of 8 August 1998, more than 2300 green turtle nests were recorded (Troëng et al., 1999). Adult green turtles from the Tortuguero population illegally harvested by humans vastly exceed jaguar depredation. It is estimated that 1783 green turtle females were taken by humans at the nesting beach in 1997 (Troëng, 1997). A minimum of 10,166 green turtles were captured in the feeding grounds of Nicaragua in 1996 (Lagueux, 1998). Bass et al. (1998) analyzed mtDNA markers and used maximum-likelihood analysis to estimate that no less than 91.1% (± 3.8%) of the adult green turtles captured in the northern section of the Nicaraguan fishery are from the Tortuguero population.

The number of jaguars preying upon green turtles at Tortuguero National Park is not known. However, a female with two cubs were sighted in 1997, a juvenile jaguar was encountered in 1998, and a female with two cubs were seen in 1999. In 1998 and 1999 jaguar tracks were found along ca. 23 km of beach. Based on these observations, it seems likely that at least one female, two juvenile jaguars, and two cubs were active in the study area. Jaguars stay with their mothers for 1–2 years and become sexually mature after 2–4 years (C. Miller, *pers. comm.*). Female jaguars reach maturity at an earlier age than do males (C. Miller, *pers. comm.*). Assuming that the cubs born in 1997 are still alive, they should soon recruit into the adult population.

The jaguars probably killed the turtles by biting their necks and consuming the neck muscle. Jaguars can break the carapace of smaller chelonian prey (Emmons, 1989), but their powerful bite may be unable to penetrate the thick carapace of an adult sea turtle. Also, sea turtles lack the ability of terrestrial and freshwater turtles to retract the head. Hence a jaguar can kill a green turtle by attacking its neck rather than trying to break its carapace.

Considering the abundance of nesting green turtles, the number of dead turtles encountered seems both low and erratic (Fig. 1). In 1998–99 only sea turtles killed in the previous 24 hrs were counted and it is likely that additional turtles were killed and dragged into the vegetation where they were not encountered. The 1998–99 numbers of sea turtles killed by jaguars should therefore be considered minimum estimates. However, it could also be that sea turtles are not a preferred prey item and were only utilized when other food items could not be found with ease (Chinchilla, 1997). Jaguars display feeding behavior similar to other large cats (Eisenberg, 1989); since turtles are easily approached compared to other large prey, they may have served as "practice prey" for the younger jaguars (Schaller, 1972). For these reasons the jaguars may have focused more on green turtles as prey in June–July during the first part of the nesting season and lost interest as green turtles continued to arrive (Fig. 1).

Several hypothetical factors may be involved in causing the observed increase in jaguar predation on nesting sea turtles at Tortuguero. The jaguar population may have increased in recent years as a result of protective measures and enforcement of protective legislation in Tortuguero National Park. Deforestation for agriculture and cattle ranching, inland from Tortuguero, may be pushing jaguars toward the coast where more intact forest and suitable jaguar habitat remain. Possibly a decline in populations of other prey may have left the jaguars with less prey options and increased pressures on sea turtles. Hunting pressure on jaguars in Barra del Colorado Wildlife Refuge and the Indio-Maiz region of Nicaragua may be forcing jaguars southwards, into Tortuguero National Park.

Further studies of the Tortuguero jaguar population are clearly needed in order to determine what the main causative factors are of the increase in jaguar predation of sea turtles. Researchers are encouraged to pursue jaguar studies at Tortuguero.

Acknowledgments. — The study was coordinated by Caribbean Conservation Corporation (CCC) under a research permit from the Ministry of Environment and Energy

(MINAE) of Costa Rica. E. Rankin and A. Rankin conducted the majority of the track surveys. K. Bjorndal, A. Meylan, P. Pritchard, A. Rhodin, and C. Taft provided constructive comments on a draft of this contribution.

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Received: 4 March 1999
Reviewed: 27 February 2000
Revised and Accepted: 7 April 2000

Chelonian Conservation and Biology, 2000, 3(4):753–755

Mud Accumulation in Nesting Aquatic Turtles (Emydidae) in Illinois

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The red-eared slider (*Trachemys scripta elegans*) is a common and widely distributed turtle in North America (Conant and Collins, 1991; Ernst et al., 1994). This turtle is, nevertheless, subject to considerable exploitation in parts of its range (reviewed by Tucker and Moll, 1997). In some cases, harvesting of local stocks has affected local demographics (Warwick et al., 1990). Populations of sliders, and other turtles, are also adversely affected by other human disturbances including highways and roads (e.g., Ruby et al., 1994), fires (e.g., Bigham et al., 1965; Dodd et al., 1994), fences (Tucker and Filoramo, 1996), and other dangers (reviewed by Ernst, 1995).

Agricultural activities are also sources of mortality (Ernst, 1995) and injury (Saumure and Bider, 1998). Generally, mortality is due to encounters between turtles and agricultural equipment or due to habitat modification resulting from cultivation. However, the agricultural environment may also hamper normal life history activities to lesser degrees short of outright mortality.

For instance, Saumure and Bider (1998) found evidence of reduced recruitment and slower growth in populations of the wood turtle (*Clemmys insculpta*) that occur in agricultural settings compared to those occupying less disturbed habitats. Herein, we examine mud accumulation, a previously unrealized handicap suffered by aquatic turtles that enter agricultural fields to nest.

Methods. — We caught sliders (*Trachemys scripta elegans*) in June 1998 near Stump Lake in Jersey County, Illinois (see Tucker, 1997 for details), and a single painted turtle (*Chrysemys picta*) in June 1997 at Stump Lake.

We weighed turtles along with accumulated mud with a spring balance (nearest 10 g) in the field. Bladders of all turtles were emptied prior to weighing (Kinney et al., 1998) and all turtles were gravid when captured. Turtles were marked for later identification. Mud was removed by washing the turtles after we returned to the laboratory. We then reweighed the turtles (nearest 10 g) and measured straight-line plastron length (nearest mm) and maximum carapace length (nearest mm) for each female. Mass of accumulated mud was determined by subtract-