The influence of embedded roadway lighting on the orientation of hatchling sea turtles (*Caretta caretta*)

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Artificial light interferes with hatchling orientation ("seafinding"). In Boca Raton, Florida, U.S.A., State Road A1A parallels the beach in front of two city parks and an incomplete vegetation barrier backs the beach. High-pressure sodium vapor (HPS) cobrahead streetlights on 11 m tall poles are often visible from nest sites. This 1.0 km length of roadway was modified by installing embedded lighting (light emitting diode [LED] "smartshields") in the roadway, and low mounted, louvered 100-watt HPS luminaries on each side of the road. Existing cobrahead streetlights were extinguished. During the 2001 sea turtle nesting season, we did "arena" experiments (simulated hatchling emergences from a nest) on the beach when (i) only the filtered HPS streetlights were on, (ii) only the embedded/louvered lights were on, and (iii) all lights were turned off. Hatchling orientation was disrupted when the streetlights were on, but not when the embedded/louvered lights were on. Hatchling performance when all lights were off matched their performance when the embedded/louvered lights were on. However even under the best of conditions (all roadway lights off) hatchling orientation was less accurate than at a totally dark beach, probably because of extraneous lighting from developed areas inland, and to the North and South. We conclude that embedded/louvered lighting is superior to HPS-filtered lighting as a method to protect sea turtle hatchlings at nest sites near coastal roadways.

Magnetic orientation behavior of hatchling loggerheads disrupted by magnets that produce distortion weaker than the geomagnetic field strength

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Laboratory experiments have revealed that sea turtles can garner both directional and positional information from the earths magnetic field. Recent experiments have shown that a magnet with an intensity stronger than the earths ambient field can disrupt this ability in hatchling loggerheads; it is believed that this behavioural change is the result of a disruption in the direction-finding sense of these turtles. In the current study, the orientation ability of loggerhead hatchlings bearing magnets which produced distortions at least an order of magnitude less than the strength of the earths field at various possible locations of a putative magnetoreceptor were tested. Control turtles which bore magnetically-inert brass bars were significantly oriented in the predicted eastward direction whereas turtles which bore magnets on the head, mid-carapace, or posterior carapace were randomly orientated. These results indicate that even a relatively small magnetic field distortion can disrupt normal magnetic orientation behaviour; this change in behavior may be the result of an influence on the position-finding sense of these turtles.

Impact of fire ant stings on sea turtle hatchling survival

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INTRODUCTION

The most destructive exotic ant species in the United States is the red imported fire ant, *Solenopsis invicta*, which arrived in Alabama by ship from South America less than 80 years ago. This predaceous ant has spread across the southeast US from Texas to North Carolina, killing off native invertebrates and vertebrates and causing tremendous economic damage. *S. invicta* has a growing reputation as a killer of hatchling birds and ground-nesting reptiles. Allen et al. (1997, 1998, 2001) found increased mortality and detrimental effects on hatching alligators, red-eared sliders, and red-bellied turtles when exposed to fire ants.

Most sea turtle nesting areas on the East Coast of the US are now infested to varying degrees with *S. invicta* (Allen et al. 2001). Hatching sea turtles are particularly vulnerable to attack by ants after pipping but before complete emergence from the nest. Fire ants respond rapidly and aggressively to food source cues such as mucus and moisture and often invade nests and attack the emerging hatchlings. The venom injected results in formation of a white pustule within 24-48 hours. Alkaloids and proteins present in the fire ant venom cause a local sting site reaction and may cause subsequent allergic responses. In humans, the venoms also display vasoactive, hemolytic and neurotoxic properties. Lesions may lead to skin necrosis, secondary infections and sepsis (Goddard et al. 2000).

A study of ant distribution and within-nest mortality during year 2000 nesting season at Juno Beach, Florida, found ant infestations at 62.5% of marked nest sites, with a significant correlation of ant infestation with proximity to dune vegetation. Four species of predatory ants were identified at nest areas. *S. invicta*, *Pheidole megacephala*, *S. geminata* and *Wasmannia auropunctata*. Nests with more than 100 ants at the bait had 57% more dead hatchlings (pipped or hatched) found within the nest chr-

ing post-emergence monitoring, compared to nests without ants (Wetherer et al., in press).

The impact of ants on hatchlings, however, is not limited to within-nest mortality. Hatchlings stung while pipping or emerging may suffer increased mortality directly due to envenomization and subsequent infection, or indirectly via misorientation and increased beach and at-sea predation due to decreased vigor. Our study is the first to examine this source of mortality in sea turtles.

