



OLIVER BORN

Gharials (*Gavialis gangeticus*) are massive crocodylians with long, slender snouts equipped with sharp teeth ideally suited for capturing fish in deepwater portions of riverine systems on the Indian Subcontinent.

The Gharial: Going Extinct Again¹

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The Gharial (*Gavialis gangeticus*) is a massive crocodylian, exceeded in size only by the Saltwater Crocodile (*Crocodylus porosus*). Historically, male Gharials of up to 6 m (nearly 20 ft) were commonly encountered, but such large individuals are unknown today. The species is characterized by its elongated, narrow snout, which varies in shape as an animal ages, becoming proportionally shorter and thicker over time. The bulbous growth on the tip of a male's snout, called "ghara" after the Indian word meaning "pot," is present in mature individuals, which utilize the structure to modify and amplify "hisses" snorted through the underlying nostrils. The resultant sound can be heard for nearly a kilometer on a still day. The ghara also renders Gharials the only visibly sexually dimorphic crocodylian.

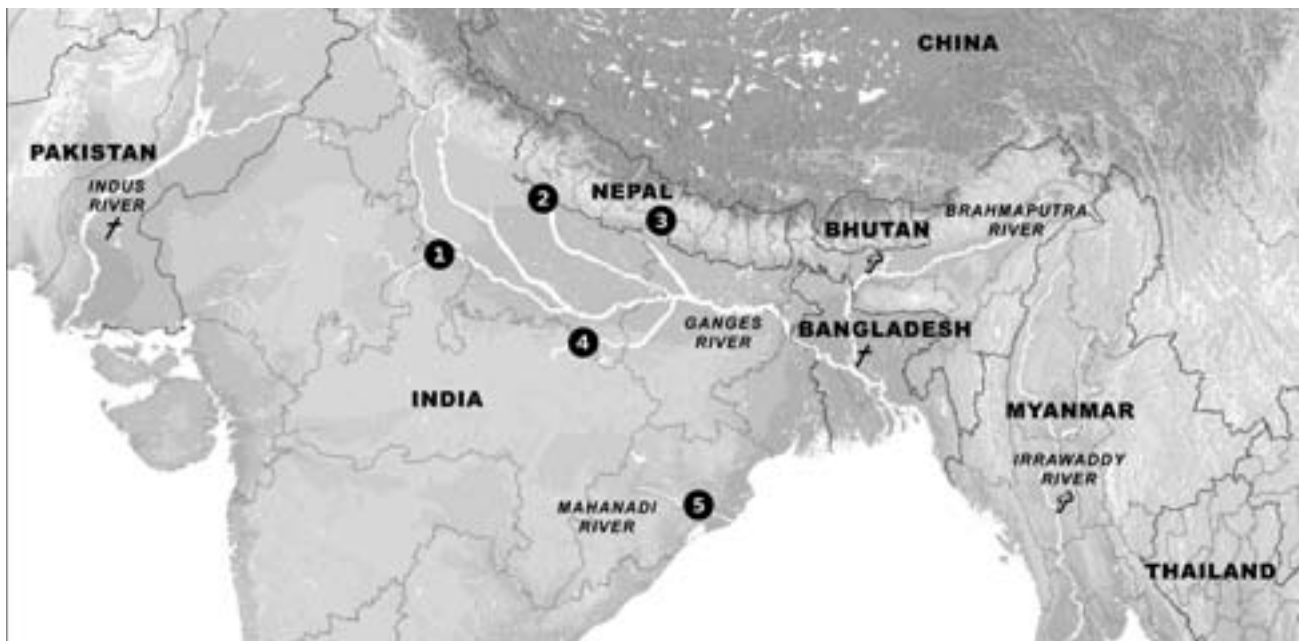
The well-developed laterally flattened tail and webbed rear feet provide tremendous maneuverability in the Gharials' deep-water habitat, where their diet consists primarily of fish. On land, however, an adult Gharial can do little more than push itself forward and slide on its belly, and it will leave the water only to bask or to nest on sandy beaches. Males will guard a territory in which several females live. Mating usually occurs during December and January and nesting from March to May,

which corresponds to the dry, low water season. Females will excavate an egg chamber in the sandy banks above the flood line, depositing up to 60 eggs and carefully covering them. The eggs are the largest of any crocodylian species, weighing an average of 160 g. Eggs hatch after 83–94 days. Female Gharials dig up the young in response to hatching chirps, but, unlike many other crocodylians, do not assist the hatchlings to the water. They will, however, guard the hatchlings for some time. Although this remarkably gentle animal once thrived in the deep rivers of India, Nepal, Pakistan, Bangladesh, Bhutan, and Myanmar, it is now virtually extinct in all but the first two of these countries, where it is limited to 2% of its former range.



