Physical factors influencing Muscidae and *Pimelia* sp. (Tenebrionidae) infestation of Loggerhead turtle (*Caretta caretta*) nests on Dalaman Beach, Turkey

YUSUF KATILMİŞ & RAŞIT URHAN

Department of Biology, Faculty of Arts and Science, Pamukkale University, P.O. Box 286, Denizli, Turkey

(Accepted 15 November 2006)

Abstract

The physical factors affecting the infestation of individual loggerhead turtle (*Caretta caretta*) nests by Muscidae and *Pimelia* sp. were determined in the 2002 and 2003 hatching seasons on Dalaman Beach, Turkey. The data were collected from the middle of July to the middle of September in both years. The most significant factor, by *t*-test, for *Pimelia* sp., was the distance of the nest from vegetation (*P* < 0.001), and the most significant factor for Muscidae was the depth from the surface to the egg chamber (*P* < 0.001). The distances of nests from vegetation were found to be significant factors for both *Pimelia* sp. and Muscidae. For conservation, it should be noted that the relocation of nests from the water’s edge to further inland or to a hatchery site closer to vegetation may increase insect infestation and reduce hatching success.

Keywords: Caretta caretta, egg, nest, Pimelia sp., Muscidae, infestation, Dalaman Beach, Turkey

Introduction

The presence of larvae from two dipteran families (Phoridae and Sarcophagidae) in marine turtle nests has been the subject of relatively few studies. Larvae of the dipteran family Phoridae have been documented in nests of green (*Chelonia mydas*) (Fowler 1979) and hawksbill turtles (*Eretmochelys imbricata*) (Bjorndal et al. 1985) in Costa Rica. Fowler (1979) suggested that the larvae feed on weakened or already dead hatchlings and that they pose no real threat to the reproductive success of turtles. However, Moll and Legler (1971) reported females of the same species of Phoridae invading turtle eggs (of *Trachemys scripta*), entering through the initial tears made in the shells by the hatchlings. The flies then oviposited on the eyes and yolk sacs of the hatchlings turtles, which subsequently died. Occasionally, the larvae, which readily feed on non-viable turtle eggs, may attack viable eggs. The first instar larva is able to enter the egg through the larger pores of the latter’s shell (Acuna-Mesen and Hanson 1990). However, *Eumacronychia sternalis* (Sarcophagidae,
Diptera) was reported to infest green turtle eggs on the Pacific coast of Mexico and reduce hatching success by at least 30% (Lopes 1982). Iverson and Perry (1994) reported that Eusenotainia also infest fresh water turtle (Terrapene carolina) nests. Sarcophagids of the genera Phorosinella and Eusenotainia were recorded in nests of leatherback turtles (Dermochelys coriacea) and olive Ridley turtles (Lepidochelys olivacea) in Mexico, but did not seriously affect the survival of either turtle species (Andrade et al. 1992). Vasquez (1994) noted that larvae of Eusenotainia rufiventris live on leatherback turtle hatchlings. Insect infestation was first reported by Baran and Türkozan (1996) in the Mediterranean. Türkozan (2000) also found these types of infestations on another beach (Kızılot beach, central Mediterranean coast of Turkey). Broderick and Hancock (1997) mentioned various insect groups infesting marine turtle eggs in northern Cyprus. Eleven dipteran species, with Sarcotachina aegyptica being dominant, were recorded in turtle nests in northern Cyprus (McGowan et al. 2001a). On Fethiye beach, tenebrionid larvae caused the most damage by penetrating the eggs and hatchlings of loggerhead turtles, destroying 8.1% of the eggs in infested nests and 0.6% of hatchlings (Baran et al. 2001). Recently, some invertebrate infestation has also been reported on Dalaman beach. Pimelia sp. (Tenebrionidae) and Muscidae larvae were found in 36 and 39%, respectively, of loggerhead turtle nests (Katilmis et al. in press).

Site factors influencing marine turtles’ nesting are location in relation to vegetation and high water mark, nest depth and humidity (Hays and Speakman 1993; Hays et al. 1995), temperature (Stoneburner and Richardson 1981) and sand type and compactness (Cardinal et al. 1998; Foote and Sprinkel 1994; Mortimer 1995). According to Ackerman (1997), offspring sex, phenotype and hatching success were significantly affected by location choice of the female marine turtle. However, Blamires and Guinea (1998) suggested that this situation affects the probability of nest predation. Factors affecting insect infestation of marine turtle nests were first investigated by McGowan et al. (2001b), including the depth of the egg chamber, distance to high water mark, number of dead, hatchling emergence duration and second transplanted nests. The most significant factor was the depth of the egg chamber.

Material and methods

This study was carried out on Dalaman Beach, which is one of the main nesting sites for loggerhead turtles (Caretta caretta). All data were collected from the middle of July to the middle of September in 2002 and 2003.

