

DIET, GASTROLITH ACQUISITION AND INITIATION OF FEEDING AMONG HATCHLING MORELET'S CROCODILES IN BELIZE

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Morelet's crocodile (*Crocodylus moreletii*) inhabits freshwater wetlands throughout much of the Atlantic lowlands of Mexico, Guatemala and Belize (Groombridge, 1987). Nesting occurs during June-July, and hatchlings emerge in August-September after an incubation period of approximately 75 days (Platt, 1996). The ecology of hatchling Morelet's crocodiles has not been investigated, and indeed few field studies have been conducted on hatchling crocodilians of any species (Neill, 1971; Valentine, Walther, McCartney & Ivy, 1972; Delany, 1990; Platt, Rainwater & Thorbjarnarson, 2002). Such studies are difficult undertakings owing to the small body size, cryptic habits and largely nocturnal activity of hatchling crocodilians. In particular, little is known concerning the diet of hatchling *C. moreletii*. Alvarez del Toro (1974) stated in a largely anecdotal account that hatchlings consume only terrestrial and aquatic insects, and Schmidt (1924) found primarily aquatic insect remains in the stomachs of seven juveniles ranging from 29 to 74 cm in length. Furthermore, the acquisition of gastroliths by neonate crocodilians is poorly documented (Fitch-Snyder & Lance, 1993), and our literature search revealed that virtually nothing is known concerning the initiation of feeding by wild hatchlings. Dietary studies are fundamental to understanding the ecology of an organism (Rosenberg & Cooper, 1990), and among crocodilians, diet is known to affect growth, behaviour and reproduction (Lang, 1987).

Here we characterize the diet, and report on the acquisition of gastroliths and initiation of feeding by

hatchling *C. moreletii*. Our study was conducted during 1994 at Gold Button Lagoon (GBL) in northern Belize (Platt, 1996). GBL (17° 55' N; 88° 45' E) is a 142 ha man-made lagoon located on the 10 526 ha privately owned Gold Button Ranch, approximately 32 km south of Orange Walk Town in Orange Walk District. An estimated 175 non-hatchling crocodiles inhabit GBL (Platt, 1996), one of the highest densities (1.2 crocodiles/ha) found anywhere in Belize (Platt & Thorbjarnarson, 2000). GBL is characterized by dense stands of *Typha* and *Eleocharis* along the shoreline, and floating mats of *Nymphaea* in shallow water. Water levels fluctuate depending on the amount of local rainfall, and are highest late in the wet season (September to November).

Crocodile nests were monitored during incubation from June through September as part of a larger study on nesting ecology (Platt, 1996). Each nest was initially inspected weekly to determine losses from predation and flooding, but daily inspections (usually before 1000 hours) were conducted as the estimated hatching date approached. Once hatching occurred, we returned after dusk to capture hatchlings by hand with the aid of a headlight. Hatchlings were generally found in dense aquatic vegetation adjacent to the nest site. The following morphometric data were collected from each hatchling: total length (TL, tip of snout to tip of tail measured along the ventral surface), snout-vent length (SVL, tip of snout to anterior margin of cloacal vent measured along the ventral surface), and head length (HL, measured dorsally from the tip of snout to median posterior edge of the cranial roof). Each hatchling was permanently marked for future identification by notching the dorsal edge of a unique series of three caudal scutes (Jennings, David & Portier, 1991), and then released at the capture site, usually within an hour.

Hatchlings were recaptured on subsequent nights and stomach contents obtained by stomach flushing (Taylor, Webb & Magnusson, 1978). A flexible plastic tube (5.5 mm exterior diameter), lubricated with vegetable oil was eased down the oesophagus and into the stomach. Water (c. 4 cm³) was slowly poured into the tube until the abdomen became visibly distended. Gently palpating the abdomen caused a mixture of water and stomach contents to surge into the tube. The hatchling was then inverted, and this mixture directed across a fine mesh screen. The process was repeated (usually three to four times) until only water free of stomach contents was obtained. No hatchling was stomach flushed more than once in a seven-day period. Although we did not evaluate the effectiveness of this technique, Fitzgerald (1989) sacrificed juvenile caimans (*Caiman crocodilus*) after stomach flushing, and concluded most food items were recovered. Stomach contents were sorted and prey items identified to the lowest possible taxonomic category. Non-food items such as stones, seeds and vegetable matter were also recorded. Occasionally unmarked hatchlings were found among pods of marked hatchlings during recapture efforts. Because pods typically consist

