FUNDAMENTALS OF BIODIVERSITY

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Message

Biodiversity is a term applied for all living creatures that perform functions in the environment. It is the variability of species or genes or ecosystem for all tiny creatures to big animals and plants. Diversity of biotic organisms is therefore regarded as biodiversity. Uses of biodiversity elements are versatile as it covers various aspects of our use pattern depending upon various geographical habitats. So, the basic question is, "What are the fundamentals of biodiversity"?. Its pattern and ordination over time too is also another aspect. Authors deal with this to produce a fine tune of diverse write up to make the book complete. I personally convey my sincere thanks and gratitude to all the authors and editors as well as well wishers who have made contributions to make such a beautiful book for us. Again I convey my love and affections to the entire team of the publisher to make such a wonderful book.

Thanks,

Debjani Basu

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Foreword

I feel immense pleasure that the Book 'Fundamentals of Biodiversity' has been written by many authors from varied angles though its integrity is very compact. Authors have presented their articles in a lucid manner both for research and review articles. Editors of the Book have made their contributions to tap or hold the arrangement of articles sequentially even if they amplify the quality of the books best for all kinds of researchers and readers. Publishers make the design and arrangement of pages in a very fine manner and in a good orientation. I convey my best wishes to all authors, beloved technicians, staff members of the publisher and editors to make the book special for all diverse readers.

Thanks,

C.Bhattacharya

Prof. (Dr.) Chandan Bhattacharya

Professor, Department of Genetics and Plant Breeding,

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Preface

Biodiversity is a term for all biota in a versatile manner. It broadcasts the variations of all biota. The level of its diversity reflects in a wide range i.e. species, genus and ecosystem. So, the components of biodiversity are all species but within species variation of genes also act as diverse components. Some broad aspects in biodiversity are habitats in which variations take place. So, habitats and or ecosystems are also biodiversity. In a nutshell the variation of organisms in different levels i.e. from gene to species to ecosystem is biodiversity. Biodiversity falls under the category of plants so called Phyto-diversity, if it is under the category of animals is called Zoo-diversity, but smaller microorganisms also under species diversity. Genetic variations within species and species variations within ecosystem are also called biodiversity. In this book authors are trying to make complete the articles in which research and extension work have been placed in a sequenced manner. It's all valued for fundamentals of Biodiversity.

Editors,

Fundamentals of Biodiversity

Place: Lalgarh, Jhargram, W.B.

1 Butterfly Diversity in Gopegarh Eco-park, Midnapore, W.B. India

Somdatta Ghosh*

ABSTRACT

Butterflies are attractive insects in the world, takes major part in pollination and extension of plant diversity. They are also indicator species for habitat or vegetation changes. This present documentation records the butterfly diversity of Gopegarh Eco Park, Paschim Medinipur district, W.B. A total of 42 species belong to 33 genera and four families have been recorded. Among all families, Nymphalidae followed by Lycaenidae and Pieridae are the most abundant. Eco parks are parks with to maintain sound ecological balance and recreational purpose together. So it is a great need to prepare a list of butterflies by which the difference in the species diversity at present from nearby forest area and changes from the past or in the future should be assessed.

Keywords: *Habitat, Lycaenidae, Nymphalidae, Pieridae,*

INTRODUCTION

Butterflies are widely recognized as key taxa for biodiversity monitoring because they reflected changes in land use patterns (Kocher & Williams 2000) and as ecological indicators (Brown 1991) as they are sensitive to any alteration to their habitats or local weather (Rosenberg et al. 1986; Dennis 1993). In addition, butterfly and plant diversity are directly inter dependant on each other. Hence the conservation of butterflies is necessary to understand their natural history and ecology for the maintenance of ecosystem health. Transition zones are defined as the boundaries between

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biogeographical regions, which represent areas of biotic overlap, and being favoured by ecological and historical changes allow a combination of taxa belonging to various biotic components (Morrone 2004).

Gopegarh ecopark was a part of natural forest of Jhargram range and now maintained by forest department mainly for recreation. Natural vegetation is mostly replaced by planted trees and gardens. Still this zone is attached with natural forest and adjacent riverbed. But regular eradication of weed and lower storey vegetation may hamper the butterfly diversity. So it is a great need to prepare a list of butterflies by which the difference in the butterfy species diversity at present from nearby forest area and changes from the past or in the future should be assessed. These changes are also directly dependent on change of flora.

MATERIALS AND METHODS

Study Area: The study was conducted in and around of Gopegarh Heritage Eco-Park; adjacent to Midnapore Town in West Midnapore District of West Bengal, India. The study area is situated beside the banks of river Kangasabati on one side and the other sides, sparse plantation dominated by to dense forest, dominated by Sal, , which connects with Jhargram Forest range. The location is also adjacent to Vidyasagar University Campus and government Sericulture Farm. The study area (22.4223N & 87.3040E) is with temperature 11-26 C in winter and 24- 40 in summer months; average relative humidity was between 66 and 90%.

The dominant plant species found in park noted are (Ghosh et al,2020).

Sampling: The survey for butterflies was done using Pollard walk method (Pollard et al. 1975; Pollard 1977) in linear trails of 500 m during Morning (07.00 to 11.00 AM), September to February on sunny days. All the species encountered and their relative abundance was recorded. Random sampling was conducted, as the park is manually managed by weeding; same trails are not always usable. Occasional surveys were also undertaken during day time. Photographs were taken by author using Sony cybershot 30x, 20.1 mp point & shoot camera. Most of the species were identified through photographs taken from different angle. Identification of specimen was done following Kehimkar (2008) and Smetacek (2017). Further, help was also taken from www. ifoundbutterflies.org.

