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PREDATION ON HATCHLING DIAMONDBACK TERRAPIN, *MALACLEMYS TERRAPIN* (SCHOEPFF), BY THE GHOST CRAB, *OCYPODE QUADRATA* (FABRICIUS). II.

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ABSTRACT: *Actual and presumed predation by the ghost crab on a total of 16 hatchling diamondback terrapin was observed on a barrier island in southern New Jersey in October 1990, 1991 and 1992. Hatchlings are attacked and killed by bites to the head. Feeding starts on the head and typically continues posteriorad until all soft parts, as well as the anterior portions of the shell, are consumed. Predation is probably opportunistic. Hatchlings probably represent only a minor food of the abundant and highly-active crab, but the crab could be a significant source of mortality on the much less abundant hatchlings.*

OCYPODE QUADRATA and some congeners (*O.ceratophthalmus*, *O. cordimanus*, *O. kuhlii*) are rapacious predators on the eggs and hatchlings of almost all species of sea turtles as well as of several species of birds (least tern, sooty tern, white-tailed tropicbird, Cape rock thrush, black skimmer)in the southeastern United States, Australia and Africa (Beebe, 1904; Bustard, 1966, 1979; Carr, 1967; Comins, 1961; Dodd, 1988; Ernst and Barbour, 1972; Hendrickson, 1958; Phillips, 1987; Sprunt, 1948). Other reports of unspecified crab predators on turtles are probably also referable to *O. quadrata*, as well as to other species of *Ocypode* (see reviews in Dodd, 1988; and Ernst and Barbour, 1972). Arndt (1991) reported predation on hatchlings of *Malaclemys terrapin* by *O. quadrata*, the only species of *Ocypode* found in the United States, and this paper extends those observations.

METHODS AND MATERIALS—*Survey area*—Field work was done on Little Beach Island (LBI), Edwin B. Forsythe National Wildlife Refuge, Atlantic County, New Jersey. LBI is an uninhabited y-shaped barrier island ca. 5.5 km long and a maximum of ca. 2 km wide. High to low dunes in all stages of succession occur along all of the eastern (ocean-facing) side of the island, on much of the western (saltmarsh-facing) side, as well as at the inlet-bordered southern and northern ends; much of the interior is low, and contains 2 large bays and tidal creeks and salt marsh pools. Vegetation in the survey area ranged from absent to heavily vegetated by 1 or more species of several grasses, forbs, and shrubs.

Washed-up debris was locally abundant. Additional description and a figure of the island are in Burger and Montevecchi (1975).

Survey dates and hours—The survey area was visited on 31 October, 2, 4 and 7 November 1990; 18 and 23 October, 6 November 1991; and 10, 15 and 23 October 1992. All visits were between 1200 and 1700 hrs.

Survey methodology—Areas were searched in 1990 for greatest sign of crab (individual alive or dead specimens, burrows, tracks) and terrapin (individual alive or dead specimens, carapaces, tracks, and dug-up nests), other terrapin predators, and of predator-terrapin interaction. The areas of highest crab and terrapin density, namely the southern tip of the island and the southern half of the eastern shore, were systematically visually surveyed in 1991 and 1992. I started from the SW edge of the island, then walked E for ca. 0.5 km, and then continued N on routes of an additional straight-line distance, depending on date, of about 2.2, 2.5, or 4.3 km; actual distances walked were about 10% longer. Each survey was conducted only while walking away from the SW portion of the island, and usually required 3 to 4 hours. On each visit I surveyed a swath of ca. 5-8 m, its width determined by the immediate topography; type and abundance of vegetation; frequency of sign of crab, terrapin and other possible turtle predators; and abundance of debris. Swath location varied slightly on each visit, but was always located between the upper beach and about 50 m inland. Field work in 1990 was perfunctory and preliminary. All crab and terrapin sign are distinctive and cannot be confused with those of other species. The tracks of *Ocypode* and of hatchlings are quickly distorted and then eliminated by wind and rain, and thus their relative ages can be determined. Direction of movement can also be determined from tracks. Likewise, an active crab burrow opening, be it open or closed, can be differentiated from an inactive opening (pers. obs., and see Cowles, 1908; Milne and Milne, 1946; and Frey and Mayou, 1971).

Burrow excavation—Seven burrows of *Ocypode* found closest to attacked and to freshly killed hatchlings were excavated within 2 to 5 days after the actual and the presumed attacks to search for prey remains and crab feces.

Temperature recording—Air temperature (in shade, at ground level, and out of the wind) and soil temperature (at 1-1.5 cm depth and in the sun) were usually recorded with a field thermometer where hatchling and crab activity were pronounced.

