Study of Variation in Body Temperature of Freshwater Turtles

A Dissertation submitted for the partial fulfillment of the requirements

for the award of M.Sc. degree in

Environmental Science

Submitted By

LAMEEZ ALI

Roll no. 2001052002

Enrollment No. 1700100581

Department of Environmental Science

Integral University, Lucknow.

Internal Supervisor:

DR. MONOWAR ALAM KHALID

DSW, HOD, Department of Environmental Science, Integral University,

Lucknow, Uttar Pradesh

External Supervisor:

DR. SHAILENDRA SINGH

Director, Turtle Survival Alliance Foundation-India.

Lucknow, Uttar Pradesh

June, 2022

Turtle Survival Alliance - India

Committed to conserving India's freshwater ecosystems

F.F., D 1/ 317, Sector F, Jankipuram, Lucknow,
Uttar Pradesh, India -226021
Email: tsa.indiaprog@gmail.com
Tele-Fax: +91-522-4001167

Letter No. HR/IU/2022-1032 Date: 01.08.2022

CERTIFICATE

This is to certify that, the dissertation entitled 'Study of Variation in Body Temperature of Freshwater Turtles' submitted to Integral University, Lucknow for the partial fulfillment of the degree of Master of Environmental Science is a record of authentic research work carried out by Ms. Lameez Ali under my supervision and guidance from 04 April to 30 June 2022. The content of this thesis are the original work of the candidate and does not form the basis of an award for any previous thesis or degree.

The assistance and help received during the dissertation work and source of literature have been duly acknowledged.

Sincerely,

Shailendra Singh

(Dr. Shailendra Singh)
Director, Turtle Survival Alliance – India
Regional Vice Chair (South Asia) IUCN/SSC/TFTSG

DECLARATION

I, **Lameez Ali**, do hereby declare that the dissertation entitled "**STUDY OF VARIATION IN BODY TEMPERATURE OF FRESHWATER TURTLES"** has been undertaken by me for the award of degree of Masters of Environmental Science. I have completed this study under the guidance of **Dr. M.A. Khalid**, DSW, HOD, Department of Environmental Science, Integral University, Lucknow, and **Dr. Shailendra Singh**, Director, Turtle Survival Alliance Foundation-India, Lucknow, Uttar Pradesh.

I also declare that the contents of the report have never been published anywhere before except the quotations and references which have been duly acknowledged in the concerned places. It reflects the work done solely by me during my internship (from 15th March, 2022 to 15th June, 2022).

Lameez Ali
M.Sc. EVS, IV Sem
Integral University, Lucknow

LIST OF FIGURES AND TABLES

CONTENTS

AKNOWLEDGEMENT

First and foremost, I might prefer to express my sincere and profound feeling to my external supervisor, **Dr. Shailendra Singh,** who gave me this monumental chance to be a part of this organization and explore the world of turtles. I'm deeply indebted to him for his valuable guidance, technical expertise, and knowledge that he shared and bestowed upon me.

I express my sincere gratitude towards **Ms. Sreeparna Dutta** and **Ms. Arunima Singh**, for the dear time spent by them in creating my dissertation work far more realistic and scientific and for teaching me all that was needed for the study by perpetually guiding and supporting me. Their friendly nature helped me to understand things simply and comfortably.

I might conjointly prefer to convey my thanks to **Dr. Saurabh Dewan** and **Mr. Bhaskar Dixit,** for their kindness and the constant care that they showered on me.

I need to specially thank **Dr. M. A. Khalid**, HOD, Department of Environmental Science, Integral University, for his immense support and guidance throughout my course and my thesis work. He has been incredibly patient and generous and giving along with his time. My time under his guidance has been pure bliss.

I would like to extend my thanks to **Pradeep Rai** and **Balram Singh Rajpoot**, for their contribution and help during the entire duration of field work and study as well as for my time in TSA office.

I would like to thank **Ayush Sharma**, for his support and help in data analysis, and my friends and teachers for their constant support during the internship.

Lastly, I would like to express my gratitude towards my parents and my family members for their support, love and guidance throughout the duration of this study.

ABSTRACT

Of the 360 currently recognized turtle and tortoise species, more than half are Threatened according to the IUCN Red List. Of these, 127 species are Endangered or Critically Endangered, facing the risk of extinction in this century (Stanford et al, 2020). India falls under the category of one the most biodiverse country globally in terms of chelonian population with 29 species of freshwater turtles and tortoises and 6 marine turtle species. The North Indian state of Uttar Pradesh alone supports fifteen of the twenty-nine species of fresh water turtles and tortoises found in the Indian subcontinent (Singh *et al*, 2009).

The lesser Sarju River in the foothills of Himalayas, represent over 30% of the freshwater turtle and tortoise species found in India. It originates from a swampy wetland, Gandarwa Taal in proximity to Nanpara town of Bahraich district situated along the Indo-Nepal border. The river travels a total distance of 205 km from its source to confluence, and during this study 6 out of 9 species of freshwater turtles and tortoise were recorded, belonging to two families Trionychidae (n=42) with 3 species and Geomydidae (n=269) with 3 species, with *P. tecta* being the most abundant (n=164). The species encountered are identified as *Geoclemys hamiltonii, Hardella thurjii, Lissemys punctata, Nilssonia gangetica, Nilssonia hurum, and Pangshura tecta.*

This study was carried out to study the effect of temperature variations in the species temperature, to understand the relation between habitat, mass, size and sex of species to that species temperature. The study was conducted in the month of April, 2022 between 1100 to 1830 hrs and with nets being checked every two hours in a twelve-hourly cycle (4am – 4pm) every day. A total of 311 individuals were sampled during the study, with average body temperatures of females and males calculated as 28.7 °C and 30.1 °C respectively. Multiple correlation and linear regression analysis were

performed which indicated no significant relation between species body temperature (*Tb*) and species mass and size.

The study states the possible effects of rapidly increasing global temperatures and climate change on the overall existence of turtles. It points out viable options and areas that can be worked on with respect to effects of temperature on turtles and the threats that engulf the species when the temperature rises.

Keywords: *Freshwater turtles, temperature, Sarju, climate change and mitigation.*

CHAPTER 1: INTRODUCTION

Background

‘Testudines’ or ‘Chelonii’ (turtles, terrapins and tortoises) is one group reptiles that lack teeth are covered with bony plates fused to the vertebrae and ribs enclosing their soft body parts. Chelonians are an integral part of world ecosystems for concerning 300 million years and have vie vital roles in human culture for a minimum of 400,000 years. The chelonian shell may be an outstanding biological process adaptation, facilitating success in terrestrial, fresh water and marine ecosystems. According to (Anders *et al*, 2011), the basic body structure and form of the turtle shell has been the reason behind the successful survival of turtles throughout the million-year long process of natural selection. (Turtle Conservation Fund 2002) highlighted threats originating from anthropogenic exploitation and developmental pressure, for increased vulnerability of turtle extinction, in spite of their successful adaptation, including delayed sexual maturity, high fertility rate, low natural mortality, high juvenile death rate and long life-span. Of the 360 currently recognized turtle and tortoise species, more than half are Threatened according to the IUCN Red List. Of these, 127 species are Endangered or Critically Endangered, facing the risk of extinction in this century (Stanford *et al*, 2020).

Folkloric existence of turtles

Turtles have an important role in the culture of many people around the globe, and have been since ancient times. Hindu mythology regards turtle as an incarnation of Lord Vishnu (Kurma Avatar, one of the 10 avatars) as a giant turtle supporting the world. River Yamuna, mythologically called as 'Mother Yamuna' used the turtle as her 'vahan' (vehicle) (Rao, 1987). An earlier relevancy a divine incarnation as a turtle identifies the animal with Hindu deity (the god Brahma), who took that form so as

to make offspring. In Hindu mythology the globe is assumed to rest on the backs of four elephants who stand on the shell of a gigantic turtle. The Shatapatha Vedic literature identifies the planet as the body of Kurmaraja, the "king of tortoises", with the world being its plastron, the atmosphere its body, and the carapace being the gate to heaven. Following these beliefs turtles and tortoises are often found in the temple premises, in ponds and tanks, wherever devotees can offer them food. There are depictions of turtles on walls and pillars of the temples. Various communities serve and protect turtles in their own way, such as, The Bharuch Muslim communities of Gujarat rescue and save turtles during the drought month and feed them. In places like, Tamil Nadu, Kerela and Bihar, people worship land tortoises by glorifying them with vermillion. A group of socially interactive people of the Kamar tribe in India, show admiration for the turtles.

