
Insect Infestation of Mediterranean Marine Turtle Eggs

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There are numerous threats to marine turtle populations, many of which are because of man. There are also natural threats such as predation of eggs and hatchlings. These factors must be studied in an effort to assess their impact on these endangered species. Few studies have been conducted on the effect of insect infestation of marine turtle eggs.

Lopes (1982) identified *Eumacronychia sternalis* (Diptera; Sarcophagidae) living on eggs of the green turtle (*Chelonia mydas*) nesting on the Pacific coast of México. They were reported to have infested nearly 90% of nests transplanted to hatcheries as well as some *in situ* nests. Their data indicated that infestation reduced hatching success by at least 30%.

Other studies have documented larvae of the dipteran family Phoridae, specifically *Megaselia scalaris*, in nests of green (Fowler 1979) and hawksbill (*Eretmochelys imbricata*) turtles (Bjorndal et al. 1985) in Costa Rica. Several studies have shown that larvae of phorids also infest eggs of fresh water turtles (Acuña-Mesen and Hanson 1990; Vogt 1981) and a review of these is given by Iverson and Perry (1994).

In the Mediterranean, only coleopteran larvae have been reported infesting eggs of the loggerhead turtle (*Caretta caretta*) in Turkey (Baran and Türkozan 1996). No other published data exist on insect larval infestation of marine turtle nests in the Mediterranean. Our study was carried out in 1994 and 1995 on the north coast of the island of Cyprus (eastern Mediterranean), where both *Chelonia mydas* and *Caretta caretta* nest (Broderick and Godley 1996). Work was carried out at the main nesting site at Alagadi and other beaches along the coast. After hatching had occurred, nests were excavated to examine the clutch remains and determine the hatching success of individual nests. In the event of insect larvae being discovered among the remains, the number of infested eggs was recorded and the larvae taken to the laboratory to rear. Occasionally, we found pupae while collecting sand samples from the wall of the nest for other analyses. Samples were kept in glass jars covered with muslin at room temperature and checked at two-day intervals. When adult insects were observed they were left for at least 24 h to allow cuticles to harden before they were removed and preserved in alcohol. Samples were then returned to the U.K. for identification. In some instances other invertebrates were recorded in the nest and either identified immediately or preserved for later study.

In 1995, 11 of the hatched *C. caretta* nests at Alagadi were infested with insect larvae. This represents 23% of hatched nests that were excavated. In nests of *C. mydas*, insect larvae were recorded in 5 (9%) nests. In these clutches, infestation had occurred in 4.6% ($N = 5$, $SE = 1.45$) of *C. mydas* eggs and 10.6% ($N = 11$, $SE = 4.81$) of *C. caretta* eggs. Infested nests also were found at other beaches, although their effects were not quantified.

In Cyprus, *C. mydas* lay their eggs at a greater depth than *C. caretta* (Broderick and Godley 1993). This may account for the lower rate of infestation of *C. mydas* nests, their greater depth making them less accessible to burrowing female insects or their larvae. An additional factor may be that *C. mydas* covers her eggs with a large mound of sand, possibly masking their smell. Although levels of infestation are given for those nests that were hatched and excavated, we do not know to what extent unhatched nests may have been infested. In addition, infestation may have occurred in hatched nests at an earlier date and larvae migrated away from the nest to pupate in the sand. Nests can be marked accurately at laying and in principle be excavated at any time to search for insect infestation. However, this intrusive method may not be compatible with proper conservation practice.

Adult insects were reared successfully from seven nests. These samples have been identified as containing four species of flies from two different families (Diptera: Sarcophagidae and Phoridae) and one species of wasp, *Brachymeria podagarica* (Hymenoptera: Chalcididae). The sarcophagids are *Sarcophaga* (*Parasarcophaga*) *crassipalpis*, *Sarcotachina subcylindrica* and a species of *Wohlfahrtia*, possibly *indigens*. The phorid was the well-known polyphagous species *Megaselia scalaris*, which is worldwide in its distribution.

Sarcophaga (*P.*) *crassipalpis* and *S. subcylindrica* were found in the nests of both species of turtles. *Megaselia scalaris* was reared from a *C. caretta* and the *Wohlfahrtia* sp. from a *C. mydas* nest. The wasp is known to be a widespread parasitoid of muscoid flies, including the Sarcophagidae (Beaver 1986) and, in this instance, was found in association with *S. (P.) crassipalpis* in a *C. mydas* nest.

During earlier work in 1994, two other sarcophagids were recorded, both of which were reared from *C. caretta* nests. These were a species of *Sarcophaga* (*Parasarcophaga*), either *argyrocephala* or *hirtipes*, and an as yet unidentified member of the tribe Amobiini, subfamily Miltogramminae. Other observations include one larva of a beetle (Coleoptera: Scarabaeidae), not identifiable to species level, found in a *C. mydas* nest. In addition, one of the nests with fly larvae also contained an antlion larva (Neuroptera: Myrmeleonidae), and in several other nests enchytraeid worms (Annelida) were recorded in eggs of *C. caretta*.

There are several stages at which turtle nests could be attacked by insects. At the time of laying, eggs are exposed and cloacal secretions may act as an attractant. Infrequently, flies have been observed (by ACB) landing on eggs at this time. However, compared to the incubation period for the turtle eggs in Cyprus of 42–60 days (Broderick and Godley 1996), the life cycle of these insects is brief, particularly in the prevailing high temperatures found in Cyprus. *Megaselia scalaris*, for example, may complete this process in 20–25 days (Disney 1994) and *Sarcophaga* in as little as 13 days (Busvine 1980).

Members of the family Sarcophagidae, known colloquially in English as flesh-flies, are strongly attracted to both freshly dead and decomposing animal tissue. They are viviparous, the female producing active first instar larvae. The flies probably deposit their larvae on the sand and the larvae then burrow to the food source. This has been observed and experimentally demonstrated with another species that is predatory on earthworms (Lopes 1982). Several members of the Phoridae are able to burrow as adults through the soil, up to a depth of one meter, in order to lay their eggs on buried corpses (Disney 1994). We believe that turtle nests are exposed to potential infestation by insects at any time during the development of the embryo, despite being buried immediately after laying.

Lopes (1982) indicates that insect infestation is much higher in transplanted *C. mydas* nests. This may be because of exposure or damage to some of the eggs during this process, concentrating the nests in a small area, or a combination of these factors. To reduce the latter problem, a number of separate hatchery sites, relocated each season, might be considered as a preventative measure. Our observations of the parasitoid wasp *Brachymeria podagarica* indicate that, in Cyprus at least, it may exert some natural biological control over the sarcophagid fly infestations. Whether this insect could or should be encouraged in artificial hatcheries is debatable, but may be worth investigation.

These infestations may be primary factors in the reduction of the success of a nest or only affect moribund eggs or embryos. Their attraction to the nest in the first instance is likely the result of decay; whether they will subsequently attack viable eggs after utilizing their initial food source is not known. In a study on *Graptemys pseudogeographica*, a species of freshwater turtle, Vogt (1981) recorded infestation in eggs containing live hatchlings and suggested that most infestation occurred at pipping. Although it seems possible that infestation of nests poses a direct threat to incubating clutches, these insects may, in effect, remove decaying material from the nest, thereby decreasing the risk of further infection.

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