

Population Status and Distribution of Gharial (*Gavialis gangeticus*) in Nepal

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Abstract

Gharial (Gavialis gangeticus), biological treasure of the Indian subcontinent now restricts its existence in few big river systems of India and Nepal only. Innumerable threats posed to Gharial and its natural habitat led to extinction of the species from Bhutan, Burma and Pakistan and almost extinct from Bangladesh. Despite of the concerted Gharial conservation effort of Nepal and India since mid-twentieth century, the species finds its status as Critically Endangered on the IUCN 2007 Red list. Realizing the fact that a basic step in any conservation plan involving mega herpetofauna is to estimate its population status and structure and its geographic distribution, Department of National Parks and Wildlife Conservation (DNPWC) and World Wildlife Fund (WWF) Nepal held Gharial census on January-February 2008. The census estimated a total of 81 Gharials in Nepal. Out of total Gharial recorded during the census, 70 Gharials were recorded through direct sighting while 11 were based on indirect observations. Factors responsible for decreasing Gharial population were flood and dam construction, habitat destruction and decline in food quality & quantity. Over fishing, use of gill nets and river poisoning adversely affected the quality and quantity of fishes that serve as main food for Gharial. Contradictory to the past findings decreasing Gharial population was not attributed to the illegal egg collection and poaching of male Gharial for "Ghara". Deliberate killing was only found to take place in case the animal got entrapped in fishing nets. We conclude that Gharial should receive high conservation priority in future too. Efforts to restore the population through artificial breeding have much to do for maintaining present population. However, declining population, despite of several Gharial releases, should be addressed through more detailed scientific study. Census should be based on direct sighting through extensive field observation. Gharial release should precede scientific field study for assessing habitat suitability and follow with intensive monitoring program. The emphasis should be given for preparing specific Gharial Conservation Action Plan for regulating conservation activities to help conserve Gharial in Nepal.

भारतीय उप-महाद्विपमा पाइने घडियाल गोही हाल नेपाल र भारतका केही ठूला नदीहरूमा मात्र सिमित हुन पुगेको छ । घडियाल र यसको प्राकृतिक वासस्थानमा परेका विभिन्न जोखिमहरूका कारण भूटान, म्यानमार र पाकिस्तानबाट यो गोही लोप भैसकेको छ भने बंगलादेशबाट लोप हुँदैछ । विसौ शताब्दीको मध्यबाट घडियाल संरक्षणका प्रयासहरू गरिदै आएको भएतापनि हाल यो गोही विश्व संरक्षण संघको अति संकटापन्न वन्यजन्तुको सूचिमा रहेको छ । कुनै पनि जनावरको संरक्षणको लागि सर्वप्रथम वर्तमान अवस्था र वितरण क्षेत्रको बारेमा जानकारी हुन आवश्यक पर्दछ । त्यसैले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग र डब्लु डब्लु एफ नेपालले २०६५ साल पौष र माघ महिनामा नेपालमा घडियाल गोहीको अध्ययन गरेको थियो । अध्ययनबाट नेपालको कोशी, राप्ती, नारायणी, ववई र कर्णाली नदीमा गरी जम्मा ८१ वटा घडियाल गोही फेला परेका थिए । जसमध्ये ७० वटा प्रत्यक्ष गणना गरिएको थियो भने बाँकी ११ वटा अप्रत्यक्ष विधिबाट अनुमान गरिएको थियो । नदीमा आउने बाढी, बाँध निर्माण तथा वासस्थान विनास एवं आहारा प्रजातीको मात्रा र गुणस्तरमा आउने

