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Impact of Temperature on Sex Ration of Gharial Population in National Chambal Sanctuary, Rajasthan

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ABSTRACT

Temperature dependent sex determination (TSD) is a type of environmental sex determination. It is a natural process, but due to changing climate, this process is getting disturbed. A vivid example of this is the disturbing sex ratio of alligators in the Chambal river of Rajasthan. The annual census shows that although there has been a steady increase in the overall number of gharials in the NCS, but there have been clear and noticeable changes in their sex ratio in relation to the annual temperature. In 2016, the difference in male: female ratio was 1:8.32, which reached 1:13.4 in 2020. Thus, after 2016, where there has been a relative decrease in the mean temperature, its effect is visible in gharials in the form of an increased number of females, while the number of males has increased much less than that of gharials in the NCS, Rajasthan part. The sex ratio shows the deviation from the perspective of climate.

Keywords: *Chambal River, Gharial, Nesting Behaviours, M/F Ratio, Climate Change.*

INTRODUCTION

The river system is a suitable climate for all the organisms in it, providing them with food, habitat and breeding facilities. But any fluctuation in this system directly or indirectly affects all the creatures living in it. In this way, those changes occurring in a natural habitat, which pose a challenge to the sustainability of it and the organisms found in it, are included in the category of Climate Change.

Like all the major rivers of India, the Chambal river is also facing deterioration; The main reason for this is the increasing interference of man in the ecosystem of the River. Its direct impact is on the creatures living in the River, in which Gharial (*Gavialis gangeticus* Gmelin) is the most prominent.

The largest population of this animal declared critically endangered by the IUCN, is found in the Chambal river in India. Although, the ghariyal population is assessed annually through the local forest department and independent researchers. (Meena et al., 2017).

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But the study related to the sex ratio in the population and the thermal effect on it is probably the first. This study aims to assess the effects of temperature and rainfall fluctuations over the years on the sex ratio in the present population of gharials present in the Rajasthan part of NCS.

STUDY AREA:

NATIONAL CHAMBAL SANCTUARY: The National Chambal Sanctuary (NCS) lies between 25°02' to 26°29′ N and 75°40' to 79°14′E. It consists of the large arc described by the Chambal River between Jawahar Sagar Dam in Rajasthan and the Chambal-Yamuna confluence in Uttar Pradesh. Along this arc, two stretches of the Chambal are protected as the National Chambal Sanctuary; the upper stretch, extending from the Jawahar Sagar Dam to the Kota Barrage, and the lower stretch, extending from Keshoraipatan in Rajasthan to the Chambal-Yamuna confluence at Bareh in Uttar Pradesh.

The Government of India conveyed administrative approval for the establishment of the National Chambal Sanctuary in Order No. 17-74/77-FRY (WL) dated 30 September 1978, declared under Section 18(1) of the Wild Life Protection Act, 1972.

Encompassing with in itself the rare variety of species, unique geographical structures, and a different bio-geographical realm, National Chambal Sanctuary (NCS) totally represents a highly important, diverse and also vulnerable ecosystem. The River harbours a variety of aquatic life like the elusive Ganges River Dolphin (Platanista gangetica), Gharial (*Gavialis gangeticus*), Mugger (*Crocodylus palustris*), seven species of freshwater turtles, the Otter (*Lutra perspicillata*), Indian Skimmers (*Rynchops albicollis*) in large numbers and several species of fishes. Many studies have been carried out on the ecology and behaviour of the reptilian species found in NCS between Pali- Pachnada stretch, but very few studies emphasizing from Keshoraipatan to Pali Bridge. Keeping in mind the biodiversity significances of riverine stretch, a systematic scientific census has been conducted to find out to population status of Ghariyal in NCS, Rajasthan.

