Conservation of the Gharial (*Gavialis gangeticus*) at the Madras Crocodile Bank Trust, Chennai, India

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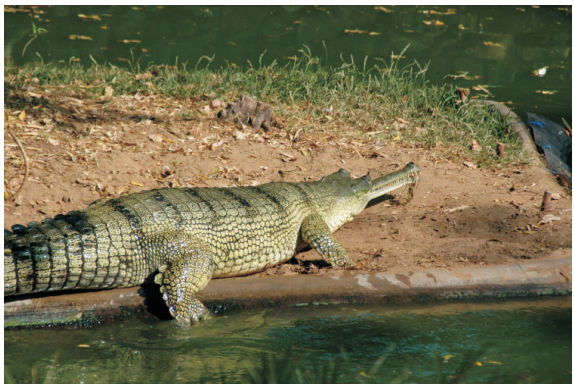
Gavialis gangeticus are in serious decline in the wild. In this short article we provide an overview of Gharial ecology and current conservation measures taking place at the Madras Crocodile Bank Trust in India.

Introduction

The Gharial (*Gavialis gangeticus*) is the sole survivor in the Archosauromorpha and the oldest crocodilian species that exists (Gad 2008). It is a large species, with males recorded up to six meters although individuals of this size are rare nowadays (Daniel 2002; Whitaker 2007).



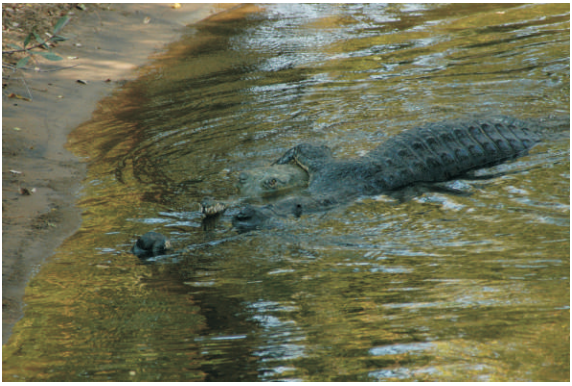
Adult Gharials range from a dark olive, light brown and light olive colour (Daniel 2002). They are easily distinguished from other crocodilians by an elongate, narrow snout. This unusual snout shape varies between individuals and becomes proportionally thicker and shorter as the animal ages. The upper jaw is lined with 27 to 29 virtually symmetrical teeth on each side. The mandible is lined with 25 to 26 teeth on each side where the first three teeth slot into notches within the upper jaw (Daniel 2002). The tip of an adult male snout has a bulbous shaped growth called a "Ghara" (narial excrescence) (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007). The Ghara assists the male to produce snorting/hiss noises which may provide a function in territorial disputes (Daniel 2002; Whitaker 2007). Unusually, female Gharials have also been observed to have a Ghara. This characteristic means the Gharial is the only crocodilian with females that can develop male characteristics.

The Gharial is a fresh water crocodilian, inhabiting deep pools and gorges situated at junctions and bends of rivers (called *Kunds*). It is thought that Gharials spread further through river systems when the monsoon rains are in heavy flow and then return to their perennial *Kunds* when the rains recede (Daniel 2002). Like all crocodilians, the Gharial is a very adept swimmer and has webbed hind feet and a laterally flattened tail that gives it superior manoeuvrability in water that is vital for capturing fish, its preferred prey.

However, the Gharial is quite the opposite when moving out of water; they are rather sluggish and move with a sliding motion by pushing with hind and fore-limbs. This is unlike other species of crocodilian, which can hold their body weight off the ground and undertake running and galloping movements (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007). Due to this minor disadvantage, Gharials' only really leave the water to bask, nest or defend nest sites (Whitaker 2007).

The Gharial is mostly piscivorous (fish eater) (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007) and its ecological adaptation of longirostrine (elongate) jaws is thought to have evolved because of this diet (Densmore & Owen 1989; Tarsitano *et al.* 1989). However, Gharials can also be generalist feeders and have preyed on mammals, reptiles, amphibians, birds and even corpses (Whitaker & Basu 1982; Daniel 2002). Like other crocodilians Gharials' stomachs can contain stones to help with digestion.