F. WILLIAM ZEGLER

Gharials basking on sand banks at the Katerniaghat Sanctuary.



JOHN BINNS

Gharials were once distributed across approximately 20,000 km² of riverine habitat of the Indus, Ganges, Brahmaputra, and Irrawaddy river systems. Today populations are limited to a few refuges: (1) National Chambal Sanctuary; (2) Katerniaghat Sanctuary; (3) Chitawan National Park; (4) Son River Sanctuary; (5) Satkosia Gorge Sanctuary. No breeding is occurring in the Satkosia Gorge Sanctuary. Scattered individuals are known to occur along other rivers in India and Nepal, but no reproduction has been documented in decades. Solid crosses indicate that populations are presumed to be extirpated, and outlined crosses mark populations that are extirpated.

Early Records

Early records for the Gharial are mainly anecdotal. Old references indicate the Gharial's abundance: common in the Indus River in Pakistan (Francis 1910, Rao 1933); Gandak River in Nepal (I.A.K. 1921); Jumuna River in Uttar Pradesh (Hornaday 1885), and Kosi River in Bihar (Shortt 1921). Several authors mentioned seeing groups basking together. In 1885, Hornaday wrote that he had counted 64 Gharial in two hours on the banks of the Jamuna. Adams (1867) wrote: the Gharial "abounds in all the great rivers of Northern India ... Ten or twenty may be frequently seen together. Hundreds of Gharial were observed on the Narayani River (Nepal) prior to the construction of the Gandak barrage ... in 1964 and in the early 1950s about 235 Gharial were counted along the Narayani River between Narayanghat and Tribeni" (Maskey 1999). With a historic range of thousands of river kilometers of habitat over an area of about 20,000 km², from the Indus to the Irrawady, the Gharial had an inferred population of 5,000 to \geq 10,000.



Many large males were killed by hunters from Nepal or Europe well into the 20th Century. This hunt was in what was to become the Royal Chitwan National Park and occurred just before the protected area was created. Today, only four large, mature males like that in the photograph remain in the Narayani and Rapti rivers around the park. Photograph courtesy of Olivier Born.