The study area of the current study was Keshoraipatan to Gadi Tidawali (Naka, Samona) of National Chambal Sanctuary, Rajasthan, GPS coordinates varied from 25°17'03.95"N, 75°56'26.54"E to 26°49'48.30"N, 78°13'02.76"E. The study area of first stretch (FS) was Keshoraipatan to Pali, geographical coordinates varied from 25°17'03.95"N, 75°56'26.54"E to 25°50'47.37"N, 76°33'48.78"E. The study area of the first stretch was divided day-wise namely zone-wise (table 1) as follows-

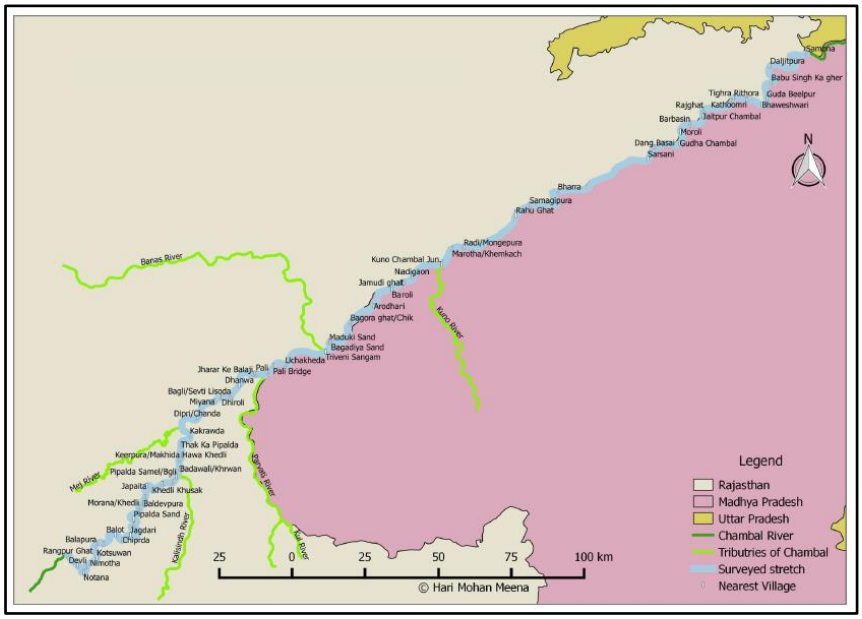
Table 1: Covered first stretch zone-wise during survey of NCS, Rajasthan

Zone	Zone Name	Length (kms.)
Zone FS 1	Chipa Ghat/ Rangpur Ghat to Kotsuwan	16.50
Zone FS 2	Kotsuwan down to Nimoda Hari Ji Ka	7.50
Zone FS 3	Nimoda Hari Ji Ka to Mandawara Bridge	22.0
Zone FS 4	Mandawara Bridge to Keerpura Ghat/ Makhida Ghat	37.50
Zone FS 5	Keerpura Ghat/ Makhida Ghat to Sevti Lisoda/ Bagli	40.00
Zone FS 6	Sevti Lisoda/ Bagli to Jharar K Balaji UP	13.00
Zone FS 7	Jharar K Balaji UP to Pali	6.50
Total Length		**143.00**

The study area of the second stretch (SS) was Pali to Gadi Tidawali (Naka, Samona), geographical coordinates varied from 25°50'47.37"N, 76°33'48.78"E to 6°49'48.30"N, 78°13'02.76"E. The study area of the second stretch was divided day-wise, namely zone-wise (table 2) as follows-

Table 2: Covered second stretch zone-wise during the survey of NCS, Rajasthan

Zone	Zone Name	Length (kms.)
Zone SS 1	Pali to Rameshwar	22.00
Zone SS 2	Rameshwar to Katarnipura	43.00
Zone SS 3	Katarinipura to Atar	47.00
Zone SS 4	Atar to Sarseni	64.00
Zone SS 5	Sarseni to Rajghat	32.00
Zone SS 6	Rajghat to Kuthiyana	30.00
Zone SS 7	Kuthiyana to Gadi Tidawali	14.00
Total Length		**252.00**



