

**Morphometry, Nutrition and Health of the
Marsh Crocodile (*Crocodylus palustris*) Conserved in the
Chittagong zoo, Bangladesh**



A Report by

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Intern ID:17; Session: 2014-2015

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Khulshi, Chittagong-4225, Bangladesh

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Abstract

The crocodiles are one of the largest living reptiles, and an integral part of one of the ancient groups of reptilians, widespread and dependent on aquatic habitats of the tropical and sub-tropical regions. In addition to their ecological importance and identification as the 'key stone' species, they also play very important economic role. Most of the populations of the species have been depleted in their ranges due to over harvesting for different uses particularly with regard to their highly valued skin. Consequently, out of 23 living species, almost half of them are listed in different categories of IUCN red list as threatened species and facing severe threats for their survival. The purpose of Chittagong zoo is recreation, exhibition, conservation, education and research on wildlife. The current study aimed to focus the morphometry, habitat, nutrition, health and reproduction of the marsh crocodile conserved (*Crocodylus palustris*) in the Chittagong zoo, Bangladesh.

Keywords: Crocodile, habitat, health, morphometry, nutrition, reproduction

Introduction

Crocodile is a reptilian animal which is found almost all over the world except Europe (Silva et al., 2010). Crocodiles were originated about 175 million years ago and till date it has been an integral part of biodiversity in different geographical locations throughout the world (Whitaker et al., 2003). There are 23 crocodylian species under 3 families in the world. Crocodiles are long lived animals and the available information suggests that freshwater crocodiles can live more than 40 years (Vyas et al., 2012). Keeping a crocodile is a long term commitment, and many people purchase a crocodile in the belief that they will

leave it away once it grows quite large (**Guggisberg et al.,1972**). Compared with many other animals, crocodiles grow rapidly to large adult sizes and increase in length to at least 20 to 30 times from hatchlings and 1,000 times in weight by 10 to 20 years (**Mitra et al.,2003**).However, growth rates may vary significantly between individuals depending upon temperature, frequency of feeding, quality of food and social factors.Despite these variations, all crocodiles show a fairly typical growth pattern, i.e., initial growth rates are rapid, often for several years, but slowly begin to decline as the animal matures(**Vyas et al.,2017**).

Crocodiles play an important role in the wetland ecosystems (**Whitaker et al.,1989**).They help keep the balance in the complex web of life in freshwater and estuarine ecosystems (**Rao et al.,1994**).Besides, crocodile meat is a low-fat, low cholesterol and high protein meat. Crocodile meat is not only delicious, it is good for heart, lungs, blood circulation and it is known to cure asthma and coughing .It is rich in omega 3 fatty acids, which many other meats do not contain in great quantity. Omega-3 normalises and regulates cholesterol triglyceride levels by reducing the enzyme activity that causes the liver to metabolise fat. It is anti-arrhythmic, anti-thrombotic, anti-atherosclerotic, and anti-inflammatory. Crocodile meat is believed to have anti-carcinogenic and anti-arthritic properties reducing the symptoms of inflammatory diseases such as asthma and arthritis(**Martin et al.,2003**).Despite many promising features, the species is threatened by unregulated hunting for skins, habitat destruction, death in fishing nets, egg collection and illegal hunting(**Choudhury et al.,2013**). Although a number of populations exist throughout its range, they are isolated and their numbers are low. Several populations are feared to be extinct in Bangladesh. It was, therefore, aimed to assess the current status of crocodiles, human crocodile interaction, and the causes of decline of crocodiles and to build up awareness among local people for conservation of crocodiles in the Chittagong zoo, Bangladesh.

2. Materials and method

2.1 Study area

The study was undertaken in Chittagong zoo, Chittagong, Bangladesh. Chittagong zoo is a zoo in Chittagong Bangladesh located about three kilometres north-west of the city, alongside at the entrance of Foy's Lake, opposite the foothills of the mountains of USTC Medical College. In 1988, MA Mannan, former Deputy Commissioner of Chittagong district and some other elites of the city, initially took initiative to establish a private zoo at Foy's Lake for the purpose of recreation, education and research on zoo animals. It is situated at hilly land of Foy's lake, south-khulshi, Chittagong. Later, on February 8, 1989 the zoo was opened for the visitors. Initially 4.90 acres of land was allocated by the Bangladesh government, which afterwards increased to 6 acres. In the wet season, the zoo is hot, oppressive, overcast and the dry season is warming humid and mostly clear. Over the course of the year, the temperature typically varies from 58 to 90°F and is rarely below 53- 93°F. The average rainfall of this area is 0.5 inches in February to June and 17.8 inches from July to September.

