Breeding Difficulty of Marsh Crocodile (*Crocodylus Palustris*, Lesson, 1831) in Safari Park of Bangladesh

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Abstract

An assessment of Marsh crocodile's (*Crocodylus palustris* LESSON, 1831) habitat, its feasibility in supporting the total population, feeding, hatching difficulty and variations in egg and clutch size of Marsh crocodile were carried out in Bangabandhu Sheikh Mujib Safari Park for one year (July 2010 to June 2011). Major problem identified was the breeding failure, i.e. till now no hatching were found. Mainly two local weather variables (average temperature and humidity) were identified as the most obstructing parameters. Higher temperature (average 37.03°C) and Lower Humidity (average 75.33%) in comparison with standard range of incubation temperature and humidity for Marsh crocodile were seems to be vital reason for the failure of hatching. Understanding of the identified problem of this paper can direct the wildlife conservationist and the policy maker to take proper action for conserving the Marsh Crocodile in Bangladesh.

Key Words: marsh crocodile, habitat, hatching, Bangabandhu sheikh mujib safari park

Introduction

Crocodylians are the world's largest reptiles and perhaps the most aggressive animal. From the fossil record we find that the first crocodile-like ancestors appeared about 240 million years ago (Rao 1994). In Bangladesh two species of crocodile namely Marsh Crocodile (*Crocodylus palustris* LESSON, 1831) and Salt Water Crocodile (*C. porosus* SCHNEIDER, 1801) were previously abundant. But currently marsh crocodile has already been extinct from Bangladesh (Rao 1994). Its global range includes India,

Iran, Nepal, Pakistan and Sri Lanka. In India the population of *C. palustris* has also been depleted considerably throughout the range and present population rise is estimated to be around 5,000 (Sharma 1998). The best remaining populations are in Tamil Nadu (400 crocodiles) and Gujarat (200 crocodiles) (Sharma 1998). Generally it inhabits rivers, lakes and other large bodies of water in the plains and up to 600 m in the hills (Daniel 1983).

Introduction of 8 males and 32 females of *C. palustris* in 3 different captive centers of Bangladesh from Madras Crocodile Bank, India in 2005 become the headline in daily

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news. Before that the number of this crocodile were only 3 in Khan Jahan Ali Majar Pond, Bagerhat, due to unsuccessful breeding program in the last 15 years. This critical situation was first brought to light by Romulus Whitaker, Vice Chairman, Conservation Specialist Group (CSG) for South Asia, who visited Bangladesh in late 2003. The skin of the species are sold with higher price in international markets for which through poaching sharp decline occurred of this species. Government of Bangladesh distributed 5 crocodile in Dhaka Zoo, 6 in Khan Jahan Ali Majar and the rest 29 in Bangabandhu Sheikh Mujib Safari Park (Bhattacharya 2005). Bangabandhu Sheikh Mujib Safari Park is the only safari park of Bangladesh. It is under the administration of Wildlife Management and Nature Conservation Circle, Forest Department, Ministry of Environment and Forest. This park is engaged in conservation and regeneration of different endangered and extinct wildlife of Bangladesh and this was the first step in ex-

tensive rearing place for reintroduction program of marsh crocodile in natural condition. But in between 2005 and 2010 no reproduction was achieved from this species, although they have laid 200-300 eggs every year. To find out the reasons for no hatching of the laid eggs the present in-depth study was conducted in between July, 2010 and June, 2011.

Materials and Methods

Study area

Bangabandhu Sheikh Mujib Safari Park is located on previously declared reserve forest land of Fashiakhali Foest Range of Forest Department in Chakaria Upazilla, under Cox's Bazar District, Bangladesh established in 1996 (Fig. 1). It is situated beside the Chittagong-Cox's Bazar Highway, 47 km north of Cox's Bazar town and lies within $21^{\circ}40'6.7''\text{N}$ - $21^{\circ}40'6.9''\text{N}$ Latitude and within $92^{\circ}04'6.84''\text{E}$ - $92^{\circ}04'6.85''\text{E}$ Longitude comprising an area of 900 ha. Survey conducted by IUCN showed that 138 plant species, 11 amphibians, 58 reptiles, 221 birds and 43 mammals are available in both captive and natural condition in this park (Choudhury et al. 2004). Crocodile enclosure covering $2,000\text{ m}^2$ comprised of a pond surrounded by both valley and moderate terrain. In this enclosure out of 29 adult 24 were females and 5 males. From 4th April 2011 seven female crocodile started to lay eggs and observation started from that date.