Surveyed Stretch in NCS, Rajasthan

MATERIALS AND METHODS

GHARIAL:

The Gharial (*Gavialis gangeticus* Gmelin 1789), or the Long-snouted Crocodile, is a freshwater Crocodile of the family Gavialidae. The Ghariyal gets its name from the Hindi word ‘ghara’ meaning pot or vessel. The adult male Gharials possess this protuberance at the tip of their long snouts, resembling an inverted pot. Only adult males have the 'ghara' (Tigerwatch, 2009). The Ghariyal is protected under the Indian Wildlife Protection Act (IWPA), 1972, as Schedule-I species, which provides a higher degree of protection and is categorized as Critically Endangered (CR) by IUCN and enlisted in Appendix-I of CITES. The species now has only been restricted to the river systems of India and Nepal. Ghariyal is not known to attack humans (Ahmed et al., 2009). High sensitivity to disturbance seems to be a major challenge for long-term conservation of Ghariyal.

Ghariyal has an interesting ecosystem and habitat. They spend most of their time in the water because they prefer to live in deep, swiftly flowing rivers. They are experts at building nests and laying eggs in the sand that has amassed on the riverbanks. They prefer shaded areas in hotter days in the summer. They are unable to walk in semi-upright positions, unlike other crocodiles, due to their frail limbs. It's incredible that an adult female can travel up to 80 km (10 miles) to find a place suitable for nesting and basking.

In gharials, the mating process starts in the month of December in the form of congregation. They do matting in the months of December to January. In the end of February to the middle of March, they make a trial nest and inspect the spot in the wild.

The female has a special technique for burying the egg in a sand nest so that it receives the right amount of warmth during incubation and is shielded from water currents. The nest can hold clutch size between 18 to 50 eggs at once. The bulk of the eggs hatch between 60-70 days after being deposited, depending on the temperature. Eggs hatch during mid-May to mid-July. Both the male and the adult female aid in easy hatching, and the male is also in charge of parental care throughout the monsoon.

Incubation temperature determines sex in the mugger crocodile, Crocodylus palustris. Exclusively females are produced at constant temperatures of 28.0°C through 31°C. At 32.5°C, only males are produced. Both sexes are produced in varying proportions at 31.5, 32.0, and 33.0°C. Embryo survival is not affected within this range, but the developmental rate and total incubation time are strongly temperature dependent. (Lang & Whitaker, 1989).

In ghariyals like other crocodilians, sex is not determined at the time of fertilization but depends on the temperature of the developing eggs. The hatchlings are all female if the temperature is cool, around 30 °C. Warmer temperatures, around 34 °C, hatch all males. (Woodward & Murray, 1993).

The female-male pattern in *Alligator mississippiensis* and *Caiman Crocodylus* was believed to depend on temperature, with females developing at low temperatures and males at high temperatures, but it was later found that males actually develop at intermediate temperatures, while Females develop at lower and higher temperatures. Jeffrey William Lang and Harry V. Andrews (1994).

The temperature of the nest plays a determining role along with various climatic factors in sex determination. This fact is proved by studies done on American alligators (Bock et al., 2020).

Data Collection: All relevant data were collected by adopting the following methods- Time of sampling was between 1000h and 1600h coinciding the basking time of Gharials. in the study area. Whenever the basking Gharials were observed, their size class, numbers, basking substratum, and basking site characteristics were recorded. The selected area was surveyed on a row boat and on foot. The double observer method was used for counting the study species from both banks of the River. The GPS locations of basking points of gharials were recorded without disturbing them and perpendicular point location on the river bank was recorded if Gharials were observed surface leaping or basking in the River in various substratum such as stone, and sand bank.

The hydrological features of the River, ambient and water temperature, habitat features, shoreline and bank characteristics were also recorded. The climatic parameters like temperature and rainfall were obtained from local meteorological department.

