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Dental Management of a captive born Indian Giant Squirrel *Ratufa indica*

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Abstract:

Introduction: Indian Giant Squirrel (*Ratufa indica)* is endemic to India, restricted in distribution to the Western and the Eastern Ghats and the Saputara mountain ranges. Despite, a decreasing population, The International Union for Conservation of Nature (IUCN) currently has this species on its list of "least concern" species. Understanding the importance of its preservation the Rajiv Gandhi Zoological Park and the Wildlife Research Centre (RGZP & WRC), Pune, Maharashtra State India has undertaken a breeding program. The health of animals in captivity demands more attention and maintaining their oral health is essential as well as challenging.

Methods (Case description) and Results: A 3 year-old captive born Indian Giant Squirrel presented with loss of appetite and generalised lack of activity. Clinical examination under sedation with Inj. Ketamine IM (20mg/kg body weight) revealed a root piece of the upper incisor and an ulcer in the palate over the anterior maxillary region due to an overgrown lower incisor. The retained root piece was extracted and the overgrown incisor was trimmed and de-occluded, thereby treating the cause of the ulcer. The squirrel recovered following the surgery.

Conclusion: This is a first of its kind report from India where the ailing Indian Giant Squirrel (*Ratufa indica*) was successfully administered dental treatment.

Keywords: Ratufa indica, Indian Giant Squirrel, Dental extraction and treatment, Endemic Indian species, Veterinary dentistry India, captive born, zoo dentistry India

Introduction:

Oral health shares risk factors common to systemic health[1]. Dental treatment encompasses two domains, prevention and intervention, but tertiary care is delivered more frequently compared to primary prevention[2,3]. However, the problem management of toothed animals has been gaining increased attention in the past few decades [4,5] . Dental caries is a multi-factorial disease which is known to be a common entity in captive animals[6] as compared to its presence in wild animals. Change in the oral environment and a subsequent ecological shift is a fore-runner for the causation of this condition[7]. Exercising vigil in early detection of oral diseases aids in increasing the overall quality of life and decreases the mortality rate for captive animals[8]. So far research has been solely focused on domestic animals and a paucity of literature exists about wild animals and animals in captivity. Only since the past three decades has attention been directed towards the prevention and arrest of dental problems in them[9]. Earlier dental treatment was performed on large wild animals like Cheetah (*Acinonyx jubatus*), Sea Otter (Enhydra lutris), Asian Elephant (*Elephas maximus*), African Elephant (*Loxodonta africana*), and Orang-utan (*Pongo pymaeus*)[10]. There have been scanty published reports of dental treatments from India. If any, they are seen as newspaper articles rather than scientific literature.

Indian Giant Squirrel (*Ratufa indica*) is an Indian endemic arboreal and solitary diurnal squirrel. It is 35-51 cm in size and has varying bright pelage with a long

brownish- maroon 60 cm long tail. The back is a mixture of maroon and black and the under parts are cream and buff[11]. It is commonly seen in mixed deciduous and evergreen forests in India and its natural diet consists of fruits, vegetation and grains[12]. The populations are dwindling due to habitat loss and poaching and it is the state animal of Maharashtra, a western state in India where the present study was undertaken. In this first of its kind report from India, focused on a native species, we describe extraction of decayed tooth and trimming of an overgrown incisor in a Giant Squirrel in captivity at the Rajiv Gandhi Zoological Park and Wildlife Research Centre (RGZP & WRC), Katraj, Pune, Maharashtra State, India.

Case history and clinical examination:

A 3 year-old captive born female Giant Squirrel weighing 1.5 kg from the RGZP & WRC manifested with loss of appetite and generalised lack of activity. The keepers noted a blackish tooth remnant on the anterior maxillary region along with an overgrown lower incisor. Clinical examination under sedation using Inj. Ketamine IM (20mg/kg body weight) revealed a decayed root fragment in the maxillary anterior tooth bearing region on the left, and an overgrown lower central incisor leading to a traumatic ulcer on the anterior palate. On visual examination, the solitary ulcer had a raw eroded surface with sloping margins, roughly measuring 5×5 mm in dimension and had whitish slough in the centre. The upper incisor was missing.

Pre-operative procedures:

The vital parameters monitored during sedation were pulse rate and respiratory rate using clip-on pulse oxymeter attached to the toe which was continued till the end and body temperature was also simultaneously monitored. Pre-operative vitals were within normal range (temperature was 104.6 degree Fahrenheit and pulse rate was 76 bpm).

Operative procedures:

Once a complete sedation was obtained based on physical parameters, the surgical procedure was initiated. 1% Lignocaine with 1:200,000 Adrenaline (1% Xylocaine) was used to achieve local anaesthesia. Local infiltration was done in the labial vestibule and palatal region in the maxilla and in the labial and lingual vestibules of the mandible; an Apexo elevator was utilized for elevating the root fragment followed by extraction using paediatric root forceps[13]. Complete removal was ensured and socket curettage was done using a curette to get rid of any possible granuloma at the apex. Bleeding was arrested using pressure packs moistened with 1% Xylocaine. Subsequently, the overgrown incisor was trimmed using animal nail clippers, followed by smoothening of the ragged edges using finishing and polishing burs (Mani Inc, Japan). The same procedure for trimming the incisor was previously conducted twice, the first time in May and the second time in August 2020.

Post-operative care:

10% w/w Povidine Iodine ointment USP (Betadine®, India) was applied to the ulcer which had subsequently healed as confirmed on the second visit in August 2020. Additionally, we administered Inj. Enrofloxacine (Floxidine TM Vet) 5mg/kg body weight stat as an antibiotic; while we used Melonex (Meloxicam) 0.1 mg/kg BD for analgesia. The squirrel started consuming food offered to it immediately from the next day, was healthy and no complications were noted. Continued follow up visits revealed no ulcer progression. Healing was noted and generalised wellness of the squirrel was assured. The squirrel till date is recurrently monitored for overgrowing incisor.

Discussion:

The dental formula of the squirrel is I 1/1, C 0/0, PM 1-2/1, M 3/3 × 2= 20-22[14]. RGZP & WRC is one of 3 prestigious zoos in India where the unique captive breeding program for Indian Giant Squirrel is undertaken.

Dental and oral problems though seen in the wild are more prevalent in captivity[3]. The commonly noticed problems reported are dental fractures, malocclusions, periodontal disease[4] and enamel hypoplasia[8]. Etiologies differ but commonly include diet, primarily influenced by consistency and texture, developmental malformations, geriatric issues and injury[4, 8, 15]. Improperly textured diets can result in injury, excessive attrition and even overgrowth at times, if too soft[15], as in our case. Extraction, the most common treatment in zoo dentistry, particularly in young animals, frequently leads to malocclusion and its ensuing pathologies[8]. Dental professionals agree that dental caries in captive

animals is a culmination of changed diets that are quite different from that consumed in the wild in terms of texture, nutrition and frequency[16]. Increased care of the captive animals also invites its own problems which their counterparts in the wild hardly experience[17]. Wild Indian Giant Squirrels consume fiber rich vegetation which naturally controls the overgrowth of incisors by constant wear. In comparison, an overgrowth of incisors occurs in captivity due to consumption of soft food items, since captive animals are provided with high nutrition diet[15.] Plaque accumulation also aggravates problems, hence, elsewhere, higher proportion of animals undergo daily plaque control using tooth brushing and other measures of plaque control[18].

Several issues prove to be roadblocks to oral examination. The animals need to be either sedated or require general anesthesia, which are associated with ethical issues and inherent complications. The animals also undergo stress during handling and so, the risk to benefit ratio needs to be weighed meticulously[5]. We used Ketamine due to a higher safety margin which showed positive results and previous experience at our zoo dictated its use. General anaesthesia was not deemed necessary because it was a short procedure, hence eliminating the need for muscle relaxants. We recommend its use in Indian Giant Squirrels for short, minor surgical procedures and it has proven to be safe based on previous experiences at our center.

Regimes of oral prophylaxis and plaque control are far too infrequently undertaken. To combat this problem few zoos have initiated alteration in their diet texture and started incorporating of hard biscuits or bones which act as detergent foods thereby aiding in mechanical plaque control[19]. We included a similar change in dietary regime for the squirrel in our dental treatment by incorporating hard food items (hard biscuits, pods and nuts). One of the etiological factors behind overgrown incisor was addressed by offering hard food items to the squirrel.

Zoo personnel understand that captive-animal dentistry is an inter-disciplinary approach between dentists, veterinarians, keepers and vet technicians but this approach needs further evolution[18]. The study conducted by Glatt[18] showed that 96% of zoos under the American Zoos Authority and Aquariums conducted dental examination as a part of the annual health checkup of captive animals. This study also mentions that one individual from the Scuiridae family underwent extraction and the other had malocclusion. There are no such reports/studies conducted in India and regular dental examinations could be incorporated in the captive animal examination protocol. No scientific reports regarding the dental treatment of Indian Giant Squirrel are available. In the past, as per news-paper reports, a root canal treatment was performed on a tigress (*Panthera tigris*) in 2018 at Nagpur, Maharashtra, India and some form of dental treatment (not clearly mentioned) was offered to a Sloth bear (*Melursus ursinus*) at Agra, Uttar Pradesh, India in 2013. We feel that a cross-sectional questionnaire based study on regular dental checkups in zoo animals in India should be coordinated as it would be useful for disease prevention and timely treatment planning. With the help of wildlife biologists, dental practitioners can understand which dental diseases are rampant in the captive animals[20]. The field of zoo dentistry is gaining traction and should be visualized as a collaborative multi-disciplinary effort and zoo authorities should be more forthcoming to advance networking hands towards the betterment of animals in captivity. Continued collaboration and education among animal health professionals is crucial and more focus on dental and oral health examinations as a part of general health examinations of captive animals from India will improve the general health of captive animals and reduce morbidity.

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Conflict of interest: Authors declare no conflict of interest.

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Temporal Trend Analysis of Abiotic Factors (Rainfall, Temperature and Relative Humidity) at Peechi-Vazhani Wildlife Sanctuary, Kerala, India

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Abstract

The present study examined the significance of potential trends in rainfall, temperature, and relative humidity across Peechi-Vazhani Wildlife Sanctuary of Kerala state, on a monthly, seasonal, and annual basis. The data of 30 years (1988-2017) were processed to check out the climatic variability using the non-parametric Mann-Kendall test and Sen's slope estimator test, to estimate the direction and magnitude of the trend over time. The statistical analysis of the time series data highlights the points (1) An increasing trend of rainfall noted for January, February, March, April, May, September, November, and December with a Z positive value. The remaining months and annual rainfall showed a declining trend. In a season-wise observation, North-East monsoon, Summer, and Winter represented a rising trend, besides South-West Monsoon showed a falling trend. (2) Temperature analysis observed a decreasing trend for April; whereas noted a significant rise in annual temperature and for the remaining months. For June to October, the confidence level is 95%. For the seasons, South-West Monsoon showed a positive trend at a 95% confidence level. (3) The critical measurement, relative humidity observed as dependent on temperature in almost all the time series, i.e., the temperature rises, relative humidity decreases, and vice versa.

Keywords: *Climatic variability, Mann-Kendall test, Sen's slope estimator test,*

Introduction

A better understanding of the patterns of climatic parameters viz. rainfall, temperature, humidity, their variability, and trends is essential to determine the current and future climate scenarios and develop appropriate strategies based on them. The changes in a particular climate system that accelerate and intensify extreme events will alter the environmental process and hydrological cycle (Feng et al. 2016). Over the past centuries, the occurrences of extreme events have randomly increased throughout the World. Especially the high-intensity rainfall created several flash flood risks during the recent years. The nature of climate change-induced issues is varying in different places. Earth pays its significant portions for the excessive risk effects in the form of shortage of water, flooding, droughts, sea level rises, water quality decline, saltwater intrusion, and water table fluctuations.

Given the above points, this study examines the trend of rainfall, temperature, and relative humidity across Peechi-Vazhani Wildlife Sanctuary (WLS), on a monthly, seasonal, and annual basis. Moreover, this study tried to find out any relationship is existing between them. These three variables are critical in the hydrological cycle and the environmental process. The trend analysis of climatic variables viz. rainfall, temperature, and humidity on different spatial scales will help predict future climate scenarios. Trend analysis of climatic variables determining whether the trend is in an increasing or decreasing manner and analyzing the magnitude of trend and its statistical significance by using the statistical methods such as parametric and non-parametric test (Jain and Kumar 2012; Kocsis and Anda 2018; Pal et al. 2017; Radhakrishnan et al. 2017). Regression analysis is one of the parametric tests. Here, the dependent variable is the climate parameter, and time is the independent variable. The regression line corresponds to the long-term trend of climate variability (Radhakrishnan et al. 2017). Among the non-parametric tests, the Mann-Kendall test (MK Test) and the Sen's slope estimator are the most frequently used methods. Mann-Kendall test's purpose is to ascertain the climatic variable's statistical significance for a given confidence level (Hussain et al. 2015). Sen's slope estimator determines the magnitude of trend or the slope of the tendencies (Kocsis and Anda 2018; Pal et al. 2017).

2. Study area

Peechi-Vazhani WLS is a part of the Western Ghats, located in Thrissur district of Kerala state. It lies between 10° 28' - 10° 40' N latitude to 76° 18' - 76° 28'E longitude and has an area of 125 sq. km (Figure 1). The moist deciduous forest covers nearly eighty percent of the WLS, while evergreen and semi-evergreen patches are confined to the higher altitude areas and catchments of Peechi and Vazhani reservoirs. Sanctuary has six sections, such as Vazhani, Velllani, Vaniyampara, Peechi, Mannamangalam, and Olakara-Ponmudi. Plantation of teak (Tectona grandis) and Indian bombax (Bombax ceiba) are Practiced in a considerable portion of the sanctuary.

3. Materials and Methods

Monthly rainfall, temperature, and relative humidity data of thirty years (1988 to 2017) for Peechi-Vazhani WLS collected from NASA POWER Data Access Viewer (https://power.larc.nasa.gov/data-access-viewer/). The time-series analysis of the data was done on a monthly, seasonally, and yearly basis. Based on Kerala weather patterns (http://www.kerenvis.nic.in/Database/CLIMATE_811.aspx) selected four seasons as Summer (March-May), South-West Monsoon (June-September), North-East Monsoon (October-November), and Winter (December-February).