Gharials commence their reproductive cycle at different ages depending on gender. Females usually become reproductively mature at 7-8 years old (2.5 m) and males 13-18 years old (3.0 m approx), when the male will grow the "Ghara" (Daniel 2002; Whitaker 2007). The males with the most prominent "Gharas" will be the most dominant within their group hierarchy (Whitaker & Basu 1982). Males become territorial during the breeding season and are believed to use their "Ghara" as leverage in mounting the female by hooking her snout (Daniel 2002). The male Gharial will guard a territory where a number of females accommodate. Receptiveness of females to reproduction begins in the cooler months of December and January (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007).



The process of nesting begins from March to May and is synchronized with the dry season when low water levels occur. Interestingly, the nesting season has been reported not to alter by more than 10 days within any given year (Romulus Whitaker, pers. comm.). All the females in the area will start and finish nesting within one week of the first excavated nest. The female will excavate the nest within sandy banks where they are placed above a river's flood-line to prevent drowning of the egg chamber. The chamber is approximately 30-60 cm deep and 20 cm wide. A female will deposit 20-95 (average clutch 40 eggs) hard-shelled eggs and cover them carefully with excavated sand (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007). The female then guards her nest from potential predators including jackals, rats, pigs, monitor lizards and people (Daniel 2002).

The eggs of the Gharial are recorded to be one of the largest of any crocodilian with an average weight of 160 g and shell sizes of 55-57 mm. The optimum incubation temperatures for these large eggs are between 28-32°C and have an incubation period of approximately 83-94 days.

Once hatched young Gharials' will start to chirp. As is noted in other crocodilians the female will respond to this signal from the hatchings and begin excavating the chamber to allow her young to exit the nest. The female will rarely give physical assistance to her young toward the waters edge, but will guard her hatchling clusters for some time after (Whitaker & Basu 1982; Daniel 2002; Whitaker 2007). The hatchlings measure 325-375 mm and weigh approximately 75-97 g. Their growth rate is about 10 cm per year (Daniel 2002).

Status and Conservation

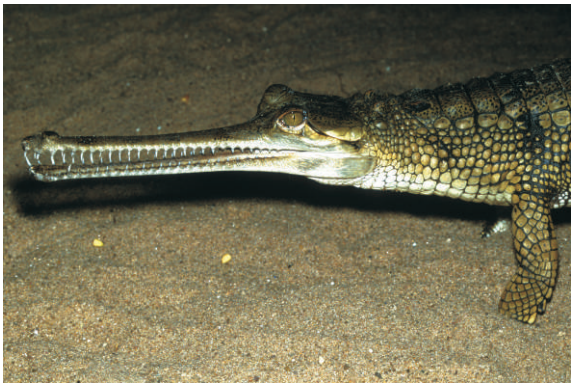
The Gharial was once a thriving species with a wide distribution throughout Pakistan, Bhutan, Nepal, Myanmar and Bangladesh. Its range covered approximately 20,000 km^2 of the Ganges, Indus, Irrawady and Brahmaputra, Gandak, Jumuna, and Kosi rivers (Daniel 2002; Whitaker 2007; Gad 2008). Today, it is not nearly as populous and thrives in just 2 % of its previous range. Such a perilous existence is emphasized in India and Nepal where the current area occupied by the species is less than 250 km^2 (Whitaker 2007).

Ganges Gharial *Gavialis gangeticus*
Chisapani Gorge,Karnali River, Nepal.
Photo Mark O'Shea

In the 1970s Gharials came close to extinction. Conservation efforts ensued by environmentalists and cooperative governments that led to some measures to reduce the threat of extinction. Full protection was then granted in the hope of reducing poaching losses, although these measures were slow to be implemented. By 1976, the estimated total population of wild Gharial in the world had declined from 5,000-10,000 in the 1940s to less than 200, a decline of about 96%. By 2006, the mature Gharial population in India stood at less than 200 and less than 35 adults for Nepal (IUCN 2007). The species is virtually extinct in Pakistan, Bangladesh and Bhutan (IUCN 2007). Only two records for the species were recorded from Myanmar in 1927 and it is presumed long extinct.