Fig. 1. Map of the forest zones of Bangladesh showing the study area (Source: Banglapedia 2003).

Fig. 2. Google image of the crocodile enclosure in the study area.

Methods

In the present study different land type inside the crocodile enclosure was assessed. Assessment was also made on the plant species inside the enclosure. Feasibility study was made as the space scarcity usually deemed to be a vital problem of breeding. The space per crocodile was calculated dividing the total space of the enclosure by the no. of crocodile. Simultaneously the presence of different land type, water quality and presence of shading trees and breeding ground were assessed so as to evaluate the habitat related problem. Feeding data was taken using weighing balance (Range: 1-100 kg). Denied feed were also collected and measure in order to measure the accurate intake of meat. Feeding was provided twice in a week by the authority (Monday and Friday).

For the purpose of keeping the daily air temperature and humidity data of crocodile enclosure digital hygrometer named HME^R THERMO/HYGRO/CLOCK 6111 were used. Data were taken three times (Morning- 7:00 am, Noon- 1:00 pm, Afternoon- 6:00 pm) a day and the average of a single day were taken for the further interpretation. Electronic Balance (E-Fashion, Model-SFE 200 H, Capacity-200 g, Division-0.1 g made in China) were used to measure the weight of eggs. Diameter tape and slide calipers were used to compute the diameter and length of eggs. Eggs were measured after being confirmed that they have started rotten. All the eggs were taken into account and their average value were taken for each of the specific female crocodile. Marker Sign Pen was used to mark the eggs according to the specific female crocodile. The purpose of marking the eggs was to identify the eggs of a specific female so that it can provide the hatching report of a specific crocodile.

Fig. 3. Land types of marsh crocodile enclosure in the study area.

Results and Discussion

Assessment of Marsh crocodile enclosure

Fig. 3 refers different land type and their area details of Marsh Crocodile enclosure of 2,000 m² in the Safari Park. There were three types of land namely low hills, flat plain and natural depression. Low hills comprises of 250 square meter area (12.5% of the crocodile enclosure), flat plains 240 square meter area (12.0% of the crocodile enclosure) and natural depression 1510 square meter (75.5% of the crocodile enclosure). Low hills sloped away to natural depression. For sound physiological activity the available space for crocodiles should be divided into land and water areas to ensure all the behavioral aspects of Crocodile (Huchzermeyer 2003). Thus the study area has ensured its comfortable habitat. Crocodiles here in the study area climb upwards to low hills to take rest and warm themselves in winter and also in rainy season when there remain speedy flow of water in the depression. Moreover they make hole at

Table 1. Land utilization pattern by marsh crocodile in the study area

Serial No.	Type of land	Pattern of use by marsh crocodile
1	Low hills	Resting, basking, heat control support
2	Flat plains	Feeding, basking, breeding
3	Natural depression	Swimming, propelling, mating, feed from natural source

Fig. 4. Image of the crocodile habitat in the study area.

the bottom of the low hill probably to keep them warm (Table 1). Thus the study area was a comfortable ground for the marsh crocodile.

The depression inside the enclosure was followed by a natural lake, which in year round receives the seepage water from the surrounding hills of the park (Fig. 2). A spill way was constructed to maintain a certain water level in the crocodile enclosure depression. Flat plain facilitate basking, breeding and feeding. There were three feeding spot inside the crocodile enclosure to avoid conflicts among this large population of crocodiles. Natural depression is the main land type where crocodiles pass their maximum time. It facilitates swimming, propelling, mating, and natural feeding. In enclosure there were 29 crocodiles i.e. for each crocodile 69 m² area which deemed to be sufficient for them in captive condition. The minimum length of an enclosure for a single crocodile should be equal to twice the length of the crocodile and its width equal to one length of the crocodile, i.e. minimum space requirement for every single marsh crocodile is 15 m² (Huchzermeyer 2003). Thus it is clear that space provided for the crocodile larger enough for their easy movement and feeding. It is noted that, by the fiscal year 2011-2012 the enclosure is going to be expanded to a larger area, which will provide 700 m² per crocodile.

In addition crocodile habitat requires a shaded area as part of the thermogradient (Huchzermeyer 2003). Table 2 shows that there were 56 individuals of 10 woody plant species inside the crocodile enclosure of the Safari Park. These plants provide shade to the crocodile and also increase the landscape beauty of the enclosure. In Zoo the crocodile

generally kept in artificially constructed pond, for shade they have building and water supply is completely artificial. But here this Park the depression was completely natural thus water supply also natural and of very good quality as there is continuous flow of water throughout the year and for shading purposes they use the shadow under the tree species and also the hole made by them adjacent the depression.