After the hatchlings’ emergence, nests were excavated and their contents removed. During nest excavation, dead embryos and hatchlings, empty eggshells, living hatchlings and insect infestation on the eggs and hatchlings were recorded. The locations of larvae and other insects in the nests were recorded and the specimens were preserved in 70% ethanol. Specimens were identified only to the family or genus level according to the available literature sources (Anon 1987; Booth et al. 1990; Lodos 1995; Elzinga 2000).

Some physical factors were chosen to determine the cause of insect infestation, including depth of the egg chamber, diameter of the egg chamber, distance of land-ward vegetation, distance to the water’s edge, humidity and sand grain size in nests. To determine of depth and diameter of the egg chamber, it was measured at three different positions and arithmetic average taken. To measure distance of landward vegetation, the closest plant community to the nest was recorded. To determine distance to the water’s edge, the distance between high water and the nests was measured. To determine humidity of the egg
chamber, after emptying remains from the nests, sand samples were taken by a manual scrape from the bottom to the top of the nests. These sand samples were put into plastic bags and recorded with nest data in indelible marker. These plastic bags were then placed in a second plastic bag to prevent loss of humidity. Weight of the moist sand samples was measured and recorded on the same day. Sand samples were dehydrated for 8 h at 60°C temperature in an oven in the laboratory and the dry weight measured and moisture ratio calculated. Sand from each nest was sieved and classified according to Wentworth (1922). All samples were either of fine, medium or coarse sands. Statistical analyses were performed using the SPSS 10.0 (using an independent t-test as to whether Muscidae and *Pimelia* sp. exist in nests) programme.

**Results**

A total of 122 nests were studied from 2002 and 2003. Physical factors were analysed statistically and it was found that the most significant factor for *Pimelia* sp. was distance from landward vegetation. Fewer *Pimelia* sp. were found in the nests further from vegetation. Another factor influencing infestation of *Pimelia* sp. was distance from water’s edge. Fewer *Pimelia* sp. were found in the nests closest to the water’s edge. Depth of the egg chamber, diameter of the egg chamber, humidity and sand grain size were not significant factors for infestation of *Pimelia* sp. (Table I).

The most significant factor influencing Muscidae infestation was depth of the egg chamber. Nests at shallower depths were more likely to be infested than those at greater depths. Other factors influencing infestation of Muscidae were distance from landward vegetation and sand grain size. Fewer Muscidae were observed in the nests further from vegetation. Sand grain size is an important factor influencing Muscidae infestation – nests having a larger sand grain size were more likely to be infested by Muscidae. Diameter of the egg chamber, distance from water’s edge and humidity were not significant factors for infestation of Muscidae (Table II).

**Discussion**

Nests transplanted to a common hatchery site suffered increase insect infestation in Michoacán, Mexico (Andrade et al. 1992). However, Vásquez (1994) suggested that the

| Physical factor                     | Number of nests | Average | S.D  | t     | Degree of freedom | P      |
|-------------------------------------|-----------------|---------|------|-------|------------------|--------|
| Diameter of egg chamber             | + 44            | 25.00   | 3.03 | 0.282 | 120              | 0.779  |
|                                     | – 78            | 24.85   | 2.82 |       |                  |        |
| Depth of egg chamber                | + 44            | 49.48   | 4.80 | 0.924 | 120              | 0.357  |
|                                     | – 78            | 50.44   | 5.86 |       |                  |        |
| Distance from landward vegetation   | + 44            | 4.09    | 5.64 | 6.267 | 120              | <0.0001*|
|                                     | – 78            | 12.69   | 8.05 |       |                  |        |
| Distance from the water’s edge      | + 44            | 24.32   | 8.23 | 3.521 | 120              | 0.001* |
|                                     | – 78            | 18.42   | 9.23 |       |                  |        |
| Humidity                            | + 27            | 3.414   | 1.892| 0.976 | 73               | 0.333  |
|                                     | – 48            | 3.059   | 1.253|       |                  |        |
| Sand grain size                      | + 28            | 1.96    | 0.69 | 0.537 | 80               | 0.593  |
|                                     | – 54            | 1.87    | 0.78 |       |                  |        |
number of nests and their density had no effect on infestation levels in Michoacán. In another study, Lopes (1982) reported that transplanted *Chelonia mydas* nests had higher insect infestation than non-transplanted nests. This contrasts with findings by McGowan et al. (2001b), who indicated that transplanted nests possessed fewer infested eggs in northern Cyprus. Nevertheless, in the same study of infestation by Diptera larvae, the most significant factor was found to be the depth of the egg chamber. In addition, it was reported that infestation of dipteran larvae decreases with increasing distance from the high water mark. In our study, it was found that the most significant factor for Muscidae infestation was the depth to the egg chamber (*P*<0.0001). Other significant factors were sand grain size and distance from landward vegetation. The results show that fewer Muscidae were in nests further from vegetation and having smaller sand grain size. Both studies indicated that depth of egg chamber was the most significant factor for Diptera infestation. However, our study indicated that distance from the water’s edge was not a significant factor for Diptera infestation. Similarly, Vásquez (1994) reported that distance from water’s edge had no effect on infestation of Diptera on leatherback turtle nests. However, distance from the water’s edge was a significant factor for infestation of *Pimelia* sp., and unlike Diptera infestation, fewer *Pimelia* sp. were in the nests closest to the water’s edge.

