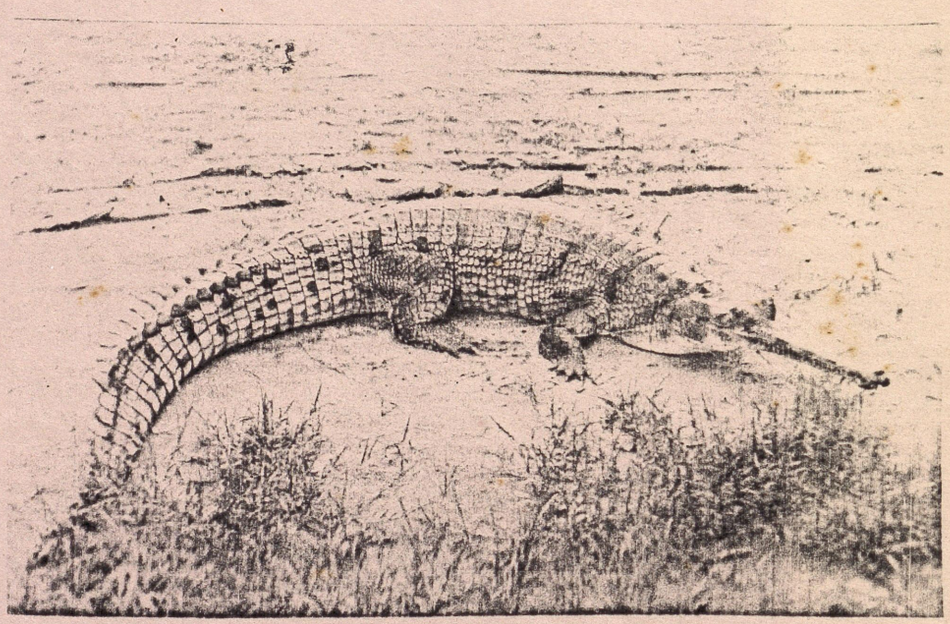
Nesting Ecology of the Gharial in National Chambal Sanctuary

By R. J. Rao



WILDLIFE INSTITUTE OF INDIA

New Forest, Dehra Dun.

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STUDY REPORT

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ABSTRACT

The results of a study on the nesting ecology (1985-1988) and population monitoring of gharial in the Chambal river are presented. The data are based on intensive studies conducted at a major communal nesting site, Baroli during 1985-1987 and surveys at other nesting areas during and after nesting. Annual surveys were conducted during 1985-1988 as a follow-up to the surveys conducted earlier to evaluate the success of gharial rehabilitation programme in the National Chambal Sanctuary.

The results indicate a year-by-year increase in the number of nesting sites. From 570 km length of the river during 1978 only 6 places were known where nesting occured, while in 1988 it was 15 places. In 1988 communal nesting (a place with more than two nests) occured at 11 places. Nesting is not found in areas where there is no sand. The banks opposite the sand bank where nesting occured were, during 1987, muddy or hard soil (53.3 % instances) and rocky (40%). Nesting also occured on the alluvial deposites in between rocks (6.6%).

Nesting of gharial is seasonal and most of the nesting completes during late March and early April. Gharials dig probe pits and trial nests before actual nesting. They select a site which is usually 7 m away from water and 1.5 m above water level

for nesting to avoid any possible flooding of the nests. Mean clutch size is 38.4 with a range of 17-55 (n=51) and the egg dimensions are: length 77.0-94.0 mm ($\bar{x}$ = 86.1mm; n=120), breadth 59.0-64.0 ($\bar{x}$ = 61.3mm, n = 120). Mean egg weight is 185.5g. Mean incubation period is 62.3 days with a maximum period of 75 days. Female opens her nest at hatching time, help hatchlings to emerge. Hatching success is high (up to 100%) at Chambal due to nest protection by management staff, captive hatching programme and nest guarding phenomena of females. During 1987 nest loss is recorded due to predation (19.5%) mostly at communal nesting sites and mis-handling of eggs by inexperienced management staff (5.1%). The survival value of hatchlings is greater at the communal nesting sites since more than one female is available for hatchling attendance and a larger creche of hatchlings is formed due to congregation of several smaller creches. The male takes part in general attendance at the nesting area.

The recovering status of gharial is evident from a year-by-year increasing nesting activity and per km sighting density. A total number of 33, 37, 45 and 50 nests were located during 1985,1986, 1987 and 1988, respectively. Annual egg production in 1985, 1986, 1987 and 1988 is 1254, 1406, 1710 and 1900, respectively. Sex ratio during 1988 was 1 male vs 4 females.

The density of gharial in Chambal was 0.29/km in 1978, 1.6/km in 1985-86 and 1.89/km in 1988. During this decade period the gharial population was increased and the number of gharial nests was also increased from 12 in 1978 to 50 in 1988. The results have indicated the conservation status of gharial in the National Chambal Sanctuary.

Although commercial fishing has been banned since 1978, the management will have to increase its vigil over any illegal fishing which can quickly reverse the trend of recovery of the gharial population. Measures to be taken to improve the situation concerning gharial population are suggested.

1. INTRODUCTION

The Gangetic gharial Gavialis gangeticus occurs in the Gangetic, Brahmaputra, Indus and Mahanadi River systems (Smith,1933). It is found in India, Bangladesh, Nepal and Bhutan (IUCN, 1982, Whitaker and Basu, 1983). Khan (1987) in his report to the Chairman of the Crocodile Specialist group stated that 'the gharial in the Indus in the Province of Sind had gone completely extinct'. During early 1970's there was a great concern on the status of the gharial populations, which were depleted throughout their former range due to habitat loss and disturbance, killing for skins and mortality by drowning in fishing operations (FAO, 1974; IUCN, 1982). On an all India basis this species first received legal protection in 1972 under Wildlife (Protection) Act. Recognising their endangered status, the Government of India started a massive rehabilitation programme for gharial under the Crocodile Project in 1975. Suitable habitats were identified and given protection by declaring them as sanctuaries where captive reared crocodiles are released (Bustard, 1980) Fig.1).

While evaluating the success of Crocodile conservation Project in India, Antoon de Vos (FAO, 1982) emphasised the need for monitoring the released Crocodiles to determine the effectiveness of rehabilitation programme. In order to evaluate the success

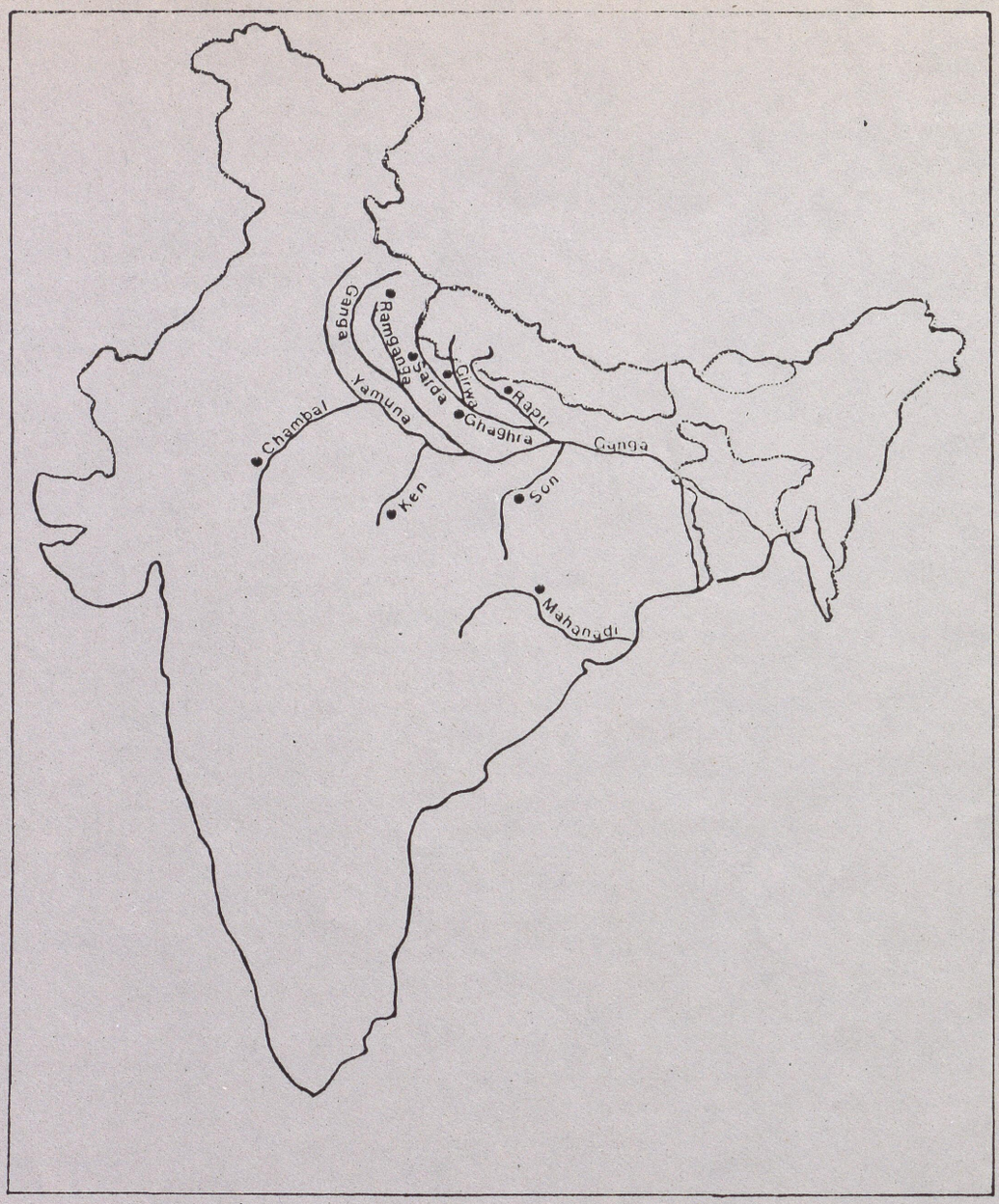


Fig. 1. Map of India showing gharial reintroduction sites.

of releases and the growth in a specific crocodile population, scientifically based monitoring programme has been undertaken in the National Chambal Sanctuary where a gharial rehabilitation programme is under progress since 1979.

From 1983, extensive monitoring of the gharial population in the National Chambal Sanctuary is being carried out by the Research team of the Crocodile Research Centre of the Wildlife Institute of India. This included the use of Radio-tracking method and annual surveys (Singh, 1985). From October 1983, the author remained involved in monitoring of the gharial population including study on gharial nesting activities in the National Chambal Sanctuary. Data collected from 1985-1987 on timing, movement and behaviour of nesting gharial, as well as hatching success of eggs are presented. This report summarises both the available information (Singh, 1985) and recent data on the status of gharial in the Chambal river. The nesting ecology data available till 1978 (Singh, 1978) are also referred to where applicable. This study was carried out in conjunction with a major study on the Ecological relationships among freshwater turtles in the Chambal river (Rao, 1987). It is hoped that the results of this study will help for taking suitable measures for the conservation management of the gharial in the Chambal river.

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3. STUDY AREA

This study was conducted in a stretch of 400 km of the Chambal river, which is under the management of the National Chambal Sanctuary.

3.1 Chambal river

The Chambal river is perennial, having its origin in Vindhyan Range near Mhow district of Madhya Pradesh. It flows in a North-eastern direction, passing through Rajasthan up to the point where its major tributary, Parbati joins it near Pali. Thereafter, it flows in an eastern direction, forming the boundary of M.P. and Rajasthan and M.P. and Uttar Pradesh. It joins the Yamuna River near Bareeh of Etawah district of U.P. The Yamuna, in turn, flows south-east direction till it meets the Ganges at Allahabad. Kali Sindh, Parbati, Banas and Kunoo are the important tributaries of the Chambal river. A series of multipurpose dams at Gandhi Sagar (M.P.), Rana Pratap Sagar (Raj.), Jawahar Sagar (Raj.) and Kota barrage (Raj.) have been erected in the upper reaches of the Chambal river (Fig. 2).

The deep and fast flowing Chambal river varies considerably. At places the river is shallow and fast and there are many shallow riffle areas. The substrate ranges from mud and silt to sand and rock. At low water periods (April-June) the river is 150-250 m wide and has a maximum depth of 20 m. During wet season (July - September) the river floods naturally and high extents of erosion

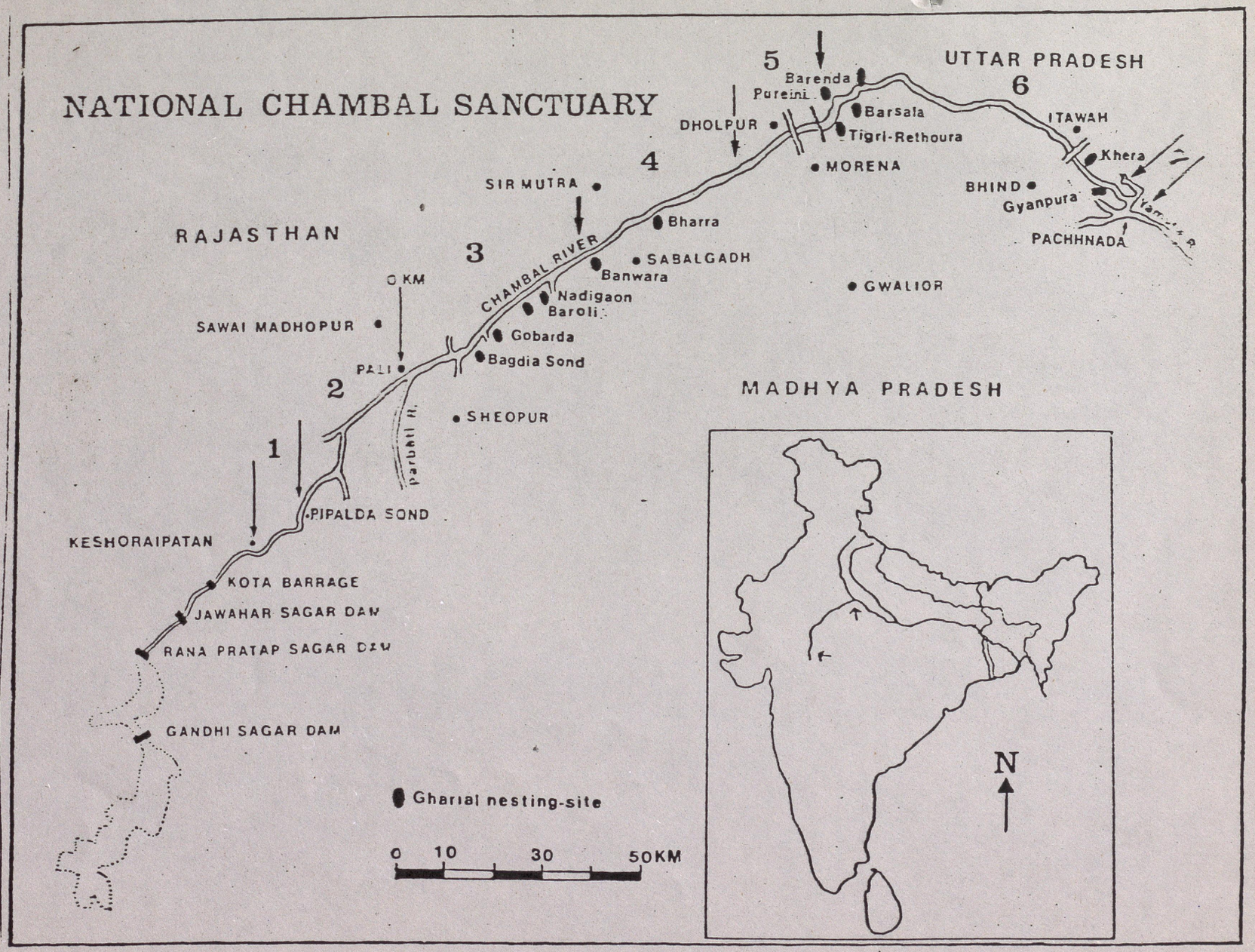


Fig. 2. Map of the National Chambal Sanctuary showing some of the important land marks and gharial nesting sites in different zones. Numbers in between arrows represent the zone numbers.

and deposition of soil take place. During this period the maximum depth of the river is around 50 m. The water temperature ranges from 15°C during winter to 33°C during summer.

3.2 National Chambal Sanctuary

During 1978/79, the Chambal river was declared as a Crocodile Sanctuary under Crocodile Project with an aim to provide fully protected habitat for conservation and propagation of gharial Crocodilian and other wild animals. The National Chambal Sanctuary extends over the Chambal river from Jawahar Sagar Dam to Kota barrage and after a gap of 18 km free zone, from Keshoraipatan (Raj.) through Pali to Pachhnada (U.P.) where Kunwari, Pahuj and Sindh rivers form a confluence with the Yamuna River. The total length of the river inside the Sanctuary is about 600 km. The width of the river that is included inside the Sanctuary is 1000 m from either bank in Rajasthan and Madhya Pradesh while Uttar Pradesh has a greater width totalling to an area of 635 sq.km. (Singh, 1985). Geographically, the Sanctuary lies between the Lat. 25°30' N and 26°52' N and Long. 76°28" E and 79°01' E.

3.3 Climate

Climatological data were recorded for the years of the study (1985-87) from the Meteorological station set-up at Deori Gharial Rearing Centre (DGRC) in June 1983. Maximum and minimum thermometer kept inside the Stevenson's screen was used to record daily air temperature. Rainfall was recorded daily with a rain gauge. Data on relative humidity was recorded during 1985.

3.3.1. General

The Sanctuary area is located in the Northern tropical region where during a year three distinct seasons are distinguished. The duration of hot season is normally from 15 March to 30 June. The rainy season is from July through September. The area receives most of the rainfall from South-Western monsoon. The winter season is from middle of October to February. Gales are very common during summer season, when wind velocity goes up to 12.4 km per hour during the month of June.

3.3.2. Air temperature

Maximum and minimum temperature recorded daily at DGRC were averaged monthly (Fig.3). The highest average maximum temperature was recorded during June (45.26) in the year 1987 and the lowest (6.29) average minimum temperature was recorded during January 1986. The hottest temperature (49.0°C) was recorded in May during all three years and coolest temperature were recorded during January 1985 (4°C), Jan. - December, 1986 (3°C) and January 1987 (3°C).

3.3.3. Relative humidity

Relative humidity varies considerably during different seasons and also during a 24 hour period. The highest (94%) relative humidity was observed during January 1985. The lowest (40%) relative humidity was recorded during May 1985.