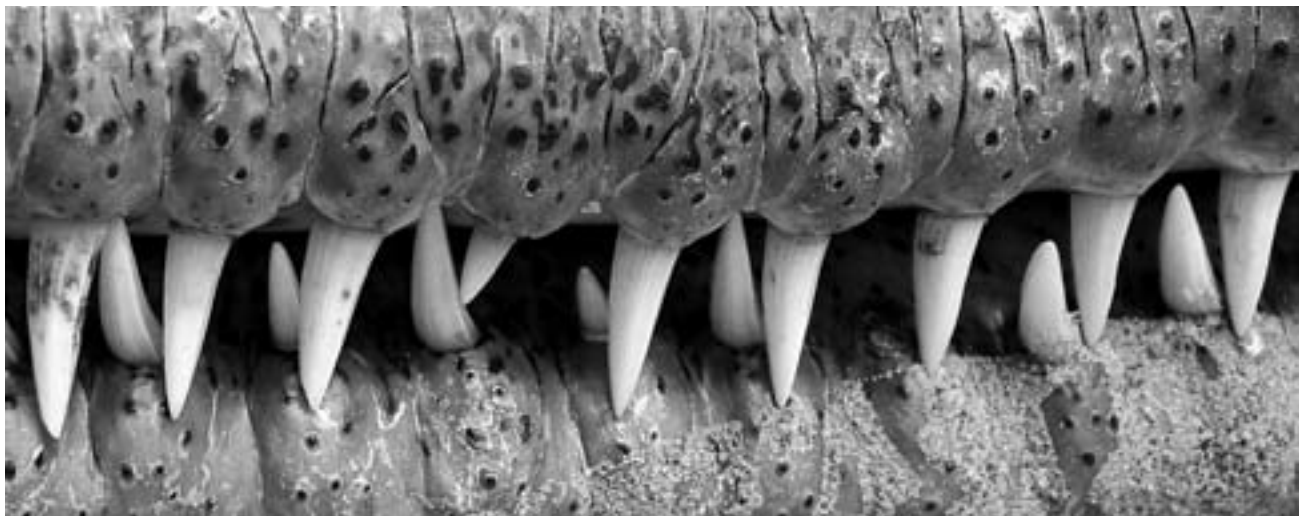
Current Status

By 1976, the estimated total population of wild Gharials had declined from an inferred 5,000–10,000 animals in the 1940s and throughout its huge former range (spanning the rivers of the northern part of the Indian Subcontinent from the Indus in present-day Pakistan 3000 km eastward across the Gangetic floodplain to the Irrawady in Myanmar) to fewer than 200 (Whitaker 1974), a decline of about 96%.

The Indian government subsequently accorded protection to the Gharial under the Wildlife Protection Act (WPA) of 1972. Project Crocodile began in 1975 under the auspices of the Government of India with the aid of the United Nations Development Fund (UNDP) and Food and Agriculture Organization (FAO). The project included an intensive captive-breeding and rearing program intended to restock habitats with low numbers of Gharials. An acute shortage of Gharial eggs was overcome by their purchase from Nepal. A male Gharial was flown in from the zoo in Frankfurt, Germany, to become one of the founding animals of the breeding program.

Sixteen crocodile rehabilitation centers and five crocodile sanctuaries (National Chambal Sanctuary (NCS), Katerniaghat Wildlife Sanctuary (KWS), Satkosia Gorge Wildlife Sanctuary, Son Gharial Sanctuary, and Ken Gharial Sanctuary) were established in India between 1975 and 1982. By 2004, 12,000 Gharial eggs had been collected from wild and captive-breeding nests, and over 5,000 Gharials reared to about a meter or more in length (roughly three years of age) and released into the wild. Over 3,500 of these were released in NCS, the largest Gharial reserve in the country, sprawling across 425 km² in the states of Uttar Pradesh, Madhya Pradesh, and Rajasthan.

In 1982, a report by a wildlife biologist for the FAO/UNDP listed Project Crocodile among the most successful conservation projects in the world. However, in 1991, the Union Ministry of Environment and Forests felt that the project had served its purpose, and stopped funds for its captive-breeding program. Funds were also withdrawn for the egg-collection program. The thousands of crocodiles seen in various rearing stations and captive breeding centers clearly attested to the success of the project. However, little had been done to



The very sharp interdigitated teeth are well adapted for capturing fish, which are Gharials' primary prey.

Table 1. Past and present numbers of adult Gharials in the major river systems of the Indian Subcontinent.

Subpopulation (river systems)	Three Generations Ago (1946 – inferred)	Present (2006 – inferred)	Estimated Reduction
Indus River		Nil	
Ganges River		< 200	
Mahanadi River		2	
Irrawady River		Nil	
Totals	5,000–10,000	< 200	96%



OLIVIER BORN

Gharials, such as this adult female, are powerful swimmers but graceless on land. The laterally compressed tail serves both to propel the animal and as a base from which to strike at prey.



OLIVIER BORN

The elongated, narrow snout reduces resistance as Gharials snag fish. It varies in shape as an animal ages, becoming proportionally shorter and thicker over time.



DON BOYER, SAN DIEGO ZOO

The ghara, a bulbous growth on the tips of snouts of mature males, is used to amplify the hiss produced by compressing the underlying nostrils.

involve the local communities in conservation, and that has been the key failure in securing the future of the species in nature. In 1997–1998, monitoring exercises by the forest departments of Madhya Pradesh, Rajasthan, and Uttar Pradesh located over 1,200 gharials and over 75 nests in NCS — but no surveys occurred between 1999 and 2003.