RESULTS—Air temperature during the surveys ranged from 8.3-25.0 C and soil temperature from 21.0-37.6 C. Crabs and hatchlings were active on most survey dates, and crabs were abundant in those areas where terrapin sign was frequent. I found a maximum of ca. 23 ghost crab at their burrow entrances and/or prowling on the sand on each date as late as 4 November. On 15 October, on a survey route of about 3.3 km, I counted 951 large open, and 430 large plugged closed and presumed active, burrows, all with a minimum burrow opening dimension of about 2 cm, i.e. sufficient to accomodate an *O. quadrata* large enough to be a potential predator on hatchling terrapin. Fresh tracks of up to ca. 10 hatchling terrapin and generally heading away from the ocean were found on each date as late as 31 October. Three terrapin nests with still-buried hatchlings and/or fresh egg shells were found by following hatchling tracks backward. The first hatchling of an additional nest was observed to break through the sand above its nest on 23 October. Several nests freshly dug up by unknown predators were found on each of several dates.

A total of 16 dead or wounded hatchling terrapin was found. One hatchling had apparently just been attacked and released by a crab as the latter seized another hatchling (Arndt 1991). Another 7 of the 16 were fresh carcasses, in some cases not yet dead, and with presumed bite marks on the head. Such marks were as those noted on the 1 hatchling above that had just been released. Five of the 9 hatchlings were found 3.5 cm to 6.4 cm from a crab burrow (Fig. 1), and 4 at 23 cm to 150 cm from a burrow. I observed a crab to pull 1 of these fresh carcasses into its burrow, and another crab to appear inside its burrow entrance where there was a wounded hatchling lying just outside. These 9 hatchlings were found on 10, 18 and 31 October. Air temperatures then ranged from 20.5 C to 25 C.

FIG. 1. Attacked terrapin hatchling as found outside a ghost crab burrow opening.

Of the 7 other terrapins, 6 lacked all, or almost all, soft parts, and 1 had considerable remains of soft parts. This last hatchling was strongly misshapen, but I still count it as prey of *Ocypode*. One of these hatchlings was 24 cm, and another was 91 cm, from an active burrow opening; the remainder were several meters from a burrow. These hatchlings were found on 10, 15 and 23 October.

The condition of the 16 hatchlings when found was: 7 with sign of feeding only on the head, which in 1 included removal of the guts; 3 with sign of feeding on the head and with 1 or both front legs removed, which in 1 included removal of the guts; 1 cleaned of all flesh and with only the tail remaining; and 5 cleaned of all flesh (Fig. 2). Those hatchlings found wounded and alive showed no or few presumed bite marks on the shell, those found dead showed slightly more shell damage, and those found devoid of flesh showed the greatest amount of shell removal (e.g. Fig. 2, far right shell).

The 7 burrows of adult *Ocypode* searched for food remains and feces ranged in length from 119 cm to 135 cm. One crab was found in each of 3 burrows, and 4 lacked a crab. No burrow yielded prey remains or feces.

DISCUSSION—An attack by *O. quadrata* on the head probably kills or wounds the hatchling and prevents its escape. All flesh is then typically consumed. A hatchling found with flesh remaining suggests that the crab had not yet finished feeding, was interrupted in feeding by the availability of other potential prey, or was driven from the prey.

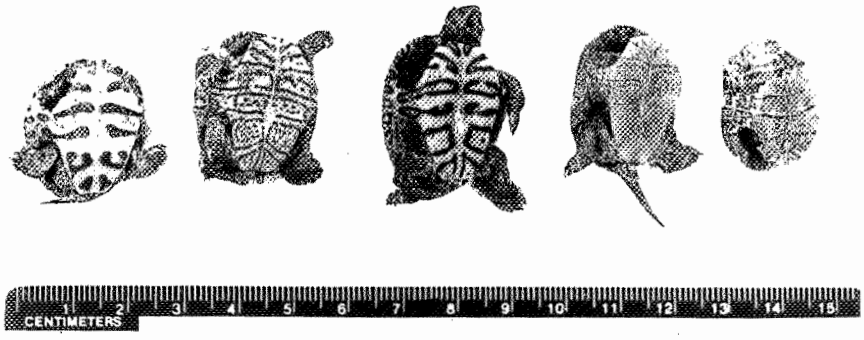

FIG. 2. Terrapin hatchlings fed on by ghost crab: the two on the left were fed upon by captive crab, the three on the right were found in the wild.

Regarding the possibility that all or some of the hatchlings were not killed by the crab but rather were the remains of other predators, or that they were scavenged by the crab after they were found dead or wounded, strong circumstantial, in addition to the direct evidence, indicates that they were crab-caught. 1) Of 15 hatchlings examined for presumed crab bite marks on the shell, 11 showed such marks on the anterior edges of the carapace and/or plastron, or small holes in the carapace. The former marks matched those noted on the shell of the 2 hatchlings fed upon by captive crab (Arndt 1991). 2) Other possible predators on hatchlings on the island are Norway rat, raccoon, red fox, otter, and several species each of gulls, herons, and egrets (pers. obs., and N. Sterling, pers. comm. 1993). However, the small and still-soft hatchlings would probably have been swallowed intact by these birds, or been totally macerated and then ingested by the mammals, with thus no or little likelihood of a shell remaining intact. 3) I noted several cases of hatchling and crab tracks to intersect, after which the former ended, but hatchling fates are not known. 4) No proof that any vertebrate or invertebrate predator or scavenger killed and/or cleaned a dead hatchling was ever obtained.

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