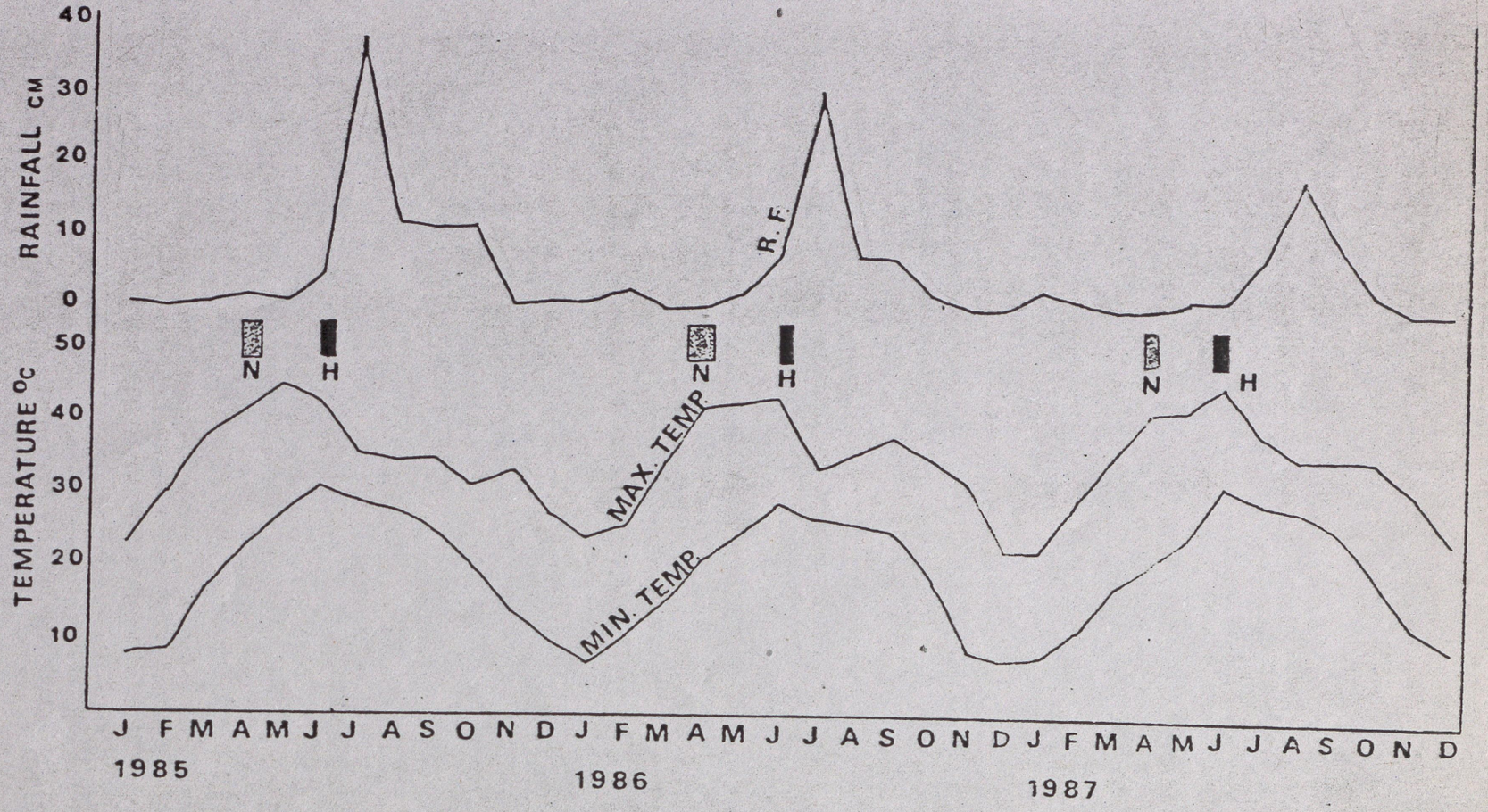


Fig. 3. Meteorological data over a period of 3 years (1985-87). Note the nesting (N) and hatching (H) periods in different years in relation to temperature (°C) and rainfall (CM).

3.3.4. Rainfall

During the study period maximum (77.4 cm) annual rain fall was recorded during 1985. The annual rain-fall was decreased from 1986 (59.8cm) to 1987 (45.1 cm). Maximum rain-fall was recorded during the month of July 1985 (36.5 cm). In 1986 and 1987 the maximum rain-fall was in July (29.7cm) and August (18.7 cm), respectively (Fig. 3).

3.4 Soil erosion

The entire Sanctuary area is faced with a serious soil erosion problem so much so that the delicate ecological balance has been up-set. The main factors effecting soil erosion are climate, topography, geological formation, nature of soil, vegetation and biological agencies. The monsoon rain, followed by a long period of dry weather, the soft friable and deep soil, steep slopes, excessive grazing and absence of vegetation cover all contribute to accelerate erosion along river banks. Soil erosion by wind in this tract is quite prominent. The soil is blown off by high velocity winds coming from Rajasthan, in the form of prominent dust stroms during summer. This results in gradual blowing off of top soil and ultimate exposure of subsoil and parent rock.

3.5 Flora

There is no forest area in the M.P. territory of the Sanctuary except a few plantations carried out in the past as measures to check soil erosion. The natural vegetation of the area consists of mixed deciduous forests to thorny bushes. The ravines are characterised by Khair (Acacia catechu) and babool (Acacia arabica) trees. The Rajasthan side of the river bank is greener at many places.

Tamarix dioca is a major xerophytic vegetation that occur in the form of bushes on the sandy river banks and also appear through succession after 3-4 months of highest flood. Aquatic and semi-aquatic vegetation are similar along entire Chambal river. The most common emergents occuring along the banks of Chambal river are cattails (Typhya sp.) and several species of grasses (Graminae).

A list of plant species found in association with nesting banks, aquatic plants and other tree species along the Chambal river is given in table 1. The plant species were identified with assistance from the Botany Department of Jiwajee University, Gwalior.

Table 1. List of aquatic and terrestrial plants in the National Chambal Sanctuary. (Rao and Singh, 1984; Sharma and Rao, unpublished data)

Aquatic plants

1. Hydrilla verticellata
2. Vallisnaria spiralis
3. Potomegeton crispus
4. Potomegeton demersum
5. Imperata cylindrica
6. Nitella sp.
7. Zennichelia sp.
8. Chara sp.

Plants adjacent to river bank near nesting sites of gharial

1. Tamarix dioca (Dominant species)
2. Heliotropium echiwaldi
3. Pluchia crispa
4. Typha sp.
5. Saccrum spontanium
6. Tephrocia purpuria
7. Solanum xanthocarpum
8. Celocia caromandeliana
9. Heliotropium subulatum
10. Rumex dentatum
11. Xanthium strumarium
12. Argemone maxicana
13. Chrozophora parviflora
14. Euphorbia microphylla
15. Cynodon dactylum

Tree species on the river bank

1. Acacia arabica (Babul)
2. Acacia catechu (Khair)
3. Acacia leucophobia (Remja)
4. Dalbergia sissoo (Sheesum)
5. Azadirachta indica (Neem)
6. Zizyphus marutiana (Ber)
7. Prosopis julumhora (Vilayti babul)
8. Albizzia lebbeek (Siris)
9. Anogeissus pendula (Khardhai)
10. Anogeissus lotifolia (Dhov)
11. Butea monosperma (Chola)
12. Pongamea pinnata (Kanji)
13. Bosvelia serrata (Salia)

3.6 Fauna

The important wildlife species present in the river stretch of the Sanctuary are the Gharial Gavialis gangeticus, the mugger Crocodylus palustris, seven species of freshwater turtles Trionyx gangeticus, Lissemys punctata, Chitra indica, Kachuga kachuga K. dhongoka, K. tentoria and Hardella thurgii, the Gangetic dolphin Platanista gangetica, & the otter Lutra sp.

A variety of fish also occur in the Chambal river. Besides, around 120 species of birds were identified in the National Chambal Sanctuary (Rao, 1986; Sharma and Singh, 1986). Among the different species of birds found in the Sanctuary are: Birds of prey, Bar-headed goose, Brahmany Duck, Teals, common cranes, cormorants, egrets, Black and white ibises, Brown-headed gulls, painted storks, Black-necked stork, white-necked stork, common cranes, Sarus cranes, herons, spoon bills, Pelicans etc.

The other important terrestrial animals present in the ravines of the Sanctuary are land monitor lizard, variety of lizards and snakes, sambhar, spotted deer, jackal, hyena, fox, wolf, langur, porcupine, hares, desert cat, blue bull, wild boar etc.

3.7 Sanctuary management

The National Chambal Sanctuary is managed by the Forest Departments (Wildlife wing) of Rajasthan, Madhya Pradesh and Uttar Pradesh. The Sanctuary head-quarters of M.P., U.P. and Rajasthan are at Deori, Dist. Morena; Agra and Kota, respectively. Stopping of fishing activity, maintaining full protection from poaching, extending protection to habitat and rehabilitation of gharial under 'grow and release' scheme proposed by Bustard (FAO, 1974) are the management stratagies adopted in the National Chambal Sanctuary. Rehabilitation of gharial has been taken up in the Sanctuary from 1978. The first batch of 15 captive reared gharial were released in the Chambal river during 1979 and by the year 1983 a total number of 823 gharial were released in the Chambal river by the Uttar Pradesh Forest Department (Singh, 1985). During 1984-87 the U.P. Forest Department released a total of 464 captive reared gharial in the Chambal river (Table 2).

3.8 Field station

Deori Gharial Rearing Centre, District Morena was selected as the field station. The Centre is 7 km North of Morena and 17 km South of the Chambal river, beside National Highway No. 3 (Agra - Bombay Road) (Fig. 4).

Table 2. Gharial releases in the National Chambal Sanctuary during 1979-1987. (updated over Singh, 1985)

Year and Month of release	Place	No. gharial	Total No. gharial
1979 - May, Nov.	Jeora	15	
December		60	75
1980 - March	Barenda	15	
	Kenjra	45	
	Pureini	50	110
1981 - March,	Kuthiana	44	
April	Chinnouni	83	
	Sahaspura	43	
	Baroli	83	253
1982 - January,	Deogarh	45	
February &	Nadigaon	50	
March	Baroli	49	
	Rameswar	43	187
1983 - January	Kenjra	24	
	Keori	74	
	Deogarh	50	
	Pureini	50	198
1984 - March	Pali	38	
	Pali	30	68
1985 - February,	Barenda	20	
March &	Barenda	20	
April	Barenda	20	
	Pali	10	
	Rameswar	20	99
1986 - February,	Udi	1	
March &	Rameswar	20	
April	Rameswar	19	
	Rameswar	20	60
1987 - March &	Rameswar	48	
December	Baroli	50	
	Pinahat	49	
	Pinahat	48	
	Nandagawan	42	237
		Total	1287

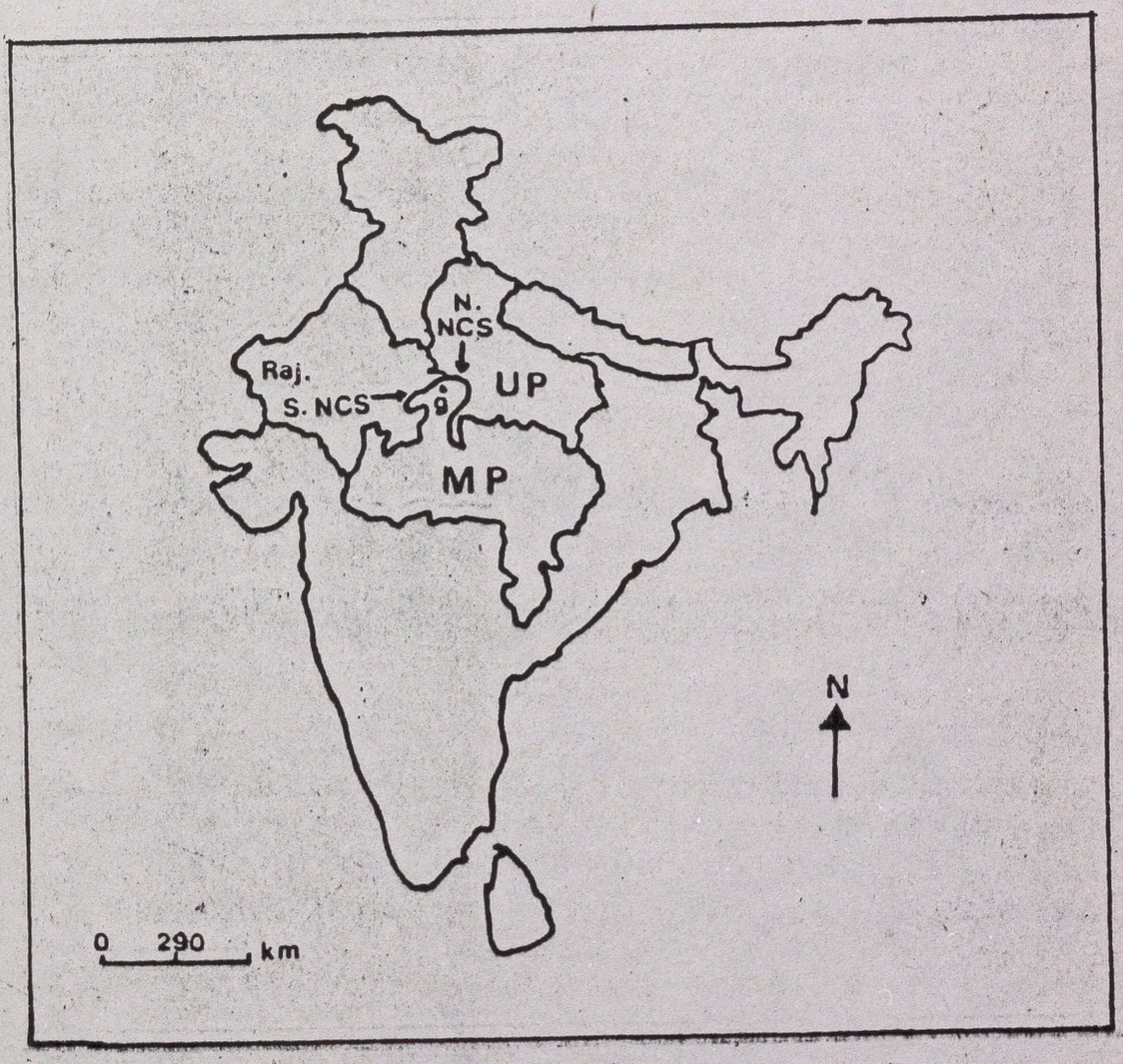


Fig. 4. Map of India showing location of National Chambal Sanctuary and the field station. S.NCS and N.NCS = South National Chambal Sanctuary and North National Chambal Sanctuary; g = Deori gharial rearing centre.

4. METHODS

4.1 Nest surveys

Since 1976, gharial eggs are being collected from different nesting sites for the captive rearing programme by the U.P. Forest Department. A total of 5 nesting sites were identified all along the Chambal river during 1984 (Rao and Singh, 1987). To collect information on the distribution and relative densities of gharial nests all these nesting sites were surveyed during March-April, 1984. Nests were located with assistance from the field staff by probing with stain-less rod (Singh, 1978), where signs of actual nesting are seen.

In 1985, intensive studies on time of nesting, nesting sequences, nest distribution, sequences of hatching and post-hatching social organisation were carried out in a colonial nesting site at Baroli, which is around 180 km west of the field station. In addition, areas where adult gharial had been sighted during the annual surveys (1984-88) were also surveyed to locate new nesting sites. Information from local people were also gathered to locate nesting sites. All the nesting sites were marked on Topographic maps.

After locating the nests, they were excavated carefully. Data were noted on the situation of nest — distance from water, height above water level, nature of soil and the total area of nesting site. Measurements of individual nests were recorded seperately with information on clutch size and egg measurements. Care has been taken while handling the eggs.

Data on extent and pattern of nest predation was recorded. Incubation period was determined by calculating the number of days between the exact date of egg deposition and nest opening by the female.

Incubation and hatching of gharial eggs in hatcheries at Kukrail Crocodile Rehabilitation Centre, U.P. were reported by Choudhury et al (1983). Similar methods were followed by the Madhya Pradesh Forest Department. One nest each during 1981-1982, 1984,1985; 2 nests during 1987 and 4 nests during 1988 were collected by the M.P. for incubation in the hatcheries at DGRC. Data were recorded on the nest temperature and hatching success. Hatchlings were weighed and measured at the Centre.

Gharial nesting was monitored during 1985-1987 to identify new nesting sites and to determine any increase in the nest numbers. During this report preparation information on new nesting sites, number of nests and hatching of the eggs during 1988 nesting season was also collected with the help of field staff.

4.2 Population survey methods

The basking behaviour of gharial in the Chambal was studied in detail (Rao and Singh, 1987) and all the basking places along 400 km stretch of the Chambal river were identified while participating in the surveys conducted during 1983-85. During 1985-88 annual surveys were conducted in the Chambal river by boat and by walking along the banks in addition to the regular surveys conducted throughout the year (from 1985 to 1988), except during monsoon (July - September) along important stretches. The methods used for surveys in the Chambal river during 1983-85 were followed (See Singh, 1985). Similar procedures were adopted to collect similar type of information that was collected during the earlier surveys (1983-85) for a comparision of the results. All the visible gharial were counted and marked in the field map sheets. Total length of gharial sighted was determined in feet, which was converted into metric systems during data analysis. Weather conditions were recorded during the surveys. Measurements were also made, at 5 km intervals, of air and water temperature, water depth and river width. Disturbances along the river banks like agriculture, sand mining, illegal fishing, ferry services, cattle grazing and wood collection were recorded.

5. GHARIAL HABITAT

5.1 Habitat types

Gharial habitat has been extensively studied in Narayani River (Bustard, 1979,1980), Mahanadi River (Singh, 1978), Chambal river (Choudhury 1981) and Girwa River (Shrivastava, 1981). Recent studies by Singh (1985) and Rao and Singh (1987) gave fairly clear accounts on the basking and nesting ecology of gharial in the Chambal river.

Depending on the presence of rapids/falls which seperate the river into different stretches that restrict the free movement of gharial and also depending on the important nesting sites, Singh (1985) divided the river stretch from Keshoraipatan to Pachhnada into Seven Zones. They are as follows: (See Figure 2)

Zone 1 :	Keshoraipatan - Chiparda (142/113)	- 29km
Zone 2 :	Chiparda - Pali (113/0)	-113 km
Zone 3 :	Pali - Rahu Ka Gaon (0/110)	-110 km
Zone 4 :	Rahu Ka Gaon - Basai Dang(110/170)	- 60 km
Zone 5 :	Basai Dang - Pureini (170/235)	- 65 km
Zone 6 :	Pureini - Gyanpura (235/370)	-135 km
Zone 7 :	Gyanpura - Pachhnada (370/425)	- 55 km

Among them Zones 1 and 2 are not suitable for gharial as these stretches are very shallow with many rapids except at Pipalda Sand, a potential gharial nesting site from where a batch of gharial hatchlings were collected during 1979 for rearing at Kota (Singh, 1985). However, there was no further report on breeding of gharial at this place. Singh (1985) opined that due to shallowness and disturbance in this river stretch, the population at Pipalda Sand might have shifted down Pali. Gharial are present in the Zones 3 - 7 (Singh, 1985).

To describe the Gharial habitat the Chambal river was classified into 4 habitat types depending on the nature of the bank and the river depth during hot season. They are: (See Plate 1 - 6).

Type 1 : Both the banks are muddy, formed by erosion of ravines adjacent to the river and the river depth varies from 5 to 15 m. Most of these banks are used for extensive agriculture. Gharial sightings are neglible and no nesting activity in this type of habitat.

Type 2 : Both the banks are sandy or one bank is sandy and the other bank is either muddy or hard soil formed by the erosion of ravines. Deep and shallow waters with a depth of 2 to 15 m. Sand bars and sand peninsulas are present. Mid river islands with alluvial deposits are also present. There are

alterations to the sand banks every year due to erosion and deposion during monsoon high waters.

Type 3 : One bank is sandy and other bank is rocky. Rocks are also present in the mid river islands. River depth varies from 4 to 12 m. Gharial lay eggs in such habitats, provided there are steep sand banks. Because of monsoon high waters the sand banks alter considerably making the steep sand banks into flat sand banks. Vegetation on nesting sites is present, dominant species is Tamarix dioca.

Type 4 : Both the banks are rocky with alluvial deposits. The river is deep and fast and at some places shallow riffle areas are present. Maximum depth of the river is about 20 m. This type of habitat is less suitable for gharial. Nesting usually occurs in the alluvium that is deposited in between Rocks. Alterations of the nesting sites occur every year as in type 2 and 3 habitats.



Plate 1. Chambal river at Pureini in the North National Chambal Sanctuary. Both the banks are sandy (Habitat Type 2). The river bank in the foreground was used by 10 gharial for nesting during 1985.

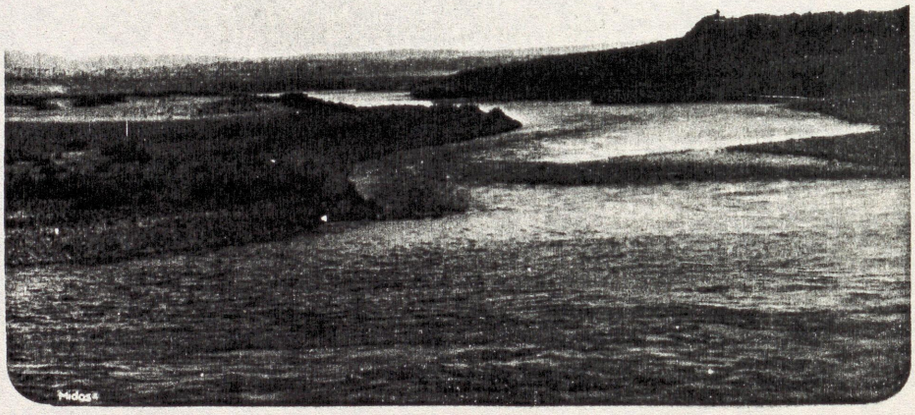


Plate 2. Chambal river at Banwara in the South National Chambal Sanctuary. Both the banks are rocky with alluvial deposits (Habitat Type 4).