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ह्रास आदि कारणहरूले गर्दा प्राकृतिक वासस्थानमा घडियालको संख्या घट्दै गइरहेको छ। अत्याधिक माछा मार्ने, जालको प्रयोग गर्ने, विष हाल्ने कार्यहरूले घडियालको मुख्य आहारा माछालाई नकारात्मक प्रभाव पारेको छ। पूर्ववत् रूपमा उल्लेख गरिए जस्तो २०६५ को अध्ययनबाट अवैध रूपमा हुने घडियालको अण्डा संकलन र घाराको लागि भाले घडियाल मार्ने गरेको पाइएन। घडियाल गोहीको संरक्षणलाई भविष्यमा उच्च प्राथमिकता दिइनुपर्ने, कृत्रिम प्रजननबाट यसको संख्या बढाउने कार्यक्रमले निरन्तरता पाउनुपर्ने, घडियाल प्रजनन केन्द्रबाट छोडिएका गोहीको विस्तृत अध्ययन गरिनुपर्ने, गणना प्रत्यक्ष विधिबाट नियमित रूपमा हुनुपर्ने आवश्यकता छ भने घडियाल संरक्षण कार्ययोजना तर्जुमा गरी संरक्षण र व्यवस्थापनका कार्यक्रमहरूमा थप जोड दिनु जरुरी भएको छ।

Key Words: Gharial conservation, Population status, Captive breeding, Threats

Background

Habitat loss, land cover change, over exploitation, alien species, infectious diseases and even global climate change are all recognized causes of herpetofaunal diversity decline (Alford et al., 2001; Collins and Storfer 2003; Cushman 2006; Goode et al., 2004). Even though these processes are continuously taking place all over the world. Thus, a basic step in any conservation plan involving mega herpetofauna is to estimate its population status and structure and its geographic distribution.

Despite many conservation efforts, wild population of *Gravialis gangeticus* is in declining state. The situation is very critical that *G. gangeticus* is the first crocodilian species to be re-categorized as *Critically Endangered* in the 2007 IUCN Red List. In the first half of the 20th Century, the Gharial was common throughout its range, with an inferred population in the 1940s of between 5,000 to 10,000 (Whitekar et al., 1974). By 1970, however, it was apparent that the Gharial was in serious decline and this prompted scientific surveys to determine the extent of the problem. In fact, the Gharial probably would be on the verge of extinction if proper attention on Gharial conservation program were not implemented in India (Bustard, 1979) and Nepal (Maskey and Mishra, 1982) in 1970s and 80s. Fortunately, there has been some recovery through conservation programs, and a reasonable amount of hope lies with the conservation and management programs which are now in place. Full protection was granted in the 1970s in the hope of reducing poaching losses, although these measures were slow to be implemented at first.

Ecology of Gharial

The Gharial is the only surviving member of a once well represented family, Gavialidae (Maskey, 1989). It mostly inhabits large bodied, deep fast-flowing rivers in the plains (Shah and Tiwari, 2004). The species is characterized by its long and slender snout. Its name has been derived from the large, cartilaginous protuberance on the end of the adult male's snout resembling to a *Ghara* or earthenware pot common in India and Nepal (Smith, 1931).

The Gharial is unique as it is the only crocodilian which is sexually dimorphic (males look obviously different from females). They have short legs and spend most of their time in the

water. Adults feed primarily on fish for which jaws and interlocking set of 27-29 undifferentiated teeth on each side of upper jaw and 25-26 teeth in the lower jaw (Shah and Tiwari, 2004) have adapted perfectly for holding struggling prey (CSG, 2000). The thin shape gives the snout low resistance under water, which is suited to fast lateral snatching movements under water.

Usually Gharials will not reach sexual maturity before 13 years for the male and 16 years for the female, when they are nearly three meter in length (Maskey and

Mishra, 1981; Bustard, 1984; Singh, 1999; Whitaker, 1987). One male will guard a harem of several females and will mate with all of them. The mating period occurs for two months during November, December and into January, while nesting happens in March, April and May (Whitaker, 1983). Nesting is done during the dry season in holes excavated in river sandbanks (Whitaker and Basu, 1983; Groombridge, 1987; Bustard, 1980).

The breeding life of Gharial is considered to be 50 years and the life span 100 years (Whitaker and Basu, 1983; Singh, 1999). Individuals less than 0.6 meter long are considered hatchlings, 0.6 to 0.9 meter are yearlings, between 0.9 to 2.7 meter are sub adults and those larger than 2.7 meter are considered adults (Hussain, 1999). Breeding females may lay eggs from 14 to 62 in numbers in one clutch (Maskey, 1989). In the wild, the survival rate of young hatchings is not more than one percent (Singh, 1978; Murthy and Menon, 1977; Roy et al., 1982). As all reptiles, Gharials practice a thermo taxis activity (basking) catching sun-ray, upon which their energy depends. Beaches, next to clean and deep water, are the preferred habitat of Gharials (Maskey et al., 1995).