RESULTS AND DISCUSSION

In this short study period, 47 species of 36 genera belonging to five families was recorded (Table 1). Nymphalidae family is the dominant among all families, followed by Lycaenidae and Pieridae; least in Papilionidae, and Hesperiidae. 17 (39.5%) species belong to Nymphalidae family, 11 (25.5%) Lycaenidae, 10 (23.3%) species from Pieridae, and four (9.3%) species of Papilionidae and five (11.6 %) from Hesperiidae. (Fig.3). My study shows that 30 genera represent only one species. is the dominant genus with four species followed by and . Depending on the availability of butterflies, 42 species categorized as very common, common, less common, rare, very rare. The most frequent species were Common Gull and Common Wanderer followed by Mottled Emigrant Psyche and Common Jezebel upto December. In January to February, Grass Jewel, Tiny Grass Blue, Pointed Ciliate Blue, pierrot and grass yellows are very common followed by common mormon. Glassy Tiger are rare in winter. Some photographs taken by author are attached below herewith.

Among the butterfly species recorded, most are 'common' species (Sarma et al. 2012) and much less in number compared to urban area of Midnapore (Biswas et al, 2019) or total undivided district (Dwari and Mndol,2020; Mahata et al 2020). Natural inhabitants of forest species are less than expected, so as Lycaenidae members also which are mostly favouring lower storey vegetation. This situation indicates diminishing condition of vegetation diversity within the park. But there are many species which were declared legally protected, viz., Gram Blue and Common Gull under Schedule II under wildlife protection Act 1972. Hence habitat protection with larva food plant conservation is necessary. Antropgenic interference and weed destruction may affect their life cycle. As the boundaries between these regions are areas of high biotic interaction they deserve special attention.

Table 1. : List of butterflies recorded from Gopegarh Eco Park, Paschim Medinipur district, West Bengal

Sr No	Family	Common name	Species	Distribution Status
1	Papilionidae	Lime Butterfly,	*Papilio demoleus* (Linnaeus)	LC
2		Common Mormon,	*Papilio polytes* (Linnaeus)	C

3		Common Rose	*Pachliopta aristolochiae* (Fabricius)	C
4		Tailed Jay	*Graphium agamenomnon* (C. & R. Felder)	R
5	Pieridae	Common Emigrant	*Catopsilia pomona* (Fabricius)	C
6		Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus)	C
7		Common Grass Yellow	*Eurema hecabe* (Linnaeus)	C
8		Small Grass Yellow	*Eurema brigitta* (Cramer)	C
9		Three Spot Grass Yellow	*Eurema blanda* (Boisduval)	C
10		Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus)	C
11		Psyche	*Leptosia nina* (Fabricius)	VC
12		Common Gull	*Cepora nerissa* (Fabricius)	VC
13		Common Jezebel	*Delias eucharis* (Drury)	VC
14		Common Wanderer	*Pareronia valeria* (Cramer)	VC
15	Lycaenidae	Monkey Puzzle	*Rathinda amor* (Fabricius)	LC
16		Dark Cerulean	*Jamides bochus* (Stoll)	C
17		Common Pierrot	*Castalius rosimon* (Fabricius)	VC
18		Ape Fly	*Spalgis epius* (Westwood)	C
19		Plum Judy,	*Abisara echerius* (Stoll)	LC
20		Grass Jewel	*Chilades trochylus*	VC
21		Lesser Grass Blue	*Zizula otis* (Fabricius)	VC

22		Plains Cupid	*Chilades pandava* (Horsfield)	C
23		Slate Flash	*Rapala manea* (Hewitson)	C
24		Pea Blue	*Lampides boeticus* (Linnaeus)	R
25		Lime Blue	*Chilades lajus* (Stoll)	LC
26	Nymphalidae	Tawny Coster,	*Acraea violae* (Fabricius)	C
27		Common Sailer	Neptis hylas (Linnaeus)	LC
28		Chocolate Pansy	*Precis iphita* (Cramer)	VC
29		Peacock Pansy	*Precis almana* (Linnaeus)	C
30		Lemon Pansy	*Precis lemonias* (Linnaeus)	C
31		Grey Pansy	*Precis atlites*(Linnaeus)	VC
32		Great Eggfly	*Hypolimnas bolina* (Linnaeus)	LC
33		Danaid eggfly	*Hypolimnas misipus* (Linnaeus)	LC
34		Common Castor,	*Ariadne merione* (Cramer)	LC
35		Baronet	*Symphaedra nais* (Forster)	LC
36		Common Evening Brown	*Melanitis leda* (Linnaeus)	VC
37		Lesser Three Ring,	*Ypthima inica* (Hewitson)	C
38		Common Palmfly	*Elymnias hyperemnesta*	LC
39		Common Indian Crow	*Euploea core* (Cramer)	LC
40		Glassy Tiger	*Parantica aglea* (Cramer)	VR

41		Striped Tiger	*Danaus genutia* (Cramer)	C
42		Plain tiger	*Danaus chrysipus* (Cramer)	C
43	Hesperidae	Grass Demon	*Udaspes folus* (Cramer)	VC
44		Indian Palm Bob,	*Suastus gremius* (Fabricius)	LC
45		Chestnut Bob	*Lambrix salsala* (Moore	C
46		Common Dartlet	*Oriens gola* (Moore)	C
47		Brown Awl	*Badamia exclamationis* (Fabricius)	R

VC- Very Common, C - Common, LC - Less Common, R - Rare, VR - Very Rare

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Figure: 1,2. Common Gull; 3. Common Wanderer;
3. Common Grass yellow

4. Palm judy; 5. Tawny coaster; 6. Slate flash
7. Common pierrot; 8. Common castor

9. Evening Brown.10 Three ring.11. Common Crow
12. Chocolate pansy. 13 . Grey pansy

14. Lemon Pansy; 15. Danaeid eggfly 16. Common Mormon
17. Lime. 18. Plain tiger 19. Common Sailor; 20. Barronet.

2

Morphological Diversity in Seedlings of Four Invasive Taxa of Asteraceae with a Note on Their Role in Human Health-Care

Avinash Mundhra

ABSTRACT

The present investigation deals with morphological characterisation of juvenile stages of four invasive species of Asteraceae family. Seedling organs such as cotyledons, hypocotyl, first two leaves, subsequent leaves, etc. of these species offers several characters of taxonomic value and with the help of these characters an analytical key has been constructed for the identification of these species much before flowering and fruiting stages. Early identification at seedling stage will help in eradicating them from undesirable places before their successful establishment.