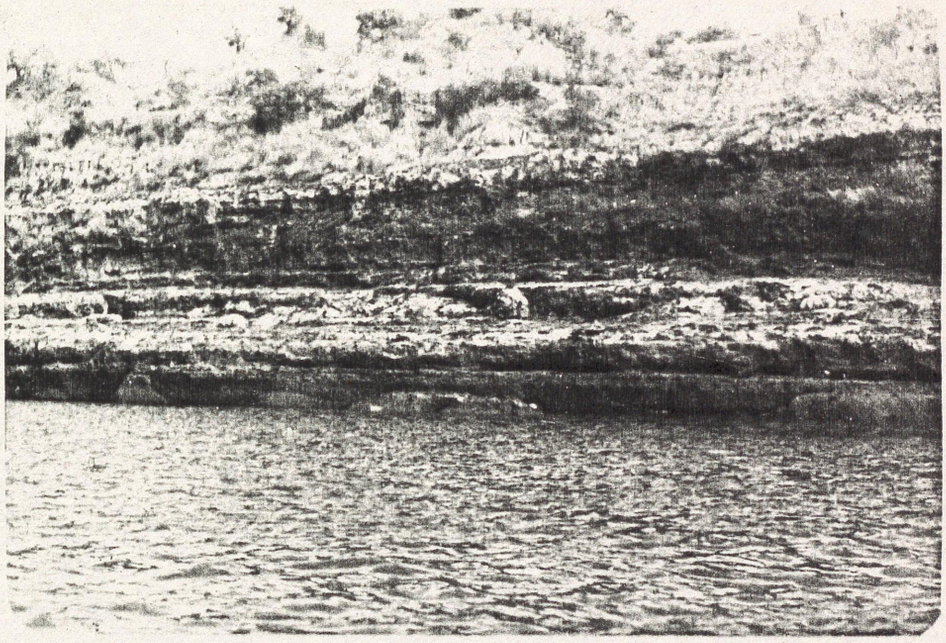


Plate 3. Hard soil river bank (Habitat type 1)

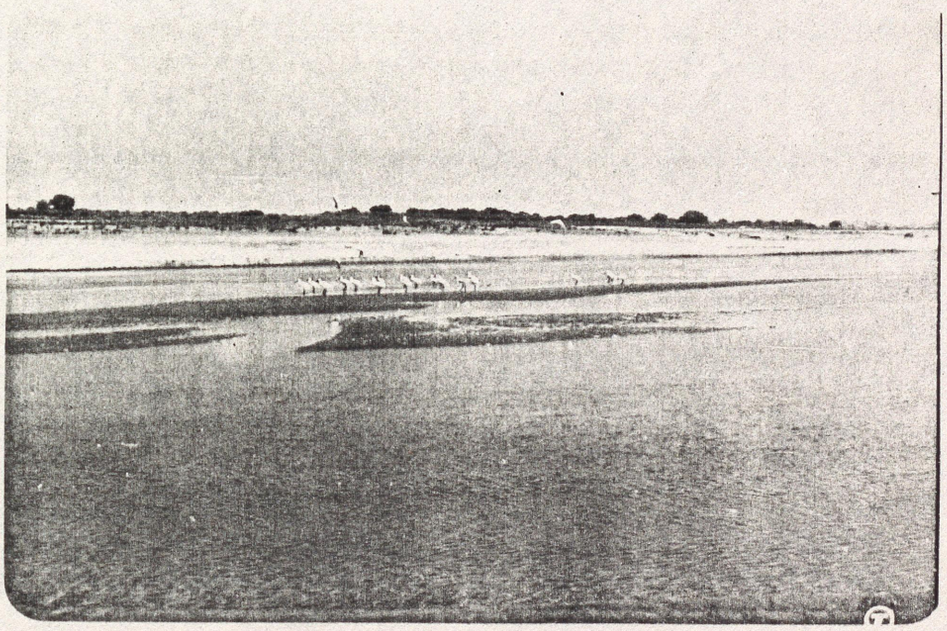


Plate 4. Sandy river bank and sandy peninsulas in the mid river. (Habitat Type 2)

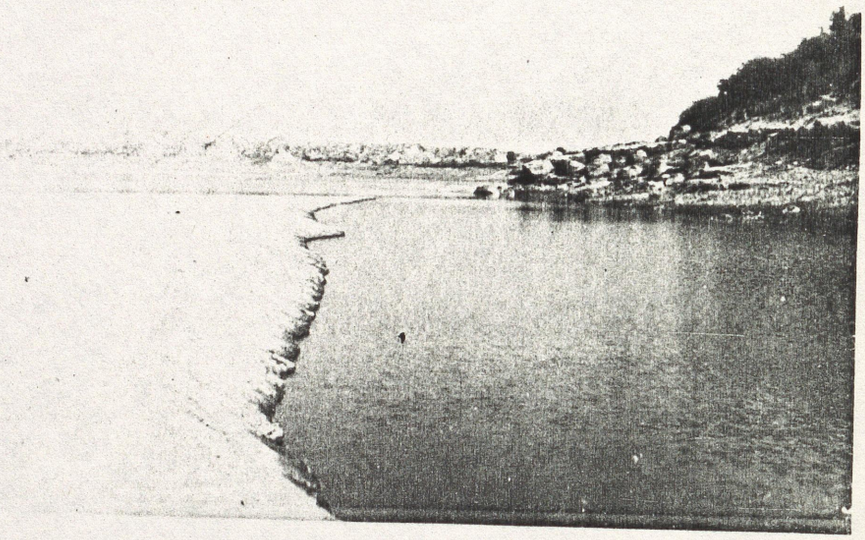


Plate 5. One bank of the river is sandy and other bank is rocky (Habitat Type 3).



Plate 6. Rocky river banks with shallow riffle areas (Habitat Type 4)

6. GHARIAL NESTING IN THE CHAMBAL RIVER

6.1 Nesting distribution - 1985-87

According to Rao and Singh (1987) a total of 5 nesting sites were identified in the Chambal river till 1984. Surveys conducted during 1985-1987 to locate new nesting sites have shown progressive results. The results of surveys are shown in Table 3. A total number of 7, 10 and 12 nesting sites were identified during 1985, 1986 and 1987, respectively, where a total of 33, 37 and 45 nests were located. Of the 45 nests located during 1987, twenty seven nests (60%) were located in the South Chambal river (Pali to Rajghat - 195km) with a density of 0.13 nest per km and rest of the 18 nests (40%) were located in the North Chambal river (Rajghat to Bareeh -210km). The density was 0.08 nest per km (Fig. 5 & 6).

Table 4 shows the number of nests located during 1987 in different habitat Types. More than half of the nests (24 =53.3%) were in the Type 2 habitat; 18 nests (40%) were in the Type 3 habitat; 3 nests (6.6%) were in the Type 4 habitat and none in Type 1 habitat. Because gharial prefer to lay eggs on sand bank (Rao and Singh, 1987) nesting was not found in the areas where there is no sand. In the Type 2 habitat where sand bars and peninsulas are present gharial bask on these peninsulas near nesting sites and keep watch on the nests against nest predation. Similarly, rocks on the other side of the nesting bank in the Habitat Type 3 and 4 are used by gharial for basking thereby guard the nests.

Table 3. Number of gharial nests in the National Chambal Sanctuary(1985-88) (Updated over Singh, 1985) (See Figure 5 & 6 for nesting site location)

Nesting site	Number of nests			
	1985	1986	1987	1988
Bagdia sond	?	1	2	2
Gobarda	-	1	2	3
Baroli	12	14	14	9
Nadigaon	1	2	3	10
Banwara	1	1	1	1
Bharra	5	5	5	4
Basaidang	-	-	?	1
Tigri-Rebhoura	2	6	8	5
Papripura	-	-	-	1
Pureini	10	1	2	4
Daljitpura	-	-	-	1
Barsala	-	4	2	2
Barenda	-	-	3	3
Khera	-	-	1	2
Gyanpura	2	2	2	2
Total	33	37	45	50

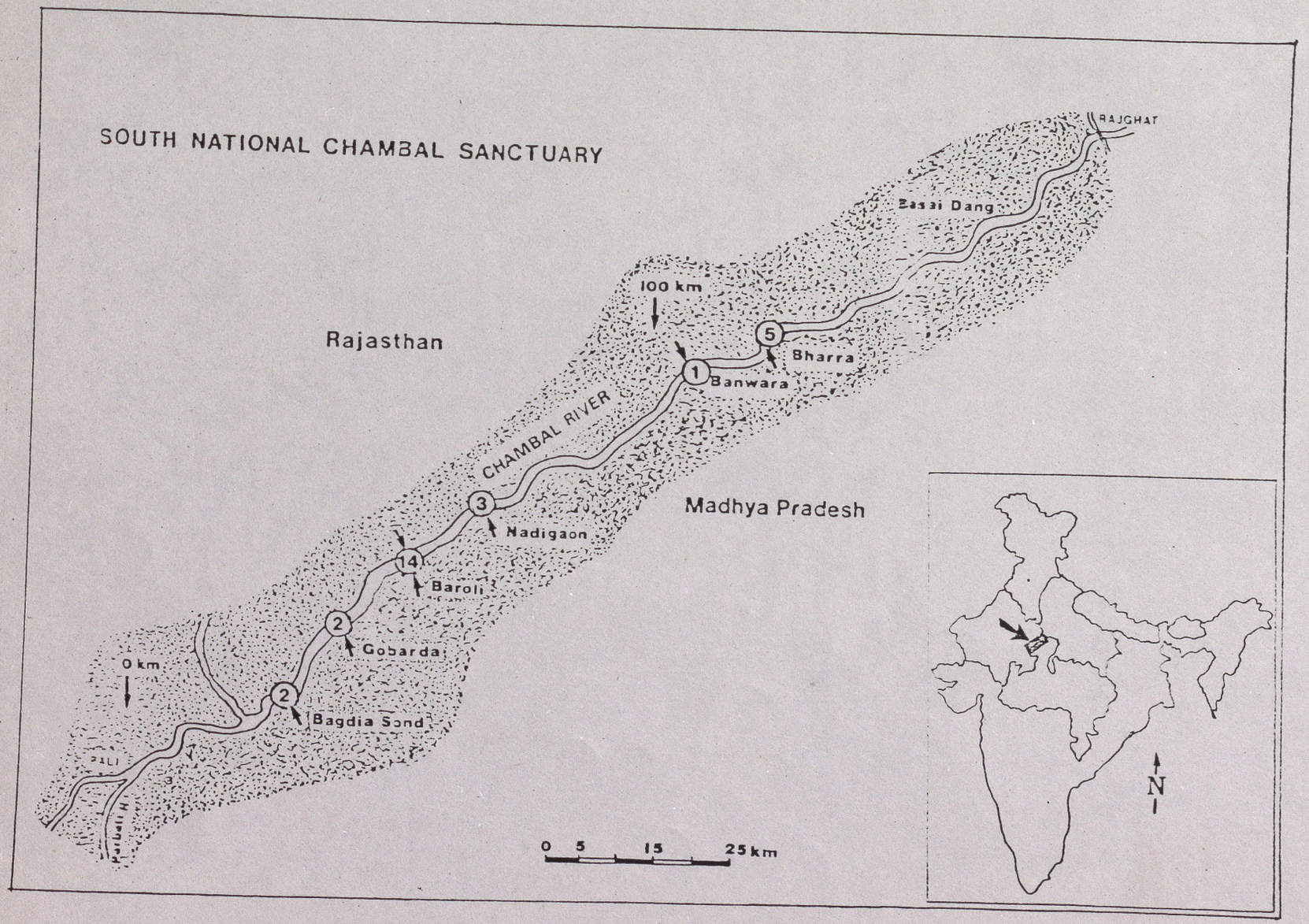


Fig. 5. Map of South National Chambal Sanctuary showing gharial nest distribution and relative densities at different nesting sites during 1987.

Arrows point out nesting banks. Numbers show the number of nests.

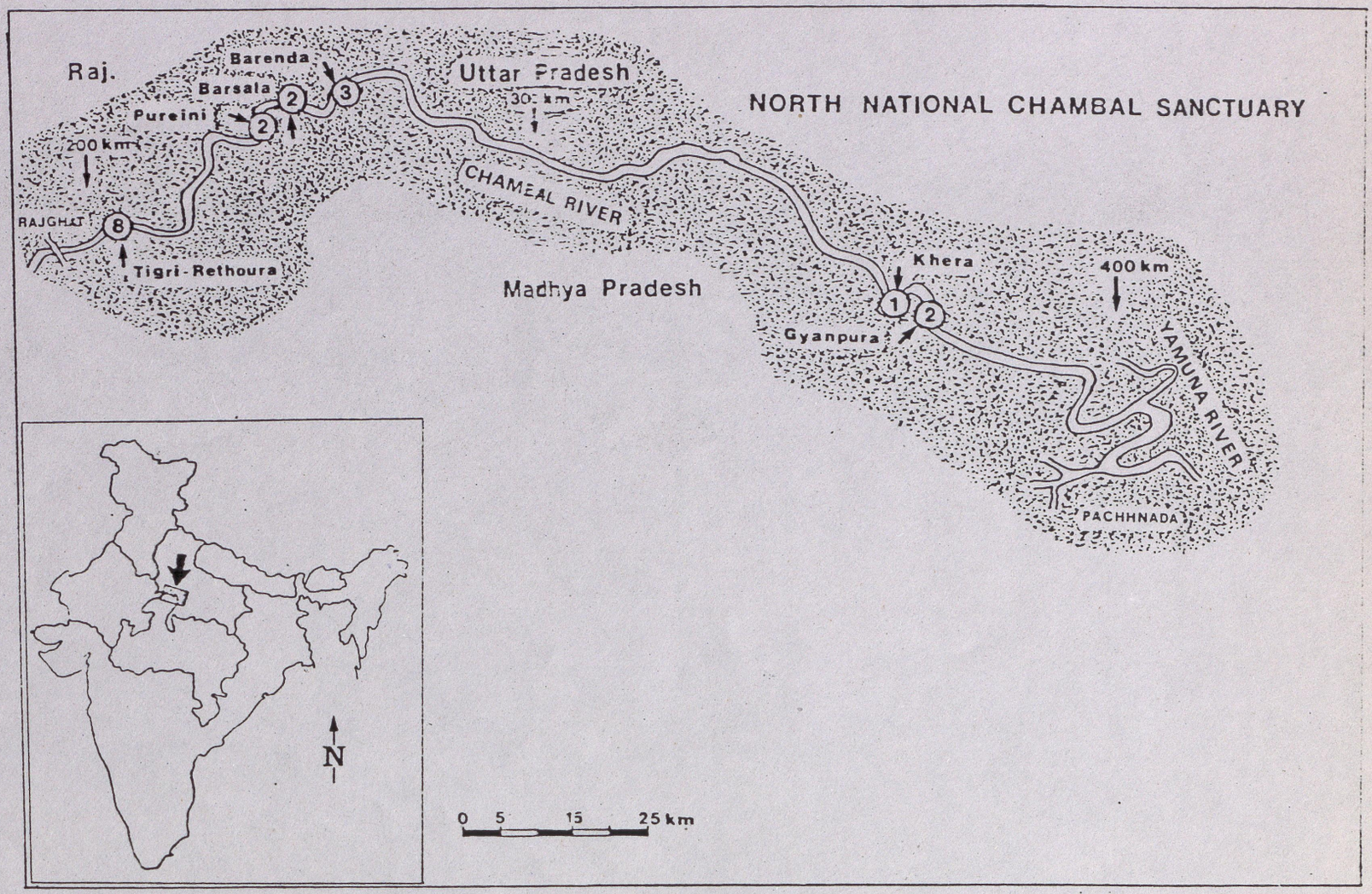


Fig. 6. Map of North National Chambal Sanctuary showing gharial nest distribution and relative densities at different nesting sites during 1987. Arrows point out nesting banks. Numbers show the number of nests.

Table 4. Number of gharial nests located in different habitat types during 1987. Percentages are in parentheses.
(See text at page 22 for description of habitat types)

S.No.	Nesting site	Location km*	Habitat Type 1	Habitat Type 2	Habitat Type 3	Habitat Type 4	Total No. nests
1.	Bagdia Sond	27	-	-	2	-	2
2.	Gobarda	45	-	-	-	2	2
3.	Baroli	57	-	1	13	-	14
4.	Nadigoan	67	-	-	3	-	3
5.	Banwara	113	-	-	-	1	1
6.	Bharra	130	-	5	-	-	5
7.	TigriRehoura	207	-	8	-	-	8
8.	Pureini	229	-	2	-	-	2
9.	Barsala	242	-	2	-	-	2
10.	Barenda	260	-	3	-	-	3
11.	Khera	360	-	1	-	-	1
12.	Gyanpura	368	-	2	-	-	2
			0	24	18	3	45
			(0)	(53.3)	(40.0)	(6.6)	

*** Pali as Zero km.**

Nest distribution during 1985-87 along different Zones are shown in Table 5. During 1987, maximum number of nests (21 =46.6%) were located along the Zone 3 in which a total number of 14 nests (66.6%) were located from Baroli nesting site. A total number of 6 (13.3%0; 10 (22.2%) and 8 (17.7%) nests were located along Zone 4, 5 and 6, respectively(Fig.2).

According to nest distribution three important Core areas were selected for intensive conservation programmes (Fig. 7 and Table 6). Area I is approximately 109 km. During 1987, a total number of six nesting sites and 27 gharial nests were found along the Core area I giving a density figure of 0.24 nest per km. Along 90 km (approx.) of the Core area II four nesting sites were identified where a total of 15 nests was located. The density per km was 0.2 nests. The last nesting area, inside the Sanctuary, was considered as Core area III which was approximately 24 km. Along this area a total of 3 nests were located in 2 nesting sites. The density of nests was calculated as 0.12 nest per km. There is a gradual increase in the number of nesting sites and number of nests from 1985 to 1987 along different Core areas (One nest along the Core area II was not located during 1986).

Table 5. Summarised results of gharial nesting surveys during 1985-1987 along different Zones in the Chambal river. Percentages are in parentheses

*** Pali as zero km.**

Zone No.	Mile post*	Number of nests		
		1985	1986	1987
Zone 3	0/110	13 (39.3)	18 (48.6)	21 (46.6)
Zone 4	110/170	6 (18.1)	6 (16.2)	6. (13.3)
Zone 5	170/235	12 (36.3)	7 (18.9)	10 (22.2)
Zone 6	235/370	2 (6.0)	6 (16.2)	8 (17.7)
		33	37	45

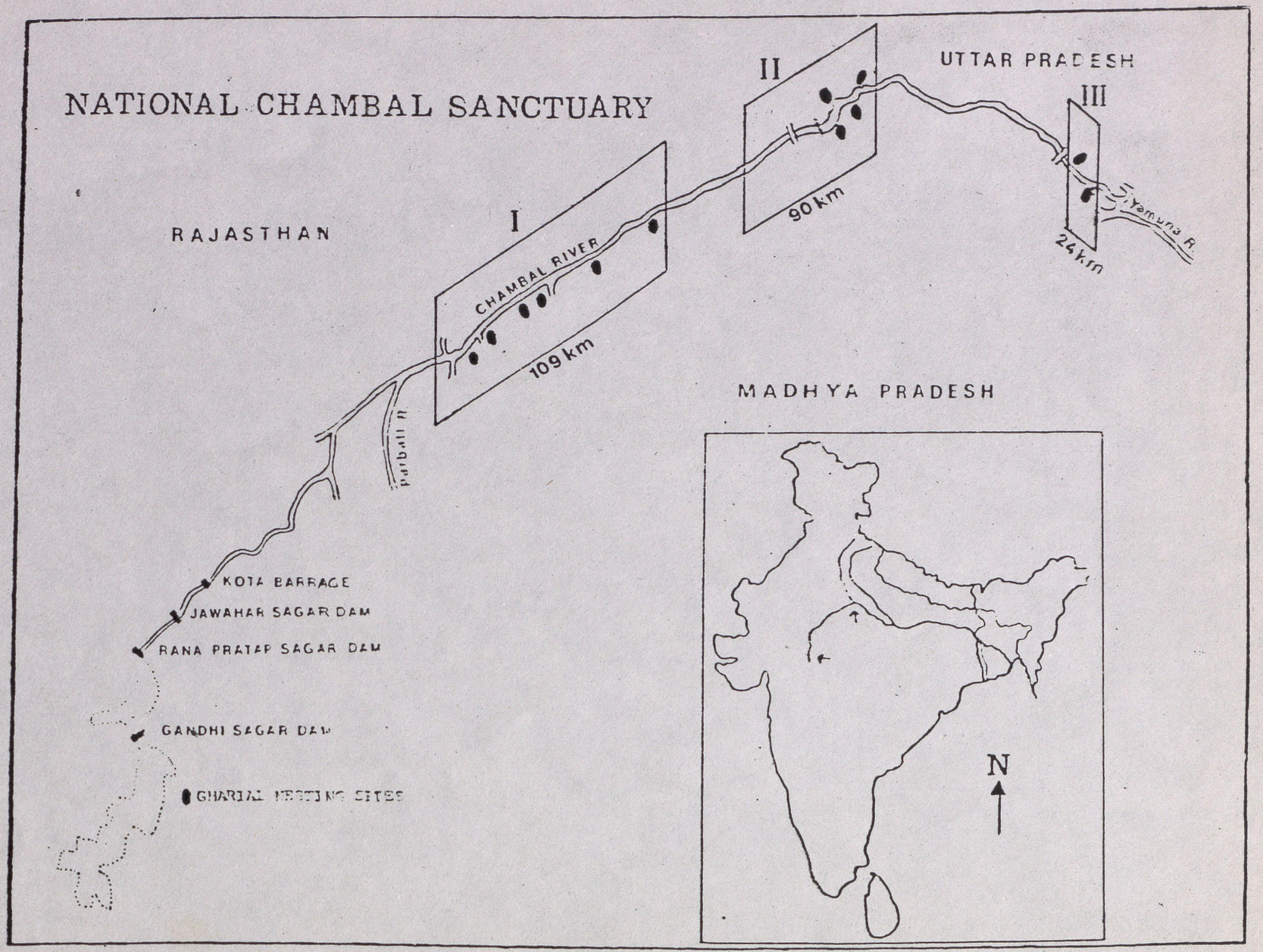


Fig. 7. Map of National Chambal Sanctuary showing gharial nesting sites in different core areas during 1987.

