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High hatching success of saltwater crocodile (*Crocodylus porosus*) in a commercial Crocodile Farm of Bangladesh

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Abstract: An extensive study was conducted from March 2007 to February 2012 on hatching success of saltwater crocodile (*Crocodylus porosus*) in the Reptiles Farm Ltd. (RFL) located at Hatiber village of Uthura union under Bhaluka upazila in Mymensingh. The study was mainly based on direct field observation and some previous data collected by farm's technicians. A special type of incubator having 98-100% moisture and 31-33^{0}C temperature was maintained to improve the hatching success. Yearly hatching success in captivity was 95.8%, 95.15%, 97.44%, 96.03% and 94.53% in 2007 through 2011, respectively. The average rate of hatching success in RFL was 95.8 ± 1.09%. Hundred percent hatching success was found in 29 out of 56 clutches. Clutch size varied from 19 to 68 eggs. Unhatched eggs were 4.19%, of which most of the embryos died before hatching. The average time required for incubation was 79 ± 3, 79.5 ± 4.5, 80 ± 4, 80.5 ± 4.5 and 78.5 ± 3.5 days in the above mentioned period. Compared to the wild habitat, captive environment in controlled weather and predation might improve hatching rates. This study suggests that conservation of this endangered species is possible by captive breeding and reintroduction program.

Keywords: Clutch size, incubation, hatching, captive breeding, saltwater crocodile.

Introduction

Reptiles Farm Ltd. (RFL) is the first commercial saltwater crocodile *(Crocodylus porosus*) farm in the Indian subcontinent, located in the Mymensingh district, Bangladesh (24°26′52.38**″** N and 90°15′50.94**″** E). The aim of the farm is to produce crocodile commercially while protecting and promoting wild crocodile population in Bangladesh. Crocodile farming is a new concept for the entrepreneurs of Bangladesh as this industry has never existed in Bangladesh. The geophysical and climatic condition of Bangladesh is suitable for crocodile farming as it is the historical living place of saltwater crocodile. Farming of this reptilian species has been spreading all over the world because of high demand for its skin, meat, bones and usage in ecotourism. During the last decade international demand for crocodile skin increased tremendously which resulted in lucrative crocodile farming to the entrepreneurs of the world (Magnusson, 1984; Cox & Rahman, 1994).

Since saltwater crocodiles have commercial importance and a critically endangered species in Bangladesh, the main target of the farm is to make an effective breeding success in captivity that may help to establish a successful commercial crocodile farm as well as may help in reintroduction of this species in nature. The ability of individual crocodile to mate successfully and produce viable offspring in captivity is a significant indicator as to how effectively husbandry and management practices are being engaged within a facility (Elsey *et al.,* 1994). The capacity of RFL was to incubate 5000 eggs at a season. In captivity, mating, egg laying, and the more or less synchronized hatching dates can be controlled (Trutnau & Sommerlad, 2006). Although, almost all crocodilian species can breed in captivity, some seems to be particularly suited for keeping and breeding in the farms. Breeding in the farm contributes to conserve the species and also allowed to legally raise animals that are listed in appending 1 and 2 of CITES for commercial use (Trutnau & Sommerlad, 2006). Therefore, current study was conducted on the breeding activities of saltwater crocodile (*Crocodylus porosus*) in a commercial crocodile farm to reveal the factors affecting hatching rates in captivity.

Materials and Methods

***Study Area*:** Reptiles Farm Ltd. (RFL) situated in Hatiber village of Uthura union under Bhaluka upazila in Mymensingh. It is spread over 13.4 acres of land and located on 24°26′52.38**″** Northern altitude and 90°15′50.94**″** Eastern longitude (Fig 1)**.**

Study was conducted between March 2007 and February 2012 in the Reptiles Farm Ltd (RFL). The observation was started early in the morning and was continued still afternoon. The study was mainly based on direct field observation and some previous data collected by the farm technicians for their computer record. Weather data has been collected from the weather recording devices located at the farm.

We observed female breeders along with the technicians during egg laying time when and whether the breeders laying eggs in the ponds. Eggs were collected within 24 hours or immediately after egg laying. Female crocodiles

had showed less aggressiveness for exhaustion. Angle of collected eggs from the mound nest was maintained and numbered with pencil markers. Collected eggs were cleaned up and placed on plastic tray on moisture soil and maintained the collected orientation of the eggs in the nest. One tray was for one clutch and a collected time of the clutch was recorded. Once eggs were collected, the top orientation of the egg in the nest was marked and placed in the incubator in approximately the same position to prevent embryo mortality (Hutton & Webb, 1994; Ojeda *et al.*, 1998). A special type of incubator is on the farming area, where 98-100% moistures and 31-33^{0}C temperature was maintained for the better success of hatching. We used incubation trays because it allowed easy access to the eggs in order to remove infertile eggs and may reduce the danger of rotting and contamination. Easy air access to the incubator room also prevents overheating from the metabolic heat produced by the embryo with the banding pattern on the eggs. Eggs which were showed banding pattern kept as fertile and which were not selected as infertile.

Fig. 1. Location map of the study area.

