***INT. J. BIOL. BIOTECH.*, 11 (4): 605-610, 2014.**

DISORIENTATION OF HATCHLINGS OF MARINE TURTLE: AN OVERVIEW

Fahmida Iffat

Marine Biological Research Laboratory, Karachi, Pakistan
fahmida.iffat@hotmail.com

ABSTRACT

Marine turtle hatchlings, emerge from nests mostly at night. The lights reaching nesting sites from various sides cause disorientation to the emerging hatchlings. The paper discusses observations as well as some experiments conducted elsewhere in support of the evidence that light is the main factor responsible for disorientation of marine turtle hatchlings. Types of such artificial light sources and proposals to modify them to minimize disorientation in the interest of better conservation have been described.

Keywords: Marine turtle, nests, hatchlings, emerge, disorientation, beachfront, horizon, light intensity.

INTRODUCTION

Two species of marine turtles, *Chelonia mydas* and *Lepidochelys olivacea*, have been reported to regularly nest along Sindh and Balochistan coasts, Pakistan. Main nesting places in Sindh are Hawkesbay and Sandspit beaches of Karachi. In Balochistan the main nesting sites are Taq near Ormara coast, Astola Island and Daran near Jiwani coast. There are a number of studies on marine turtles from Pakistan including Asrar (1999), Firdous (1988, 2010), Ghalib and Zaidi (1976), Iffat (2009) Groombridge, *et al.* (1988), Kabrajee and Firdous (1984), Khan *et al.* (2005, 2010), Minton (1966), Rahman and Iffat (1997) and Waqas *et al.* (2011), which dealt with various aspects of marine turtles of Pakistan concerning nesting behavior, egg laying, population, tagging, captive rearing, hatchlings, emerging, releasing and conservation. The aspect of disorientation of hatchlings due to the light glare, has been mentioned as a casual factor but not highlighted as a serious threat to conservation of turtles.

The purpose of this paper is to (1) review the scientific studies on the sea finding ability of hatchlings (2) review the documentation of hatchling disorientation caused by artificial lighting (3) describe the types of light sources known to disorient hatchlings and (4) propose ways in which these artificial lights can be reduced in number or modified to minimize disorientation of sea turtle hatchlings.

The paper highlights the problem of disorientation of hatchlings of some species of marine turtles along with review of a few experiments on specific aspects of how hatchlings orient towards the sea.

OVERVIEW

Marine turtle hatchlings emerge from nests mostly at night. Day time emergence not observed (Iffat 2009). Bustard (1967) indicated that diurnal emergence is inhibited by the heat of the day. He concluded that underground hatchling movement in green turtles is slowed when sand surface temperature rises above 28.5^{o} C. the advantages of a temperature dependent nocturnal emergence are: (i) The sand attains the lethal temperature often during the day on many nesting beaches (ii) predators especially crows, kites and gulls are diurnal and elevated day time temperature may slow down the movement of hatchling while crawling to the sea, thus exposing them to longer period of danger of predation.

The emergence of marine turtle hatchlings more often around midnight, is a natural. phenomenon. The mechanism enabling hatchlings to orient properly towards the sea, has been studied by various authors. Mrosovsky (1978) and Ehrenfeld (1979) provided excellent reviews on the water finding ability of hatchlings. They concluded that the natural light on the horizon is the main visual cue in orientation. The common factor causing disorientation is the artificial light intensity. It has been observed that bright artificial light along nesting beaches disorient hatchlings causing them to spend extended period of time wandering landward or along the beach. Such disorientation usually results in an increase in their mortality.

Geotaxic orientation (taking up of a direction in relation to the slope of the beach) was hypothesized as the primary mechanism for orientation of hatchlings of loggerhead turtles (Parker, 1922). Nests are often located in such a way that the hatchling would have to crawl upward before reaching the downward slope to the water. Geotaxic orientation has since been shown to play a minimal role, in the ocean finding behavior of sea turtle hatchlings (Hendrickson; 1958; Carr and Ogren, 1960; Ehrenfeld, 1968; Mrosovsky and Shettleworth, 1974).

