Flags Reduce Sea Turtle Nest Predation by Foxes in NE Brazil

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The north coast of Bahia state is one of the principle reproductive sites for loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*) sea turtles in Brazil (Marcovaldi & Laurent 1996). In this region, nearly 200 km of beach from the city of Salvador to the border with Sergipe are patrolled by staff of Projeto TAMAR (Brazilian National Sea Turtle Conservation Program), resulting in the protection of all nests during egg incubation.

In Mangue Seco beach, starting in the 2005/2006 nesting season, emphasis has been placed on protecting nests in situ by leaving them in their original locations, rather than relocating most to open-air hatcheries, which had been the main strategy up until then. For in situ incubation, all freshly laid nests were verified and had wire panel grids (metal rounded by plastic) placed 5-10 cm below the surface of the sand and above the nest cavity. The mesh size was large enough to allow hatchlings to pass through it during their emergence from the nest (Marcovaldi & Laurent 1996; Marcovaldi & Marcovaldi 1999). However, starting in 2005/2006, there was a substantial increase in the predation rate of incubating eggs, despite the use of the wire panels. The main predator was identified as the crab-eating fox (*Cerdocyon thous*), based on direct observation, bibliographic research and foot-print identification (Fig. 1).

One of the different management actions to reduce nest predation that was considered is predator removal (Barthon & Roth 2006; Meier & Varnham 2004; O'Toole 2003; Ratnaswamy & Warren 1998; Woolard et al. 2004; Yerli et al. 1997; Zeppellini et al. 2007). However, given the possible cascade effects of removal or eradication programs, as well as ethical and legal implications, this option was not pursued. As an alternative, we investigated the use of flags over the nests as a possible deterrent to foxes. We used flags made from 1.20 m wooden sticks with 50 x 80 cm resistant textile. On some flags, we also attached a metal rattle, to check if adding sound to the flags would increase their predator avoidance effectiveness (Fig. 2).

Following an analysis of predation rates in different areas of Mangue Seco, we selected an extension of 19 km of beach to analyze nest predation events and to test the effectiveness of the flags to reduce predation rates. During the 2007/2008 nesting season, from September to March, the beach was patrolled daily and all nests were registered. The study area contains permanent post markers placed at 1 km intervals along the beach and were used to record nest site positions and to guide the flag use.

Three different treatments were used to protect the nests: grid (G), grid and flag (GF), grid and flag with rattle (GFR), and applied independently to nests laid between the kilometers, following this sequence described above. This standardized placement strategy helped avoid concentrating a particular treatment in particular areas of the study beach. Nests protected only with grids were considered as control nests in the study.

A total of 635 nests were recorded in the study area: 388 olive ridley nests, 97 loggerhead nests, 3 hawksbill nests, and 147 non-identified nests. Fox predation was observed in 145 nests (22.8%), of which 66 (45.5%) were olive ridley nests, 65 (44.8%) were non-identified nests, 13 (9.0%) were loggerhead nests and 1 hawksbill nest. Predation rates indicate no clear preference for nests of a particular sea turtle species, which is consistent with the opportunistic foraging behavior of crab-eating foxes (Berta 1982, Michalski et al. 2006).

Eighty-eight nests were predated before monitors could set protection of any kind, comprising 62.07% of all instances of nests with animal predation. Two nests were harvested for human consumption before protection, and were excluded from animal predation analyses (Table 1). Furthermore, of the 545 nests that received some kind of protection, 57 (10.4%) were predated, of which 44 (77.2%) were protected with only a grid (Table 1).

A significant difference was observed between the rate of predation of nests protected with grids alone vs. nests with grids

Figure 1. *Cerdocyon thous* footprints and one individual found as road-kill near the study area.