Importance

Turtles and tortoises play a key role in the environment and the ecosystems they dwell in. They're scavengers and are sometime referred to as the "Vultures of the Aquatic System" as they feed on dead decaying organic matter, weed or injured and diseased animals. They help maintain the health of the pond or river they're found in, keep the invasive fish species in check by preying on them, and simultaneously be a source of food and protein for other predators that feed on turtle eggs or juveniles of the same. By removing the polluting matter from the aquatic systems, they keep urban pollution in check to some extent as well. Turtles also help in distributing plant seeds while/ after feeding on them, and also that of some herbs, shrubs and once passed through the digestive system help effectively in germination of seeds. Turtle species surviving on various plant varieties for food and shelter, can immensely influence the plant community composition and vegetative structure in wetlands as well as drylands (Van Dijek 2000). Thus, the service they provide as a

biological agent for dispersal of floral varieties, and to have an impact on the biodiversity through symbiotic coalition varied multitube of organisms (Upadhyay *et al*, 2016).

Status of Freshwater Turtles Uttar Pradesh

Uttar Pradesh is the fourth-largest state of India with a total area of 243,290 square kilometers (93,935 sq mi), and is engulfed by Uttaranchal in the North, along with Nepal touching its northern borders, Bihar to the East, Madhya Pradesh to the South, and lined with Rajasthan, Delhi, Himachal Pradesh and Haryana to its West. The state is home to four major ecozones, which are; Terai, Vindhyan, Gangetic Plain, and Semi-arid region. This region has the second highest species diversity in terms of turtle population in India, with 13 of 15 species of freshwater turtles and tortoises found in India existing here.

Table-1.1: Annotated checklist of freshwater turtles and tortoises of Uttar Pradesh with their protection status

SI No.	Scientific Name	Common Name	IUCN Status	CITES	IWPA Status
1	*Batagur kachuga*	Red Crowned Roof Turtle	Critically Endangered Alcd	Appendix II	Schedule I
2	*Batagur dhongoka*	Three Striped Roofed Turtle	Critically Endangered Alcd+2cd	Appendix II	Not listed
3	*Hardella thurji*	Crowned River Turtle	Endangered Alcd+2cd	Appendix II	Schedule I

4	*Geoclemys hamiltonii*	Spotted Pond Turtle	Endangered Alcd+2cd	Appendix I	Schedule I
5	*Morenia petersi*	Indian Eyed Turtle	Endangered Alcd+2cd	Appendix II	Not listed
6	*Melanochelys trijuga*	Indian Black Turtle	Least Concerned	Appendix II	Not listed
7	*Melanochelys tricarinata*	Tricarinate Hill Turtle	Endangered B1+2c	Appendix I	Schedule I
8	*Pangshura smithi*	Brown Roofed Turtle	Near Threatened	Appendix II	Not listed
9	*Pangshura tecta*	Indian Roofed Turtle	Vulnerable	Appendix I	Schedule I
10	*Pangshura tentoria*	Indian Tent Turtle	Least Concerned	Appendix II	Not listed
11	*Nilssonia gangetica*	Indian Softshell Turtle	Endangered Ald+2d	Appendix I	Schedule I
12	*Nilssonia hurum*	Indian Peacock Softshell Turtle	Endangered Alcd+2d	Appendix I	Schedule I
13	*Chitra indica*	Indian Narrow-Headed Softshell Turtle	Endangered Alcd+2cd	Appendix II	Schedule IV
14	*Lissemys punctata*	Indian Flapshell Turtle	Vulnerable	Appendix II	Schedule I
15	*Indotestudo elongata*	Yellow-Headed Tortoise	Critically Endangered Alcd+2cd	Appendix II	Schedule IV

Being one of the most threatened species, turtles and tortoises face the major risk of extinction due to habitat loss and degradation. To save turtles from extinction with current scenarios, protection of important species habitat is of utmost importance (Arunima Singh *et al*, 2021). With 80% (around 340) taxa occurring in 16 major hotspots, protecting roughly 24 million sq km or about 16.0% of Earth's land surface would protect the majority of turtles on Earth (TTWG, 2017; Stanford *et al*, 2020). Spread long the Indo-Nepal border, the Terai Arc Landscape (TAL), is considered to be a turtle biodiversity hotspot, and falls under the category of top priority in terms of need of conservation amongst 200 ecological areas (Singh *et al*, 2008). It supports more than half the population of freshwater turtle species of India (Singh *et al*, 2011). Belonging to one of the most biodiverse turtle habitat regions (Rao, 1990; Das, 2002**)**, it was declared a global turtle priority area in the 'Indian Freshwater Turtles and Tortoises Conservation Priority Areas and Initiatives Workshop 2010' (Singh and Horne, 2011).

1.1 OBJECTIVES

1. To document the mean temperature of species during the month of study
2. To document the interspecies variation in body temperature
3. To understand the relationship among body temperature, turtle body size, mass and sex

CHAPTER 2: LITERATURE REVIEW

2.1 Diversity and Distribution of Turtles

Of the 360 currently recognized turtle and tortoise species, more than half are Threatened according to the IUCN Red List. Of these, 127 species are Endangered or Critically Endangered, facing the risk of extinction in this century (Stanford *et al*, 2020). The global diversity of turtles and tortoises (chelonians, order Testudines) that has existed in modern times (since 1500 CE), and currently consists of approximately 357 species, of which 58 are polytypic, with 129 additional recognized subspecies, or 486 total taxa of modern (living and extinct) turtles and tortoises (including one unnamed subspecies) (Turtle Taxonomy Working Group, 2021). Of these, 10 taxa of tortoises and freshwater turtles (2.1%of all modern taxa) have gone extinct, reducing to a number of 476 total taxa of living turtles and tortoises, comprising of 345 species and 469 taxa of freshwater or terrestrial and 7 species (and taxa) of marine (Turtle Taxonomy Working Group, 2021).

Currently, 171 turtle species (62.4% of the 274 species red-listed, 47.9% of all 357 recognized modern species) are officially regarded as globally Threatened (Critically Endangered [CR], Endangered [EN], or Vulnerable [VU]) (IUCN Red List 2021-3 (version 3.1). An additional provisional threat assessment done by the IUCN Tortoise and Freshwater Turtle Specialist Group documented 183(51.3%) species as Threatened (CR, EN, or VU) (Turtle Taxonomy Working Group, 2021).

India falls under the category of one the most biodiverse country globally in terms of chelonian population with 29 species of freshwater turtles and tortoises and 6 marine turtle species. India has a rich variety of freshwater ecosystems comprising of rivers, lakes, ponds, wetlands, aquifers, and streams. Around 10% of India's animal species are associated with freshwater ecosystems, including several endemic

species. The aquatic turtle species found in India are classified into two categories or types- Hard-shell turtle (Emydidae turtle) and Soft-shell turtle (Trionychid turtle). The hard-shell turtles are characterized by bony thick external framework or structure including plastron, whereas soft-shell turtles have gristle or cartilaginous, softer outer covering including the plastron. A country-wide survey conducted by (Moll 1984), during the late 1980's gave an insight of India's freshwater turtle's fauna, of which little was known. Minimal studies dealing with taxonomy and distributional ranges of the species was conducted by (Smith 1933); (Pritchard 1979); (Daniel 1983); (Das 1985); (Moll 1984) and their occupancy in different biogeographical zones, in different states was identified by (Rodgers and Panwar 1988). The first publication on the biology and overall distribution along with coloured identification keys of species belonging to the Indian subcontinent (comprising India, Bangladesh, Pakistan, Nepal, Sri Lanka with additional information on their natural history, was published by (Das 1990). It includes data on 41 species and subspecies of turtles and tortoises of five families, based on previously existing records, literature and museums.

The existence of 27 aquatic turtle and tortoise species in India was documented by Choudhury *et.al* (2000). It included the following genus with their species number (*Amyda*-1, *Aspideretes*-3, *Batagur*-1, *Cuora*-1, *Cyclemys*-1, *Chitra*-1, *Geomyda*-1, *Geoclemys*-1, *Geochelone*-1, *Hardella*-1, *Indotestudo*-2, *Kachuga*-6, *Lissemys*-1, *Melanochelys*-2, *Morenia*-1, *Manouria*-1, *Pyxidea*-1, *Pelochelys*-1).

The highest species density around the world includes the upper region of the Ganges and Brahmaputra Basin in India (Buhlmann *et. al*, 2009) and with the existence of nineteen species co-existing, he declared the Ganges-Brahmaputra confluence as a global site.

A report by (Rao, 1990; Das, 2002), suggested that a diverse chelonian fauna is found in the Gangetic plains and the Terai region which amounts to 20 species. Study on the ecological relationship among specific species inhabiting the Chambal River, a major tributary of the Ganga River system was done by (Rao 1990), followed by identification of 12 freshwater turtle species in the upper Ganga River in Uttar Pradesh, North India by (Rao 2001). A study conducted by (Singh et al. 2009) on the distribution and abundance of turtle species, in over 100 wetlands within 20 districts of the state of Uttar Pradesh with the aim of prioritizing their importance as turtle habitats concluded the presence of 15 of 29 freshwater species of the Indian Subcontinent.