When hatchlings were blindfolded, they wandered in a confused and aimless manner, whether on a sloped beach or not, Ehrenfeld and Carr (1967). The evidence strongly indicates that orientation of sea turtle hatchlings depend largely on a visual response to light. Carr and Ogren (1960) have demonstrated that the mechanism for orientation is not simply a genetically imprinted compass sense. Hatchlings of green turtle, hatched on the east coast of Costa Rica, were taken to the Pacific side and were able to orient toward the water immediately. They accomplished this inspite of the fact that the compass direction, they took, was opposite the direction they would have taken had they been released on their native shore. Thus, compass sense does not appear to be a factor in the hatchlings' ability to locate the sea.

Daniel and Smith (1947) conducted experiments both in the laboratory and field on loggerhead turtles, and concluded that natural seaward light was the critical stimulus that orients a hatchling toward the ocean. Thus light over the open water provides an effective stimulus even when the ocean is hidden by other structures under natural conditions. The relationship between light intensity and the topography of the horizon has been emphasized by many authors as being the predominant factor in ocean finding behavior (Ehrenfeld and Carr, 1967). Verheijen and Wildschut, 1973). The difference in light intensities between the seaward and landward directions occurs mainly at the respective horizons and the hatchlings are able to accurately discriminate between these light intensities under natural beach conditions (Limpus, 1971). Mortimer (1982) reported that at Ascension island, which is the nesting ground for an isolated and unique population of green turtles, coastal activities and associated lights have drawn emerging hatchling away from the sea. Marine turtles that hatch under unnatural lighting condition, continue to orient towards the brightest horizon, (Mrosovsky 1972).

Although vision is essential for orientation on land, especially for the discrimination between light intensities, it has been established that sea turtles are myopic (near sighted) when their eyes are out of water therefore, the orientation of sea turtle is not dependent on sharp, clear retinal images(Ehrenfeld and Koch, 1967). This was substantiated by experiment in which adult green turtles were fitted with spectacles containing filters that blurred their vision. These filters failed to impair orientation (Ehrenfeld and Carr, 1967).

Turtles, in general have both photopic (daylight vision) and scotopic (night vision) mechanisms, as well as the ability to discriminate colour and brightness (Armington, 1954). Use of light in the night discourages turtles from nesting, (Khan *et al*., 2010). In the eye of the green turtle, cones predominate and rods are few. Oil globules which are usually associated with the cones are not organized in any discernible pattern and provide further evidence that the eye is more suited to the marine environment than to the air (Granda and Haden, 1970).

Experiments were conducted to determine what qualities of light were most responsible for stimulating hatchling orientation. Parker (1922) stated that sea turtle hatchlings were attracted to blue light from the ocean and that this was the stimulus to initiate orientation. Mrosovsky and Carr (1967) examined this colour preference and concluded that hatchling did indeed demonstrate a preference for the shorter wavelengths of blue and green, as compared to red, if given a choice between the two. Ehrenfeld and Carr (1967) and Mrosovsky and Shettleworth (1968), also demonstrated that hatchlings preferred blue light over red, but it may be a response to brightness rather than a response to the colour hues which means that shorter wavelength light (blue and green) seemed brighter to the hatchlings. Colour filter experiments have shown that blue light is not necessary for sea finding orientation and that the stimulus for orienting toward the water is primarily based on light intensity, rather than colour discrimination (Ehrenfeld and Carr, 1967; Ehrenfeld, 1968). Verheijen and Wildchut (1973) have stated that it is unlikely that hatchling can even discriminate colour at night under conditions of low illumination.

The water finding ability of hatchlings can be said to react "tropotactically to light"; that is, they compare the light intensities at the horizon level and balance the brightness inputs entering in both of their eyes, enabling them to maintain an orientation towards the light from open horizon, Mrosovsky, 1972). Under most natural beach conditions, this light is in the direction of the sea and away from the darker objects. However, landward artificial bright lights can reverse this, (Ehrenfeld, 1968. He emphasized that the collective glow of the lights located inland for several miles can disorient hatchlings.

