STUDIES ON INDIRECT EVIDENCES OF PRESENCE OF WILDLIFE FROM DIFFERENT NATIONAL PARKS OF DOOARS, WEST BENGAL, INDIA

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ABSTRACT: ***Observing wildlife at their natural habitat is practically a chance factor. However, there is alternative way by which it is possible to study the presence of wildlife and also their activities by indirect methods. North Bengal, especially Dooars is extreme rich in wildlife; therefore, there are many National Parks, Reserve forest as well as Wildlife Sanctuaries at this terrain. Studies on presence of wildlife by means of indirect evidences from different National Parks of Dooars reveals many untold stories. From this study it also evident that Dooars region is still harboring very good verities of wildlife, therefore, this is the demand of time to conserve these forests, as well as wildlife not only to save them from quick destruction but also to maintain human civilization.***

Key words: Jaldapara National Park, Gorumara National Park, Buxa National Park (Also Tiger Reserve), Species Diversity, Richness, Shannon index, Simpson index.

INTRODUCTION:

In India as well as at global level there are a good number of forests available for eco-tourism and a handsome amount of revenue is generated from visitors or tourists. Like other parts of the world, in India also such forests are distributed in many states throughout the country. Every such forest are varied in their own characteristics, local climatic conditions, floral distribution and wildlife distribution pattern; but one thing is common for all these, i.e., after visiting one such forests maximum tourists express their opinion or rather complaints that there are no such wildlife visible in the forest. This view is also supported by the content of the Figure

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No. 1. And this is the inspiration that this research project is undertaken. Indirect evidences of presence of wildlife plays a vital role in the forest's studies for both academic and tourism interests.

There is very little literature available on studies of indirect evidences of presence of wildlife at national as well as at international level. At national level, a survey on carnivores and prey at Kalesar National Park was studied by Sharma *et. al.,* in 2013; in 2008 Datta *et. al.,* studied on large carnivore and prey abundance at Namdapha National Park and in 2013 Manoj *et. al.,* studied on forest and wildlife scenarios of Northern West Bengal. At international level, in 2002 Little *et. al.,* studied on wildlife passages at USA and in 2010 Callaghan *et. al.,* studied on abundance of koala at Australia by studying indirect evidence of plants. Therefore, this present work is highly significant in its nature and demand of the time.

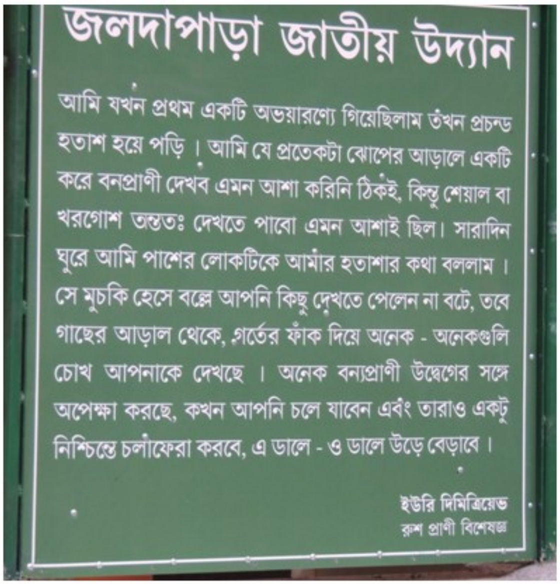


Fig.1: A wildlife related caption present at Jaldapara National Park (Quoted by Yuriy Dmitriev, A Russian Zoologist).

West Bengal is the fourth most populous state of India and is situated at the eastern region of the country. Out of its total geographical area, 13.38% comes under the recorded forest category compared to the national figure of 23.38%. Of the total forest area of West Bengal, 59.38%, 31.75% and 8.87% are categorized under reserved, protected and un-classed forests respectively. Furthermore, protected areas comprise 3.26% of its geographical area consisting of 14 Wildlife Sanctuaries and 6 National Parks. The state has two tiger reserves viz. Sundarbans and Buxa. Sundarbans (of Indian side) border the neighbouring country Bangladesh towards southeast while Buxa borders the mountainous country Bhutan in the north. Sundarbans has been declared a biosphere reserve which includes Sundarbans Tiger Reserve and Sundarbans National Park. In addition, two elephant reserves are also found in the state towards its northern and southern sides namely Eastern Dooars and Mayur Jharna respectively (Forest Survey of India, 2009). Encroachment of forests, loss of habitats, habitat degradation, and developmental activities like construction of roads and railway lines and increasing number of both human beings and wild animals, especially wild herbivores, are bringing human and wildlife in close proximity resulting in many human-wildlife conflicts in the state. For example, the state forest report of West Bengal details that during the years 2010-2011, 96 persons, 3 persons and 4 persons were killed by the wild elephants, leopards and gaurs respectively. In addition, 2 persons and 12 persons were also injured by the leopards and gaurs respectively. In the same period 2 elephants died to retaliatory killings and 19 met accidental death. One leopard and 4 gaurs were also reported to die due to accidents during 2010 - 2011 assessment years (State Forest Report, 2010-2011). Sometimes it is not possible to study wild animals directly, therefore, in this present study we are trying to study the presence of wildlife based on indirect evidences like pug mark, foot print, feeding signs, trails and tunnels, rub mark and scat (poop).

Forests and protected areas of North Bengal:

The northern part of West Bengal includes three districts viz. Jalpaiguri, Darjeeling and Cooch Behar. Current status of the forest areas in these three districts is presented in Table-1. Jalpaiguri has the largest geographical area of 6,227 sq. km followed by Cooch Behar (3,387 sq.

