

AGGRESSIVE BEHAVIOR BY ADULT MORELET'S CROCODILES *CROCODYLUS MORELETI* TOWARD YOUNG

R. HOWARD HUNT

ABSTRACT: The behavior of mixed groups of adult and young Morelet's crocodiles, *Crocodylus moreleti* was observed at the Atlanta Zoological Park during three reproductive periods. While maintaining a strong protective response toward all young approached by humans, adults threatened and occasionally attacked young (40-75 cm in total length), especially when these young were in contact with or approached small hatchlings. This aggressive behavior resulted in the segregation of successive age classes. Hatchlings (23-40 cm) were never threatened or attacked by adults.

COMPETENT observers are beginning to understand the complexities of crocodilian parental behavior. A female Nile crocodile, *Crocodylus niloticus*, has been observed picking up 19 hatchlings in her mouth and transporting them 15 m to water (Pooley, 1974; Pooley and Gans, 1976). An American crocodile, *Crocodylus acutus*, was photographed as she excavated her young from the nest and carried them to water (Ogden and Singletary, 1973). Hatchling transport has also been reported for the spectacled caiman, *Caiman crocodilus* (Alvarez del Toro, 1969, 1974), the Morelet's crocodile, *Crocodylus moreleti* (Hunt, 1975), and the American alligator, *Alligator mississippiensis* (Kushlan, 1973).

Immature crocodilians vocalize when distressed, attracting adults to their defense. This behavior crosses species boundaries as Neill (1971) discovered in New Guinea when he grabbed a young vociferous New Guinea crocodile, *Crocodylus novaeguineae* and was attacked by an adult estuarine crocodile, *Crocodylus porosus*. Many wild and captive adult alligators will attack humans holding young alligators (total length = 23-150 cm) producing distress calls. The continued protective response by adults toward young is difficult to reconcile with accounts of aggression by adults toward young. Adult *A. mississippiensis* have been seen stalking 6-month-old (total length = 30-40 cm) alligators (Herzog, 1974). Philip Owens (*personal communication*) at the Corkscrew Swamp Sanctuary, Florida, observed adult alligators taking juveniles

(total length = 60-90 cm) into their mouths shaking and then releasing them uninjured.

Here I report observations of and experiments with captive Morelet's crocodiles in mixed age groups of young and adults at the Atlanta Zoological Park. The overall purpose of this study was to detect changing behavior of adults toward growing young. The adults protected all young of several age classes from human intruders but frequently threatened (no contact) and occasionally attacked young crocodiles (total length = 40-75 cm). Immediately after the 1975 hatching period, a juvenile with a hatchling in his mouth was introduced to the adult crocodiles to determine if adults would injure a cannibalistic juvenile.

MATERIALS AND METHODS

Seven individually recognizable adult *C. moreleti* were divided into two groups in January 1973. Group I contained a male (AZP 29) and two females (AZP 23, 26). Two males (AZP 19, 20) and two females (AZP 21, 25) were in Group II. Each group lived in a solarium 9 m x 9 m furnished with a 4,500-l pool and a planted area 4.5 m x 9 m. The average air temperature was maintained at 32°C. The adults were fed whole chickens once a week, and the young received shrimp, minnows, mice and crickets three times a week. Self-piercing monel no. 1 tags were attached to the toe webbing of hatchlings and monthly samplings of young were caught and measured.

The following terminology is used for

age groups: (1) hatchling—1 day to 1 yr of age, average total length = 23–50 cm; (2) yearling—1 to 2 yr of age, average total length = 50–65 cm; (3) juvenile—2 to 3 yr of age, average total length = 65–100 cm; (4) young—1 day to 3 yr of age.

Observers were provided with an excellent view of the crocodiles from a darkened area along one side of each solarium and separated by a glass partition. Available light was sufficient for most observations but for night illumination a single 250-W infrared floodlight was placed in each solarium. An audio amplifier (Pace Maker® PM33) and speaker transmitted vocalizations from within each solarium to the observation area. At least one 5-minute check of the two groups of crocodiles was made by staff members every 2 h, from 0900 to 1800, seven days a week. During episodes of significant crocodile activity the author spent from one to 10 h observing the activity to its conclusion.

For the past three years, young *C. moreletii* have lived with adults. Fresh crocodile eggs were removed from nest mounds and incubated at 30°C in 30-l Styrofoam® boxes containing slightly damp peat moss. When the babies within the eggs vocalized, the Styrofoam® box containing the eggs was buried in the mound, and in most cases, the female released the hatchlings from the nest. Representative babies from three successive hatches (1973–1975) lived with Group I. Adults in Group II did not live with young until July 1975 when nine young were introduced.

