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Predaceous fire ants (Hymenoptera: Formicidae) at sea turtle (Testudines: Cheloniidae) nesting beaches and hatcheries in El Salvador

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Abstract

As in many other parts of the world, in El Salvador, few sea turtle (Testudines: Cheloniidae) eggs develop and hatch in situ on nesting beaches. Instead, conservationists relocate most sea turtle eggs to hatcheries for protection. Hatchery managers incubate the eggs in artificial nests within protected enclosures and then release the hatchling sea turtles into the ocean. We surveyed ants (Hymenoptera: Formicidae) on 2 sea turtle nesting beaches and at 14 sea turtle hatchery sites in El Salvador to evaluate the potential threat of predaceous ant species to sea turtle eggs and hatchlings. Of the ant species we found, only the tropical fire ant, *Solenopsis geminata* (F.) (Hymenoptera: Formicidae), is a known threat to sea turtle hatchlings. We found *S. geminata* at 5 of 7 (71%) and 7 of 30 (23%) baits along sea turtle nesting beaches at Las Bocanitas and Las Isletas, respectively, and within the nest enclosures at 7 of 14 (50%) hatchery sites. Given the widespread use of hatcheries for protecting sea turtle eggs worldwide, we believe it is important for hatchery managers to recognize the potential threat that predaceous ants pose to hatchling sea turtles. Hatchery managers may be unknowingly releasing apparently healthy but stung hatchlings to the ocean, only to have the hatchlings soon die from sting-related impairment. Fortunately, because of the small size of the incubation enclosures, controlling ants at hatcheries by using chemicals that have low toxicity to vertebrates and that degrade quickly (e.g., hydramethylnon) should be safe, simple, and relatively inexpensive.

Key Words: conservation; endangered species; predaceous ant; sea turtle hatchery

Resumen

Al igual que en muchas otras partes del mundo, en El Salvador, pocos huevos de las tortugas del mar (Testudines: Cheloniidae) se desarrollan y eclosionan en situ en las playas de anidación. En cambio, la mayoría de los conservacionistas trasladan la mayoria de los huevos de las tortugas del mar a criaderos para su protección. Los gerentes de los criaderos incuban los huevos en nidos artificiales dentro de recintos protegidos, y luego, libera los neonatos de las tortugas marinas en el océano. Se realizó un sondeo de las hormigas en dos playas de anidación de tortugas marinas y en 14 centros de incubación de tortugas marinas en El Salvador para evaluar el potencial de amenaza de las especies de hormigas depredadoras (Hymenoptera: Formicidae) a los huevos y crías de tortugas marinas. De las especies de hormigas que encontramos, sólo la hormiga de fuego tropical, *Solenopsis geminata* (F.) (Hymenoptera: Formicidae), es una amenaza conocida a crías de tortugas marinas. Encontramos *S. geminata* en 5 de los 7 (71%) cebos y 7 de los 30 (23%) cebos en las playas de anidación de tortugas marinas en Las Bocanitas y Las Isletas, respectivamente, y dentro de los recintos de nidos en siete de 14 (50%) sitios de incubación. Debido al uso generalizado de los criaderos para proteger los huevos de tortugas marinas en todo el mundo, creemos que es importante que los gerentes de criaderos reconozcan la potencial amenaza de las hormigas depredadoras a los neonatos de tortugas marinas. Los gerentes de criaderos pueden estar liberando al mar, sin saber, neonatos que son aparentemente sanos pero fueron picados, sólo para tener crías que mueren de una incapacidad relacionada con las picaduras. Afortunadamente, debido al pequeño tamaño de los recintos de incubación, el control de hormigas en los criaderos que utilizan métodos químicos debe ser seguro, simple y relativamente barato.

Palabras Clave: conservación; especies en peligro de extinción; hormiga depredadora; criadero de tortugas marinas

Conservationists often find it difficult to adequately protect threatened and endangered species in their natural habitat. In the case of sea turtles, conservationists commonly relocate complete clutches of sea turtle eggs from high-risk nesting beaches where eggs are vulnerable to human poaching, depredation by animals, and loss by tidal inundation (e.g., Mortimer et al. 1993; Marcovaldi & Marcovaldi 1999; García et al. 2003; Chacón-Chaverri & Eckert 2007; Patino-Martinez et al. 2012). These eggs are then usually incubated at protected hatcher-

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ies to increase survival rates of eggs and hatchlings. Such relocation efforts can contribute positively to sea turtle conservation, especially when beaches have near 100% egg mortality. Poorly managed hatcheries, however, can undermine conservation efforts (Prichard 1980). The dense concentration of nests in hatcheries can make a very large reproductive output vulnerable to complete loss by a single catastrophic event, such as contamination by microorganisms or attack by predators. In the present study, we examined the threat of predaceous ants on sea turtle nesting beaches and at sea turtle hatcheries.