TABLE No. 1: Current Status of forest areas in three districts of northern West Bengal

Fores Areas (All areas in km^2)	Districts			All over West Bengal	All over India
	Jalpaiguri	Darjeeling	Coachbehar		
Geographical area	6,227	3,149	3,387	88,752	3,287,240
Reserved forests	1,483	1,115		7,054	423,311
Protected forests	217		42	3,772	217,245
Un-classed state forests and others	90	89	15	1,053	127,881
Total recorded forest area	1,790	1,204	57	11,879	768,437
Recorded forest area in %	28.75	38.23	1.68	13.38	23.38

km) and Darjeeling (3,149 sq. km). Recorded forest areas, however, do not follow this trend as Cooch Behar has the least area under forest, being just 57 sq. km, which in percentage comes out to be miniscule 1.68% of the geographical area of the district. Moreover, although Jalpaiguri has more recorded forest area (1,790 sq. km) than Darjeeling (1,204 sq. km) in terms of their respective geographical areas, district

Darjeeling is more forested (38.23%) as compared to Jalpaiguri (28.75%). More distinctively the data show that although Jalpaiguri is almost double the size of

TABLE No. 2: Protected Areas of North Bengal			
Protected areas	**Area (km²)**	**Bio-geographic zone**	**District**
Wildlife sanctuaries (WLS)			
Buxa WLS	**267.92**	**7B**	**Jalpaiguri**
Chapramari WLS	**9.60**	**7B**	**Jalpaiguri**
Jorepokhri Salamander WLS	**0.04**	**2C**	**Darjeeling**
Mahananda WLS	**158.04**	**7B**	**Darjeeling**
Senchal WLS	**38.88**	**2C**	**Darjeeling**
National parks (NP)			
Jaldapara NP	**216.51**	**7B**	**Jalpaiguri and Coochbehar**
Buxa NP	**117.10**	**7B**	**Jalpaiguri**
Gorumara NP	**79.45**	**7B**	**Jalpaiguri**
Neora Valley NP	**88.00**	**2C**	**Darjeeling**
Singalia NP	**78.60**	**2C**	**Darjeeling**
Reserve Forests			
Buxa Tiger Reserve	**Core area: 977.51 Buffer area: 370.29**	**7B**	**Jalpaiguri**
Eastern Dooars Elephant Reserve	**Core area: 484 Buffer area: 493.51**	**7B**	**Jalpaiguri**

Darjeeling it lags behind the former by about 10 percentage points in terms of recorded forests. More disturbing scenario is observed for the Cooch Behar district, which is almost similar in size to Darjeeling but lags way behind in terms of the area under forest. The Buxa forest region is situated around 180 km from the Siliguri town and is known for tiger, leopard, elephant, clouded leopard, Himalayan black bear, gaur, pangolin and python. The forest can be further categorised into Buxa National Park, Buxa Wildlife Sanctuary and the Buxa Tiger Reserve. It shares the boundary with the Phipsu Wildlife Sanctuary of the neighbouring country Bhutan and thus serves as an international migratory tract and corridor for the elephants between Manas National Park (Assam, India) and the forests of Bhutan. Chapramari forest, in Kalimpong subdivision of the Jalpaiguri district, is located on the banks of river Murti and close to the National Highway 31, which connects the northeast region with the rest of India. Chapramari Wildlife Sanctuary is distinctively known for its elephant population. Jaldapara National Park, in Alipurdwar subdivision of Jalpaiguri district, is situated about 121 km for Siliguri and is home to a great diversity of flora and fauna. It is home to the great Indian on horned rhinos. Chilapata forest, which forms an important elephant corridor between Buxa Tiger Reserve and Jaldapara National

Park, is spread near Jaldapara in the Dooars. Located about 72 km from Siliguri and further to the north of Jaldapara is Gorumara National Park. It has similar fauna to Jaldapara National Park with leopards and elephants too. Towards western parts of the Dooars in the Tarai region and between the Teesta river to the east and the Mahayana river to the west is spread Baikunthapur forest. The forest area is spread over both the Jalpaiguri and Darjeeling districts. Mahananda Wildlife Sanctuary also comes under Darjeeling Wildlife Division2, 6. A brief description of National Parks and Wildlife Sanctuaries is given in Table-2. Here forest data of entire North Bengal is given, however, our study area is only confined to National Parks of the Dooars / Duars region only (Fig.: 2 & 3).

Fig. 2: Location map of Gorumara N P and Jaldapara N P. **Fig. 3:** Location map of Buxa Tiger Reserve as wel as National Park (N P)