By 2006, the inferred mature gharial population in India had plummeted to fewer than 200 adult individuals (Andrews 2006, Sharma and Basu 2004) and fewer than 35 adults in Nepal (Maskey 2006). The species is virtually extinct in Pakistan (Whitaker and Basu 1983), Bangladesh (Whitaker 1976, Khan 1979, Faizuddin 1983), and Bhutan (Singh 1991). Only two records for the species were recorded from Myanmar in 1927, and it is presumed to be extinct in that nation.

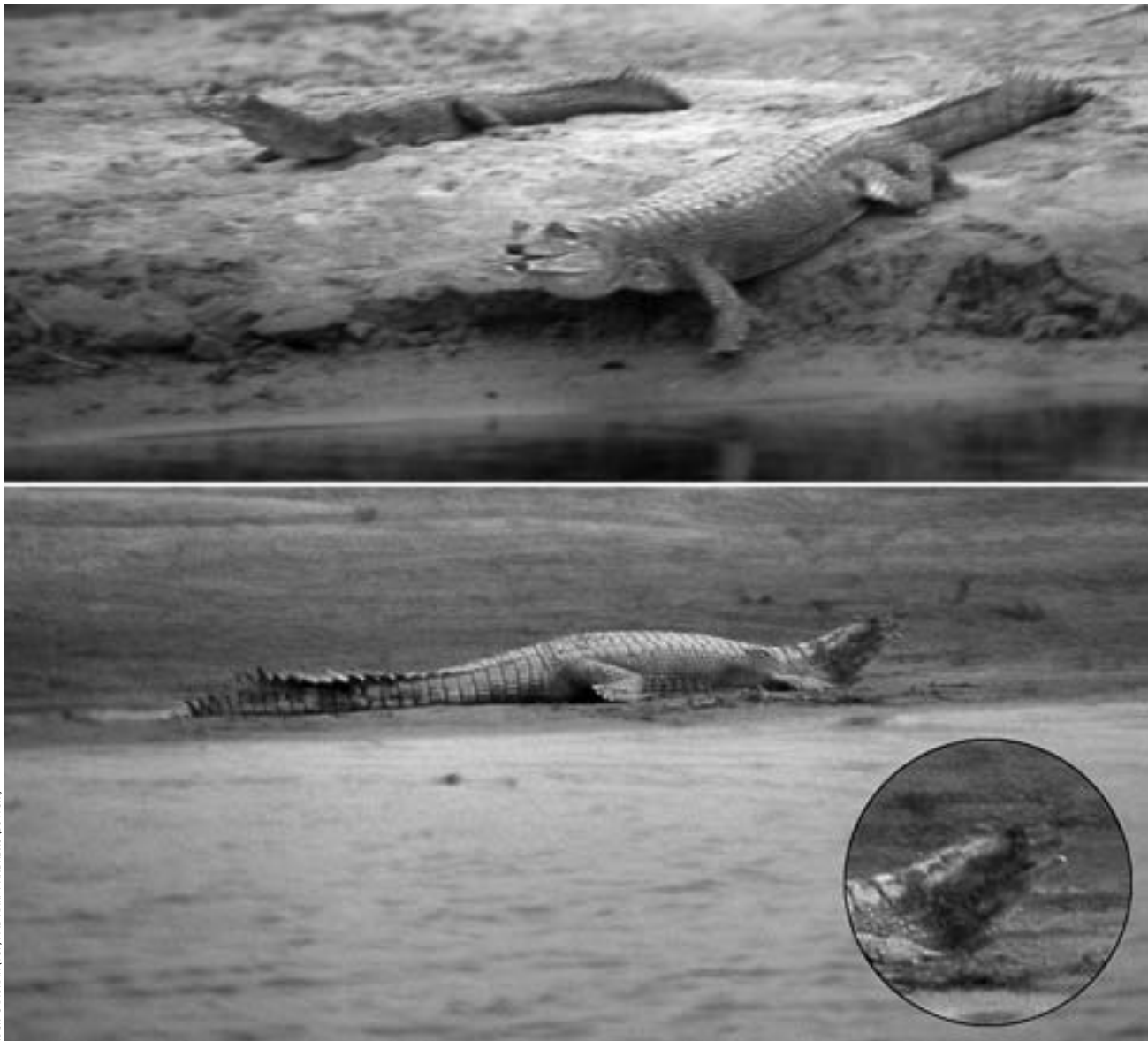
Reasons for Decline

The drastic decline in the Gharial population over the last 60 years (three Gharial generations) can be attributed to over-hunting for skins and trophies, egg-collection for consumption, killing for indigenous medicine, and killing by fishermen. In addition, dams, barrages, irrigation canals, siltation, changes in river course, artificial embankments, sand-mining, riparian agriculture, and land-use changes to accommodate domestic and feral livestock have combined to limit the range of Gharials as a consequence of excessive, irreversible loss of riverine habitat. These threats have not ceased, indeed have increased and continue to compromise the survival of the species. The misguided megaplan to interlink the major Indian rivers will be the final nail in the coffin. Gharial declines have gone hand-in-hand with declines of other riverine taxa once reportedly abundant and now endangered. These include the Ganges River Dolphin (*Platanista gangetica*), Smooth-coated Otter (*Lutrogale perspicillata*), and the Mugger



ROD WHITAKER

Illegal sand-mining operations have contributed to the irreversible loss of Gharial habitat at the National Chambal Sanctuary.



RAJIV CHAUHAN (TOP) AND HARRY ANDREWS (BOTTOM)

Fishermen, who illegally set nets in the National Chambal Sanctuary, will cut off Gharials' snouts, leaving them to starve.

Crocodile (*Crocodylus palustris*), in addition to numerous waterfowl and well-known game and edible fish species such as the

Mahseer (*Tor* sp.) and Hilsa (*Hilsa illisha*). GMTF is collaborating with WWF-India to form "Riverwatch," which will monitor all of these endangered river taxa.

Nest Counts

The mature Gharial population was estimated by using nest counts, as they are easily visible and counted at well-known locations that have been monitored for decades. This is likely to be an accurate assessment for numbers of mature animals, because of the unknown number of immature males that are routinely counted as "adults," before they grow a ghara at 12–15 years of age. Females reach sexual maturity when they are around seven years old and about 2.4–2.7 m in total length. Males do not mature until they are about 4 m in length at 15–18 years of age. Using the only published data on ratios of males in the mature Gharial population (14%) (Hussain 1999), we inferred that a proportion of all 'adults' reported in censuses are actually subadult males.