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TABLE 1. Frequencies and percentages of occurrence of prey taxa and non-food items recovered from hatchling Morelet's crocodiles ($n = 71$) at Gold Button Lagoon, Belize (August to October 1994). N = number of hatchlings containing a particular item. Percentages do not sum to 100 because multiple items were often recovered from a single hatchling.

| Stomach contents | N | % |
|------------------|-----|------|
| Prey | | |
| Insects | 60 | 84.5 |
| Arachnids | 21 | 29.5 |
| Gastropods | 2 | 2.8 |
| Fish | 12 | 16.9 |
| Non-food items | | |
| Vegetation | 4 | 5.6 |
| Stones | 8 | 11.2 |
| Seeds | 2 | 2.8 |

of neonates from a single nest (Platt, 1996), we assumed unmarked hatchlings had simply eluded our initial capture efforts and age was assigned based on that of other pod members.

One hundred and six *C. moreletii* hatchlings from six pods were captured and marked at GBL from 17 August to 1 October 1994. Mean (\pm 1SD) hatchling morphometrics were: TL=26.9 \pm 1.3 cm (range = 23.9 to 29.5 cm); SVL=13.0 \pm 0.5 cm (range = 11.8 to 14.1 cm); HL= 4.0 \pm 0.2 cm (range = 3.6 to 4.5 cm); HL/SVL ratio=0.30 \pm 0.009 (range = 0.27 to 0.32). Seventy-two hatchlings ranging from 4 to 24 days old were recaptured and stomach flushed 86 times. Stomach contents were recovered from 71 hatchlings; 15 had empty stomachs and were excluded from our analysis. Results are presented in Table 1. To our knowledge, no mortality occurred as a result of capture or stomach flushing and numerous recaptures have since been made (Platt, Rainwater & McMurry, unpubl. data).

Our results indicate that hatchling *C. moreletii* feed primarily on invertebrates. Insects were the most frequently recovered prey, followed by arachnids. Insects, arachnids or both were recovered from 69 (97.1%) hatchlings. Most remains consisted of highly macerated bits of chitin and fleshy material not identifiable to a particular taxon. However, we were able to identify representatives of three insect orders: Coleoptera, Orthoptera and Odonata. Others have photographed hatchling *C. moreletii* capturing adult Odonata (Richard & Carol Foster, pers. comm.). Likewise, the few available studies suggest that insects are important prey for hatchlings of other species as well (*Caiman crocodilus*: Staton and Dixon, 1975; Thorbjarnarson, 1993; *Caiman yacare*: Cintra, 1989; *Alligator mississippiensis*: Delany, 1990).

Aquatic gastropods appear to be relatively unimportant prey for hatchling *C. moreletii*. Only two opercula (length = 5 mm) were found among the stomachs we examined, most likely from *Pomacea flagellata*, a

freshwater ampullarid snail abundant at GBL. The opercula length indicates these were small juvenile snails.

Fish were the only vertebrates recovered from hatchling *C. moreletii*, but comprised a minor component of the diet. The occurrence of fish was inflated by the recovery of *Petenia splendida* scales from six hatchlings in a single pod. Based on scale size, the fish was estimated to be an adult 15 to 20 cm long and undoubtedly consumed as carrion, perhaps supplied by the attending female. However, while maternal provisioning of hatchling crocodilians has long been suggested (McIlhenny, 1935), it remains to be convincingly documented (Lang, 1987). With the exception of *Astyanix fasciatus* fins recovered from a single hatchling, other fish remains consisted of unidentifiable bits of bone and flesh.