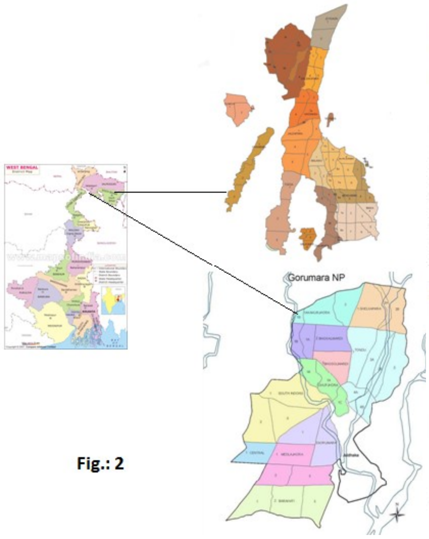


Fig.: 2

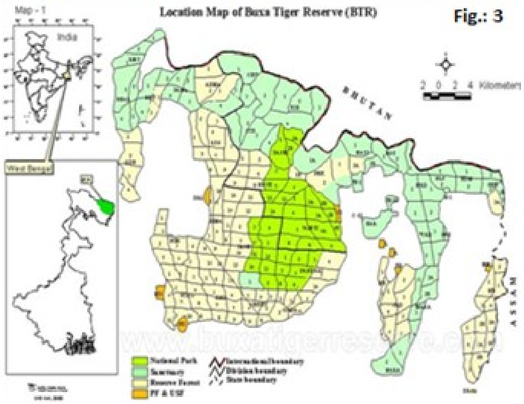


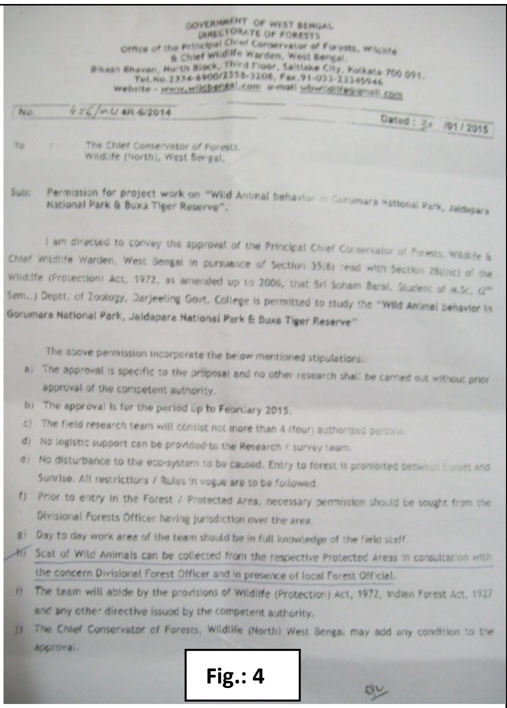
Fig.: 3

MATERIALS AND METHODS:

This entire study is strictly based upon observation and in possible cases collection. We studied the presence of indirect evidences of wildlife at three National Parks *viz.* Jaldapara, Gorumara and Buxa (Also Tiger Reserve) for one year duration from September, 2014 to August, 2015 with appropriate permission of the authorities (Fig.: 4 & 5).

During this one year study period we visited those mentioned places at least twice in a month and all the data are noted with finer details and record also maintained chronologically.

In every possible case photography has been done with Canon 60 E digital camera. During this study we also collect the pug marks by using plaster of Paris in the presence of Staff of the Forest Department (Fig.: 6, 7, 8 & 9). We also collected both dry and fresh scat, also called poop absolutely in the presence of Forest Staff for future use (Fig.: 10, 11, 12 & 13). At all the location of evidence collection we recorded the location points by using GPS device.



GOVERNMENT OF WEST BENGAL
DIRECTORATE OF FORESTS
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No. 456/WL/4R-6/2014 Dated : 30 /01 / 2015

To : The Chief Conservator of Forests, Wildlife (North), West Bengal.

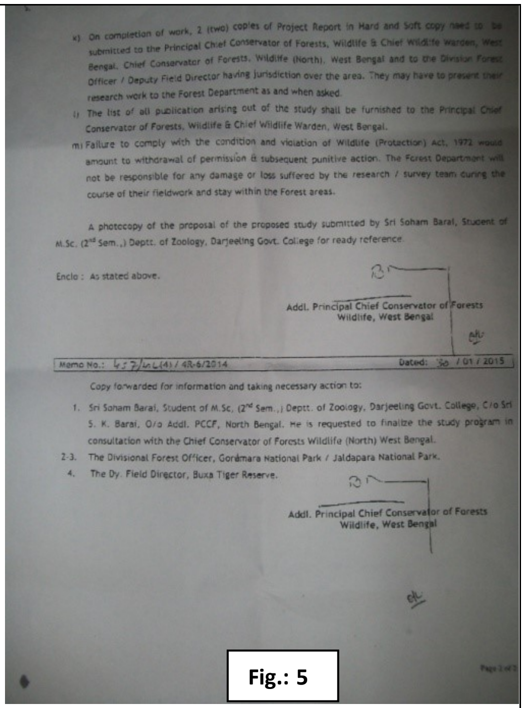
Sub: Permission for project work on "Wild Animal behavior in Gorumara National Park, Jaldapara National Park & Buxa Tiger Reserve".

I am directed to convey the approval of the Principal Chief Conservator of Forests, Wildlife & Chief Wildlife Warden, West Bengal in pursuance of Section 35(8) read with Section 28(1)(c) of the Wildlife (Protection) Act, 1972, as amended up to 2006, that Sri Soham Baral, Student of M.Sc. (2nd Sem.,) Deptt. of Zoology, Darjeeling Govt. College is permitted to study the "Wild Animal behavior in Gorumara National Park, Jaldapara National Park & Buxa Tiger Reserve"

The above permission incorporate the below mentioned stipulations:

a) The approval is specific to the proposal and no other research shall be carried out without prior approval of the competent authority.
b) The approval is for the period up to February 2015.
c) The field research team will consist not more than 4 (four) authorized persons.
d) No logistic support can be provided to the Research / survey team.
e) No disturbance to the eco-system to be caused. Entry to forest is prohibited between Sunset and Sunrise. All restrictions / Rules in vogue are to be followed.
f) Prior to entry in the Forest / Protected Area, necessary permission should be sought from the Divisional Forests Officer having jurisdiction over the area.
g) Day to day work area of the team should be in full knowledge of the field staff.
h) Scat of Wild Animals can be collected from the respective Protected Areas in consultation with the concern Divisional Forest Officer and in presence of local Forest Official.
i) The team will abide by the provisions of Wildlife (Protection) Act, 1972, Indian Forest Act, 1927 and any other directive issued by the competent authority.
j) The Chief Conservator of Forests, Wildlife (North) West Bengal may add any condition to the approval.