To test the adult protective response, experimental introductions were conducted by tethering a juvenile (total length = 68 cm) to a 560-g piece of cork and taping a hatchling in its mouth. A dead hatchling and also a live 2-week-old hatchling (total length = 23 cm) were used on separate occasions. The live hatchling was secured inside a 2.5 cm × 9 cm clear plastic tube, permitting it enough freedom of movement to vocalize. The completed unit was positioned inside the juvenile's mouth at the mandibular symphysis to provide maximum

visibility of the hatchling. White adhesive tape closed the juvenile's jaws around the plastic tube containing the hatchling. The dead hatchling was taped in the juvenile's mouth in a similar manner. A tape recorder was used to record hatchling distress calls for playback experiments.

RESULTS

Observations.—In August 1973, *C. moreletii* hatched from eggs produced by the two females in Group I. Female A [= AZP 26] opened her nest and carried the hatchlings to water but female B [= AZP 23] did not respond to the vocalizations of her hatchlings in the nest mound. Nine of these hatchlings (total length = 23 cm) were left with the Group I adults. They spent most of their time basking on the shore near a pile of rocks and logs in the territory of female B.

The two females, A and B, became extremely aggressive toward each other after the August hatching period. Neither female was dominant and each maintained a distinct territory.

By 10 months of age, the nine hatchlings (total length = 40–50 cm) had become very secretive and rarely entered the water. On several occasions female B and male X [= AZP 29] stalked hatchlings hiding in rock piles. If approached closer than 1 m by these two adults, the hatchlings would grunt several times and would move further back into their rock retreat. At 2130 on 30 July, female B swam underwater toward a hatchling eating minnows in the shallows. The young *C. moreletii* ceased feeding when she almost touched it with her snout and both remained motionless for 10 minutes. The hatchling finally crawled out just before the female lunged from the water, throwing water spray on the bank. The threat display ended when the young *C. moreletii* fled under a rock pile near the nest mound.

Eggs from females A and B failed to hatch in 1974 but in mid-September of 1974, female A released a substitute clutch from female C [= AZP 25] in Group II. Most of the 30 hatchlings remained near

TABLE 1.—Summary of observed aggressive behavior toward young by ♀ Morelet's crocodile A [= AZP 26].

Dates	No. young		No. threat displays on 40–75 cm young	Average length of young threatened (cm)	No. attacked (seized) by AZP 26	Average length of young attacked (cm)
	22–40 cm	40–75 cm				
1974						
21–30 Nov	24	15	3	55	—	—
1–31 Dec	20	19	12	50	2	40
1975						
1–31 Jan	15	24	21	55	—	—
1–28 Feb	11	28	5	60	1	65
1–31 Mar	6	33	—	—	—	—
1 Apr–10 Jun	—	39	9	60	—	—
10–24 Jun	—	39	30	60	2	50
24–30 Jun	3	37	6	60	1	60
1 Jul–31 Aug	2	33	29	55	2	50
1–3 Sep	7	28	2	65	—	—
4–17 Sep	5	3	—	—	—	—
18–25 Sep	37	3	—	—	1*	68

* Experimental juvenile killed by AZP 26.

female A but some individuals wandered over the entire solarium.

From August to the end of October 1974 female B was observed threatening the nine yearlings on 16 occasions. In a typical threat episode, she slowly approached a young *C. moreletii* from the water, then quickly lunged and snapped at it. She initiated eight of these threats in water and on nine occasions threatened yearlings mingling with hatchlings. At 2100, on 30 October, a yearling swam behind a vocalizing hatchling. Female B lunged at the yearling and chased it from the water.

By mid-November of 1974, female B died of osteomyelitis resulting from a fight injury. Before the death of female B, female A was not aggressive toward young, but when she assumed the territory of the dead female, she threatened yearlings.

From 21 November 1974 to 3 September 1975 female A was observed threatening or attacking young (total length = 40–75 cm) on 117 occasions (Table 1). Sixty-eight percent of all her threats and attacks occurred when young emerged from their refuge areas during evening feeding periods and 90% were initiated in the water. Twenty-nine percent of this female's threats

and attacks were directed at yearlings when they fed or mingled with hatchlings (total length = 23–40 cm). On 6 December 1974 she threatened a yearling when it attempted to take a chick head from a hatchling. Five days later, she ignored two yearlings feeding near several hatchlings until they pursued one hatchling with food in its mouth. The female lunged at the pursuers and forced them from the water. On 2 January 1975 she lunged at a yearling when it swam near six hatchlings. The hatchlings remained stationary but the yearling left the water, only to return 1 h later. Another yearling grabbed several shrimp and a hatchling's foot simultaneously on 17 January 1975 and dragged the vocalizing hatchling under a pile of rocks. Although she could not see the distressed hatchling, female A lunged at four yearlings in the water. Several rapidly growing hatchlings reached 40 cm in November 1974 and were threatened and attacked by the female. By April 1975 all the 8-month-old hatchlings exceeded 40 cm and were subjected to threats by the female. On 5 April 1975 a yearling (total length = 50 cm) chased several hatchlings with no interference from female A.