3.1. Trend analysis

Trend analysis of a time series includes the magnitude of the trend and its statistical significance (Hussain et al. 2015). Typically, the magnitude of the trend over time is detected either by using a parametric test (regression analysis) or non-parametric test (Sen's estimator method) (Jain and Kumar 2012). Both of these have a linear trend over the time series. This study used both the Mann- Kendall test and Sen's estimator method; statistical significance of trend analysis was measured by using Mann- Kendall test, whereas magnitude of the trend was analyzed by using Sen's estimator method (Jain and Kumar 2012; Pal et al. 2017; Pohlert 2016; Hussain et al. 2015).

3.2. Mann- Kendall test

The non-parametric Mann- Kendall test is a statistical method used to verify climatic variables' statistical significance (Pal et al., 2017). It is commonly employed to estimate the monotonic, i.e., an increasing

or decreasing trend of environmental, climate, or hydrological time series data(Radhakrishnan et al., 2017). The Mann Kendall statistic S for the trend calculated from the equation (1)

$$s = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \text{sgn}\,(x_j - x_i) \qquad \ldots \text{Eq (1)}$$

Here n is the number of data points. x_j and x_i are the values in time series.

Assume the value of x_j and x_i are equal to θ. Then the value of sgn(θ) is computed and showing in equation (2)

$$\text{sgn}(\theta) = \begin{cases} 1 & if\ x_j - x_i > 0 \\ 0 & if\ x_j - x_i = 0 \\ -1 & if\ x_j - x_i < 0 \end{cases} \qquad \ldots \text{Eq (2)}$$

Here the value of S indicates the trend direction. A positive value indicates an increasing trend, and a negative value indicates a decreasing trend. When the sample size is larger, i.e., n>10, the S statistic is approximately acting as normally distributed with the below-provided mean (Equation 3) and variance (Equation 4).

$$E(S) = 0 \qquad \ldots \text{Eq (3)}$$

$$\text{Var}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{n} t_i (t_i - 1)(2t_i + 5)}{18} \qquad \ldots \text{Eq (4)}$$

The standard normal distribution Z statistics (computed with the equation (5)

$$z_{MK} = \begin{cases} \frac{s-1}{\sqrt{Var(s)}}, & if\ S > 0 \\ 0, & if\ S = 0 \\ \frac{s+1}{\sqrt{Var(s)}}, & if\ S < 0 \end{cases} \qquad \ldots \text{Eq (5)}$$

At a significance level α, the null hypothesis rejected, implying that a significant trend exists. The Mann-Kendall test checks the null hypothesis and alternate hypothesis of increasing or decreasing trend at 95% confidence level.

3.3. Sen's slope estimator

For detecting the magnitude of the trend of climatic variables, the non-parametric Sen's slope estimator has used. The slopes Ti is calculated using the equation (6)

$$T_i = \frac{x_j - x_k}{j - k} \text{ for } i = 1, 2, 3, \ldots, n \qquad \ldots \text{Eq (6)}$$

Here are the data values at time j and k respectively; where j>k

Then the Sen's slope is computed from the median of the n values of, shown in equation (7)

$$Q_i = \begin{cases} \frac{T_{n+1}}{2}, & n\ is\ odd \\ \frac{1}{2}\left(\frac{T_n}{2} + \frac{T_{n+2}}{2}\right), & n\ is\ even \end{cases} \qquad \ldots \text{Eq (7)}$$

The positive and negative value of are represents increasing and decreasing trends, respectively.

4. Results and Discussion

Trend analysis of rainfall, temperature, and relative humidity of Peechi-Vazhani Wildlife Sanctuary for monthly, seasonal, and annually for 30 years (1988-2017) was done using Mann- Kendall test with Sen's estimator method. It is essential to make the data series are serially independent. For this purpose, before the Mann- Kendall test, prewhitening has been done to all the series.

4.1. Rainfall trend analysis

The Mann- Kendall test (Z value) and Sen's slope estimator (Q value) values have shown in Figure 2. The monthly rainfall trend data analysis revealed significant changes in the rainfall pattern; some months showed increasing trends while others showed decreasing trends (Figure 3). Eight months (January, February, March, April, May, September, November, and December) showed a non-significant increasing trend with a positive value of Z statistics; whereas the other four months (June, July, August, and October) showed a non-significant declining (negative) trend. At the same time, annual rainfall exhibited a significant upward trend over the recorded years (Figure 3). In a season-wise observation, north-east monsoon, summer, and winter showed a non-significant rising trend and noted a falling trend for southwest monsoon (Figure 4).

4.2. Temperature and Relative humidity trend analysis

The result of the Mann-Kendall test (Z value) and

Sen's slope estimator (Q value) of temperature and relative humidity has graphically represented in Figures 5 and 6. With the Mann- Kendall test, calculated the temperature and relative humidity trend. Sen's estimator determined the slope's magnitude. Both the temperature data and relative humidity data series are represented in a single graph to check any relationship between them (Figure 7, Figure 8). Several studies showed that humidity is enormously dependent on the temperature; also, many researchers found that high-temperature results in high-intensity rainfall (Hardwick et al., 2010; Manabe and Wetherald, 1967; Meehl et al., 2007; Ross et al., 2002). The present study observed an increasing temperature trend for annual (significant) and all the months except April (negative). Connected with these points, noted an upward trend for June, July, August, September, and October at a 95% confidence level. In a season-wise analysis, three seasons, such as the southwest monsoon (the significant positive trend at 95% confidence level), the northeast monsoon (non-significant), and winter (significant), showed a positive increasing trend of temperature, and summer exhibited a non-significant downward trend (Figure 8). Also noted that relative humidity was dependent on temperature in almost all the time series, i.e., the temperature rises, relative humidity decreases, and when the temperature goes down the relative humidity goes up.

Conclusion

The study results portrayed a significant variation in the rainfall, temperature, and relative humidity in the month to month, season to season, and year to year data. The annual data of rainfall from 1988 to 2017 shows a significant increasing trend. In a season-wise observation, summer, north-east monsoon, and winter represented a rising trend, while southwest monsoon showed a falling trend. Simultaneously, the trend for annual temperature, southwest monsoon, and winter was significantly increasing. Mainly, the recent six-year data showed a sharply rising trend. The relative humidity depends on temperature, so the relative humidity goes down when the temperature is up and vice versa. In the context of climate change, an understanding of temporal distributions and changing patterns of climatic parameters are the requirements to develop future action plans, particularly in the protected areas. This study suggests focusing future studies on the effects of climatic variability on all the creatures, specifically the flora of Peechi-Vazhani Wildlife Sanctuary, which is more vulnerable to climate change effects.

List of Figures

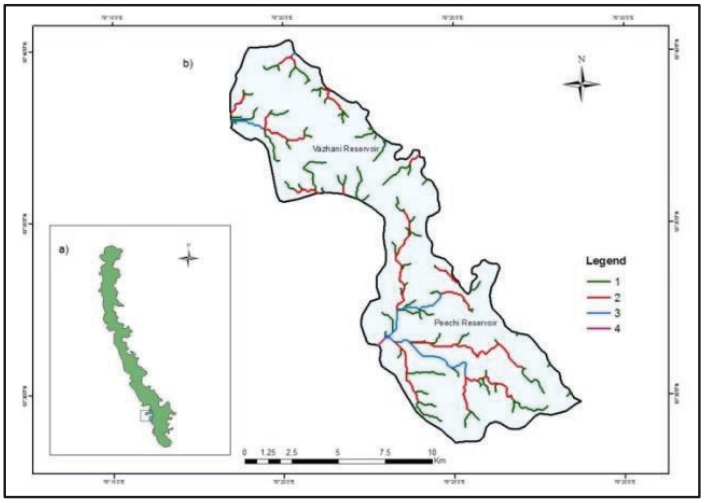


Figure 1. Map showing (a) The Western Ghats; (b) Peechi-Vazhani WLS

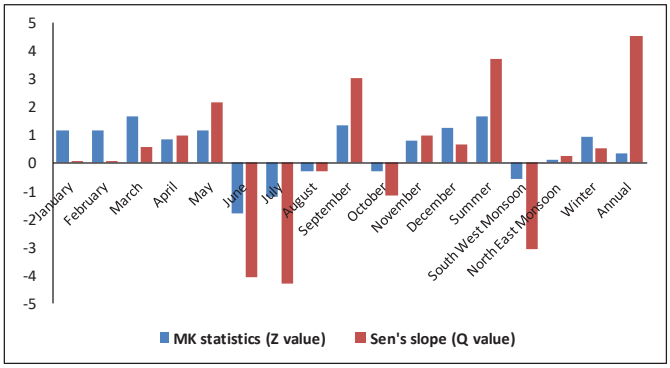
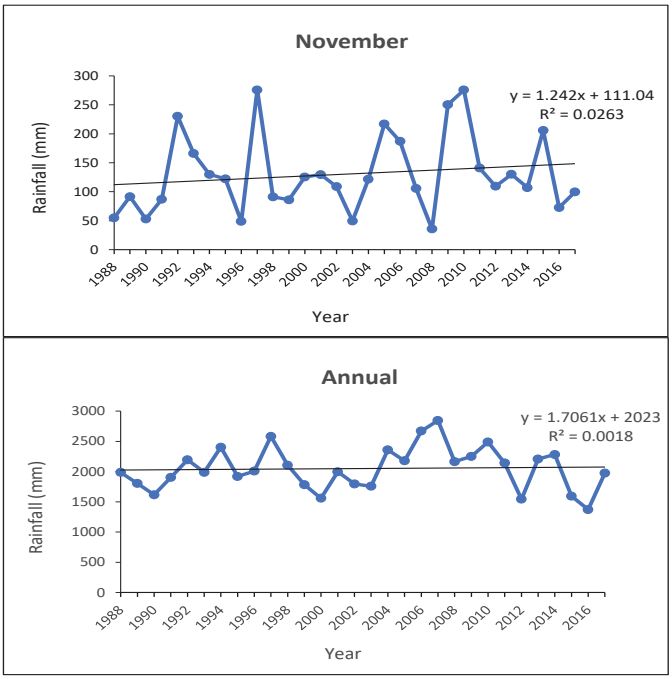


Figure 2. Mann-Kendal trend test and Sen's slope value of rainfall trend analysis

Figure 3. Rainfall trend for 1988-2017 on a monthly and annual basis with linear least square regression lines .(Cont. on next page)



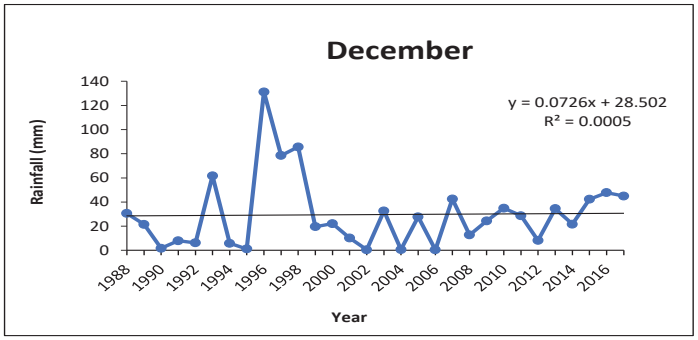


Figure 3. Rainfall trend for 1988-2017 on a monthly and annual basis with linear least square regression lines

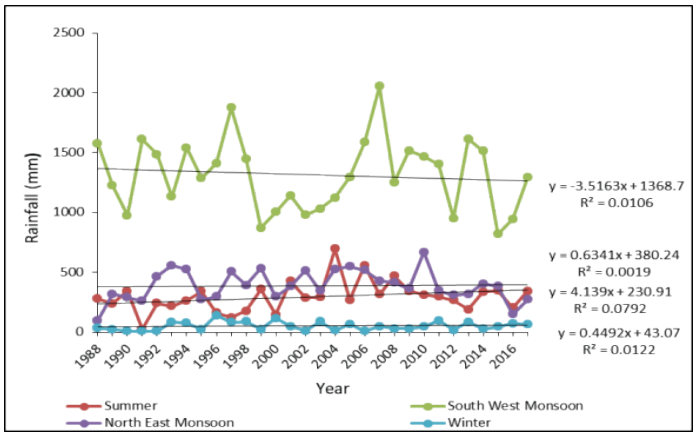


Figure 4. Rainfall trend for 1988-2017 on a seasonal basis with linear least square regression lines

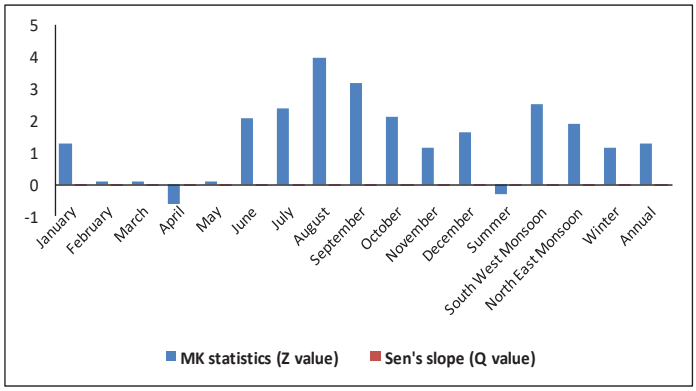


Figure 5. Mann-Kendal test and Sen's slope value of temperature trend analysis

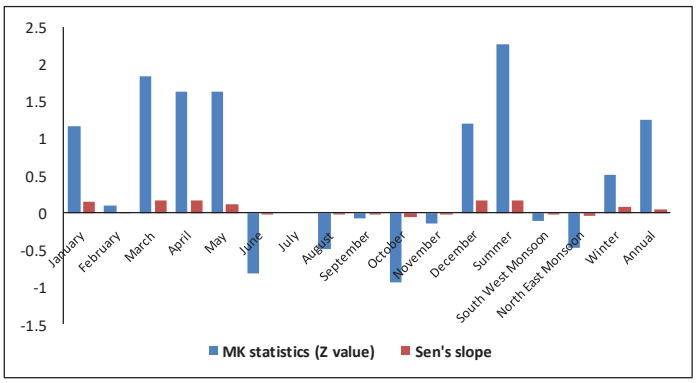


Figure 6. Mann-Kendal test and Sen's slope value of relative humidity trend analysis