Keywords: *Seedling, Invasive, Morphology, Asteraceae.*

INTRODUCTION

Invasive plants are those plants which have invaded the soil of India through various means or agencies, and has almost naturalized in different parts of India including West Bengal (Richardson et al., 2000). The invasive plant species cause economic and/or environmental damage, and recognized as the second worst threat for species extinction after habitat destruction in 21st Century. However, majority of them are also used by local people in the treatment of various ailments and diseases and their seedlings are primary contributor of active constituents for large scale production of medicinal drugs. Naturally there is a need to identify these plants

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at the earliest so as to control their menace from undesirable places and at the same time to exploit their immense medicinal potential through proper utilization. The study of seedling morphology of these invasives can greatly help in this regard. Seedling characters are equally important and reliable like floral characters in the delimitation of taxonomic groups. In spite of the fact that the seedling organs are limited in number, their characters variation is very diverse and in a specific combination, these morphological characters enable prompt identification (Vogel, 1980; Mundhra et al., 2012; Bose and Paria, 2017).

The family Asteraceae (or Compositae) is one of the largest and advanced angiospermic families, with over 1600 genera and 2500 species distributed throughout the world. Many taxa of Asteraceae contain important biomolecules such as essential oils, saponins, lignans, polyphenolic compounds, phenolic acids, polysaccharides, etc. which are often linked with their pharmacological activities such as anti-inflammatory, antioxidant, anti-platelet and antimicrobial activity (Rolnik and Olas, 2021). Most invasive plants belong to the Asteraceae family and majorty of them shows high allelopathic properties and harmful effects on natural biota (Mugendhiran et al. 2020). The members of Asteraceae are easily recognized by their typical inflorescence referred to as capitulum where centripetally arranged flowers on a flat axis are surrounded by bracts. However, the family Asteraceae has not been investigated thoroughly from seedling morphological point of view and in this connection an attempt has been made to document morphological characters of juveline plants of some members of this family and to provide a key for their identification at an early stage.

REVIEW OF LITERATURE

Attention has been paid to seedlings quite early in botanical science in many parts of the world and many research papers pertaining to seedling morphology of varios taxa of seed plants at the level of family, genus and species can be found in taxonomic publications (Muller, 1978; Vogel, 1980; Nozzolillo, 1985; Tillich, 2003; Henderson, 2006; Garwood et al., 2009; Miller and Miller, 2011; Almeida, 2013). However, this field has received very little attention in India and some notable contributors are Sampathkumar (1982), Balasubramanyan and Swarupanandan (1986) and Paria and his associates (1998, 1999, 2008, 2009, 2015). The family Asteraceae has been investigated extensively from the view point of many botanical disciplines including floral morphology, anatomy, palynology, phytochemistry, pharmacology, embryology, etc. (Pandey and Singh, 1983; Pullaiah, 1983; Talukdar and Mukherjee, 2008; Jana and Mukherjee, 2012; Sokovic et al., 2019; Michel et al., 2020). Seedling morphology of few species of Asteraceae was also investigated earlier (Ahammed and Paria, 1996; Mundhra, 2016) but the species under consideration in this present investigation has not been dealt with properly.

MATERIALS AND METHODOLOGY

In the present investigation, various localities of different districts of West Bengal were explored for the collection of plant materials including fruits, seeds, and/or seedlings of four investigated invasive species of the family Asteraceae. The list of investigated taxa is given below (in alphabetical order):

1. *Eclipta prostrata* (L.) L.
2. *Parthenium hysterophorus* L.
3. *Synedrella nodiflora* (L.) Gaertn.
4. *Tridax procumbens* L.

Seedlings of different stages of the investigated species were collected from natural habitats. The seedlings were also raised from collected seeds in the botanical garden of Botany Department of R.B.C. College, Naihati and compared with those of natural seedlings collected from the field. The different stages of seedlings were photographed, pressed, dried and preserved in the form of herbarium sheets and the morphology of seedlings was described following the standard scheme (Vogel, 1980; Mundhra and Paria, 2009). Venation pattern of seedling leaves were studied following standard methodology (Hickey, 1973) with slight modification. Distinguishing features of seedlings were selected to construct an artificial key for the identification of investigated taxa at the juvenile stages, i.e. much before flowering and fruiting stages. Furthermore, the nativity of the invasive species, phenology, vernacular names, and correct scientific names were recorded from relevant literature (Khare, 2007; Reddy, 2008; Hassler, 2019).

RESULTS

The present investigation deals with seedling morphological studies of four invasive species of Asteraceae. The accepted scientific name, vernacular name, flowering-fruiting time (phenology) and their medicinal values were recorded from relevant literature and also through interaction with local people during collection trips (Table

1). The morphological studies of the seedling stages of invasive species of Asteraceaae have revealed marked variations in their juvenile plant morphology which are documented below:

Eclipta prostrata (L.) L. (Fig 1a): Germination epigeal, phanerocotylar. Tap root 20 mm - 25 mm long, pubescent. Hypocotyl strongly elongating, 15 mm - 20 mm long, pubescent, pale green in colour. Cotyledons two, opposite, foliaceous, persistent up to 6 leaves stages, exstipulate, petiolate; petiole 25 mm - 30 mm long, pubescent; blade wide ovate (2.5 - 5 mm x 2 - 4 mm), base obtuse, margin entire, apex rounded, surface pubescent, primary veins three, venation acrodromous. Internodes strongly elongating; first internode 15 mm - 18 mm long, second internode 16 mm - 22 mm long, next internodes almost equal to that of first one, terete, pubescent, brownish in colour. First two leaves opposite, exstipulate, petiolate; petiole 2 - 4 mm long, pubescent; blade simple, ovate (6 mm - 9 mm x 4 mm - 6 mm), base cuneate, margin entire, apex obtuse, surface pubescent, primary veins one, venation semicraspedodromous. Subsequent leaves opposite decussate, ovate, other characters almost same as that of the first two leaves except measurements.