During eight attacks, female A used her mouth to seize young (total length = 40–65 cm). A typical attack occurred on 14 February 1975 at 1840 after she swam underwater toward a yearling. The yearling did not appear to be aware of the female until she contacted it with her snout. She quickly grabbed and lifted it from the water. After relaxing her grip until she held the vocalizing yearling by its tail, female A released the uninjured yearling. It quickly swam to the shore and crawled into a pile of rocks and logs. The other yearlings and hatchlings living with Group I vocalized during the 4-minute seizure.

Three 10-month-old hatchlings (total length = 30 cm) that had been reared in stock tanks apart from adults were introduced to Group I on 24 June 1975. Female A slowly and carefully picked up one of the vocalizing hatchlings in her mouth and transported it to the water. This hatchling carrying behavior contrasted greatly with the abruptness she showed in seizing larger young (total length = 40–75 cm).

On 10 June 1975, all 29 eggs laid by female A were removed from her mound and incubated artificially. She continued to guard her intact nest but juveniles occasionally basked on the slopes of the mound.

The hatching eggs of Female A were buried in her nest mound on 2 September 1975. She released the hatchlings after dark but only five live hatchlings and a dead embryo (total length = 18 cm) were present on 3 September. Several juveniles were particularly attracted to those hatchlings encumbered with egg membranes. Female A chased one juvenile after it picked up the dead embryo but she was unable to contend with all 28 young scattered around the hatchlings. Although cannibalism was not observed, 25 of the yearlings and juveniles were removed, leaving three small yearlings (total length = 40–45 cm).

On 18 September 1975 female A released a second group of 32 hatchlings (from eggs laid by female C in Group II). The gre-

gariou hatchlings remained near the female and were not molested by the remaining three, secretive yearlings.

Group II did not live with young until 3 July 1975. Four yearlings and one hatchling were transferred on that date from Group I to Group II. An additional four yearlings were introduced to Group II from stock tanks, where they had been reared apart from adults.

Both before and after the introductions, male Z and female C in Group II were chased from the water and occasionally pursued on land by the dominant pair of crocodiles. Because of their preoccupation with escaping injury from the dominant crocodiles, male Z and female C were not observed protecting or threatening young crocodiles.

From 3 July to 8 September 1975, female D [= AZP 21] made 11 threats on young (total length = 40–75 cm). In her only attack, she seized a yearling in her mouth but released it uninjured. Threatened yearlings and juveniles fled from female D but they often returned. She chased one yearling from her nest mound on 10 August 1975 at 1300 but it returned to bask 20 min later.

On 8 September 1975 at 0930 we buried the hatching eggs from female D in her nest mound. Using all four feet, she scraped the overburden away from the eggs and gently scooped the hatchlings into her mouth. In the water, she opened and closed her mouth, producing a flow of water around the hatchlings. Several juveniles grunted and moved closer to the vocalizing hatchlings. One juvenile near the nest mound nipped first at an egg shell and then at a hatchling. It retreated when female D approached. She chased other juveniles approaching hatchlings but the juveniles avoided her by taking refuge in rock and log debris. One juvenile under a log pilswallowed a hatchling headfirst. The eight juveniles and one yearling were removed from Group II on 11 September 1975.

Male X in Group I was observed threatening young (total length = 40–75 cm)

on six occasions from 26 July 1974 to 15 April 1975. On 29 July he lunged at a hatchling (total length = 45 cm) eating minnows in the water but his attack was interrupted when female A raised her head to his.

During this study, five of the adults (males X, Y; females A, B and C) maintained a strong protective response toward vocalizing young held by the author. On 3 August 1974, while measuring a hatchling in the solarium containing Group I, I was chased by the three adults. On 1 January 1975 I noosed a yearling that female A had just threatened. As I measured the vocalizing yearling, male X and female A lunged from the water forcing me to retreat. A week later, I noosed a hatchling (total length = 34 cm) swimming in the solarium pool and again, the adult pair lunged at me. On 3 July 1975 I captured a yearling from an elevated walk .5 m above Group II. When the yearling vocalized, female D and male Y lunged from the water and bit at my legs.