The drastic decline in Gharial populations over the last 60 years (three generations for the Gharial) can be attributed to a variety of causes including over-hunting for skins and trophies, egg collection for consumption, killing for indigenous medicine, and killing by fishermen (IUCN 2007). While hunting is no longer considered to be a significant threat, the construction of dams, barrages, irrigation canals, siltation, changes in river course, artificial embankments, sand-mining, riparian agriculture, and domestic and feral livestock have combined to cause an extreme limitation to Gharial range due to this excessive, irreversible loss of riverine habitat. Hussain & Badola (2001) documented plans for 276 irrigation projects in the Chambal River basin alone and such threats have not ceased.

Hope was placed in conservation and management programs that have only really come to their fruition since 2004.



Ganges Gharial, *Gavialis gangeticus,* Chambal River, Madya Pradesh, India. Photo Mark O'Shea

There are now nine protected areas for this species in India which are linked to both captive breeding and 'ranching' operations where eggs collected from the wild are raised in captivity and then released back into the wild (the first being released in 1981). More than 3000 animals have been released through these programs, and wild Indian population reintroduction is estimated at around 1500 animals. However, the release of captive Gharials has not been as successful as expected. Recently more than 100 Gharials died in India in the Chambal River from an unknown cause with gout-like symptoms (Roy 2008).

This recent death toll is expected to have decreased the number of breeding pairs to less than 400. Tests of the deceased carcasses suggest the possibility of poisoning by metal pollution sequestering.

Recently this species has moved from Endangered to Critically Endangered on the 2007 Red List of endangered species of animals and plants issued by the World Conservation Union, and qualifies for protection under the CITES (Convention on International Trade of Endangered Species) Appendix II (Choudhury et al., 2009).

The present day situation means that only a handful of relatively safe refuges for the Gharial are left. These include: Katerniaghat Sanctuary, Son River Sanctuary, Chitawan National Park, National Chambal Sanctuary and Satkosia Gorge Sanctuary (Satkosia has no reported breeding). Furthermore, there are records of scattered specimens in rivers through India and Nepal, but unfortunately, there have been no breeding of these individuals recorded for decades (Whitaker 2007). Orissa is another area of India where populations of Gharial have been recorded. It is the only state to hold all the Indian crocodile species including the Saltwater Crocodile (*Crocodylus porosus*), Mugger Crocodile (*Crocodylus palustris*) and the Gharial (*Gavialis gangeticus*). Today, only a small population of juvenile and adult Gharials survive in Orissa and they are only found in the Mahanadi River (Daniel 2002; Gad 2008).

The IUCN Red Data Book (1975) was the first inventory to document the Gharial's status. Today the situation has become worse and the IUCN Red Data Book of 2009 lists all populations of the Indian Gharial as 'Critically Endangered'. In 1997, the estimated population of sexually mature Gharials in India and Nepal was 342, however anotherreport in 2006 showed a decline with only 182 mature individuals being estimated (Choudhury et al. 2007). This nine year decline (within one generation) shows a 47 % drop in mature Gharials. With such drastic declines as this, it will not take long for the Gharial to become extinct throughout its known range (Whitaker 2007; Gad 2008; Choudhury et al., 2007).

The decline of the Gharial over the past 60 years has been noted alongside the decline of other endangered species such as the Mugger Crocodile (*Crocodylus palustris*), Ganges River Dolphin (*Platanista gangetica*) and the Smooth-coated Otter (*Lutrogale perspicillata*) (Whitaker 2007).

The demise of Gharials is not thought to be a natural occurrence. They have been suggested by many native people as possessing medicinal and practical use and have subsequently been collected. Such erroneous superstitions of their benefit include using incense sticks produced from the Ghara as a pesticide in crop fields. The 'Tharu' a local tribe in Nepal, also believe that labour pain will be relieved when a Ghara is situated under the birthing mothers pillow. Medicinal benefits are also believed be gained from the consumption of Gharial eggs (Gad 2008). Another cause of decline is thought to be attributable to some fishermen that believe Gharials compete with them by depleting fish stocks. Some fishermen have been reported to deliberately trap Gharial in nets, remove their jaws and abandon them to starve to death. Furthermore, illegal nets are often left within the water column when fishermen flee from fishing in illegal areas, causing Gharials to be entangled and slowly drown (Whitaker 2007).

However, it is not only direct killing that is causing declines. The constant construction and manipulation of land from sand-mining, agriculture, irrigation channels, dams and siltation of watercourses all contribute to degradation of riverine habitat that is essential for Gharials. One of the final steps that may secure the extinction of Gharials is a proposal to interlink the major rivers within India (Whitaker 2007).