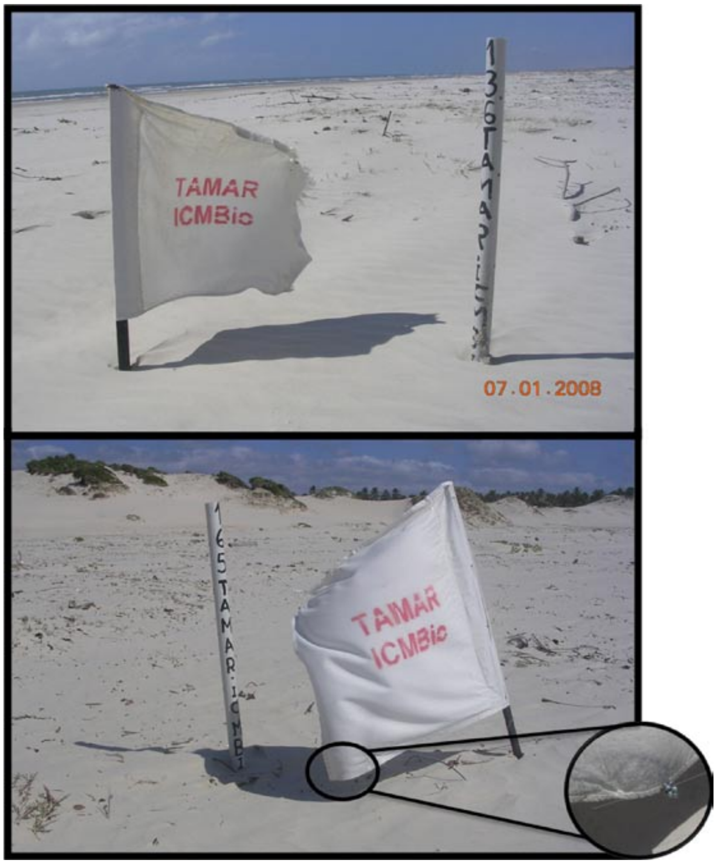

Figure 2. Flags used to reduce nest predation by wild dogs in northeastern Brazil. Upper flag does not contain rattles in contrast of the lower, in which the small circle indicates the rattles in detail.

Treatment	Successfully Hatched	Animal Predation	Other	Total
Grid	169 (78.2%)	44 (20.4%)	3	216
Grid/Flag (GF)	182 (94.3%)	7 (3.6%)	4	193
Grid/Flag/ Rattle (GFR)	129 (94.9%)	6 (4.4%)	1	136
Total	480 (88%)	57 (10.5%)	8	545
Flagged Nests (GF&GFR)	311 (94.5%)	13 (3.9%)	3	327
Predated before protection	n/a	88	2	90

Table 1. Nest protection strategies and numbers of nests predated and successfully hatched. Nests initially marked and subsequently lost (through tidal erosion, human predation, or other reasons) are grouped in the Other column.

and flags ($x^2 = 25.98$, d.f. = 1, $p < 0.001$), and also between nests protected by grid alone vs. those protected with grids and flags with a rattle ($x^2 = 17.65$, d.f. = 1, $p < 0.001$). This indicates the flag protection effectiveness as a good method to reduce nest predation when compared to the grid itself. However there was no significant difference in rate of predation between nests protected by flags with or without a rattle ($x^2 = 0.11$, d.f. = 1, $p > 0.05$). Thus, it appears that the rattle did not increase the efficiency of the flags to deter predation. Overall, 324 nests were protected with grids and flags (with or without rattle), and the rate of predation of this group was 3.95%, which was significantly lower than 24% predation rate for nests protected by grids alone ($x^2 = 37.52$, d.f. = 1, $p < 0.001$).

We suggest that flags are a simple and low cost solution to reduce sea turtle nest predation by foxes in northern Bahia. It may be the case that constant coastal winds, typical of northern Bahia, may contribute to the effectiveness of the flags, and flags may be less a less effective deterrent in other areas. There is also the possibility that over time, foxes may habituate to the flags and even begin to associate flags with a food source, as has been observed in the Mediterranean (Yerli et al. 1997). However, Tubberville & Burke (1994) tested whether flag markers attracted mammalian predators of fresh water turtle nests, and found that predators did not develop an association between flags and food availability. Tubberville & Burke (1994) also recommended alternating between different kinds of markers, to reduce the likelihood that mammalian predators may associate certain markers with turtle nests. Overall, we recommend that long term research is needed to properly address these issues.