Experiments.—To determine if any circumstance could provoke our adult C. more-letti into injuring juveniles, a 68-cm specimen that had lived with Group II from 3 July to 11 September 1975 was reintroduced on 16 September with a dead hatchling in its mouth. The juvenile was tethered to a piece of cork heavy enough to restrict mobility, and a recording of hatchling distress calls was played continually during each of two 30-min introductions. Female D seized the vocalizing juvenile and shifted it about in her mouth for 2 minutes until it fell out uninjured. At 1800, after undulating her tail, she again grabbed the juvenile on the shore and pulled it into the water. Its distress vocalizations attracted several hatchlings and male Y. Although the juvenile was vigorously seized several more times by the female it was not injured.

On 19 September 1975 at 1715 the same individual was reintroduced to Group II under the same conditions as the 16 September introduction except a live hatchling in a tube was substituted for the dead one

and no recording was used. Female B swam to the shore and approached the two vocalizing youngsters. She gently bit the hatchling's tail that protruded from the tube and tried to pull it from the juvenile's mouth. When she could not free the hatchling from its protective tube she relaxed her grip. At 1730, female D lunged at the juvenile and grabbed it with her mouth. After carrying it to the water she relaxed her grip but seized the juvenile again when it shook its head in an attempt to free itself of the hatchling. The female finally released the vocalizing juvenile after the male approached her. The experiment was concluded at 1830 with no injuries to any of the crocodiles.

The experiment was repeated on 25 September 1975 at 1800 for Group I, using the same live hatchling and juvenile. The juvenile had lived with Group I from August 1973 to 3 July 1975. Its reintroduction on the shore with the hatchling in its mouth produced no immediate action from the adults. After 10 min, the juvenile tried to shake the hatchling from its jaws, provoking an open-mouth vocalization from the hatchling. Female A reacted to the vocalization by lunging from the water at the tethered juvenile. The juvenile could not drag the cork rapidly enough to escape and the female caught it at mid-body, in her mouth (Fig. 1). She carried it into the water and swam at the surface of the pool for 10 min. The juvenile vocalized (lower than the hatchling's vocalizations) and appeared to be uninjured until 1825 when the female lifted it by the tail and shook it vigorously with lateral movements of her head. The uninjured hatchling fell from the tube in the juvenile's mouth and swam to the shore. Female A released the juvenile at 1840 but it was too weak to swim. Although no more hatchling distress calls were heard by human observers, female A attacked the juvenile a second time and again released it. Without inflicting additional injury, male X held the floundering juvenile in his mouth for 2 min. Then the female took the juvenile into her



FIG. 1.—Female Morelet's crocodile A [= AZP 26] seizing juvenile with hatchling.

mouth a third time and swam with it to a shallow area of the pool where she lifted and shook it several more times. At 1855, the male rammed his snout into female A and she dropped the juvenile. The male and female were unusually aggressive toward human intrusion at this time, hampering removal of the dying juvenile. Death of the juvenile resulted from three deep puncture wounds under its jaw, and a broken tail. With complete mobility, the juvenile would have probably dropped the shrieking hatchling and escaped from female A. During the study period, this was the only observed attack by an adult that resulted in injury to a young *C. moreleti*.

DISCUSSION

Cott (1961) remarked on the difficulty of finding *C. niloticus* between 2 and 5 yr of age (total length = 60–120 cm) in protected wild areas such as below Murchison, in the Kafue and Luangwa Reserves,

at Mweru Wa Ntupa, and Ndumu Reserve, Zululand where all other age groups were abundant. The secretive behavior of the 2 to 5-year-old crocodiles was attributed to cannibalistic adults. Pooley (1969) reported that on 12 July 1967, 20 *C. niloticus* (total length = 45–60 cm) were released into the Inyamithi pan, Ndumu Game Reserve, Zululand. After 3 months only one of the young crocodiles remained in the area, inhabited by white pelicans, monitors and a large population of adult *C. niloticus*. It was assumed that the white pelicans ate most of the young crocodiles but it was also possible that adult crocodiles chased the young from the release area.