Feeding of Marsh Crocodile

Diet of Marsh Crocodile includes beef, chicken and Fish. They got fish from the natural depression as natural source. But beef and chicken were given two times per week on an alternate basis. Because it was previously observed that continuous feeding with same type of item bore them and they start denying food. So, they were usually fed with beef in Monday and with chicken in Friday. Table 3 depicts that for 29 *C. palustris* in the Park over the period of July 2010 to June 2011 the budget of feed was 5,200 kg of meat i.e. for each crocodile 3.45 kg of meat per week. Consumption of feed shows that chicken (1.67 kg per week by each crocodile) is more preferable to crocodile than beef (1.65 kg per week by each crocodile). This might be for less energy requirement in consuming chicken in comparison to beef. Moreover it might be for the fact that the chicken has different part of its body with different taste rather beef is only with meat and bones.

Laying records of Marsh Crocodile

A total of 293 eggs were laid by seven female crocodiles

Table 2. Woody plant species detail inside the enclosure of crocodile enclosure of the study area

Serial No.	Local name	Scientific name	No. of individuals	Location	Average height in meter	Average DBH in centimeter
1	Acacia	<i>Acacia auriculiformes</i>	24	Both in slope and over the low hills	3.72	3.30
2	Agar	<i>Aquilaria agalocha</i>	1	Over the low hills	3.60	2.21
3	Baitta Garjan	<i>Dipterocarpus costatus</i>	6	Over the low hills	4.15	5.23
4	Ful Koro	<i>Albizia saman</i>	7	In the slope of low hills	1.62	0.80
5	Jarul	<i>Lagerstroemia speciosa</i>	6	In the slope of low hills	2.20	2.48
6	Kanthal	<i>Artocarpus heterophyllus</i>	3	In the slope of low hills	0.85	Recently planted
7	Khudi Jam	<i>Syzygium fruticosum</i>	2	In the slope of low hills	5.82	8.20
8	Kathbadam	<i>Terminalia catappa</i>	4	Over low hills	0.72	Recently planted
9	Tejbuhal	<i>Cinnamomum cicutodapne</i>	2	Over the low hills	4.21	5.52
10	Telsur	<i>Hopea odorata</i>	1	Over the low hills	7.50	9.10

Table 3. Details of twenty nine individual of *Crocodylus palustris* in the Safari Park over the period of July 2010 to June 2011

Month	Type and quantity of feed (kg)								
	Beef			Chicken			Total		
	Given	Denied	Consumed	Given	Denied	Consumed	Given	Denied	Consumed
July, 2010	250	10.5	239.5	200	5.6	194.4	450	16.1	433.9
August, 2010	200	6	194	200	4.5	195.5	400	10.5	389.5
September, 2010	200	10.6	189.4	250	5.4	244.6	450	16	434
October, 2010	250	13.6	236.4	200	6.5	193.5	450	20.1	429.9
November, 2010	200	9.8	190.2	200	6.6	193.4	400	16.4	383.6
December, 2010	200	10.3	189.7	250	6.4	243.6	450	16.7	433.3
January, 2011	250	14.3	235.7	200	7.2	192.8	450	21.5	428.5
February, 2011	200	9.6	190.4	200	5.6	194.4	400	15.2	384.8
March, 2011	200	6.8	193.2	250	4.5	245.5	450	11.3	438.7
April, 2011	250	7	243	200	4.5	195.5	450	11.5	438.5
May, 2011	200	8.5	191.5	200	5.3	194.7	400	13.8	386.2
June, 2011	200	4	196	250	5.2	244.8	450	9.2	440.8
Total	2,600	111	2,489	2,600	67.3	2,532.7	5,200	178.3	5,021.7
Weekly average	1.72	0.07	1.65	1.72	0.05	1.67	3.45	0.12	3.32

Feeds given two times in a week i.e. Friday and Monday.