Fig.: 4



k) On completion of work, 2 (two) copies of Project Report in Hard and Soft copy need to be submitted to the Principal Chief Conservator of Forests, Wildlife & Chief Wildlife Warden, West Bengal, Chief Conservator of Forests, Wildlife (North), West Bengal and to the Division Forest Officer / Deputy Field Director having jurisdiction over the area. They may have to present their research work to the Forest Department as and when asked.
l) The list of all publication arising out of the study shall be furnished to the Principal Chief Conservator of Forests, Wildlife & Chief Wildlife Warden, West Bengal.
m) Failure to comply with the condition and violation of Wildlife (Protection) Act, 1972 would amount to withdrawal of permission & subsequent punitive action. The Forest Department will not be responsible for any damage or loss suffered by the research / survey team during the course of their fieldwork and stay within the Forest areas.

A photocopy of the proposal of the proposed study submitted by Sri Soham Baral, Student of M.Sc. (2nd Sem.,) Deptt. of Zoology, Darjeeling Govt. College for ready reference.

Enclo : As stated above.

Addl. Principal Chief Conservator of Forests
Wildlife, West Bengal

Memo No.: 457/WL(4)/ 4R-6/2014 Dated: 30 / 01 / 2015

Copy forwarded for information and taking necessary action to:

1. Sri Soham Baral, Student of M.Sc. (2nd Sem.,) Deptt. of Zoology, Darjeeling Govt. College, C/o Sri S. K. Baral, O/o Addl. PCCF, North Bengal. He is requested to finalize the study program in consultation with the Chief Conservator of Forests Wildlife (North) West Bengal.
2-3. The Divisional Forest Officer, Gorumara National Park / Jaldapara National Park.
4. The Dy. Field Director, Buxa Tiger Reserve.

Addl. Principal Chief Conservator of Forests
Wildlife, West Bengal

Fig.: 5

Fig. 4 & 5: Permission letter from Additional Principal Chief Conservator of Forests Wildlife, W.B.

For collection of evidences we follow the path in the jungle showed by the Staff of the Forest Department (Fig.: 14 & 15). In some cases we went beside the pond/ pool/ lake/ river etc. water resources within the forest in search of presence of evidences of wildlife with proper permission from the authorities (Fig.: 16, 17 & 18).

For quantitative analysis of data we use one computer programme, known as "Past". By using this programme we analyze different parameters like, Dominance; Diversity index, Richness, Shannon index, Simpson index etc. The details of different parameters are as below:

Dominance:

Ecological dominance is the degree to which a taxon is more numerous than its competitors in an ecological community, or makes up more of the biomass. Most ecological communities are defined by their dominant species.


Fig.: 6


Fig.: 7


Fig.: 8

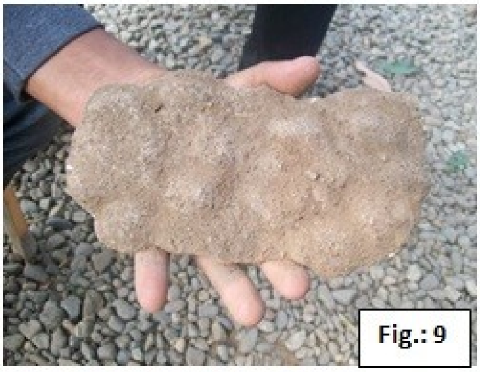


Fig.: 9

Fig.: 6, 7, 8 & 9: Different steps of collection of pug mark (of Leopard).


Fig.: 10


Fig.: 11


Fig.: 12


Fig.: 13

Fig.: 10, 11, 12 & 13: Collection of scat of rhino, elephant, leopard and sambar.

Fig. 14 & 15: Venture in the forest in search of presence of wildlife evidences.

Fig. 16 & 17: Visit beside water body within the forest in search of presence of wildlife evidence.

Fig. 18: Showing location of different forests at Dooars. Our study sites are marked with circles.

DIVERSITY INDEX:

A diversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant.

When diversity indices are used in ecology, the types of interest are usually species, but they can also be other categories, such as genera, families, functional types or haplo types. The entities of interest are usually individual plants or animals, and the measure of abundance can be, for example, number of individuals, biomass or coverage. In demography, the entities of interest can be people, and the types of interest various demographic groups. In information science, the entities can be characters and the types the different letters of the alphabet. The most commonly used diversity indices are simple transformations of the effective number of types (also known as 'true diversity'), but each diversity index can also be interpreted in its own right as a measure corresponding to some real phenomenon (but a different one for each diversity index). [Hill, 1973; Jost, 2006; Tuomisto, 2010a and Tuomisto, 2010b].

True diversity, or the effective number of types, refers to the number of equally abundant types needed for the average proportional abundance of the types to equal that observed in the dataset of interest (where all types may not be equally abundant). The true diversity in a dataset is calculated by first taking the weighted generalized mean Mq−1of the proportional abundances of the types in the dataset, and then taking the reciprocal of this. The equation is [Tuomisto, 2010a and Tuomisto, 2010b]:

$$^{q}D = \frac{1}{M_{q-1}} = \frac{1}{\sqrt[q-1]{\sum_{i=1}^{R} p_i p_i^{q-1}}} = \left(\sum_{i=1}^{R} p_i^q\right)^{1/(1-q)}$$

The denominator M_{q-1} equals the average proportional abundance of the types in the dataset as calculated with the weighted generalized mean with exponent q-1. In the equation, R is richness (the total number of types in the dataset), and the proportional abundance of the ith type is pi. The proportional abundances themselves are used as the nominal weights. When q = 1, the above equation is undefined. However, the mathematical limit as q approaches 1 is well defined and the corresponding diversity is calculated with the following equation:

$$^{1}D = \frac{1}{\prod_{i=1}^{R} p_i^{p_i}} = \exp\left(-\sum_{i=1}^{R} p_i \ln(p_i)\right)$$

which is the exponential of the Shannon entropy calculated with natural logarithms (see below).

