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BIO-ECOLOGY OF MARSH CROCODILE (*CROCODYLUS PALUSTRIS*) IN CAPTIVITY AT KARACHI ZOO

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ABSTRACT

The mugger or marsh crocodile (*Crocodylus palustris*), belonging to family Crocodylidae is found throughout the Indian subcontinent and the surrounding countries. It is one of the two crocodilians species found in Pakistan, the other being the Gharial or Gavial which is categorized as extinct in captivity/wild due to habitat loss and poaching. The different bio ecological aspects of marsh crocodile such as status, housing, food, feeding/breeding behavior, parental care, medical issues and conservation efforts in captivity of Karachi Zoo were studied during the period March 2007 to March 2009. As cold-blooded predators, *C. palustris* can survive long periods without food. Female egg size and clutch size were inversely related. The female shows a high degree of parental care behavior. In case of any danger female protects the hatchlings in her mouth. Crocodiles suffered from infections very rarely.

Key words: extinct, captivity, habitat loss, poaching, status, conservation, mouth brooding.

INTRODUCTION

Most modern Zoos in Europe and North America have started displaying wild animals mainly for the conservation of endangered or threatened species and also for educational and research purpose in addition to its primary role of entertainment.

Crocodylus palustris is listed as Vulnerable in the IUCN Red List of Threatened Species (2013). According to Santiapillai and Silva (2001) mugger crocodile viable populations occurred only in protected areas and the species became locally extinct over large parts of its range. In 2013 total global population of *C. palustris* estimated at less than 8,700 in an international workshop in Colombo, Sri Lanka (IUCN, 2013).

In Pakistan, about 600 individuals of *C. palustris* are known to exist in four major wetland systems of Sindh (Javed and Rehman, 2004; WWF, unpublished reports, 2007-2009). In Balochistan small populations are meagerly spread along rivers, mainly near estuaries (Javed and Rehman, 2004; Rehman, 2007). In Punjab the species is reported to be extinct (Chaudhry, 1993).

The global conservation status of *Crocodylus palustris* in some areas of its range is declining (IUCN, 2013).In Pakistan except Sindh province the conservation status of the species in all other provinces are extensively diminishing. Reintroductions of the species were attempted in Pakistan but results are not satisfactory. In addition to this species were sharply declined in the captive habitat of Karachi Zoo.

Therefore study of different aspects of bio ecology of the species is necessary for captive breeding and augmentation of present captive stock of Karachi Zoo as well as supplementation of wild population under the IUCN guidelines. The successful examples of supplementation of Arabian oryx, golden lion tamarin and several other species were reported by (Wilson and Stanley-Price, 1994). This would help keeping individuals of the species alive which are disappearing from the wild environment.

In this research it was felt a more systematic monitoring of the ecology of Karachi Zoo particularly to understand the dynamics of the species and investigate the causes of their decline, should be undertaken. Efforts are required to exploit knowledge about husbandry; suitable housing, food preference, feeding/breeding behavior, parental care and medical issues of species. This study was conducted with a view to achieving the proper and coordinated conservation management of the species among different Zoos of Pakistan.

MATERIAL AND METHODS

In order to study the physical environmental variables, the temperature and humidity were recorded at three different times at the present study site.

An electronic digital Thermometer (TES – 1310) equipped with a wire along with a probe and LCD display (made in China) was used to take temperature of the environment as well as body temperature of the animals.

An Electronic digital scale SCA-301equipped with a high precision strain gauge sensor system, LCD display was used for taking weights of animals and hatchlings up to 5 kilograms.

A Cyber-shot Digital Camera of Sony make DSC w230 Carl Zeiss Vario-Tessar12.1 mega pixels resolutions with 4 x optical smart zoom lens and A Cyber-shot Digital Camera of Sony make DSC-P10 5.0 mega pixels resolutions with 3x optical smart zoom lens were used for photography of animals, their behavior .