Ants (Hymenoptera: Formicidae) might not seem to pose a serious threat to vertebrates. Several species of predatory ants, however, are known to attack and kill the hatchlings of ground-nesting birds and reptiles. Sea turtles are particularly vulnerable to attack by ants because hatchlings typically take from several hours to several days after pipping before they emerge from their nests (Godfrey & Mrosovsky 1999). During this time, ants may invade the nests and attack trapped hatchlings. Ants also sting hatchlings as they exit the nest. Hatchlings may die as a direct result of the ant stings or as an indirect result due to impairment caused by stings. Fire ants (*Solenopsis* species) (Hymenoptera: Formicidae) in particular pose an important threat to sea turtles. For example, in the Wassaw National Wildlife Refuge, Georgia, Moulis (1997) found a significant decrease in emergence success from nests of the loggerhead sea turtle, *Caretta caretta* (L.) (Testudines: Cheloniidae), infested with *Solenopsis invicta* Buren compared with uninfested nests. However, lowered emergence success might account for only a small portion of the increased mortality caused by fire ants. For example, Krahe (2005) compared the survival of hatchling loggerheads that had been stung by *S. invicta* with the survival of unstung hatchlings and found a tremendous impact of stings: after 10 d, only 33% of the stung hatchlings survived versus 95% of unstung hatchlings. In addition, the few stung loggerhead hatchlings that survived were significantly smaller and lighter than unstung hatchlings (Krahe 2005).

In many parts of the world, the tropical fire ant (*Solenopsis geminata* [F.]) is ubiquitous in open, disturbed environments, including beaches (Wetterer 2011). For example, Wetterer (2006) surveyed ants on an important sea turtle nesting beach at Tortuguero National Park on the Atlantic coast of Costa Rica and found *S. geminata* at 32 of 42 sites (76%) surveyed along the beach, including virtually all of the more highly disturbed sites adjacent to the town of Tortuguero. Previously, researchers documented ants preying on sea turtle eggs and hatchlings at Tortuguero but did not identify the ants; however, *S. geminata* was the only likely candidate. Crossland (2003: p. 137) found that on sea turtle nesting beaches in Suriname, fire ants (almost certainly *S. geminata*) “were common in nests close to vegetation cover and preyed upon emerging hatchlings. Dead hatchlings formed ‘plugs’ blocking nest emergence to live hatchlings, increasing mortality rates.”

Predaceous ants may pose an especially potent threat at sea turtle hatcheries. Hughes (1970) reported that predaceous driver ants (*Dorylus* sp.) attacked sea turtle eggs in a South African hatchery and caused almost 100% mortality of the eggs. Hughes (1971) observed ants attacking hatchlings as well, writing, “The ant invasion of a nest can be extremely rapid in that at least one clutch had hatched successfully but had been discovered by the ants when the hatchlings were halfway to the surface. Thirty out of seventy-eight hatchlings were killed en route to the surface.” Hughes (1972) reported that after using chemical control, ants were no longer a problem at the hatchery.

Here, we surveyed ants on sea turtle nesting beaches and at sea turtle hatcheries in El Salvador to evaluate the presence of predaceous ant species that may threaten sea turtle eggs and hatchlings. We discuss the implications of our findings for the management and conservation of sea turtles, and we offer recommendations for controlling ants at sea turtle nesting beaches and at hatcheries.

Materials and Methods

STUDY AREA

El Salvador is the smallest (21,040 km^2) and most densely populated (342 people per km^2) country in Central America. Four species of sea turtles nest along the 307 km Salvadoran coastline (in order of decreasing abundance): olive ridley (*Lepidochelys olivacea* [Eschscholtz]), green (*Chelonia mydas* [L.]), hawksbill (*Eretmochelys imbricata* [L.]), and leatherback (*Dermochelys coriacea* [Vandelli]), which combined lay approximately 9,000 to 13,000 egg clutches per year in El Salvador (Vasquez et al. 2008). Human consumption of sea turtle eggs is illegal in El Salvador (República de El Salvador 2009), but as a result of limited enforcement, few employment options, and high-density human populations near nesting beaches, local residents collect nearly 100% of the eggs (Liles et al. 2011). This renders the protection of sea turtle nests in situ (i.e., at the original site of deposition) infeasible on most beaches.

Consequently, starting in 1975, conservation organizations have established hatcheries and purchased sea turtle eggs collected by local residents (Liles et al. 2014). Eggs not purchased by conservation organizations are sold illegally for human consumption on local markets (Liles et al. 2014). Although hatcheries vary in size and quality, most are approximately 100 m^2 with a capacity of approximately 200 sea turtle nests, and they are located near the vegetation line on broad sandy nesting beaches. In 2012, the 37 hatcheries operated along the coast of El Salvador incubated nearly 1,700,000 eggs yielding over 1,450,000 hatchlings (MARN 2013).