The Madras Crocodile Bank Trust

In 1976 Romulus Whitaker, a leading authority in Herpetology, and a hand full of similar minded people founded the first crocodile conservation-breeding centre known as The Madras Crocodile Bank Trust (MCBT). It is located 40 km south of Chennai and backs onto the Bay of Bengal. The 'Crocbank' as it is also known, was founded primarily to conserve and observe integral behavioural/breeding patterns of the three Indian crocodilians, the Mugger (Crocodylus palustris), the Gharial (Gavialis gangeticus), and the Saltwater Crocodile (Crocodylus porosus).

The 3.2 ha of land that the MCBT was built on began with 30 Mugger Crocodiles. Today, the success of the MCBT captive breeding efforts has assured the release of over 5000 Mugger Crocodile progeny. From 1987 the MCBT became the Centre of Herpetology, and was recognized as a premier herpetofaunal institution within India. The Centre and now holds over 2400 crocodilians from 14 different species. Additionally the Centre houses 12 endangered turtle and tortoise species and an albino Spectacled Cobra (*Naja naja*).

The Centre endeavours to establish research projects and has produced an impressive volume of over 500 scientific publications.

The Centre has also served as a regional service centre for South Asian Herpetological studies. Both Indian and foreign scientists frequently visit it to use the facilities, especially the extensive library and resource centre.

One crucial factor responsible for past failures in conservation efforts to protect crocodilians in India was a lack of involvement in projects by local people.

When protected areas were declared local people lost access to natural resources they had enjoyed for generations, causing resentment toward the animals and conservation plights. Future success of conservation efforts will depend on working with local communities to find mutually beneficial strategies. Such strategies would likely include alternative livelihoods for fishermen on some stretches of river to conserve habitat upon which both Gharials and fishermen depend.

The focus of current conservation efforts is now on habitat protection, enforcement of protection status, community involvement, education and awareness, and Gharial/human conflict mitigation.

Conservation priorities for Gharial that have been recognised as key objectives include:

Lobbying for political support for Gharial and river biodiversity conservation, particularly in the three main Gharial states in India: Uttar Pradesh, Madhya Pradesh and Rajasthan.

Enforcement of the existing wildlife laws and protection by the Forest and Police Departments in India and Nepal.

Increased patrolling of Gharial protected areas.

Annual monitoring of all surviving Gharial populations.

Formulation and implementation of management plans for each of the key protected areas for Gharials.

Development of research programmes on key aspects of Gharial biology such as dispersal and migration, hatchling survival and habitat requirements (in particular to survive the monsoon 'flush' effect).

Determination of possible alternative habitats for future release of captive bred Gharials.

Socioeconomic research with riparian people living alongside Gharials to advise cooperative eco-development schemes.

Development of appropriate awareness campaigns along with eco-development programmes to increase the standard of living for riparian people whilst minimizing unsustainable dependence on river resources.

Fund-raising, international and national awareness programmes.

The Gharial Conservation Alliance

In combination with efforts at the Centre for Herpetology, the Gharial Conservation Alliance (GCA), members, and partner organizations are conducting combined research to better understand Gharials. The research is intended to develop and execute efficient conservation strategies. This research includes:

Population Surveys and Monitoring - This is vital to determine the status of Gharial populations, monitor success of conservation efforts and help to devise future conservation strategies by providing concrete information to governments for policy decisions. A survey of the Chambal River was recently completed (April 2007). Surveys of other known and potential Gharial habitat areas are intended to be conducted later this year.

Hatchling Survival and Dispersal - GCA members and partners in the field are monitoring Gharial nests, hatching rates and hatchling survival. A satellite-tracking study is to be carried out with hatchlings released into the Mahanadi River in Orissa to determine their survival rates and track their dispersal movement. Similar tracking studies would be extremely beneficial for Gharial population management and to determine the effectiveness of restocking programs. If wild releases are to be carried out, monitoring such as this will be necessary. The GCA is seeking to carry out similar studies throughout Gharial range areas.

Gharial Information Database (GID) - The GCA has initiated the creation of a Gharial Information Database, combining all past and current population data, ecological data, captive breeding and husbandry information, and other relevant biological data on Gharials. The GID will continually update as future surveys and research are conducted.