Depth of the egg chamber is related to burrowing ability of the larvae, as suggested by McGowan et al. (2001b). However, they considered that larvae find the decayed eggs and hatchlings by smell. In the present study, it was found that depth of the egg chamber, distance from landward vegetation and sand grain size were significant factors influencing Muscidae infestation in Dalaman.

No statistically significant difference was reported for Tenebrionidae larvae for distance from landward vegetation and plant remains in the nests at Fethiye (Baran et al. 2001). For the Tenebrionidae family in Dalaman, however, it was found that the most significant factor was distance from landward vegetation for *Pimelia* sp. These larvae were more frequently observed near landward vegetation and in plant remains in the nests. However, fewer *Pimelia* sp. larvae were found in nests closest to the water’s edge; thus suggesting that Tenebrionidae feed on plants and plant remains.

Our results showed that nests closer to vegetation had greater *Pimelia* sp. and Muscidae infestation than those further away. Therefore, relocation of nests from inundation to sites further inland, close to vegetation, may increase the infestation rate of eggs and hatchlings. The main findings of this study are that, when relocating nests to a safer area, the new sites

| Muscidae                      | Number of nests | Average | S.D. | t   | Degree of freedom | P      |
|------------------------------|-----------------|---------|------|-----|-------------------|--------|
| Diameter of egg chamber      | + 46            | 24.89   | 3.46 | 0.031| 120               | 0.976  |
|                              | – 76            | 24.91   | 2.50 |     |                   |        |
| Depth of egg chamber         | + 46            | 45.89   | 3.64 | 8.139| 120 <0.0001*      |        |
|                              | – 76            | 52.63   | 4.85 |     |                   |        |
| Distance from landward vegetation | + 46     | 7.00    | 8.28 | 2.736| 120 0.007*        |        |
|                              | – 76            | 11.16   | 8.05 |     |                   |        |
| Distance from the water's edge| + 46            | 22.33   | 9.13 | 1.655| 120 0.100         |        |
|                              | – 76            | 19.47   | 9.28 |     |                   |        |
| Humidity                     | + 29            | 2.794   | 1.126| 1.814| 73 0.074          |        |
|                              | – 46            | 3.434   | 1.675|     |                   |        |
| Sand grain size              | + 32            | 2.16    | 0.72 | 2.543| 80 0.013*         |        |
|                              | – 50            | 1.74    | 0.72 |     |                   |        |
should be (1) sufficiently distant from vegetation, (2) have a predominantly small sand grain size and (3) be deep enough (>50 cm) to prevent fly infestation.

Reference

Ackerman RA. 1997. The nest environment and the embryonic development of sea turtle. In: Lutz PL, Musick JA, editors. The biology of sea turtles. CRC Marine Science Series. Boca Raton, FL: CRC Press. p 83–106.

Acuna-Mesen RA, Hanson PE. 1990. Phorid larvae predators of turtle eggs. Herpetological Review 21:13–14.

Andrade RM, Flores RL, Fragosa SR, Lopez CS, Sarti LM, Torres ML, Vasquez GB. 1992. Efecto de las larvas de diptero sobre el huevo y las crías de tartuga marina en el Playon de Mexiquillo, Michoacán. In: Benabib NM, Sarti LM, editors. Memorias del VI encuentro interuniversitario sobre tortugas marinas en México. Mexico: Publicaciones de la Sociedad Herpetológica Mexicana. No. 1. p 27–37.

Anon . 1987. Manual of nearctic Diptera. Volume 2, Ottawa, Ontario: Biosystematics Research Centre. Monograph no 28.

Baran I, Türkozan O. 1996. Nesting activity of the loggerhead turtle, Caretta caretta on Fethiye beach, Turkey, in 1994. Chelonia Conservation and Biology 2:93–96.

Baran I, Ozdemir A, Ilgaz C, Türkozan O. 2001. Impact of some invertebrates on eggs and hatchlings of Loggerhead turtle, Caretta caretta, in Turkey. Zoology in the Middle East 24:9–17.