Our female *C. moreleti* threatened and attacked young crocodiles (total length = 40–75 cm) more frequently during egg incubation and hatching periods, although these young were subject to attacks and threats at any time of the year, especially when competing with hatchlings (total length = 23–40 cm). Because of the space limitations in the solaría, dispersal of threatened hatchlings (total length = 40–50 cm, age = 4–11 mo), yearlings and juveniles from nest sites was not as effective as it would be in a wild situation. The female could not protect all the emerging hatchlings from the excessive number of juveniles remaining near nest mounds at the end of the incubation period but the experiment with female A showed that juveniles eating hatchlings risked death if captured by an adult female. Under most circumstances, threatened young *C. moreleti* became secretive and this secretiveness segregated them from gregarious hatchlings (total length = 23–40 cm) remaining near the female.

Acknowledgments.—I am grateful to the members of my staff who made many useful observations on crocodilian behavior. I thank Kent Benedict for processing the photograph and Barbara Vaughn for typing the manuscript.

LITERATURE CITED

ÁLVAREZ DEL TORO, M. 1969. Breeding the spectacled caiman, *Caiman crocodylus* at Tuxtla Gutiérrez. *Zool. Int. Zoo Yearbook* 9:35–36.

- . 1974. Los Crocodylia de Mexico. Instituto Mexicano de Recursos Naturales Renovables, A.C., Mexico. In Spanish. Reviewed by H. M. Smith, *Copeia* 1975:189–190.
- COTT, H. B. 1961. Scientific results of an inquiry into the ecology and economic status of the Nile crocodile, *Crocodylus niloticus* in Uganda and Northern Rhodesia. *Trans. Zool. Soc. London* 29:211–356.
- HERZOG, H. A. 1974. The vocal communication system and related behaviors of the American alligator, *Alligator mississippiensis* and other crocodilians. M.A. thesis, Univ. Tennessee, Knoxville. 83 p.
- HUNT, R. H. 1975. Maternal behavior in the Morelet's crocodile *Crocodylus moreleti*. *Copeia* 1975:763–764.
- KUSHLAN, J. A. 1973. Observations on maternal behavior in the American alligator, *Alligator mississippiensis*. *Herpetologica* 29:256–257.
- NEILL, W. T. 1971. The last of the ruling reptiles: Alligators, crocodiles and their kin. Columbia Univ. Press, New York.
- OGDEN, J., AND C. SINGLETERY. 1973. Night of the crocodile. *Audubon* 75:32–37.
- POOLEY, A. C. 1969. Preliminary studies on the breeding of the Nile crocodile, *Crocodylus niloticus* in Zululand. *Lammergeyer* 10:22–44.
- . 1974. Parental care in the Nile crocodile. *Lammergeyer* 21:43–45.
- , AND C. GANS. 1976. The Nile crocodile. *Sci. Am.* 234:114–124.

Received: 1 March 1976
Accepted: 17 January 1977

Department of Herpetology, Atlanta
Zoological Park, Atlanta, Georgia 30315,
USA

IDENTIFICATION AND DISTRIBUTION OF *HYLA VERSICOLOR* AND *HYLA CHRYSOSCELIS* IN WISCONSIN

ALAN P. JASLOW AND RICHARD C. VOGT

ABSTRACT: *Hyla chrysoceles* is absent in much of the northern half of Wisconsin, whereas *Hyla versicolor* is much more widespread in the state. Pulse rates of mating calls of both species were significantly and positively correlated with esophageal or calling-site temperatures. The regressions of pulse rate on temperature for the two species were significantly different ($P < .001$). There was no overlap of pulse rates for the two species at any temperature measured in Wisconsin (14.8–29.0/s for *H. versicolor*; 41.4–71.4/s for *H. chrysoceles*). Calling *H. versicolor* ♂♂ are significantly larger and tend to be darker than *H. chrysoceles* ♂♂. Mean size of *H. versicolor* ♂♂ was 42.6 mm (SD = 2.02); *H. chrysoceles* ♂♂ were 35.2 mm (SD = 3.69).

JOHNSON (1966) recognized that *H. versicolor* included a sibling species, *H. chrysoceles*, and that the only means of identification in the field is by mating call. The calls of both species consist of a series of pulses (Fig. 1), and *H. versicolor* has the slower pulse repetition rate. Zweifel (1970) found that pulse rate alone is not sufficient for identification when the two species are not found together. He showed that pulse rates for the two species from Delaware, New Jersey, and Virginia were the same

when calls of *H. versicolor* at the highest temperatures were compared to calls of *H. chrysoceles* at the lowest temperatures. The species can also be separated by cytological evidence (Bogart and Wasserman, 1972; J. P. Bogart, *personal communication*). *Hyla versicolor* is tetraploid and *H. chrysoceles* is diploid.

Throughout the literature *H. versicolor* and *H. chrysoceles* are reported to be largely allopatric. Parapatric populations were reported by Noble and Hassler (1936),