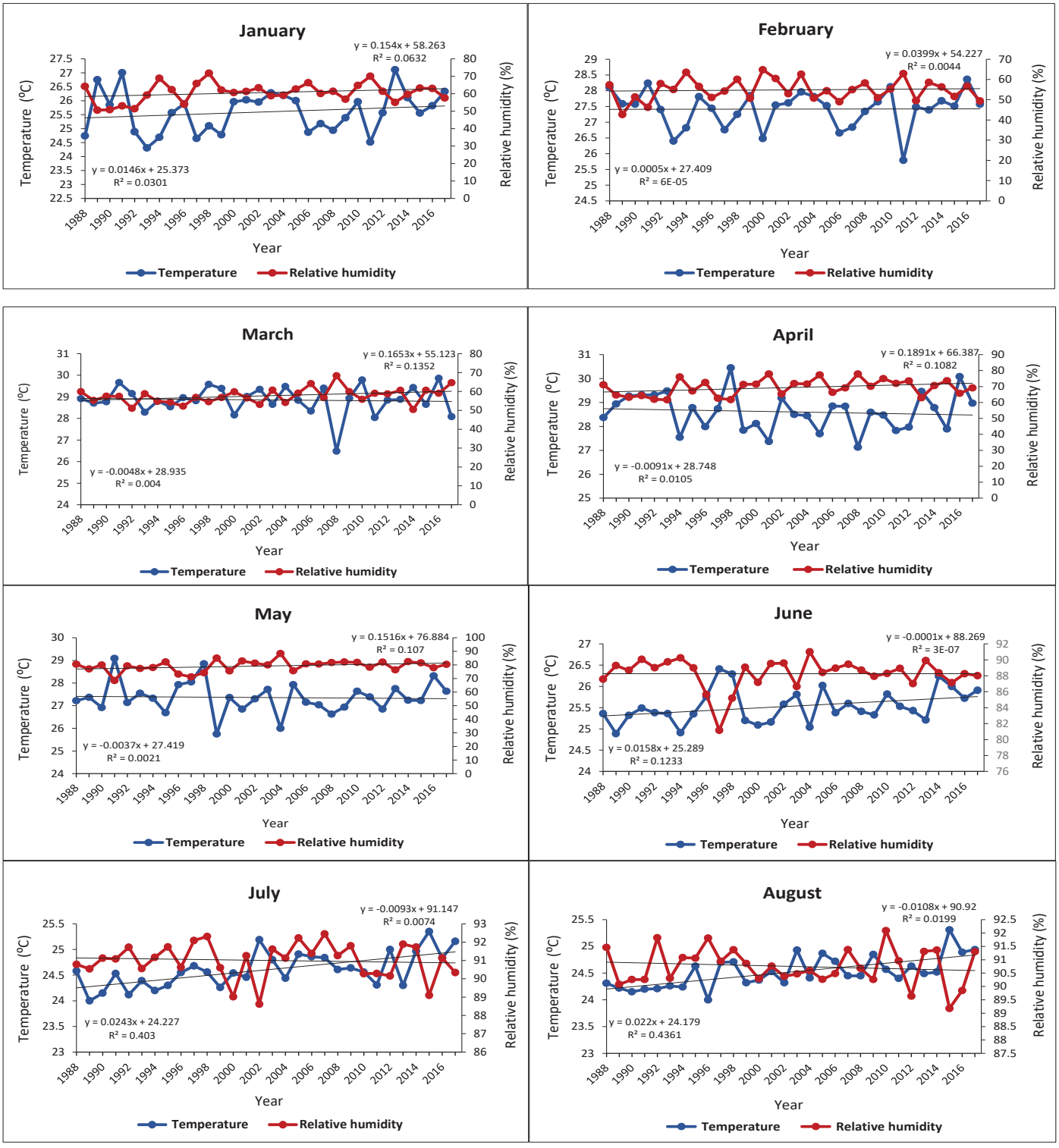


Figure 7. Temperature and relative humidity trend for 1988-2017 on a monthly and annual basis with linear least square regression lines (Cont. on next page)

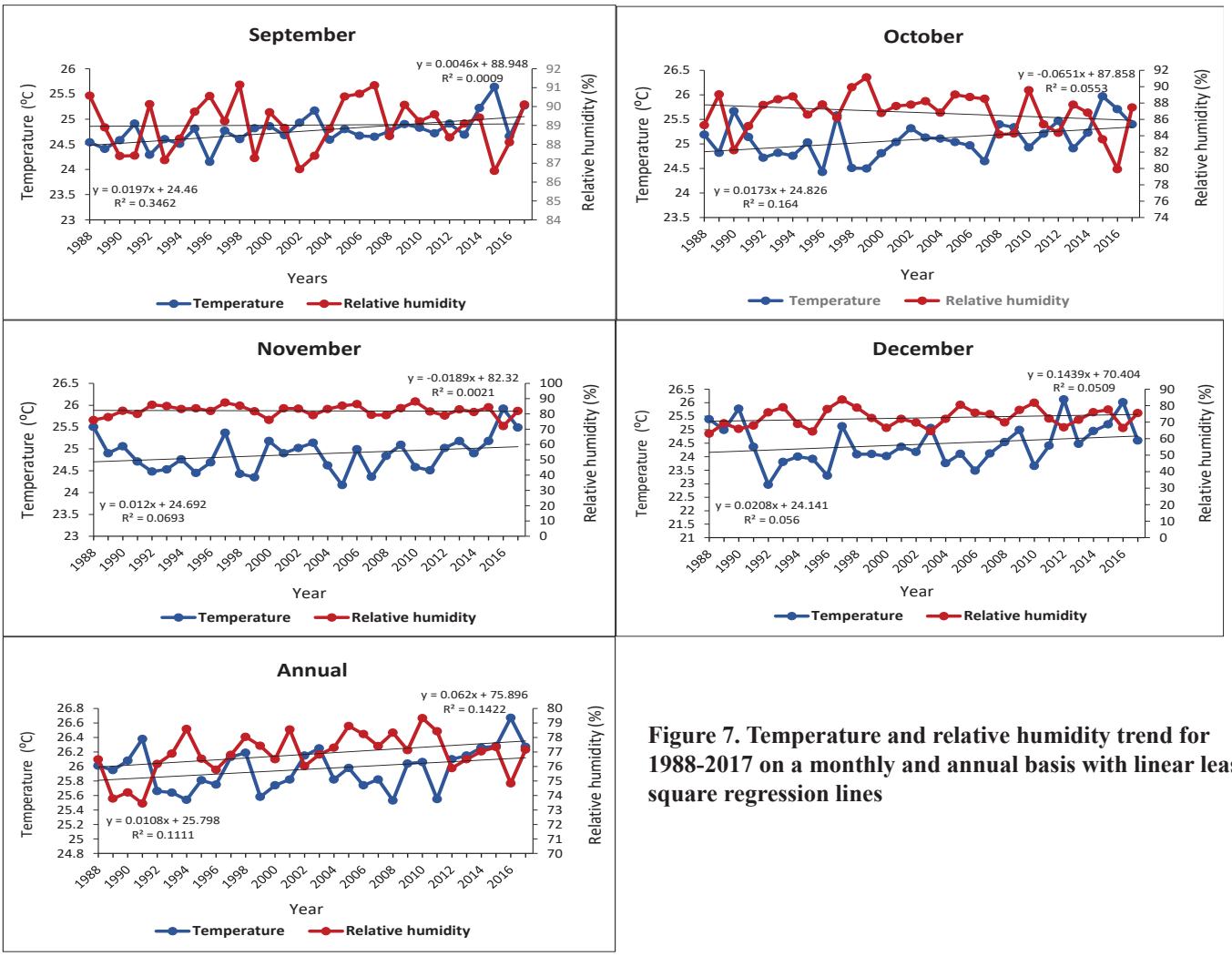


Figure 7. Temperature and relative humidity trend for 1988-2017 on a monthly and annual basis with linear least square regression lines

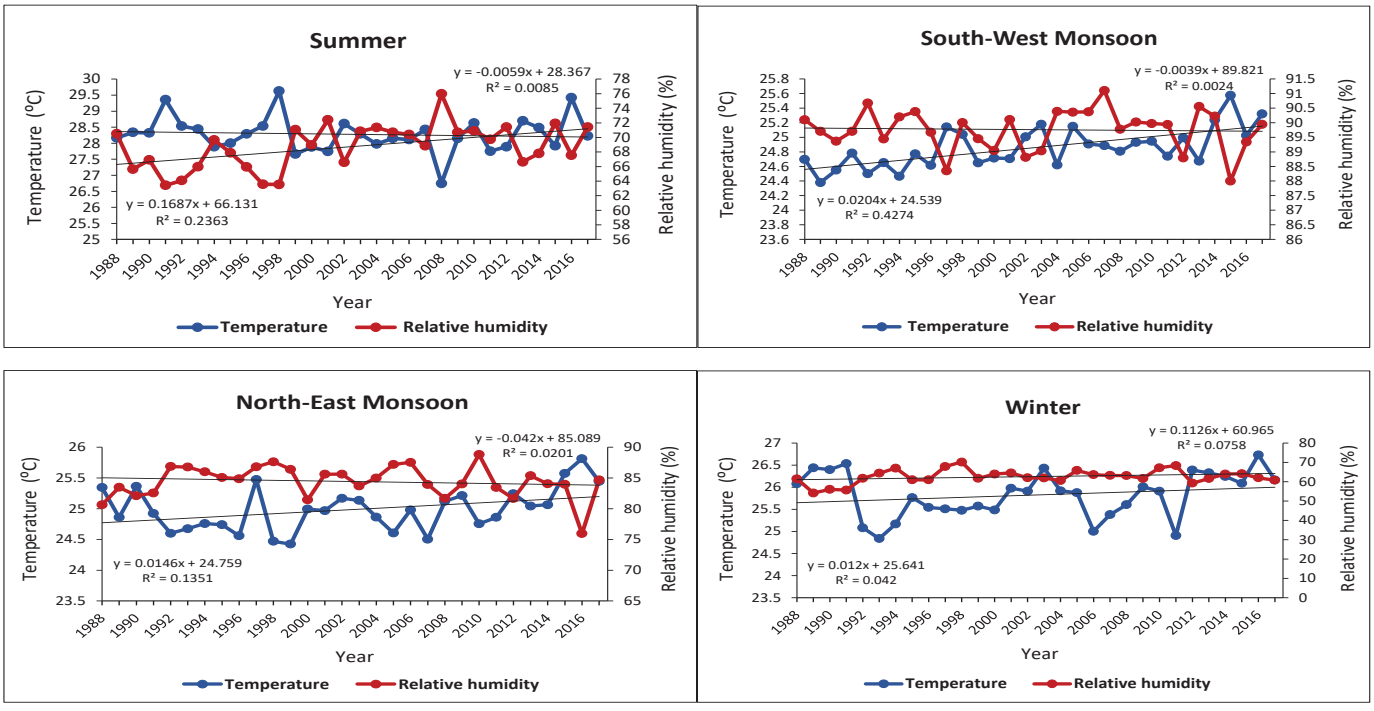


Figure 8. Temperature and relative humidity trend for 1988-2017 on seasonal basis with linear least square regression lines

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- Manuscript Preparation: Shalu George

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Assessment of Carbon Storage Potential of Dominant Tree Species in an Educational Campus, Kolkata, West Bengal

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Abstract:

This study was undertaken in February, 2021 to determine the role played by the forest cover in lowering the level of carbon dioxide in the atmosphere within the premises of an educational institute in Barasat, North 24 Parganas district, West Bengal (India). Twenty-two dominant tree species from the eight sampling sites were surveyed, out of which the highest and lowest above ground stem biomass was exhibited by *Azadirachta indica* and *Manilkara zapota* respectively. The soil pH at the sampling sites ranged between 3.6 to 6.1 and the Soil Organic Carbon ranged from 0.38 to 1.3 %. The near surface atmospheric CO_2 level showed highest value of 423 ppm and lowest value of 358 ppm at the sampling sites. The study results demonstrate the uniqueness of urban trees to store excess carbon as biomass. In order to sequester surplus carbon, the community managers need to identify tree species composition and undertake planting of productive, longer-living and large trees which can be maximized for ecosystem functioning.

Key words: Urban Forest, Carbon sequestration, CO_2, Biomass

Introduction

Several manufacturing and processing units, factories, congested set-ups, along with increasing vehicles beyond the carrying capacity are encountered in several cities. The rise in population by way of migration

from rural areas is adding to the burden. A common consensus among climatologists and environmentalists is that increasing greenhouse gas emissions (GHGs) in the environment is because of humans and their uncaring lifestyle, besides deforestation and burning of fossil fuels, world over thereby altering the climate of the earth. CO_2 is a major contributor to the total greenhouse effect. Beginning from 1850, in a duration of 50 years, almost 100 gigatons of carbon was discharged into the atmosphere due to changes in land-use (Pandey, 2002). Most of the increase in levels of atmospheric CO_2 has started since 1940. Currently, the CO_2 levels are rising by 4% in a span of 10 years (Jo and McPherson, 2001). Trees have been drawing considerable attention globally in combating climate change issues (Dwyer *et al*., 1992), since they absorb and store carbon. Of the total amount of bound carbon on earth, it is estimated that 90% is confined in the world's forests, including forest soil, forest floor (litter), and trees. Trees can store about 14.97 kg of carbon as total tree biomass for each cubic foot of wood (Sampson *et al*., 1992). In 2001, the governments world over made comprehensive political commitments to tackle the issue of climate change. After years of negotiating extensively the Marrakech Accord to the United Nations Framework Convention on Climate Change (UNFCCC) was ratified and the governments agreed to implement the obligations covered under the Kyoto Protocol to lower GHG emissions in a span of next ten years. Under the Marrakech agreements, many forestry and land use plans are inclusive of the Kyoto Protocol which would serve as road maps to help in carbon sequestration and mitigate climate change, through re-vegetation, reforestation, proper crop management and planning.