Gharials bask on the sand banks for long periods during the winter when water temperatures and water level is low. Whitaker et al. (1974) remarked on the Gharial's predictable habit of returning to the same spot every day for basking, which contributes to their vulnerability to poaching. Sand banks for both basking and nesting are important habitats for Gharial survival. The highest densities of Gharial in the Narayani were observed in areas where the maximum occurrence of sand banks and deep channels were available. In winter, Gharials appear to spend most of their time basking and less time feeding, presumably to avoid the coldness of the water. In contrast, in summer, they spent most of their time in water to avoid the heat of the day. Thermoregulation and dietary needs appear to be important factors in determining their use of sand banks (Maskey, 1989).

Photo 1: Female Gharial in Karnali River at Laguna Machan



Source: Thapaliya, B.P., 2008

Gharial distribution

Gharial once inhabited most of the river systems of the Indian sub-continent. Its range extended throughout the gangetic plain, West to the Indus River in Pakistan, North and Northeast to Nepal and Bhutan, East to Myanmar and South to Orissa in India (Neill, 1971). The major river systems occupied by the Gharial included the Indus in Pakistan; the Mahanadi, Chambal, Brahmani and Bhima of India; the Ganges and its tributaries of India, Nepal and Bangladesh (Neill, 1971; Whitaker et al., 1974; Behura and Singh, 1978). It was also reported to occur abundantly in the Jamuna River in Uttar Pradesh, India (Hornaday, 1885) and the Koshi River (Short, 1921). In Myanmar, it was recorded from the Maingtha River, a part of Irrawady River and Kaladan River (Smith, 1931).

The Gharial population plummeted due to organized hunting for skin in the 1950s and 1960s in very short time (Whitaker, 1987) leading to few scattered and isolated population in India, Nepal, Pakistan and Bangladesh (Behura and Singh, 1978). Gharial is now considered to be confined within the river systems of the Brahmaputra (India and Bhutan), the Indus (Pakistan), the Ganges (India and Nepal) and the Mahanadi (India) with small populations in the Kaladan and the Irrawady in Myanmar (CSG, 2007). In Nepal, the species inhabited Koshi, Kali Gandaki, Narayani, Rapti, Karnali and Babai River systems. Maskey (1984) reported extinction of Gharial from Koshi River of Nepal and later in 2008, census conducted in 38.9 km stretch of Koshi river from Chatara to Koshi Barrage could not detect any Gharial and their signs (DNPWC, 2008).

Gharial conservation initiatives

From the early 20th century till 1940s, Gharial population was reported to be around 5000 – 10000 individuals (Whitaker et al., 1974). Indian sub-continent suffered rapid decline in Gharial population thereafter where Western Europe realized stabilization of herpetofaunal decline in 1960s (Houlahan et al. 2000). Uncontrolled exploitation of the species and rapid habitat loss in Asia dropped down its population to 150 – 200 animals during the early 1970s (Singh, 1978; Das, 1981; Whitaker, 1987; Groombridge, 1987; Maskey, 1989). The first working meeting of crocodile specialists at Bronx Zoo, New York held in March 1971 expressed major concern over the extinction of this animal (Das, 1981).

In 1973, India and Nepal both listed this animal as protected species in their legislation and thereby provided adequate legal protection. Simultaneously, Indian government started captive breeding program with the help of FAO and UNDP. The species was literally brought back from the brink of extinction by this restocking program. Till date, over 3,000 juveniles reared in six breeding centers have been released in 12 different rivers. Among them, the major release program was done in Chambal River, where 1,718 individuals were released during the period of 1979-1993 (Ross, 1998).