RAJIV CHAUHAN

Gharials quickly drown when they become enmeshed in illegal fishing nets at the National Chambal Sanctuary.



NICK BAKER

This female Gharial has a fishing net tangled around her snout. If she cannot rid herself of the net, she will slowly starve to death over a period as long as a year.

Breeding Populations

The Chambal River supports the largest breeding subpopulation and is the largest remaining Protected Area for Gharials, with an estimated 48% of the total population. The total number of nests found in the National Chambal Sanctuary in 2006 was 68. The other large breeding population of Gharials in India is in the Katerniaghat Wildlife Sanctuary (KWS), where 20 nests were found in 2006. The only other known breeding population in India is the Son River Sanctuary, where two nests were found in 2006 (for the first time in 30 years; Andrews 2006).

Since many female Gharials nest every year in captivity, the assumption that the above-cited nest counts indicate the presence of 90 reproducing female Gharial in India is reasonable. Consequently, the reported paucity of mature males (with their very conspicuous gharas) on the Chambal in the surveys of 2005 and 2006 and the resulting drastically low estimate of mature

males are likely to be accurate for that river (Andrews 2006, Rao, pers. comm.). However, a total of 20 nesting females and six mature males were counted in the KWS by independent observers in 2006 (B.C. Choudhury, H.V. Andrews, R. Whitaker, pers. obs.). The total inferred number of mature Gharials in the three remaining wild breeding subpopulations in India is therefore 107, based on observed nest numbers and inferred numbers of mature males.

Other Subpopulations

Two other small, non-reproducing populations of Gharials are known to exist in India (Ken River in Madhya Pradesh and Mahanadi River in Orissa). These have been supplemented by the reintroduction of captive-bred stock (as in all present Gharial locations). A few scattered Gharials may also remain in the Brahmaputra River of northeastern India, but confirmed sightings date to 1993 (Choudhury 1997). These other subpopulations in India contain a total estimated 40 mature animals (no mature males nor any breeding have been reported). The Gharial is undoubtedly extinct in the Indus (Pakistan/India) and Irrawady (Myanmar) river systems.