METHODS

From August through October 2001, we studied hatchling loggerhead turtles (*Caretta caretta*) obtained either by opportunistic collection on Juno Beach (n=72) or via the hatchling rehabilitation tank at Marinelife Center of Juno Beach (n=35). Hatchlings were weighed, measured (straight carapace length), marked with nail polish for identification, and examined for lesions caused by ant stings, which began to be visible within 24-48 hours of collection. We recorded lesion locations and photographed them. Hatchlings displaying physical or neurological defects were excluded from the analysis. All hatchlings were maintained in a common outdoor seawater pool at the Marinelife Center in Juno Beach. Hatchlings were monitored every other day during their study periods for weight, length, survival, and changes in locations and severity of lesions. After ten days in the study, all hatchlings in apparent good health were scheduled for release (delivery to offshore feeding grounds via boat). The minimum number of monitoring days experienced for released hatchlings was twelve days.

RESULTS

Ants on nests. Twelve of nineteen excavated nests (63%) had ant activity in the nest area during excavation; eight (42%) had *S. invicta* present. Other, non-predatory ant species included *Dorymyrmex bureni* and *Paratrechina bourbonica*. All three ant samples taken on dead hatchlings contained only *S. invicta*. Lesions developed only on hatchlings taken from nests with *S. invicta* present.

Number and location of ant stings. We noted 139 separate white lesions apparently due to fire ant stings, on 50 hatchlings (mean=2.8 per hatchling). Overall, 82% of the stings were on rostral parts of hatchlings: snout, chin, head, eye, neck, and leading edge of the foreflippers ("wrist"). Only 18% were found on caudal areas: rear flipper, feet, axillae, tips of forelflippers (see Fig. 1). This pattern is consistent with ant attacks at the beach surface as hatchlings vertically migrate from the egg cavity.

Mortality of stung hatchlings. We found increased mortality in stung (n=50) versus unstung (n=57) hatchlings, a difference that increased over the 12 day rehab period: at four days (26% vs. 9%; p=0.1); at six days (28% vs. 12%; p<0.05);and at 12 days (77% vs. 44%, p<0.025).

DISCUSSION

Our analysis suggests that ant predation is a significant contributor to hatchling mortality during the first twelve days of post-nest life. The marked increase in mortality noted for stung hatchlings between six and twelve days may be the result of infections secondary to the ant lesions. Additional data from siblings with known history is needed to confirm the study's findings.

During the next nesting season, we plan to continue this research and obtain larger samples of sibling hatchlings for comparisons of vigor, orientation and survival. In the future, we wish to investigate other possible sources of post-emergence mortality related to fire ant stings, evaluating whether (1) invasion of nests by ants may induce premature or diurnal emergence of hatchlings seeking to escape, increasing risk of hypothermia and predation, (2) ant stings and soft tissue damage may disrupt normal visual orientation and/or divert attention from orientation to escape activities; (3) damage to soft tissues and flippers may decrease hatchling vigor and negatively affect navigation once hatchlings are launched into the waves; (4) feeding behavior may be impacted, lowering growth and vigor; and (5) there is increased risk of secondary infections and necrotic lesions.

Acknowledgements. This study was funded by Environmental Defense, and supported by the Marinelife Center of Juno Beach. Thanks to Jessica Olsen, undergraduate assistant extraordinaire. Dr. Michael Salmon, and all the folks at Marinelife Center, who provided advice and facilities.

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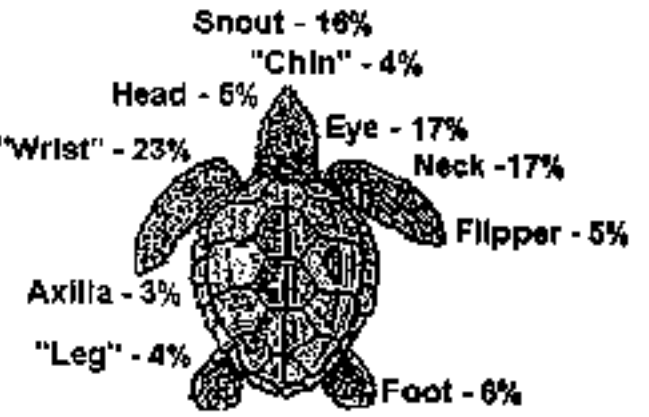

Fig. 1. Percent of total stings observed by location.