The value of q is often referred to as the order of the diversity. It defines the sensitivity of the diversity value to rare vs. abundant species by modifying how the weighted mean of the species proportional abundances is calculated. With some values of the parameter q, the value of M_{q-1} assumes familiar kinds of weighted mean as special cases. In particular, q = 0 corresponds to the weighted harmonic mean, q = 1 to the weighted geometric mean and q = 2 to the weighted arithmetic mean. As q approaches infinity, the weighted generalized mean with exponent q−1 approaches the maximum p_i value, which is the proportional abundance of the most abundant species in the dataset. Generally, increasing the value of q increases the effective weight given to the most abundant species. This leads to obtaining a larger M_{q-1} value and a smaller true diversity (^qD) value with increasing q.

When q = 1, the weighted geometric mean of the p_i values is used, and each species is exactly weighted by its proportional abundance (in the weighted geometric mean, the weights are the exponents). When q > 1, the weight given to abundant species is exaggerated, and when q < 1, the weight given to rare species is. At q = 0, the species weights exactly cancel out the species proportional abundances, such that the weighted mean of the p_i values equals 1 / R even when all species are not equally abundant. At q = 0, the effective number of species, ^0D, hence equals the actual number of species R. In the context of diversity, q is generally limited to non-negative values. This is because negative values of q would give rare species so much more weight than abundant ones that ^qD would exceed R [Tuomisto, 2010a and Tuomisto, 2010b].

The general equation of diversity is often written in the form [Hill, 1973 and Jost, 2006]:

$$^qD = \left(\sum_{i=1}^{R} p_i^q \right)^{1/(1-q)}$$

and the term inside the parentheses is called the basic sum. Some popular diversity indices correspond to the basic sum as calculated with different values of q [Jost, 2006].

Richness:

Richness *R* simply quantifies how many different types the dataset of interest contains. For example, species richness (usually notated *S*) of a dataset is the number of different species in the corresponding species list. Richness is a simple measure, so it has been a popular diversity index in ecology, where abundance data are often not available for the datasets of interest. Because richness does not take the abundances of the types into account, it is not the same thing as diversity, which does take abundances into account. However, if true diversity is calculated with q = 0, the effective number of types (^0D) equals the actual number of types (R) [Jost, 2006 and Tuomisto, 2010b].

Shannon Index:

The Shannon index has been a popular diversity index in the ecological literature, where it is also known as Shannon's diversity index, the Shannon–Wiener index, the Shannon–Weaver index and the Shannon entropy. The measure was originally proposed by Claude Shannon to quantify the entropy (uncertainty or information content) in strings of text [Shannon and Weaver, 1948]. The idea is that the more different letters there are, and the more equal their proportional abundances in the string of interest, the more difficult it is to correctly predict which letter will be the next one in the string. The Shannon entropy quantifies the uncertainty (entropy or degree of surprise) associated with this prediction. It is most often calculated as follows:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

where p_i is the proportion of characters belonging to the ith type of letter in the string of interest. In ecology, p_i is often the proportion of individuals belonging to the ith species in the dataset of interest. Then the Shannon entropy quantifies the uncertainty in predicting the species identity of an individual that is taken at random from the dataset.

Although the equation is here written with natural logarithms, the base of the logarithm used when calculating the Shannon entropy can be chosen freely. Shannon himself discussed logarithm bases 2, 10 and e, and these have since become the most popular bases in applications that use the Shannon entropy. Each log base corresponds to a different measurement unit, which have been called binary digits (bits), decimal digits (decits) and natural digits (nats) for the bases 2, 10 and e, respectively. Comparing Shannon entropy values that were originally calculated with different log bases requires converting them to the same log base: change from the base a to base b is obtained with multiplication by $\log_b a$ [Shannon and Weaver, 1948].

It has been shown that the Shannon index is based on the weighted geometric mean of the proportional abundances of the types, and that it equals the logarithm of true diversity as calculated with q = 1 [Tuomisto, 2010a]:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i = -\sum_{i=1}^{R} \ln p_i^{p_i}$$

This can also be written:

$$H' = -(\ln p_1^{p1} + \ln p_2^{p2} + \ln p_3^{p3} + \cdots + \ln p_R^{pR})$$

which equals:

$$H' = -\ln p_1^{p1} p_2^{p2} p_3^{p3} \cdots p_R^{pR} = \ln\left(\frac{1}{p_1^{p1} p_2^{p2} p_3^{p3} \cdots p_R^{pR}}\right) = \ln\left(\frac{1}{\prod_{i=1}^{R} p_i^{p_i}}\right)$$

Since the sum of the p_i values equals unity by definition, the denominator equals the weighted geometric mean of the p_i values, with the p_i values themselves being used as the weights (exponents in the equation). The term within the parentheses hence equals true diversity ^1D, and H' equals $\ln(^1D)$ [Hill, 1973; Tuomisto, 2010a and Tuomisto, 2010b].

When all types in the dataset of interest are equally common, all p_i values equal 1 / R, and the Shannon index hence takes the value $\ln(R)$. The more unequal the abundances of the types, the larger the weighted geometric mean of the p_i values, and the smaller the corresponding Shannon entropy. If practically all abundance is concentrated to one type, and the other types are very rare (even if there are many of them), Shannon entropy approaches zero. When there is only one type in the dataset, Shannon entropy exactly equals zero (there is no uncertainty in predicting the type of the next randomly chosen entity).

Simpson Index:

The Simpson index was introduced in 1949 by Edward H. Simpson to measure the degree of concentration when individuals are classified into types [Simpson, 1949]. The same index was rediscovered by Orris C. Herfindahl in 1950 [Herfindahl, 1950]. The square root of the index had already been introduced in 1945 by the economist Albert O. Hirschman [Hirschman, 1945]. As a result, the same measure is usually known as the Simpson index in ecology, and as the Herfindahl index or the Herfindahl–Hirschman index (HHI) in economics.