Mrosovsky (1972) stated that any type of visual light stimulus will have some effect on orientation of the turtle hatchlings. Artificial lights introduced on the landward horizon can lead to hatchling orienting in the wrong direction if the illumination has a greater intensity than that of the seaward horizon. Hendrickson (1958) noted that green turtle hatchling could be "guided at will" up and down the beach with a flashlight Ehrenfeld (1968) fitted adult green turtles with masks containing a light source over each eye. By independently varying the brightness of these lights, he could control the direction of movement of the turtles: they would turn toward the side of the eye that was receiving the bright illumination.

McFarlance (1963) documented that artificial road lighting provided a strong enough stimulus to overcome the natural phototaxis involved in orientation in Southeastern Florida. Because of the bright street lights, hatchlings were found disoriented on the highways that were parallel to the beaches. I would like to mention a personal observation of November 02, 2009 at about 1:30am at Hawkes Bay nesting beach. Closer to 3rd turtle hatching enclosure, several green turtle hatchlings were seen completely disoriented, on the back slope running parallel to the road east ward, away from the beach, because of the brightness of several vehicular lights. Hatchling disorientation was also observed and documented by Philibosian (1976) for Hawksbill turtle in the U.S Virgin Island and Bandre and Mackmakin (1983) for loggerhead turtle (*Caretta caretta*) in Florida.

Mann (1977) studied the quantity of artificial lighting present on six Southeastern Florida beaches and documented disorientation of turtle hatchlings by determining the directional bearings that the hatchlings took upon emergence from their nests. His results clearly demonstrated a landward orientation taken by those hatchlings on beaches with intense beachfront illumination. He also described the paths taken by disoriented hatchlings on the beach. He stated that majority of hatchlings crawled in the direction of other light sources.

Moorehouse (1933) was able to draw hatchlings back onto the beach by shining a bright light in the surf. Similarly, Carr and Ogren (1960) stated that an intense artificial light could override the natural orientation and draw hatchling out of the ocean. Fletemeyer (1979) conducted a variety of experiments to test whether hatchlings were disoriented by coastal lights after entering the sea. He concluded that hatchlings were initially disoriented by the lights, but would eventually orient properly due to the swimming instinct along the wave direction.

Mortality due to disorientation

Mortality of disoriented hatchlings is due to a variety of factors. In many cases, hatchlings simply lost in sand and succumb to the heat and dehydration. Mann (1977) found hatchlings crawling on the beach during the day with their eyelids dried shut. Hatchlings that remain on the beach may orient correctly once daylight arrives, but high temperatures (above 24^{o}C) can weaken the hatchlings response to all stimuli, thus inhibiting activity (Mrosovsky and Shettleworth, 1968).

Disorientation of hatchlings increases the exposure time to predators. The extended period of time spent on the beach by disoriented hatchlings allows the predators greater opportunities to capture them. The predators of hatchlings are quite numerous including diurnal species. Birds such as gulls, crows and kites and feral dogs have been found to prey on disoriented live hatchlings at Hawkesbey/Sandspit beaches. Ghost crabs (*Ocypoda* sp.) and feral dogs have been found to be the most efficient nocturnal predators of sea turtle hatchlings. In the early morning several dead hatchlings can be seen near crab burrows.

PROBLEM LIGHT SOURCES

There are several lights which can cause disturbance to the newly emerging hatchlings to find natural seaward direction. Some of such lights are described below.

Beachfront building lights

On beachfront buildings homes, outdoor lights for security, decoration or recreational use on the nesting beaches may be responsible for of the disorientation of hatchlings. The intensity of one light may be low, but if such lights are numerous, they may significantly brighten the landward horizon and cause hatchlings to crawl away from the seaward direction.

Floodlight or spot light fixtures are particularly detrimental to hatchlings because they frequently are located on the roofs and other beach structures and illuminate large sections of beach.