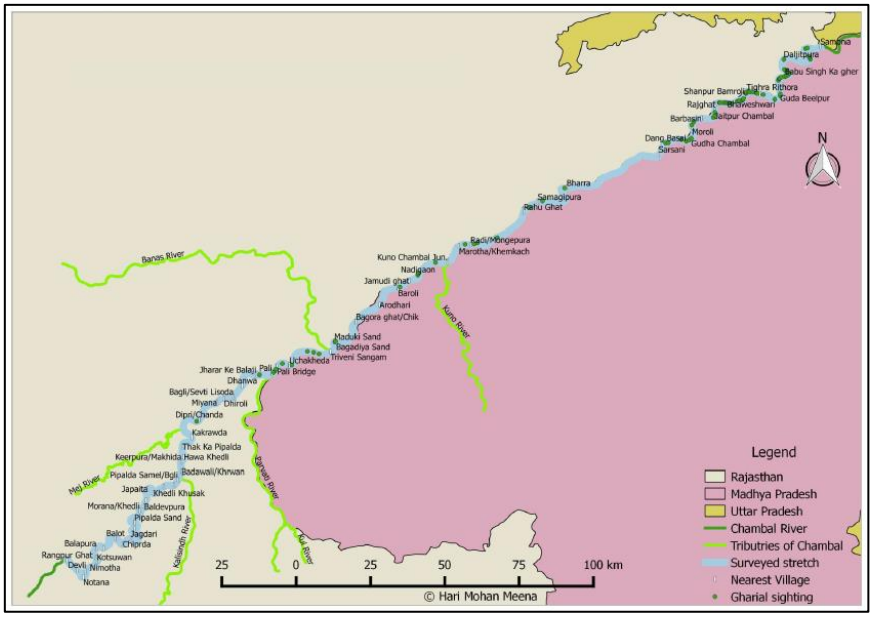
Equipment Used- Spotting of Ghariyal was done using field binoculars such as Olympus (10 X50), Bushnell (8 X42). Photographs were taken using Nikon Coolpix (18 megapixels, 42X), Nikon 3100 DSLR. GPS Garmin eTrex

and Garmin-72 were used to locate coordinates.

OBSERVATIONS AND RESULT

Basking Substratum Use

The NCS offers various types of basking substratum for Gharials. The basking substratum used by Gharials and muggers were categorized as Mudbank, Sand bank, Stone, Grass and surface leaping on water if they were found immobile and sun bathing. The basking substratum use analysis is based on the recorded data of gharials (n=14).



Major sites of Gharial distribution in NCS, Rajasthan

A detailed study is conducted between 2015 and 2021 in the 395 km National Chambal Sanctuary, Rajasthan part, the following observations were procured-

Table-3: Different age groups estimated in the study area (2015-2021)

Year	Male	Female	% of Male v/s Female	% fluctuation in Males	% fluctuation in Females
2015	29	272	10.66	-	-
2016	31	258	12.01	+6.8	-5.14
2017	37	465	7.95	+19.35	+80
2018	44	527	8.34	+18.91	+13.33
2019	50	566	8.83	+13.63	+7.4
2020	49	661	7.41	-2	+16.78
2021	50	670	7.46	+2.04	+1.3

Both sexes, viz. male and female ghariyals, were counted in the study area during the year 2019 to 2021 (Table-3). Under which the maximum number of 50 males were observed in the year 2019 & 2021. Its numbers were 49 in 2020, 44 in 2018, 37 in 2017 respectively; 31 males were counted in 2016 and 29 in 2015. The highest number of female ghariyals were observed in the year 2021 with 670 followed by 661 in 2020, 566 in 2019, 527 in 2018, 465 in 2017 and 272 in 2015 respectively. Whereas in the year 2016, the lowest number of 258 females was reported.

Data are analyzed on the basis of male & female Ghariyal population from 2015 to 2021. Comparision between male & female population shows that males are only 10.66% compared to females in 2015; 12.01% in 2016; 7.95% in 2017; 8.34% in 2018; 8.83% in

2019; 7.41% in 2020 and 7.46% in 2021 respectively.