2.2 Status of Turtles in Sarju River

The lesser Sarju River in the foothills of Himalayas, represent over 30% of the freshwater turtle and tortoise species found in India. It originates from a swampy wetland, Gandarwa Taal in proximity to Nanpara town of Bahraich district situated along the Indo-Nepal border. The river travels a distance of 205 km before meeting the Ghaghra River at Chandapur, from North to South-East in direction, further flowing South-East to meet the river Ganga at Chapra in Bihar district. The Ghaghra-Sarju River System is a major tributary of the Ganges River Basin that flows through the Terai Arc Landscape (TAL) (Arunima Singh *et al*, 2021), which is located in the foothills of the Himalayas, along the Indo-Nepal border, and is considered to be a turtle diversity hotspot, falling under top 200 eco-zones requiring immediate conservation attention (Singh *et al*, 2008). It was recognized as a fundamental conservation region in the National Strategic Planning Meeting (2010) for its high turtle diversity, that includes some of the rare species such as the Indian Softshell Turtle (*Nilssonia gangetica*), Indian Narrow headed Softshell Turtle (*Chitra indica*), *N. hurum* and *H. thurjii* (Arunima Singh *et al*, 2021). (Singh *et al*, 2008) conducted

a few studies owing to scarce pre-existing information on the chelonian diversity, and documented the presence of eight turtle species in the unprotected river with large populations of *C. indica* and *H. thurjii* in the lesser Sarju river.

During the survey carried out by (Arunima Singh *et al*, 2021), a total of 289 individuals were identified which included nine species which were identified as; *C. indica, L. puncata*, *N. gangetica*, *N. hurum*, *H. thurjii*, *G. hamiltonii, P. tecta*, Indian Tent Turtle (*P. tentoria flaviventer*) and Indian Eyed Turtle (*Morenia petersi*), which reconfirmed the presence of eight species documented by (Singh *et al*, 2008) with the addition of one more species.

CHAPTER 3: STUDY AREA

Situated in the foothills of Himalayas, the Terai Arc Landscape (TAL) is spread over approximately 6500 sq km and is a beaming hotspot for chelonian diversity supporting more than 50% (14 species) of freshwater turtle species found in India. The comprises of numerous small and seasonal rivers, and some of the major rivers include, Yamuna, Ghaghra, Sarju, Rapti, Gomti and Sharda.

River Ghaghra is the largest tributary of river Ganga. It is called Karnali or Manchu in upper reaches and originates from the Himalayan glacier about 60 km South-West at Mansarovar at an elevation of 4800 m. Ghaghra river spans a total catchment are of about 127,000 sq. km, and hasa total length of about 1080 km. Various tributaries are Sarju, Sarda, Rapti, Kwano, Little Gandak, Seti etc. The portion of Ghaghra basin falling in Uttar Pradesh lies between east longitudes 79°29' to 84°49’ and north latitudes 25°47' to 30°31' encompassing an area of 31,503.00 sq.km within the state.

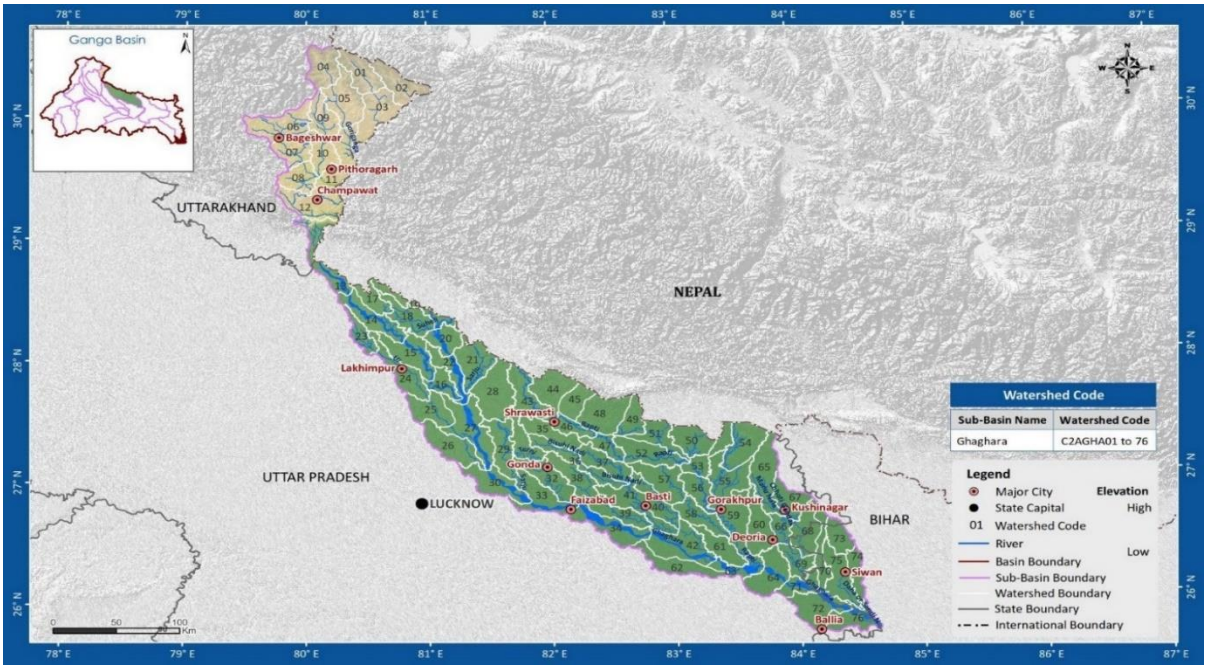

Fig 3.1: Ghaghra Basin and watersheds, Upper Ganga Basin Organization, (Central Water Commission)

Lesser Sarju river originates from a swampy wetland, Gandarwa Taal close to Nanpara town of Bahraich district along Indo-Nepal boarder (Arunima Singh *et al*, 2021). The river travels a distance of 205 km before meeting the Ghaghra River at Chandapur, from North to South-East in direction, further flowing South-East to meet the river Ganga at Chapra in Bihar district. The entire stretch of the slow flowing Lesser Sarju River is heavily vegetated along its bank and consists of shallow and narrow channels in upstream (about 60 km), wider and deeper pools in the middle and lower sections (Arunima Singh *et al*, 2021).

3.1 Climate

The work site was based in two locations- Baraich and Gonda, Uttar Pradesh. The general, overall temperature of both cities were analyzed for the study.

Bahraich has a mild, and generally warm, temperate climate, with summer months ranging from April to July. It's is followed by the monsoons season occurring between July and mid-September. At an average temperature of 31.4 °C (88.5 °F), May is the hottest month of the year. At 14.6 °C (58.4 °F) on average, January is the coldest month of the year.

Gonda has a warm and temperate climate. The city receives more rainfall in the summer months than winters. Average temperature in Gonda is 24.8 °C (76.7 °F).). with May being the warmest month of the year. The temperature in May when averaged, comes out to be around 31.8 °C (89.3 °F). The coldest month happens to be January, with an average temperature of 15.0 °C (59.0 °F).

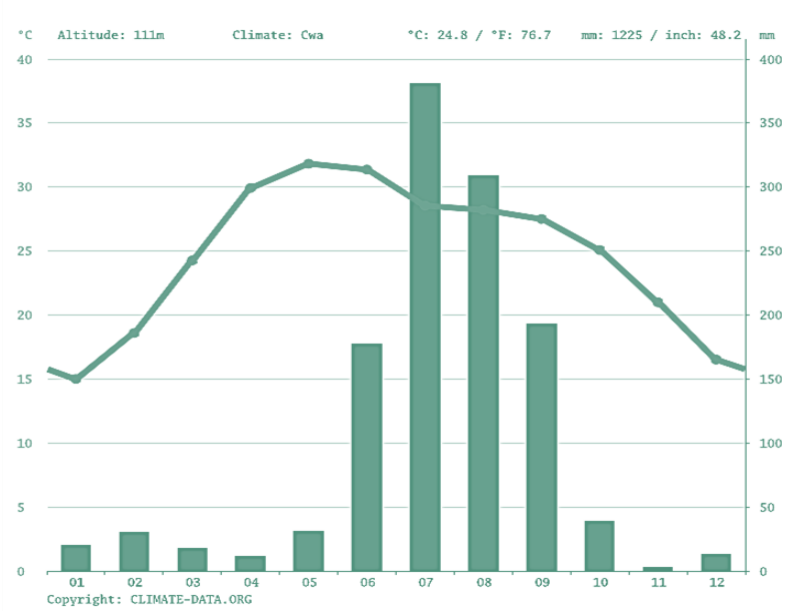

Fig 3.1.1: Monthly Normal Maximum and Minimum Temperatures and Total Rainfall from the year 1991 – 2021, Bahraich, UP. (climate-data.org).