The level of atmospheric carbon dioxide has been increasing slowly with time in the Indian sub-continent and some researchers have demonstrated an average increase of 2.05 ppm/year, from carbon dioxide concentration of 372 ppm in 2002 to 386 ppm in 2008 (Nayak *et al*., 2014). This increasing trend in the level of carbon dioxide is also observed in West Bengal, with percent rise in carbon dioxide emissions found to be 50.79% from 1980 to 2000 (Ghoshal and Bhattacharya, 2008)

The capture of atmospheric carbon dioxide and its storage in various components of an ecosystem over a period of time is carbon sequestration. Forest act as an important component in this process of carbon sequestration and storage; provide certain treatment options such as sinks that promote carbon regeneration (Kumar *et al*., 2018). The producer community or the plants take up atmospheric CO_2 for the process of photosynthesis, by which the removal of carbon dioxide occurs and finally stored in plant tissues as stored carbon and thereby acting as sink and storehouse of surplus carbon (Nanda *et al*., 2016). The long-term source/sink dynamics with respect to carbon dioxide in the forest is dependent on the growth, age and maturity of the tree. Forest resources are affected by human influences as well as by factors such as fuel extraction and harvesting of biomass (Nowak and Crane, 2002). The rate and extent of carbon storage enhances in young stands, but diminishes over time as the stands age. A study from pine species in the southeastern US has shown that the carbon storage rate dips to zero value when it reaches age 100 (Veld and Plantinga, 2005). Rising carbon dioxide levels increase rate of photosynthesis in trees which lead to enhanced growth and production of biomass. At double the normal concentration of carbon dioxide, the growth increased by 25% and this has been proved by the Free Air Carbon dioxide Enrichment (FACE) test. Scientific studies present substantial proof that increasing levels of atmospheric carbon dioxide by way of emissions can impact positively on the productivity of plants (Schaffer *et al*., 1997; Pan *et al*., 1998).

The present study was undertaken to build up a baseline data set of the carbon sequestration and stored carbon content in the dominant tree species in Kingston Educational Institute campus and their role in modulating the local and regional climate. The Above Ground Biomass (AGB) (which is the summation of above ground stem biomass, above ground branch biomass and above ground leaf biomass), Below Ground Biomass (BGB), and Soil Organic Carbon (SOC) all together contribute to the total carbon content in a plantation site or forest. The biomass of trees is dependent on number of factors such as rainfall, solar intensity, availability of nutrients, and property of soil universally in all sites. The stored carbon in the above ground stem biomass of the dominant trees, and soil pH and organic carbon was measured through three field studies during 11th February, 2021 to 4th March, 2021.

Materials and Methods

Study Location

The campus of Kingston Educational Institute is located in Berunanpukuria, which is 6 km away from

Barasat City in the state of West Bengal. It is adjacent to West Bengal State University, Barasat. Eight sampling sites were selected based on stratified random sampling design (Table 1; Figure 1) for better cross-sectional study and to generate lower variance for the estimated population.

Table 1. Sampling Sites chosen during the study period in the campus

Sl. No.	SAMPLING SITES	SITE DESCRIPTION	COORDINATES
1.	Site 1 (S1)	Entry point	22^{0}44’21.7”N; 88^{0}26’15.0”E
2.	Site 2 (S2)	Playground	22^{0}44’18.2”N; 88^{0}26’15.1”E
3.	Site 3 (S3)	Canteen area	22^{0}44’15.3”N; 88^{0}26’16.2”E
4.	Site 4 (S4)	Pond area	22^{0}44’13.4”N; 88^{0}26’14.9”E
5.	Site 5 (S5)	Front side of Kingston Model School	22^{0}44’07.8”N; 88^{0}26’14.0”E
6.	Site 6 (S6)	Backside of Kingston Model School	22^{0}44’06.2”N; 88^{0}26’15.1”E
7.	Site 7 (S7)	End point of Kingston Educational Institute	22^{0}44’05.1”N; 88^{0}26’14.3”E
8.	Site 8 (S8)	Backside of B.Ed. building	22^{0}44’09.8”N; 88^{0}26’12.0”E

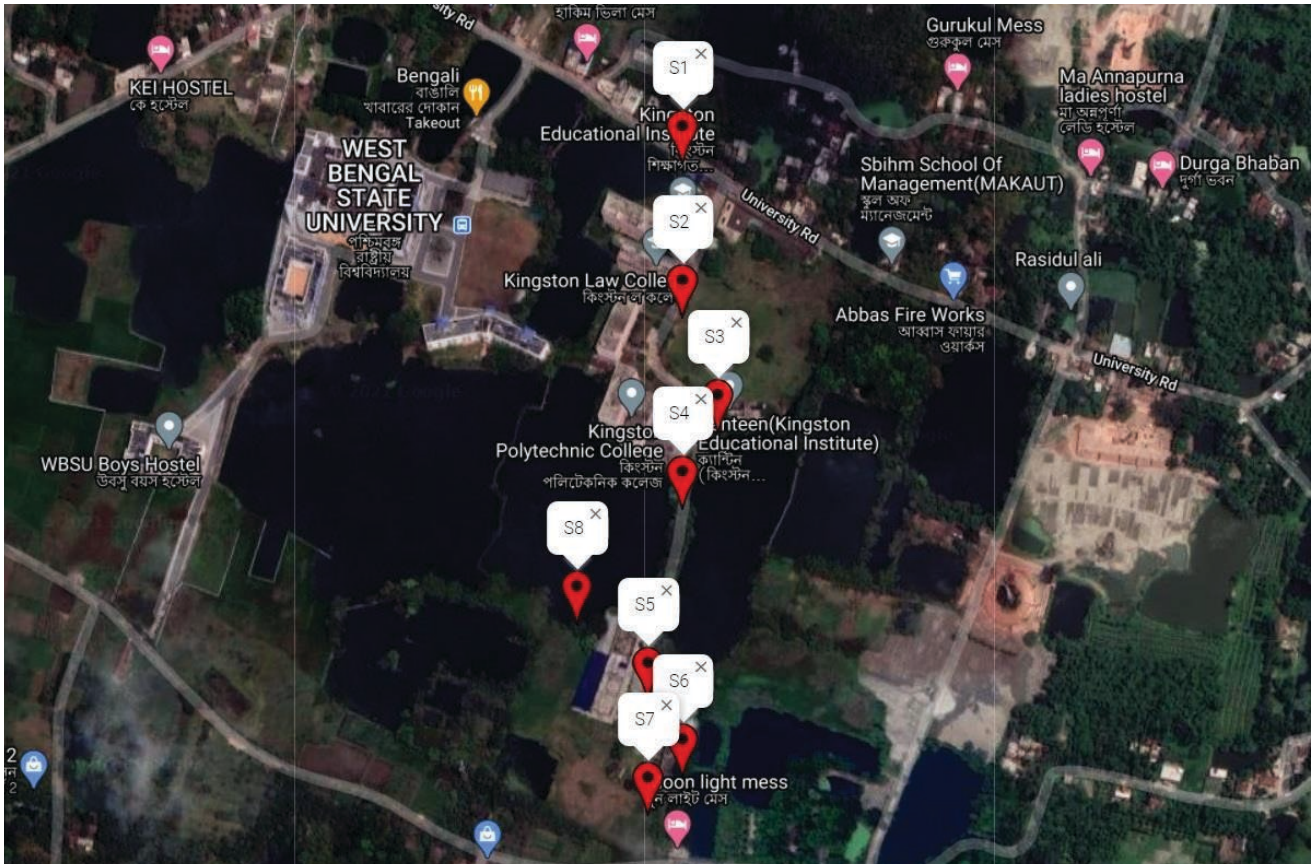

Figure 1. Satellite image of all the selected sites in the Kingston Educational Institute, Barasat

[S1 = Entry point; S2 = Playground; S3 = Canteen area; S4 = Pond area; S5 = Front side of Kingston Model School; S6 = Backside of Kingston Model School; S7 = End point of Kingston Educational Institute; S8 = Backside of B.Ed. building]

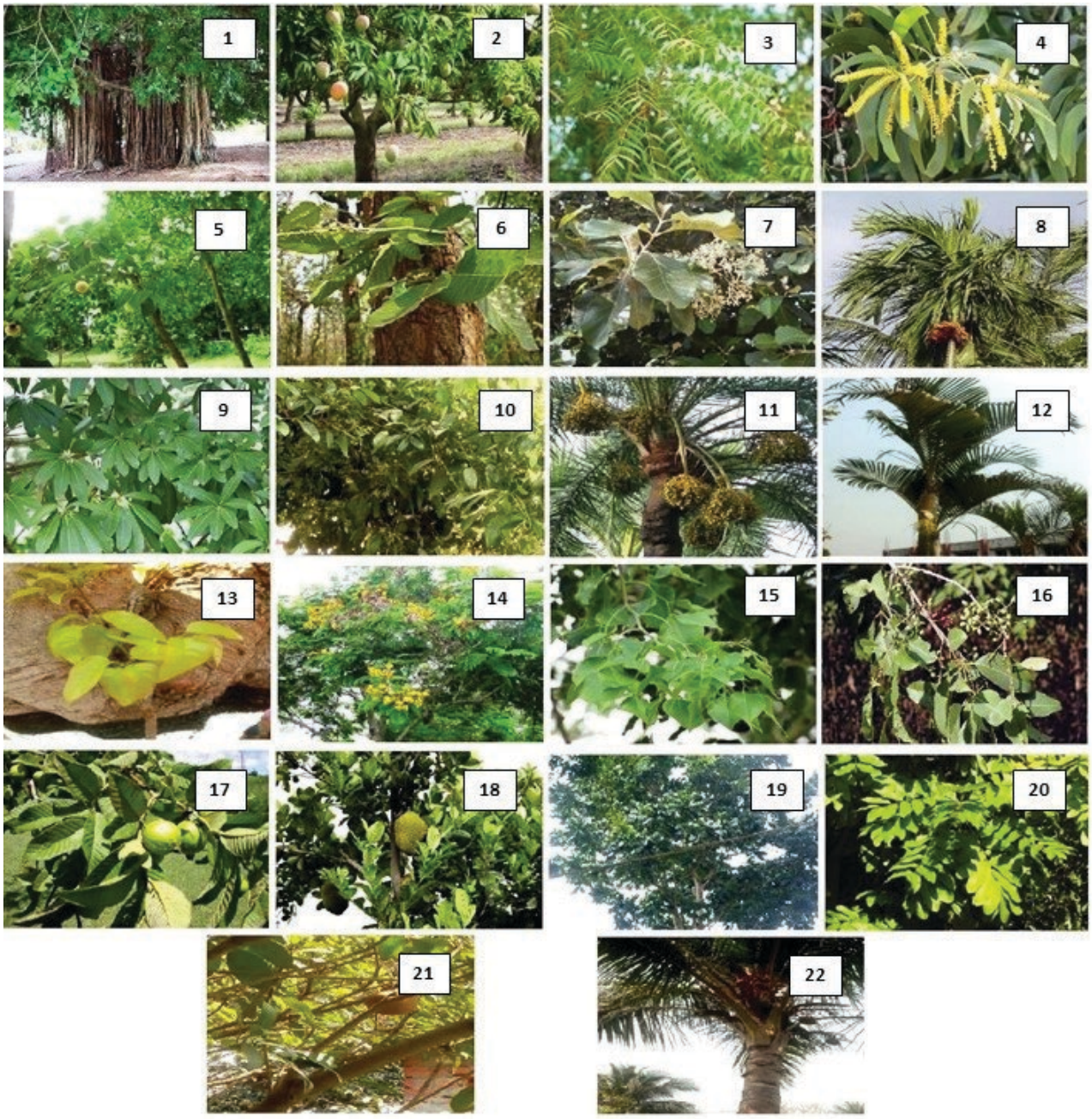

Figure 2. Dominant tree species in the study area: (1) *Ficus benghalensis*, (2) *Mangifera indica*, (3) *Azadirachta indica*, (4) *Acacia auriculiformis*, (5) *Neolamarckia cadamba*, (6) *Shorea robusta*, (7) *Tectona grandis*, (8) *Areca catechu*, (9) *Alstonias cholaris*, (10) *Cinnamomum tamala*, (11) *Phoenix dactylifera L.*, (12) *Dypsis lutescens*, (13) *Philodendron hederaceum*, (14) *Peltophorum pterocarpum*, (15) *Dalbergia sissoo*, (16) *Syzygium cumini*, (17) *Psidium guajava,* (18) *Artocarpus heterophyllus*, (19) *Swietenia macrophylla*, (20) *Khaya anthotheca*, (21) *Manilkara zapota*, (22) *Cocos nucifera*

The following trees namely *Ficus benghalensis* (Banyan), *Neolamarckia cadamba* (Kadam), *Peltophorum pterocarpum* (Radhachura), *Mangifera indica* (Mango), *Acacia auriculiformis* (Sonajhuri), *Shorea robusta* (Sal), *Azadirachta indica* (Neem), *Areca catechu* (Betel), *Alstonia scholaris* (Saptaparni/ Devils tree), *Cinnamomum tamala* (Tezpata), *Syzygium cumini* (Jamun), *Dalbergia sissoo* (Shisham/Sisu), *Tectona grandis* (Segun), *Khaya anthotheca* (Lambu), *Swietenia macrophylla* (Mehogany), *Artocarpus heterophyllus* (Jackfruit), *Manilkara zapota* (Sabeda), *Cocos nucifera* (Coconut), *Phoenix dactylifera L.* (Date

palm), *Dypsis lutescens* (Areca palm), *Philodendron hederaceum* (Heartleaf), *Psidium guajava* (Guava) and few others are dominant tree species in the study area (Fig. 2).

Analysis

The Above Ground Stem Biomass (AGSB) of individual trees of selected dominant species was estimated as per the standard procedure and expressed as tonnes/ha. Soil pH and Soil Organic Carbon (SOC) were analyzed as per the standard protocol.