Percentage increase in male population from 2015 to 2021 shows that 6.8% males are increased in 2016; 19.35% increased in 2017; 18.91% increased in 2018; 13.63% in 2019 and 2.04% increased in 2021 but 2.0% males were decreased in 2020.

Percentage increase or decrease in the female population represents that initially 5.14% decrease in the female population in 2016 as compare to 2015 but after that female population increase gradually as 80% in 2017; 13.33% in 2018; 7.4% in 2019; 16.78% in 2020 and 1.3% in 2021.

Table 4- Rainfall pattern during the study period in Rajasthan (2015-2021)

Year	Actual Rainfall (MM)	Normal Rainfall (MM)	Departure from Normal (%)
2015	457.0	419	+9
2016	536.4	419	+28
2017	454.9	419	+9
2018	393.3	419	-6
2019	583.6	415	+41
2020	449.8	415	+8
2021	485.3	414.5	+17

Table 4 shows that the years 2021 and 2016 were the rainiest years in terms of rainfall. While the year 2018 was the least rainy year of all the 7 years studied, with 6% less rainfall than the average.

Table-5: Temperature pattern during study period in Rajasthan (2015-2021)

Year	Maximum (°c)	Minimum (°c)	Average (°c)
2015	37.75	16.75	26.41
2016	36.37	17.41	27.16
2017	36.83	16.16	26.83
2018	37	17.08	26.83
2019	36.83	15.75	26
2020	36.33	16.25	26.25
2021	35.5	16	26

It is known from table-5 that the highest maximum temperature (37.75) was recorded in the year 2015 while the lowest maximum temperature (35.5) was recorded in 2021. Whereas the lowest minimum temperature (15.75) was recorded in 2019 and the highest minimum temperature (17.41) was recorded in 2016.