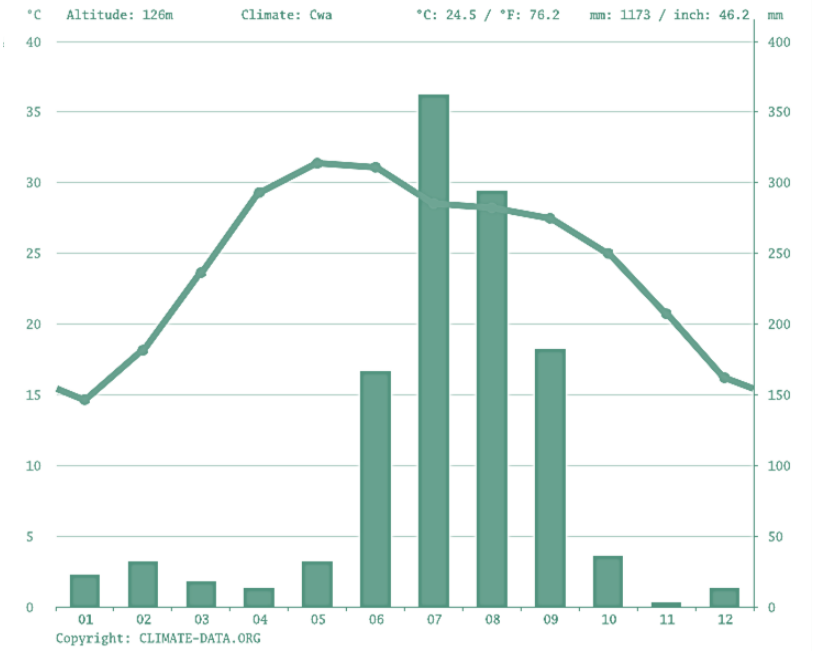

Fig 3.1.2: Monthly Normal Maximum and Minimum Temperatures and Total Rainfall from the year 1991 – 2021, Gonda, UP. (climate-data.org). (Cwa= Köppen-Geiger Climate Classification)

3.2: Study site

Fig 3.2.1 Map of site 1 prepared using Google Earth Pro V 7.3.4.8248

Fig 3.2.2: Site 1, Katraghat

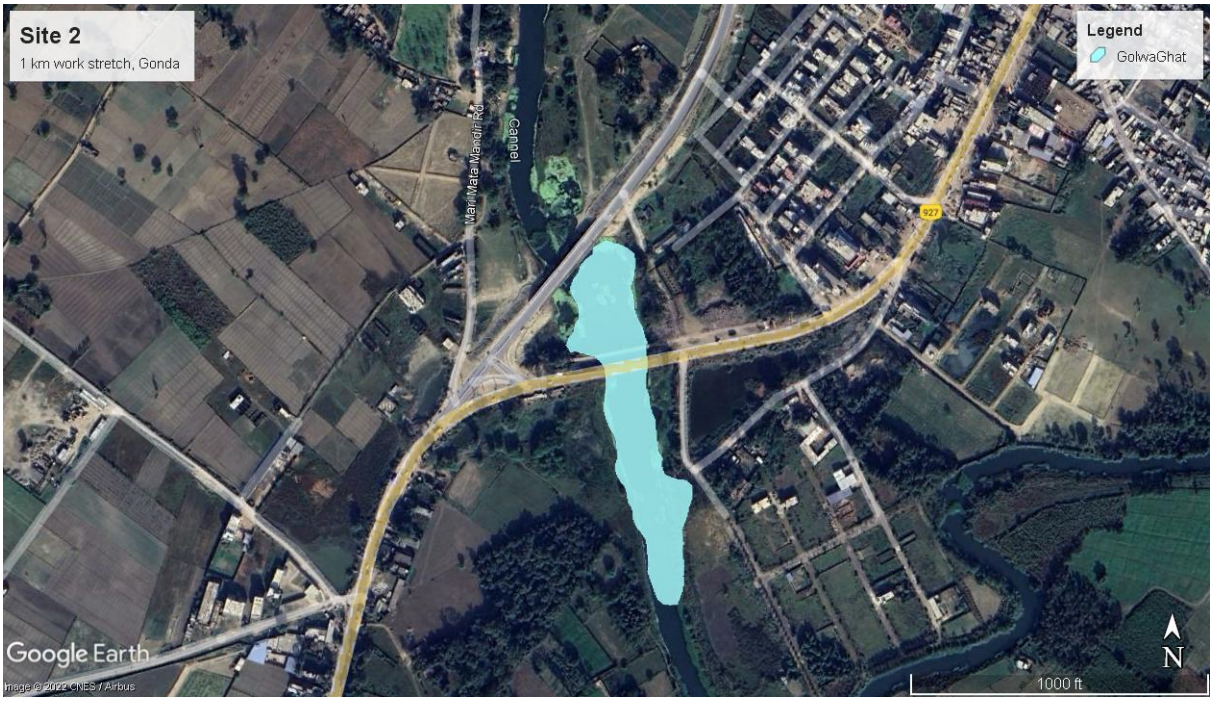

Fig 3.2.3: Map of site 2 prepared using Google Earth Pro V 7.3.4.8248

Fig 3.2.4: Site 2, Golwaghat

CHAPTER 4: METHODOLOGY

4.1 Research Design

Steps involved in the completion of this study include-

1) Literature Review
2) Selecting the Study Criteria
3) Data Collection
4) Data Analysis

Not much is documented when it comes to the variation in body temperature of freshwater turtle species and this lack of information was assessed in the first month of the study, through previously documented papers and studies conducted globally. To further continue the study on turtles in the lesser Sarju river, ongoing projects of Turtle Survival Alliance (TSA) on the river were studied. A basic knowledge of turtle and tortoise classification and their identifiable characteristics were looked into. Information on species of freshwater turtles and tortoises found in India along with their identification key were studies.

4.2: Data collection

In order to assess the turtle species for the study, a sheet was prepared where morphometric data including (CL, CW, PL, H and body mass) were recorded.

Two sites of 1.22 km (Katraghat) and 1 km (Golwaghat) were sampled approximately 62.9 kms apart. Turtles being exothermic, their surfacing and basking behaviour is observed to be maximum during pre-winter (October – November) and after winter months (April – June) (Arunima Singh *et al*, 2021). Hence, this survey session was carried out in the month of April 2022. The sampling was done during the day between 1100 to 1830 hrs with a total of 67.5 hrs spent on the study. The

nets were checked for species every two hours in a 12 hourly cycle (4am -4pm and 6am -6pm) every day.

The captured species were marked using the Cagle Scute-Notching method (1939) and were released at the same site capture. Turtles were grouped by sex (male, female, and juvenile), identified by their external body characteristics (plastron carapace, tail length) and body size (Souza, 1995; Souza and Abe, 1997, 1998). For each species capture, its body measurements were noted (carapace length, width, height and plastron length, tail length, width and cloacal length) using caliper and vernier caliper to the nearest 0.1mm and the mass of the turtle was measured using the Virgo WHA08 digital weighing scale to the nearest 0.5 grams. The body temperature (*Tb*) of the species was noted immediately post capture using Vici TM803 digital thermometer with the precision of up to 1 °C. The temperature was taken by inserting the 5mm probe in the cloaca of the species for 30 seconds. The probe was cleaned and sanitized before and after every session and the thermometer was calibrated using boiling water.

Fig 4.2.1: Digital Thermometer used for the study

Fig 4.2.2: Digital weighing scale used for the study.

Fig 4.2.3: Recording temperature of *Hardella thurjii* (F)

4.3: Data analysis

For the analysis of species temperature for the month of April 2022, simple arithmetic mean (AM) was calculated (n=169); (n= no. of individuals). Versus graphs were plotted between body temperature (*Tb*) and mass and size of species. To analyse the relation between body temperature of species to that of its mass and size, correlation was determined followed by regression analysis.

Correlation is the measurement that is used to quantify the relationship between variables. If an increase or decrease in one variable causes a corresponding increase or decrease in another, then they are said to be directly correlated. While an increase in one and decrease in another indicated an indirect correlation. This relationship is given by the correlation coefficient.

A correlation coefficient such a Pearson's correlation coefficient is used to give a signed numeric that indicates the direction and strength of the correlation.

Pearson's Correlation Coefficient

The coefficient for Pearson's correlation (*r*) is calculated using the formula

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Where,

r = Pearson's correlation coefficient

x = Values in the first set of data

y = Values in the second set of data

n = Total number of values

Regression determines the nature of the correlation, or in simple terms, it determines, how does the change in variable affect each other. Linear regression is the most common type of regression and it is used to find the line that is best-fitted to establish a relation between variables.

Linear Regression

Formula for linear regression equation is given by

$$\boldsymbol{y = a + bx}$$

a and *b* are given by the following formulas:

a (intercept) = $\frac{\boldsymbol{\Sigma y \Sigma x^2 - \Sigma x \Sigma xy}}{\boldsymbol{(\Sigma x^2) - (\Sigma x)^2}}$

b (slope) = $\frac{\boldsymbol{n\Sigma xy - (\Sigma x)(\Sigma y)}}{\boldsymbol{n\Sigma x^2 - (\Sigma x)^2}}$

Where,

x and y are two variables on the regression line.

b = Slope of the line.

a = y-intercept of the line.

x = Values of the first data set.

y = Values of the second data set.

Analysis for correlation and regression can be done using a scatter plot (to determine the strength of the relationship between two variables).