Streetlights and other public light fixtures

McFarlance (1963) documented numerous incidences of disorientation of hatchlings caused by streetlights located along highway in South Florida. He observed that 95% of the hatchlings which came out of one nest got disoriented toward the road and were crushed by passing automobiles. Fletemeyer (1979) also reported many dead loggerhead hatchlings along one km road in Ft. Lauderdate, Florida, and concluded that streetlights running along the shoreline were responsible for their disorientation. Banre and Mackmakin (1983) state that streetlights located over a hundred yards away from nests, can attract hatchlings landwards.

Vehicular lights

Vehicular lights generally do not pose as great a threat to hatchlings as the bright stationary lights. The light from coastal traffic, with some exception, is blocked by dune and other beach structures. Still there are some places at Hawkes Bay/ Sandspit, where direct glare of headlights may prevent hatchlings from crawling to the sea. Motorcyclists have been observed to drive direct on the beach with their headlight on. These can not only disturb the nesting turtles, but also disorient hatchlings.

Flashlights

The time of emergence of hatchlings may coincide with the time when beach walkers are scouring the beach with flash light. A bright torch or flash light can attract hatchling from the time of emergence till even after they have entered the surf. Most of the beach walkers, being ignorant, do not realize that light can cause disorientation of hatchlings.

Miscellaneous problem light sources

It has been documented that offshore lights are also a source of disorientation of a large number of sea turtle hatchlings. De Silva (1982) reported that brightly lit fishing boats, anchored off shore in Malaysia, attracted a large number of hatchlings. Many of these were subsequently eaten by predatory fish that were also attracted to the lights. Mann (1977) reported that in Hawaii, ships with bright deck lights anchored offshore, attracted dozens of hatchlings. He discussed increased predation of hatchling by fish near Pompano Beach due to their attraction to the brightly illuminating boats. Philibosian (1976) observed that in US Virgin Islands, hatchlings of hawksbill were attracted to stadium lights during a baseball game and crushed on nearby roads.

Under construction beachfront buildings are also source of concern because they are usually brightly lit for security reasons. A housing scheme along Hawkesbay and Sandspit beaches, Karachi has been planned and development work is underway. The effect on hatchlings, by the overall illumination of reflected light from the huge project from landside, is uninvestigated. It is feared that artificial light source can be visible and shine directly on the nesting sites, which may cause disorientation. It is suggested that utmost care should be taken by the management to save the nesting beach from installation of such lights.

PROPOSED SOLUTIONS

Eliminating the Light Sources on the beach:

The most effective solution to the hatchling disorientation problem is to eliminate or reduce problem lights. In many cases, turning off beachfront lights can be easily accomplished once owners of the buildings are informed of the hatchlings disorientation problem.

Many light sources allow large amounts of light to escape into unwanted areas. This misdirected glare is not only wasteful, but can be highly detrimental to the emerging hatchlings. Some artificial coastal lights seem to serve no function at all, yet are left on the entire night.

Elimination of light sources can be divided into three categories; (i) year-round elimination, (ii) seasonal elimination and (iii) nightly elimination. Eliminating shoreline light for entire year is preferable because management practices and light reduction measures would not have to be initiated every nesting season. The process of eliminating specific problem lights seasonally can be time consuming and early nests can hatch before such efforts are made. Year-round elimination is the most useful option for conservation. On the nesting beaches, a proper coastal management plan should prohibit the year-round use of all beachfront lights.

Seasonal restrictions on the use of beachfront lights should begin before the beginning of the nesting season and continue throughout the hatching season. At Hawkesbay and Sandspit beaches this period may be from July 1 to December 31. During the period of restriction, caution should be taken that lights are not turned back on when adult nesting activity is continuing.

Nightly restrictions can be utilized for those lights that cannot be turned off for safety reasons or because of nightly public activity. These lights could be placed on automatic timers that are preset to go off at a time when public activity ceases. A suggested time for shut off is midnight, because mostly the hatchlings start emerging after mid night . This would allow the emerging hatchlings to orient correctly.