The assessment of diet was also determined by giving variable food items. Their liking and disliking and variation in quantities of consumption during different seasons and supplementing dietary items during breeding period were found important. Besides, the items causing food poisoning and the shelf life of the consumable item were also kept in mind. Moreover presentation of diet in natural way was also taken into consideration. Exposure to ultraviolet (UV) light as sunlight and coetaneous vitamin -D synthesis was also noted.

Initially 8 hour monitoring was conducted to determine the full activity of a specifically marked individual or a pair during morning, afternoon and night. Every activity and behavior was noted on a sheet on hourly basis in which the animal or pair was engaged. Seasonal changes in behaviour due to extreme summer and winter and interaction of visitor or staff were also recorded. The present study provides a picture of flora and vegetation cover within the enclosure of the species.

OBSERVATIONS

Crocodylus palustris

Conservation Status

Crocodylus palustris is listed as Vulnerable (Criteria A1a) in the IUCN Red List of Threatened Species (2013). Wild population less than 2500 adults and habitat fragmented and declining (last assessed in 1996).The estimated worldwide population of *Crocodylus palustris* is 5 to 10,000 individuals.

The global conservation status of *Crocodylus palustris* in some areas of its range is declining (IUCN, 2013). In Pakistan except Sindh province the conservation status of the species in all other provinces are extensively diminishing. Reintroductions of the species were attempted in Pakistan but results are not satisfactory. In addition to this species were sharply declined in the captive habitat of Karachi Zoo.

The main threats are habitat destruction, egg collection, and illegal hunting for the hide and alternative medicine markets. Mugger crocodiles also become trapped and drown in fish nets as they try to feed on entangled fish.

In Pakistan, *Crocodylus palustris* are available in captivity in 3 zoos and 1 Safari of Sind Province, namely Karachi Zoo (14), Landhi Korangi Zoo (2), Karachi Safari (2) and Hyderabad Zoo (2) and 4 zoos of Punjab province, namely Lahore Zoo (1), Bahawalpur Zoo (1), Gadwala Zoo (5), Faisalabad (1); some privately managed facilities also exists in Sindh province (Qazi, pers. Comm.).

Zoo Enclosure

In Karachi Zoo crocodiles have been kept in two enclosures having an area of about 35840 sq ft. The bigger and older one has a big paved cemented water pool which was irregular in shape and 3.5 feet in depth with sufficient area as a basking place. One side of the pool was having an island. The surface of island was covered with suitable river sand and dry leaves which serve as insulation layer for incubation. The other enclosure is smaller in size. It has a big 4.0 ft deep water channel running throughout the enclosure. On both the sides of the water channel big grassy lawns are available as a basking place. On the other hand 4 breeding cubical are provided with sand beds for egg laying of the females. Adjacent to the breeding cubical another cubical covered with iron fence is available with shallow water channel, which is used as a nursery for young hatchlings.

Both the enclosures were covered with a 5 .0 ft protective wall which was further strengthened with strong spot weld 5.0 ft mesh which also ensure safety as well as clear vision to the visitors. The fence of the enclosure must be strong enough (10 gauge), properly constructed as the crocodiles are good diggers and climbers. The poles used for the fence must be strong enough to support the weight of a climbing animal.

Large size enclosure reduces excessive territorial violent behavior, injuries and stress. On the contrary in small size enclosures the animal becomes sluggish due to decrease in activity area.

In the enclosure good quality of water is provided, maintained and effectively cleaned on regular basis with minimum disturbance to the animals. The water in the enclosure should also be kept clear in order to provide safety to keepers as well as for better public viewing. Since the crocodiles are strong predators, highly skilled trained staff be deputed for the enclosure to avoid any untoward accident.

The Karachi Zoo administration had already moved a proposal to the higher authority for installation of filtration, aeration and circulation of water systems which will improve the water quality, hygiene enabling the visitors to see the animal under water.

Enrichment:

Sufficient vegetation was provided around both the enclosures, on the island of older enclosure and in front of the breeding cubicals which provides shade and is very useful for thermoregulation and breeding purpose of the animals.

