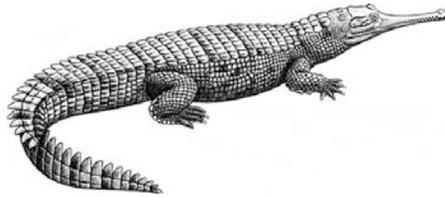




Gharial conservation In Royal Chitwan National Park, Nepal



Gharial Status, December 2005

J.M. Ballouard¹ and A. Cadi¹

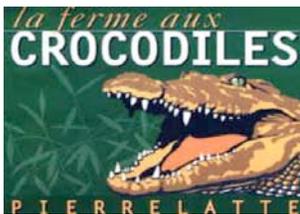
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1 INTRODUCTION

Gharial (*Gavialis gangeticus* Gmelin, 1789), the only survivor of the Gavialidae family (Maskey and Percival, 1994) was classified on the red list of IUCN in 1975 (Maskey, 1989). It is easy to distinguish from the others by its narrow snout. In spite of its wide distribution and its previous abundance, it is the least known of the 23 species in the world (Whitaker and Basus, 1983). Gharial is one of the seven of the most threatened crocodiles in the world, but there are conservation programmes nowadays. Previously occurring in the Indian sub-continent, including rivers of Pakistan, Burma, North India, Nepal and Bhutan, its population suddenly fell at the beginning of the seventies, due to human pressure. Hunting, habitat destruction, and competition for its only food source, fish, seem to be responsible for its disappearance (Maskey, 1989). At that time the estimated population was about 250 or 300 individuals in the entire Ganges (Grenard, 1991).

In Nepal, it used to be found in all major river systems; today the Gharial occurs only in main rivers such as the Karnali, Babai, Kali Gandaki, Narayani and Koshi, with minimal village settlements (Maskey, 1989) (figure1).

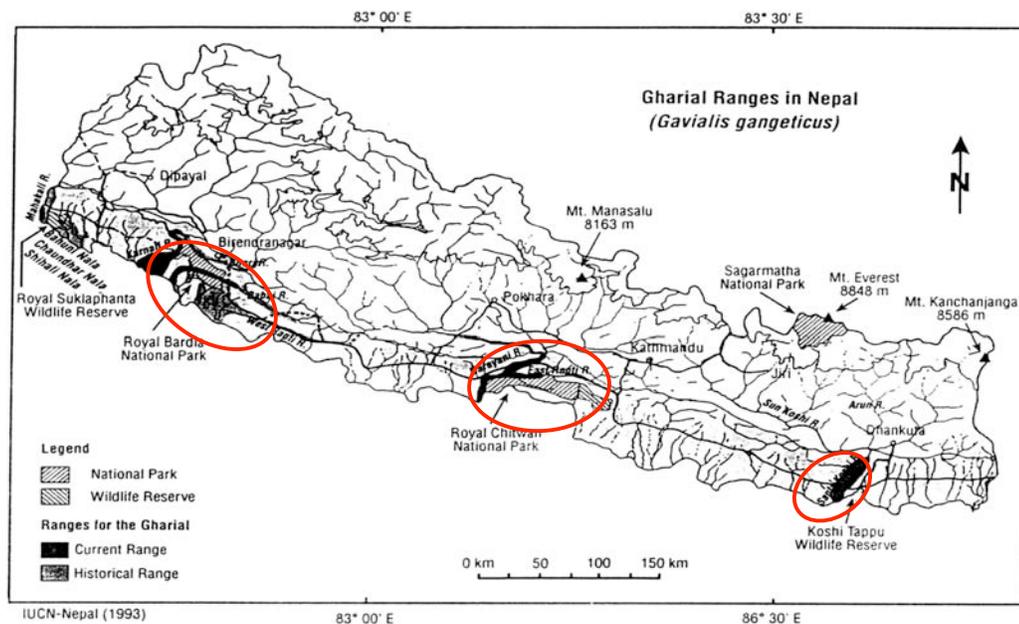


Figure1: Gharial distribution in Nepal: Royal Chitwan National Park (RCNP), Royal Bardia National Park and Koshi Tapu Wildlife Reserve.

Classed in subsidiary 1 of CITES (Convention on International Trade in Endangered Species) in 1975, the species has been saved by captive breeding programmes and reintroduction in India and Nepal.

In 1978, The Gharial Conservation Project in Royal Chitwan National Park was created in Nepal thanks to the Government. Since 1981, through this program, young gharials reared in captivity were introduced into their original environment and thus reinforced the wild population. Most of the Gharials were introduced into the Narayani and Rapti rivers inside Chitwan Park. These

combined programs restored the population to approximately one thousand individuals (Andrews and Mc Eachern, 1994).