Stem biomass estimation

The non-destructive method was used to determine the stem biomass for each tree species in which the measurement of Diameter at the Breast Height (DBH) was done after evaluating the circumference with a measuring tape and height using a laser beam (BOSCH DLE 70 Professional model). Spiegel relascope was used to determine Form Factor according to the method outlined by Koul and Panwar (2008). The stem volume (V) was determined by the following formula.

$V = FH\Pi r^2$

where H is the height of the target tree, F is the form factor and r is the radius of the tree derived from its DBH.

The stem cores are used to estimate the specific gravity (G) and using the expression $B_S = GV$, the stem biomass (B_S) was calculated.

Stem Carbon estimation

Direct estimation of percent carbon was done by CHN analyzer (Vario MACRO elementar). The analysis was carried out on a portion of fresh stem sample of target trees of each species after oven drying at 70^0C, mixed randomly and grounded to pass through a mesh size of 0.5 mm. The value obtained was converted to stored carbon per species (in tonnes) taking into account the AGSB (above ground stem biomass) for each species and number. Ultimately to calculate the CO_2 –equivalent, the total stored carbon is multiplied by 3.67.

Soil pH analysis

A micro pH meter (Systronics, Model No, 362, sensitivity ± 0.01) was used to determine the pH of the soil at the sampling sites. Before measurement of the sample the pH meter was standardized using a buffer (pH =7.0).

Soil Organic Carbon

To determine the Soil Organic Carbon, the samples were collected within 5 cm from the upper layer from all the eight selected sites in the Kingston Educational Institute campus and dried at 60 ^{o}C for 48 hrs. The soil samples were sieved through a mesh size of 2 mm and ground finely in a ball – mill. The finely dried samples were mixed randomly to get a representative picture of the selected 8 sites separately. The organic carbon content was determined in percentage using the modified version of Walkley and Black method (1934).

Results

In the current study, the total value of AGSB and AGSC for each tree species is given in Table 2.

The AGSB of the dominant trees species in the study site is in the order *Azadirachta indica* (9.65 tonnes/ha) > *Mangifera indica* (9.12 tonnes/ha) > *Ficus benghalensis* (8.86 tonnes/ha) > *Khaya anthotheca* (7.56 tonnes/ha) > *Shorea robusta* (5.65 tonnes/ha) > *Peltophorum pterocarpum* (5.28 tonnes/ha) > *Philodendron hederaceum* (4.60 tonnes/ha) > *Areca catechu* (4.30 tonnes/ha) > *Cinnamomum tamala* (3.80 tonnes/ha) > *Cocos nucifera* (3.42 tonnes/ha) > *Artocarpus heterophyllus* (3.12 tonnes/ha) > *Acacia auriculiformis* (3.10 tonnes/ha) > *Dypsis lutescens* (2.70 tonnes/ha) > *Tectona grandis* (2.18 tonnes/ha) > *Alstonia scholaris* (2.10 tonnes/ha) > *Neolamarckia cadamba* (1.80 tonnes/ha) > *Dalbergia sissoo* (1.75 tonnes/ha) > *Swietenia macrophylla* (0.96 tonnes/ha) > *Phoenix dactylifera L.* (0.84 tonnes/ha) > *Psidium guajava* (0.38 tonnes/ha) > *Syzygium cumini* (0.28 tonnes/ha) > *Manilkara zapota* (0.26 tonnes/ha).

Similarly the AGSC follows the sequence of *Azadirachta indica* (4.76 tonnes/ha) > *Mangifera indica* (4.28 tonnes/ha) > *Ficus benghalensis* (4.15 tonnes/ha) > *Khaya anthotheca* (3.56 tonnes/ha) > *Shorea robusta* (2.72 tonnes/ha) > *Peltophorum pterocarpum* (2.41 tonnes/ha) > *Philodendron hederaceum* (2.27 tonnes/ha) > *Areca catechu* (1.93 tonnes/ha) > *Cinnamomum tamala* (1.65 tonnes/ha) > *Cocos nucifera* (1.62 tonnes/ha) > *Artocarpus heterophyllus* (1.48 tonnes/ha) > *Acacia auriculiformis* (1.38 tonnes/ha) > *Dypsis lutescens* (1.22 tonnes/ha) > *Alstonia scholaris* (1.04 tonnes/ha) > *Tectona grandis* (1.02 tonnes/ha) > *Neolamarckia cadamba* (0.84 tonnes/ha) > *Dalbergia sissoo* (0.78 tonnes/ha) > *Swietenia macrophylla* (0.46 tonnes/ha) > *Phoenix dactylifera L.* (0.36 tonnes/ha) > *Psidium guajava* (0.17 tonnes/ha) > *Syzygium cumini* (0.13 tonnes/ha) > *Manilkara zapota* (0.11 tonnes/ha).

Table 2. List of dominant tree species in Kingston Educational Institute campus with their respective AGSB, AGSC and CO_2-equivalent (in tonnes / ha)

Sl. No.	Species	AGSB (tonnes / ha)	AGSC (tonnes / ha)	CO_2- equivalent (tonnes / ha)
1.	***Ficus benghalensis***	8.86	4.15 (46.8%)	15.22
2.	***Mangifera indica***	9.12	4.28 (49.90%)	15.70
3.	***Azadirachta indica***	9.65	4.76 (49.3%)	17.46
4.	***Acacia auriculiformis***	3.10	1.38 (44.5%)	5.06
5.	***Neolamarckia cadamba***	1.8	0.84 (46.4%)	3.07
6.	***Shorea robusta***	5.65	2.72 (48.1%)	9.97
7.	***Tectona grandis***	2.18	1.02 (46.7%)	3.74
8.	***Areca catechu***	4.30	1.93 (44.9%)	7.09
9.	***Alstonias cholaris***	2.10	1.04 (49.6%)	3.82
10.	***Cinnamomum tamala***	3.80	1.65 (43.5%)	6.07
11.	***Phoenix dactylifera L.***	0.84	0.36 (42.9%)	1.32
12.	***Dypsis lutescens***	2.70	1.22 (45.2%)	4.48
13.	***Philodendron hederaceum***	4.60	2.27 (49.3%)	8.32
14.	***Peltophorum pterocarpum***	5.28	2.41 (45.7%)	8.86
15.	***Dalbergia sissoo***	1.75	0.78 (44.8%)	2.88
16.	***Syzygium cumini***	0.28	0.13 (46.4%)	0.46
17.	***Psidium guajava***	0.38	0.17 (44.5%)	0.62
18.	***Artocarpus heterophyllus***	3.12	1.48 (47.3%)	5.42
19.	***Swietenia macrophylla***	0.96	0.46 (48.2%)	1.70
20.	***Khaya anthotheca***	7.56	3.56 (47.1%)	13.07
21.	***Manilkara zapota***	0.26	0.11 (43.8%)	0.42
22.	***Cocos nucifera***	3.42	1.62 (47.3%)	5.94

CO_2-equivalent follows the sequence of *Azadirachta indica* (17.46 tonnes/ha) > *Mangifera indica* (15.70 tonnes/ha) > *Ficus benghalensis* (15.22 tonnes/ha) > *Khaya anthotheca* (13.07 tonnes/ha) > *Shorea robusta* (9.97 tonnes/ha) > *Peltophorum pterocarpum* (8.86 tonnes/ha) > *Philodendron hederaceum* (8.32 tonnes/ha) > *Areca catechu* (7.09 tonnes/ha) > *Cinnamomum tamala* (6.07 tonnes/ha) > *Cocos nucifera* (5.94 tonnes/ha) > *Artocarpus heterophyllus* (5.42 tonnes/ha) > *Acacia auriculiformis* (5.06 tonnes/ha) > *Dypsis lutescens* (4.48 tonnes/ha) > *Alstonia scholaris* (3.82 tonnes/ha) > *Tectona grandis* (3.74 tonnes/ha) > *Neolamarckia cadamba* (3.07 tonnes/ha) > *Dalbergia sissoo* (2.88 tonnes/ha) > *Swietenia macrophylla* (1.70 tonnes/ha) > *Phoenix dactylifera L.* (1.32 tonnes/ha) > *Psidium guajava* (0.62 tonnes/ha) > *Syzygium cumini* (0.46 tonnes/ha) > *Manilkara zapota* (0.42 tonnes/ha).

The growth of the tree species both in terms of height and girth is the best indicator to assess the absorbing power of CO_2 from the ambient air. The growth of the tree is also a function of soil condition particularly pH, which regulates the availability of nutrients to the trees. In the present study, the soil pH value ranged between 3.6 – 6.1, which clearly indicates the deteriorated condition of the soil due to the accumulation of litter and detritus.

The soil pH in the selected sites is in the order of Front side of Kingston Model School (6.1) > Playground (5.9) > Entry point (5.6) > Pond area (5.3) > Canteen area (4.7) > Backside of Kingston Model School (4.1) > Endpoint of Kingston Educational Institute (3.8) > Backside of B.Ed building (3.6) as represented in the bar graph Figure 3.

In case of Soil Organic Carbon (SOC), the sequence is Backside of B.Ed. building (1.30 %) > Endpoint of Kingston Educational Institute (1.21 %) > Pond area (1.10 %) > Backside of Kingston Model School (1.04 %) > Canteen area (0.93 %) > Entry point (0.73 %) > Playground (0.46 %) >Front side of Kingston Model School (0.38 %) as represented in the bar graph Figure 4.

The near surface atmospheric CO_2 level is of the order Endpoint of Kingston Educational Institute (423 ppm) > Playground (421 ppm) > Canteen area (416 ppm) > Entry point (413 ppm) > Backside of Kingston Model School (407 ppm) > Front side of Kingston Model School (397 ppm) > Pond area (393 ppm) > Backside of B.Ed. building (358 ppm) as represented in the bar graph Figure 5.

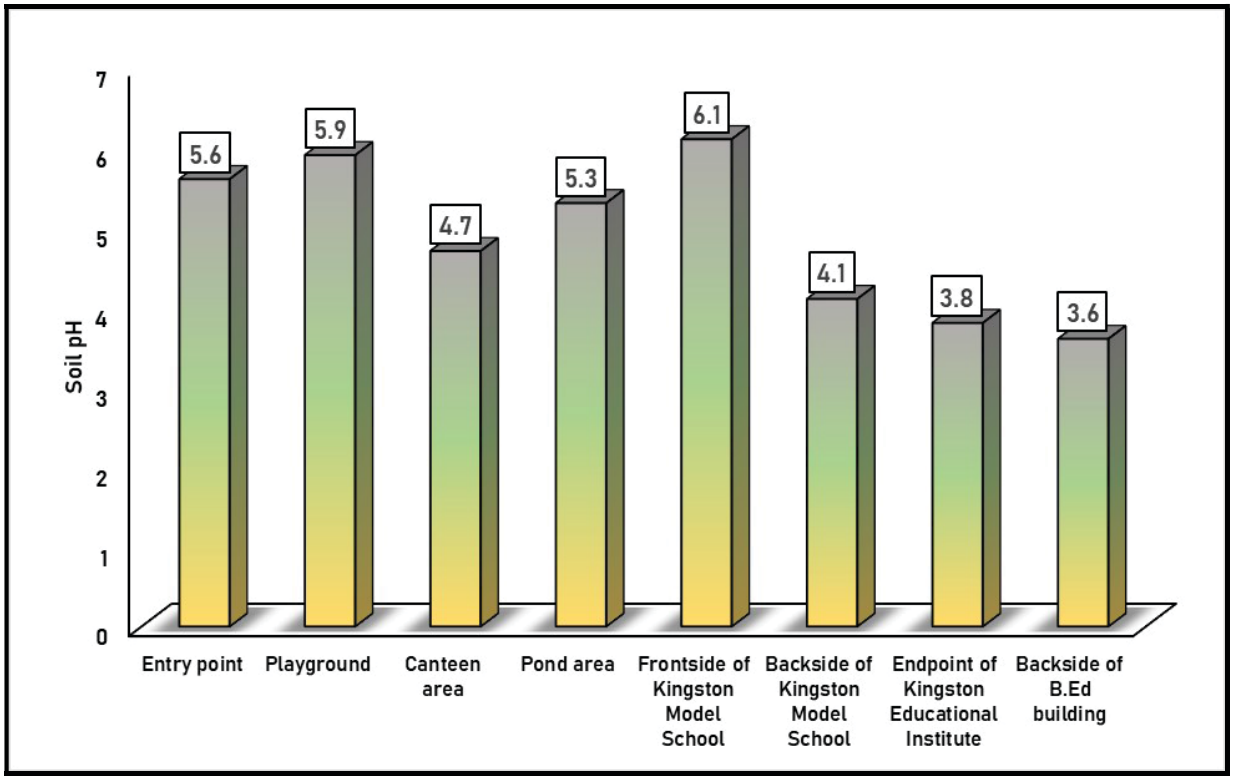

Figure 3. Soil pH at eight selected sites in Kingston Educational Institute at Barasat