Behaviour

The Mugger crocodile is a freshwater species that prefers slow-moving shallow waters. Muggers appear to be sluggish and heavily built animals, but they are very active and alert in the event of danger or during hunting. Crocodiles are mostly active at night. Crocodiles are highly territorial animals whose adult males often kill juveniles. Among adult males aggressive interactions, violent fights and injuries were observed very often due to territorial behavior. They were regularly seen basking in the sun with a mouth gaping posture. Crocodiles sweat through their mouth and the gesture of lying with their mouth wide open is just a way to cool off.

They use the water, sun and shade to regulate their body temperature and move between these warm and cool parts of their environment to adjust it. They are excellent diggers and climbers. The crocodiles are fast moving, strongly built, powerful and unpredictable predators.

The crocodile is a quadruped with four short splayed legs. They crawl on their belly. Some travel a fair distance, as they are good at walking, running, sliding, jumping and swimming. They used to lift their whole body off the ground while walking. In this way it could move over rough terrain without getting scratched. A faster way of moving on land is running. This could be quite fast, but could be sustained over short distances only.

Sliding occur when the body is not lifted off the ground. This kind of motion was used over short distance on land and always when going into water. Sliding could damage the chin, the belly skin and the soles of the feet. They cannot turn their necks. They have ability to maintain strenuous activity for only short periods of time, after which they become totally exhausted. Large size crocodiles often die during capture operations if they are allowed to struggle excessively.

All crocodilians evolved to life in the water, and have their eyes and nose on the top of the skull so that they can see and breathe while the rest of their body is submerged. The crocodilian body is designed primarily for swimming. During swimming the front legs were held parallel to the thorax while the hind legs were spread out to act as rudders. The sideways movements of tail provide the propelling force for slow and rapid swimming. At lower temperatures the swimming speed was seen reduced.

They feel distress due to high fluctuation in temperature (extreme low or high) and inability to regulate temperature. Besides handling and capturing, the other common stress factors are movement in the vicinity, sudden noise and inability to hide. Low body temperature reduces the activity of the animal. Temperature below 28^{o}C and above 36^{o}C was observed to increase the stress level and may lead to mortality especially in juveniles. Crocodiles can produce sounds during distress as well as in aggressive displays. Crocodiles use many sounds to communicate with other crocodiles. The sense of sighting, hearing and smell are well developed and the animal remains very alert during basking in land.

Feeding Behaviour

Crocodiles are carnivorous (meat eating) or piscivorous (fish eating) animal. Freshwater crocodiles eat fish. In Karachi Zoo fresh marine fish (Moori) was given once a day regularly to crocodiles. After a few bites, a crocodile may swim away and another crocodile takes its place. The crocodile large in size usually get most of the food.

In captivity hatchlings feed on fish pallets minced young fish whereas in the wild Crocodile's hatchlings predominantly feed on water insects and young fishes. With the advance of age the dietary habits of the hatchings shift to small animals such as minced crabs, prawns, fish, frog's tadpoles and insects. It is customary to adhere strictly to high protein and calcium rich diet for juveniles of less than one year as they are highly susceptible to disease and mortality.

As cold-blooded predators, crocodiles can survive long periods without food. Smaller crocodiles appear to feed throughout the year. They prefer fresh food. Increase in food consumption was observed generally during warmer months of the year reducing their intake during cooler periods. The wet season seems to be the period when growth and feeding were at maximum in crocodiles of all sizes. Larger crocodiles are affected more by cool weather and their food intake is greatly reduced or can stop altogether. They can live for months at a time without feeding as they carry extensive energy supplies in the form of fat.

Crocodiles are ambush hunters. They wait for the prey to come close and then rush to attack. When the crocodile sees it prey it moves deep under water without making any noise and significant movement. It keeps only its eyes above water surface. When it feels it has reached sufficiently close to the target it whistles out of water with wide open jaws and most of their attempts are successful. They have very powerful jaws. Each crocodile jaw has 24

sharp teeth, used for grasping and crushing, but not chewing. The stomach of the crocodile is small in relation to the size of prey in most cases; larger prey is squeezed tightly until all movement stops. The crocodiles tear off the large prey into smaller pieces by shaking its mouth and the whole body vigorously. During this process crocodile twist, turn, and roll its mouth and body to swallow by raising their heads in air and gulping down the food. A crocodile can dive more than half its body length into the air or out on the bank to catch its prey. They are waiting patiently and striking fiercely. The Mugger is also cannibalistic in habit and rarely becomes a man-eater unless provoked or in case of territorial encounters.