***Parthenium hysterophorus* L.** (Fig 1b): Germination epigeal, phanerocotylar. Tap root 10 mm - 25 mm long, glabrous. Hypocotyl shortly elongating, 9 mm - 12 mm long, glabrous, brown in colour. Cotyledons two, opposite, foliaceous, persistent up to 7 - 9 leaves stages, exstipulate, petiolate; petiole 4 mm - 6 mm long, glabrous; blade spathulate (3 mm - 4 mm x 2 mm - 3 mm), base obtuse, margin entire, apex emarginate, surface glabrous, primary vein one, venation hypodromous. Internodes compressed-reduced, first and second internodes less than 2 mm long, terete, pubescent, green. First two leaves opposite, exstipulate, petiolate; petiole 5 mm - 7 mm long, pubescent; blade simple, ovate (4 mm - 6 mm x 2 mm - 3 mm), base attenuate, margin entire to repand, apex obtuse, surface pubescent, primary veins one, venation semicraspedodromous. Subsequent leaves alternate, blade ovate-pinnately dissected, margin irregularly incised, apex obtuse with subrounded base, other characters almost same as that of the first two leaves except measurements.

***Synedrella nodiflora* (L.) Gaertn.** (Fig 1c): Germination epigeal, phanerocotylar. Tap root 10 mm - 15 mm long, glabrous. Hypocotyl strongly elongating, 20 mm - 30 mm long, glabrous, pale green. Cotyledons two, opposite, foliaceous, persistent up to 5 - 7 leaves stages, exstipulate, petiolate; petiole 8 mm - 12 mm long, sparsely pubescent; blade ovate (15 mm - 20 mm x 8 mm - 10 mm base cuneate, margin entire, apex obtuse, surface sparsely pubescent, primary vein one, venation semicraspedodromous. Internodes shortly elongating; first internode 12 mm - 18 mm long, second internode 5 mm - 8 mm long, next internodes almost equal to that of second one, terete, pubescent, green. First two leaves opposite, exstipulate, petiolate; petiole 2 mm - 3 mm long, pubescent; blade simple, ovate (5 mm - 8 mm x 3 mm - 4 mm), base cuneate, margin serrate, apex acute, surface pubescent, primary veins one, venation semicraspedodromous. Subsequent leaves opposite, ovate with distantly serrate margin, other characters almost same as that of the first two leaves except measurements.

***Tridax procumbens* L.** (Fig 1d): Germination epigeal, phanerocotylar. Tap root 15 mm - 25 mm long, pubescent. Hypocotyl shortly elongating, 12 mm - 18 mm long, pubescent, pale green. Cotyledons two, opposite, foliaceous, persistent up to 5 - 7 leaves stages, exstipulate, petiolate; petiole 1 mm - 3 mm long, pubescent; blade suborbicular (5 mm - 6 mm x 4 mm - 5 mm), base rounded, margin entire, apex rounded, surface pubescent, primary veins one, venation semicraspedodromous. Internodes strongly elongating; first internode 30 mm - 38 mm long, second internode 35 mm - 40 mm long, next internodes almost equal to that of first one, terete, pubescent, green. First two leaves opposite, exstipulate, petiolate; petiole 3 mm - 5 mm long, pubescent; blade simple, ovate (10 mm - 15 mm x 5 mm - 8 mm), base attenuate, margin entire, apex acute, surface pubescent, primary veins one, venation semicraspedodromous. Subsequent leaves opposite, ovate, margin minutely dentate, other characters almost same as that of first two leaves except measurements.

From the above descriptions, diagnostic seedling features were screened out to construct an analytical key to facilitate the identification of these taxa at juvenile stage i.e. much before the flowering and fruiting stage.

KEY TO THE SEEDLINGS OF INVESTIGATED TAXA
(Only valid for taxa mentioned)

1a. Subsequent leaves alternate, cotyledons spathulate………… *Parthenium hysterophorus*
1b. Subsequent leaves opposite, cotyledons ovate or suborbiular:
  2a. First two leaves with margin entire:
    3a. Cotyledon wide ovate, with obtuse base and acrodromous venation having primary vein > 1 in number; first two leaves with obtuse apex…. *Eclipta prostrata*
    3b. Cotyledon suborbicular, with rounded base and semi-craspedodromous venation having primary vein 1 in number; first two leaves with acute apex … ……………………………………… *Tridax procumbens*
  2b. First two leaves with margin toothed, hypocotyl glabrous...… *Synedrella nodiflora*

DISCUSSION

All the investigated invasive taxa of Asteraceae have immense medicinal values and are used in traditional human health care system for the treatment of many ailments such as diarrhoea, dysentery, rheumatism, respiratory and skin diseases including hair loss, whitening of hair, cuts, and wounds, etc. (Table 1). The seedling morphological studies in all four invasive herbaceous species of Asteraceae show epigeal, phanerocotylar germination and a well-developed taproot system. Hypocotyl length varies within and between species but the presence or absence of epidermal processes on the surface of the hypocotyl helps to identify the investigated species. In the investigated taxa, only photosynthetic cotyledons or foliaceous cotyledons (Paracotyledons) have been observed. The size and shape of the cotyledons differ compared to the mature foliage leaves and can be utilized as taxonomic marker for species identification. The length of epicotyl and subsequent internodes vary in different species. In the present study, first two leaves and subsequent leaves are also different from the preceding cotyledons in shape. *Parthenium* sp. differs from other three investigated species in the phyllotaxy of their subsequent leaves which can be used as a diagnostic character in species delimitation. Morphological diversity is also noted in the form of bases, apices, margins and shapes of juvenile leaves.