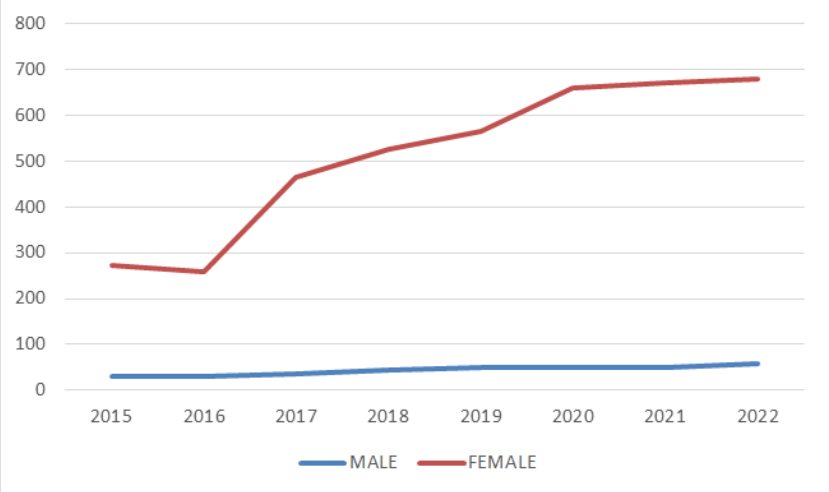


Fig.-1: Year-wise changes in Male-Female Sex

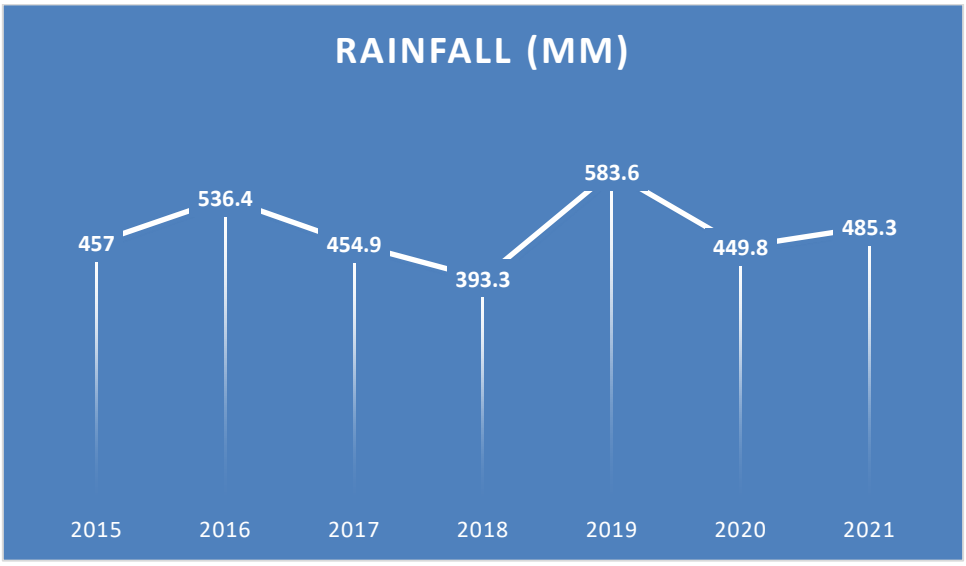


Fig.-2: Rainfall pattern during study period in Rajasthan (2015-2021)

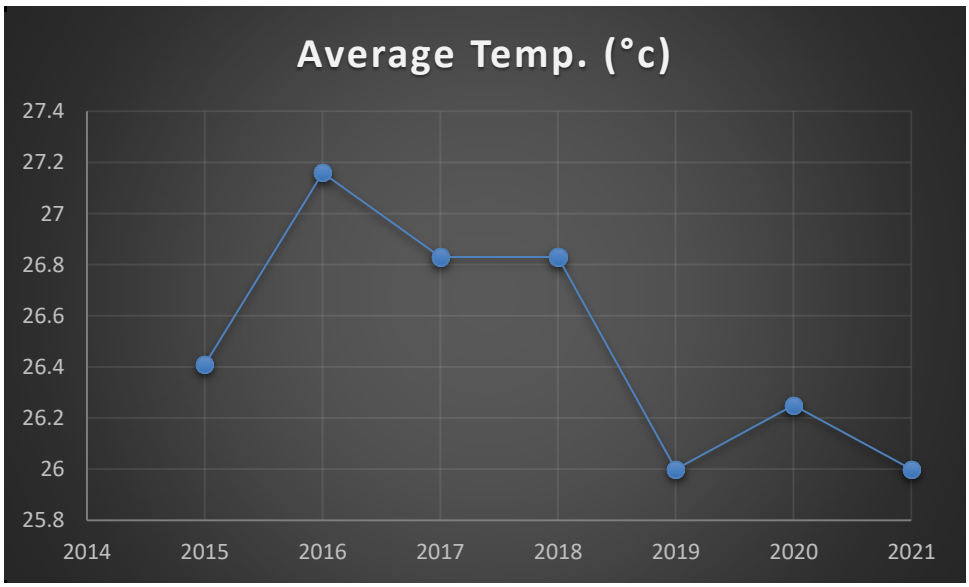


Fig.-3: Temperature pattern during study period in Rajasthan (2015-2021)

CONCLUSION

The result obtained from the data is that during the study duration, there was a continuous increase in the number of male gharials in the study area except 2020. Also, other than 2015, there has been a continuous increase in the number of female gharials since the year 2016. (Fig. 1)

Based on fig.1 & 3, it is concluded that annual temperature has a determining effect on the sex ratio in the Ghariyal population in NCS, Rajasthan Part. While there has been a relative decrease in average temperature after the year 2016, its effect has been sustained in gharial. This is visible in the form of an increased number of females. In contrast, the number of males has increased very little in comparison, which shows the deteriorated sex ratio of gharial in NCS, Rajasthan Part.

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Author contribution:
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