CHAPTER 5: RESULTS

During the period of study two sites, Katraghat (27.124426° N - 81.661545° E) and Golwaghat (27.553866° N – 81.57935° E), were sampled for species, and a total of 311 species representing six out of nine found in the Sarju river. Three of them belonged to the Geomydidae family viz., *H. thurjii*, *G. hamiltonii*, *P. tecta* and the remaining three, *L. puncata*, *N. gangetica*, *N. hurum* belonged to family Trionychidae.

5.1: Interspecies Temperature Variation

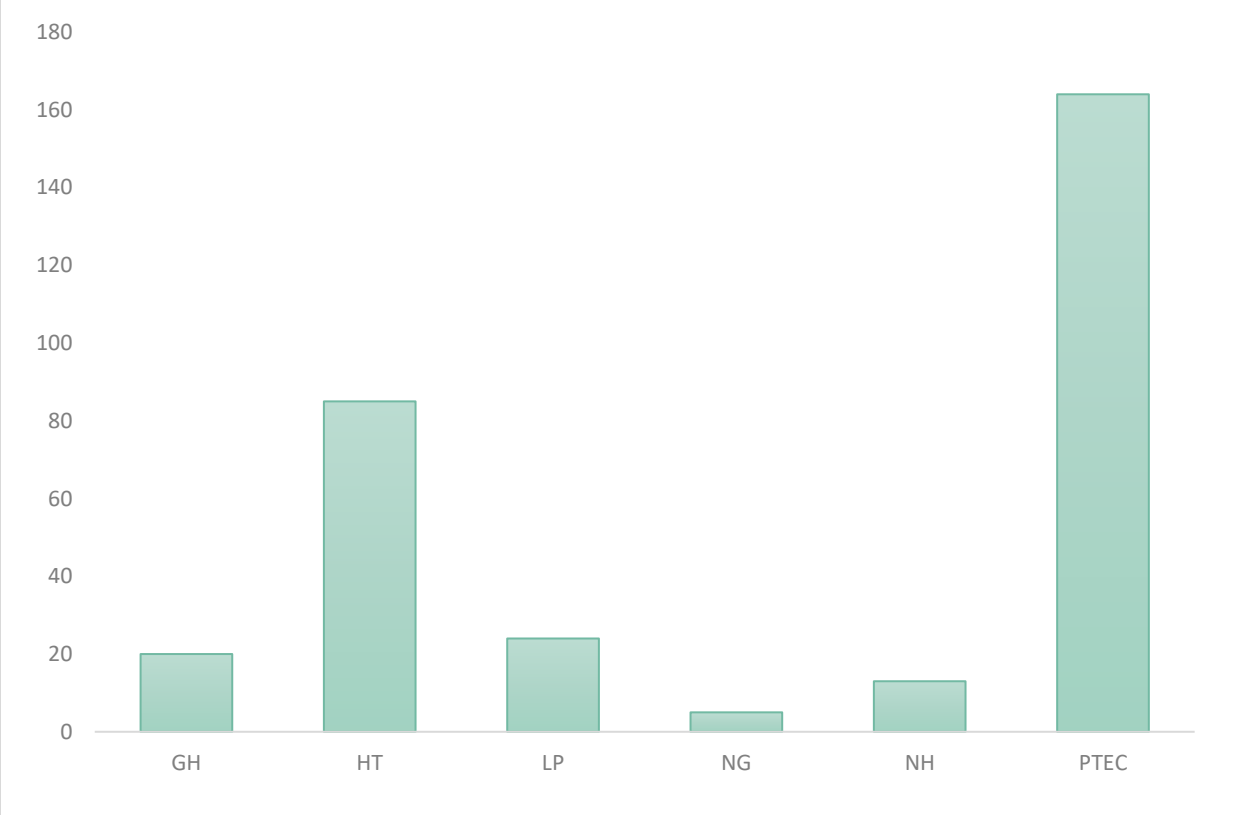

Fig 5.1.1: Graph showing total species count encountered during study. GH (n= 20), HT (n= 85), LP (n= 24), NG (n= 5), NH (n= 13), PTEC (n= 164).

GH= *Geoclemys hamiltonii*, **HT**= *Hardella thurjii*, ***LP***= *Lissemys punctata*, ***NG***= *Nilssonia gangetica*, ***NH***= *Nilssonia hurum*, ***PTEC***= *Pangshura tecta*

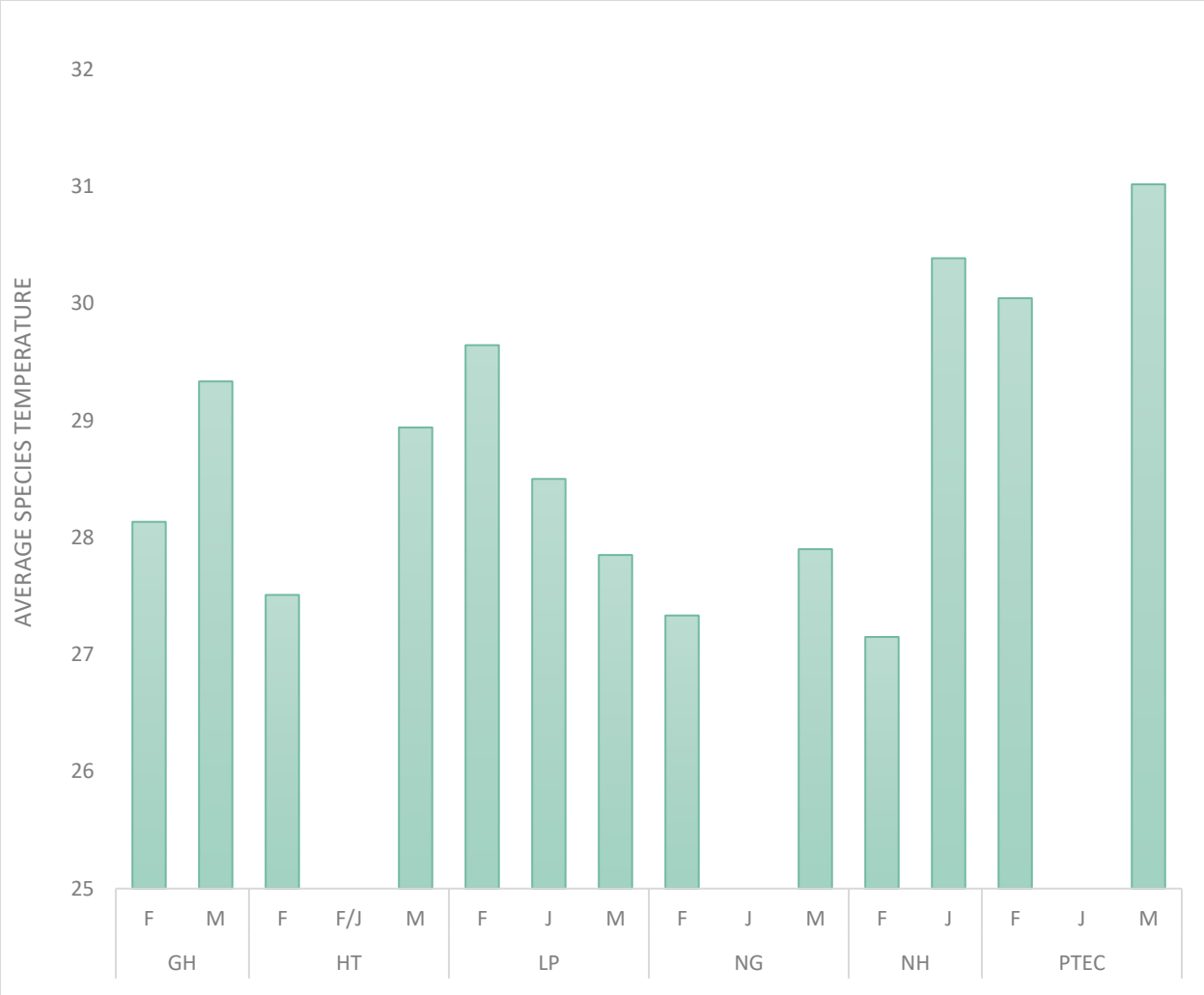

Fig 5.1.2: Graph depicting species and sex wise, average body temperature.

According to this graph, the average body temperature of males, females and juveniles of different species encountered were recorded as GH(F)=28.1 °C, GH(M)=29.3 °C, HT(F)= 27.5°C, HT(F/J))= Not recorded, HT(M)= 28.9 °C, LP(F)= 29.6 °C, LP(J)=28.5 °C, LP(M)= 27.8 °C, NG(F)= 27.3 °C, NG(J)= Not recorded, NG(M)= 27.9 °C, NH(F)= 27.1 °C, NH(J)= 30.3 °C, PTEC(F)= 30.0 °C, PTEC(J)= Not recorded, PTEC(M)= 31.0 °C.