The measure equals the probability that two entities taken at random from the dataset of interest represent the same type [Simpson, 1949]. It equals:

$$\lambda = \sum_{i=1}^{R} p_i^2$$

This also equals the weighted arithmetic mean of the proportional abundances p_i of the types of interest, with the proportional abundances themselves being used as the weights [Hill, 1973]. Proportional abundances are by definition constrained to values between zero and unity, but their weighted arithmetic mean, and hence $\lambda \geq 1/R$, which is reached when all types are equally abundant.

By comparing the equation used to calculate λ with the equations used to calculate true diversity, it can be seen that 1/λ equals ^2D, i.e. true diversity as calculated with q = 2. The original Simpson's index hence equals the corresponding basic sum [Jost, 2006].

The interpretation of λ as the probability that two entities taken at random from the dataset of interest represent the same type assumes that the first entity is replaced to the dataset before taking the second entity. If the dataset is very large, sampling without replacement gives approximately the same result, but in small datasets the difference can be substantial. If the dataset is small, and sampling without replacement is assumed, the probability of obtaining the same type with both random draws is:

$$l = \frac{\sum_{i=1}^{R} n_i(n_i - 1)}{N(N-1)}$$

where n_i is the number of entities belonging to the ith type and N is the total number of entities in the dataset [Simpson, 1949]. This form of the Simpson index is also known as the Hunter–Gaston index in microbiology [Hunter and Gaston, 1988].

Since mean proportional abundance of the types increases with decreasing number of types and increasing abundance of the most abundant type, λ obtains small values in datasets of high diversity and large values in datasets of low diversity. This is counterintuitive behavior for a diversity index, so often such transformations of λ that increase with increasing diversity have been used instead. The most popular of such indices have been the inverse Simpson index (1/λ) and the Gini–Simpson index (1 − λ) [Hill, 1973 and Jost, 2006]. Both of these have also been called the Simpson index in the ecological literature, so care is needed to avoid accidentally comparing the different indices as if they were the same.

Berger – Parker Index:

The Berger–Parker [Berger and Parker, 1970] index equals the maximum p_i value in the dataset, i.e. the proportional abundance of the most abundant type. This corresponds to the weighted generalized mean of the p_i values when q approaches infinity, and hence equals the inverse of true diversity of order infinity ($1/{}^{\infty}D$).

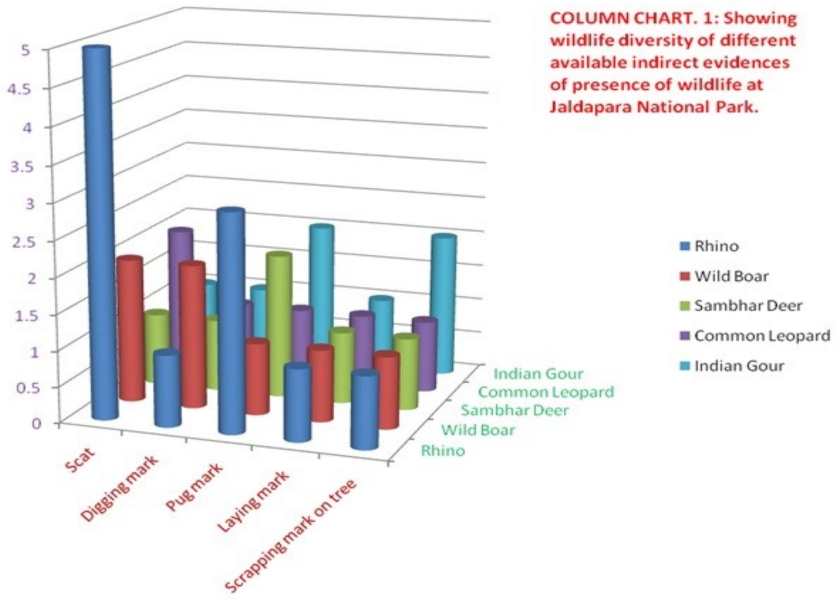
RESULT S AND OBSERVATIONS:

Data of different indirect evidences like scat, digging mark, pug mark, laying mark and scrapping mark on tree etc. of different animals were obtained from Jaldapara

National Park which are showing at Table No. 3 and this table also shows different quantitative values which are generated by using "Past" programming.

TABLE No. 3 : AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT JALDAPARA NATIONAL PARK (Forest Area: 216.51 KM^2 / Survey Area: 16 KM)					
Name of the Animal	**Scat**	**Digging mark**	**Pug mark**	**Laying mark**	**Scrapping mark on tree**
Rhino	5	1	3	1	1
Wild Boar	2	2	1	1	1
Sambhar Deer	1	1	2	1	1
Common Leopard	2	1	1	1	1
Indian Gour	1	1	2	1	2
DIFFERENT INDEXES (Generated by PAST)					
0	**A**	**B**	**C**	**D**	**E**
Taxa_S	5	5	5	5	5
Individuals	11	6	9	5	6
Dominance_D	0.2893	0.2222	0.2346	0.2	0.2222
Shannon_H	1.414	1.561	1.523	1.609	1.561
Simpson_1-D	0.7107	0.7778	0.7654	0.8	0.7778
Berger-Parker	0.4545	0.3333	0.3333	0.2	0.3333

Cylinder Column Chart: 1 also showing the pattern of distribution of indirect evidences and richness of wildlife at the Jaldapara National Park. By comparing the obtained data from Table No.: 3 and Chart: 1 this is found that *Rhinoceros unicornis* (rhino) is the most dominant wildlife at Jaldapara National Park, whereas, least dominance is found in case of common leopard, *Panthera pardus* and Sambhar Deer (*Cervus unicolor*). During our studies we obtained scat as



COLUMN CHART. 1: Showing wildlife diversity of different available indirect evidences of presence of wildlife at Jaldapara National Park.

maximum samples as indirect evidence with dominance value of 0.2893, the Shannon index is 1.414, Simpson index is 0.7107 and the Berger-Parker index is 0.4545. Minimum samples obtained as indirect evidences were found to be laying mark. A total five number of taxa were found including *Rhinoceros unicornis* (Indian One-horned Rhino), *Sus scrofa* (Wild Boar), *Cervus unicolor* (Sambhar Deer), *Panthera pardus* (Common Leopard) and *Bison bison* (Indian Gour).

