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OBSERVATIONS ON REPRODUCTION AND BEHAVIOR OF CAPTIVE PHILIPPINE CROCODILES (Crocodylus mindorensis Schmidt)

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A breeding facility for the endangered Philippine Crocodile (Crocodylus mindorensis Schmidt) was established in 1980 at Silliman University, Dumaguete City, Philippines. As of February 1984, the breeding program has produced 21 surviving juveniles ranging from hatchling to 3 years of age. Observations on the behavior of those captive adults and juvenile crocodiles are described. Courtship, mating and nest building occurred each year between January and May. Eggs were laid variously between April and August during the years 1981-1984; with multiple clutches by the same female in 1981 and 1982. The mean clutch size was 15.7 (range: 7-25). The incubation period was 77 to 85 days. The female remained near the nest during incubation, and for that period and a few months thereafter was very aggressive. Vocalization of pipped young cued the female to open the nest and transport the hatchlings or eggs to the water. Hatchlings and young were very wary of human intruders. Fighting among the young resulted from close confinement.

Key words: Crocodylus mindorensis, Philippine Crocodile, endangered species, breeding, incubation, hatching, behavior.

The Philippine or Mindoro Crocodile (Crocodylus mindorensis), has generally been treated as a subspecies of the New Guinea Crocodile (Crocodylus novaeguineae) by most authors. However, Neill (1971), and Wermuth and Mertens (1977) recognized it as a distinct species on the basis of cranial features and cervical and lateral squamation. We follow the latter view.

The Philippine Crocodile was once widely distributed throughout the Philippines on the islands of Luzon, Samar, Masbate, Mindoro, Negros, Jolo, Mindanao, and Busuanga; but the species is now severely depleted, being represented by only a few relict populations (Ross, 1982a, 1982b; Ross and Alcala, 1982). One population is known from the upper Pagatban River on Negros Island. Two other populations are on Mindanao: one in Calarian Lake in Zamboanga City and one at Liguasan Marsh in Midsayap, North Cotabato Province (Ross and Alcala, 1983). We believe that small populations still exist in Lake Naujan on Mindoro Island, in the Nabunturan area in Davao del Norte on Mindanao Island

(Ross and Alcala, 1983), and in the headwaters of the Ilog River in southwestern Negros (report from local residents). We estimate that these wild populations total no more than a few hundred individuals, although we lack data other than occasional reports and some personal sitings.

In addition, there are 42 known animals in captivity in the Philippines, twenty-five (4 adults and 21 juveniles) are at the facility described here. Another 17, mostly adult, captive animals are owned by private individuals on the islands of Luzon and Cebu, and in Negros Occidental. A few individuals also exist in captivity elsewhere.

This paper describes aspects of reproduction and behavior of adult and juvenile C. mindorensis at the Silliman University crocodile breeding facility during 1982-1984.

MATERIALS AND METHODS

In 1980 a crocodile breeding facility was established at Silliman University, Dumaguete City, Negros Oriental, Philippines. The purpose of this facility was to provide a suitable breeding habitat for the propagation and rearing of captive C. mindorensis. Due to the probable high mortality in the wild, progeny of this program will be retained at the facility for the first few years of their life. If suitable, protected habitat is later available, these offspring may then be liberated into the wild or incorporated as additional brood stock.

The oval-shaped (15.0 x 11.6 m) breeding pen is located adjacent to the University's Marine Laboratory about 2 km north of the main campus. It is enclosed by a 1.9 m high fence with a 9 cm thick, reinforced concrete base buried 10 cm deep. The concrete projects upward and is topped with an imbedded 1.2 m metal fence that inclines inward about 20 degrees. A large rectangular pond (11.1 x 3.8 x 1.3 m) is situated slightly to one side on the longer axis of the pen. The pond walls are concrete and the bottom is mud. Water depth is kept at about 1 m by addition of fresh water. A concrete incline allows the animals easy access to both water and land. Three small, shallow, concrete ponds were also built in the pen, each large enough to accommodate one adult crocodile. The land-to-water ratio in the pen is about 3:1. Pond water is changed every few months by pumping. During high tides, sea water 50 m away seeps into the large pond, making the water somewhat salty, about 5 ppt. Water temperature in the pond varies from 25° to 32°C. Trees surrounding the pen are pruned to assure sufficient direct sunlight for the animals at all times. Space is available in the

Marine Laboratory for incubating eggs and for the care of young animals.