The temperature and humidity data was collected from the thermometer and hygrometer attached within the incubator. Door of the incubator was opened for 30 minutes at the morning and 30 minutes at the evening in order to maintain oxygen level. In constant temperature, 75-85 days were required for hatching in the incubator. Banded and damaged eggs were recorded on regular basis. Non-banding eggs were sorted out within 48 hours after placing in the incubator.

Results and Discussion

Monsoon is the mating season for the crocodiles. Afterward crocodile started to make nest and egg laying. A total of 2371 eggs were collected from 56 clutches from 2007 to 2011 at the Reptiles Farm Ltd. (RFL) where the male and the female breeders had mated successfully. The clutch size varied from 19 to 68 eggs. The number of banded eggs varied from 1 to 60 per clutch. Of the total eggs, we found 1768 (74.5%) banding eggs, of which 1694 (95.8%) eggs were hatched successfully in the incubator.

The average time required for incubation was more or less similar in each year (78.5±3.5 – 80.5± 4.5 days, Table 1). Incubation took place from 80 to 90 days, although the period of incubation might be greatly extended according to the weather conditions (Whitaker *et al.,* 1981). Required time for hatching in the incubator was comparatively less because of controlled temperature, humidity and fresh oxygen circulation on the regular basis (Hutton & Webb, 1994; Ojeda *et al.,* 1998). We maintained very high level of humidity to avoid dehydration of eggs. Dehydration of eggs results in malformed hatchlings or premature death of the embryos. The incubation temperature not only determines the sex of hatchlings but also maintains body temperature of crocodiles in their

later life (Huchzermeyer, 2003). A lack of fluid inside the eggs suggests that an egg is infertile or that the embryo died at an early stage. As the embryo grows, blood vessels and blood can be distinguished inside fertile eggs. Embryos may die in their eggs for a variety of reasons. Possibilities include wrong incubation temperature, low relative air humidity, poor nutrition, lack of oxygen, nutrients, water in the eggs and mechanical damages (Trutnau & Sommerlad, 2006).

Table 1. Incubation period of eggs in the incubator of the farm from 2007 to 2011

Year	No. of clutches	No. of banded eggs	Days required		
			Maximum	Minimum	Average ±sd
2007	6	143	82	76	79.0±3.0
2008	9	289	84	75	79.5±4.5
2009	15	431	84	76	80.0±4.0
2010	13	429	83	77	80.5±4.5
2011	13	476	82	75	78.5±3.5

The total number of banded eggs and eggs hatched had been gradually increased from 2007 to 2011 (143 – 476 eggs and 137 – 450 nestlings, respectively, Fig. 2). We found 100% hatching success in 29 clutches out of 56 clutches studied and these are 4 clutches out of 13 clutches in 2011, 8 out of 13 in 2010, 10 out of 15 in 2009, 4 out of 9 in 2008 and 3 out of 6 in 2007. Hatching success was 95.8 % in 2007, 95.15% in 2008, 97.44% in 2009, 96.03% in 2010 and 94.53% in 2011. The average hatching success was 95.8 ± 1.09%. Average unhatching rate in the farm was 4.2% where embryo died before hatching.

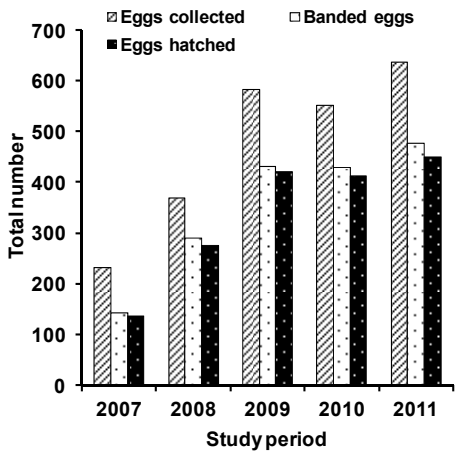

Fig. 2. Yearly hatching records of the eggs of saltwater crocodile in captivity (2007 - 2011).

In the wild, survivorship can be typically as low as 1% reported by Mayer *et al*. (1998), whereas survivorship of hatchlings hatched from eggs in captivity in our study was significantly high (95.8 ± 1.09%). It was reported that 70% hatching success was found in *C. porosus* when provided with ideal conditions (Mayer *et al*., 1998). The hatchlings were kept in mild disinfectant water in a basin and the basin was kept in the incubator for acclimatization of the hatchlings with prevailing temperature and humidity. The time required for hatching of banded eggs varied from 1 to 3 days. Hatchlings were placed in a dark, nurturing pen with shallow and hot water at 30 - 33^{o}C until their body temperature increases to 35^{o}C. Temperatures above 36^{o}C or below 28^{o}C have been found to increase significantly stress levels and mortality in hatchlings and should be avoided (Turton *et al.,* 1994). Tanks can be concrete or plastic with simple and effective drainage and a constant warm temperature (Elsey *et al*., 1994; Mayer *et al*., 1998).

Conclusion

Keeping and breeding of crocodile in the captivity is an effective protective measure. Breeding also makes possible to commercially exploit crocodiles legally within the framework of CITES. We found that control of air temperature and air humidity can improves hatching rates. We also observed that protection from predators and providing provisioning food may increase survival rate of young crocodiles.

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