Table 6. Gharial nesting densities during 1985-1987 along three core areas. * Pali as zero km.

Area No.	Location (km*)	Total distance (km)	No. Nesting sites 1985	1986	1987	No. nests 1985	1986	1987
Core Area I								
Rameswar-Bharra	22-131	109	4	6	6	19	24	27
Core Area II								
Basaidang-Barenda	172-262	90	2	3	4	12	11	15
Core Area III								
Samanna - Titaoli	357-381	24	1	1	2	2	2	3

6.1.1. Nesting distribution - 1988

During 1988, a total of 50 gharial nests were located in a total number of 15 nesting sites, an increase of three nesting sites and 5 nests over 1987 (Table 3 and 7). There were changes in the nesting sites and the number of nests in different nesting sites. There may be two more nests in addition to the two nests located at Bagdia Sond nesting site as adult gharial sighted during annual survey in February 1988 were more than 2 (see Table 19). Thorough search has to be conducted during 1989 nesting season at this place to get exact number of nests. There was an increase of 1 nest at Gobarda (2 nests in 1987). The nesting site at Gobarda on M.P. side of the river bank where 2 gharial nested during 1987 was washed out during 1987 monsoon floods. All three gharial had migrated 2 km down-stream and laid eggs on the Rajasthan side of the bank. Number of nests were reduced at Baroli from 14 in 1987 to 9 in 1988. Because of constant disturbance some gharial had shifted to down-stream and laid eggs at Nadigaon nesting site. A total of 10 nests were found at Nadigaon during 1988, an increase of 7 nests over 1987. Nesting site at Tigri-Rethoura was a steep sand bank during 1987 where 8 gharial had nested. The steep sand bank was washed out during 1987 floods.

Table 7. Gharial nesting data during 1988.

S.No	Nesting site	No. nests	State Territory	Zone no.	No. nests	Core Area	No. nests
1.	Bagdia Sond	2	M.P.				
2.	Gobarda	3	Raj.	Zone 3	24	Core Area I	29
3.	Baroli	9	Raj./M.P.				
4.	Nadigaon	10	M.P.				
5.	Banwara	1	Raj.	Zone 4	6		
6.	Bharra	4	Island				
7.	Basaidang	1	Island				
8.	TigriRehtoura	5	M.P.				
9.	Papripura	1	Raj.	Zone 5	10		
10.	Pureini	4	Raj.			Core Area II	17
11.	Daljitpura	1	M.P.				
12.	Barsala	2	M.P.				
13.	Barenda	3	U.P.	Zone 6	10		
14.	Khera	2	U.P.			Core AreaIII	4
15.	Gyanpura	2	M.P.				
		50					

Note: See table 5 & 6 for places under various Zones and Core areas

Due to loss of suitable nesting site only five gharial nested at this place and the rest have moved down-stream. Three new nesting sites were identified. They are: Basai dang, Papipura and Daljitpura where 1 nest each was located.

There was an increase in the number of nests along different Core areas - 29 along Core area I, 17 along Core area II and 4 along Core area III (Table 7). Number of nesting sites was also increased from 4 in 1987 to 7 in 1988 along Core area II. New nesting sites were not found along Core area I and III (Fig. 8 and Table 7).

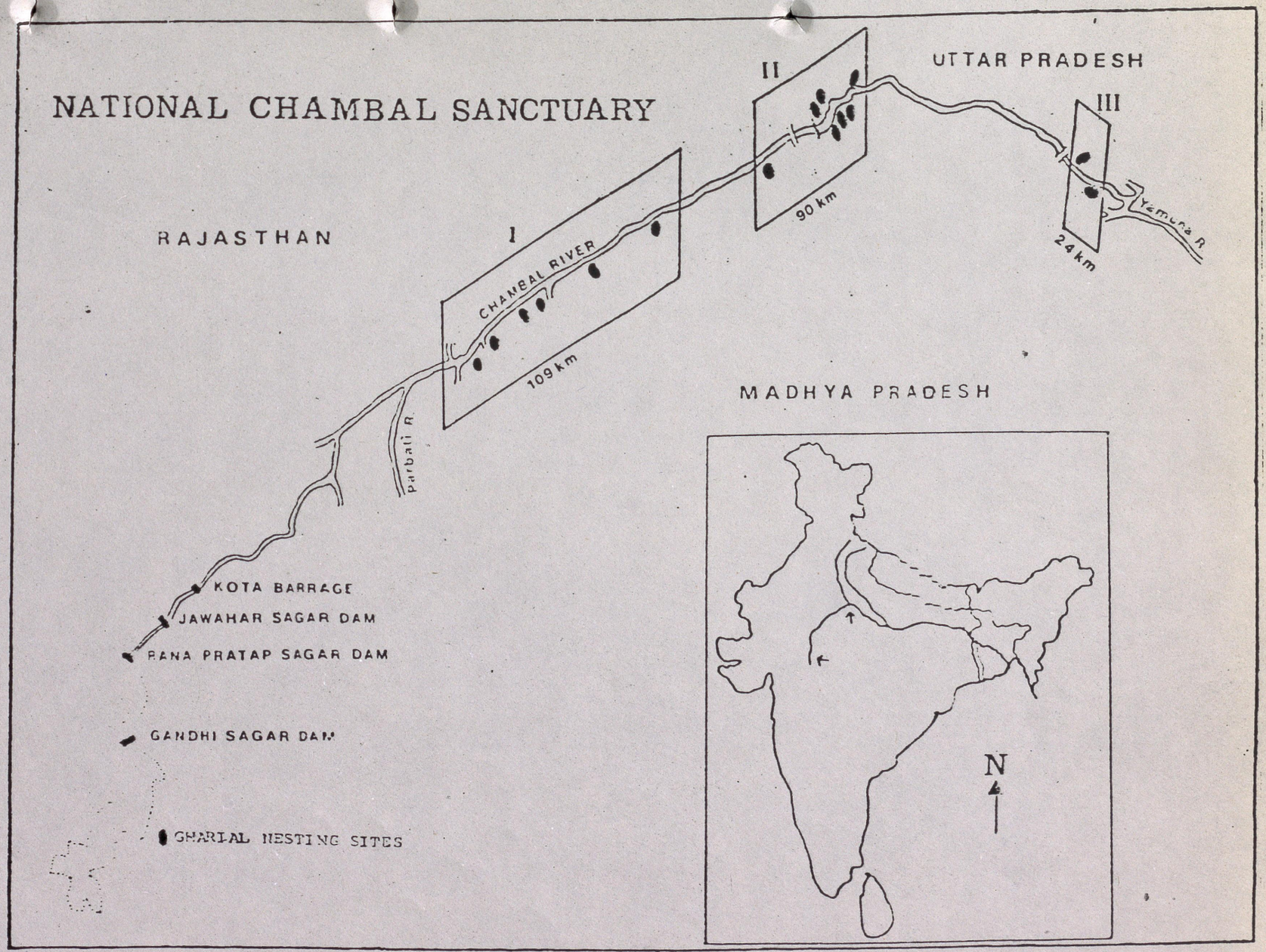


Fig. 8. Map of National Chambal Sanctuary showing gharial nesting sites in different core areas during 1988.

6.2 Nesting sites

Names of important villages of Madhya Pradesh/Rajasthan and Madhya Pradesh/Uttar Pradesh near gharial nesting and basking sites are given in Table 8 and 9. Details of different nesting sites in different Zones (3 - 7) and their management problems are summarised below.

6.2.1. Zone 3

1. Bagdia sond

This nesting site was identified in the month of February 1986 during annual gharial census surveys. This nesting site is located 25 km down-stream of Chambal-Parbati confluence, Pali (Fig. 5 and Plate 7). This is the first sand bank in the Chambal river after Parbati joins Chambal at Pali. The nesting site is of Type 3 habitat. The nesting site is an island of approx. 4 sq.km Access to the nesting site is possible only with boat for 2 months during wet- season. During summer and winter seasons (Oct.-June) the nesting site is easily approachable from Southern side (M.P.) of the river on foot from the village, Bagdia Sond, which is 3 km east of the nesting site. The island is extensively used for agriculture by the local villagers. The villagers dig trenches along the river bank to grow vegetables. Illegal fishing activity do come to notice from this area.

Table 8. IMPORTANT VILLAGES OF RAJASTHAN/M.P. NEAR GHARIAL BASKING AND NESTING SITES IN THE NATIONAL CHAMBAL SANCTUARY

(up-dated over Singh 1985)

** Gharial nesting sites

* Pali (Sawai Madhopur) Chambal/Parbati confluence as Zero Km.

S.No	Mile post*	Rajasthan	Madhya Pradesh
1.	22	Barwas	Rameshwar ghat
2.	27**	Piluwsla	Bagdia Sond
3.	40	Bagharu	Dateti
4.	45**	Kureri	Gobarda
5.	57**	Karanpur	Baroli
6.	67**	Ghunsol	Nadigoan
7.	85	Rodham	Barotha
8.	103	Mandrael	Atqr
9.	113**	Onrh	Banwara
10.	120	Kherladanda	Nareka pura
11.	130**	Karitir(136km)	Bharra
12.	145	Pali/Sewar	Chinnouni
13.	163	Barpura	Sarsaini
14.	172**	Basai Dang	Sawda
15.	179	Chalipura	Tursipura
16.	187	Dev ka pura	Bindwa
17.	207**	Tighra	Rethoura
18.	197**	Sankarpura	Bhavesuri
19.	225	Chilpura	Babusingh ke gher
20.	233**	Pureini	Pura Dalgit
21.	242**	Barsala	Garhi
22.	252	Samouna	Holapura

Table 9. LIST OF IMPORTANT VILLAGES OF U.P./M.P. NEAR GHARIAL BASKING AND NESTING SITES IN THE NATIONAL CHAMBAL SANCTUARY
(Up-dated over Singh, 1985)

** Gharial nesting sites

* Pali (Sawai Madhopur) Chambal/Parbati confluence as Zero Km.

S.No.	Mile post*	Uttar Pradesh	Madhya Pradesh
1.	260**	Kachiara	Rached
2.	265	Barenda	Pura Gadarian
3.	280	Nagla Keori	Raipur
4.	287	Jeora	Khurd
5.	290	Pura Shivlal	Kuretha
6.	297	Kenjra	Shas Ka pura
7.	320	Nandagawan	Salimpura
8.	333	Bhanwar	Bijora
9.	342	Baswara	Jori
10.	360**	Khera Ajabsingh	Naigarh
11.	368**	Kasaua	Gyanpura
12.	380	Jagtauli	- (U.P.)
13.	390	Khundaul	-
14.	395	Chaprauli	-
15.	405	Patharra	-

Information gathered from local villagers revealed that gharial have been nesting at this place well before 1986. Perhaps, this information has been wrongly cited "Dateti" nesting site in the previous work (Singh, 1985). It is presumed that the breeding population at this nesting site might be migrated from Pipalda sond where nesting of gharial was reported till 1979 (See page 22). The male gharial at this place would be about 6 m. Only one nest was found during 1986 and 2 nests each were located during 1987 and 1988. There may be more nests at this place. A thorough survey is needed to prove this in the next nesting season.

Other important wild animals in this area are turtles, mugger, otters, and different species of resident and migratory birds. Turtles, mostly Kachuga species lay eggs on the gharial nesting site. Indian skimmer and River tern also lay eggs on the sand banks.

2. Gobarda

This nesting site was identified during 1986. This place is 45 km down-stream of Pali (Fig. 5 & Plate 8). This area comes under Type 4 habitat. The nesting bank formed by alluvial deposits is around 100 sq. m. Huge rocks are present at the nesting site. Rocks were also present below the sand. During 1986, one nest was found and 2 nests were located during 1987. Nests were found on southern bank (M.P.) of the river. During 1987 monsoon floods the nesting site was washed out. A total of 3 gharial nested during 1988 on the other side (Raj.) of the bank, 2 km down-stream of the 1987 nesting site. This area is undisturbed, however, occasional illegal fishing was reported from this place. The nesting site is accessible on foot from a village Milawali, which is 2 km away from the river on M.P. territory.

Adult muggers were found at this place. This place is a good nesting site for mugger. One mugger nest was found 50 m away from gharial nests during 1988. Otters and turtles are present at this place.



Plate 7. A nesting bank at Bagdia Sond. Note the track of nesting female. Nest was located 50m away from the water.



Plate 8. A nesting ground at Gobarda. Sand from this nesting bank was washed out during 1987 monsoon floods.

3. Baroli

Gharial nesting at this place was known since 1976. However, no systematic study has been conducted on the nesting of gharial at Baroli till the initiation of the present study. Baroli is located 57 km down-stream of Pali (Fig. 5 and Plate 9 & 10). The nesting habitat is of Type 3 habitat. The nesting site is an island of approx. 1 km in length that rises to about 7 m above water during the dry season. More than 850 m length of the island is covered by sand and xerophytic bushes while the remaining area is covered by rocks and Acacia plants. During the summer when the water level of the river goes down, the right (southern) bank of the island connects with the main-land. During 1985 and 1986 nesting occured on the left bank of the island along side which the river is more than 10 m deep and fast flowing. The nesting site is accessible during winter and summer seasons on foot from the village Baroli (2.5 km from the river in M.P.)

This is the major communal nesting site. A total of 12 and 13 gharial nests were found on the island during 1985 and 1986, respectively. One nest during 1986 was located on Northern bank (Rajasthan) of the river. During 1986, the steep sand bank on the nesting site was completely washed out in the monsoon floods. The erosion was mainly due to cutting of vegetation on the island by the neighbouring villagers. All female gharial, except one,



Plate 9. A colonial nesting bank at Baroli where highest number (13) of gharial nests were located during 1986. The nesting site was washed out during 1986 monsoon floods.

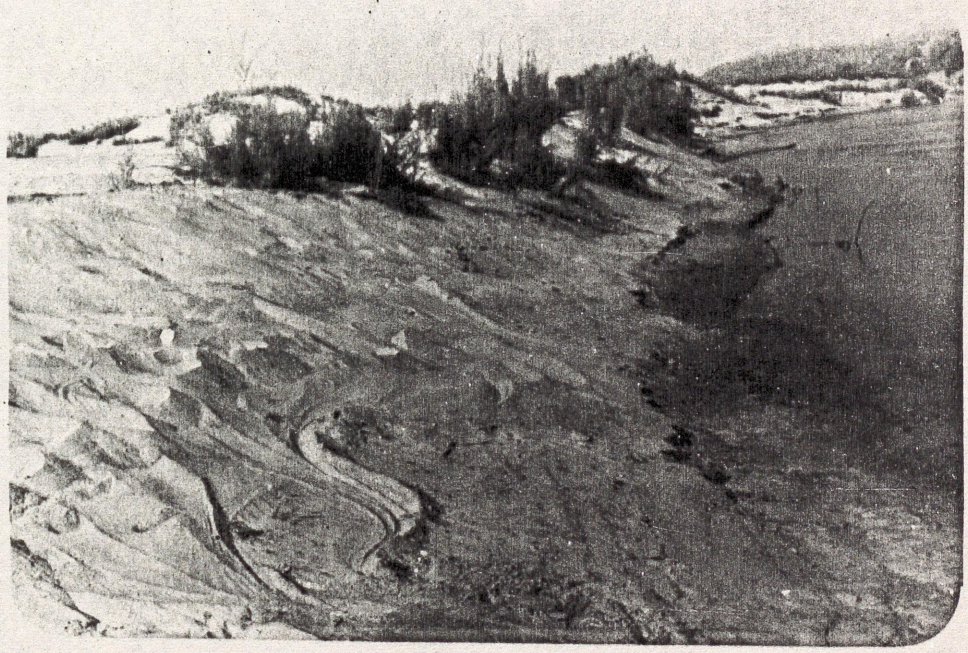


Plate 10. A nesting bank at Baroli. Note the tail markings of nesting females on the sand bank.

laid eggs on northern bank of the river in three areas seperated by 1.5 and 0.5 km, respectively. Only one nest was found on the island (Fig. 9). During 1988, two nests were found on the island and 7 nests were located on northern bank (Raj.) of the river in two sites (4 + 3) seperated by 1.5 km. Remaining gharial have migrated to down-stream. There are two adult male gharial at Baroli, one is of 6.5 m (approx.) in length and the other is an young male that would be about 5 m in length. This young male was first sighted during October 1986. Both male gharial are taking part in breeding without any territorial fights.

Other important animals are turtles, mugger, otters and migratory birds. Nesting of Kachuga species occur on the gharial nesting bank (Plate 12). Some nests of Kachuga species were also found in between gharial nests. This may be an advantage for turtle to avoid any possible predation of their eggs by jackal. Predation of turtle nests was high at this place and some turtle nests near gharial nests were also found to be predated. Gharial nests were also predated by jackal at this communal nesting site (See Table 15). Mugger also nest at this place (Plate 11). A total of 3 mugger nests were located near gharial nests during 1987, however, all nests were predated by jackals.

Disturbance at this nesting site is high. People carry on agriculture on the river banks, cut vegetation from the island and also from the river banks and operate illegal fishing (Plates 13 &14).