Research on Gharials that is happening in Asian regions now includes; **India** - National Chambal Sanctuary, Chambal River; Population survey and monitoring, nesting surveys. Katerniaghat Wildlife Sanctuary, Girwa River; Nesting, hatchling survival/dispersal, population surveys and monitoring. Son Gharial Sanctuary, Son River; Population surveys and monitoring. Ken Gharial Sanctuary, Ken River; population surveys and monitoring. Sathkosia Gorge Sanctuary, Mahanadi, Orissa; Post-release monitoring of captive bred Gharials-satellite telemetry. Corbett National Park, Ramganga River; Population surveys and monitoring. Brahmaputra; population surveys and habitat suitability assessment. Gorumara Wildlife Sanctuary, West Bengal; “Soft release” of captive bred Gharial and post-release monitoring. Bihar; population surveying and habitat suitability assessment. **Nepal** - Royal Chitwan National Park, Rapti-Naranyani Rivers; population surveys and monitoring. **Bhutan** - Captive breeding. **Pakistan** - Captive breeding.

The following research studies are intended to be conducted in the future by the GCA:

Sustained research on hatchling survival, dispersal and migration of all size classes of Gharials and refinements of supplementation techniques.

Research on river water management and impact of dams, barrages, canals, pollution, and excessive water extraction on water levels and flow.

A study on Gharial fishing techniques and fish ecology with a view to mitigate conflicts with people.

Study on Gharials’ relationship with commercially valuable fish to determine whether they are beneficial or detrimental to fisheries.

Study and mapping of threats such as fishing, sand-mining, riverbed cultivation, and pollution resulting in solutions.

Study of the relationship between Gharial and mugger to determine whether an increase in mugger numbers is detrimental to Gharial survival.

A Future for Gharials

It is hoped that with such careful conservation planning by organisations like the Madras Crocodile Bank Trust (MCBT) and the Gharial Conservation Alliance (GCA) that the Gharial may have a chance at surviving. However, with such devastating recent population decline we ask herpetologists and conservations alike to consider supporting, in any way possible the intended actions of these groups. Perhaps more importantly we ask the wider conservation community to continue to support programs seeking to research Gharials before their populations become unviable and unsustainably driven toward guaranteed extinction.

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Ganges Gharial, *Gavialis gangeticus*
Sri Lankan captive
Photo: Mark O'Shea

References

Choudhury, B.C., Singh, L.A.K., Rao, R.J., Basu, D., Sharma, R.K., Hussain, S.A., Andrews, H.V., Whitaker, N., Whitaker, R., Lenin, J., Maskey, T., Cadi, A., Rashid, S.M.A., Choudhury, A.A., Dahal, B., Win Ko Ko, U., Thorbjarnarson, J. & Ross, J.P. (2007). Gavialis gangeticus. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. <www.iucnredlist.org>. [Accessed: 19 November 2009].

Daniel, J.C. (2002). *The Book of Indian Reptiles and Amphibians*. Oxford: Oxford University Press.

Densmore, L.D. & Owen, R.D. (1989). Molecular systematics of the order Crocodilia. *Amer. Zool.* 29, 831-841.

Gad, S.D. (2008). Indian Gharial (*Gavialis gangeticus*) on the verge of extinction. *Curr. Sci.* 94, 1549.

Hussain, S.A. & Badola, R. (2001). Integrated Conservation Planning for the Chambal River Basin: A Landscape Level Perspective. National Workshop on Regional Planning for Wildlife Protected Areas, New Delhi (Wildlife Institute of India).

Roy, B. (2008). BBC: Crocodile Blues. Icon Films and the Gharial Conservation Alliance <www.iconfilms.co.uk/gharial> [Accessed: December 2009].

Tarsitano, S.F., Frey, E. & Riess, J. (1989). The evolution of the Crocodilia: a conflict between morphological and biochemical data. *Amer. Zool.* 29, 843-856.

Whitaker, R. & Basu, D. (1982). The Gharial (*Gavialis gangeticus*): a review. *J. Bombay Nat. Hist. Soc.* 79, 531-548.

Whitaker, R. (2007). The Gharial: going extinct again. *Iguana* 14, 24-33.