F. WILLIAM ZEIGLER



SUSHANT DEY, DOLPHIN CONSERVATION PROJECT

Gharial declines have gone hand-in-hand with declines of other riverine taxa, such as the Ganges River Dolphin (*Platanista gangetica*, above) and the Mugger Crocodile (*Crocodylus palustris*, top right). The latter was photographed at the Katerniaghat Sanctuary along one of the Ganges River tributaries.



MATT VAUGHAN, FORT WORTH ZOO

Sexual dimorphism in Gharials is readily apparent. Only males develop the protuberance at the tip of the snout, the “ghara,” from which the species derives its name.



DON BOYER, SAN DIEGO ZOO

Gharials have been successfully bred in captivity; this group of hatchlings were produced at Kukrail, India.



COLIN STEVENSON

A captive Gharial from St. Augustine's in Florida.

U.S. Institutions with Gharials

Busch Gardens, Tampa
 Cleveland Metroparks
 Ft. Worth Zoo
 Honolulu Zoo
 National Zoo, Washington, DC
 St. Augustine Alligator Farm
 San Antonio Zoo
 San Diego Zoo

U.S. Efforts to Aid Gharial Conservation

Although the critical work to protect Gharials from extinction in the wild is most needed in their native habitat, zoos in the United States support these efforts wherever possible. In 2004, the Cleveland Zoo and the San Diego Zoo started a fund to help support *in-situ* conservation. Since then, the two zoos have contributed \$26,000 to the Gharial Multi-Task Force (GMTF). These funds are used for Gharial surveys, ongoing monitoring of known populations, and operational expenditures by the local associates of the GMTF. Although they do not keep Gharials, the Dallas Zoo recognized the precarious position of the wild population and recently joined in contributing to the fund. A plea has been extended to other AZA institutions to contribute to this important endeavor.

Another objective is to create a self-sustaining population to serve as a genetic reservoir for the species. To accomplish this, the current U.S. population of 21 animals would have to be supplemented by captive-reared animals from India. Although no Gharials have been born in captivity in the United States (possibly due to the fact that the potential breeders have yet to reach sexual maturity), over 4,500 animals have been raised in captivity and returned to the wild in India, proving that a self-sustaining captive population is attainable.

A self-sustaining population of Gharials in the United States would have the additional benefit of increasing the number of institutions that keep these alluring animals. This would help to raise awareness and funds for Gharial conservation and create a broader base of support for pressuring the Indian and other governments to act decisively to protect Gharials in the wild.

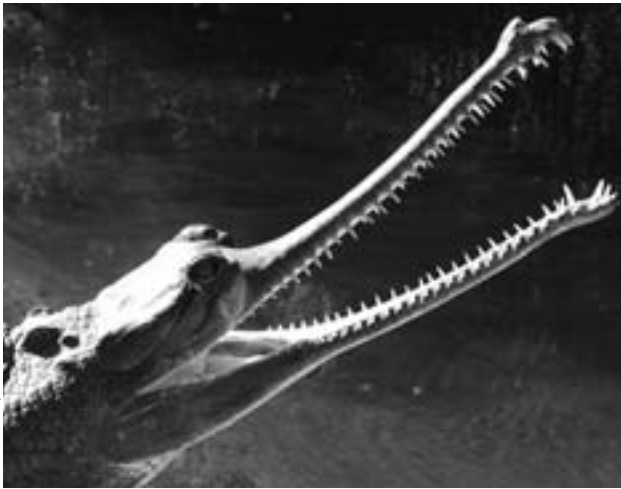
Also, the actions of some conservation organizations that focus on species other than Gharials have contributed to their conservation. One example is the Turtle Survival Alliance. This coalition of zoos, institutions, and individuals with divisions in the United States, Europe, and Austral-Asia, supports the protection of critical habitat for turtles such as the Red-crowned Roofed Turtle (*Kachuga kachuga*), which is sympatric with Gharials in part of their range. Asian turtles and Gharials both are faced with the threats of habitat destruction, poaching, and high mortality due to illegal fish-netting practices. While the alliance focuses on turtles, other endangered species, such as Gharials and the Indus River Dolphin, benefit from efforts to protect habitat and enforce laws that protect wildlife.