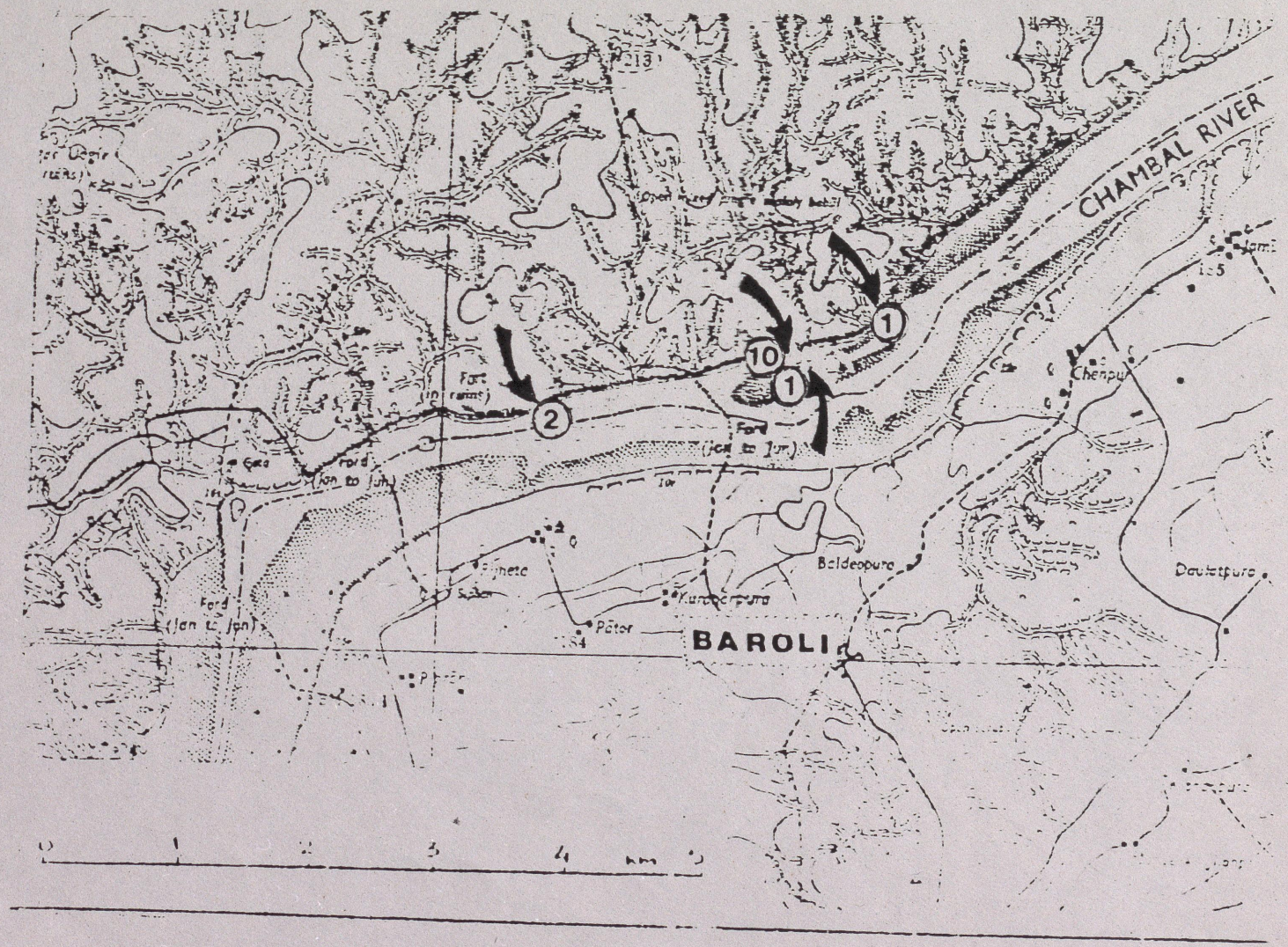


Fig. 9. Gharial nesting distribution at the Baroli nesting site during 1987. Arrows point out nesting banks. Numbers show the number of nests.

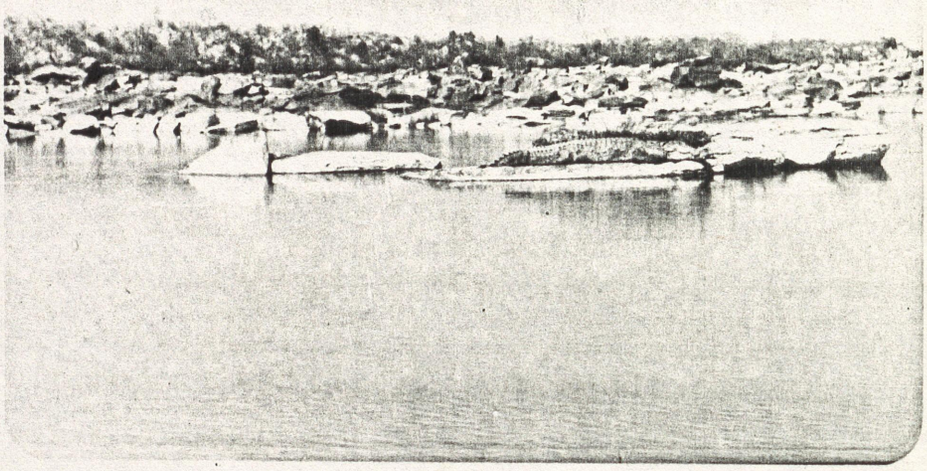


Plate 11. Mugger Crocodylus palustris also lay eggs in the nesting bank of gharial at Baroli.

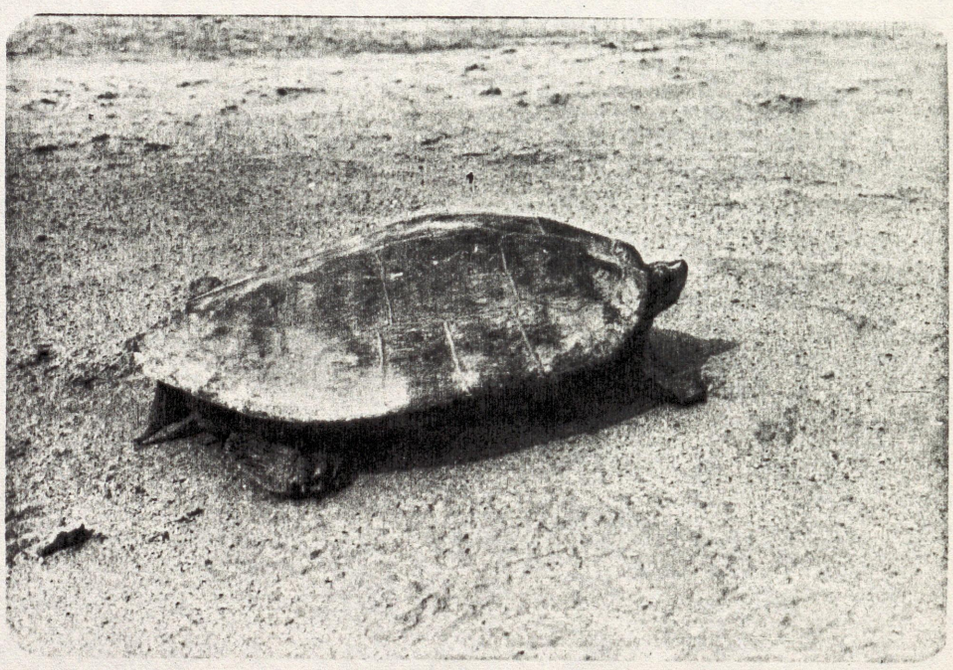


Plate 12. Kachuga dhongoka one of the 3 Kachuga species which lay eggs in between gharial nests.

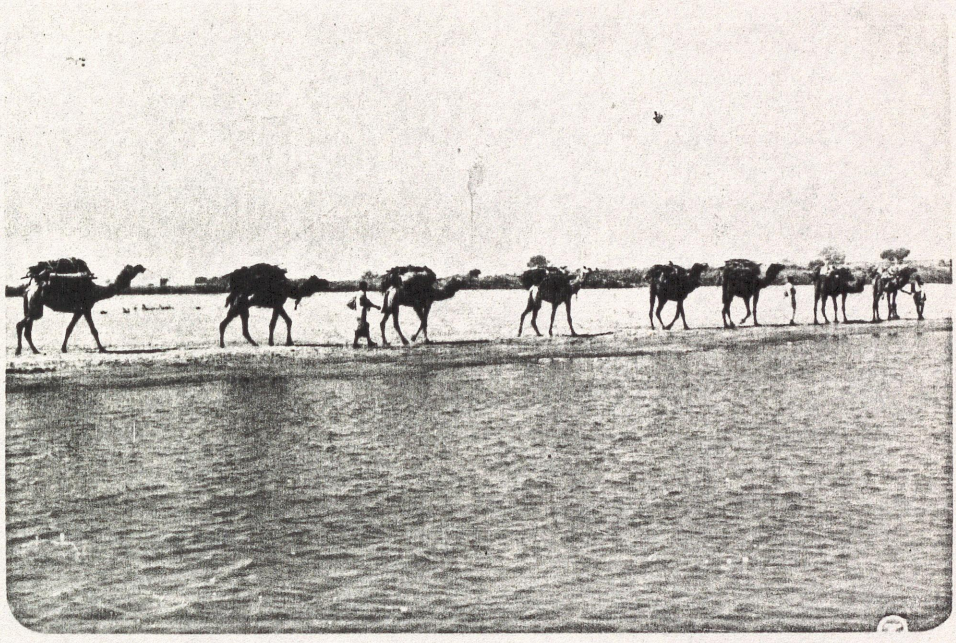


Plate 13. Human disturbances on the river banks. Wood cutters taking wood on camel-backs.

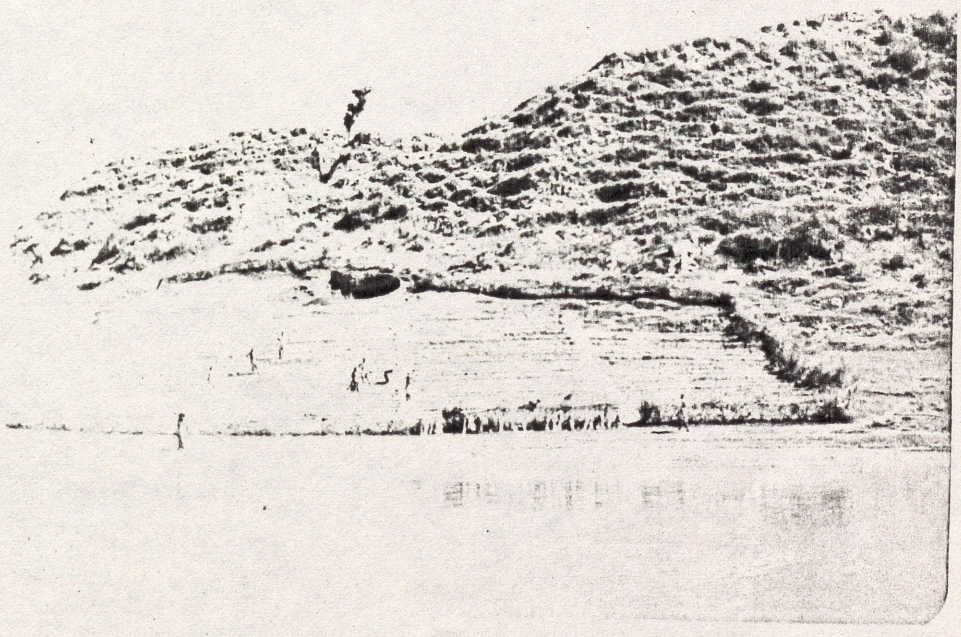


Plate 14. Agricultural practices on the river banks.

4. Nadigaon

Gharial lay eggs on an island which is approximately 1.5 km in length. The island is partially covered by bushes of Tamarix dioca. The area is of Type 3 habitat. The nesting site is 68 km down-stream of Pali (Fig. 5 and Plate 15) and is accessible from M.P. side. During 1985, 1986 and 1987 the number of nests found at this place were 1, 2 and 3, respectively. During 1988 there was a sudden increase in the number of nests. A total number of 10 gharial nests were located, most of the nests were laid by the gharial those who have migrated from Baroli nesting site, which is 10 km away in the up-stream.

Other reptiles which lay eggs at this nesting site were mugger and turtles (Kachuga sp.). During 1988, a total number of seven mugger nests were located at this place. All 10 gharial nests and seven mugger nests were present in an area of 500 m. Otters were also present and during winter many wet-land birds visit this place. Turtle egg predation by jackal was found, but predation of gharial and mugger eggs were not found. Protection to the eggs is only by mother. One clutch of mugger eggs was collected by the Madhya Pradesh Forest Department during 1987 for captive rearing programme. On 19 Feb., 1985 during the annual survey two male gharial were seen fighting at this place. One male was resident and other male was from Baroli, which was relocated at Baroli on 28 Feb. with severe injuries to its snout.

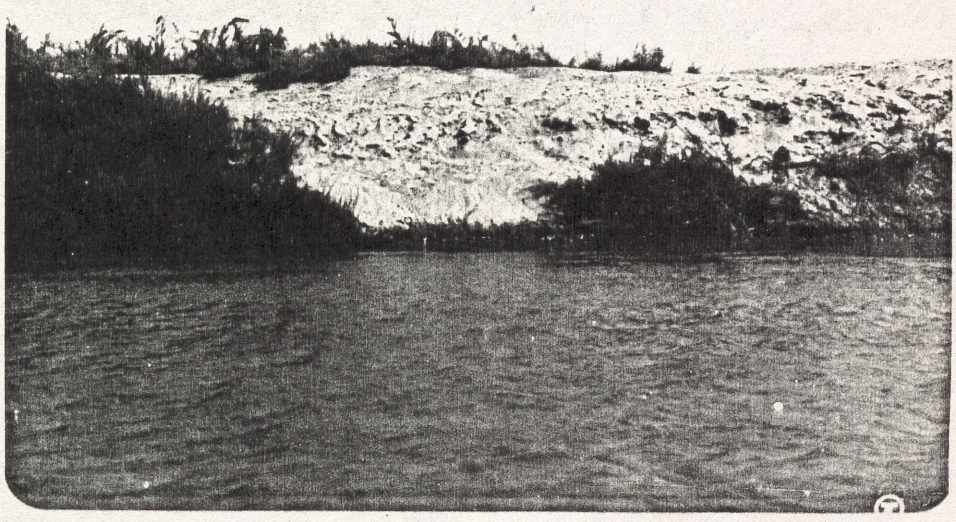


Plate 15. A colonial nesting bank at Nadigaon. Note the steep sand bank and thick vegetation (Tamarix dioca). Muggers also lay eggs at this bank.

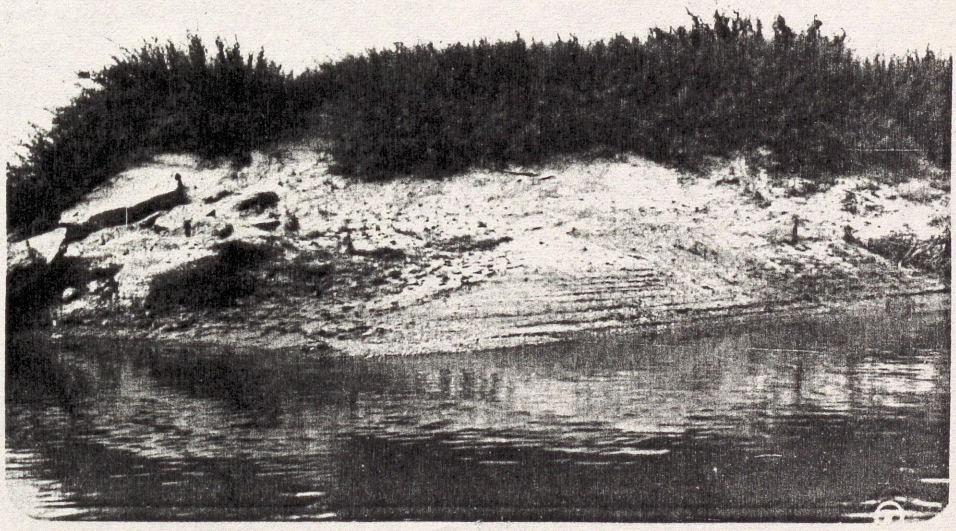


Plate 16. A colonial nesting bank on an island at Bharra. Alluvium in the foreground is used by gharial for nesting.

6.2.2. Zone 4

5. Banwara

Gharial nesting was reported for the first time during 1984. It was confirmed during 1985 when one nest was located on Northern side of the river (Rajasthan) on an island of approx. 500 sq.m. This area is 112 km down-stream of Pali (Fig. 5). A big water-fall/rapid located 3 km up-stream of the nesting site at Rohu ka gaon seperates the river from where free movement of aquatic fauna become restricted. The nesting site at Banwara is rocky (Type 4 habitat) with a small sandy area (100 m) covered by xerophytic bushes (Tamarix dioca) where one gharial had nested during 1985-1988.

Turtle (Kachuga sp.) also use this sand bank for nesting. Signs of occurence of otters and mugger were found at this place.

This area is undisturbed except occassional illegal fishing activity.

6. Bharra

Bharra is an important nesting site from where Uttar Pradesh Forest Deprtment had collected eggs during the initial stages of the 'grow and release' programme. This place is situated 130 km down-stream of Pali(Fig. 5 and Plate 16). Access to the nesting bank is with boat. The nesting site is of Type 3 habitat. Gharial lay eggs on alluvial deposits on a mid-river rocky island. The island is covered by rocks and xerophytic vegetation (Acacia sp.). The nesting area where 5 nests were located during 1985 and 1986 is 35 x 12 m. During 1986 one nest was located on the mainland (M.P.) and 4 nests on the island. Only 4 nests were located during 1988 at this nesting site.

Important wild animals present in addition to gharial at this place are turtles, mugger, otters and dolphins. Mugger used adjacent island for nesting and turtles laid eggs on the main-land. Dolphin sightings were common at this place and 10 km up-stream from this place is the upper limit for the dolphin distribution in the Chambal river. Migratory birds also visit this place.

The area is undisturbed except occasional illegal fishing activity and wood cutting from the northern side (Raj.) of the bank.

6.2.3. Zone 5

7. Tigri-Rethoura

This nesting site is located in the North Chambal river and is 208 km down- stream of Pali and 15 km down-stream of Rajghat (Fig. 6). The habitat is of Type 3. The nesting site is an island of 100 m in length where 2 gharial had nested till 1985. However, due to erosion of soil on the island the gharial abandoned the island and started nesting on the main-land on M.P. side of the river bank. A total of 6 and 8 nests were located on the main-land during 1986 and 1987, respectively. Again in 1987 monsoon high-waters the steep sand bank on the mainland was washed out making the nesting site into flat sand bank where only 5 gharial had nested during 1988 nesting season and the remaining gharial have migrated down-stream for egg-laying. Uttar Pradesh Forest Department is regularly collecting gharial eggs from this place. Madhya Pradesh Forest Department has collected eggs from this place during 1987 and 1988.

Freshwater turtles (Kachuga sp.) also use the nesting site both on island and on mainland for nesting. One dead specimen of Brahminy terrapin Hardella thurgii was found at this place, which is a record specimen for Chambal river. Otter tracks were observed. Dolphin sightings are very common. Many migratory birds visit this place.

Disturbance at this place is minimal. This place is best suitable for visitors to see wild animals.

8. Pureini

Pureini is located in the North Chambal river, 230 km down-stream of Pali (Fig. 6 and Plate 1). Nesting occurs on the northern bank (Rajasthan), which is an open sand bank. This nesting site is one of the oldest and important nesting site. From 1976 U.P. Forest Department is regularly collecting gharial eggs from this place. The nesting site is of Type 2 habitat. This place is accessible from Dholpur city, which is 30 km west to the nesting site. During 1985, a total of 10 gharial nests were located at this place. The nest distribution is shown in Fig. 10. However, in 1986 only one gharial had nested at this nesting site and the remaining gharial had migrated to other places for nesting. Reasons for this shifting are not known. It is presumed that all gharial might have disturbed due to continuous egg collection under management practices or due to human activities like agriculture and illegal fishing near nesting site. A total of 2 and 4 nests were located during 1987 and 1988, respectively. Egg collection was stopped from 1987 onwards from this nesting site.

Other important aquatic animals found at this place are mugger, turtles and dolphins. Different species of migratory birds visit this place.

Human activities are more at this place. Local villagers carry on extensive cultivation on the banks and also near nesting sites. There are reports of illegal fishing activities at this place. During February 1987, an adult gharial (18 feet) was killed at this place.