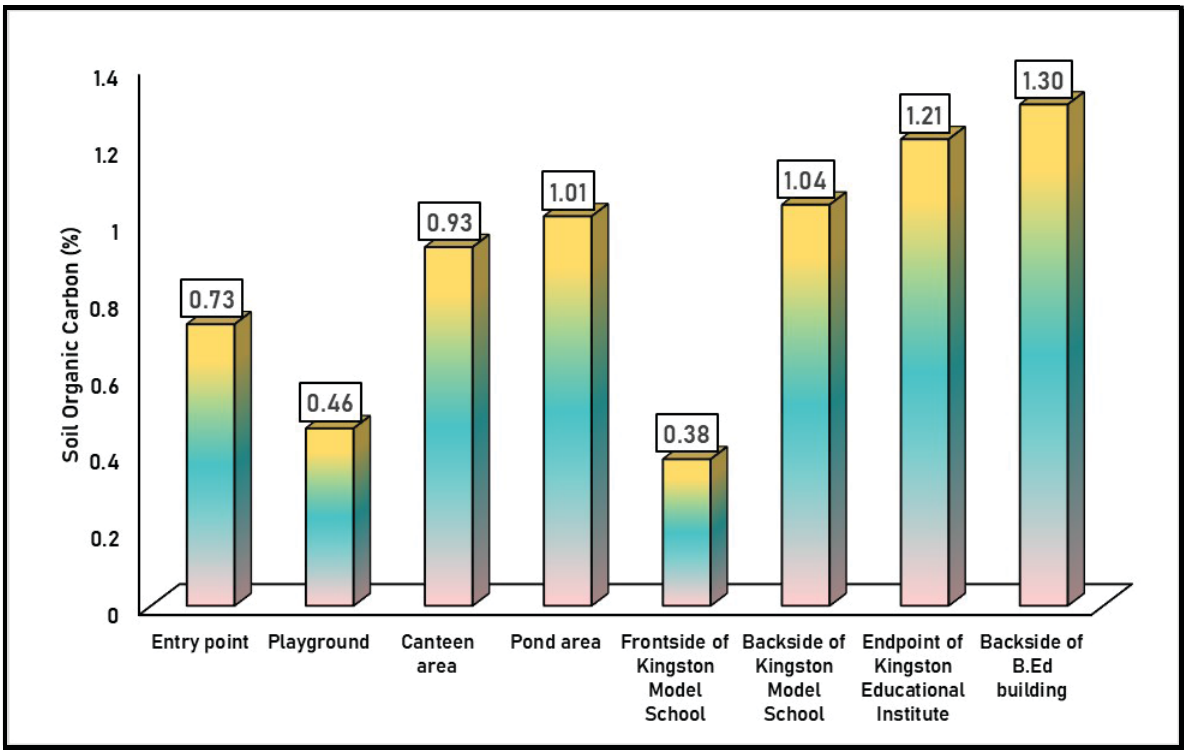

Figure 4. Soil Organic Carbon (%) at eight selected sites in Kingston Educational Institute at Barasat

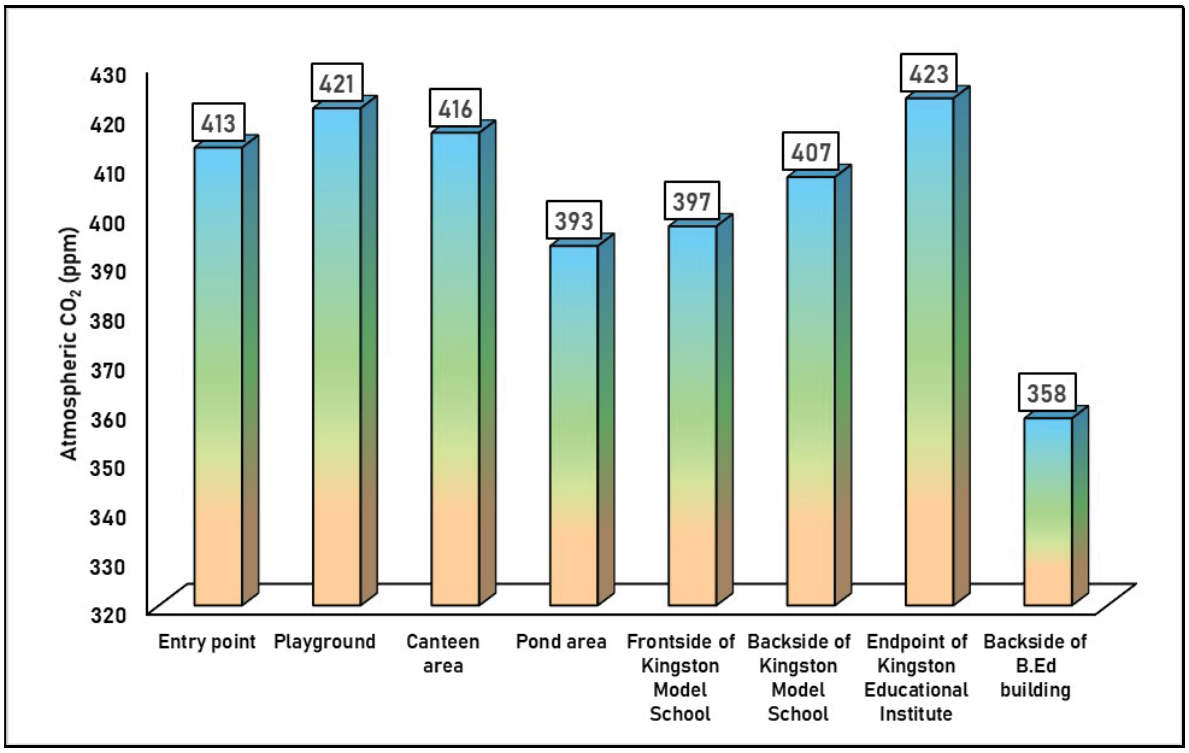

Figure 5. Near Surface Atmospheric CO_2 (ppm) at eight selected sites in Kingston Educational Institute at Barasat

Discussion

Various studies have been carried out in the field of biomass and forestry which laid emphasis on production of timber, forest conservation, and environmental management (Putz and Chan, 1986; Tamai *et al*., 1986; Komiyama *et al*., 1987; Clough and Scott, 1989; McKee, 1995; Ong *et al*., 1995). The rising problem of global warming worldwide has brought the attention of researchers and scientist on urban foresty and their importance to act as sinks of carbon. The carbon sequestration capability of the plants is inter-related to the biomass production capacity, which in turn is dependent on the interaction of various ecological factors such as edaphic, climatic, and environmental conditions. Hence, data would vary from one region to another based on the difference in ecological factors and therefore, the region wise carbon sequestration potential of variety of land types needs to be worked out.

In the present study, the trends of AGSB, AGSC and CO_2-equivalent are all similar except *Alstonia scholaris*, which exceeded *Tectona grand*is both in terms of AGSC and CO_2-equivalent. This might be due to a higher percentage of carbon in *Alstonia scholaris* (49.6%) compared to *Tectona grandis* (46.7%) due to which even with a higher biomass of *Tectona grandis* (2.18 tonnes/ha) compared to *Alstonia scholaris* (2.10 tonnes/ha), the species exhibited less CO_2 equivalent.

The soil pH values were significantly low in the canteen area, the backside of Kingston Model School, endpoint of Kingston educational Institute, and the backside of the B.Ed. building. In all these cases the soil is acidic, which needs to be upgraded through the application of a calculated amount of lime. The SOC values ranged from 0.38% in the front side of Kingston Model School to 1.30% at the backside of the B.Ed. building. The presence of huge biomass of plant litter along with decomposed detritus is the reason for the high level of SOC at the backside of the B.Ed. building.

The near-surface atmospheric CO_2 ranged from 358 ppm at the backside of the B.Ed. building to 423 ppm at the endpoint of Kingston Educational Institute. Basically, huge litter was seen dumped on the soil surface at the endpoint of the Institute. The process of decomposition of this litter biomass contributes an appreciable amount of CO_2 in and around the vicinity. The falling and accumulation of litter in different sites of the Educational Institute may be one of the reasons behind considerable near-surface atmospheric CO_2 within the Institute campus. Soil management by applying 2% lime for 6 months at fortnightly intervals is recommended to upgrade the quality of the soil. This, in turn, will accelerate the growth of the tree in the institute campus.

Conclusion

The study was undertaken to compute the carbon storage potential of the different plant species in the present locale. The results validated the existence of significant variation in AGSB and AGSC between species which suggests that selective plantations need to be adopted in urban areas to reduce the atmospheric CO_2 levels in cost-effective way and promoting environmental health, thus mitigating air pollution across Kolkata and her suburbs which have been listed as the fourth most air polluted cities in the world. It was further observed that *Azadirachta indica* showed the highest above-ground carbon in the institute campus. Moreover, managing soil quality would facilitate the biomass and carbon storage capacity of urban forestry.

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Declaration

All requisite information and data were collected without causing any harm to the environment. The authors declare they have no competing interest and they totally agreed for the publication of this research.

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Sighting of Little Crake *Zapornia parva* in Ahmedabad District, Gujarat

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Figure 1

Little Crake *Zapornia parva* (earlier known as: *Porzana parva)* is a small sized cCrake elonging to family Rallidae . Members of this family are specially adapted to live and move smoothly in dense vegetation with their laterally compressed body and relatively long legs and toes (Del Hoyo et al. 1996, Taylor & Van Perlo 1998). The species is morphologically similar but smaller to Baillon's Crake (Rasmussen and Anderton 2012). The species inhabits emergent vegetation in wetlands, flooded valleys and water bodies like ponds and ditches (Cramp and Simmons 1980).

In Indian subcontinent it occurs in winter and considered as passage migrant in East of Afghanistan, Baluchistan. There are two museum records available from India from Bombay & Karanataka (Rasmussen and Anderton 2012, Grimmett et al.2012). In Gujarat this species was not included by Parasharya et al. (2004), however Ganpule (2016) had included it in the checklist of Gujarat based on the records of Mallord and Showler (2010). After that there were very few additional records of the species from Gujarat.

Bird watchers Ashvin Trivedi from Jamnagar sighted and photographed the bird on 10th December 2017, at Ranjitsagar dam, located about 10 km from Jamnagar (Trivedi 2018), Palash Thakkar, Krinal Jani & Dhananjay Joshi observed it at Limbasi village in Kheda district in December 2018 (Thakker et al. 2019). Asharaf Sama had observed at Nalsarovar, Ahmedabad on 13 March 2019 (Sama 2019). Gaurang Bangda, Narendra Parmar and Dhaval Vargiya sighted at Mokarsagar wetland at Porbanadar, on 11th December 2019 (Vargiya & Bagda 2020). Pravin Patel sighted the species in Surat on 28th February 2019 (Patel 2020).

On 15th October 2018, I visited Adaroda village

(23°-30' N, 73°-02' E), District Ahmedabad. The village is located about 40 km south-west of Ahmedabad city, 10 km North-west of Bavla town, 15 km south-west of Sanand town. The site is predominantly occupied by paddy fields fed by local canals. On 18;36 hours I came across a crake perching on the bank of a canal along the road from Sabasar to Adaroda. I took some record shots (Figure 1).

Photographed bird had longer primary projections than that of Baillon's Crake. It had a red spot at the base of bill, and less strongly marked barring on side, lack of white spots on wing covers. Based on these pointers, the bird was identified as Little Crake *Zapornia parva* using standard field guides and books (Rasmussen and Anderton 2012, Grimmett et al.2012).

On 21st March 2019, I visited Nalsarovar Bird sanctuary (22.8286° N, 72.0575° E) with Kasam Sidani. In the early morning we came across a crake feeding in a reed patch at Kayla village dam. We took some photographs (Figure 2) before the bird disappeared behind reeds. Photographs were compared with standard field guides and the bird was identified as Little Crake. Both these records are from central Gujarat indicating the extent of its distribution range and presence of suitable habitat.

Figure 2

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Gharial *Gavialis gangeticus* Needs Urgent Conservation Attention: A Review of Literature

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The gharial, *Gavialis gangeticus* (Gmelin 1789) is a piscivorous reptile endemic to the Indian subcontinent naturally occurring in approximately 20,000 km^2 of riverine habitat along the Indus, Ganges, Mahanadi, Brahmaputra and Irrawaddy river systems (Smith, 1939; Singh, 1978; Whitaker *et al*., 1974; Groombridge, 1987; Whitaker, 1987; Hussain, 1991, 1999, 2009). Gharials prefer calm and quiet areas of fast-flowing rivers. It is currently estimated that there are <200 breeding adult *G. gangeticus* in the wild. This represents a decline in the population of over 80% since the 1940s (a time-span equating to roughly 3 generations), and qualified it for Critically Endangered (CR) listing on the IUCN Red List (Choudhury et al. 2007; http://www.iucnredlist.org/apps/redlist/details/8966/0, accessed 27th February 2011).

As per a report of the Wildlife Trust of India, there are 1,255 gharials in the Chambal river of Madhya Pradesh and 255 in the Gandak river of Bihar (Photo: CPR Environmental Education Centre, Chennai)

The causes of this decline include historic over-hunting for skins, trophies, eggs and indigenous medicine, and more recently the construction of dams, barrages, irrigation canals, siltation, changes in river courses, artificial embankments, sand-mining, riparian agriculture, domestic and feral livestock, pollution and fishing, which remains a major threat as gill nets continue to rapidly kill gharial of all sizes even in protected areas (Hussain, 1999, 2009).

The common name 'gharial' derives from the Hindi

word '*ghara*' meaning pot or vessel, recognizing the resemblance to an inverted pot of the large protuberance at the tip of the snouts of adult male Gharials. Gharials are the only crocodiles that show sexual dimorphism. They are also accorded much importance in Indian mythology, including their depiction as the holy 'vehicle' of the goddess Ganga. Gharials have slender snouts armed with numerous sharp teeth that intersect to trap fish, which are the primary constituent of their diets. Their mating season is during the months of November, December and January. Sand banks, sand bars and sand islands play a significant role in the ecology of Gharials as they are used preferentially as basking and nesting sites (Gharial Multi-Task Force, 2006). Throughout the summer months of March, April and May, female gharial clamber onto sand banks and islands exposed by receding river levels to nest communally, a large number of females using the same sand bank to lay their eggs in the sand (Rao and Singh, 1993). Parental care by the female has been observed for the first few days after birth.They are a long-lived crocodilian species with a generation length (the age at which 50% of total reproductive output is achieved) of 20 years (Rao*et al*., 1995).Reaching a length of up to 6 metres, gharial are also the second-longest crocodilians after the saltwater or estuarine crocodile (*Crocodylus porosus*) majorly found across Australia.