However, in 1994, in spite of 432 young gharials having been reintroduced into Nepal's rivers, only 58 wild gharial and 75 reintroduced gharials were accounted for (Maskey and Percival, 1994). Up until 2001, in spite of young gharials being released every year, sightings were relatively infrequent.

In 2001, the collaboration with the Crocodile Farm of Pierrelatte (France) focused on saving the crocodile species. To determine the main difficulties of that reintroduction program, the gharials reintroduced in the Park were to be followed with an individual identification system and radio monitoring system (Cadi and al, 2002). Between 2003 and 2004, two successive teams of French research students studied the gharial population in the wild. During this period, recommendations concerning the release site and period of release were formulated (Priol and al, 2003). However, in 2003; in spite of 417 gharials having been released in Royal Chitwan National Park; only 40 of them have been counted and monitored. In 2004, population disturbance, fishing nets which kill the young gharial directly, water quality and a dam downriver from the Park have been identified as the main threats for the Gharial (Ballouard and al, 2004). With regards to the difficulties of establishing the young gharials inside Royal Chitwan National Park, one of the priorities to save the Gharial from extinction is to protect the captive group and improve breeding (op.cit, 2004; Cadi and al, 2005). The construction of a new facility at Kasara gharial breeding centre targeted this goal.

Knowledge of animal population status is the main factor in being able to make recommendations to improve the conservation of the species.

In this context, the goal of this census is to know the status of gharial in Chitwan, and assess the evolution of the population and its dynamics since 2003. This will confirm and identify the next measures required to protect the gharial population in Chitwan. These measures will be included in the protection of natural resources in the Terai Arc Landscape.

2 MATERIALS AND METHODS

2.1 Study area

RCNP (932 km² with an average altitude of 150 m above sea level) is situated in the Terai plains, in south central Nepal. The Park, which has a subtropical climate, extends from longitude 83°50' to 85°00' East and latitude 27°15' to 27°40' North. RCNP was established in 1973 and was listed in 1984 as a World Heritage Site by UNESCO for its varied biological resources and large number of endangered species (Mishra and al, 1991).

The two main rivers, Narayani and Rapti delineate the North and West borders. The Narayani, with a significant flow (1000-1700 m³/s in low water periods) has a hydraulic power which depends on the climate of the Himalayas. With its freezing temperature, this river flows directly from mountain sources to the Park where it slows down. The Rapti, with a low flow, is confined to the Terai's plain before entering the Park. It depends on local rains and has a warmer flow (Maskey, 1989).

The study area comprises 114 km of river and is situated on the Narayani (from Ratanpur where it divides into two channels, to Tribeni at the end of the Southern Park limit on the Indian border); and on the Rapti (from Sauhara (Bawanipur) to its confluence with the Narayani) (figure 2).

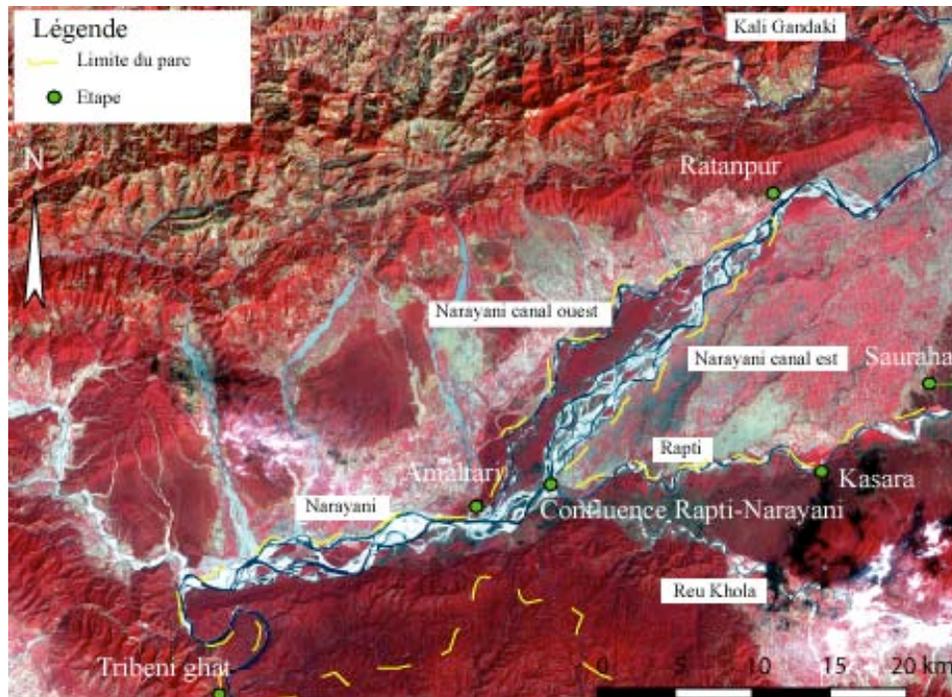


Figure 2: the study area (2001)