The captive brood stock consists of three adult females and one male. The first female was captured when about a year old in early 1971 from the Pagatban River, southern Negros; she reached sexual maturity in 1981. The second female was acquired in July 1982 and the third in August 1984. The male was donated to the facility in 1980, and was estimated to be at least 15 years old (Ross, 1982b, 1982c). On 18 September 1980, the first female measured 1.3 m in total length and weighed 14 kg; the male measured 2.1 m and weighed 47 kg. Both animals were introduced into the breeding pen at the same time on this date. The second female measured 1.5 m in total length and weighed 24 kg; the third, 1.7 m and 27 kg, at the time of acquisition.

Daily behavioral observation of the penned adults began shortly after their confinement at those times when maintenance and care services were performed. In addition, there were ten 24-hour observation periods from 1981 to 1984. Observations of the behavior of hatchlings and juveniles began in 1981.

Some eggs (N=22) from the 1981, 1982, and 1983 clutches were incubated in the laboratory in an artificially constructed nest of moist humus and leaf litter, with a 50-watt bulb as an external heat source. The orientation of these eggs, as observed in the natural nest, was maintained in the laboratory. We hastened the hatching process of laboratory incubated eggs by enlarging the punctured end of eggs once hatching had begun.

RESULTS

Breeding Behavior and Nest Building

The breeding season of the Philippine Crocodile in captivity was observed from 1981 through 1984. Courtship and mating began in January and continued until about May. This period of time includes the driest season in southeastern Negros. Matings occurred usually between 0400 and 0700 hrs. While in the water the female emitted a series of brief high-pitched groaning or bellowing sounds. The male responded by joining the female in the pond, usually after producing similar but lower-pitched sounds. In the water, the female performed such movements as rubbing its snout on the male's head and swimming over and under the male for as long as 30 minutes, while continuing to vocalize. Copulation followed. In this process, lasting a few seconds, the male mounted the female and presumably lowered his tail under the female's tail to effect intromission. After copulation both male and female usually remained in the water for some time. Nest building began as early as 10 February in 1984, 27 February in

1982, and about the first of March in 1981 and 1983, a generally continued until a week before egg-laying in Apr (1981-1983) and May (1984).

Only the female built the nest, using the same site duri the four years of study. A mound-type of nest was constructe from a mixture of sand and plant material (mostly the latter consisting of dry grass, rotting leaves, and twigs. The female facing away from the nest, used primarily its hind legs t "shovel" dirt to the nest site. Nest building occurred for brie periods of time during the day and at night, but mostly at night This activity continued from February through April or May. Th nests varied in size from about 1.5 to 2.0 m on the short axi and from 2.0 to 2.7 m on the long axis. Nests in each instanc were about 0.5 m high. The nesting materials were compact probably as a result of the female frequently lying on top of th nest.

Oviposition and Clutch Caracteristics

Multiple clutches were laid by the same female in 198 (April, June, and August) and 1982 (April and August), using th same nest each year, for annual totals of 32 and 33 egg respectively. Single clutches of 20 (April 1983) and 25 (Ma 1984) were laid in the following years. The average of these clutches was 15.7 (range = 7-25) with an annual mean of 27.5 Oviposition occurred at night or in the early morning. The egg were deposited in about three layers in the egg chamber, whic was excavated by the female near the center of the nest. Thi was later covered with a layer of rotting leaves about 15-18 c thick.

The eggs were hard-shelled, elliptical, smooth, and white Eggs subsampled from the 1981 production (N=14) wer substantially smaller and lighter and more variable in weigh than subsamples from the successive two years (N=14). The value of these subsamples were as follows: for 1981, axial length 66.5 $\pm$ 3.01 mm (range = 62-72, N=14), axial width = 38.8 $\pm$ 31.4 (range = 37-41, N=14), mass 60.7 g $\pm$ 14.8 (range = 32.5 -74.5 g N=9); and pooled values for 1982-1983, axial length = 70.9 $\pm$ 2.1 (range = 67-75, N=14), axial width = 43.1 $\pm$ 2.48 (range = 40-46 N=14), mass = 81.5 $\pm$ 3.12 (range = 74-86 g, N=14). Difference in axial length, axial width, and mass between the 1981 and 1982 1983 samples were statistically significant (t=4.53, df=26 P=<.001; t=7.0, df=26, P<0.001; t=424, df=21; P<.001).