2.2 Preparation of questionnaire

Before collection of data, a structured questionnaire was prepared in accordance with objectives of the study. A cross sectional survey was conducted using the questionnaire. Later on, the questionnaire was validated. The questionnaire included both open and close ended questions on habitat, behaviour, food, nutrition, reproduction, hazard, common diseases, treatments and local people's perception about crocodile.

2.3 Collection of information

The data was collected by using primary data collection method from zoo curator, zoo attendant, and other people working in the zoo area and also from

group discussions. The survey was carried out in Chittagong zoo from 15 to 17 February, 2020 for adult crocodiles and 19 to 21 February, 2020 for the juveniles. Information related to the population, morphometry, habitat and distribution of crocodiles were collected. The sites of the habitat of crocodiles were visited in zoo and interview was conducted in the study area. All the information was compiled and analysed to prepare the manuscript.

3. Results

3.1 Demography

The marsh crocodile (*Crocodylus palustris*) in the Chittagong zoo lives in fresh water where the depth of water is 3 feet. There are two adult crocodiles with a length of 2.5 meters for the female and 3.0 meters for the male. They are 30 years old and brought from Safari Park, Cox's Bazar, Bangladesh. The weight of the female and male was 600.0 kg and 700.0 kg, respectively. The length of the adult crocodile's tail was 1.8 meters. The hatchling weighed 300 g. There were 14 young in the zoo and their average age was 9 years.

3.2 Morphology

The adult crocodiles of the zoo was grey to brown with little banding. The colour of the juvenile was light tan with black cross banding on body and tail. The size was medium to large. Their snout was broad in appearance and enlarged scutes were present around the throat. They had acute senses, which was an evolutionary advantage that made them successful predator. The eyes, ears and nostrils were located on top of the head, allowing them to lie low in the water, almost totally submerged and hidden from prey. The tail was long and massive, and the skin was thick (Murray et al., 2019). Overall, its external morphology was a sign of its aquatic and predatory lifestyle. In the zoo, it was seen that its body enabled it to swim swiftly. It tucked its feet to the side while swimming made it faster by decreasing water resistance. They had webbed feet which they used to propel

them through the water, but allowed them to make fast turns and sudden move in the water to initiate swimming. Webbed feet were an advantage in shallow water, where they moved around by walking. The nostrils were closed during submergence. They had smooth skin on their bellies and sides, while their dorsal surfaces were armoured with large osteoderms. The armoured skin had scales and was thick and rugged, providing some sorts of protection(Caldwell et al.,2013). They had unique body form that allowed their eyes, ears, and nostrils to be above the water surface while most of the animal was hidden below.

3.2.1 Teeth

The adults had 64 and the juveniles had 50 teeth.They are able to replace each of their 80 teeth up to 50 times in their lifespan of 35 to 75 years(Scully 2002). They had discernible molars, incisors and canine teeth and odontogenic stem cell in their dental lamina in standby that can be activated if required.They had powerful jaws with many conical teeth and short legs with clawed webbed toes.

3.2.2 Tongue

Their tongues were attached to the roof of their mouth, so they could not move it. This made it impossible for them to stick it outside of their narrow mouths. The tongue played no part of feeding. As they spent much time underwater, the tongue helped to keep the throat closed, protecting it airways. They had salt glands on their tongue.They had no sweat glands and released heat through their mouths. In the zoo it was seen that they used to sleep with their mouths open and panted like a dog.

3.2.3 Biting

The crocodiles in the zoo were fed by grabbing and, they had evolved sharp teeth for piercing and holding onto flesh, and powerful muscles to close the jaws and hold them shut. However, it was an advantage rather than a disadvantage to the

crocodile since the properties of the teeth allowed them to hold the prey with the least possibility of the prey animal escaping. Cutting teeth, combined with the exceptionally high bite force, would pass through flesh easily enough to leave an escape opportunity for prey. The jaws could bite down with immense force, by far the strongest bite of any animal (Bates et al., 2012). The space for the jaw muscle in the skull was very large, which was easily visible from the outside as a bulge at each side. The muscle was very stiff. It was almost as hard as bone to touch, as if it were the continuum of the skull. Another trait was that most of the muscle in a crocodile's jaw was arranged for clamping down. Despite the strong muscles to close the jaw, they had extremely small and weak muscles to open the jaw.