2.2 Species biology

Ghrial, essentially piscivorous is the most aquatic crocodile. With its long brawny tail, its narrow head and its long body, its aerodynamics are (increased) improved? in water. Young gharials can reach a length of one meter in eighteen months. Female maturity appears around ten years of age at a length of 2.6 meters. Males mature around 13 or 14 years at a length of 3 meters (Whitaker and Basu, 1983). The species is social; harems are constituted during the cold season (December, January), males are territorial (Grenard, 1991). During the hot season, just before the monsoon (March-April), females make a hole in a sandbank to lay 15 to 65 ovum. After 71 to 93 days of incubation, young gharials hatch in July just before the monsoon. Whitaker and Basu (1983) think that temperature is an important influence on determining gender. During the first year, a high mortality of 95 % is registered in natural areas (Rao and al, 1995). As all reptiles, gharials practice a thermotaxis activity (basking) catching sun rays, upon which their energy depends. Beaches, next to clean and deep water, are the preferred habitat of gharials (Maskey and al, 1995).

2.3 Sustainable strategy of Ghrial conservation

In the natural environment, less than one gharial out of a 100 reaches a length of two meters. Environmental disasters factors, like monsoons are the main causes of high mortality (Rao and al, 1995). In the RCNP the rest are destroyed during the heavy rain season because of the dam located to the South. To allow the young gharial to emerge, the eggs are taken out of the natural environment then incubated at the Ghrial Monitoring Centre. When the Ghrials reach a length of approximately two meters, they are released into their original environment to boost the population (Maskey and Percival, 1994). Currently, with four males and approximately 20 females

in the RCNP, approximately six nests annually are providing the Gharial Project with juveniles from the wild. Additionally, every year, the breeding gharials at Kasara farm have between five and eight nests. Since 1981, the Gharial have been released using the same method every year, most of the time in groups of 10 during the hot, dry season (March-April). The gharials are introduced into an enclosure for better adaptation, and leave the enclosure on their own. Thus, all the young gharials observed in the Park come from the Breeding Centre, as releasing young gharials has become the only method to improve the gharial distribution in Nepal (Maskey, 1989). To date, the Gharial Conservation Project has introduced 537 animals into Nepal, of which 457 were released in the RCNP (appendix 1). As of February 2006 the centre has 447 of them and has reached an historical record: two males and 12 breeding females, 154 one year olds and 196 hatchlings (table 1).

Table 1: Gharial status in the Kasara Breeding Centre in December 2005 and February 2006

gharial number		
date patch	1 December 05	1 February 06
78,79,80,91	14	14
2000	12	12
2000	12	12
96,97,2001	10	10
2001	14	14
2002	32	32
2003	3	3
2004	156	154
2005	207	196
TOTAL	460	447

Gharial borned from 1996 to 2001 are destined for the releasing. In 2002 and 2003 only 32 and 3 young gharials respectively come from nesting. This is due to the very low survival of the young gharials the first year. During the current year 2005, 11 babies died between December and February (Table 1).

2.4 Census

To take a census of the gharial population and estimate its structure along the 112 kms of river in the Park, monitoring was conducted once in December 2005 inside the Park. The study areas covering both rivers inside the Park were divided into five different sections (table 2 and figure 2).

2.4.1 Population status

According to Witaker and Basu (1983), Rao and al (1995), given the characteristics of the basking behaviour of the Gharial, for an optimal census, observation is done while these are basking during the day time, particularly in winter. During the day, the data is collected from one plastic kayak at the most convenient time depending on the season, from 10 a.m. to 4 p.m. in the cold season (November to February) and 8 a.m. to 2 p.m. in the hot season (March to May). These seasons correspond to the periods of high basking time (Priol et al, 2003).

Due to time constraints, this census didn't follow the same method as in 2003 and 2004. Previously, the census was done 7 times. However, this subsequent single census was completed by local survey (Park rangers, fishermen and nature guides).

Table 2: length of monitoring stages

River	Stage	Length (km)
Rapti river	Bawanipur-Kasara	17
	Kasara-Confluence Narayani-Rapti	21
Narayani river	Ratanpur-Amaltari, West channel	24
	Ratanpur-Amaltari, East channel	24
	Amaltari-Tribeni	28

One observer with (X 10) binoculars covers the whole of the area likely to host animals involved in basking activities. For each Gharial site, the status of the animal is estimated, distinguishing immatures from adults and identifying sex (this keeping in mind that the relation between the Size and the age is estimated according to literature standards) (Witaker and Basu, 1983):

- TL (Total Length) < 2.20 m (Immatures from the latest release)
- 2.20m < TL < 2.80 m (sub adult)
- TL > 2.80 m without ghara (mostly adult females or possibly male sub adults)
- TL > 2.80 m with ghara (adult males)

It is Important to note that the quality of the sexe and size estimation depend of factors like distance, light, weather conditions...