At substrate (egg chamber) temperature of 28-33^{o}C (mean 30.6^{o}C) for 32 records taken at different times of day for bot laboratory and naturally incubated eggs, the incubation varie from 77 to 85 days, with a mean of 81 days. In any one clutch eggs differed in incubation period by as much as eight days Only 63 of 110 (57%) of the eggs for the four years were fertile Of these, 32 (51%) hatched; and, as of late 1984, 21 offsprin survived.

Hatching of the 1983 clutch was observed and photographed. The female began opening the nest at about 0430 hrs. on 5 July by excavating it with her fore and hind limbs. She then took the eggs or hatchlings one at a time in her mouth and transported them to the water (Illustrations A and B). Of 11 hatchlings, seven hatched at the nest site and four after the female reached the water. One egg contained a near-term young and was not hatched by the female. It was removed from the nest, taken to the laboratory and broken to release the young.

Observation of hatching of eggs incubated in the laboratory provided the following data. The young inside the egg shells produced croaking sounds at hatching time, especially when the eggs or substrate was disturbed. Similar sounds were also heard at the nest site a few hours before hatching in one instance, 26 June 1982. The first visible sign of hatching for laboratory-incubated eggs was the emergence of the snout at one end of the shell. A jerky forward thrust of the animal propelled the head, body, and part of the tail out of the shell within the next few minutes. The hatchling moved forward quickly when stimulated, vocalizing at varying intervals and dragging the shell to which it was connected by the embryonic membranes. The embryonic tissues remained attached for about an hour before the animal broke free of them. One hatchling bit the tissues to free itself. Three out of five young had not been able to hatch spontaneously 12-15 hours after they were heard to croak. Whether they could have hatched on their own without assistance from us is not known.

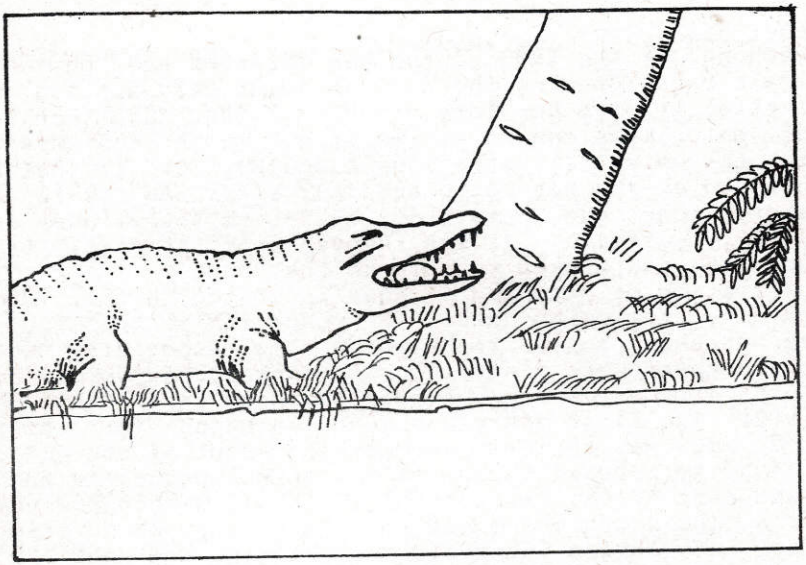
Behavior of Adults

In a typical 24-hour day the female spent about 18 to 19 hours in the immediate vicinity of the nest, 12 to 13 of these hours (0600-1900±) in repairing the nest, moving around the nest, chasing intruders, and lying on the nest. The remaining 5 to 6 hours (0100-0700±) were spent swimming in the pond with the male and sometimes included mating activities.

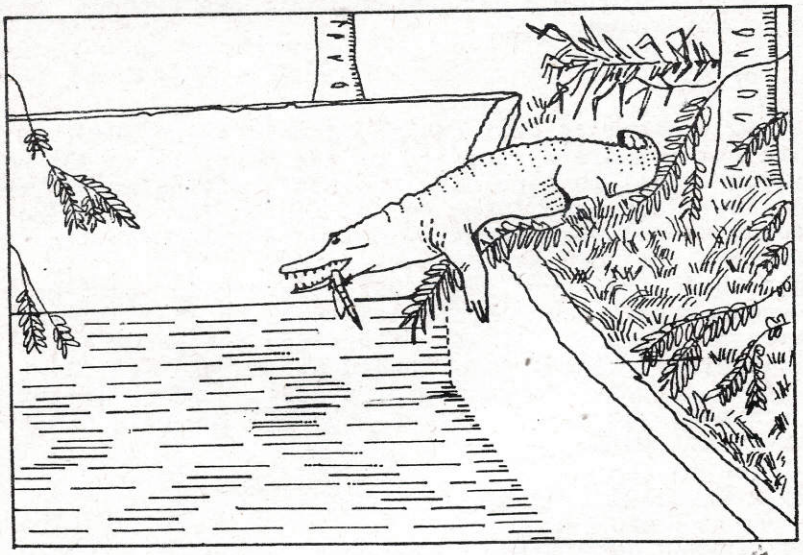
Aggressive behavior was first observed in the female about two weeks before egg-laying, increasing in intensity as incubation progressed. It was maintained for about three months after hatching. The female lunged at human intruders coming within four or five meters of the nest. When attacking, it opened its mouth and made hissing sounds. The male did not show behavior of defending the nest.