The Gharial is unique as it is the only crocodilian which is sexually dimorphic (males look obviously different from females). They have short legs and spend most of their time in the water. Adults feed primarily on fish for which jaws and interlocking set of 27-29 undifferentiated teeth on each side of upper jaw and 25-26 teeth in the lower jaw (Shah and Tiwari, 2004) have adapted perfectly for holding struggling prey (CSG, 2000). The thin shape gives the snout low resistance under water, which is suited to fast lateral snatching movements under water. Usually Gharials will not reach sexual maturity before 13 years for the male and 16 years for the female, when they are nearly three meter in length (Maskey and Mishra, 1981; Bustard, 1979; Bustard, 1984; Singh, 1999; Whitaker, 1987). One male will guard a harem of several females and will mate with all of them. The mating period occurs for two months during November, December and into January, while nesting happens in March, April and May (Whitaker, 1983). Nesting is done during the dry season in holes excavated in river sandbanks (Whitaker and Basu, 1983; Groombridge, 1987; Bustard, 1980). The breeding life of Gharial is considered to be 50 years and the life span 100 years (Whitaker and Basu, 1983; Singh, 1999). Individuals less than 0.6 meters

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

Crocodiles are important for several aspects, such as their existence indicates the healthy aquatic ecosystem and their hide and meat has a big commercial value (Whitaker, 1987). As a "keystone species" crocodile maintain structure and function in aquatic ecosystem by their activities (King 1988). These ecological roles include selective predation on fish species, recycling of nutrients and maintenance of wet refugia during drought season. Crocodiles are very important to the river ecosystem and to humans. They contribute to the health of the ecosystem and biodiversity. They are the top predator and as such are an essential part of the biodiversity of these habitats (Deppert, 2004). They prey on the slow moving predatory fish thus removing the diseased individuals, thereby maintaining good stocks of commercially valuable fish in any water body. Few studies done in Africa, Australia and America indicate that the presence of crocs in a water system actually boosted fish stocks (Deppert, 2004). A loss of any species of crocodilian would represent a significant loss of biodiversity, economic potential and ecosystem stability (IUCN, 1998). Crocodiles are called the indicators of a clean aquatic environment and play a crucial role in freshwater ecosystems. These crocodiles feed on the weak and sick fish keeping the fish population strong and healthy. They also keep the water clean and uncontaminated by scavenging on dead animal matter. Without the crocodiles in the water systems, the larger predator fish will eat the smaller commercially important fish, resulting in a smaller population of fish for the fishermen. The crocodiles will eat the larger predator fish thereby allowing a greater population and commercial catch of fish in the river.

Bangladesh:A review of crocodiles in Bangladesh (Cox and Rahman 1994) prompt that though fewer numbers of the species continued to be reported into the 1980's it's going to not be found in the wild. The species is heavily impacted by fishing activities and habitat degradation. A part of the distribution on the Padma River is periodically moved into Indian jurisdiction as the river channel changes during floods. Stray individuals are reported occasionally. However, surveys area unit required to prove whether or not there's a breeding population of Gharial in Bangladesh.

Bhutan: The Gharial is believed to be extinct. (T. maskey 2006)

India: The Chambal watercourse has out and away from the biggest population of breeding Gharial within the wild, with around 48% of the whole population (IUCN 2008). In 2007, 77 nests were found at intervals the Chambal Sanctuary whereas 24 were found in Katerniaghat life Sanctuary (Rao 2007). In 2006, 2 nests were set within the Son watercourse Sanctuary (Andrews 2006). Recent reports confirm that stray animals may persist in the upper Brahmaputra River. A cause for concern was the forceful decline of *G. gangeticus* in the Chambal during the winter of 2007-2008. A poisonous substance is suspected, and the resulting deaths of over 100 Gharial, including around 60% of the sub-adults as well as some adult females in the lower Chambal, represents a significant loss. Evidence points toward pollution as the main cause for this event and is yet another indication that India's rivers are dying (GCA 2008). Most of the country's rivers aren't any longer capable of supporting their once-abundant life, with solely fragments of appropriate environment remaining (GCA 2008; IUCN 2009).

Nepal: Six nests were counted in 2006 within the Chitwan parkland (16 nests were recorded there in 1977) and also the total population of mature *G. gangeticus* in the country is estimated 35 (IUCN 2009). Around three hundred animals were free in Chitwan, so again, an introduction has not worked, though maybe this supplementation has helped avert total extinction (GCA 2008).

Pakistan: During in-depth surveys underneath taken by WWF-Pakistan under the "Indus for All Programme and Pakistan Wetlands Programme" in 2008 and 2009, there was no indication of the presence of Gharial. The species is considered virtually extinct in Pakistan.

Myanmar: Historic reports of Gharial have not been verified for many years. (Whitaker, 1975)

After the 17th CSG (Crocodile Specialist Group) meeting, a task force was established to focus on the Gharial and ensure that effective conservation plans were established, and more importantly, what actions were carried out based on these plans. Since 2006 the Gharial Conservation Alliance (GCA; www.gharials.org) has established a presence among the present *G. gangeticus* Range States. In June 2009, the ground-controlled approach convened a Gharial Pre-Species Recovery coming up with Workshop, during which the CSG participated (Webb 2009), and from that the primary draft of a Gharial Species Recovery Plan was developed (GCA, pers. Comm.). GCA additionally expedited a radio-telemetry study on Gharial movement within the space stricken by the 2007-2008 winter die-offs. GCA/CSG personnel also confirmed the presence of a fourth breeding population in India: the Ramganga River, Corbett Tiger Reserve, and Uttarakhand State.

Protection of suitable habitats (India): All protected areas that harbor gharial (Chambal, Katerniaghat, Corbett, Ken and Son River) need effective protection. Habitats contiguous with established Protected Areas (Ghagra below Katerniaghat life Sanctuary and the Yamuna below National Chambal Sanctuary) should be enclosed as these areas are also important for the long-term survival of the species. The Central and State Governments should maintain the integrity of stream ecosystems so that they can harbor aquatic fauna. This includes controlling the pollution of rivers by industry, development of infrastructure, and river fishing.

Monitoring existing populations (India): A program of continuous observation of Gharial populations is crucial. The 2007/2008 die-off of 113 sub-adult and adult Gharial along the Chambal from what has been identified as a nephrotoxin(s) (Whitaker et al. 2008) serves as a harsh warning. Nesting and basking sites should be identified and mapped; census techniques need to be refined so that they are scientifically credible.

Identification and Minimization of negative anthropogenic influences (India): This wide-ranging action needs to include all the stakeholders such as the Ministry of Irrigation and Water Resources, river development, local fishing methods, sand mining and general human/livestock disturbances of Gharial habitats. These activities that negatively impact the entire riverine ecosystems need to be identified, pinpointed and mapped.

Ensure that conservation programs involve local people (India): Major threats to Gharial include accidental drowning in fishing nets, and often, animals found entangled are intentionally killed or de-beaked by fishermen. In some areas, collecting Gharial eggs for native consumption is an additional threat. A comprehensive program involving local people awareness generation in the conservation of Gharial is vital to ensure the long-term and continuing success of any management program. This set up should embrace instructional materials, signs, and instill pride amongst the locals in having such a rare crocodilian reptile in their rivers.

Research (India): Research, encouraged by the Ministry of Environment and Forests and State Wildlife Authorities, needs to address key management issues such as the Gharials role in the ecosystem, fish ecology, relationship between Gharial and Mugger (*Crocodylus palustris*), establish minimum water flow needed for the survival of Gharial and other river fauna as well as investigate the genetic relationship of remnant populations. Socioeconomic studies are also needed to better understand the impact of local anthropogenic pressures on the habitat. This is essential so as to draft realistic management plans.

Development of international coordination: Gharial populations present in the rivers that run between India and Nepal. Independent conservation programs are running in every country. Coordinated management of those shared populations would enhance conservation effectiveness. Joint surveys, training, comparison of population trends and coordinated regulations and protection can lead to enhancement in the population of the Gharials.

Gharials need immediate conservation attention for its' immediate survivability. Its' endemic presence in the Indian subcontinent deserves more coordinated approach in the concertedconservation of the species. Some of the recommendations are listed as under;

- A pan-Asian coordinated project is to be undertaken

for region specific species conservation.

- Habitat Conservation of all crocodile species is urgently required. Madras Crocodile Bank and Trust is doing amazing work on this initiative. In-Situ and Ex-Situ conservation practices done in this bank deserves special mention. Gharial Ecology Project (GEP) conceived by Madras Crocodile Bank and Trust in Chambal is a dedicated initiative on these lines.
- Secondary chemical poisoning has proved fatal for the in-breeding populations of Gharials across India. The Croc Bank played a crucial role in saving the remaining populations and has extensively worked on the ecology of the Gharials. Such projects require proper funding and coordinated supported from the Ministry of Environment, Forests and Climate Change (MOEFCC), Government of India.
- Lack of skill in handling Gharials resultin local fishermen damaging Gharials caught in their fishing nets, by chopping off the tips of the jaws. Care must be taken to prop open the jaws of such damaged animals, so that the animal can breathe without nostrils through its open mouth via its throat.
- Gharials struggle little when captured in nets, and must be removed quickly to avoid any injuries. Once the snout is tied shut, and the limbs are restrained, a burlap bag over the head to cover the eyes results in minimal stress during capture and handling in boats and on land. Once released, Gharials become alert and bound for the water.
- Recent fluctuations in temperature changes, sea-level rise, influx of salinity in fresh water, bioaccumulation of toxic pollutants in riverine water has resulted in dangerous decline in Gharial populations. Pollution and river damming is a big threat to these species.
- Radio tagging of Gharials help in tracking the movement of these species. GEP is doing commendable work in radio tracking of these threatened species. It has marginally helped in increase of populations and requires further developments.

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Capture of *Papilio polytes* Linnaeus, (Lepidoptera:Papilionidae) by orb-weaving spider *Parawixia dehaani* Doleschall, 1859 (Araneae: Araneidae): A new record from Gangajalghati, Bankura, West Bengal, India.

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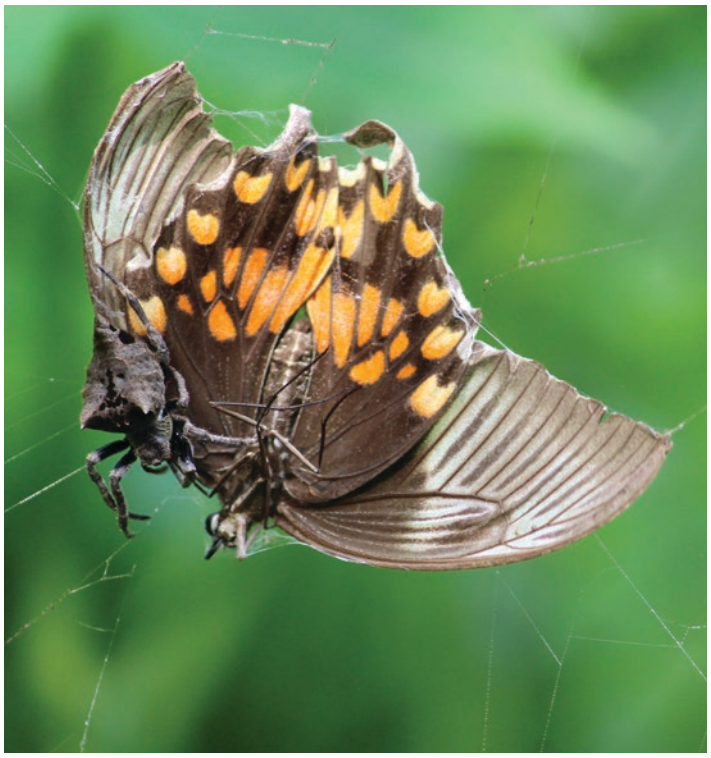
Introduction:

Spiders (Araneae) are one of the most abundant, important and diverse groups of terrestrial arthropods that inhabit both natural and agricultural habitats and play an important role as generalist predators in ecosystem (Cotes et al. 2018). A recent study has estimated that the annual prey kill of all the spiders of the earth ranges between 400–800 million metric tons and insects and collembolans make more than 90% of the total amount of prey captured (Nyffeler and Birkhofer 2017).

Parawixia dehaani (Doleschall 1859) belongs to the family Araneidae and is distributed in the Oriental-Australian region including Sri Lanka, India, Bangladesh, Philippines, Indonesia and New Guinea (Biswas and Raychaudhuri 2017; Wijerathna et al. 2017; Whyte and Anderson 2017, World Spider Catalog 2021). *Parawixia dehaani* is a nocturnal spider and builds a vertical orb web having an open hub with a damaged look (Whyte and Anderson 2017). Genus *Parawixia* has distinctive morphological features like dark marks between median and lateral eyes, paired dark spots on the carapace, paired light patches on the sternum and paired tubercles on the abdomen (Levi 1992).

A number of studies have reported the spider



from different states of India including Assam (Gupta et al. 2015; Saha et al. 2015) Sikkim, West Bengal (Tikader 1982, 1987), Odisha (Choudhury et al. 2019), Karnataka (Tikader 1982; Nijagal et al. 2020) Tamil Nadu (Caleb 2020), and Kerala (Rajeevan et al. 2019). In West Bengal a number of studies have reported the species from several districts of Northern and Southern part of the state viz Alipurduar (Ranade et al. 2015), Darjeeling (Saha et al. 2016), Jalpaiguri (Biswas and Biswas 1992; Sen et al. 2015; Roy et al. 2017), North 24-Parganas (Biswas and Biswas 1992), South 24 Parganas (Majumder 2007) and others. These spiders have been reported to wait away from the web in a special retreat, connected with the hub by a trap-line thread. They react immediately to web agitation caused by the trapped insects and attack the prey (Tikader 1987). The common Mormon (*Papilio polytes* Linnaeus 1758) is a butterfly that belongs to the family Papilionidae and is a common species of Bankura district in West Bengal (Nayak 2020b). The subspecies *Papilio polytes romulus* Cramer, [1775] exhibits female-limited Batesian mimicry in which this palatable form mimics *Pachliopta hector*, an unpalatable butterfly (Kunte et al. 2014). To date, however, there has been no published report of *Parawixia dehaani* and its predatory behaviour from any part of Bankura district. The present study recorded a complete photographic documentation of a common Mormon butterfly trapping by *Parawixia dehaani*.