These seedling characters as described above are immediate outcome of the seeds following germination and subsequent development, thereby representing as taxonomic markers as well as parameters of genetic diversity. This investigation of invasive species seedlings of Asteraceae clearly shows that their identification at juvenile sages will enable their eradication from undesirable places well before they establish themselves through flowering-fruiting. The investigated species have also got profound medicinal values in spite of being weeds and as such can be exploited commercially through cultivation at desirable places. Furthermore, the current study is exploratory in nature, involving a small number of invasive Asteraceae species, and further studies involving more species would most likely be extremely beneficial in understanding the relationship between ecology and morphology.

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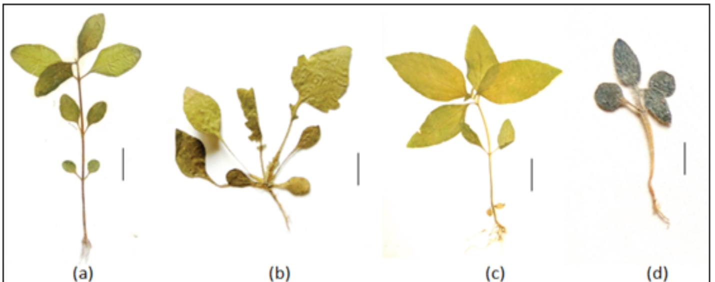

Fig. 1: Seedling morphology of investigated invasive species of Asteraceae (scale bar -1 cm)

a- *Eclipta prostrata*, b- *Parthenium hysterophorus*, c- *Synedrella nodiflora*, d- *Tridax procumbens*

Table 1: Investigated taxa of Asteraceae with their medicinal importance

Scientific Name	Vernacular name	Nativity	Phenology	Medicinal Properties
1. *Eclipta prostrata* (L.) L.	Keshute/ Keshori/ Bhringaraaj	Trop. South America	Throughout the year	Plant used in hepatitis, spleen enlargements, chronic skin diseases. Leaf promotes hair growth. It's extract in oil is applied to scalp before bed time in insomnia. Fresh juice used to treat scorpion stings.
2. *Parthenium hysterophorus* L.	Gajar Ghas, Parthenium	Trop. America	Throughout the year	Plant used as anti-amoebic, antidysenteric, febrifuge, analgesic, emmenagogue.
3. *Synedrella nodiflora* (L.) Gaertn.	Syndrela	West Indies	July - Dec.	Boiled leaves used as laxative. Leaves made into paste and applied to treat rheumatism.
4. *Tridax procumbens* L.	Targanda	Trop. South America	Throughout the year	Leaves used as styptic in bleeding wounds, antidiarrhoeal, antidysenteric and also used for bronchial catarrh.

3 Zooplankton Diversity and Relation with Physico-chemical Parameters in the River Teesta

Tapan Sarkar

ABSTRACT

A survey was conducted on the river Teesta for the analysis of zooplankton diversity indices and it's relation with physico-chemical parameters. A total of 17 genera of zooplankton were obtained, composed of Protozoa (5 genera), Rotifera (5 genera), Cladocera (4 genera) and Copepod (3 genera).Zooplankton density, number of zooplankton genera, Shannon-Wiener diversity index (H'), Zooplankton evenness index (J'),Margalef's richness index and zooplankton dominance index were ranged from 9-38 org./L, 7-14, 1.88-2.54, 0.956-0.987, 2.50-4.0 and 0.081-0.160 respectively. Seasonal value of Zooplankton density, number of zooplankton genera, Shannon-Wiener diversity index (H'), and Margalef's richness index were maximum in winter and minimum in rainy season but dominance index showed opposite relation. Zooplankton density, number of zooplankton genera, Shannon-Wiener diversity index (H'), and Margalef's richness index showed positive correlation with TDS, EC, DO, TA, TH and CL but negatively correlated with water temperature, depth of water, and FC.

1. INTRODUCTION

The river Teesta is a 309 km long river that flows through the Indian states of Sikkim and West Bengal before entering Bangladesh, where it flows into the Brahamaputra. The river originates from the Pahunri glacier near Khangehung Lake in North Sikkim at an altitude of 7068 meters (Meetei*et al.*, 2007). The river Teesta is fed by

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many rivulets that arise in the Thangu, Yumthang, and Donkia-La ranges. The river then flows past the town of Rangpo, Sikkim, and enters West Bengal at Teesta Bazaar. The river Teesta, after meeting with the Rangeet river, changes its course southward to enter West Bengal (Chaudhuri and Chaudhuri, 2015). The river reaches the plains of the district Darjeeling at Sevoke and then flows through the district of Jalpaiguri and enters Bangladesh at Rangpur District, finally meeting with the river Brahmaputra at Fulchori(Bisht, 1993 and Joshi, 2004).

Plankton plays an important role in cycling organic matter in water bodies. Plankton strongly influences certain non-biological qualities of water, such as pH, colour, taste, and odour. The diversity and abundance of plankton community depends on climatic condition, availability of nutrients and physico-chemical parameters of water (Rocha *et al*., 1999).

Zooplankton are influencing all the functional aspects of an aquatic ecosystem, such as food chains, food webs, energy flow and cycling of organic matter (Sharma and Lyngoskar, 2003). Zooplanktons are important food sources for many small to large aquatic organisms. Zooplankton may also serve as a bio-indicator (Contreras *et al*., 2009). The Cladocera are an important food source for both young and adult fishes (Pennak, 1978). Aims of the present study were to analysis the monthly and seasonal variation of zooplankton density and diversity indices and relation with physico-chemical parameters.