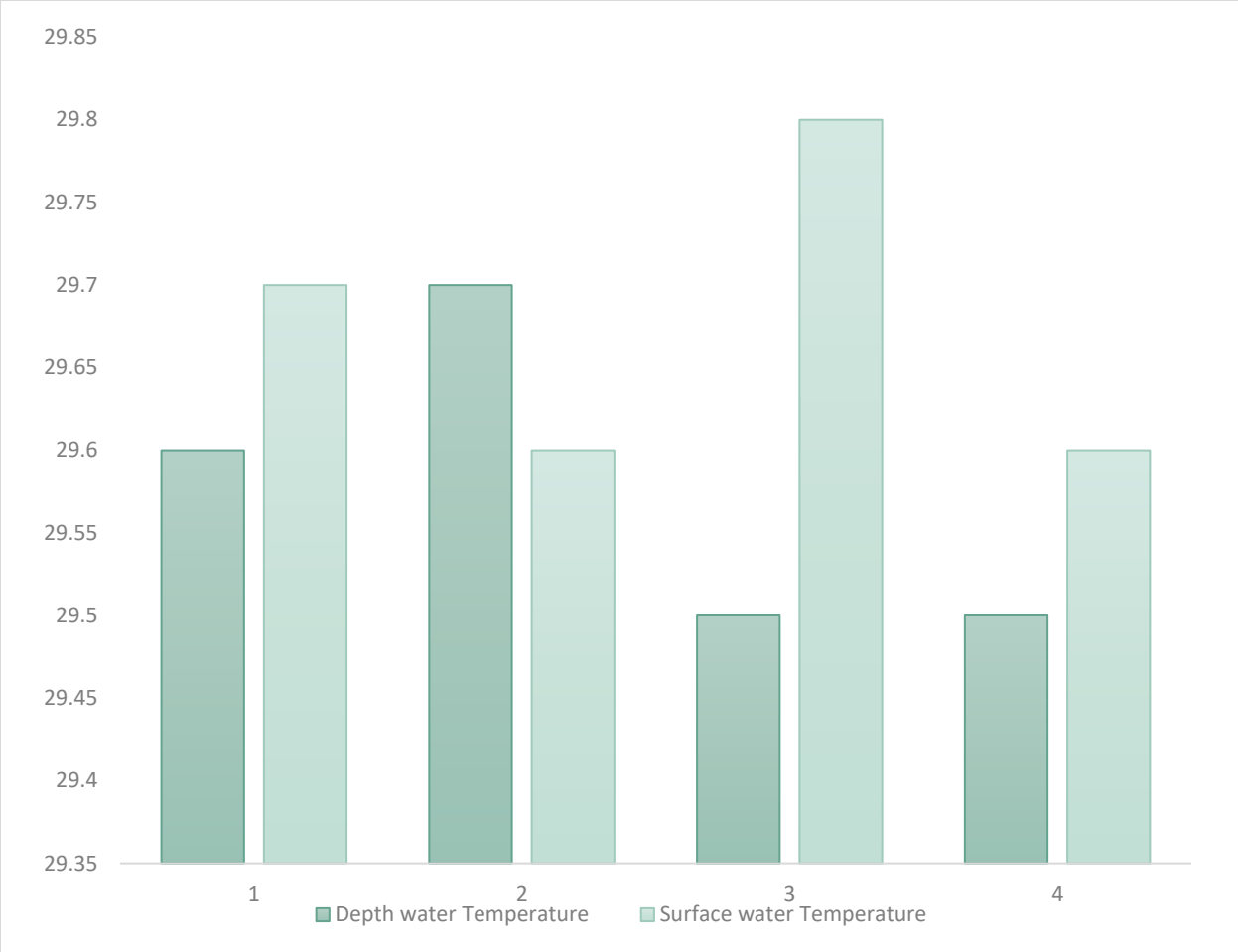

Fig 5.1.3: Graph depicting habitat (water) temperatures recorded at a set time of 4:00 pm (IST) over the course of four days at Katraghat.

5.2: Relation Between Mass, Sex and Temperature of Species

The correlation and regression performed to determine the relation between species body temperature (*Tb*) (dependent variable) and mass and size of species (independent variables) showed a negative (downhill sloping) correlation of r = -0.2 and r = -0.5 respectively. Which indicates little or no relation with the studied parameters. A negative correlation describes the extent to which two variables move in opposite directions, i.e., with an increase in one variable, there's a decrease in another.

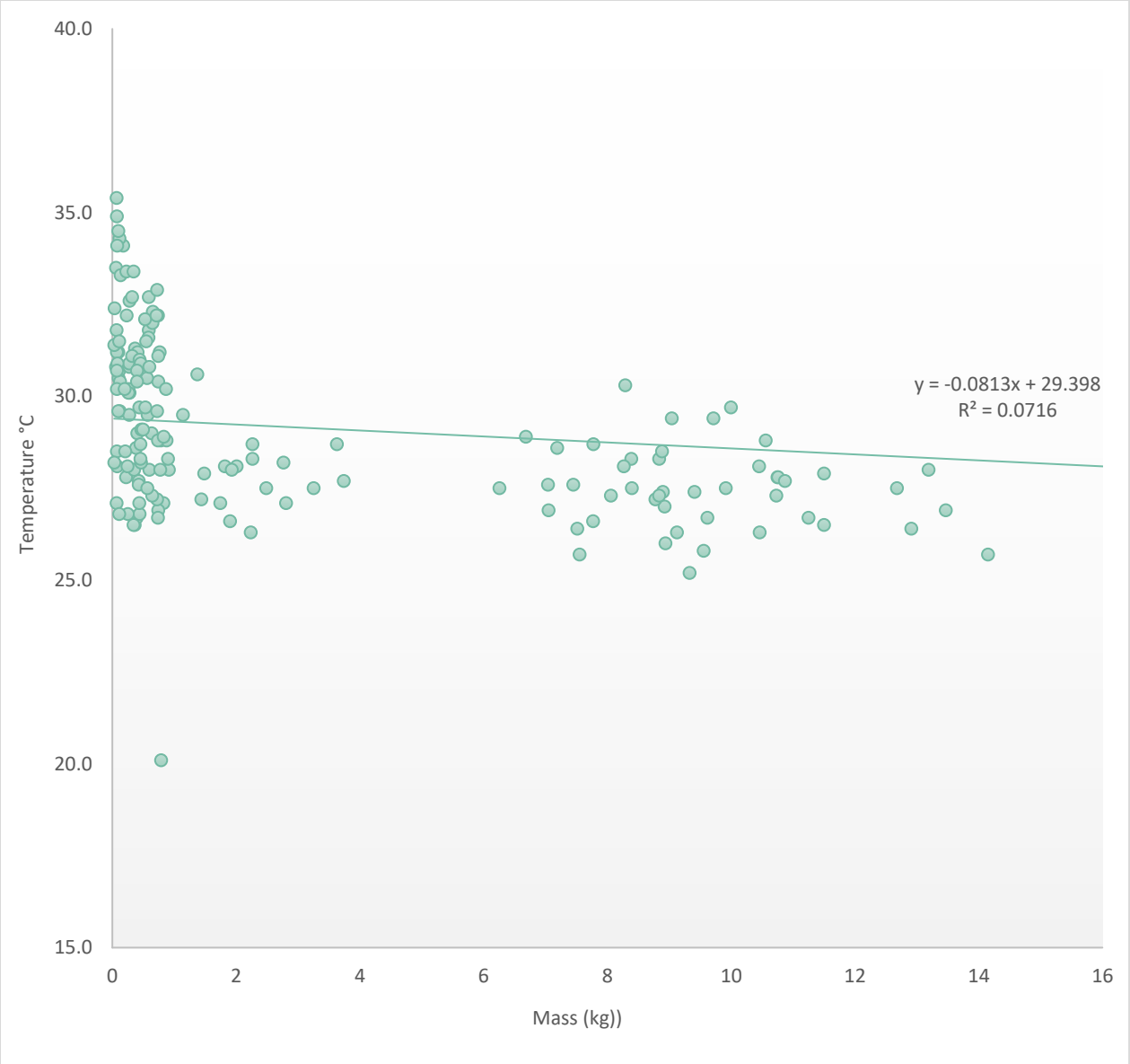

Fig 5.2.1: Linear regression graph of mass of species vs temperature of species

This graph indicates the relationship between mass and temperature of species. On working out the correlation coefficient, the value came out to be -0.267541614, which indicates that mass has a very weak (or negligible) negative (downhill sloping) linear relationship with the species temperature.