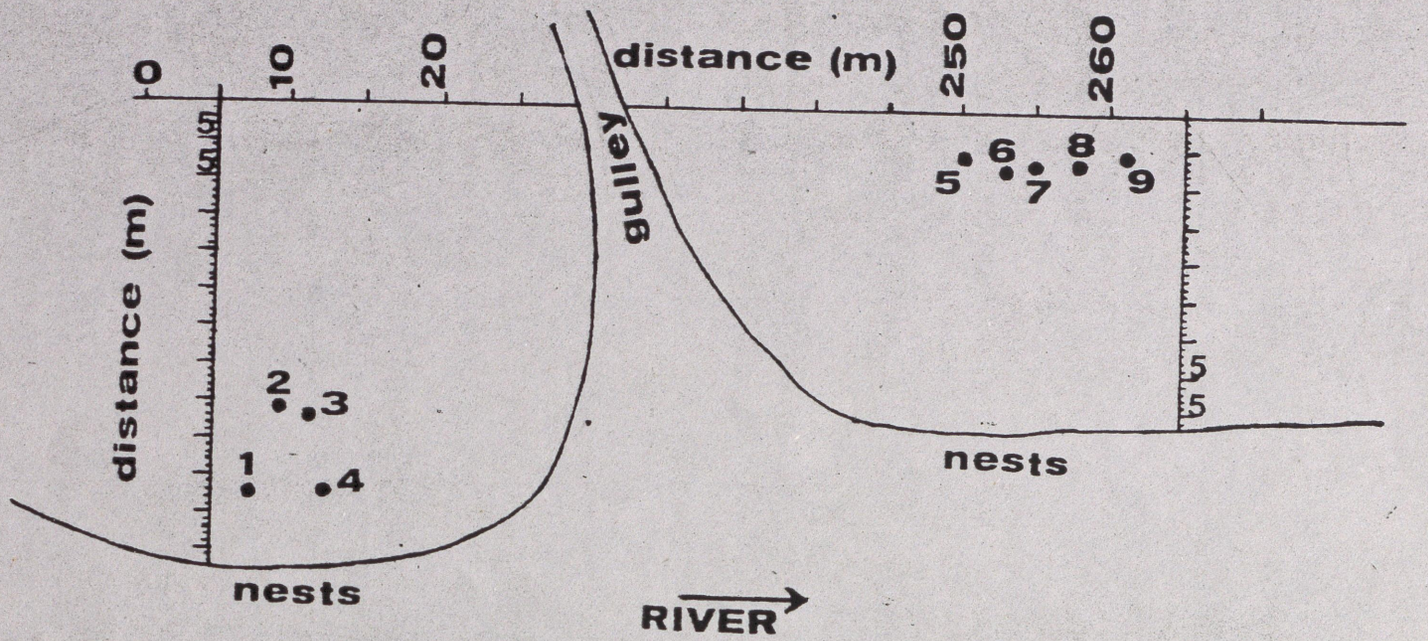


Fig. 10. Nest distribution pattern at the colonial nesting site Pureini. The number attributed to the nests are indicative only of the sequences in which these were detected, not necessarily laid.

(Data of Year 1985)

6.2.4. Zone 6

9. Barsala

Barsala is located 240 km down-stream of Pali and this nesting site is accessible from Dholpur city, which is 40 km west of the nesting site. This place, as potential gharial nesting site, was identified during annual gharial census surveys in 1985. During 1986, a total of 4 gharial nests were found at this place. Some gharial might have migrated from Pureini, which is 15 km in the up-stream. The nesting site is an island of approx. 1 km in length that rises 4 m above water during the dry season. Xerophytic bushes (Tamarix dioca) are present on the nesting island. The island is accessible from M.P. side during summer season. During 1987, only 2 gharial nests were located from this place. It is presumed that remaining ones might have migrated to other places. During 1988 also only 2 gharial nests were found at this nesting site.

Kachuga species lay eggs at this nesting site. Dolphins are sighted and many migratory birds visit this place during winter season.

The area is undisturbed except some occassional illegal fishing activities. Gharial eggs from one nest during 1988 were predated, possible predator was jackal which predate most of the turtle nests at this nesting site.

10. Barenda

Nesting was found at this place for the first time during 1987. This nesting site was used by three gharial. The nesting site is located in the territorial borders of Uttar Pradesh and is located 260 km down-stream of Pali. The nesting site is on main-land and the habitat is of Type 2. It is accessible both from Dholpur (Rajasthan) and Pinahat (U.P.). During 1988, three gharial nests were located at this place. Eggs from two nests were collected by the U.P. Forest Department for captive rearing programme.

Other important aquatic fauna found at this place are turtles, mugger and dolphin. Mugger and gharial bask very close together at this place. Migratory birds visit this place.

Disturbance at this place is minimal. There are reports of agriculture on the banks and illegal fishing activities at this place.

11. Khera

This place is located 360 km down-stream of Pali and is situated on U.P. side of the river bank. The nesting habitat is of Type 2. Only 1 nest was found at this nesting site for the first time during 1987. During 1988 two nests were located at this place.

Turtles, dolphins and migratory birds are the other important fauna found at this place. This place is less disturbed.

12. Gyanpura

Gyanpura is the last nesting site in the Chambal river. It is located 370 km down-stream of Pali (Fig. 6) and is close to the Chambal-Yamuna confluence. The nesting site is of Type 2 habitat and is situated on M.P. side of the river bank. The nesting site is accessible on foot from a village Gyanpura, which is 3 km from the nesting site in the M.P. Gharial nests were located from this place since 1979. Every year 2 nests were located from this place.

Other important aquatic fauna at this place is turtles and dolphins. Wet-land birds visit this place during winter season.

Disturbace in the form of agriculture and illegal fishing is considerably more at this place.

6.2.5. New nesting sites -1988

During 1988 a total of three new nesting sites were located where one nest each was found (Table 3). They are: 1. Basai dang:- 172 km down-stream of Pali; habitat Type 4; turtles, mugger and otters are present; gharial nest on island. 2. Papripura:- 215 km down-stream of Pali; habitat Type 2; gharial nest on main-land on U.P. river bank. 3. Daljitpura:- 235 km down-stream of Pali; gharial nest on main-land on M.P. river bank; habitat Type 2; turtles (Kachuga sp.) lay eggs on gharial nesting bank and dolphins are present.

6.3 Nesting activities

Details of nest biology collected from colonial nesting sites at Baroli and Pureini during 1985 are presented below. Part of the data on pattern and significance of communal nesting has been prepared as a research paper by the author and L.A.K. Singh during 1986. Data collected on nesting at other nesting sites during the following years (1986-88) were also included during data analysis.

6.3.1 Nest pattern

Gharial are communal hole nesters, preferring sand banks for nesting (Singh, 1978; Choudhury, 1981; Whitaker and Basu 1983). They mostly prefer steep slope sand banks (83.7%) with fine sand and also lay eggs on gentle slope sand banks (16.3%) with coarse sand (Rao and Singh, 1987). Bustard (1979) reported unusual behaviour of gharial that used mud bank for nesting due to loss sand banks in between dams and a barrage. Gharial selects a place that is 1 to 3 m ($\bar{x}$ = 1.4m) above water level and mean distance of 7.2 m (Range 2.9-11.5m) away from water to lay eggs to avoid any possible flooding of the nests. They dig nest holes and lay eggs. The eggs are between 30-50 cm below the surface. The diameter of the nest at the surface and at the bottom are 36 cm (mean) and 45 cm.

6.3.2 Nesting season

Nesting of gharial in Chambal occurs seasonally during late March - early April. Similar nesting season of gharial was reported by Singh (1978); Bustard (1980); Whitaker and Basu (1983) and Choudhury et al., (1983).

6.3.3 Pre-nesting activities

Because the breeding season commences with the peak winter months (November - February), it has been difficult to distinguish hauling out activities for basking from those exclusively as a territorial display at the future nesting site (Rao and Singh, Subt.). The latter may be distinct when hauling out is over 5 m away from water, occasionally much high above the usable nesting bank. Territorial hauling at the nesting site of Baroli had commenced by 19 February in 1985.

'Probe pits' (Plate 17) were dug after 09 March. These pits are shallow, 15-20 cm deep and as much wide. 'Trial nests' were found only after 23 March. These, as explained in Singh (1978) are fully dug uncovered nesting chambers without the eggs being actually laid in them (Plate 18).

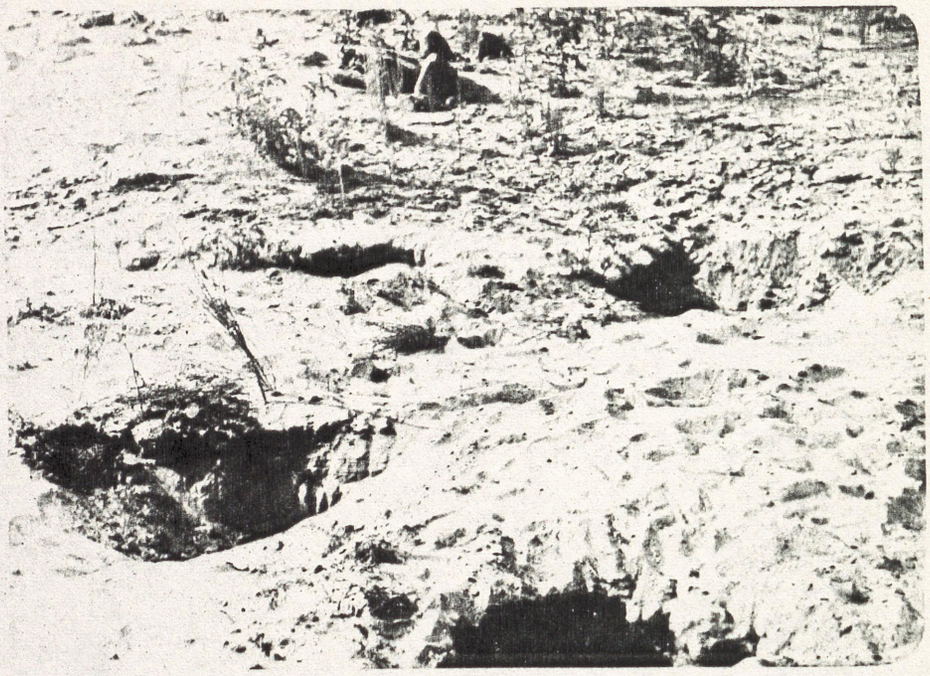


Plate 17. Probe pits dug by gharial at Baroli nesting site.

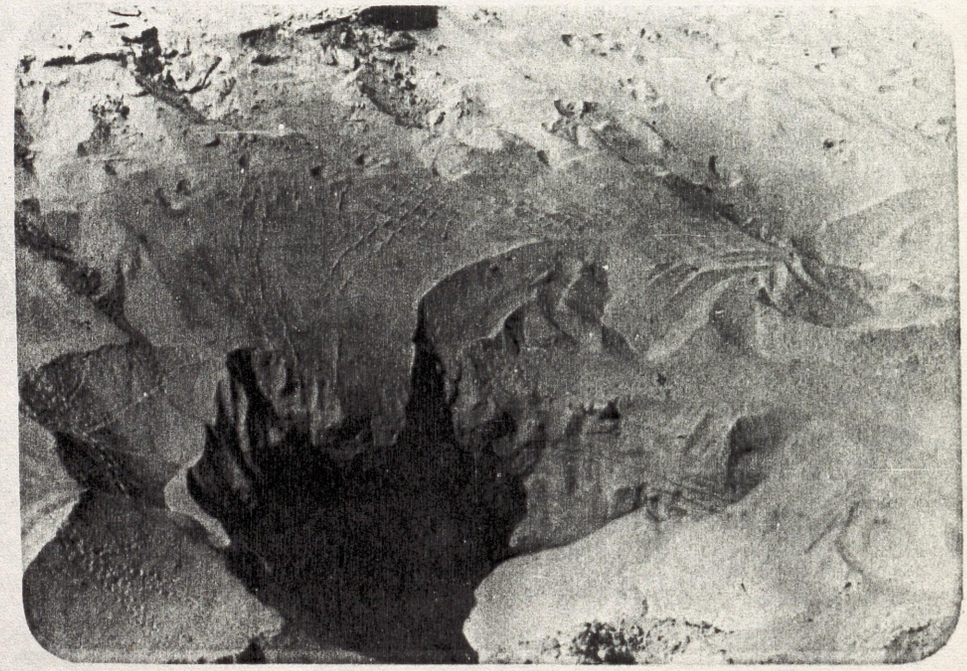


Plate 18. Trail nest of gharial at Baroli nesting site.

6.4 Nesting

Nesting activity started at Baroli on 26 March in both 1985 and 1987 and 17 March in 1986 and concluded on the night of 9, 8 and 6 April in 1985, 1986 and 1987, respectively (Table 10, 11 and 12). The total number of nights during which nesting occured was nine in both 1985 and 1987. Exact egg laying dates for 6 out of 14 nests in 1986 were not known. Egg laying spanned 15 days in 1985, 23 days in 1986 and 12 days in 1987. The mean temperatures during the nesting season of 1985, 1986 and 1987 were 28.3, 25.3 and 29.5 C respectively. The lower temperature of 1986 was probably the cause of the longer nesting season when compared to 1985 and 1987 (Fig. 3). Detailed nesting sequences recorded in 1985 are as follows:

On the first night three nests were made, on the second night two nests and on seven other nights there was one nest each. The relative positions of different nests at Baroli in 1985 are shown in Table 13 and Fig. 11. The nests made in the first night were seperated from each other by a distance of 241 m and 2 m. The nests laid on the second night were seperated by 26 m. The minimum distance seperating two adjacent nests was from 0.8 to 23.4 m. Irrespective of the above, any two adjacent nests also occupied different heights above the water level (last column, Table 13). Gharial at Baroli used the

Table 10. Data on gharial nesting at Baroli during 1985 -

No. Nest	Date located	Date laid	Date hatched	No. eggs	No. eggs collected	Incubation period (days)	No. eggs hatched	No. hatchlings dead	No. eggs spoiled	No. eggs predated
1	27·3	26·3	-	17	-	-	-	-	17	-
2	27·3	26·3	3·6	51	48*	-	45	-	3	-
3	28·3	26·3	4·6	43	40**	69	40	-	3	-
4	29·3	28·3	6·6	45	39*	-	37	-	6	-
5	30·3	28·3	1·6	31	-	65	31	-	-	-
6	1·4	30·3	30·5	54	-	61	47	2	5	-
7	2·4	1·4	3·6	45	43*	-	35	-	2	-
8	5·4	4·4	7·6	50	-	64	47	2	1	-
9	10·4	9·4	10·6	35	-	62	23	-	12	-
10	4·6	29·3	3·6	32	-	66	30	-	2	-
11	7·6	3·4	6·6	24	-	65	23	-	1	-
12	12·6	12·4	11·6	37	-	61	35	1	1	-
				464	170		236	5	53	

* Collected by U.P.

** Collected by M.P.

Table 11. Data on gharial nesting at Baroli during 1986

No. Nest	Date located	Date laid	Date hatched	No. eggs	No. eggs collected	Incubation period (days)	No. eggs hatched	No. hatchlings dead	No. eggs spoiled	No. eggs predated
1	17·3	17·3	31·5	26	-	75	17	-	9	-
2	28·3	25·3	6·6	27	-	72	24	-	3	-
3	29·3	25·3	5·6	38	-	71	23	-	2	13
4	30·3	29·3	1·6	50	-	64	29	-	21	-
5	30·3	27·3	4·6	44	-	69	33	-	11	-
6	5·4	3·4	1·6	30	-	59	30	-	-	-
7	6·4	?	2·6	23	-	-	19	-	4	-
8	6·4	5·4	10·6	36	12*	66	21	1	2	-
9	6·4	?	?	37	34*	?	?	-	3	-
10	9·4	8·4	?	43	38*	?	?	-	5	-
11	19·5	?	?	51	47*	?	?	-	4	-
12	2·6	?	2·6	38	-	?	38	-	-	-
13	30·5	?	30·5	32	-	?	31	-	1	-
14	26·5	?	26·5	36	-	?	36	-	-	-
				511	131		301	1	65	13

* collected by U.P.

Table 12. Data on gharial nesting at Baroli during 1987

No. Nest	Date located	Date laid	Date hatched	No. eggs	No. eggs collected	Incubation period (days)	No. eggs hatched	No. hatchlings dead	No. eggs spoiled	No. eggs predated
1	27·3	26·3	21·5	48	...	55	20	-	1	19
2	27·3	26·3	22·5	44	-	56	22	-	3	19
3	28·3	26·3	27·5	35	-	60	33	-	2	-
4	28·3	27·3	27·5	35	-	60	28	-	7	-
5	28·3	27·3	28·5	26	-	61	22	-	4	-
6	30·3	29·3	26·5	41	-	57	3	4	2	32
7	30·3	28·3	28·5	31	-	59	23	-	8	-
8	31·3	30·3	9·6	39	38**	69	32	1	6	-
9	4·4	3·4	28·5	32	-	54	27	-	5	-
10	5.4	4·4	1·6	35	-	57	11	-	2	22
11	6·4	5·4	21·5	25	-	46+	18	2	1	4
12	6·4	5·4	30·5	41	-	54	39	-	2	-
13	7·4	6·4	30·5	55	-	53	53	-	2	-
14	31·5	?	31·5	36	-	?	34	-	2	-
				515	38		333	7	47	96

** collected by M.P.

+ opened by predator.

Table 13. Gharial nest distribution at Baroli during 1985

Nest no.	Distance from water (m)	Height above water level (m)	Sl. number of the nearest nest	Distance from the nearest nest (m)	Distance from nest laid prior to it (m)	Height above nest laid prior to it	Clutch size
1a	6.5	1.0	4	23.5	-	-	17
1b	5.5	1.1	1c	2.0	241.7	0.1	51
1c	7.2	1.4	1b	2.0	2.0	0.3	43
2a	8.0	1.3	7	6.0	14.2	-0.1	45
2b	8.8	1.5	12	0.8	26.2	0.2	31
3	5.2	1.0	6	1.7	3.8	-0.5	54
4	11.5	1.2	1a	23.5	228.4	0.2	45
5	9.0	1.5	1b	4.0	214.2	0.3	50
6	8.5	1.5	3	1.7	12.5	0.0	35
7	7.5	0.9	2a	6.0	26.7	-0.6	32
8	9.0	1.5	12	1.2	30.2	0.6	24
9	6.0	1.3	2b	0.8	1.2	-0.2	37

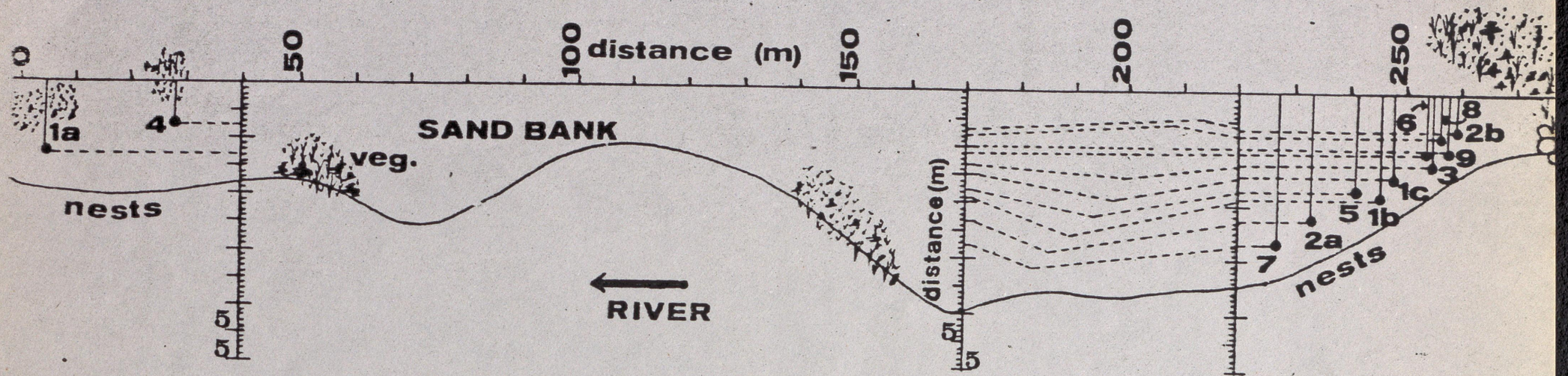


Fig. 11. Nest distribution pattern at the colonial nesting site Baroli. Veg.= Vegetation. The scale touching the river and sand bank are only to indicate distances (not the height) of the nests with respect to shoreline and other nests. (Data of Year 1985)

same continuous sand bank yet there were to sub-locations (Fig. 11). The first, in the up-stream, had three groups of nests. In first there were the nests 2b, 3, 6, 8 and 9, in the second 1c, 1b and 5, and in the third 2a and 7. The second sub-location was down-stream and includes nests 1a and 4.