Nepal started captive breeding program of Gharial in 1978 with the support of Frankfurt Zoological Society. This programme aimed at rehabilitating the wild population through egg collection, captive rearing and release of young into river systems within the protected areas. At present there are two breeding centers in operation in Nepal (Chitwan National Park and Bardia National Park). Till now, 691 individuals have been released in the Narayani River and other different major river system of Nepal such as Rapti, Koshi, Karnali, Babai etc. (Andrews and Mc Eachern, 1994 and DNPWC, 2008).

Studies of Gharial in Nepal

Gharial monitoring has been conducted periodically by the Department of National Parks and Wildlife Conservation in collaboration with partner organizations. Gharial and its habitat study have been carried out by different workers (Maskey, 1989; Maskey, 1998; Mishra, 2002; Ballouard and Cadi, 2005 and Pandit, 2007) for varied purposes complementing the conservation effort of Nepal to save the species from extinction.

Pandit (2007) monitored Gharial in Shikaruli – Amaltari and Amaltari – Triveni sections of the Narayani River and recorded 19 individuals. The counting based on direct sighting in Sunachuri – Kasara and Kasara – Rapti Narayani confluence sections of Rapti River resulted 20 individuals. Far more sightings of female compared to male Gharials resulted in Sex ratio of 1 Male: 9 Female from the monitoring.

Mishra (2002) recorded 12 individuals in Chitwan National Park between Sauraha and Kasaraghat in the Rapti River and estimated minimum 50 Gharials in the Narayani River on the basis of park staff information. In Bardia National Park, 8 individuals were directly observed in the sample segments of Karnali and Babai Rivers and 28 more animals were added in estimation through interview from concerned people (Mishra, 2002)

Maskey (1998) reported a minimum of 55 wild Gharials and 50 released Gharials surviving in Narayani, Kali Gandaki, Karnali and Babai River system. A field study in 1997 showed a decreasing population status and a distorted sex ratio of Gharial in Nepal (Mishra, 2002). The sex ratio of male to female in the wild was estimated at 1:6 in 1984, whereas this had increased to 1:9 in 1987 and 1:10 during 1997. The low number of male was attributed to heavy poaching of males (Maskey, 1998), because local people believe in various mystical power of the "*Ghara*" of males found in their snouts (Maskey and Mishra, 1981).

Ballouard et al. (2005) counted 49 individuals in December of 2005 which was the highest number compared to the similar census done in 2003 and 2004 that resulted 38 and 34 individuals respectively in Chitwan population.

Department of National Parks and Wildlife Conservation (DNPWC) and WWF Nepal conducted Gharial census on January-February 2008 that estimated a total of 81 Gharials in Nepal. Out of total Gharial recorded during the census, 70 were directly recorded and 11 were based on indirect counts (DNPWC, 2008).

Population status

Ghrial population trend in Nepal was difficult to predict because of periodic releases and irregular monitoring and recording system. Moreover, censuses carried out in the past had adopted different techniques of population estimation. Lack of uniform monitoring or census techniques rendered the census results incompatible for comparison. However, the information of Ghrial population in the past years (Table 1) has been presented for general comparison with the present census result.

Table 1: Distribution of Ghrial population in Nepal

Year	Karnali	Babai	West Rapti	East Rapti	Narayani/Kali Gandaki	Koshi	Total
1976	6	6	NA	NA	NA	NA	
1977	NA	NA	NA	NA	58	NA	
1978/79	10	NA	NA	NA	NA	NA	
1980	NA	NA	NA	NA	53	NA	
1983	NA	NA	NA	NA	60	NA	
1984	NA	NA	NA	NA	57	NA	
1985	NA	NA	NA	NA	NA	NA	
1986	NA	NA	NA	NA	56	NA	
1987	9	7	3	NA	51	NA	
1992*	7	37 (7+30)	NA	NA	100 (40+60)	4	148
1993	NA	NA	NA	NA	NA	NA	128
1997/98**	17	25	2	NA	57 (36+21)	4	105
2002***	4+2	30	NA	12	50-55		96-103
2008#	6	10	NA	24	41		81

Source: Maskey, 1989; Maskey, 1998 and Mishra, 2002, DNPWC Field Survey 2008

* In 1992 there were 7 wild and 30 released Ghrials in Babai River and in Narayani/Kali Gandaki 40 wild and 60 released Ghrials recorded.