During our studies at the Gorumara National Park, this is found that Indian Gour or *Bison bison* and Common Leopard, *Panthera pardus* are the dominant wildlife of this forest. Maximum samples obtained as indirect evidences were found to be scat, followed by pug marks with dominance value of 0.1289 and 0.1243, the Shannon index of 2.119 and 2.138, Simpson index of 0.8711 and 0.8757 and the Berger-Parker index of 0.2 and 0.1538 respectively (See Table No. 4). The Gorumara National Park is very rich in its biodiversity and during our study we found presence of indirect evidences of nine species, *viz. Bison bison,* Indian Gour; *Sus scrofa,* Wild

TABLE No. 4 : AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT GORUMARA NATIONAL PARK (Forest Area: 79.45 KM^2 / Survey Area: 16 KM)					
Name of the Animal	Scat	Digging mark	Pug mark	Laying mark	Scrapping mark on tree
Indian Gour	1	1	2	2	1
Wild Boar	1	2	1	1	1
Common Monkey	3	1	1	1	1
Sambhar Deer	2	1	1	1	1
Indian Elephant	1	1	2	1	1
Leopard Cat	2	1	1	1	1
Common Leopard	2	1	2	1	1
Little Egret	2	1	1	1	1
Indian Peacock	1	1	2	1	1
DIFFERENT INDEXES (Generated by PAST)					
0	A	B	C	D	E
Taxa_S	9	9	9	9	9
Individuals	15	10	13	10	9
Dominance_D	0.1289	0.12	0.1243	0.12	0.1111
Shannon_H	2.119	2.164	2.138	2.164	2.197
Simpson_1-D	0.8711	0.88	0.8757	0.88	0.8889
Berger-Parker	0.2	0.2	0.1538	0.2	0.1111

boar; *Macaca sp.,* Common Monkey; *Cervus unicolor,* Sambhar Deer; *Elephas maximus indicus,* Indian Elephant; *Felis bengalensis,* Leopard Cat; *Panthera pardus,* Common Leopard; *Egretta garzetta,* Little Egret; and *Pavo cristatus,* Indian Peacock. The abundance and distribution of presence of indirect evidences of different wildlife can also be observed at Cylinder Column Chart: 2.

Buxa Tiger Reserve is also an important National Park at Dooars. Here at Buxa, we found Common Leopard, *Panthera pardus* as the dominant wildlife (See Table No. 5). Beside *Panthera pardus* we also found here *Pavo cristatus,* Indian Peacock; *Bison bison,* Indian Gour; *Elephas maximus indicus,* Indian Elephant; *Macaca sp.,* Common Monkey; and most interestingly presence of *Cuon alpines,* Wild Dog.

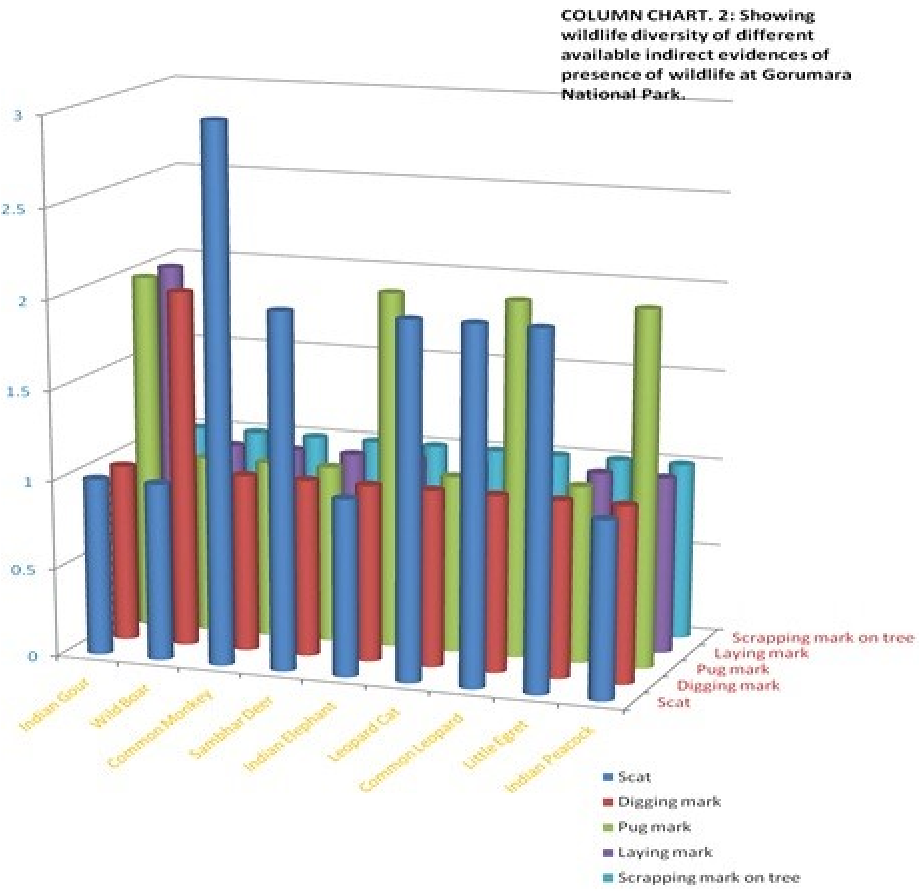
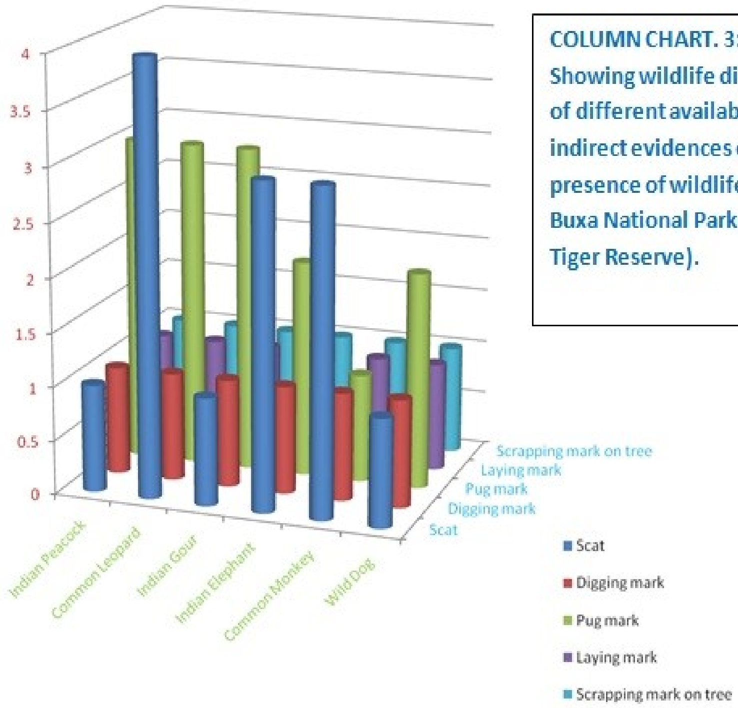