First, to ascertain the evolution of the population, as for 2003 and 2004 studies, we refer to "wild population" as the population minus the gharial released since 2002, despite the high probability that the population may come from releases effected since 1981 (Priol and al, 2003). On the other hand the gharial released since 2002 will be counted separately to ascertain their survival since 2002.

Status and evolution of the wild gharial population was studied in 2003, 2004 and 2005. It is important to note that one year is considered after each monsoon, started from October to April or May the year following.

Keeping in mind the high probability that an individual might not be counted by direct sightings or by survey observations, we shall reserve a minimum number.

2.4.2 Study of the released gharial

From March 2002 to date, 76 gharials have been released at different spots in the park. Before each release, so as to be able to visually recognize each gharial in its natural environment, numbered cattle marks identifying each individual were attached to a vertical scale of the tail. Additional notches guarantee a long term study of the animals (figure 3). In addition, 20 individuals were equipped with radio transmitters, 10 in March 2002 and 10 in November 2003 (table 2). From the beginning of the French global study in March 2002 study, the 56 gharials reintroduced until February 2004 will give us the estimate of young gharial survival inside the Park.

This study didn't include the additional 20 gharials released in November 2004 and April 2005 (table 3).

Figure 3: mark on scales with notches and cattle marks.

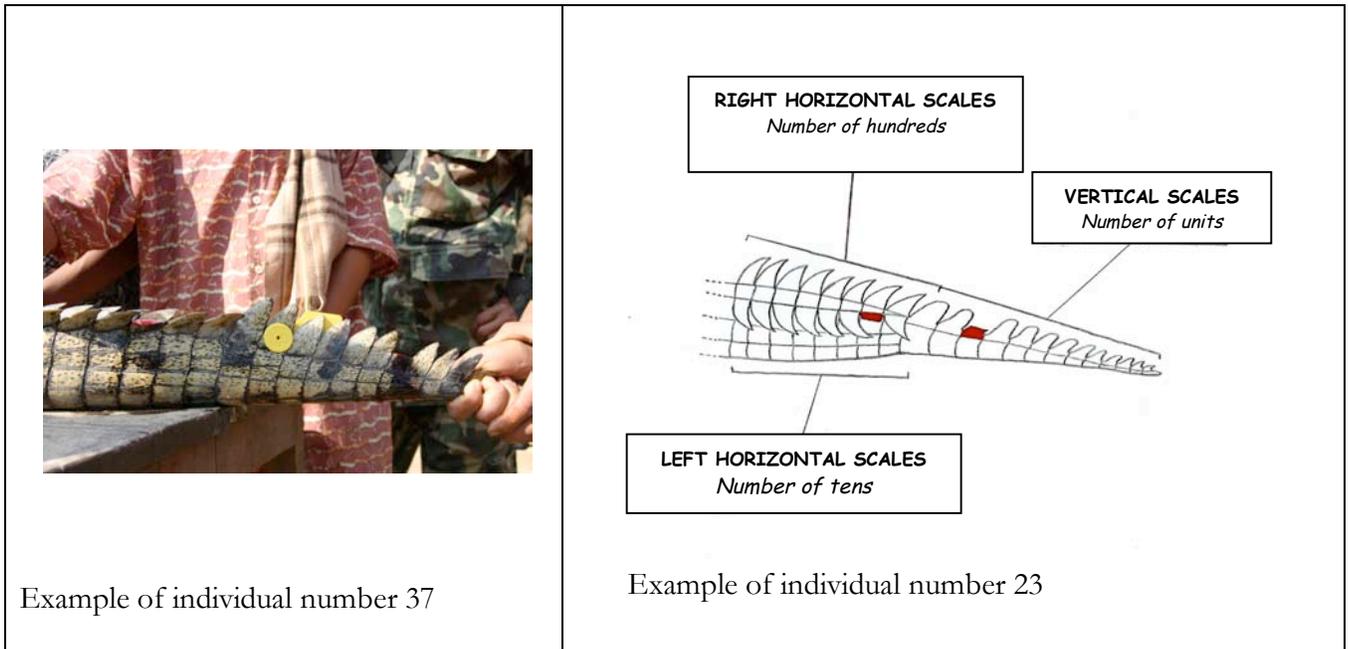


Table 3: Assessment of gharial released since March 2002 in the RCNP.