Timer-adapted lights could prevent hours of wandering and reduce the hatchling mortality that occurs due to exposure to daytime predators as well as rise in temperature.

Prevent direct light on the beach

(A) Shading or screening the existing light sources

Those beachfront lights, which cannot be turned off, may be modified to include shades or screens. If positioned correctly, this would prohibit direct light from being cast over the nests and on the beach.

Hatchlings that are shaded from a direct light source are often able to orient toward the open seaward horizon (Mann, 1977).

(B) Use Structural Barriers to block the Light Source

Structure barriers, could be placed between a light source and the beach to prevent direct light from illuminating nest sites.

(C) Lowering the Elevation of the Light Source:

Shoreline lights, if any, should be set at as low an elevation as possible. Similarly Security lights at construction sites should also be placed low to prevent direct light from spilling out on the nesting beach.

REFERENCES

Armington, J.C (1954). Spectral sensitivity of the turtle, *Pseudemys*. *J. Comp. Physiol. Psychol*., 47: 1-6.

Asrar, F.F. (1999). Decline of marine turtle nesting populations in Pakistan. *Mar. Turtle Newslet.,* 83: 13-14.

Bandre, P. and D. Mackmakin (1983). The effects of beachfront lighting on hatchling *Caretta caretta* in Florida for the 1983 nesting season. Unpublished report to Florida Department of Natural Resources 1-12.

Bustard, H.R. (1967). Mechanism of nocturnal emergence from the nest in green turtle hatchlings. *Nature*, 214: 317.

Car, A. and L. Ogren (1960). The ecology and migrations of sea turtles. 4. The green turtle in the Caribbean Sea. *Bull. American Mus. Nat. Hist*., 121: 1-48.

Daniel, R.S. and K.U. Smith (1947). The sea-approach behavior of the neonate loggerhead turtle. *J. Comp. Physiol. Psychol*., 40:413-420.

De Silva, G.S. (1982). The status of sea turtle populations in East Malaysia and South China Sea. In: *Biol. and conservation of sea turtles* (ed.: KA. Bjordnal), pp.327-337. Washington DC Smithsonian. Institution Press.

Ehrenfeld, D.W (1968). The role of vision in the sea-finding orientation of the green turtle. 2. Orientation mechanism and range of spectral sensitivity. *Anim. Behav.* 16: 281-287.

Ehrenfeld, D.W (1979). Behaviour associated with nesting. In: *Turtle perspective and research* (ed. by Harless and Morlock, pp. 417-434, New York, Wiley-Interscience.

Ehrenfeld, D.W and A. Carr (1967). The role of vision in the sea-finding orientation of the green turtle (*Chelonia mydas*). *Anim. Behav*., 15: 25-36.

Ehrenfeld, D.W and A.L. Koch (1967) Visual accommodation in the green turtle. *Science*, 155: 827-828.

Firdous, F. (1988). Conservation of turtles at Sandpit and Hawkes Bay Karachi. In: *Proceedings Of International Conference on Marine Sciences of Arabian Sea*(ed. by Thompson, M.F and N.M Tirmizi), pp.217-222. American Institute of Biological Sciences, Washington D.C:

Firdous, F., Sohail Barkati and Solaha Rahman (2010). Hatchling and rearing of two species of marine turtles from Karachi. *Records Zoological Survey, M/o Environment Islamabad Pakistan*, 19: 55-60.

Fletemeyer, J.R. (1979). Ascension Island development: lessons from Florida. *Mar. Turtle Newslet*., 11: 2-3.

Ghalib, S.A. and S.S.H. Zaidi (1976),. Observations on the survey & breeding of marine turtles of Karachi coast. *Agric. Pakistan* 27: 87-96.

Granda, A.M. and K.W. Haden (1970). Retinal oil globule counts and distribution in two species of turtles. *Psendemys scripta elegans* (Wied) and *Chelonia mydas mydas* (Lin). *Vis Res*., 10: 79-84.

Groombridge, B., A.M. Kabraji and A. L. Rao (1988). Marine turtles in Baluchistan (Pakistan). *Mar. Turtle Newslett.*, 42: 1-3.