6.4.1 Clutch size

Mean clutch size of gharial in Chambal was 38.4 with a range of 17-55 (n=51) (Plate 19) (Data on clutch size during 1988 is not included). Whitaker and Basu (1983) reported a mean clutch size of 42 (range 10-64, n=10) from Chambal. According to the data given by Choudhury et al, (1983) the mean clutch size of gharial in Chambal was 42.6 with a range of 5-64 eggs (n=30). Bustard (1980) after examining 35 clutches of gharial eggs from Narayani river, reported the mean clutch size as 31.7 and the maximum 61 eggs. However, Singh (1978) reported a mean clutch size of 33±10 eggs ranging from 10 to 61 eggs collected from Nepal. The mean clutch size of gharial calculated during the present suty is less when compared to the data collected during 1976-78 by Choudhury et al (1983) when there were only 10-12 females nesting. However, from 1978 to date the number of nesting females was increased, new females started nesting (See section 6.8). Since, younger females lay



Plate 19. Gharial eggs removed
from a 50 cm deep nest pit.

less number of eggs (Singh, 1978; Rao and Singh, Subt.) the eggs in the nests from which the clutch size was recorded during 1985-1987 were, perhaps, laid by new younger females, possibly of the released ones that have matured.

6.4.2 Egg measurements

Eggs range in length from 77 to 94.0 mm with a mean length of 86.1± 10.6 mm (N=120) (Table 14). The breadth of eggs ranged from 59 to 64.0 mm with an average breadth of 61.3 ± 1.3 mm. Mean egg weight is 185.5 ± 15.5 g (range 145-210g). Rao and Singh (1987) reported the mean length (cm) x breadth (cm) x weight (g) of the gharial eggs as 8.7 x 5.9 x 176.0. Singh (1978), after measuring 65 eggs collected from Nepal, reported the mean weight of the eggs as 154.6 g and the mean length and breadth is 82.2 and 56.5 mm, respectively. These eggs might be laid by young females as the mean egg weight is comparatively less than the mean egg weight from the Chambal.

6.4.3 Incubation

Period of incubation was observed at Baroli in 1985-1987 (Table 10, 11 and 12). The average incubation period during 1985 was 63.1 days (range 61-69) and in 1986 and 1987 the average incubation period was 68 (range 59-75) and 56.9 days (range 53-61), respectively. The nest temperature ranged from 25 C (March) to 35 C (June). Whitaker and Basu (1983) reported that the nests

Table 14. Data on the egg dimensions and hatchling sizes.

	Weight (g)	Length (mm)	Width (mm)
Egg dimensions	$\bar{x}$ = 185.5	$\bar{x}$ = 86.1	$\bar{x}$ = 61.3
	SD = 15.5	SD = 10.6	SD = 1.3
	Range = 145-210.0	Range = 77.0-94.0	Range=59.0-64.0
	N = 60	N = 60	N = 60

	Weight (g)	Length (cm)
Hatchling size	$\bar{x}$ = 125.0	$\bar{x}$ = 35.5
	SD = 16.7	SD = 11.3
	Range = 80.0-145.0	Range= 33.0-43.0
	N = 103	N = 103

in Chambal took an average of 60-65 days for hatching. One clutch each collected in 1985 and 1986 from Baroli for captive rearing programme took longer period (69 days) for hatching at 32-33 C maintained during last 10 days of incubation. Egg incubation is temparature related. It is observed that when the eggs were brought after around 50 days of incubation in the nature to hatchery (Choudhury et al., 1983) the change in the incubation conditions and temperature affect the period of incubation. All hatchery incubated eggs take longer periods than field nests for hatching. Choudhury et al., (1983) reported a maximum incubation period of 71-76 days for the hatchery incubated eggs. They have collected eggs from the Chambal after 41 days of incubation in the field. The eggs took further 30 -35 days to hatch. Singh (1978) also reported a mean incubation period of hatchery incubated gharial eggs collected from Narayani River as 83 days. The longer incubation period reported by Singh might be due to artificial incubation conditions and also due to low temperature in Nepal during nesting period. Low temperature during 1977 in Nepal affected the hatching period of gharial eggs —eggs took 94 days to hatch during 1977 as against 83 and 84 days in 1976 and 1978 (Bustard, 1980). Similar results were reported in case of freshwater turtle (Kachuga sp.) eggs by Rao and Singh (1985).

6.4.4 Hatching

Studies on hatching pattern at Baroli in 1985 revealed that hatching commenced on 31 May and ended on 11 June with an incubation period ranging from 61-69 days. Hatching success was 65.7 to 100% (The clutch of 17 eggs in which no eggs hatched is not included in this percentage). Hatching in the wild was ascertained by counting the number of empty shells after the mother had opened a nest (Singh and Rao, 1986) (Plate 20).

During the last week of May and first week of June 1985, when the hatching time was approching, haul out tracks to the nests were numerous. The number of such tracks gradually decreased as and when a nest hatched. Hatching started 30 May and ended 6 June during 1986 and hatching started 20 May and ended 1 June during 1987. Mean temperatures during hatching period was 33.1 C in 1985, 33.1 C in 1986 and 37.4 C in 1987. Hatching occured before the onset of rainy season (Fig. 3).

6.4.5 Hatchling size

Mean total length of hatchlings recorded during 1985 and 1987 at Deori Gharial Rearing Centre was 35.5 $\pm$ 11.3 with a range of 33 cm to 43 cm (n=103) (Table 14 and Plate 21). Mean weight of the hatchlings was 125.0 $\pm$ 16.7 g with a range of 80 to 145 g (n=103).

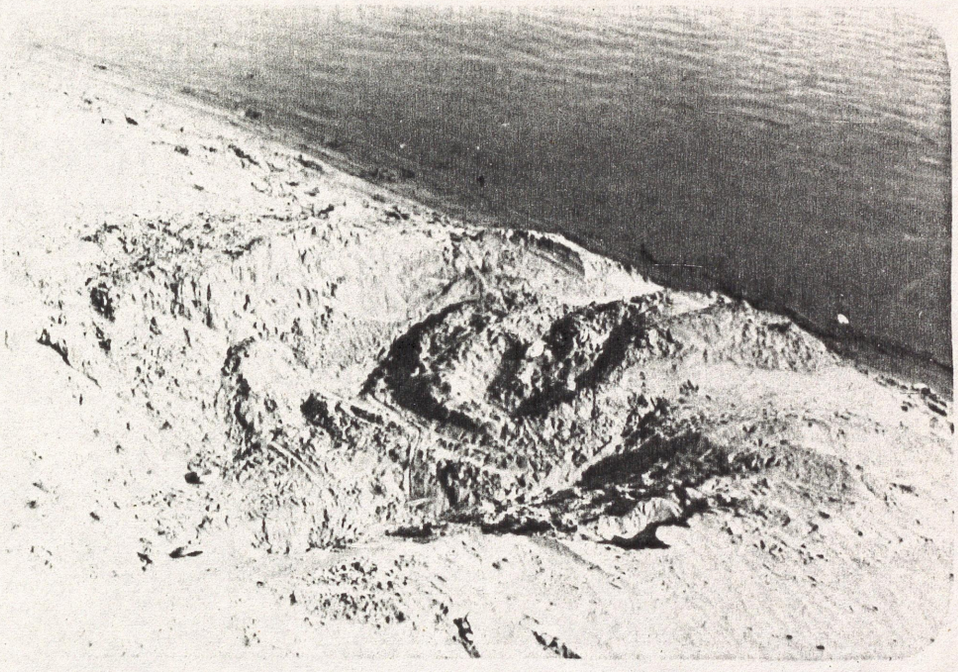


Plate 20. Hatched gharial nest at Baroli nesting site. Note the presence of hatchlings on the river bank down the excavated nest.

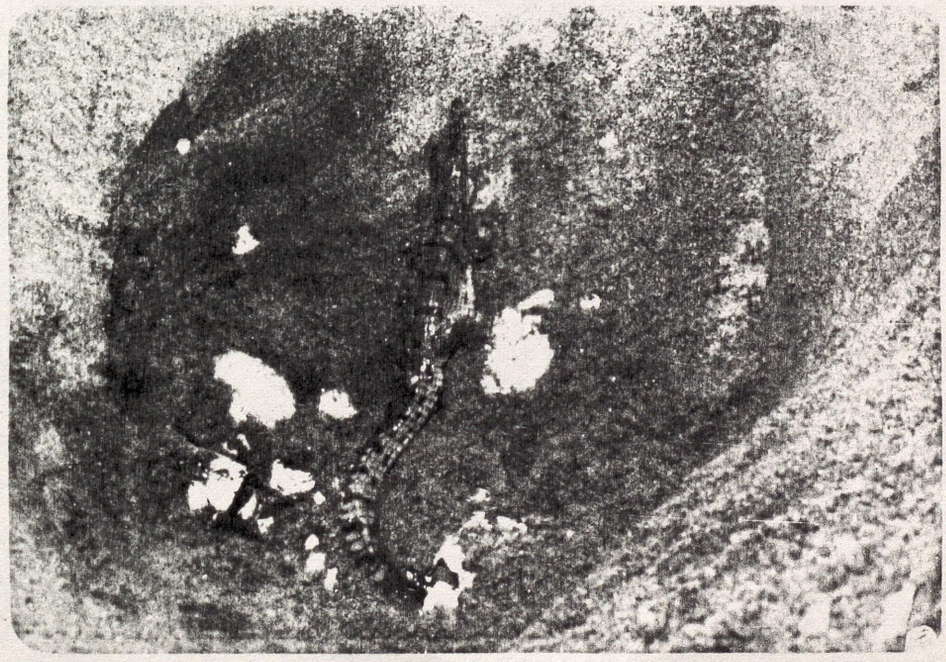


Plate 21. Gharial hatching.

6.5 Parental care

Maternal behaviour of gharial was reported by several investigators (Singh and Bustard, 1977; Bustard, 1980; Basu and Bustard, 1981). Male gharial also plays key role in the protection of hatchlings (Rao and Singh, Subt.). After hatching the juveniles usually remained in water just below the nest from which they hatched (Plate 20). At that time empty shells mark the area from the opened nests up to water. When these markings are cleared all hatchlings tend to congregate and form a larger creche. About a month after hatching, with the first flooding in the river, dispersal of hatchlings from the site commenced and after the flood, in October-November sighting a hatchling becomes rare at the nesting location due to dispersal and mortality in the floods and predation.

Each creche of hatchlings is attended by a female. Therefore, when the size of a creche increased (due to the joining of two smaller ones) the number of attending females decreased. Although, it has been difficult to exactly identify attending females, it is, however, clear that the larger females are always at attendance and the smaller ones remain away in mid-stream islands.

Only one male was seen keeping a watch on the area from downstream (the direction from which an intruder may approach the nesting bank). Usually the human or animal 'intruder' was followed until the male gharial reached the hatchlings to find the attending females. Later the male returned back to his 'guard position'.

On June 6, 1986 at 1845 hrs two females and a male were observed in the water below the nest site where 84 hatchlings were lying on the bank. A jackal was found two meters away from the bank, which unsuccessfully tried to catch the hatchlings but was chased away by a female.

6.6 Nesting success

Predation on gharial eggs was reported by Whitaker and Basu (1983). The major predators are jackals. Although female keep regular watch on its nest, jackals quite successfully predate some nests mostly (only) at communal nesting sites where more than 2 nests are present. Of 13 nests at Baroli in 1986 one nest was partially predated by jackal before female chased away the jackal. A total of 23 eggs were successfully hatched out from this nest. In 1987, a total of 96 eggs (19.8%) in 5 nests were predated at Baroli by jackal. Of the 6 nests at Tigri-Rethoura during 1986 one nest was predated by jackal. Loss of eggs by predators at the other nesting sites was not found during the study period.

At some nesting sites steps have been taken to protect the nests by covering with wire-mesh. Continued protection by the field staff, removal of eggs for hatchery incubation and the nest guarding phenomena of female, all these contributed for a high nesting success in the Chambal.

6.7 Fate of gharial eggs

Data collected from 40 nests during 1985-87 at Baroli nesting site are summarised in Table 15. Egg production during 1985, 1986 and 1987 was 464, 511 and 515, respectively. Of the 1490 eggs 333 eggs (23.3%) were collected for hatchery incubation by the M.P. and U.P. Forest Departments and 1157 eggs (77.6%) were left in situ. Hatching success during 1985 was more (80%) than that of 1986 (79.2%) and 1987 (68.9%). Overall hatching success during all three years was 75%. Egg loss including mortality of hatchling immediately after hatching was 19.7% in 1985, 20% in 1986 and 31% in 1987. Predation was more during 1987 (19.8%). Occasionally, management practices have done some unintentional harm. During 1985-87 a total of 60 eggs (5.1%) were spoiled while searching the eggs by following probing method at Baroli. Every year 50 - 100 gharial eggs get spoiled in all nesting sites due to probing during nest searching when inexperienced staff are on the job. There are cases of spoiling of an entire clutch due to mishandling by inexperienced and overenthusiastic field staff. Reasons for egg rotting were not known. Perhaps, yolk oozing out from eggs punctured as a result of nest probing attract fungus (Singh, pers. commu. 1988).

Table 15. Summarised results of the fate of gharial eggs at Baroli during 1985-1987. Percentages are in parentheses

Year	No. nests	No. eggs	Eggs collected by U.P.	Eggs collected by M.P.	Eggs collected by Total	Eggs left in situ	Eggs hatched	Egg failure: Dead hatchlings	Egg failure: Spoiled by probing	Egg failure: Predated	Egg failure: Infertile	Egg failure: Rotted	Egg failure: Total
1985	12	464	130 (28)	40 (8·6)	170 (36·6)	294 (63·3)	236 (80)	5 (1·7)	18 (6·1)	- (0)	9 (3)	26 (8·8)	58 (19·7)
1986	14	511	131 (25·6)	- -	131 (25·6)	380 (74·3)	301 (79·2)	1 (0·2)	17 (4·4)	13 (3·4)	7 (1·8)	41 (10·7)	79 (20)
1987	14	515	-	32 (6·2)	32 (6·2)	483 (93·7)	333 (58·9)	7 (1·4)	25 (5·1)	96 (19·8)	9 (1·8)	13 (2·6)	150 (31)
	40	1490	261 (17·5)	72 (4·8)	333 (22·3)	1157 (77·6)	870 (75·0)	13 (1·1)	60 (5·1)	109 (9·4)	25 (2·1)	80 (6·9)	287 (24·8)

6.8 Annual egg production

The studies on the nesting activities of gharial in the Chambal indicated that the nesting female number has increased significantly since the 1978 estimates. According to Singh (1985) the breeding females during 1978, before declaration of the Sanctuary, were 12 - 13 and the number increased to 28 in 1984 (Singh et al., 1984). The increasing trend in the number of gharial nests in the Chambal is shown in Table 16. During 1988, a total of 50 gharial had nested, an increase of 38 (76%) nests over 1978. Annual egg production during 1978 has been estimated to be around 456 (clutch size 38) and estimated egg production in 1984, 1985, 1986, 1987 and 1988 was 1064, 1254, 1406, 1710 and 1900, respectively (Table 17).

Of the total 6270 eggs laid in the Sanctuary during the Four years of study (1985-1988) a total of 1590 (25.3%) and 223 (3.5%) eggs were collected by the Uttar Pradesh and Madhya Pradesh Forest Departments, respectively for the 'grow and release' programme and a total of 4457 eggs were left in situ for natural hatching (Table 17). Hatching success at Baroli during 1985-87 was 75% (see table 15) where egg loss was considerably more when compared to other nesting sites. If the hatching success is considered as 75% in all the nesting sites, then the possible number of eggs, that were left in situ, hatched during 1985-88 are estimated to be around 3342 (53.3% of the total eggs).

Table 16. Number of G. gangeticus nests located in different nesting sites in the Chambal river during 1978 and 1984 (Singh, 1985) and 1985-1988.

Year	No. nests	Number of nesting sites	
		Communal *	Other
1978	12	6	?
1984	28	5	?
1985	33	5	2
1986	37	6	4
1987	45	10	2
1988	50	11	4

Table 17. Data on gharial egg production during 1985-1988. Percentages are in parentheses.

Year	Total No. nests	Total No. eggs *	Eggs collected by U.P.	Eggs collected by M.P.	Total	Eggs left in situ	Possible No eggs hatche **
1985	33	1254	498 (39.7)	40 (3)	538 (42.9)	716 (57.0)	537 (42.8)
1986	37	1406	515 (36.6)	0 (0)	515 (36.6)	891 (63.3)	668 (47.5)
1987	45	1710	223+ (13.0)	65 (3)	288 (16.8)	1422 (83.1)	1066 (62.3)
1988	50	1900	354 (18.6)	118 (6.2)	472 (24.8)	1428 (75.1)	1071 (56.3)
	165	6270	1590 (25.3)	223 (3.5)	1813 (28.9)	4457 (71.0)	3342 (53.3)

* Clutch size = 38

** Hatching success = 75% (Ex. Baroli)

\+ Hatchlings were collected

7. GHARIAL POPULATION TREND

During 1983-84 and 1984-85 surveys were conducted in the Chambal river by the Crocodile Research Centre of the Wildlife Institute of India in collaboration with all three State Forest Departments to study the population trend of gharial. Results of these surveys indicated that the density of gharial in Chambal was 1.08 gharial/km in 1983-84 and the density of gharial per km during 1984-85 was 1.42 (Table 20). Monitoring of gharial population in Chambal is being continued. During the 1985-86 and 1987-88 surveys the total number of gharial sighted, in various sizes, in the Chambal river was 618 and 804, respectively. The number of gharial sighted in different 5 km units along the Zones 3 through 7 are shown in Table 18 and 19. Table 20 gives summarised results for all surveys conducted in the Chambal river during 1983-1988. All gharial sighted were grouped into different size classes (below 1.5m; 1.5-2.7m; females- above 2.7m and males). Table 20 gives a comparision of the trend of gharial population in different years. Changes in gharial population (percentages) along Zones 3-7 during different years (1983-1988) are shown in Figure 12.

During 1983-84 a total number of 451 gharial were sighted in Zone 4, 5, 6 and 7. Of the 451 gharial 320 gharial (70.9%) were of 1.5-2.7m size group. During 1984-85 also maximum number

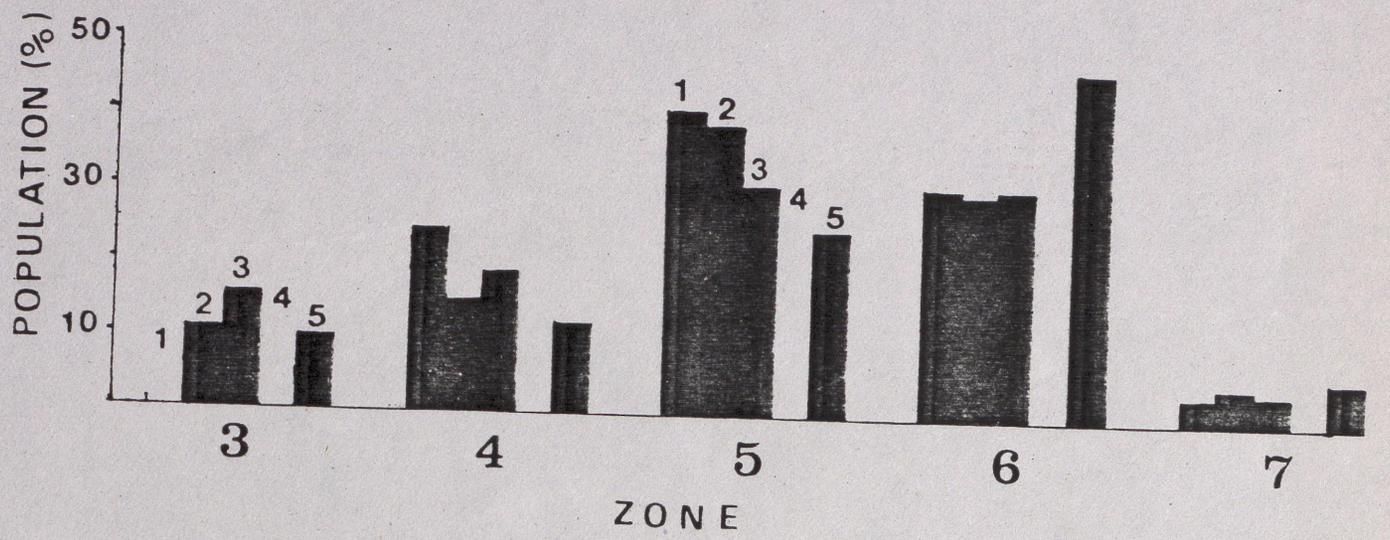


Fig. 12. Gharial population (%) along different Zones (3-7) during 1983-1988. Numbers on vertical bars represent year of the survey (1983-84(1).....1987-88(5)). Survey along Zone 3 during 1983-84 and survey during 1986-87 in all zones were not conducted.

of gharial (376/62.1%) were of 1.5-2.7m size group. During 1985-86 and 1987-88 below 1.2m size class represented 48.2 and 42.4 percent in total count, and the values for 1.5-2.7 size class were 41.4 and 46.1 percent in total count, respectively. Maximum number of gharial (379) were sighted along Zone 6 during 1987-88 where 139 gharial were released during December 1987. The number of gharial sighted along Zone 7 during 1983-84 was 17 and during 1987-88 a total number of 49 gharial, including two females and a male were sighted along this Zone. The increase in the population along Zone 7 indicated movement of gharial down-stream towards the Yamuna confluence, which is unsafe for them. This needs a thorough monitoring of the population along Zone 7 and control the pressure of human activities on the gharial, which force the gharial to migrate down-stream and enter into the Yamuna river.