Date of released	Number of gharial	Individual number	Marks	Location of the release site : river, locality
March 2002	10	1-10	N + C + R	Narayani west channel
March 2003	6	11-16	N + C	Narayani, Amaltari
April 2003	20	17-36	N + C	Narayani west channel, Divyapuri
November 2003	10	37-46	N + C + R	Narayani west channel, Lamichaur
February 2004	10	01-10	N	Rapti, Badsenigath
November 2004	10	47-56	N	Rapti,
April 2005	10	57-66	N	Rapti
TOTAL	76			

* N = Notches ; C = Cattle marks ; R = Radio-transmitters

3 RESULTS

3.1 Assessment of the Gharial Status and dispersal in December 2005

39 different gharial locations have been recorded by direct observation and 10 using local survey. A total of 49 gharials have been counted during this study, 4 are male adults, 21 considered as females, 11 as Sub-adults and 11 Immatures. However, 3 have not been identified (Table 4).

Table 4: Gharial density and total number of locations (Males, Females, Immatures) in each river's sector of the RCNP in December 2005.

Gharial population structure								
river	river sector	Males	Females	Sub adults	Immatures	?	TOTAL	density /10 km
Rapti	Sauraha-Kasara	2	6	6	1	-	15 (30.6%)	8.8
	Kasara-Rapti Confluence	0	0	1	4	-	5 (10.2%)	2.4
Narayani East Channel	Ratanpur-Amaltari	1	5	1	0	1	8(16.3%)	3.3
Narayani West Channel	Ratanpur-Amaltari	1	1	0	3	-	5 (10.2%)	2.1
Narayani	Amaltari-Tribenighat	0	6	3	3	-	12 (24.5%)	12
Off river Parks		-	1	-	1	2	4 (8%)	4.3
TOTAL		4	21	11	11	3	49	6,3

First, Table 4 shows quite a homogeneous gharial distribution between each river sector of the Park. However, one notices a higher concentration of gharial in the Bawanipur-Kasara and Amaltari-Tribeni zones, where 30.6% and 24.5% of the gharials were counted. This corroborates the results in 2004 (Ballouard and al, 2004). More precisely, as in 2003 and 2004, gharials are consistently concentrated at specific sites where several of them are often gathered. We can easily see that on the Amaltari-Tribenighat sector and Narayani East Channel sector.

In comparison with the 76 kilometres of Narayani river, the Rapti river, only 36 kilometres, shows the highest concentration of gharials (table 4). However with 8.8 gharials /10 km, the part between Bawanipur (Sauraha) and Kasara has the highest concentration of Gharials, with many adults. This is probably due to the quality of the habitat. On the other hand, the sector between Kasara and the Narayani confluence with the same water quality and presence of favourable habitat shows a gharial density with 2.4 gharials /10 km (This habitat has sites more than 2 meters deep, adjoining wide sand beaches (Maskey and al, 1995 Witaker and Basu, 1983)). The presence of many villages and river populations' activities such as fishing account for this. Preferred ecological sites for gharial are situated where the river forms a large bend with a deep pool and a calm area, also preferred by gharials' prey (Ciliberti, 2003). These areas also obviously attract fishermen. On these rivers alongside villages, young Gharials compete with villagers fishing on foot and in boats. They disturb young gharial during their basking activities, reduce their prey and pose the threat of capture or death with their fishing nets. Evidence of this is two young gharials found with pieces of fishing net wrapped and tangled around their snouts.

According to this observation human disturbance is probably a determinant factor for the establishment of gharials inside the Park.

The contrasted distribution of gharial is the most spectacular in Narayani East Channel. Which the exception of one female, all the gharials are located in Koriya-Mohan just downriver from the confluence with the Rapti river, in spite of the fact that the Narayani East Channel presents many habitats normally preferred by the gharial. Those sites are located in Koriya-Mohan and Litteguintha-Bimbath where the river forms a large bend against the current and provides a calm area much favoured by gharial and its prey (Ciliberti, 2003) ” (Ballouard and al, 2004). In the meantime five gharials are present in the Narayani West Channel but only in the lower part of the river. In the upper part many sites are devoid of gharials. But according to what we have seen, we cannot afford to attribute this uniquely to human disturbance. Indeed this part of the Narayani is abundant in channels which diffuse human disturbance. Water temperature factors (colder in the Narayani than in the Rapti) could be responsible for this observation. However, historically in the early 1950s about 235 gharials occurred along the Narayani River from Narayanghat to Tribeni (Maskey, 1989). Therefore, in 1987 Maskey mentioned specifically in this part of the Narayani river that the population was the most concentrated with 1.1 animal per Kilometre. He explains this by the fact that this area of the river is dissected by numerous river channels that provide suitable habitat. Hence the water quality is probably the main factor responsible for the disappearance of the gharial. Indeed, the water is contaminated by two factories downstream from Narayanghat and upstream from the Park which are dumping chemicals directly into the river (Keshab.K.C., Pers Com).