Despite observations to the contrary (McIlhenny, 1935; Neill, 1971; Delany, 1990), Fischer, Mazzotti, Congdon & Gatten (1991) contend that hatchling American alligators (*A. mississippiensis*) are unable to capture small prey effectively owing to a long snout in relation to body size (Mean HL/SVL ratio=0.31; SE= \pm 0.001; $n=288$), and instead rely on metabolism of residual yolk as an energy source. However, there was no significant difference between the HL/SVL ratios of *C. moreletii* and *A. mississippiensis* hatchlings (ANOVA; $F_{1,392}=0.62$; $P>0.05$), and the prevalence of prey remains among stomach contents indicates that *C. moreletii* neonates are adept predators. Therefore, if *A. mississippiensis* hatchlings fail to capture small prey it is unlikely to be due to morphological constraints imposed by the HL/SVL ratio, and the conclusions of Fischer *et al.* (1991) should be reassessed. Allsteadt & Lang (1995) concluded that the importance of residual yolk has been overstated; it probably serves as an immediate post-hatching energy source, diminishing in importance once feeding is initiated, and feeding may even stimulate its absorption.

Non-food items recovered from hatchling *C. moreletii* include fragments of vegetation, small stones (range = 1 to 5), and hard seeds (range = 1 to 6). Vegetation is likely consumed incidental to prey capture and has no nutritional value (Coulson & Hernandez, 1983). Stones and other hard objects are deliberately consumed and serve as gastroliths (Davenport, Grove, Cannon, Ellis & Stables, 1990; Fitch-Snyder & Lance, 1993). We found small stones and hard seeds in *C. moreletii* hatchlings ranging from 4 to 19 days old, which to our knowledge is the earliest record of gastrolith acquisition for any crocodilian. Fitch-Snyder & Lance (1993) reported stones in two six-month old *A. mississippiensis* and observed a 14-day-old hatchling unsuccessfully attempting to consume stones. Davenport *et al.* (1990) speculated that stones found in captive *Crocodylus porosus* were present when the animals were initially obtained as wild hatchlings. Our study and others indicate that gastrolith acquisition may occur soon after hatching.

Although not essential for digestion, gastroliths are thought to facilitate the breakdown of ingested prey in a manner similar to grit in the avian gizzard, and may be important for hatchling and juvenile crocodylians that consume chitin-rich diets (Sokol, 1971; Platt, Brantley & Hastings, 1990; Fitch-Snyder & Lance, 1993). Davenport *et al.* (1990) found that gastroliths rapidly disperse throughout the stomach contents after food ingestion, and probably enhance digestion by squeezing fluids from punctured arthropods. However, Taylor (1993, 1994) states that gastroliths are unimportant in digestion and serve primarily as ballast for buoyancy control in a variety of aquatic organisms, but concludes their function in crocodylians remains unresolved and warrants further investigation.

Fifteen 4-day old hatchlings from a single pod were the youngest individuals we stomach-flushed; 12 (80%) contained no prey, although a small stone was recovered from one. The remaining 71 hatchlings were \geq 7-days old and prey were recovered from 68 (95.7%), suggesting that neonate *C. moreletii* initiate feeding four to seven days post-hatching. Our findings are consistent with other observations on hatchling crocodylians under both wild and captive conditions. According to McIlhenny (1935), wild *A. mississippiensis* hatchlings begin feeding "shortly after leaving the nest", and Joanen & McNease (1976, 1977) noted that feeding in captivity was initiated three to four days post-hatching. Captive *Crocodylus niloticus* hatchlings "accept food soon after emergence" (Pooley, 1962), although Cott (1961) stated that wild hatchlings usually eat nothing until about two weeks old. Platt *et al.* (2002) reported that *C. acutus* neonates in northern Belize begin feeding within one week of hatching. Initiation of feeding is probably dependent on a variety of factors including air and water temperature, and even geographic origin of the hatchlings (Lang, 1981; Webb, Whitehead & Manolis, 1987).

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