Table No. 5 showing the abundance and distribution of presence of various indirect evidences of wildlife at Buxa Tiger Reserve or Buxa National Park. Here as indirect evidence we obtained pug marks at maximum cases, followed by scat with dominance value of 0.1837 and 0.2189, the Shannon index of 1.735 and 1.631, Simpson index of 0.8163 and 0.7811 and the Berger-Parker index of 0.2143 and 0.3077 respectively. Digging mark, laying mark and scraping mark on tree are found least in number. Furthermore, among the scat we found maximum scat of common leopard of which one sample is very interesting, because we discovered undigested intact bony parts within that scat (Fig. No. 12). By analyzing the skeletal architecture it was very easy to estimate regarding the nature of prey. The abundance and distribution pattern of presence of indirect evidences of different wildlife at Buxa National Park can also be observed at Cylinder Column Chart: 3.

TABLE No. 5 : AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT BUXA TIGER RESERVE / NATIONAL PARK (Forest Area: 117.10 KM^2 / Survey Area: 16 KM)

Name of the Animal	Scat	Digging mark	Pug mark	Laying mark	Scrapping mark on tree
Indian Peacock	1	1	3	1	1
Common Leopard	4	1	3	1	1
Indian Gour	1	1	3	1	1
Indian Elephant	3	1	2	1	1
Common Monkey	3	1	1	1	1
Wild Dog	1	1	2	1	1
DIFFERENT INDEXES (Generated by PAST)					
0	A	B	C	D	E
Taxa_S	6	6	6	6	6
Individuals	13	6	14	6	6
Dominance_D	0.2189	0.1667	0.1837	0.1667	0.1667
Shannon_H	1.631	1.792	1.735	1.792	1.792
Simpson_1-D	0.7811	0.8333	0.8163	0.8333	0.8333
Berger-Parker	0.3077	0.1667	0.2143	0.1667	0.1667



COLUMN CHART. 3: Showing wildlife diversity of different available indirect evidences of presence of wildlife at Buxa National Park (Also Tiger Reserve).

DISCUSSION AND CONCLUSION:

Beside natural reasons, there is no doubt that anthropogenic disturbances are the major causes of biodiversity loss, and Dooars is not an exception. The geographical position of various forests of Dooars is very crucial. At all direction of Dooars there is either international border line or international border is very close to them, therefore, poaching is the main obstruction for wildlife survival at this regions, because there is a high demand of rhino horn; claws, bones and furs of various wildlife at China and other countries and this is evident from daily news paper report. Another important anthropogenic problem is the presence of Railway track at some parts of forests at Dooars; hence, heavy casualties of wildlife are occurred regularly.

During this one year studies on presence of indirect evidences of wildlife at different National Parks of Dooars this is found that beside the above mentioned anthropogenic disturbances biodiversity of these National Parks are very rich. By analyzing the indirect evidences we found presence of many types of wildlife at Jaldapara, Gorumara and Buxa National Parks. As evidences we obtained scat, pug mark, laying mark, digging mark and scratching marks on tree at different places of the different forests which suggests indirectly presence of a rich biodiversity. However, there may be some question arise regarding the independentness of scat or pug mark or other evidences that - are those evidences belonging to different wildlife or same individual? During our studies there is no such scope to analyze each and every sample evidences at molecular level; therefore, we depended upon the forest personnel and their experiences. Moreover, there is very little literature available on studies of presence of indirect evidences of wildlife; therefore, making any concluding comment might be an exaggeration. However, whatever data we obtained during our studies, from these this is evident that till date the National Parks of Dooars supporting a very rich wildlife.

ACKNOWLEDGEMENTS:

Authors express their gratitude to the Chief Conservator of Forests, Government of West Bengal and all the other forest personnel for their immense unconditional help, support and co-operation during our study. Authors are thankfully acknowledging the Director of Public Instructions, Government of West Bengal for his financial assistance. We also grateful to Dr. Projjal Chandra Lama, Officer-in-Charge, Darjeeling Government College and Dr. Achinta Pal, Officer-in-Charge, Durgapur Government College for their keen interest in our study.

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