Hendrickson, J.R. (1958). The green sea turtle *Chelonia mydas* in Malaya and Sarawak. *Proc. Zool. Soc. London* 130: 455-535.

Iffat, F. (2009). *Marine turtles*. Zoological Survey Department, Ministry of Environment, Government of Pakistan Islamabad.33p.

Kabraji A. M and F. Firdous (1984). *Conservation of Turtles. Hawkes Bay and Sandspit.* Project Report, WWF & Sindh Wildlife Management Board, Karachi-Pakistan p, xxx.

Khan, M.Z., B. Hussain and S.A. Ghalib (2005). Current status of the reptilian fauna along Karachi coast with special reference to marine turtles. *J. Nat. Hist. Wildlife,* 4: 127-130.

Khan, M.Z., B. Hussain, S. A. Ghalib, A. Zehra and N. Mehmood (2010). Distribution, population status and environmental impact on reptiles in Manora, Sandspit, Hawkesbay and Cape Monze Area of Karachi Coast. *Canadian J. Pure & App. Sci*., 4: 1053-1071.

Limpus, C.J. (1978) Sea turtle Ocean finding behaviour. *Search*, 2: 385-387.

Mann, T. M. (1977). *Impact of developed coastline on nesting and hatchling sea turtles in Southeastern Florida*. MS thesis Atlantic University, Florida, USA.

McFarlance (1963). Disorientation of loggerhead hatchlings by artificial road lighting. *Copeia*, 153.

Minotn, S.A. (1966). A contribution to the herpetology of West Pakistan. Bull. American *Mus. Nat. Hist*. 134: 27-184.

Moorhouse, F.W. (1933). Notes on the green turtle (*Chelonia mydas*). *Rep. Great Barrier Reef Comm.*, 4: 1-22.

Mortimer, J.A. (1982). *Factors influencing beach selection by nesting sea turtles*. In: *Biology and conservation of sea turtles* (ed. K.A Bjordnal), pp.45-51. Washington D.C, Smithsonian Institution press.

Mrosovsky, N. (1972). The water-finding ability of sea turtles. Behavioural studies and physiological speculations. *Brain Behav Evol.*, 5: 202-225.

Mrosovsky, N. (1978). Orientation mechanisms of marine turtles. In: *Animal migration, navigation and homing* (ed. K. Schmidt-Koenig and W.T Keeton). Berlin, Springer-Verlag.

Mrosovsky, N. and A. Carr (1967). Preference for light of short wave lengths in hatchling green Sea turtle *Chelonia mydas*, tested on their natural nesting beaches. *Behaviour* XXVIII (3-4): 217-231.

Mrosovsky, N. and S.J. Shettleworth (1968). Wavelength preferences and brightness cues in the water finding behavior of sea turtles. *Behaviour* 32: 211–257.

Mrosovsky, N. and S.J. Shettleworth (1974). Further studies on the sea-finding mechanism in green turtle hatchlings. *Behavior*, 51: 195-208.

Parker, G.H. (1922). The crawling young loggerhead turtles toward the sea. *J. Exp. Zool*., 36: 323-331.

Philibosian, R. (1976). Disorientation of hawksbill turtle hatchlings, *Eretmochelys imbricata*, by stadium lights. *Copeia*, 824.

Rahman, H., and F. Iffat (1997). A revised checklist of reptiles of Pakistan, *Rec. Zool. Sur. Zoological Survey Department, Government of Pakistan, Islamabad,* 13: 63-69.

Verheijen, F.J. and J.T. Wildschut (1973). The photic orientation of Hatchling Sea turtles during water finding behaviour. *Netherlands. J. Sea Res*., 7: 53-67.

Waqas, U., S. A. Hasnain, E. Ahmad, M. Abbasi and A. Pandrani (2011). Conservation of green turtle (*Cheloniamydas*) at Daran beach, Jiwani, Balochistan. *Pakistan J. Zool.* 43:85-90.

(*Accepted for publication September 2014*0