3.2.4 Vision

The crocodiles of the Chittagong zoo had very good night vision. They had vertical-slit shaped pupils which helped to protect their eyes during daylight. In the eyes, they had tapetum lucidum which reflected incoming light back onto the retina, thus utilizing the small amount of light available at night to be best advantage. In addition to the protection of the upper and lower eyelids, they had a nictitating membrane or 'third eye-lid' that could be drawn over the eye from the inner corner while the lids were open. The eyeball surface was thus protected under the water while a certain degree of vision was still possible.

3.2.5 Hearing

They had very keen hearing. They could hear their babies calling from inside their eggs. Their tympanic membranes were concealed by flat flaps that could be raised or lowered by muscles. So the crocodiles could hear well.

3.2.6 Touching

In the mouth cavity of the crocodiles, the upper and lower jaws were covered with sensory pits which were visible as small, black speckles on the skin. These sense

organs were known as domed pressure receptors. In the zoo areas, they responded to the slightest disturbance in surface water, detecting vibrations and small pressure changes as small as a single drop. This made it possible to detect danger and intruders, even in total darkness.

3.2.7 Olfaction

The sense of smell was also very well developed of the adults and juveniles. They used olfaction in the egg prior to hatching. They had only one olfactory chamber and they detected both air-borne and water-soluble chemicals used for their olfactory system. When above water, they enhanced their ability to detect volatile odorants by gular pumping, a rhythmic movement of the floor of the pharynx. In the zoo, they were seen to close their nostrils when submerged.

3.3 Behaviour

Crocodiles are the most social reptiles. However, there was a certain form of hierarchy in crocodiles which was seen in the zoo. The largest and heaviest male were at the top, having access to the best basking site, while females had priority during a group feeding of a big kill or carcass. They used to show toleration in group feedings and tended to congregate in certain areas. The male crocodile was aggressive towards each other during mating season, to gain access to females. Crocodiles are also the most vocal of all reptiles. In the zoo, they produced a wide variety of sounds during various situations. The most common specific vocalization was made during the breeding season. They quarrelled during feeding. They also produced different distress calls and in aggressive displays to their own kind. Specific vocalisations included threat call, hatching call, chirping and bellowing.

3.4 Thermoregulation

The crocodiles of the zoo used to thermo regulate by alternately sunning themselves and retiring to shaded areas or cooler water. Larger individuals maintained stable body temperatures in the preferred range of 30-32°C (86-90 °F) for several hours, even overnight. As a result, these individuals enjoyed increased metabolic efficiency. The complex social relations between individuals were expressed as dominance hierarchies that allowed dominant animal's better access to preferred sunning and nesting sites. The crocodiles also dug burrow into the banks of lakes where they remained. Burrows extended for several metres in length and ended in a chamber where individuals sought refuge from drought or cold.

3.5 Communication

The crocodiles vocalized to communicate. In the zoo, the young used several squeaking and grunting sounds, and the adults used to grunt, growl, and hiss. In addition, members of both sexes produced a loud roar during the breeding season. They tensed the muscles of their body so that the head and tail raised high out of the water. The flanks used to vibrate so violently that water was sprayed high into the air from each side. Sounds, including roars, could be provoked by loud noise. They responded to gunshots, motors, and even people mimicking crocodile sounds. They used to communicate using chemical signals. Glands in the mandible and cloacae excreted oily chemicals that had a poorly understood function in communication.

3.6 Hunting

Crocodiles are ambush predators, waiting for fish or land animals to come close, they usually rush out to sudden attack. But in Chittagong the zoo, the crocodiles are in enclosed condition and they cannot perform hunting. Sometimes they eat fish, amphibians, molluscs, birds and reptiles in the water. What a crocodile eats varies

greatly with size and age. Crocodiles have the most acidic stomach of any vertebrate. They can easily digest bones, hooves and horns

3.7 Habitat

In the study area of the zoo, crocodiles were reared under enclosed area where there was both land and water and the area was covered by hard wire fencing system. Two enclosed area were found where front one was for adults and another behind was for the juveniles. The depth of the front areas water for adults was 3.0 feet and for young 1.0 foot.

3.8 Diets and feeding

In the zoo, the crocodiles were fed normally once a week. The amounts of feed used to depend on the age and the reproductive state of crocodiles. They were supplied chicken and beef which were given 8% of their body weight to the adult whereas for the young only 5%. In every week, adults were provided 6.0 kg meat and the juveniles were given 1.0 kg at a time. They tore the flesh by strong sharp teeth and surprisingly, swallowed the whole meat. They captured water animals in their jaws with a sideways movement of the muzzle. They had sensitive pressure receptors located in pits in the scales around the mouth that detected motion. These structures assisted in the capture of prey in the dark. To catch land animals, the zoo crocodiles floated passively or remained motionless at the edge of the water where prey habitually drank. They drank water what was supplied in the enclosure of the zoo.