2. MATERIALS AND METHODS

2.1 Sampling sites

Two sampling sites of the river Teesta, Site 1 and site 2 were selected for study. Site 1 is located at Gajol Doba (Latitude-26^{0}44′55.4′′N and longitude-88^{0}35′37.0′′E). Site 2 is located at Haldi Bari (Latitude 26^{0}23′01.2′′N and longitude 88^{0}50′38.0′′E).

2.2 Duration of study

Duration of study was two years from March 2014 to February 2016. Sampling was done at monthly interval at early morning.

2.3 Collection of zooplankton and counting technique

Zooplankton sample was collected by filtering 25 litre of surface water by plankton net (mesh size 20μ) and immediately preserved in 4% formalin solution. Sample was stained with 0.04% Rose Bengal stain. Zooplankton samples were identified under the microscope following Pennak (1978), Ward and Whipple (1959), Battish (1992) and APHA (2005). Water sample was centrifuged at 1500 rpm for 15 minutes in the laboratory and studied under high power of microscope (Magnus binocular microscope model:CH-20i). Quantitative analysis and identification of zooplankton were done on a Sedgwick Rafter cell counter. 1mL of concentrated sample was taken in the Sedgwick Rafter cell counter and counted the number of organisms present. The density of zooplankton was calculated as follows:

Number of organisms per liter (Organism/L) $= \frac{CXVr}{VrXVf}$

Where,

C = Number of zooplankton counted

Vc = Volume of concentrated sub samples used (mL).

Vr = Volume of replicate counted from concentrated samples (mL).

Vf = Volume of original grab water sample filtered through plankton net (liter).

Different biodiversity indices and Pearson's correlation coefficient matrix were determined by PAST3.0 software.

2.4 Water quality analysis

Physiochemical parameters of water were determined by APHA (2005) method.

3. RESULT AND DISCUSSION

A total of 16 genera comprising of Protozoa (4 genera), Rotifera (5 genera), Cladocera (4 genera) and Copepod (3 genera) were recorded at site 1 of the river Teesta (Table 1).

Sixteen genera of zooplankton belonged to Protozoa (4 genera), Rotifera (5 genera), Cladocera (4 genera) and Copepod (3 genera) at site 2 were recorded. A total of 17 genera of zooplankton were obtained, composed of Protozoa (5 genera, 29.41%), Rotifera (5 genera, 29.41%), Cladocera (4 genera, 23.52%) and Copepod (3 genera, 17.64 %) (Table 1 and Fig. 1). Protozoa and Rotifera were the most abundant groups. The Cladocera was low in abundance in, which may be due to predation by juvenile fish. Similar finding has been suggested by Zaret (1980). Low number of zooplankton genera in Himalayan streams has been reported by Rashid and Pandit (2008) and Negi and Negi (2010). The presence of copepods in water bodies indicates the good quality of water (Bhanga *et al.*, 2014).

3.1 Zooplankton density

The monthly variation of zooplankton density was 9-38 org./L,. Acherjee and Barat (2013) reported that the density of zooplankton ranged from 3-34 org./L in the hill stream Relli and river Teesta (Table 3 and 4) .The highest average seasonal value of zooplankton density was recorded in winter and then followed by summer and rainy season (Tables 5). Patel and Singh (2014) showed maximum zooplankton density during the summer and lowest in the monsoon. Ganeshan and Khan (2008) reported that the highest density of zooplankton was in winter and lowest in monsoon season. Sharma (2011) revealed winter peaks of zooplankton abundance in Loktak Lake.

Zooplankton density registered positive correlation with pH, TDS, electrical conductivity, dissolved oxygen, total alkalinity, total hardness and chloride. However, it found a negative correlation with water temperature, depth of water, TSS, and free CO_2 (Table 6). Similar findings were reported by Datta (2011), Keshri *et al.* (2013) and Odulate, (2017).

3.2 Number of zooplankton genera (S)

7-14 was the range of monthly variations of zooplankton genera recorded during the study period(Table 3 and 4). In the present investigation, the highest average value of the number of zooplankton genera was recorded in winter and followed by summer and rainy season during the two year study period. Bera *et al.* (2014) reported that density of zooplankton was highest during winter season and corroborates our findings. Number of zooplankton genera and density were lowest in rainy season due to environmental stress and low abundance of phytoplankton in rainy season (Table 5). Number of zooplankton genera and density were highest in winter season due to peak abundance of phytoplankton in winter season.

pH, TDS, conductivity, dissolved oxygen, total alkalinity, total hardness, and chloride have a positive correlation with number of zooplankton genera. But number of zooplankton genera is negatively correlated with water temperature, depth of water, TSS and free CO_2 (Table 6). The pattern of zooplankton community distribution depends on a complex of factors such as changes in climatic conditions, physical and chemical parameters of water and vegetation cover (Neves *et al.*, 2003). Zooplankton abundance showed positive correlation with total hardness (Shil*et al.*, 2013) and concurred with our findings. Copepod (zooplankton) distribution and abundance are affected by water depth, transparency, pH, and predators (Sarawde and Kamble, 2014).Arimoro and Oganah (2010) reported that zooplankton density is positively correlated with dissolved oxygen and total alkalinity. Electrical conductivity and TDS encourage high zooplankton growth (Acherjee and Barat, 2013). So, the number of zooplankton genera is positively correlated with electrical conductivity and TDS.

Table 1: Zooplankton diversity in the river Teesta from March 2014 to February 20016.