ANT SURVEYS

For this study, we surveyed ants along the 2 beaches where turtle eggs are protected in situ and at 14 hatchery sites where sea turtle eggs are relocated for incubation and release of hatchlings (Fig. 1). On 30 Jul 2012, we surveyed ants along a section of the guarded 1.5 km sea turtle nesting beach at Las Bocanitas, and on 2 Aug 2012, we surveyed ants along a section of the guarded 1.5 km sea turtle nesting beach at Las Isletas. We placed folded index cards containing approximately 2 g

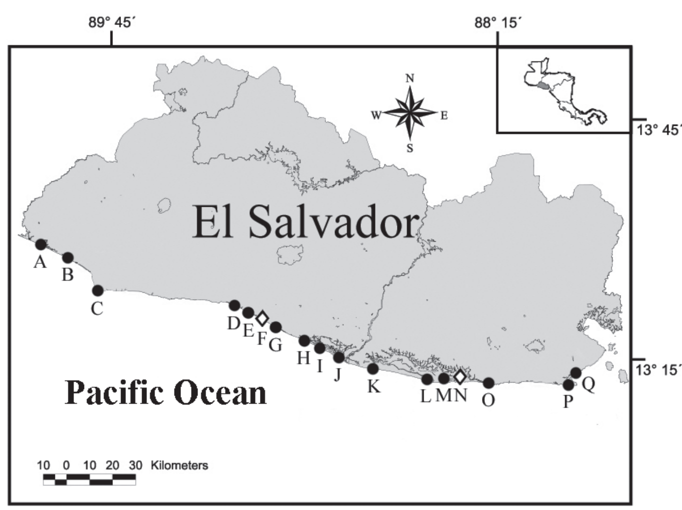

Fig. 1. Locations of study sites in El Salvador. Two sea turtle nesting beaches (diamonds) and 14 hatcheries (dots) were monitored along the coast of El Salvador in 2012. A = Bola de Monte; B = Barra de Santiago; C = Los Cobanos; D = San Diego; E = Toluca; F = Las Bocanitas; G = Zunganera; H = Costa del Sol 1; I = Costa del Sol 2; J = Isla Tasajera; K = San Juan del Gozo; L = Punta San Juan; M: La Pirraya; N = Las Isletas; O = El Espino; P = El Maculis; Q = El Tamarindo.

canned tuna in water at intervals (20 m at Las Bocanitas and 10 m at Las Isletas) near the beach vegetation line (*n* = 30 at both sites). At Las Bocanitas, dogs and crabs took most of our bait cards, leaving only 7 cards with ants. Therefore, at Las Isletas, we placed each card with a galvanized steel mesh held in place by a stake to prevent removal by animals. We laid the bait cards in the late afternoon and collected them 2 h later, placing them in individual plastic bags, later transferring all ants into 100% ethanol.

From 26 Jul to 3 Aug 2012, we surveyed ants in 14 sea turtle hatcheries. The hatchery enclosures varied in size but were typically 50 to 100 m^2. All were located adjacent to sea turtle nesting beaches. We placed 9 folded index cards containing approximately 2 g canned tuna in water within each enclosure, 1 card at each corner, 1 at the center of each side, and 1 in the center. We collected the cards 2 h later, placing them in individual plastic bags, later transferring all ants into 100% ethanol. In almost all cases, sea turtle eggs were present in the enclosures at the time of our survey. Due to security concerns, we conducted hatchery surveys during daylight hours. It is likely that ant activity was lower in the heat of the day than at night and that our surveys underestimated ant activity at the hatcheries.

In addition to the bait surveys, we searched the area surrounding the hatcheries at 13 of the 14 hatchery sites (all except Punta San Juan) to determine what ant species in the local area could potentially invade the hatchery enclosures. Voucher specimens were deposited at both the National Museum of Natural History in El Salvador and the Museum of Comparative Zoology at Harvard University, Cambridge, Massachusetts.

Results

We found 3 ant species on 7 bait cards at Las Bocanitas beach: *Solenopsis geminata* (5 baits), *Solenopsis globularia* (Smith) (1), and *Nylanderia* sp. (1). This may not be a representative sample; dogs and crabs took most of the 30 bait cards, and they may have selectively avoided cards with *S. geminata* present because of the ant's sting. Dogs and crabs are probably important predators of hatchling sea turtles on this beach.