Breeding Behaviour

In the year 1995 four crocodiles were available at Karachi Zoo but unfortunately without pairing breeding were not possible. In the year 2000 managed sexing of available six animals at Karachi Zoo which revealed that all the animals were of the same sex and did not yield any breeding result. Subsequently in 2002 procured ten numbers of animals from Sindh Wildlife department & carried out their pairing.

On the surface of enclosures island suitable river sand and dry leaves were spread which serve as insulation layer for incubation of eggs laid by the female. Male crocodiles fighting with each other in a dispute over territory especially they displayed increased aggressiveness during breeding season. They peck at each other by crossing snout and often cause serious injury. The males are always on the alert, ready to fight another male trespasser. Except males, the crocs, of all sizes, prefer to remain in groups in their reproductive size class. Male exhibits a strong dominance hierarchy and the dominant males live with several females**.** Sexes mature at the age of 5-6 years.

In December, in early morning, mid of the day and late afternoon hours sexual chasing was observed in water pond of enclosure. In which male dived at quietly swimming female. It was accompanied by a great deal of fighting on part of each, rolling, slapping one other with their long tails. It was observed that male emitted sound summoned its mate and kept at safe distance from rival.

During the breeding behaviour, the male crocodile moved his head up and down drawing closer to female step by step, until he was close enough to seize her by neck and jaws. Actual mating was usually initiated by female. Copulation was briefed and male become fierce and aggressive; mating took place usually lasting no longer than 15-20 minutes. At this point, he hooked the ends of his legs around her back. The female in turn bend her tail upwards, so as to allow her genital organ to link up with the male genital organ.

In the end of March ,2003 the female laid eggs in the pit or nest at night three to six months after mating in the wet season (Feb - Sept). The nest located in grass or within vegetation along the banks of a water pool or channel of the enclosure and build up of a large mound of vegetation and soil. All the eggs in the clutch were laid into the nest and covered with sand and nesting material. Nest, which are 8-10 cm deep, are made by scooping out earth, in which 20 eggs were laid in a clutch. The nest chamber was dug quite away from the water body in a high sloping area of the enclosure.

After about 90-95 days female dug them out help the eggs to hatch, by gently cracking the shells in her mouth 20 hatchlings hatched out with the help of the mother, who carried them gently to the water in her mouth. The mother then stayed close to the young and protected them for several weeks of time but due to large size of pond the hatchlings got into the pond water and fell victim to crows and eagles leaving us with two hatchlings one of which lived for three years while other one is still alive.

Thereafter Karachi Zoo procured 06 crocodiles from Sindh Wildlife Department in the year 2006. Out of those one pair bred in February 2007 made a nest in the month of April and started guarding it. After completion of incubation period a check of 22 eggs revealed that hatchlings did develop within the egg shells but could not come out due to low percentage of humidity. Therefore all eggs were spoilt.

In the start of May 2008 one of the females again made pit, laid eggs in the nest & started guarding it. This time in order to increase humidity in the nest we started spraying water with buckets daily and on August 9, 2008 the hatchlings make periodically short, low pace grunts as they want to come out of the eggs. Zoo keeping staff alarmed by these grunts and separated male and female from the nest and picked the eggs out from the nest which were elongated elliptical in shape and had a hard shell. Staff ruptured the eggs shell forming a slit to emerge. The snout protrudes first through the slit after few minutes then slowly the body and finally the tail comes out of the shell. The hatchlings was connected to the yolk through umbilicus, which remains up to few hours or few days after hatching, fifteen hatchlings came out of the eggs. Out of these one expired on September 9, 2008 and fourteen survived. They were immediately safely shifted to a covered pool in order to provide protection from the predators and winter weather. Initially after the birth the hatchlings do have egg yolk naturally within the body which is consumed by them. They were given pellet fish food from 2nd day of birth and some potassium permanganate was mixed in the pool water. By this time one died on September 28, and October 10, 2008, respectively but twelve out of the total of fifteen are still healthy and alive.