Also four gharials have been observed outside the Park in very small rivers which are no more than one meter deep and five meters wide. One female and one young gharial are settled on the Gundrayeni river in the Amaltari area inside the buffer zone. According to a local survey two other individuals remain in a little river outside of the park within the Tribeni area. According to previous observations, during the monsoon small rivers like the Rapti and Reu river are known to accommodate gharials when the flood is heavy in the main river. Now, our own surprising observations show that Gharial remain even though the water level is very low and decreasing. Firstly, this suggested that we should spend more time patrolling and monitoring the small tributary rivers of the Park in order to get a more precise gharial count. Secondly, mainly because they are situated in an unprotected area, they may be subject to local disturbance and poachers.

3.2 Status and evolution of the gharial population

This count recorded 40 wild gharials, which were released before 2002 and a minimum number of nine gharials released since 2002.

Because of difficulties in identifying the precise number of Gharials in the Park and in estimating the size of each gharial, these numbers may not accurately show the exact Gharial population. However it is a good indicator of the health of the gharial population in the RCNP.

3.2.1 Status and evolution of the wild gharial population since 2003

Taking into account the difficulties in establishing an exact count, this population, estimated between 34 and 40 gharials, has been quite stable for three years (Table 5).

Table 5: Total wild gharial count in 2003, 2004 and December 2005

Year	2003	2004	2005
Total wild population	38	34	40

It is important to note that in this count the status of five immature gharials couldn't been identified precisely. Some may have been released after 2002 or some may be wild ones from previous releases. In any case, we can confirm that the wild population is stable considering 35 as the minimal size of the wild population.

This year we noticed that 62.3% of the wild population is adult, most of them are females. 32.5% of the population is immature and sub adult. The status of three gharials was not able to be determined. Hereafter we consider as 40 the size of the wild population (figure 3).

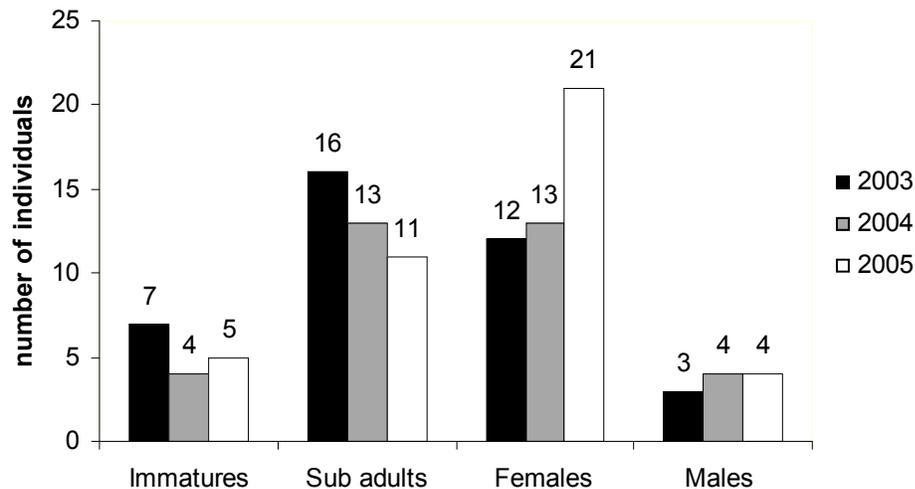


Figure 4: Evolution of the population's structure counted during monitoring in 2003, 2004 and in December 2005 in the RCNP ;(immature: TL<2.20m; sub adults: 2.20<TL<2.80 m; adult female: TL>2.80m, without ghara; male adult: TL>2.80 with ghara)

Figure 4 shows, between 2003 and 2005, a drop in the number of Immatures and Sub adults. Both categories represent 63.2% of the wild population with 24 individuals in 2003 and 36.7% with 16 individuals in 2005. At the same time we see a spectacular increase in adult females from 12 in 2003 to 21 in 2004. Given that the last gharial release was before 2001 the decrease in sub adults is not surprising as some are now considered adults. Also we have to consider the difficulties of establishing the size of each animal. However the fact that there are no more than four males is very significant, since the sex ratio might be important for the survival of the gharial. Unfortunately the lack of observations focusing on the survival of the released gharial (cf next chapter) cannot explain if the survival of males is significantly lower than females. However this observation should be considered in further studies.

3.2.2 Observation and survival of gharials released since 2002

Six gharials from the reintroduction since 2002 have been clearly identified during this census. Three gharials with notches have been observed, which means they are from the March 2002 or March and April 2003 reintroductions. Unfortunately we couldn't specify individual

identifications. According to the 76 gharials released since 2002, this result shows that the survival of the young gharials after release in the Park is very low. Below we indicate more precise results on survival of the released gharial according to the study in 2004 (Ballouard and al, 2004). The three other young gharials probably come from the 30 released since February 2005.