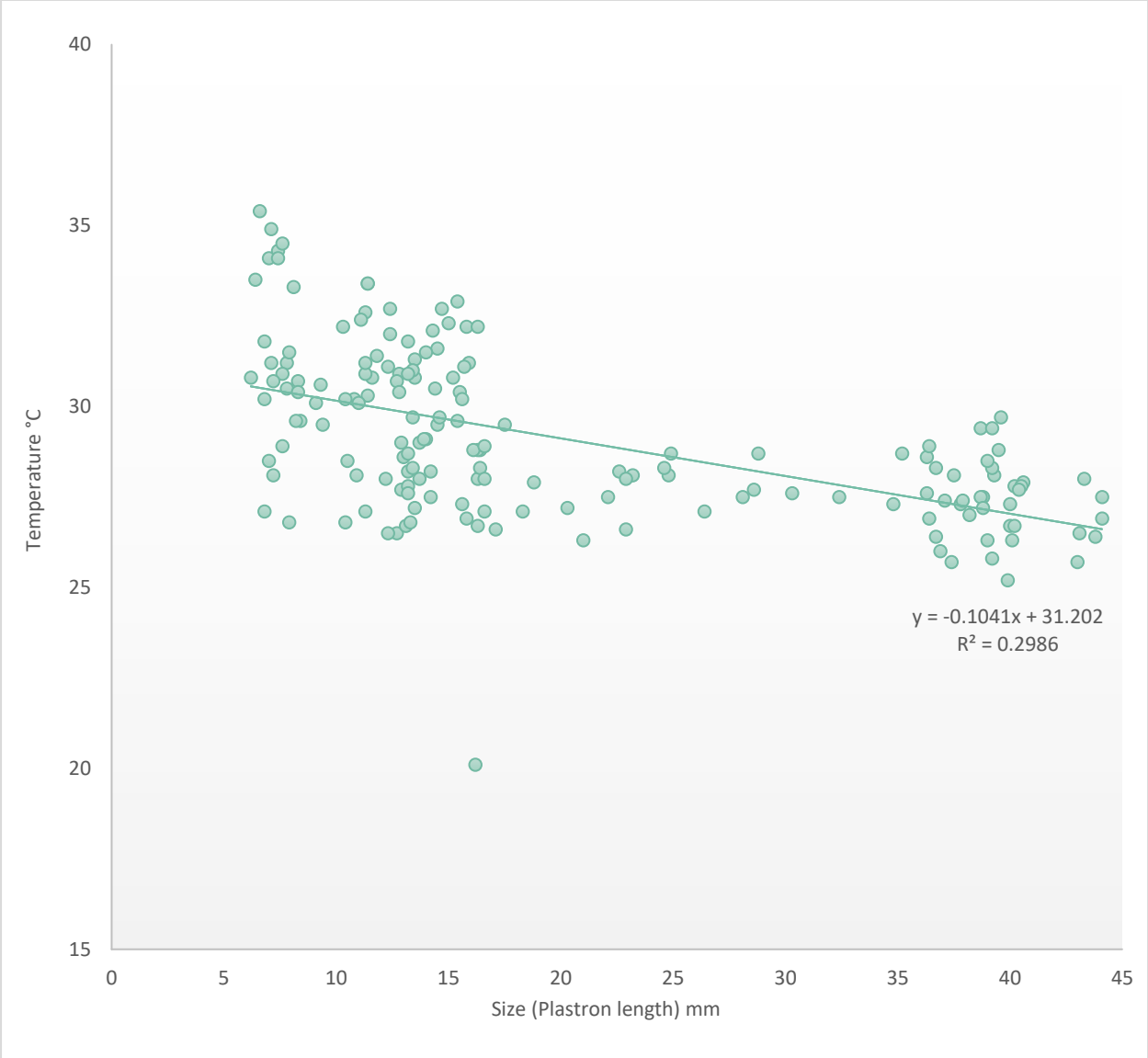

Fig 5.2.2: Linear regression graph of size of species vs temperature of species

Whereas, this graph depicts the relationship between size and temperature of species. The correlation coefficient for this parameter came out to be -0.54642637, which, indicates that the size of species has a moderate negative relationship with the species temperature. It tends to decrease with an increase in size of the species taken into consideration for this study.

CHAPTER 6: DISCUSSION

Situated at the foothills of Himalayas along the Indo-Nepal border, the Terai Arc Landscape, has a plethoric biodiversity for turtle existence. The North Indian state of Uttar Pradesh alone supports fifteen of the twenty-nine species of fresh water turtles and tortoises found in the Indian subcontinent (Singh *et al*, 2009). This enriched turtle habitat has a potential for the presence of Indian Black Turtle (Melanochelys trijuga indopeninsularis), reported earlier from Karterniaghat Wildlife Sanctuary (KWS) (Das *et al*, 2012), 19 km southeast from the origin of the lesser Sarju (Arunima Singh *et al*, 2021).

(Singh *et al*, 2009) documented 9 species of turtles in the lesser Sarju river which was re-confirmed by (Arunima Singh *et al*, 2021), however, in this study presence of 6 out 9 species in a comparatively small stretch of 1.22km and 1 km indicate high local species diversity. Total of 311 species were encountered belonging to two families Geoemydidae (n= 269) with 3 species and Trionchidae (n=42) with 3 species. The species recorded include *Geoclemys hamiltonii*, *Hardella thurjii*, *Lissemys punctata*, *Nilssonia gangetica*, *Nilssonia hurum*, *Pangshura tecta*. The habitat (water) temperatures recoded at a fixed time of 1600 hrs over the course of four days at site 1 indicate an average surface temperature of 29.6 °C and average depth temperature of 29.5 °C.

The most abundant species recorded during the study carried out at site 1, Katrghat was *Hardella thurjii* (n=72), and at site 2, Golwaghat was *P. tecta*, (n =151). *P. tecta* happens to inhabit slow moving rivers and can efficiently make use of marginal habitats of varying types.

The study was carried out to understand the effect that habitat temperature might have on the existing species or their criteria of existence for a predictive analysis. The region in study is enriched with high local turtle diversity and thus must be protected.

Not much studies have been done on freshwater turtles with respect to effect of habitat temperatures on them, hence there exists a vast research gap and thus, it offers a long-term prospect on the same. A detailed study is required to properly assess the habitat temperature and species external, as well as internal temperature in order to be able to link it with the ever-increasing global temperatures and the decline of turtle population. Chelonians are expected to be particularly vulnerable due to limited dispersal capabilities as well as widespread temperature-dependent sex determination (Christopher J. Butler, 2019). Based on previous studies on effect of climate change its effect on turtle species, there's an opening for extensive research with focus on:

1) Species' individual response towards climate change specifically with respect to microhabitat selection, phenology and thermal biology of the species.
2) Identification of skewed sex ratios along with their consequences
3) Improvement in species distribution by adopting mitigation measures (environmental variables and physiological processes), and
4) Preparedness and mitigation measures to develop/ adopt in order to deal with climate change including community participation.

The possible effects of climate change on chelonians are varied and include potential skews in sex ratios (Janzen, F.J., 1994), alteration of existing habitat (Parmesan, C.; Yohe, G., 2003) (Humphries, M.M.; Thomas, D.W.; Speakman, J.R., 2002), loss of suitable habitable environment (Hughes *et al*, 2003), and annihilation (Shinn *et al*, 2000) In addition, turtles and tortoises have limited dexterity and may not be able to

keep pace with prognosed and forethought climatic changes (Gibbon *et al*, 2000). The impacts of climate change may vary depending upon the life-history stage; many aspects of chelonian incipient are influenced by hydrology and temperature while they are in the nest (Weisrock, D.W.; Janzen, F.J., 1999), Anthropogenic climate change could affect individual growth rates (Du, W.-G.; Ji, X., 2003), fecundity (Ficetola, G.F.; Thuiller, W.; Padoa-Schioppa, E., 2009), reproductive phenology (Lovich *et al*, 2012), sex ratios via temperature-dependent determination (Janzen, F.J., 1994), and predation rates (Chessman, B.C., 2011) (Christiansen *et al*, 2012). Although turtles have survived previous periods of climate change, the existing rate of change is far more rapid and turtles may not be able to respond in time, due in part to their long generation times (Poloczanska *et al*, 2009).

Since chelonians exhibit a long life and their genetic evolution has kept them alive till date existing from the Triassic era, they exhibit slow growth and generally result in high adult survivorship with high juvenile mortality rate, they are therefore, ill-suited for rapid climate change, though some species might benefit from it. Thus, this study aims to open all possibilities to determine effect of environmental factors that may directly or indirectly turtle population in the lesser Sarju river, which is a highly biodiverse hotspot inhabiting 9 species of freshwater turtles and tortoise found in Uttar Pradesh.

References

Aditi Tondon, 2020 Bringing freshwater turtles out of their shells and into the spotlight. Accessed on: https://india.mongabay.com/2020/03/ on 13-06-2022.

Anders G. J. R., Andrew D. Walde, B. D., Van Dijk, P. P., Torsten B. & Rick H., 2011. Turtles in Trouble: Lunenburg, MA: IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, Turtle Conservation Fund, Turtle Survival Alliance, Turtle Conservancy, Chelonian Research Foundation, Conservation International, Wildlife Conservation Society, and San Diego Zoo Global, 54 pp.

Arunima Singh et al, (2021) Diversity, Distribution and Bathymetric Preferences of Freshwater Turtles in Lesser Sarju River, North India with Special Reference to *Hardella thurjii*. J. Exp. Zool. India Vol. 24, No. 2, pp. 1803-1809, 2021. ISSN 0972-0030, eISSN 0976-1780

Buhlmann, K. A. et al. 2009. A Global Analysis of Tortoise and Freshwater Turtle Distributions with Identification of Priority Conservation Areas. Chelonian Conservation and Biology. 8(2): 116–149.