Table 4. Laying Records of *Crocodylus palustris* in the study area

SL No.	ID No.	NEST ID No.	Date of laying egg	Length of Crocodile (m)	No. of egg	Average weight of eggs in each cluster (gram)	Average length of eggs in each cluster (centimeter)	Average diameter of eggs in each cluster (centimeter)
1	56	N1	04.04.2011	2.77	44	124.4	8.60	4.65
2	107	N2	04.04.2011	2.82	46	96	7.60	4.50
3	411	N3	07.04.2011	2.66	43	93.5	7.45	4.60
4	214	N4	15.04.2011	2.38	41	112	7.90	4.75
5	57	N5	18.04.2011	2.43	40	114.1	8.50	4.90
6	64	N6	21.04.2011	2.65	41	105.1	7.50	4.80
7	123	N7	25.04.2011	2.30	38	94.7	7.70	4.50
Average				2.57	41.86	105.69	7.89	4.67

by the time July-2010 to June-2011. But all eggs were found rotten at the end of the average time of hatching (generally 90-120 days) i.e. no offspring were produced. This phenomenon was continuing since 2006. They started laying eggs on 4th April, 2011 and ends on 25th April, 2011. Table 4 refers that the length of eggs laying crocodiles varied from 2.30 to 2.82 m averaging 2.57 m. The average no. of eggs per cluster was 41.86 in number. Whitaker & Whitaker (1984) mentioned that the female usually lays 25 to 30 eggs (although this may range from 10 to 48 eggs). So, the no. of eggs laid by the crocodiles here in this Park

was nearly maximum level of their capacity. This may be because of having natural state of movement inside the enclosure. Weight of eggs laid by crocodiles varied from 94.7 to 124.4 g averaging 105.69 g. Average length and diameter of eggs were 78.9 mm and 46.7 mm successively. Weight, average length and diameter of eggs were in the standard range as mentioned by Whitaker and Whitaker (1994). Most probably the soil texture, temperature and humidity are the major determinants that are obstructing the success of hatching.

Fig. 5. Temperature range deviation for incubation of Marsh Crocodile eggs in the study area.

Temperature Range Deviation in hatching of eggs

It was found that in a total 293 eggs Fig. 5 refers that the daily temperature of Crocodile enclosure in this Park vary from 23.4°C to 43.9°C. Out of total 90 days of observation for only 14 days the field temperature was within the standard range (28.0°C to 34.0°C) of temperature for incubation of crocodile egg, for 74 days the field temperature was over the maximum range of temperature and for the rest 2 days the field temperature was below the minimum range of temperature for incubation of crocodile egg. Moreover the average field temperature was 37.03°C which also higher than the maximum range of standard temperature. According to Madras Crocodile Bank and other research (Andrews 1987; Whitaker 1984) the incubation temperature for *C. palustris* egg is 28.0°C to 34.0°C. But during the incubation period of marsh crocodile in this Park, the daily temperature was higher than the standard range for most of the time (86%). This may a vital cause for the failure of egg hatching in crocodile enclosure of the park. Because of not keeping the provision for buying the highly priced digital incubator, the park management was bound to observe the natural state of breeding. Thus Digital Incubator, now a crucial instrument to have success in hatching as it can regulate the optimum temperature range (Whitaker 1987).

Humidity Range Deviation in hatching of eggs

Fig. 6 refers that the daily Humidity of Crocodile enclosure in the Park varies from 48% to 98%. Out of total 90 days of observation for only 8 days the field Humidity was

Fig. 6. Humidity range Deviation for incubation of Marsh Crocodile egg in the study area.

within the standard range (90% to 95%) of Humidity for incubation of crocodile egg, for 3 days the field Humidity was over the maximum range of Humidity and for the rest 79 days the field Humidity was below the minimum range of Humidity for incubation of crocodile egg. Moreover the average field Humidity was 75.33%, which also much lower than the minimum range of standard Humidity for incubation of crocodile eggs. Different authors (Whitaker and Whitaker 1984; Andrews 1987; Whitaker 1987) mentioned that incubation humidity for *Crocodylus palustris* egg is 90% to 95%. But our observation during the incubation period of marsh crocodile in this park the daily Humidity was lower than the standard range for most of the time (88%). This may another vital cause for the failure of egg hatching in crocodile enclosure of this Park.

Conclusions

In Bangladesh no *C. palustris* is available in nature. Only a few number of this marsh crocodile is available in Dhaka Zoo, Dhaka; Pond of Khanjahan Ali Majar, Bagerhat and in Bangabandhu Sheikh Mujib Safari Park, Cox's Bazar under captive management. So proper care, training program for its accurate management, special research on its habitat, nesting and reproduction biology and also provision for using digital incubator for hatching of eggs should be ensured as immediately as possible.

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