** In 1997/98 there were 36 wild and 21 released Ghrials in Narayani.

*** In 2002, river sections were sampled and 4 Ghrials in Karnali and 12 Ghrials in Rapti were sighted. Similarly, in Babai 30 Ghrials were guess estimates by the park staff and in Narayani/Kali Gandaki 50-55 Ghrials were guess estimates

In 2008, No guess estimates were included for population estimation.

We tested population of Ghrials in different river systems and in different years using Minitab ver 13.0. The general linear model constructed with data in table 1 (NA- were considered as 0 and number of recently released animals were excluded from the analysis) shows that there is significant difference in number of individuals in different river systems (f statistic =

40.43, P=0.00). However, Analysis of Variance (ANOVA) carried out for population of Gharials in different census years show that there is no significant difference (F statistic= 0.03, P= 0.998) in number of animals from 1976 to 2008.

Table 2: Gharials released in different river systems of Nepal

Number of Gharials released after breeding in captivity								
S.N.	Release Year	Narayani	Rapti	Kali Gandaki	Sapta Koshi	Karnali	Babai	Total
1	1981	50	0	0	0	0	0	50
2	1982	50	0	0	0	0	0	50
3	1983	25	0	35	42	0	0	102
4	1984	15	0	0	0	0	0	15
5	1985	0	5	0	0	0	0	5
6	1986	0	0	0	43	0	0	43
7	1987	43	0	0	0	0	0	43
8	1988	0	0	0	0	0	0	0
9	1989	0	0	0	0	0	0	0
10	1990	25	0	0	0	0	30	55
11	1991	0	0	0	0	0	20	20
12	1992	38	0	0	0	20	0	58
13	1993	5	0	0	0	0	0	5
14	1994	0	0	0	0	0	0	0
15	1995	27	0	0	0	3	0	30
16	1996	19	0	0	0	0	0	19
17	1997	10	0	0	0	0	0	10
18	1998	15	5	0	0	0	0	20
19	1999	0	7	0	0	0	0	7
20	2000	7	0	0	0	0	0	7
21	2001	0	0	0	0	0	0	0
22	2002	10	0	0	0	0	0	10
23	2003	36	0	0	0	0	0	36
24	2004	0	20	0	0	0	0	20
25	2005	0	10	0	0	0	0	10
26	2006	0	20	0	0	0	0	20
27	2007	24	32	0	0	0	0	56
	Total	399	99	35	85	23	50	691

Source: DNPWC, 2008

Chi-square test of released number of animals and present population in different river systems ($\chi^2 = 31.015$, P= 0.00) reveals significant difference between the observed and expected data. Moreover, analysis of variance of counts, using adjusted sum of squares resulted

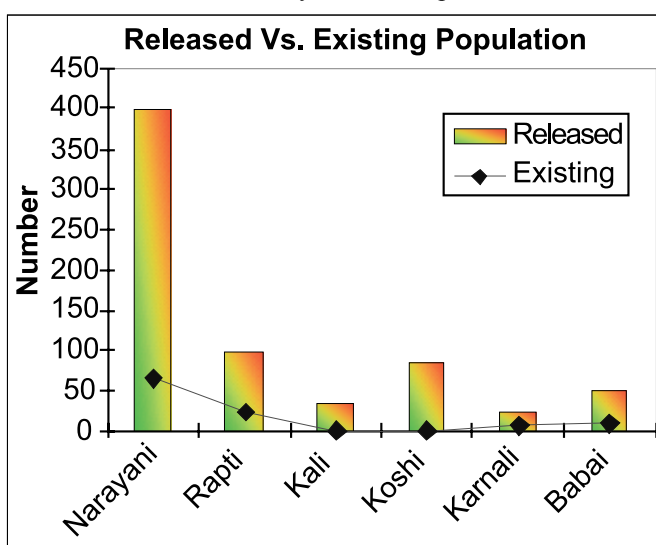
significant effect of released animals ($F = 13.35, P = 0.022$). The model validity was tested using normality of the residuals.