Cagle, F.R. (1939): A system of marking turtles for future identification. Copeia 1939: 170-173.

Chessman, B.C. Declines of freshwater turtles associated with climatic drying in Australia's Murray–Darling Basin. Wildl. Res. 2011, 38, 664–671

Christiansen, J.L.; Bernstein, N.P.; Phillips, C.A.; Briggler, J.T.; Kangas, D. Declining populations of Yellow Mud Turtles (Kinosternon flavescens) in Iowa, Illinois, and Missouri. Southwest. Nat. 2012, 57, 304–314.

Christopher J. Butler A Review of the Effects of Climate Change on Chelonians. Department of Biology, University of Central Oklahoma, Edmond, OK 73020, USA; Diversity 2019, 11, 138.

Climate data Bahraich district. Climatedata.org. Accessed at: https://en.climate-data.org/asia/india/uttar-pradesh/bahraich-24724/t/April-4/ on 15-06-2022.

Climate data Gonda district. Climatedata.org. Accessed at: https://en.climate-data.org/asia/india/uttar-pradesh/gonda-24707/ on 18-07-2022.

Daniel, J.C.: The book of Indian reptiles. Bombay natural history society, Oxford University Press, Bombay. pp. 141 (1983).

Das I (1985) Indian Turtles: A Field Guide. Calcutta: World Wide Fund for Nature-India. 119 p.

Das, I. 1990. Turtles and tortoises of India. Oxford University Press, Bombay.

Das I and Bhupathy S (2009) Hardella thurjii (Gray 1831) – Crowned River Turtle. In: Conservation Biology of Freshwater Turtles and Tortoises: A Compilation project of the IUCN/SSC Tortoise and Freshwater Specialist Group (eds. Rhodin A G J, Pritchard P C H, van Dijk P P, Saumure R A, Bhulmann K A, Iverson J B and Mittermeier R A), Arlington: Chelonian Research Monographs No. 5. pp. 023.1–023.6.

Das A, Basu D, Converse L and Choudhury S C (2012) Herpetofauna of Katerniaghat Wildlife Sanctuary, Uttar Pradesh, India. J. Threatened Taxa 4(5), 2553–2568.

Du,W.-G.; Ji, X. The effects of incubation thermal environments on size, locomotor performance and earlyfgrowth of hatchling soft-shelled turtles, Pelodiscus sinensis. J. Therm. Biol. 2003, 28, 279–286.

Ficetola, G.F.; Thuiller, W.; Padoa-Schioppa, E. From introduction to the establishment of alien species: Bioclimatic differences between presence and reproduction localities in the slider turtle. Divers. Distrib. 2009, 15, 108–116.

Ghaghra Basin and watersheds, Upper Ganga Basin Organization. cwc.gov.in.

Accessed at: http://www.cwc.gov.in/ugbo/gangabasin/ghaghra/ on 14-06-2022.

Gibbon, J.W.; Scott, D.E.; Ryan, T.J.; Buhlmann, K.A.; Tuberville, T.D.; Metts, B.S.; Greene, J.L.; Mills, T.; Leiden, Y.; Poppy, S.; et al. The Global Decline of Reptiles, Déjà Vu Amphibians. BioScience 2000, 50, 653–666.

Hughes, T.P.; Baird, A.H.; Bellwood, D.R.; Card, M.; Connolly, S.R.; Folke, C.; Grosberg, R.; Hoegh-Guldberg, O.; Jackson, J.B.C.; Kleypas, J.; et al. Climate Change, Human Impacts, and the Resilience of Coral Reefs. Science 2003, 301, 929–933.

Humphries, M.M.; Thomas, D.W.; Speakman, J.R. Climate-mediated energetic constraints on the distribution of hibernating mammals. Nature 2002, 418, 313–316.

Janzen, F.J. Climate change and temperature-dependent sex determination in reptiles. Proc. Natl. Acad. Sci. USA 1994, 91, 7487–7490.

Lovich, J.; Agha, M.; Meulblok, M.; Meyer, K.; Ennen, J.; Loughran, C.; Madrak, S.; Bjurlin, C. Climatic variation affects clutch phenology in Agassiz's desert tortoise Gopherus agassizii. Endanger. Species Res. 2012, 19, 63–74.

Moll E.O., (1984). Freshwater turtles in India: their status, conservation and Management. Hamadryad. 9(3), 9-17

Moll, E.O.: India's fresh water turtles in India their status, conservation and Management. Hamadryad, 9, 49-55, 66 (1984).

Parmesan, C.; Yohe, G. A globally coherent fingerprint of climate change impacts across natural systems. Nature 2003, 421, 37–42.

Poloczanska, E.S.; Limpus, C.J.; Hays, G.C. Chapter 2 Vulnerability of Marine Turtles to Climate Change. Adv. Mar. Biol. 2009, 56, 151–211.

Rao, R.J. 1987. Indian turtles. Vivekananda Kendra Patrika. 16(2): 79-89.

Rao, R.J. 1990. Ecological relationships among freshwater turtles in the National

Chambal Sanctuary. Final Study report, WII. Mimeo. pp. 1-212.

Rao, R. J. "The Diversity, Ecology and Conservation Management of Freshwater turtles in Ganges River System." (2001)

Rodgers, W.A. and Panwar, H.S. 1988. Planning a protected area network for India. A report to the Govt. of India. WII Dehra Dun. 2 Volumes.

Singh S, Horne B D and Dixit B M (2008) Turtle Conservation in the Terai Region of Northern India. Proceeding of Turtle Survival Alliance 61, 32-35. Singh S and Horne B D (2011) TSA India Program Expanding to Include Five Turtle Priority Areas. Proceeding of Turtle Survival Alliance 102, 91-95

Singh, S. et al. 2009. An Evaluation of Distribution, Status and Abundance of Freshwater Turtles in Uttar Pradesh. In: Freshwater Turtles and Tortoises of India. ENVIS Bulletin: Wildlife and Protected Areas, Vol. 12(1). Vasudevan, K. (Ed.). Wildlife Institute of India, Dehradun, India. pp.177

Shinn, E.A.; Smith, G.W.; Prospero, J.M.; Betzer, P.; Hayes, M.L.; Garrison, V.; Barber, R.T. African dust and the demise of Caribbean Coral Reefs. Geophys. Res. Lett. 2000, 27, 3029–3032.

Smith, M. A.: The fauna of British India. Today & Tomorrow, New Delhi (1933)

Souza, F.L., Abe, A.S. (1997): Population structure, activity, and conservation of the neotropical freshwater turtle, Hydromedusa maximiliani, in Brazil. Chel. Conserv. Biol. 2: 521-525.

Souza, F.L., Abe, A.S. (1998): Resource partitioning by the neotropical freshwater turtle, Hydromedusa maximiliani. J. Herpetol. 32: 106-112.

Stanford C B, Iverson J B, Rhodin A G J, Paul van Dijk P, Mittermeier R A, Kuchling G and Berry K H (2020) Turtles and Tortoises Are in Trouble. Curr. Biol. 30(12), PR721-R735.

TTWG [Turtle Taxonomy Working Group], Anders G.J Rhodin, John B. Iverson,

Roger Bour, Uwe Fritz, Arthur Georges, H. Bradley Shaffer, and Peter Paul van Dijk (2021) Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (9th Ed.). Supplement No. 2 of Chelonian Research Monographs No. 5*: Conservation Biology of Freshwater Turtles and Tortoises: A compilation project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group* (eds. Anders G.J. Rhodin, John B. Iverson, Peter Paulvan Dijk, Craig B. Stanford, Eric V. Goode, Kurt A. Buhlmann, and Russell A. Mittermeier.

Van Dijk, P.P., Iverson, J.B., Shaffer, H., Bour, R., Rhodin, A.G.J., 2012. In-Turtles of the World, 2011 Update: Annotated Checklist of Taxonomy, Synonymy, Distribution, and Conservation Status. Conserv. Biol. Freshwater. Turtles Tortoises A Compilation. Project. IUCN/SSC Tortoise Freshwater. Turtle. Specialist. Group. Chelonian Res. Monograph.: pp. 000.243–000.328.

Weisrock, D.W.; Janzen, F.J. Thermal and fitness-related consequences of nest location in Painted Turtles (Chrysemys picta). Funct. Ecol. 1999, 13, 94–101.

Turtle Identification Guide

(Turtles encountered during study)

A= *Geoclemys hamiltonii* ©*Arpita Dutta*

B= *Hardella thurjii* ©*Arunima Singh*

C= *Lissemys punctata* ©*Sreeparna Dutta*

D= *Nilssonia gangetica* ©*Arunima Singh*

E= *Nilssonia hurum* ©*Sreeparna Dutta*

F= *Pangshura tecta* ©*Shailendra Singh*