Sr. No.	Group	Genera	2014-2015		2015-2016	
			Site 1	Site 2	Site 1	Site 2
1.	Protozoa	*Actinophrys*sp.	-	+	-	+
2.		*Amoeba* sp.	+	+	+	+
3.		*Paramoecium* sp.	+	+	-	+
4.		*Peridinum* sp.	+	+	+	+
5.		*Arcella*sp.	+	+	+	+
6.	Rotifera	*Asplanchna* sp.	+	+	+	+
7.		*Brachionus* sp.	+	+	+	+
8.		*Filinia* sp.	+	+	+	+
9.		*Keratella* sp.	+	+	+	+
10.		*Philodina* sp.	+	+	+	-
11.	Cladocera	*Bosmina* sp.	+	+	+	+
12.		*Daphnia* sp.	+	+	+	+
13.		*Moina* sp.	+	-	+	+
14.		*Sida* sp.	-	+	+	+
15.	Copepoda	*Cyclopes* sp.	+	+	+	+
16.		*Diaptomus* sp.	+	+	+	+
17.		*Eucyclops* sp.	+	+	+	+

+= indicate present, -= indicate absent

Table 2 Percent composition of zooplankton at two sampling sites of the river Teesta during the two year study period from February 2014-March 2016.

Zooplankton Group	Sampling Sites			
	February 2014- March 2015		February 2015- March 2016	
	Site 1	Site 2	Site 1	Site 2
Protozoa	26.67	31.25	20.00	31.25
Rotifera	33.33	31.25	33.33	25.00
Cladocera	20.00	18.75	26.67	25.00
Copepoda	20.00	18.75	20.00	18.75

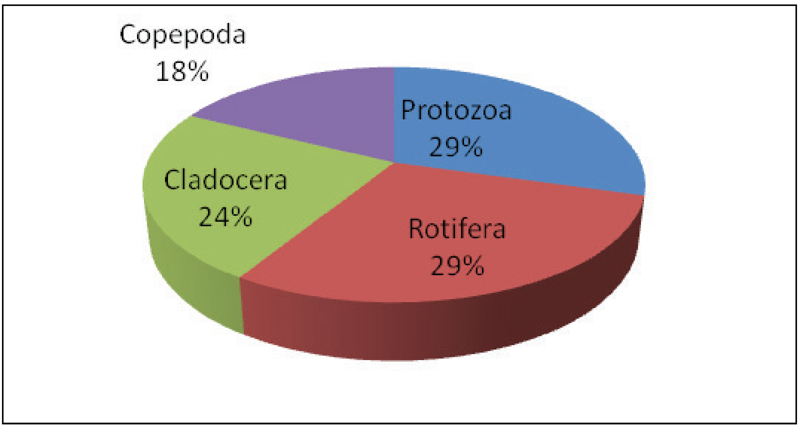

Fig. 1: Percent Composition of Zooplankton in the river Teesta.

3.3 Shannon-Wiener diversity index (H′)

Monthly variation of Shannon-Wiener diversity index (H′) ranged from 1.88-2.54during the study period (Table 3 and 4).Similar findings have been reported by Acherjee and Barat (2013) from the hill stream Relli and the river Teesta (1.37-3.04),and Basu *et al.* (2013) from the river Ichhamati (1.43 to 2.46).

But low value of Shannon-Wiener diversity index (1.347 to 1.791) in comparison to the present study was reported by Patra *et al.* (2015) from the Garati and Nonai rivers and three ponds of Moraghat forest, West Bengal. Shannon-Wiener diversity (H′) index of zooplankton at all sites of the three rivers showed almost similar pattern of monthly fluctuation.

The highest average seasonal value of Shannon-Wiener diversity index was found in winter season and the lowest value in rainy season (Tables 5). Acherjee and Barat (2013) and Bera *et al.* (2014) found maximum zooplankton diversity during the winter and lowest in the monsoon and corroborate our findings. Zooplankton diversity increased during the winter season due to higher photosynthetic activity of phytoplanktonand high nutrient concentration (Bilgrami and Duttamunshi, 1985). Lowest value of Shannon-Shannon-Wiener diversity index was found during the rainy season, which may be due to low density and fewer occurrences of number of zooplankton genera. This may be related to high water velocity and increased turbidity and volume of water. Hence, if any one of these two variables decreases or increases, it will affect the overall values of species diversity index (H’) and species richness index (R). Environmental stress such as flash floods, high water velocity and turbidity might have resulted in the dominance of a few phytoplankton species and which in turn are responsible for lowest value of richness index in monsoon season. A similar opinion has been expressed by Plafkin *et al.* (1989).

pH, TDS, electrical conductivity, dissolved oxygen, total alkalinity, total hardness and chloride all have a positive correlation with Shannon-Wiener diversity index. It is negatively correlated with air temperature, water temperature, depth of water, TSS and free CO_2 (Tables5 and 6). Datta (2011) and Palleyi *et al.* (2011) recorded that zooplankton diversity had significant and positive correlation with TSS and DO but significant and negative correlation with free CO_2 and corroborates our findings.

3.4 Zooplankton evenness index (J’)

Zooplankton evenness index (J’) was ranged from 0.956-0.987(Table 4). Similar ranges of zooplankton evenness index have been reported by Acherjee and Barat (2013) from the hill stream Relli and the river Teesta (0.865-0.998) and Bera *et al.* (2014) from the Kangasabati reservoir, West Bengal (0.75 to 0.99) which corroborates with the present findings.

3.5 Margalef’s species richness index (R)

2.50-4.0 was the range of Margalef’s richness index reported in the rivers Teesta, Similar range of Margalef’s richness index was reported by Acherjee and Barat (2013) from the hill steam Relli and the river Teesta (0.32-4.24) (Table 4). Datta (2011) recorded that the zooplankton richness index varied from 2.08 to 4.52 in two floodplain wetlands of the river Teesta in Jalpaiguri district, West Bengal. Basu *et al.* (2013) also reported similar values of Margalef richness index, ranging from 0.88 to 3.15. Bera *et al.* (2014) recorded that the range of Margalef's species richness index varied between 6.38 and 9.58 in the Kangsabati reservoir, West Bengal and higher than in the present investigation. A higher value of the species richness index is an indication of a longer food chain (Dumont, 1999).