It was observed that young females laying smaller eggs and smaller clutches than older females. Larger eggs were produced stronger and more viable hatchlings, which rapidly outgrow hatchlings from smaller eggs. There was also some indication that, an individual females, egg size and clutch size were inversely related. Hatchlings were about 70 grams and about 25-30 centimeters long.

Upon hatching the young ones measures about 30-35cm long and weigh 60- 90 grams. The growth rate is very high in the early days i.e. 6.5 to7.5cm per month and then slows down.

The incubation temperature determines the gender of the hatchlings with very high or low temperatures producing females, and temperatures of 31º to 32ºC producing males. Eagles, kite, crow, pond heron eat crocodile eggs and heavy rain destroy many nests. These factors contribute to the sounds like an alarming sign that about 75% of eggs laid will hatch. From those hatchlings that emerge, less than 1% survives to adulthood.

Parental Care

The crocodiles show a high degree of parental care behaviour, the female after laying eggs in the pit, guards the nest regularly, if any predator or human and even the male entered in this area or it sense danger from closing animal then it was attacked. Female dug them out help the eggs hatch, by gently cracking the shells in her mouth, hatchlings hatched out with the help of the mother, who carried them gently to the water in her mouth. In case of any danger female protect the hatchlings in her mouth. This mouth brooding type of parental behaviour was observed in crocodiles.

Conservation in Captivity

During the last almost one decade (i.e. from 2000 to 2008) more than 30 births took place at Karachi Zoo. The year wise detail is given below:

Year	Month	No. of juveniles
2003	June	20
2007	July	22 (Eggs spoiled)
2008	August	15

Twenty juveniles hatched out in June 2003 and 15 in August 2008, respectively, whereas in July 2007 after completion of incubation period 22 hatchlings did develop but spoilt most probably due to low humidity.

DISCUSSION

The snout of Mugger crocodile (*Crocodylus palustris*) from Karachi is broad and elongated whereas that of Gharial (*Gavialis gangeticus*) is characterized by its long, thin and the bulbous growth at the end of its snout.

According to IUCN red list (2004), 4 out of 24 crocodilian species are critically endangered, 3 endangered and 2 are vulnerable. In Pakistan, about 600 *C. palustris* are known to exist in four major wetland systems of Sindh (Javed and Rehman, 2004; WWF, unpublished reports, 2007-2009).In Balochistan small populations are meagerly spread along rivers, mainly near estuaries (Javed and Rehman, 2004; Rehman, 2007). In Punjab the species is reported to be extinct (Chaudhry, 1993).

It was described by da Silva and Lenin (2012) as extinct in wild in Iran, India, Nepal, Pakistan, Sri Lanka, Bangladesh, whereas extinct in Bhutan and probably extinct in Myanmar.

Captive breeding in Pakistan

In Pakistan, *Crocodylus palustris* are available in captivity in 3 zoos and 1 in Safari of Sind Province, namely Karachi Zoo (14), Landhi Korangi Zoo (2), Karachi Safari (2) and Hyderabad Zoo (2) and 4 Zoos of Punjab province, namely Lahore Zoo (1), Bahawalpur Zoo (1), Gadwala Zoo (5), Faisalabad (1); some privately managed facilities also exists in Sindh province (Qazi, pers. Comm.).

Globally, the crocodile specialist group of the 'IUCN Species Survival Commission' coordinates Crocodilian Conservation Programmes. The most successful ones are based on local community involvement combined with education (Ross, 1998).

Combining the captive breeding with ranching and tourism is considered the best approach for linking conservation of crocodiles with economic benefits to local communities and governments (Mazzotti 1987; Thorbjarnarson, 1992).