We found 13 ant species on 30 bait cards along Las Isletas beach (* = exotic ant species): *Pheidole angusticeps* Wilson (11 baits), *Solenopsis geminata* (7), *Pheidole radoszkowskii* Mayr (6), *Camponotus atriceps* (Smith) (4), *Camponotus* sp. (4), *Tetramorium bicarinatum* (Nylander)* (4), *Nylanderia* sp. (3), *Tapinoma melanocephalum* (F.)* (3), *Crematogaster obscurata* Emery (2), *Dorymyrmex* sp. (2), *Ectatomma ruidum* (Borgmeier) (2), *Crematogaster rochai* Forel (1), and *Paratrechina longicornis* (Latreille)* (1).

We found 13 ant species on 171 bait cards in the hatchery enclosures: *Solenopsis geminata* (24 baits), *Dorymyrmex* sp. (14), *Monomorium ebeninum* Forel (10), *Monomorium pharaonis* (L.)* (8), *P. radoszkowskii* (4), *Aphaenogaster* cf *araneoides* (3), *Pheidole pugnax* Dalle Torre (2), *Pheidole susannae* Forel (2), *Camponotus* sp. (2), *Nylanderia* sp. (1), *S. globularia* (1), *Tetramorium lanuginosum* Mayr* (1), and *T. melanocephalum** (1).

We found *S. geminata* within 7 of the 14 hatchery enclosures: La Barra de Santiago (B: 6 baits), Los Cobanos (C: 4), Toluca (E: 3), Zunganera (G: 4), Costa del Sol 1 (H: 2), Playa El Espino (O: 1), and El Tamarindo (Q: 4). One hatchery site, La Barra de Santiago, had exceptionally high numbers of *S. geminata* at 6 of 9 baits (67%). This was the only hatchery that had trees growing in the incubation area. We found large *S. geminata* colonies nesting at the base of several coconut palm trees in this area. Finally, we found *S. geminata* in the vicinity of all 13 of the hatchery sites where we made visual surveys of the area.

Discussion

Of the ant species we found on the sea turtle nesting beaches and at the hatcheries in El Salvador, only *S. geminata* is a known threat to sea turtle hatchlings (Wetterer 2006). We found *S. geminata* at 5 of 7 (71%) and 7 of 30 (23%) baits along sea turtle nesting beaches at Las Bocanitas and Las Isletas, respectively, indicating that this species could pose a substantial threat to the hatchling sea turtles on natural nesting beaches. *Solenopsis geminata* was the most common ant species we collected at baits in the hatcheries, found within incubation enclosures at 7 of the 14 hatchery sites (50%).

Given the ubiquitous use of hatcheries for incubating sea turtle eggs worldwide (e.g., Mortimer et al. 1993; Marcovaldi & Marcovaldi 1999; García et al. 2003; Chacón-Chaverri & Eckert 2007; Patino-Martinez et al. 2012), we believe it is important for hatchery managers to recognize the potential threat that predaceous ants pose to hatchling sea turtles. Hatchery managers may be unknowingly releasing apparently healthy but stung hatchlings to the ocean, only to have the hatchlings soon die from sting-related impairment. The hatcheries in El Salvador typically have caging around each artificial nest to prevent the newly hatched turtles from dispersing throughout the enclosure. This caging could also prevent emerged hatchlings from escaping any stinging ants present. Removing this caging, however, could make the situation even worse if hatchlings moving around the hatchery enclosure encounter a nest of stinging ants.

Predaceous ants may represent a particularly high risk to hawksbill turtles (*E. imbricata*) given their dire conservation status and distinct nesting ecology. Fewer than 500 adult female hawksbills are estimated to exist in the eastern Pacific Ocean (Gaos et al. 2010), placing this population of sea turtles among the most endangered in the world (Wallace et al. 2011). The beaches of El Salvador host over 45% of total hawksbill nesting activity, with the majority of deposited eggs being relocated to hatcheries for protection (Liles et al. 2011). Additionally, because hawksbills tend to choose vegetated nest sites, hawksbills egg hatcheries are generally located near vegetation where ants appear to be more abundant (M. J. Liles, personal observation). Therefore, the small extant population size of hawksbills in the eastern Pacific Ocean and the close proximity of their nests to vegetated areas increase their vulnerability to predaceous ants and should be monitored closely.

Fortunately, because of the small size of the hatchery enclosures (typically approx. 100 m^2), protecting hatchlings at the hatcheries by controlling ants with chemical methods should be safe, simple, and relatively inexpensive. Several chemicals that have low toxicity to vertebrates and that degrade quickly (e.g., hydramethylnon; Plentovich et al. 2010) have been found to be effective for controlling *S. geminata* and other predaceous ants in ecologically sensitive areas, including U.S. national parks. We found other ant species on the nesting beaches and in the hatchery enclosures, besides *S. geminata*, that are also capable of injuring hatchling sea turtles, such as *Ectatomma* species that have powerful stings (Schmidt 1990). It may be wise hatchery policy to be cautious and act preemptively, controlling all ant species within hatchery enclosures throughout times of the year when eggs and hatchlings are present.

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