Aggressive Behavior toward other Crocodiles

The female exhibited aggressive behavior toward human intruders as well as toward a conspecific female and a salt water crocodile (C. porosus) housed in an adjacent pen. A second female C. mindorensis later released into the pen in July 1982,



A



B

was also immediately attacked by the resident pair. They inflicted severe wounds on the tail region of the newly-introduced female, which was then removed from the breeding pen. This female was again attacked by another female when they were placed together in a cage in late 1984.

Hatchling and Juvenile Behavior

Hatchling as well as juvenile C. mindorensis were very wary of human intruders, and dove into the pool or immersed their whole bodies in water at the approach of people. During the first year of life, the juveniles appeared to tolerate each other when confined in small concrete tanks measuring 1 x 2 m. However, three (age 2) animals sharing the same space fought viciously, resulting in the death of two animals. Thereafter, these and older juveniles were kept in larger quarters without serious fights. Since the earlier serious fights leading to injury occurred during non-feeding times, they were probably related to crowding and not to competition for food.

DISCUSSION

The courtship, nest building and mating season (January to May) exhibited by the captive C. mindorensis, which continued for about the same period each year, includes the driest season in this part of Negros. Webb, 1980:107, notes that C. johnstoni in the Northern Territory of Australia also build their nests during the dry season, in August in that region. The type and size of nest built by C. mindorensis is similar to that reported for C. novaeguineae by Neil (1971:402). An egg chamber within the nest, similar to that of C. mindorensis, was reported by Webb (1980:107) for C. johnstoni.

Oviposition occurred from April to August, 1981 and 1982 (years of multiple clutches), and in April 1983 and May 1984 (years of single clutches). The earlier dates of oviposition are in the dry season, but the later dates are not. Neither the late dates nor multiple clutches can at this time be correlated with any weather factor or any obvious change in our maintenance of the breeding facility. Jeff Lang (personal comm.) attributes multiple clutches in C. palustris to overfeeding of the female.

The total number of eggs (32 and 33) in the years of multiple clutches was slightly higher than the number (20 and 25) for years in which single clutches were laid. However, the latter numbers or even the average 27.5 for the four years is close to that (23-25) given by Neil (1971:402) for C. novaguineae, a crocodile of about the same size. The clutch-size (12.6±3.1) reported for C. johnstoni (Webb, 1970:107) is about

half of that which we found for C. mindorensis. Reported mean clutch sizes for other crocodilians range from six in Osteolaemaus tetraspis to about 60 in C. porosus and C. niloticus (Greer, 1975). The sizes and mass of the eggs of C. mindorensis are also close to measurements given by Jelden (1981) for C. novaeguineae and for C. johnstoni (Webb, 1980:107), and smaller and lighter than similar measurements of eggs of C. porosus. Clutch size, egg size, and mass are probably a function of female body size.

Our observed incubation period (77-85 days) for C. mindorensis, under the conditions at the breeding facility, agrees closely with that of Joanen and McNease (1980) for Morelet's crocodile from the Mexico-Guatemalan area, is slightly shorter than the 84-91 days reported by Webb (1980:107) for C. johnstoni and is much shorter than the 94-120 day incubation period which they report for the West African dwarf crocodile.

A comparison of hatching success for our clutches of eggs of C. mindorensis with hatching success reported for other species shows slightly less variation. Hatching success in Morelet's Crocodile varied from 10 to 69.3%, as computed from the data of Hunt (1980). In the West African Dwarf Crocodile, hatching success of incubated eggs ranged from 7 to 93% (mean, 46.5%) for six groups of eggs (Tryon, 1980) In the American Alligator, the hatching rate of incubated eggs was 72% for eggs from captive animals and 94% for eggs taken from the wild when infertile eggs were deleted from the analysis (Joanen and McNease, 1980). Factors affecting hatching success are not clear from the data available.