7.1 Gharial population density

The density of gharial in Chambal during 1985-86 was 1.6 per km and in 1988 the density was 1.89/km. Maximum number of gharial was found along the Zone 6 during 1985-86 (31.2%) and 1987-88 (47.1%). Among the total population sighted males represented 2.2% and 1.8% and females represented 8.1% and 9.5% during 1985-86 and 1987-88, respectively. Singh (1985) gave the figures as males - 1.3% and 1.6% and females 6.8% and 7.1% during 1983-84 and 1984-85, respectively. According to him,

Table 18. Number of gharial sighted during surveys conducted in 1985-86. * Pali is considered as Zero km. (size in meters) (Based on nest data adult gharial number is adjusted)

Mile post*	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7 female	Male	Total
0-5	0	0	0	0	0	0	0	0	0	0	0
5-10	0	0	0	0	0	0	0	0	0	0	0
10-15	0	0	0	0	0	0	0	0	0	0	0
15-20	0	0	0	0	0	0	0	0	0	0	0
20-25	0	0	1	5	4	0	0	1	2	2	15
25-30	0	0	2	1	3	0	0	0	1	1	8
30-35	0	0	0	1	0	0	0	0	0	0	1
35-40	0	0	0	0	0	0	0	0	2	0	2
40-45	0	0	1	2	1	0	0	0	0	0	4
45-50	0	0	0	0	1	0	1	0	1	1	4
50-55	0	0	0	2	4	0	0	0	0	0	6
55-60	0	1	0	2	1	0	1	2	14	1	22
60-65	0	1	1	2	1	0	0	0	0	0	5
65-70	4	2	1	2	1	0	1	0	2	1	14
70-75	0	0	0	0	0	0	0	0	0	0	0
75-80	0	0	0	0	0	0	0	0	0	0	0
80-85	0	0	0	0	0	0	0	0	0	0	0
85-90	6	2	0	0	1	0	0	0	0	0	9
90-95	0	0	0	0	0	0	0	0	0	0	0
95-100	0	0	0	0	0	0	0	0	0	0	0
100-105	0	0	1	0	0	0	0	0	0	0	1
105-110	0	0	1	1	2	0	0	0	0	0	4
110-115	0	0	5	5	3	2	1	0	1	0	17
115-120	1	1	3	6	11	2	5	0	1	1	31
120-125	0	4	3	2	1	0	0	0	0	0	10
125-130	3	5	5	3	1	1	0	0	0	0	18
130-135	5	2	6	5	5	0	2	0	5	1	31
135-140	0	0	2	1	1	0	1	0	0	0	5

Table 18. contd... Number of gharial sighted during surveys conducted in 1985-86. (Size in meters) (Based on nest data adult gharial number is adjusted) * Pali is considered as Zero km

Mile post	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7	Male	Total
									Female		
140-145	0	1	0	3	0	0	0	0	0	0	4
145-150	0	0	0	1	0	0	0	0	0	0	1
150-155	0	0	0	0	0	0	0	0	0	0	0
155-160	0	0	0	0	0	0	0	0	0	0	0
160-165	0	0	0	1	0	0	0	0	0	0	1
165-170	0	0	0	0	0	0	0	0	0	0	0
170-175	1	1	8	2	1	0	0	0	0	0	13
175-180	1	1	0	0	0	0	0	0	0	0	2
180-185	18	3	0	3	1	0	1	0	0	0	26
185-190	5	1	0	1	1	1	0	0	0	0	9
190-195	1	0	0	0	0	0	0	0	0	0	1
195-200	6	0	4	0	0	0	0	0	0	0	10
200-205	2	2	3	0	0	0	0	0	0	0	7
205-210	0	2	1	3	2	0	0	2	6	1	17
210-215	0	2	1	4	1	0	0	0	0	0	8
215-220	0	3	3	3	0	1	0	0	0	0	10
220-225	4	7	21	13	6	1	2	1	1	0	56
225-230	7	1	1	2	4	1	3	1	3	1	24
230-235	3	2	0	1	1	0	2	0	1	0	10
235-240	0	0	0	1	1	0	0	0	1	1	14
240-245	5	3	4	2	1	0	0	0	2	0	17
245-250	0	0	0	1	0	0	0	0	0	0	1
250-255	1	2	3	2	2	1	0	0	0	0	11
255-260	0	3	6	3	3	0	0	0	3	1	19
260-265	2	2	1	0	1	0	0	0	0	0	6
265-270	2	2	6	5	2	0	0	0	0	0	17
270-275	1	3	2	1	2	0	1	0	0	0	10

Table 18. contd.. Number of gharial sighted during surveys conducted in 1985-86. (Size in meters) (Based on nest data adult gharial number is adjusted) * Pali is considered as Zero km.

Mile post	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7 female	Male	Total
275-280	1	2	2	2	0	0	0	0	0	0	7
280-285	3	3	3	2	4	0	0	0	0	0	15
285-290	0	2	2	2	1	0	0	0	0	0	7
290-295	4	1	3	1	0	0	1	0	0	0	10
295-300	0	0	0	0	0	0	0	0	0	0	0
300-305	1	0	8	6	3	0	0	0	0	0	18
305-310	1	2	4	0	0	0	0	0	0	0	7
310-315	1	1	3	2	1	1	0	0	0	0	9
315-320	1	0	0	0	0	0	0	0	0	0	1
320-325	0	0	0	0	0	0	0	0	0	0	0
325-330	0	0	1	0	0	0	0	0	0	0	1
330-335	0	0	0	0	0	0	0	0	0	0	0
335-340	0	0	0	0	1	0	0	0	0	0	1
340-345	1	1	0	0	0	0	0	0	0	0	2
345-350	0	2	1	4	1	0	0	0	0	0	8
350-355	0	0	0	1	1	0	0	0	0	0	2
355-360	0	0	0	0	0	0	0	0	0	0	0
360-365	0	0	1	2	2	0	0	0	2	0	7
365-370	1	4	1	7	0	0	0	0	2	1	16
370-375	0	0	0	0	0	0	0	0	0	0	0
375-380	0	1	4	6	3	1	1	0	2	1	19
380-385	0	1	2	1	1	2	0	0	0	0	7

Table 19. Number of gharial sighted during surveys conducted in 1988. (Size in meters) * Pali is considered as Zero km.

Mile post*	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7	Male	Total
									Female		
0-5	0	0	0	0	0	0	0	0	0	0	0
5-10	0	0	0	0	0	0	0	0	0	0	0
10-15	0	0	0	0	0	0	0	0	0	0	0
15-20	0	0	0	0	0	0	0	0	0	0	0
20-25	0	0	0	1	3	0	1	3	3	2	13
25-30	0	0	0	0	2	0	0	0	2	1	5
30-35	0	0	0	0	0	0	0	0	1	0	1
35-40	0	0	0	0	0	0	0	0	1	0	1
40-45	0	0	0	0	2	1	0	1	0	0	4
45-50	0	0	0	0	0	0	0	0	3	1	4
50-55	0	0	0	0	2	0	0	0	0	0	2
55-60	0	0	0	0	1	0	0	0	11	2	14
60-65	0	0	0	0	0	0	0	0	0	0	0
65-70	11	0	0	0	3	0	0	0	4	1	19
70-75	1	0	0	0	4	0	0	0	2	0	7
75-80	0	0	0	0	0	0	0	0	0	0	0
80-85	0	0	0	0	0	0	0	0	0	0	0
85-90	2	1	1	0	0	0	0	0	0	0	4
90-95	0	0	0	0	1	0	0	0	0	0	1
95-100	0	0	0	0	0	0	0	0	0	0	0
100-105	0	1	1	0	1	0	0	0	0	0	3
105-110	0	0	0	0	0	0	0	0	0	0	0
110-115	0	0	1	0	2	0	2	0	3	1	9
115-120	0	0	0	2	1	2	0	1	1	1	8
120-125	0	0	1	2	6	0	0	0	0	0	9
125-130	0	0	1	2	3	0	0	0	0	0	6
130-135	3	1	5	8	13	6	3	1	5	1	46
135-140	0	0	2	1	1	0	0	0	0	0	4

Table 19. Number of gharial sighted during surveys conducted contd.. in 1988. (Size in meters) *Pali is considered as Zero km.

Mile post*	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7	Male	Total
									Female		
140-145	0	0	1	4	2	0	0	0	0	0	7
145-150	0	0	0	0	0	0	0	0	0	0	0
150-155	0	0	0	0	0	0	0	0	0	0	0
155-160	0	0	0	0	1	0	0	0	0	0	1
160-165	0	0	1	2	2	0	0	0	0	0	5
165-170	0	0	0	1	0	0	0	0	0	0	1
170-175	3	4	4	1	0	0	0	0	0	0	12
175-180	4	1	0	0	0	0	0	0	0	0	5
180-185	4	6	2	0	1	0	0	0	0	0	13
185-190	3	6	7	0	2	1	0	0	0	0	19
190-195	0	2	0	0	0	0	0	0	0	0	2
195-200	0	0	0	0	0	0	0	0	0	0	0
200-205	2	1	2	1	1	0	1	0	0	0	8
205-210	0	0	2	3	2	1	4	1	8	1	22
210-215	7	0	1	2	2	0	0	0	0	0	12
215-220	6	2	4	4	4	0	1	0	0	0	21
220-225	3	3	3	1	1	0	0	0	0	0	11
225-230	7	8	22	11	3	3	3	0	8	0	65
230-235	0	3	0	1	1	3	2	0	2	0	12
235-240	0	0	0	2	0	0	0	0	2	0	4
240-245	10	5	9	10	4	0	0	2	2	0	42
245-250	3	3	3	1	3	0	1	0	1	1	16
250-255	0	3	2	1	1	0	1	0	1	0	9
255-260	0	1	0	2	1	1	2	0	3	1	11
260-265	0	1	0	4	1	1	0	1	4	0	12
265-270	0	2	6	1	2	0	0	0	0	0	11
270-275	0	2	2	0	0	0	0	0	0	0	4

Table 19. Number of gharial sighted during surveys conducted contd.. in 1988. (Size in meters) *Pali is considered as Zero km.

Mile post*	Upto 0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	Above 2.7	Male	Total
									Female		
275-280	0	2	8	21	1	0	0	0	0	0	32
280-285	0	2	1	16	0	0	0	0	1	0	20
285-290	0	1	0	6	1	0	0	0	0	0	8
290-295	0	3	4	14	7	3	0	0	0	0	31
295-300	0	4	6	14	11	0	2	3	0	0	40
300-305	0	0	0	0	0	0	0	0	0	0	0
305-310	2	1	1	0	0	1	0	0	0	0	5
310-315	0	1	5	3	1	0	1	0	1	0	12
315-320	0	1	20	7	3	0	1	1	0	0	33
320-325	0	0	7	2	0	0	0	0	0	0	9
325-330	0	0	2	0	0	0	0	0	0	0	2
330-335	0	0	3	10	0	0	0	0	0	0	13
335-340	0	0	2	0	0	0	0	0	0	0	2
340-345	2	3	2	2	2	1	3	1	1	0	17
345-350	2	1	1	6	2	1	0	0	0	0	13
350-355	0	1	1	0	0	0	0	0	0	0	2
355-360	0	0	1	5	2	0	1	0	2	0	11
360-365	3	0	5	2	1	0	2	0	1	0	14
365-370	0	1	1	0	0	0	0	1	2	1	6
370-375	0	0	1	0	0	0	0	0	0	0	1
375-380	0	2	1	1	2	0	0	0	2	1	9
380-385	0	0	1	2	0	0	0	0	0	0	3
385-390	0	2	2	0	0	0	0	0	0	0	4
390-395	2	3	4	3	0	2	0	0	0	0	14
395-400	1	5	2	2	0	0	1	0	0	0	11
400-405	0	0	7	0	0	0	0	0	0	0	7

Table 20. Summarised results of surveys for gharial population counts during 1983-85 (Singh, 1985) and 1985-88.

Year	Size class (m)	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Total	% in total count
1983-84	below 1.5	-	28	57	8	1	94	20.8
	1.5 - 2.7	-	73	108	123	16	320	70.9
	above 2.7-female	-	7	17	7	-	31	6.8
	male	-	1	3	2	-	6	1.3
	Total	-	109	185	140	17	451	
	%in total count	-	24.1	41.0	31.0	3.7		
1984-85	below 1.5	10	10	102	48	6	176	29.0
	1.5 - 2.7	38	71	117	128	22	376	62.1
	above 2.7-female	12**	7	14	7	3	43	7.1
	Male	3	1	2	3	1	10	1.6
	Total	63	89	235	186	32	605	
	% in total count	10.4	14.7	38.8	30.7	5.2		
1985-86	below 1.5	24	46	115	110	8	303	48.2
	1.5 - 2.7	43	63	66	73	15	260	41.4
	above 2.7-female	22	7	10	10	2	51	8.1
	Male	6	2	2	3	1	14	2.2
	Total	95	118	193	196	26	628	
	% in total count	15.1	18.7	30.7	31.2	4.1		
1988	below 1.5	18	16	122	152	33	341	42.4
	1.5 - 2.7	26	68	61	203	13	371	46.1
	above 2.7-female	27	9	18	21	2	77	9.5
	Male	7	3	1	3	1	15	1.8
	Total	78	96	202	379	49	804	
	% in total count	9.7	11.9	25.1	47.1	6.0		

* Not surveyed

** According to nesting data 13 females

gharial were present in 68.2% of the total 5 km units surveyed in 1983-84 and 78.8% in 1984-85. Results of the following surveys (1985-86 and 1987-88) indicated that among the total 5 km units (77) surveyed during 1985-86 gharial were present in 60 units (77.9%) and during 1988 out of 81 units surveyed gharial were present in 68 units (83.9%). The results indicated a more dispersal of gharial in the Sanctuary and they have occupied new areas for basking and nesting.

7.2 Natural recruitment of hatchlings

Singh (1985) reported that the survival of hatchlings from eggs is around 6.5%. During the 1985-86 survey a total of 92 hatchlings were found indicating a natural recruitment of 12.8% (Table 21). However, natural recruitment of hatchlings during 1988 was estimated to be 5.6% only. The sharp fall in the natural recruitment rate during 1988 may be due to illegal fishing activity that was reported in the Sanctuary.

Monitoring on the natural recruitment of gharial should be conducted, which gives an indication of natural recruitment of gharial to the existing population once the rehabilitation of gharial under 'grow and release' programme is stopped. It also provides information for suggesting conservation management priorities to be taken for protection of the gharial in the field.

Table 21. Data showing natural recruitment of gharial during 1985-86 and 1987-88.

Year	No. nests	Total No. eggs *	Eggs collected by U.P.	Eggs collected by M.P.	Eggs collected by Total	Eggs left in situ	No. hatchlings sighted during post-monsoon survey	Percentage of natural recruitment
1985	33	1254	498	40	538	716	92	12.8%
1987	45	1710	223**	65	288	1422	81	5.6%

* Clutch size = 38

** Hatchlings were collected.

7.3 Sex ratio

During 1983-84 and 1984-85, Singh (1985) reported adult gharial population as 6 males and 31 females and 10 males and 43 females, respectively. The sex ratio was 1 : 5 during 1983-84 and 1 : 4 during 1984-85. A total of 14 males and 51 females were sighted in 1985-86 and 15 males and 77 females were sighted in 1988 surveys. The sex ratio was estimated to be 1 : 3 during 1985-86 and during 1988 the sex ratio was 1 : 5. According to nesting data 37 and 50 gharial had nested during 1986 and 1988, respectively. All these females were fertilised by 11 males. Rest of the males (3 in 1986 and 4 in 1988) were considered as young males with prominent ghara. If the active breeding population was considered for calculating the sex ratio then the sex ratio during 1986 was 1 : 3 and in 1988 the sex ratio was 1 : 4. Maximum number of females per a 'dominent' male is 10 at Baroli and Pureini during 1985 and 8 at Tigri-Rethoura during 1987. The sex ratio at Banwara nesting site was 1 : 1 during 1985-88. It is hoped that the young males will also take part in breeding during 1989 breeding season.

7.4 Gharial population recovery

According to Singh (1985), the gharial population in Chambal (400km) during 1978 was estimated to be around 107 with a sighting density of 0.29 per km. Singh also reported the gharial population in the Chambal river during 1983-84 and 1984-85 as 451 and 605 with a density of 1.08/km and 1.42/km, respectively. During 1985-86 and 1987-88 surveys the total number of gharial sighted was 618 and 804, respectively. The sighting density of the gharial was 1.6/km in 1985-86 and 1.89/km in 1987-88. The population estimates revealed that the gharial population in the Chambal river has been recovering over the past decade from an earlier declining status. The increase in density of gharial from 0.26/km in 1978 to 1.89/km in 1988 indicates that the gharial population in Chambal is in a recovering phase.

The year-to-year variations in number of gharial that nest in the Chambal river (12 in 1978 and 50 in 1988) also confirm toward a gradual recovery of the gharial population in the National Chambal Sanctuary.

8. CONCLUSION

The population of gharial in the National Chambal Sanctuary is on the increase, sightings have been more frequent. Because of releases of captive reared gharial there is an increase in the gharial population. Nevertheless, adequate fish population due to the stoppage of fishing, and highly protected habitat with security against possible dangers are the important governing factors that contributed to the steady increase of the gharial population. Because of the efforts by the GOI/FAO/UNDP and also due to the sincere efforts by the Scientists and systematic management by State Governments, the gharial population is recovered in the Chambal river.

During the Second meeting of the Technical Committee on Crocodile Project held during 19-27 January 1987 a decision was taken to keep continue the Rehabilitation Programme of gharial in the National Chambal Sanctuary. It is suggested to continue the egg collection and release of captive reared gharial in the wild. The criteria suggested in the meeting for the successful implemention of conservation activity in the Chambal is release of 2500 gharial and attaintment of production of 50 nests in the

wild. The second criteria was already achieved in the Chambal during 1988 nesting season — 50 nests in 15 nesting sites were located. So far, a total of 1287 gharial have been released in the Chambal river. With the present rate of release programme the target of release of 2500 gharial will be reached after few more years.

Although commercial fishing has been banned in the Sanctuary to avoid drowning deaths of gharial, there are unofficial reports of gharial mortality due to illegal fishing activity in the Sanctuary. This will affect the recovery of the gharial population and may also cause a decline in the population if not checked properly.

9. RECOMMENDATIONS

1. If gharials are to be saved from any reversal of the presently recovering trend, more strong, continued and coordinated action by the State Governments will be necessary. There is a need for greater protection of gharial by management practices.

2. The National Chambal Sanctuary should be immediately up-graded to a National Park Status.

3. The Government of India should immediately act for creating a central coordinating body responsible for administration, scientific advice and research in the National Chambal Sanctuary. This is emphasised at this stage, particularly because even after ten years of management the component States of National Chambal Sanctuary view the sanctuary only at the bits coming within their political boundary without due regard to the gharials' biological necessity.

4. The Core Areas should be given high priority under management: all illegal fishing activities should be severely dealt-with and other human activities like agriculture, wood cutting, poaching and sand mining should be minimised, controlled and recorded for future reference and guidance.

5. Since, the Chambal river has high potentiality to hold a good gharial population, releases should be continued for some more years as per the recommendations of the Technical Committee of Crocodile Project (Govt. of India). It is emphasised that all releases in future should be taken up in the up-stream along Zone 3 and 4 and avoid large scale releases along Zone 6.

6. Careful monitoring of the gharial population in the Chambal river should be continued for periodic assessment of the success of rehabilitation programme.

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