In 2004, 16 distinct gharials from the batch of 36 released in March 2002, March and April 2003 have been observed. Only two individuals (1 and 4) from the 10 released in March 2002 have been found. Survival of released individuals in March 2003 was 50 % in 2003, and 20 % in 2004 (table 6).

Table 6: Survival of the 10 gharials released in March 2002 in the Park.

	Number of gharials in the Park (individual number)	Survival rate
2003	5 (1, 2, 4, 6, 8)	50%
2004	2 (1,4)	20%

From 26 gharial released in 2003, with a survival ratio of around 53.8%, 14 have been observed in 2004 (table 7).

Table 7: Survival of 26 gharials released in March and April 2003 in the Park.

	Number of gharials in the Park (individual number)	Survival rate
2004	14 (11, 13, 14, 15, 17, 18, 21, 23, 24, 29, 31, 34, 36, 32)	53,8%

Now in this current census if we count the five immature gharials as wild population, 8 immatures from the 30 gharials released since February 2004 would be present in the Park. Over 3 years of investigation, and knowing that 20 gharials have been released since November 2005, consequently for one year, we can affirm that the survival rate after 1 year is not more that 53.8%.

This survival rate must be interpreted carefully as some gharials might have left the area of study (probably down the Tribeni dam). However, these results show a high disappearance and mortality of the young gharials during the first years following their reintroduction.

According to the morphological characteristics of the gharial reintroduced, the surviving gharials are not necessarily the biggest or the strongest (Ballouard and al, 2004). However among the 14 surviving gharials from 2004, only four are males whereas 14 had been released. The competition with wild population well adapted to environment can explain young gharials' instability, particularly those of the young male. Indeed, the observation of a few local migrations of males seems to be the result of their territorial activities (Witaker and Basu, 1983)

It is important to note again that in December 2005, two sub adult gharials were observed with fishing nets tangled around their snouts. Indeed, fishing nets are probably one of the main factors responsible for this low survival of young gharials in Chitwan.

4 MAIN THREATS

According to the first census in 2003, young gharials were not found within the park's limit and adults continued to disappear (Priol et al, 2003). Since the first studies in 1997 (Madhu and Sharma, 1997) causes of the Gharial's decline have changed with time quantitatively and qualitatively.

Nowadays main factors are:

- reduced habitat and food sources due to increased demographic pressure and the creation of irrigation canals at the south end of the Park.
- pollution coming from the 2 beer and paper factories which dump waste into the Narayani at the North end of the Park
- disturbances causing stress and significant disruption in basking activity. From Ciliberti (2003) a site can have as many as 51 disturbances per day (the passing of fishermen and tourists) during optimum hours for basking activities.
- deaths caused directly by fishing nets: from Hussain (1998) although these gharial deaths haven't been quantified, it appears that fishing nets take a heavy death toll on gharials, particularly the young ones. From the radio telemetric study in 2004, this was confirmed by the observation of a dead gharial, found entangled and drowned in a fishing net, just shortly after being released. This individual would not have been found had it not been outfitted with a transmitter. In 2003, an adult female was found dead in a fishing net. In the Chambal Sanctuary in India, which has the strongest gharial population in the world, the population has dropped by 50 % in 5 years (citation CSG meeting 2004) This decline is probably attributed to gharials who have left their protected areas and have drowned in fishing nets (Basu and al, 2004).
- the dam in the south of the park which has changed the river course is responsible for the scarcity of alimentary resources (Madhu and Sharma, 1977) and the flooding of egg-laying sites during the high water period. Furthermore, keeping in mind the dispersal downstream of young gharial (around 35 km in 4 months) inevitably, some of them pass through the Tribeni dam making it impossible for them to come back into the park (Maskey, 1989). Gharials occur in India in the State of Bihar, where they are not protected; occasionally one can find them being sold in the local markets as food (local people, personal conversations, 2004).

5 RECOMMENDATIONS

Task Force Gharial (TFG), within the IUCN/SSC Crocodile Specialist Group, aims to bring together key individuals and organizations to facilitate conservation efforts on the seriously endangered Gharial (*Gavialis gangeticus*). In the context of an action plan to improve gharial conservation in Royal Chitwan National Park as a whole, led by a joint partnership between the NGO SOS crocodiles and WWF, we propose to His Majesty's Government of Nepal the following recommendations:

5.1 Protection of group

First according to the quality of the wild environment in Chitwan the protection and the improvement of the captive gharial appear essential. In view of the economic and political situation of the country, and to keep safe the captive group from any disaster we recommend a reconsideration of the Centre's management, which has a significant role in the long term conservation of the gharial.

Due to an improvement in the survival of the young gharial during the first year of their life the Kasara Breeding centre today historically accommodates more than 400 gharials. The new nursery will continue to improve this survival. However the management of the captive breeding group should be again improved.