Table 1. Feeding schedule for the young and adult crocodiles

Parameter	Adult	Young
Age	30 years	Around 9 years
Diet	Chicken meat and beef	Chicken,beef
Percentage	8% of live weight	5% of live weight
Amount	Around 6 kg	Around 1 kg
Frequency of feeding	Once in a week	Once in a week
Feeding style	Tearing flesh and swallow it	Swallow whole meat

3.8 Reproduction

The 2 adult crocodiles of Chittagongthe zoowas brought from the Safari park, Cox's Bazaar and then the female became matured and they bred by laying eggs.The 14 young crocodiles were born from the mother.

3.9 Breeding

In the zoo, the female one reached sexual maturity at 6 years old while males matured at 10 years old. Nests were provided during the dry season (December to February).They were most commonly found on sloping banks. The female laid 20 eggs and 14 eggs were hatched. Eggs hatched after a relatively short period of 55 to 75 days, and the juveniles were around 30cm long at hatching. Research into the effects of temperature upon sex of the embryo revealed male-only embryos at 32.5°C, with a greater percentage of females produced below and above this. Female-only embryos were produced between 28°C and 31°C.

3.10 Diseases

Many bacterial, viral and parasitic diseases affected crocodiles along with hepatic diseases. The disease and treatment schedules were different according to age and sex.

Table 2. Disease prevalence and treatment for the young and adult crocodiles

Diseases	Adult	Juvenile
	Parasitic infestations	Osteomalacia
	Psittacosis	
	Salmonellosis	
	Campylobacter enteritis	
	Adenoviral hepatitis	
Treatment	Fenbendazole and other Antibiotics are administered orally with feed.	Calcium supplements are given with food. Vitamin and mineral mixture are given with feed.

The main zoonotic diseases that were likely to be encountered by carers was Salmonella. Carers handling poultry used for crocodile food was also exposed to infections.

3.11 Common hazards

In the zoo there are many hazards mentioned in the Table 3. As crocodiles are instinctive predators and unpredictable animals, to decrease the risk of crocodile's attack, perception on its behaviour is important. As minimum control measures any person working near unrestrained crocodiles over 1.5 meters in length was

accompanied by another competent person who acted as a spotter or guarder. Children under the age of 16 were not allowed on enclosure of the crocodiles.

Table 3. List of animal, human and environment hazards for young and adult crocodile

Animal hazards	Human hazards	Environmental hazards
<ul style="list-style-type: none"> ▪ Physical size ▪ Breeding cycle ▪ Territoriality ▪ Sexing of crocodile ▪ Sexual maturity ▪ Temperament ▪ Treatment in captivity 	<ul style="list-style-type: none"> ▪ Behaviour ▪ Age ▪ Training ▪ Skills ▪ Behavioural knowledge ▪ Individual characteristics ▪ Experience 	<ul style="list-style-type: none"> ▪ Enclosure design ▪ Physical location ▪ Season ▪ Location to crocodiles ▪ Number ▪ Fencing construction ▪ Hazardous substances

3.12 Lifespan

Measuring crocodile age is unreliable, although several techniques are used to derive a reasonable guess. The most common method is to measure lamellar growth rings in bones and teeth. Each ring corresponds to a change in growth rate which typically occurs once a year between dry and wet season. The crocodiles of the zoo appeared that their lifespan was between 30 to 40 years.

3.13 Constraints

The space where they used to stay was not sufficient enough for them. So they quarrelled and fought among themselves. It made stress to them. Besides these, public used to disturb crocodiles and threw stones towards them. They also made a noisy environment around the crocodile enclosure.

4. Discussion

4.1 Habitat

In the zoo, it was found that as the crocodiles preferred body temperature ranging from 29 to 34°C, they were protected from climate extremes, i.e., the enclosure were provided with adequate shade. To minimise the possibility of escaping enclosed crocodiles, gate and door were provided around the enclosure. Indoor lighting in the enclosure for crocodiles was adequate to facilitate proper cleaning, routine health check-up, hygiene and maintenance. Lights were switched on only for 11 to 13 hours a day to stimulate natural day length. Adults were reared in 3 feet depth and juveniles in 1 foot depth of water. In Indian zoos, the crocodiles are reared in fresh water and coastal saltwater lagoons or in human made reservoirs. The usual depth of this water reservoirs are 5.0 meters (Taigor et al., 2010). The crocodiles do not migrate seasonally, inhabiting the same locality in wet or dry season (Whitaker et al., 1987). They also make burrows in land.