Lee Pagni and Don Boyer
 Zoological Society of San Diego



MATT VAUGHAN, FORT WORTH ZOO

The proportionally shorter snout and large ghara are apparent in this adult male.



MATT VAUGHAN, FORT WORTH ZOO

One hundred and ten sharp teeth line the slender snouts of Gharials.

Gharials in Nepal

Six nests were counted in 2006 in Nepal in Chitawan National Park (Rapti/Narayani River) and three other small, non-reproducing subpopulations are known (Kosi, Karnali, and Babai rivers). The total number of mature Gharials in all subpopulations in Nepal is inferred to be 35 animals (Maskey 1999, pers. comm.).

How Many Gharials?

Unless additional research tells us otherwise, we have to assume that the maximum number of wild, mature Gharials across the entire remaining range of the species (presently only India and Nepal) is 182 in about eight non-contiguous, fragmented habitats.

Gharial Declines in the Past Decade

In 1997, the peak year with the highest numbers of wild mature Gharials and nests recorded in the last 30 years, 226 mature animals and 81 nests were recorded in the Chambal (Sharma and Basu 2004). Although no nests were found in the Son, about 10 mature individuals occurred there. We had no nest data for Katerniaghat, where an estimated 30 mature animals were present. No nesting data from Nepal exist for this period, with an estimated 36 mature Gharials reported (Maskey 1999).

Based on the available data (Sharma and Basu 2004, Maskey 1999) and adding the 2006 estimated numbers of non-breeding mature animals (in small subpopulations outside the three Indian and one Nepali breeding subpopulations — a total of 40 animals), the estimated total mature Gharial population throughout its present range (India and Nepal) in 1997 was 342.

The decline from an estimated 342 adult Gharials in 1997 to 182 in 2006 represents a 47% decline across the species' range. This drastic decline occurred within a period of nine years, well within the span of one generation, qualifying the Gharial, under criterion C1 of the IUCN Red List, to be listed as Critically Endangered, although the current status is listed as endangered (Crocodile Specialist Group 1996).

Present Distribution of the Gharial

The total extent of occurrence of the Gharial was once on the order of about 20,000 km² (including suitable areas of the Indus, Ganges, Brahmaputra, and Irrawady river systems). Rao and Singh (1995) reported a figure of 2,986 km² (in India). In Nepal, the total area of occupancy is now under 100 km², whereas it once could have been close to 1,000 km² (Maskey, pers. comm.). Current total area occupied in India and Nepal is less than 250 km², based on river length x width and occurrence of Gharials within Protected Areas.

Table 2. Adult Gharial estimated population reduction within one generation.

Subpopulation	Past	Present	Estimated Decline in One Generation
Chambal	226 (1997)	78 (2006) 68F/10M	65%
Katerniaghat	30 (1997)	26 (2006) 20F/6M	13%
Son	10 (1997)	3 (2006)	66%
Others (India)	50 (2003)	40 (2006)	20%
Chitawan (Nepal)	20 (1999)	8 (2006)	80%
Others (Nepal)	100 (1994)	27 (2006)	73%
Totals	436	182	58%

Table 3. Rivers in India and Nepal with suitable habitat harboring breeding and non-breeding Gharial populations (habitat length x width = square kilometers of habitat; 0.3 km refers to overall average river width of 300 m). Total Gharial habitat (with Gharials) remaining in India and Nepal in 2006 is 240 km².