Identification of Prey and Predator:

Both the species were identified based on the digital photographs taken with Canon EOS 1200D DSLR Camera with a 55–250mm lens. The prey was identified as a female common mormon butterfly (*Papilio polytes* Linnaeus 1758) and the subspecies as *Papilio polytes romulus* Cramer, [1775] based on physical features with the help of field guide and available literature (Kunte et al. 2014; Kehimkar 2016) (Figure 3.a & b). The predator was identified as *Parawixia dehaani* Doleschall 1859 based on morphological characters with the help of available literature (Tikader 1982; Biswas and Biswas 1992; Uniyal et al. 2011) (Figure 2.a to c). The spider is characterized by a reddish brown cephalothorax and dark brown abdomen, eight similar eyes, strong chelicerae, long and strong hairy legs. The cephalothorax is longer than its width with granular appearance, hairs and white pubescence. The triangular abdomen is much longer than its width having two pointed spine like shoulder humps and one pointed tail hump at the posterior end and covered with pubescence and hairs as described previously by Tikader (1982). The lateral eyes are spaced apart and mounted on prominent orange-coloured tubercles.

Observations:

The author spotted the event on 3rd October 2019 at 10.10h while making a butterfly survey at the

Gangajalgati village (23°25′12.0″ N 87°07′12.0″ E) under Gangajalghati community development block of Bankura district, West Bengal, India (Figure 1.). The study area is encircled by a number of small ponds and dominated by scrub vegetation with *Adhatoda vasica*, *Alocasia indica*, *Bambusa* sp., *Ipomoea carnea*, *Ricinus communis* e.t.c.

A female common mormon butterfly was visiting on a curry tree (*Murraya koenigii*) just before the incidence (Figure 3.a). The author followed its movement and while the butterfly was trying to move away, it got trapped in a spider web (Figure 3.b). The spider was absent on the web during the trapping of the butterfly (Figure 3.b) but rushed to the prey within a minute (Figure 3.c). The spider took only four minutes (10.14 A.M to10.18 A.M) to capture the butterfly, wrapping it completely with the sticky silk threads (Figure 3.c to t). The spider retained the trapped butterfly for two days (3rd and 4th October 2019) on the web and no significant damage of the prey was detected in that time period. The author could not find the butterfly in the morning of 5th October 2019.

Discussion:

Web-building spiders exhibit higher prey capture efficiency in comparison to the non-web builders (Vermeij 1982). The spiders of Araneidae family exhibit rich diversity and form one of the largest spider families with 3059 species in 177 genera worldwide (World Spider Catalog 2021). The members of the Araneidae are Orb-weaver spiders that build spiraling sticky wheel-shaped webs and are found in a wide variety of natural habitats including bushes, gardens, tree branches, fields and forest (Nyffeler et al. 1994). Prey capture in Orb-weavers typically consists a series of events including trapping the prey, stopping the flight of insect prey and then retaining the prey for enough time to be attended by the spider (Sensenig et al. 2012; Sensenig et al. 2013). The principal components of an orb web are outer frames and supporting radial spokes, made up of stiff major ampullate silk, capture spirals, made up of flagelliform silk and glue droplets that participate jointly in capturing the prey (Sensenig et al. 2013). Previous studies have reported that a spider web architecture is influenced by both genetically determined web-building behaviours and several environmental factors like prey, microhabitat e.t.c (Harmer et al. 2011; Krafft and Cookson 2012).

Parawixia dehaani is a carnivore and known to taste a variety of food items including beetles, flies, moths, mosquitoes, wasps, etc. Studies have observed that *Parawixia dehaani* and other *Parawixia* species can trap and ingest a number of vertebrates like frogs, lizards, bats, etc. (Ranade 2015; Nyffeler and Knörnschild 2013; Sena and Sole´2019).

Traditionally the spiders have been described as the predators of live and moving prey (Turnbull 1973; Nyffeler et al.1990). In the present study the prey (*Papilio polytes*) size was much larger than the spider. *Parawixia dehaani* is a large orb weaver and studies have reported that larger spider species construct webs with higher quality silk that exhibit improved performance with strain rate, caused by the flying heavier insect prey and therefore are adapted to capture larger and faster flying insect prey (Sensenig et al. 2013). After being trapped in the web, the prey is usually treated with biting or wrapping by the spider (Nyffeler et al. 1994). In the present study the spider might have bitten the butterfly with a paralysing venom as the victim did not show any struggle. The crude venom of *Parawixia bistriata* has been reported to exhibit insecticidal activities on mosquito larva (Gimenez et al. 2014). Studies have reported that Orb weaver spiders are generally ineffective in trapping lepidopterans (moths and butterflies) and these insects constitute a very low percentage of the prey of several temperate orb weavers (Nyffeler et al. 1994). Studies have demonstrated that some prey can escape the trapping by virtue of the loose scales present on their wings and bodies (Eisner et al. 1964).

Usually, smaller prey capture events are more frequent by the orb weaving spiders than the larger ones (Venner and Casas 2005). However, many orb weaving spiders secure greater nutritional benefits from the rare large prey than smaller prey organisms and previous studies on orb weaver ecology have shown that nature maximizes the spider fitness when the orb webs trap rare, but larger prey (Blackledge 2011; Eberhard 2013; Sensenig et al. 2013). The study by Venner and Casas (2005) has shown that rare larger prey size plays a crucial role in the development of an orb-weaving spider (*Zygiella x-notata*) and directly influences its reproduction and survival. The above-mentioned view of prey capture is also known as the ‘‘rare, large prey’’ hypothesis that possesses several challenges for understanding the spider orb web function and can’t be

simplified as a general rule for orb weavers (Blackledge 2011; Eberhard 2013).

Conclusion:

Despite a number of records of prey consumed by *Parawixia dehaani* from different parts of the state, none has so far described the foraging or behavioural ecology of the spider from South Bengal. The present study reports a complete photographic documentation of predation on an adult lepidopteran by *Parawixia dehaani* for the first-time from Bankura district, West Bengal.

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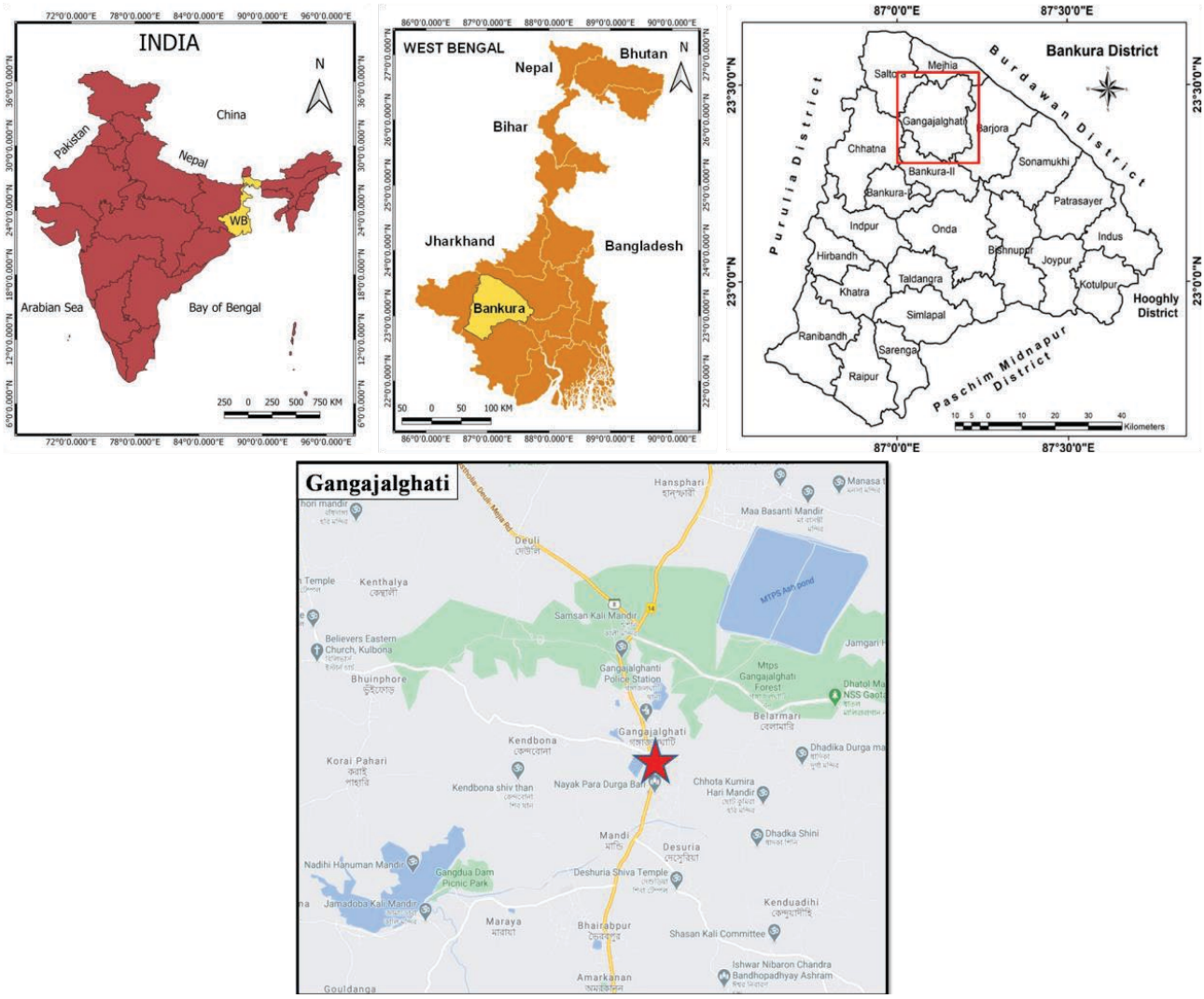

Figure 1. Geographical location of the study area: Gangajalghati village in Gangajalghati block of Bankura district, West Bengal, India. (Map data: Modified after Nayak, A. (2020a); Gangajalghati map: Google map 2021).

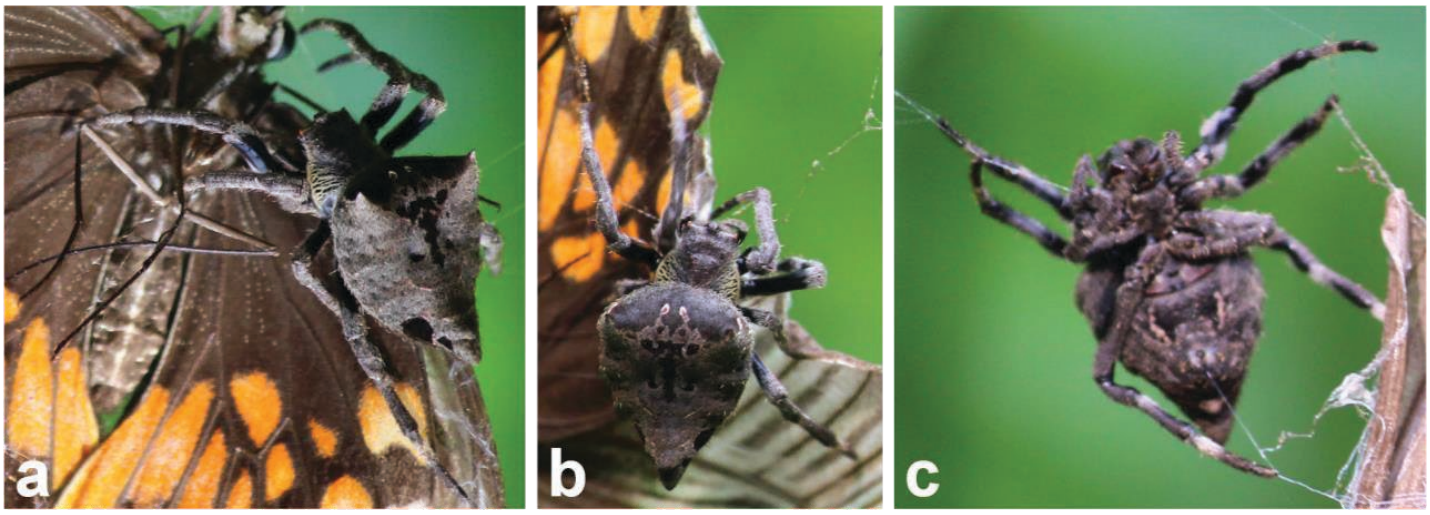

Figure 2. Dorsal (a & b) and Ventral view (c) of *Parawixia dehaani* Doleschall, 1859 photographed at Gangajalghati village of Bankura district.

Figure 3. Complete sequence of photographs (a – t) with time frames showing the wrapping of a common mormon (*Papilio polytes* Linnaeus, 1758) by the common garden spider (*Parawixia dehaani* Doleschall, 1859) documented on 3rd October, 2019 at Gangajalghati village of Bankura district.

Rare sighting of Peregrine Falcon *Falco peregrinus* at village Dalaj No.1, Indapur, Dist. Pune, Maharashtra, India.

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Citation: **Salunkhe Rajendra, Bhosale Sambhaji Rare sighting of Peregrine Falcon *Falco peregrinus* at village Dalaj No.1, Indapur, Dist. Pune, Maharashtra, India.**
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- Name of species: Peregrine Falcon
- Family: Falconidae
- Scientific name: *Falco peregrinus*
- Status: Least concern, IUCN 2019
- Date of sighting: 17th February 2020
- Time of sighting: 3.15 pm
- Weather: Sunny
- Number of times sighted: Single
- Gender of bird: Male
- Locality: Dalaj No.1, Tahsil Indapur, Dist. Pune, Maharashtra state, India
- Habitat description: Wetland of Bhima river
- Distance from human civilization: 3 km
- Any other bird/animal associates: Birds observed at the muddy wetland area were- *Phalacrocorax niger, Egretta alba, Ardea cineria, Threskiomis melanocephalus, Platalea leucorodia, Anas poecilorhyncha, Fulica atra, Charadrius hiaticula, Charadrius dubius, Charadrius alexandrines, Limosa limosa, Tringa glareola and Himantopus himantopus*
- Bird behavior: While boating in Bhima river a Peregrine Falcon was perched on a branch of dead tree in a water logged area.
- Threats to the habitat: Bird poaching.
- Previous records: No documented record of Peregrine Falcon from this locality.
- References:

1. Salim Ali (2002): The book of Indian birds. 13th edition:16 pp.

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