Bjorndal KA, Carr A, Meylan AB, Mortimer JA. 1985. Reproductive biology of the Hawksbill Turtle (Eretmochelys imbricata) at Tortuguera, Costa Rica, with notes on the ecology of the species in the Caribbean. Biological Conservation 34:353–368.

Blamires SJ, Guinea ML. 1998. Implications of nest site selection on egg predation at the turtle rookery at Fog Bay. In: Kennet R, Webb A, Duff G, Guinea ML, Hill G, editors. Marine Turtle Conservation and Management in Northern Australia. Darwin, Northern Territory, Australia: Centre for Indigenous Natural and Cultural Resource Management Centre for Tropical Wetlands Management, Northern Territory University. p 20–24.

Booth RG, Cox ML, Madge RB. 1990. IIE guides to insects of importance to man. III. Coleoptera, Cambridge University Press. 384 p.

Broderick AC, Hancock EG. 1997. Insect infestation of Mediterranean marine turtle eggs. Herpetological Review 28:190–191.

Cardinal JL, Willis B, Weaver B, Koepfler ET. 1998. Influence of meteorological and beach sand optical characteristics upon nest location of the Loggerhead Sea Turtle (Caretta caretta). In: Byles R, Fernandez Y, editors. Proceedings of the 16th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo NMFS-SEFSC 412. Miami, FL: NOAA. 30 p.

Elzinga RJ. 2000. Fundamentals of entomology. Prentice Hall: Englewood Cliffs, NJ. 495 p.

Foote J, Sprinkel J. 1994. Beach compactness as a factor affecting turtle nesting on the westcoast of Florida. In: Bjorndal KA, Bolten AB, Johnson DA, Eliazar PJ, editors. Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo NMFS-SEFSC-351. NOAA: Miami, FL. p 217–220.

Fowler L. 1979. Hatching success and nest predation in the Green Sea Turtle, Chelonia mydas, Tortuguero, Costa Rica. Ecology 60:946–955.

Hays GC, Speakman JR. 1993. Nest placement by Loggerhead Turtle, Caretta caretta. Journal of the Marine Biological Association UK 75:667–674.

Hays GC, Adams CR, Mortimer JA, Speakman JR, Boerema M. 1995. Nest site selection by sea turtle. Journal of the Marine Biological Association UK 75:667–674.

Iverson JB, Perry R. 1994. Sarcophagid fly parasitoidism on developing turtle eggs. Herpetological Review 25:425–429.

Katılmış Y, Urban R, Kaska Y, Başkale E. 2006. Invertebrate infestation on eggs and hatchlings of the Loggerhead turtle (Caretta caretta), in Dalaman, Turkey. Biodiversity and Conservation (in press).

Lodos N. 1995. Türkiye Entomolojisi IV. İzmir: E.Ü Ziraat Fakültesi. 250 p.

Lopes HS. 1982. On Eumacronychia sternalis Allen (Diptera, Sarcophagidae) with larvae living on eggs and hatchlings of the east pacific green turtle. Revista Brasileira de Biologia 42:425–429.

McGowan A, Broderick AC, Deeming J, Godley BJ, Hancock EG. 2001a. Dipteran infestation of Loggerhead (Caretta caretta) and Green (Chelonia mydas) Sea Turtle nests in Northern Cyprus. Journal of Natural History 35:573–581.

McGowan A, Rowe LV, Broderick AC, Godley BJ. 2001b. Nest factors predisposing Loggerhead Sea Turtle (Caretta caretta) clutches to infestation by Dipteran larvae on Northern Cyprus. Copeia 2001:808–812.
Moll EO, Legler JM. 1971. The life history of a neotropical slider turtle, *Pseudemys scripta* (Schoepff), in Panama. Bulletin of the Los Angeles County Museum, Science 11:1–102.

Mortimer JA. 1995. Factor influencing beach selection by nesting sea turtles. In: Bjorndal KA, editor. Biology and Conservation of Sea Turtle. Washington, DC: Smithsonian Institution Press. p 45–51.

Stoneburner DL, Richardson JL. 1981. Observation on the role of temperature in Loggerhead Turtle nest site selection. Copeia 1981:231–238.

Türkozan O. 2000. Reproductive ecology of the loggerhead (*Caretta caretta*) on Fethiye and Kızılot Beaches Turkey. Chelonia Conservation and Biology 3(4):686–692.

Vasquez LGB. 1994. Dirteros de la familia Sarcophagidae que actuan como depredadores de crias de Tortuga Laud (*Dermochelys coriacea*) en el Playon de Mexiquillo, Michoacan. Mexico City: Tesis Facultad de Ciencias Universidad Nacional Autonoma de Mexico. p 1–67.

Wentworth CK. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology 30:377–392.