In this way, we recommend:

- to establish a second group in Royal Bardia National Park because all management *ex situ* must preserve a stock in case of disaster (Rao and al, 1995). This group, a different species from that in Chitwan,, originating from India, would permit on the one hand a second stock in case of illness (epizootic diseases etc...) or destruction of the Chitwan group (political instability); and on the other hand, a second group of genes to allow the exchange between two groups. This is important for foreign zoos when they import gharial.

- the construction of a fish farm would increase autonomy and teach young gharial to hunt (by feeding them with living fish), helping their adaptation to a natural environment (currently gharial are fed dead fish or fish which are too small). And why not have a water pool to improve the physical condition of gharials just before reintroducing

We recommend that more gharial be introduced into Royal Bardia National Park in West Nepal. With the increased new stock of gharial at the Kasara Breeding Centre we can afford to release gharials in different areas of Nepal. In 1993, as the survival ratio of gharial introduced in Narayani was 7%, that of Babai and Karnali situated in the Bardia Park was 76 % and 50 %. From Maskey and Percival (1994) the main reasons for the highest ratio of survival are the low ratio of disturbance by locals and less fishing activity. As it is more difficult to access the Park (Hall and al, 2001) results show that the Babai River is rich, with more than 33 species. We can also see Gangetic Dolphin and Otters, which have almost disappeared from Chitwan although the habitat is a characteristically rich one.

The gharial's reintroduction (firm establishment) will be never be achieved uniquely through breeding gharials; indeed side-by-side management of both the wild group and the captive one is required.

5.2 Protection of sites and control of human activities

Human activities like over-fishing are directly and indirectly responsible for the disappearance of the Gharial. Based on our observations, we emphasize the fact that more controls must definitely be implemented into place.

While increasing control of illegal human activities (fishing, destruction of riverbanks) throughout the entire Park, some designated areas must be strictly protected and fishing activities must be prohibited.

These are:

Charara
Dumaria
Dudhaura
Korya-Mohan
Lamichour
Litteghintha
Bimbath

These sites, representing the quasi-totality of the wild population of the Park, constitute the main areas. To reduce the risk of the young reintroduced gharial being drowned due to entanglement in fishing nets, protected zones prohibiting fishing must be demarcated around reintroduction sites as soon as the gharials are released. We further recommend stringent monitoring of gharials in unprotected areas. These monitoring should be implemented by the Park staff throughout boat survey realised once or twice a month. This should be complemented by local foot survey made daily on the vicinity of each ranger post and on the priority areas.

5.3 Monitoring of water quality of the Narayani river

Because of widespread human development in the Terai, the rivers and groundwater in Royal Chitwan National Park are used for many human activities. According to a report on Vulnerability of the Groundwater Resources in Chitwan District, four main activities have been identified:

- Water supply, irrigation, industry, (i.e. hotels, paper and beer factories), and fish and silk farming.
- Crocodiles as a top predator in river systems are very affected by water pollution by the accumulation of toxins affecting the reproduction (egg development...). Though the use of water is extensive, no initiative to monitor water quality has been made. «Data information are lacking for vulnerability environment and ground water use situation» (Para Con Private Limited, 2005). To illustrate, this report says that the wells in the San Miguel and Bottling factories contain contaminants. So impacts of industrial pollution need further assessment and analysis. The management of industrial waste at the Coca Cola and San Miguel beer factories is poor and inadequate.
- Undoubtedly the water quality must be improved, especially in the protected areas on which biodiversity and local populations depend. We therefore urgently recommend an international convention such as RAMSAR to monitor the water quality in the Narayani River, and initiate drastic measures and regulations.

5.4 Project's direction in sustainable development and communities implications

Because of a strong relationship between local communities engaged in fishing activities and keeping in mind cultural and social aspects, gharial conservation will include a broad policy of long-term and sustainable development. Moreover the Gharial's survival can't be understood or grasped without the help of interest groups; this project must be developed on a long-term basis through awareness, information and the involvement of locals.

Awareness and education should explain the gharial's role as a key species in the cold water ecosystem. Crocodiles can be highlighted as an eco-tourist attraction. (Platt and Thorbjarnarson, 2000). In this way, the gharial as a tourist attraction (i.e. breeding centre among others) should be developed to benefit local people. It is important to encourage communication and sensitivity with post cards sold to tourists and posters distributed to local people.

With the constant growth of demographic pressure surrounding the Park, we recommend a primary quantification of fishing resources. This quantification could be done through local fishermen who could fill out a sort of index card on different species and the size of fish they caught. Simultaneously with the introduction of strict rules, the Gharial conservation policy would provide alternatives to local people. We therefore recommend the involvement of new NGOs to help install fish farms, providing food to locals during prohibited fishing periods. This fish farming could also be used as a food stock for gharial and guarantee fish purchase for the locals.

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