India

Chambal (National Chambal Sanctuary)	425 x 0.3 km = 128.0 km ²
Girwa (Katarniaghat Wildlife Sanctuary)	5 x 0.3 km = 1.5 km ²
Ken (Ken Gharial Sanctuary)	45 x 0.3 km = 13.5 km ²
Son (Son River Sanctuary)	200 x 0.3 km = 60.0 km ²
Mahanadi (Satkosia Gorge Wildlife Sanctuary)	14 x 0.3 km = 4.2 km ²
Ramganga (Corbett National Park)	20 x 0.3 km = 6.0 km ²

Nepal

Rapti/Narayani (Chitawan National Park)	60 x 0.3 km = 18.0 km ²
Karnali (Royal Bardia National Park)	10 x 0.3 km = 3.0 km ²
Babai (Royal Bardia National Park)	10 x 0.3 km = 3.0 km ²
Kosi	10 x 0.3 km = 3.0 km ²

Summary of Gharial Restocking Programs

One perspective suggests that little has been accomplished other than throwing over 5,000 juvenile Gharials into largely inhospitable habitats in Indian and Nepali rivers and leaving them to their fate. Little was done to secure the habitat. Banned from fishing in sanctuaries created for Gharials, local communities were not offered alternative employment. Combined with the lack of enforcement, Gharials are at the mercy of embittered and disempowered local people.

In Chitawan National Park (Nepal), where 457 Gharials were released, 16 nests were counted in 1977 and only six in 2006. Reintroduction was not successful there (although one argument states that at least total extinction was averted by supplementation). The principal reasons for failure was growing and uncontrolled anthropogenic pressures, including the depletion of fish resources.

In the Girwa River (Katarniaghat Sanctuary), where 909 Gharials were released (including 112 in 2006), four nests were recorded in 1977 and 20 in 2006, so 16 nesting females (2% of the total pre-2006 releases) comprised the result of 30 years of reintroductions. This seemingly poor achievement, considering the money and effort spent, suggests that enforcement is the key to Gharial survival (although some argue that the carrying capacity may have been reached).

In the third and most important remaining Gharial breeding habitat, the Chambal River (the tri-state National Chambal Sanctuary), where 3,552 Gharials were released (Whitaker and Andrews 2003) (plus 224 in 2006), 12 nests were recorded in 1978 and 68 in 2006. While nesting has apparently increased by over 500%, these recruited mature, reproducing females represent only about 2% of the total number released. The linear, riverine habitat of the Gharial presents a potentially insurmountable challenge with annual monsoonal flooding, when the newly hatched young are especially prone to being flushed downstream and out of the Protected Areas.



Large scales are used to weigh Gharials prior to release.



Animals are measured and scales are removed for individual identification prior to release.



Thousands of Gharials were hatched and raised in captivity before being released into the wild. Only a small number is thought to have survived.



Nursery facilities at Kasara Gharial Breeding Center (Royal Chitwan National Park, Nepal). Dr. Antoine Cadi (Noé Conservation) and Dr. Samuel Martin (SOS Crocodiles) check the hatchlings.



OLIVIER BORN

Hatchling Gharials are weighed and individually marked before release into the Narayani River, a tributary of the Ganges River.

With recruitment or retention of reintroduced Gharials (plus natural recruitment) over the last 30 years as low as 0.02% (Mahanadi River, Orissa) and averaging 3–10% elsewhere, the entire reintroduction strategy needs to reassessed. Scarce conservation funds and human resources need to be focused on habitat assessments, studies of Gharial ‘migration,’ fisheries assessment/enhancement, and conflict mitigation. The latter, basically recruiting support of the river people, may be particularly critical if we are to improve the survival odds of Gharial in their few remaining refuges. However, the four sites where Gharials are still breeding all had residual populations when the restocking programs began. Nowhere has restocking re-established a viable Gharial population.

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The Situation is Not Futile

Follow these three “-fuses” to help save the Gharial: **Infuse** yourself with more information. Learn more about Gharials (www.nationalzoo.si.edu, www.flmnh.ufl.edu/cnhc/csp_ggan.htm, www.ircf.org, www.gavialis.org). To stay current, sign up to receive updates from the Gharial Multi-Task Force through IRCF. **Diffuse** what you learn to your friends. A colleague recently saw a Gharial while touring India, but had no idea they were so close to extinction. Make sure everyone you know realizes that we are close to losing the few Gharials remaining in the wild. **Effuse** cash to funds that support Gharial conservation. The IRCF website allows you to donate online with 100% of the funds going directly to the Gharial Multi-Task Force. You also can support other conservation funds that protect Asian turtles, Indus River Dolphins, and even tigers, because all of them need the same riparian habitat as Gharials.

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