Previously suggested methods for reducing mammalian predation of sea turtle nests include predator removal, either by trapping, using poisons or chemical repellents, and relocation of nests out of reach of predators. There are ethical and ecological implications associated with these strategies (Barthon & Roth 2006; Bouchard & Bjorndal 2000; O'Toole 2003; Ratnaswamy & Warren 1998), not to mention legal hurdles: the crab eating fox is a is a natural predator in northern Bahia, not an exotic or introduced predator; this would make it difficult to get legal permission to remove it from coastal habitats.

In terms of ecological implications of predator removal from our study area, the crab eating fox is a generalist and opportunistic hunter, preying specially on small mammals, birds, invertebrates and fruits (Berta 1982). Its removal may have various impacts on the local environment, including reduction of seed dispersion, changes in nutrient flux and also impacts on the abundance of other sea turtle predators, such as crabs (Ratnaswamy & Warren 1998). Also, information is lacking on the abundance trends of this fox and its population dynamics with our study area, thus complicating the design of an effective removal strategy that would not extirpate the local population.

In terms of using nest relocation to reduce predation rates, while the use of hatcheries is accepted as a positive conservation strategy in some cases, and can be an important tool for environmental education (Marcovaldi & Marcovaldi 1999), they can alter hatchling sex ratios, decrease nest hatch success, and reduce the transport of nutrients from natural sea turtle nests into sandy dune environments (Morreale et al. 1982, Bouchard & Bjorndal 2000).

Our results suggests that placing flags next to sea turtle nests helps reduce nest predation and obviates the need to use more drastic predator control measures. Indeed, using flags is simple and relatively economical. We plan to investigate in the near future whether it is necessary to use grids for sea turtle nest protection, or if flags are sufficient to keep foxes from damaging nests.

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Acclimating Captive Hawksbills to Sea Prior to Release

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Head-starting and introducing captive sea turtles into the sea in other contexts are widely practiced, but methods of doing this vary and have not been adequately evaluated (Mrosovsky 2007). I believe that sea turtles raised in captivity do not have the innate skills they need in order to prosper in the wild. On the island of Nevis, in the Caribbean, since 2002 I have been releasing turtles after acclimating them to the sea. These are animals that were brought to my sea life center because they had either wandered away from the sea after hatching or were at the bottom of the nest and too weak to get to the sea. Information for 3 turtles is presented in this note. Most of the records for the first 2 were lost, so the account for these is based largely on memory. Field notes for the third individual survived. The turtles were too small to sex from external characteristics.

In preparation for eventual release, the turtles were kept in a 2000 gallon aquarium which was 5 meters long to allow them to swim as much as possible in captivity. The tank was populated with fish and invertebrates and made to resemble the wild environment as much as possible. The turtles could forage, eat invertebrates and catch fish. They caught and ate lobsters and fish and ate colonial sea squirts and sea anemones on a regular basis. This diet was supplemented with fish, lettuce and turtle pellets. When the turtles reached 24-26 cm CCL, between 16 and 18 months old, they were taken for swims to slowly acclimate them to the wild and prepare them for eventual release. This size was chosen because it is the size of the smallest hawksbills seen nearshore.

A harness was made of neoprene (wherever it touched skin) and adjustable nylon straps, buckled at the widest part of the turtle and connected to a retractable dog leash (Fig. 1). There were no straps between the turtles' back flippers. Several days before their first swims they were introduced to the harness. Every day we would put the harness on the turtle. After awhile they would wear it for a short time in the tank. When they did not avoid being handled when the harness was put on them they were taken out to the sea. Once in the water the turtles were not restricted or guided in any way until it was time to get them back to shore. On their first forays into the sea all three turtles exhibited signs of stress, as described below,