Crocodilus mindorensis, like C. niloticus and C. porosus (Pernetta and Buegin, 1983), opens its nest and carries the hatchlings to the water. The male C. mindorensis, however, apparently does not participate in the transport of hatchlings, as do males of some other crocodilian species (Hunt, 1980; Pernetta and Burgin, 1983; Tryon, 1980; Joanen and McNease, 1980).

Vocalization of the young probably stimulated the female to open the nest and help hatch the eggs, as has been reported for the American Alligator (Joanen and McNease, 1980), Morelet's Crocodile (Hunt, 1980), and C. johnstoni (Webb, 1980).

The aggressiveness toward intruders, observed for the Philippine Crocodile at the breeding facility, may have been abnormal, modified by conditions imposed as a result of captivity. However, parallel aggressiveness has been observed in other species. The intensity of the defense reaction of crocodiles varies according to species and between individuals of a species (see Tryon, 1980). Neill (1971:399) mentioned that females of C. novaeguineae in the wild guarded their nests but did not defend them against human intruders. Pernetta and Burgin (1983) stated that nests of both C. porosus and C. novaeguineae were guarded by the females.

The aggressiveness of our original captive female C. mindorensis toward other conspecific females placed in the breeding facility pen at later dates may indicate that a one-to-one sex ratio is the ideal one for captive breeding, as seems to be the case for the American Alligator (Joanen and McNease, 1971). However, the size of the enclosure may prove to be a factor, as was demonstrated for juveniles when the increase in the size of the confining pen was shown to reduce fighting between occupants.

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LITERATURE CITED

Beer, Allen E. 1975. Clutch size in crocodilians. J. Herpetoloty 9:319-322.

Hunt, R. Howard 1980. Propagation of Morelet's Crocodile. Pp.161-165 in Reproductive Biology and Diseases of Captive Reptiles (J.B. Murphy and J.T. Collins, eds.). Society for the Study of Amphibians and Reptiles. 277 pp.

Malden, Dietrich C. 1981. Preliminary studies on the breeding biology of Crocodylus porosus and Crocodylus n. novaguineae on the Middle Sepik (Papua New Guinea). Amphibia-Reptilia 3/4:353-358.

Joanen, Ted and Larry McNease 1971. Propagation of the American Alligator in captivity. Proceedings 25th Annual Conference Southeastern Association of Game and Fish Commissioners 1971: 106-116.

Joanen, Ted and Larry McNease 1980. Reproductive biology of the American Alligator in southwest Louisiana. Pp. 153-149 in Reproductive Biology and Diseases of Captive Reptiles (J.B. Murphy and J.T. Collins, eds.). Society for the Study of Amphibians and Reptiles. 277 pp.

Neill, Wilfred T. 1971. The Last of the Ruling Reptiles. Columbia University Press, New York. 486 pp.

Pernetta, J. C. and S. Burgin 1983. The status and ecology of crocodiles in the Purari. Pp. 409-426 in The Purari-Tropical Environment of a High Rainfall River Basin (T. Petr, ed.). Dr. W. Junk Publishers, The Hague. 624 pp.

Ross, Charles A. 1982a. Final Report. Smithsonian Institution/World Wildlife Fund Philippine Crocodile Project. 34 pp.

_____. 1982b. The crocodile must stay. Habitat Philippines 3:13-19.

Ross, Charles A. and A. C. Alcala 1983. Distribution and status of the Philippine Crocodile (Crocodylus mindorensis) Kalikasan, Philippine J. Biol. 12 (1-2):169-173.

Tryon, Bern W. 1980. Observations on reproduction in the West African Dwarf Crocodile with a description of parental behavior. Pp. 167-185 in Reproductive Biology and Diseases of Captive Reptiles (J.B. Murphy and J.T. Collins, eds.) Society for the Study of Amphibians and Reptiles. 277 pp.

Webb, G. J. W., H. Messel, J. Crawford and M. J. Yerbury 1978. Growth rates of Crocodylus porosus (Reptilia: Crocodilia) from Arnhem Land, northern Australia, Aust. Wildl. Res. 5: 385-399.

Wermuth, H. and R. Mertens 1977. Testudines, Crocodylia, Rhyncocephalia. Das Tierreich 100:1-174.

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