Thousands of Muggers are in captivity in Indian crocodilian breeding farms and sanctuaries. The Madras Crocodile Bank alone possess over 2000 crocodiles (Whitaker, 2007, 2008). In India, 32 zoological parks and almost all crocodile rearing centers are now breeding mugger in captivity.

Rashid (pers. comm.) reported 40 adult and 28 hatchling muggers in captivity in 7 zoos of Bangladesh, in 2009.

Food and Feeding Behaviour

In the Karachi Zoo, initially to the hatchlings fish pallets or guppies were given twice a day for a period of one month. Later on bites of small sized fish pieces with sufficient calcium powder were supplied on the tip of long stick. However, marine fish Moori was given once a day as food to the adult crocodiles.

Small tropical fish guppies or cultured insects (crickets and cockroaches) are suitable as starters for hatchlings. For juveniles of less than one year a high protein and calcium rich diet be given as they are highly susceptible to disease and mortality (Hutton and Jaarsveldt, 1987; Webb and Manolis, 1989).

Growth rates of crocodilians are rapid during the first few months of life and require feeding at least 6-7 times a week. Once individuals reach sub-adult size they only need to consume 8-10% of their body weight a week (Whitaker and Andrews, 1998). Red meat is commonly the preferred food source for adult crocodilians (Hutton and Webb, 1994). Crocodilians generally increase their level of consumption during warmer months of the year and decrease it in the cooler months (Pooley, 1990).The food was recommended to be presented in bite-sized portions to reduce the mess caused by individuals when feeding (Webb and Manolis, 1989; Pooley, 1990). Minced meat and meat high in fat should be avoided as it will only foul the water which will create an environment for disease (Lang, 1987a; Hutton and Webb, 1994). Crocodilians utilize protein instead of fat as an energy source (Hutton and Webb, 1994; Smith and Marais, 1994). During the present study minced fish or fatty fish was not given to the hatchlings to avoid its mixing with water and creating environment for infection.

Fresh chicken heads, carcasses, and fish are other options. In the wild, fish constitute the main prey item of American crocodiles (Britton, 2001).The crocodilians need to provide a varied diet for optimum results (Pooley, 1990). A poor diet will lead to decreased fertility, stunted growth, bone and teeth disorders, and reduced immunity to disease (Pooley, 1990). Overfeeding can lead to obesity and associated diseases (Pooley, 1990).

Breeding Behaviour

All crocodilian species are totally water dependent since they can mate only in water (Martin, 2008).The mugger is a hole-nesting species, egg-laying takes place during the annual dry season. Females become sexually mature at approximately 1.8-2 m, and lay 25-30 eggs (Whitaker and Whitaker, 1989).

Nests are located in a wide variety of habitats, and females are known to nest at the opening of or inside their burrow in Pakistan (Choudhury, 1993).

In captivity, some muggers are known to lay two clutches in a single year but this has not been observed in the wild (Whitaker and Whitaker, 1984).

In the Karachi Zoo, crocodiles layed single clutch each year. In the year 2003 (20 eggs per clutch), 2007 (22 eggs per clutch) and 2008 (15 eggs per clutch) were recorded. Egg laying took place during the months of March, April and May, respectively.

Incubation is reported to be relatively short, typically lasting 55-75 days (Whitaker, 1987). In the present study the incubation period lasted for 90-95days. Males are always found larger than females, and the male to female ratio of individuals in an enclosure skewed heavily towards females (Child, 1987; Lang, 1987). One to one sex ratios was considered preferable, especially in highly aggressive, territorial species and for individuals introduced from the wild (Joanen and McNease, 1971; Hutton and Webb, 1994).

Animals living in captive conditions breed more successfully at an earlier age (Joanen and McNease, 1971; Lang, 1987; Hutton and Webb, 1994). Maturity is described effectively size dependent, and can be achieved at earlier ages if growth and development is increased under captive conditions (Lang, 1987).

Matters related to number of eggs, fertility and maturity are discussed by Lang (1987). He further mentioned that decrease in fertility and clutch size will occur at about 20 years of age, depending on the species.

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