Factors affecting Gharial population

Various factors have significant role to play for determining the fate of Gharial in Nepal. The rate of fish catch is decreasing significantly in the river. This may indicate decreasing habitat quality but not solely responsible for Gharial extinction. Investigation

revealed that Koshi barrage is the main factor responsible for hindering two way movement of Gharial towards upstream once they travel beyond the dam. The dam also creates abnormal inundation during the monsoon that floods all the nests thereby hindering hatching from nests. Koshi river is very famous for its fish in Eastern Nepal. High demand of fish has encouraged commercial fishing in the river. Though fishing is regulated by issuing temporal permits to the

Figure 1: Graph showing the released vs existing pop. of Gharial in different river systems of Nepal



pro-poor community residing around the reserve that relies on fishing for their daily livelihood, it has not been properly enforced. Source: DNPWC, 2008 and field survey, 2008

around the reserve that relies on fishing for their daily livelihood, it has not been properly enforced.

Illegal collection of fishes and use of poison is also common in the area deteriorating the quantity of fish and quality of water as well. The stream characteristics of the Koshi River and pattern of regulating water flow through the barrage renders both winter and monsoon season unsuitable for Gharial.

Poaching of Gharials for their skin, male Gharials for their ghara and Gharial eggs for food or medicinal purpose are not reported. It is fortunate enough for Gharial, that when most of the wild creatures are becoming victim of humans, it is somewhat safe from human's evil intentions. However, disturbance through human activity, cattle grazing, over fishing, poisoning, use of *Mahajal* and gill nets, construction of dams for their ultimate use, habitat modification due to over exploitation of land and vegetation protecting Gharial's all contribute to the declining Gharial population in all Gharial habitat in Nepal.

Conclusion

Present total population of Gharial in Nepal is estimated to be 81 individuals as Chitwan population constitutes 65 individuals and Bardia population constitutes 16 Gharials. Koshi River lacks Gharial population at present. However, restoration program followed by intensive conservation and management activities could be helpful to colonize the habitat that seems suitable for supporting Gharial.

Captive breeding program has achieved significant success in rearing young and producing seed population for reintroducing or supplementing Gharials in different river systems of Nepal. The record of Gharial release after rearing in captivity shows that 691 Gharials have been released till date. Maintaining Gharial population through mere habitat management and other conservation initiatives might not suffice unless it is supplemented by captive reared animals.

Major constraints for Gharial conservation were identified to be habitat destruction and flood along with incidence of Gharial entrapment in fishing nets. Habitat destruction was attributed to decreasing fish population due to over fishing and poisoning, river pollution due to disposal of industrial wastes in the rivers and frequent change in river courses. The direct human influences such as illegal collection of eggs and Gharial poaching incidences were not regarded as threat for Gharial conservation as these were non-existent at present.

Regular monitoring is essential for updating the information on the status of Gharial. All monitoring should follow uniform study techniques to make scientific inferences and as far as possible all census should be based on direct observation. Indirect sightings should be validated by cross checking the information obtained before including it in to the population. Fishing should be regularized and regulation strictly enforced in all the Gharial habitats by the concerned authority. Local people should be motivated for Gharial conservation and due consideration should be given on people's basic livelihood requirements. Nepal's crocodile conservation efforts must be guided by species and habitat specific action plan.

Restocking Gharials in all the potential Gharial habitats should be continued for long term and in systematic manner. Frequency of release programs, site for releasing Gharials, season and number should be pre determined with adequate scientific justification of overall schedule and actions. Thus, future restocking should be determined by assessing the fate of previously released individuals.

Bilateral cooperation with India is essential to address the crocodile population loss to India from Nepal continuously. Most of the crocodile habitats in Nepal are contiguous with those in India. India has an effective crocodile conservation program and virtually India and Nepal are solely responsible for conservation of Gharial as these two countries only retain, though not self sustaining, Gharial population that gives hope to save Gharial from extinction. Hence, for saving Gharial from extinction mutual cooperation between India and Nepal should be highly emphasized.

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