4.2 Food and nutrition

As crocodiles are carnivores, they mostly eat meat, i.e., poultry meat and beef. The adults eat up to 8% and the young juveniles eat 5% of their body weight in a week. But in the wild condition, they feast on fish, birds, frogs and crustaceans. In Dhaka zoo of Bangladesh, crocodiles are provided small animals that have already been killed for them such as rats, fish or mice. They are also provided with different kinds of meats. They also eat live locusts. In another crocodile farm in Mymensingh, Bangladesh, the young crocodiles eat only minced poultry meat and beef. They are reared in temperature controlled chamber.

The young crocodiles are very sensitive to smell of human. At least two assigned persons are needed to supply feeds to the young daily. If the person changes, they stop eating and subsequently die (Langet et al., 1987). Adult crocodiles are supplied cow meat, poultry meat and fish as their feed. In comparison to other zoos in

Bangladesh, in Chittagong zoo, there is no big difference in the feeding habit. Only a little difference was seen in the amount of feed that is supplied to crocodiles in enclosed condition of zoo. The crocodiles of other countries such as Australian saltwater crocodiles are strictly carnivore. Fish, birds, and mammals that venture near the water's edge are all eaten. The adult crocodiles will eat almost anything that comes too close. The younger crocodiles eat small fish and insects (Bhatnagar et al., 2010)

Larger crocodiles may go for long period of time without eating a meal. In extreme situation, they may shut down and live off their own tissue for a long period of time. But most of them eat much more often than that. On average crocodiles eat about 50 full meals a year. The food does not need to be chopped to a size that is easy to eat which is similar to Chittagong zoo. After providing meat, they tear the flesh by strong and sharp teeth and swallow easily. Young crocodiles are fed once or three times per week. They are provided vitamin supplements to their diets for more benefits.

Sometimes crocodiles eat stones in the wild to help digestion. But they eat them in captivity if stones are in the enclosure. In the zoo, they are not offered stones as part of their diet, they eat them if they needed. Uneaten foods are removed within 24 hours to stop it decomposing. They drink water ad libitum according to their body weight and environmental temperature. When the weather is hot to maintain thermoregulation system, they drink much water as they need.

4.3 Health

In the study area it was found that, the juvenile crocodiles were suffered from osteomalacia and then Ca^{++} drug was given mixing with feed. After continuing several weeks, the crocodiles were cured. On the other hand, parasitic, bacterial and viral diseases were found in the adults where fenbendazole, antibiotic and vaccines were given. Adenoviral infection also affected crocodile hatchlings under 5 months of age. Clinical signs of the disease were lethargy and anorexia associated with high mortality, especially during winter months when additional

stress factors used to play a role in disease progression. Chronic adenoviral hepatitis was a cause of stunted development of crocodiles. The liver was the most commonly affected organ. However, other organs were also involved, including intestines, pancreas and lungs.

4.4 Reproduction

In the zoo, the crocodiles were found to lay eggs either in holes or mound nests. A hole nest is usually excavated in sand. Courtship takes place in a series of behavioural interactions that include a variety of snout rubbing and submissive display that takes a long time. Mating always takes place in water, where the pair can be observed mating several times. Females build or dig several trial nests which appear incomplete and abandoned later. Egg-laying usually takes place at night for 30-40 minutes (**Whitaker et al.,1984**). Females are highly protective of their nests and young. The eggs are hard shelled, but translucent at the time of egg-laying(**Whitaker et al.,2007**)

5. Conclusion

The Chittagong Zoo has recently been a unique source of recreation, exhibition, conservation, education and research for different zoo animals and reptiles. Students from different educational institutions including schools, colleges, and universities frequently visit here to learn about the captive life inside the zoo. They are guided by the veterinary officers and curators. Visitors gather information pertaining to habitat, nutrition, reproduction and health of the zoo animals even from the display board also. Despite many limitations, the authority's recent decisions for modernization of the zoo by establishing virtual museum with audio visual facilities as a common learning centre for mass people as well as equipped veterinary hospital will explore new horizon of the Chittagong zoo for the visitors.

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Biography

I am SHIPU Ghosh, daughter of SantiRanjanGhosh and Khuku Rani Ghosh. I have passed my Secondary school certificate examination (S.S.C) in 2011 and Higher Secondary Certificate examination (H.S.C) in 2013 from Chattogram board. Now I am an intern veterinarian in Chattogram Veterinary and Animal Sciences University, Khulsi, Chattogram. In future, I would like to work in the field of veterinary sector and research of zoo and wild animal.