Highest Margalef's richness index was found in winter, followed by summer and lowest value was found in rainy season (Table 5). The rainy season had the lowest value of Margalef's richness index because few zooplankton species predominated due to many environmental stresses such as floods, turbulent water, high velocity, and high turbidity. Seasonal variation of Margalef's richness index concurred with reports of Acherjee and Barat (2013) and Basu *et al*. (2013).

Margalef's species richness index (R) is positively influenced with pH, conductivity, dissolved oxygen, total alkalinity, total hardness and chloride but inversely influenced by water temperature, depth of water, TSS, and free $CO_{2,}$ in the present investigation (Tables 5 and 6). Agarwal and Thapliyal (2005) and Bera*et al.* (2014) reported that transparency, DO, and pH had positive and significant correlation with zooplankton richness. The species richness index of zooplankton is positively correlated with alkalinity (Sharma, 2011). Basu *et al.* (2014) observed that the water temperature and rainfall showed negative correlation with zooplankton richness but positively correlated with electrical conductivity, alkalinity, hardness, and dissolved oxygen (Sharma and Sharma, 2011). Agarwal and Thapliyal (2005) and Bera *et al.* (2014) showed that the water temperature, transparency, DO and pH had positive and significant correlations with zooplankton richness and concurred with our findings.

3.6 Species dominance index (λ)

The monthly variation of the zooplankton dominance index was 0.081-0.160. Basu *et al.* (2013) reported that the Simpson dominance index ranged from 0.72 to 0.92 in the river Ichamati, West Bengal. Bera *et al.* (2014) also recorded range of dominance index from 0.221 to 0.485 in the Kangsabati reservoir, West Bengal. Acherjee and Barat (2013) reported that the dominance index of zooplankton varied from 0.075 to 0.556 in the hill stream Relli and river Teesta. Maximum species dominance index was recorded in rainy season and lowest in winter.

Table 3: Shows zooplankton density and diversity indices at site 1 (Gajodoba) of the river Teesta during first and second year.

Study period		**March 2014- February 2016**											
Diversity Indices		**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**
Density (org./L)	**1st yr**	18	15	12	12	9	10	15	14	17	20	29	38
	2nd yr	23	18	18	16	13	16	17	19	20	25	26	29
No.of zooplankton genera (S)	**1st yr**	12	10	9	9	8	7	10	9	11	11	13	13
	2nd yr	12	12	11	11	10	11	11	11	12	13	14	11
S-W diversity index**(H′)**	**1st yr**	2.42	2.24	2.13	2.13	2.04	1.88	2.24	2.10	2.31	2.29	2.54	2.53
	2nd yr	2.45	2.42	2.35	2.33	2.24	2.33	2.34	2.36	2.44	2.47	2.54	2.34
Zoopalnkton evenness index (J′)	**1st yr**	0.977	0.975	0.973	0.973	0.982	0.963	0.975	0.959	0.964	0.976	0.986	0.987
	2nd yr	0.986	0.977	0.980	0.975	0.975	0.974	0.977	0.984	0.982	0.965	0.984	0.977
Margalef's sp. richness index (R)	**1st yr**	3.806	3.323	3.219	3.219	3.186	2.606	3.323	3.031	3.53	3.33	3.56	3.29
	2nd yr	3.50	3.80	3.46	3.60	3.50	3.60	3.53	3.39	3.67	3.72	3.99	3.97
Species dominance index (λ)	**1st yr**	0.092	0.111	0.125	0.125	0.138	0.16	0.111	0.132	0.107	0.11	0.082	0.081
	2nd yr	0.088	0.092	0.098	0.101	0.112	0.101	0.100	0.096	0.09	0.091	0.085	0.101

Table 4 Shows zooplankton density and diversity indices at site 2 (Haldi Bari) of the river Teesta during first and second year.

Study period		March 2014- February 2016											
Diversity Indices		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Density (org./L)	1st yr	29	13	11	12	11	9	14	11	17	19	33	28
	2nd yr	25	20	19	18	13	11	18	20	25	25	31	26
Number of zooplankton genera (S)	1st yr	12	10	9	9	7	7	9	8	10	11	13	13
	2nd yr	12	13	11	11	9	10	11	11	12	13	13	11
S-w diversity index(H′)	1st yr	2.43	2.24	2.14	2.13	1.89	1.88	2.14	2.02	2.20	2.33	2.49	2.46
	2nd yr	2.41	2.48	2.30	2.32	2.13	2.27	2.32	2.29	2.39	2.51	2.50	2.36
Zooplankton evenness index (J′)	1st yr	0.979	0.974	0.976	0.973	0.973	0.970	0.975	0.971	0.956	0.972	0.971	0.961
	2nd yr	0.971	0.968	0.961	0.968	0.973	0.986	0.968	0.956	0.963	0.979	0.976	0.986
Margalef's species richness index	1st yr	2.75	3.50	3.33	3.21	2.50	2.73	3.03	2.91	3.17	3.39	3.42	3.60
	2nd yr	3.41	4.00	3.39	3.46	3.11	2.75	3.46	3.33	3.41	3.72	3.49	3.06
Species dominance index (λ)	1st yr	0.0914	0.112	0.124	0.125	0.157	0.160	0.122	0.140	0.121	0.102	0.089	0.091
	2nd yr	0.094	0.09	0.108	0.104	0.124	0.107	0.104	0.11	0.097	0.084	0.086	0.097

Table 5: Seasonal density and diversity indices of zooplankton at two sites of the river Teesta from March 2014–February 2016.

Study period	Average					
	Site 1			Site 2		
Diversity Indices	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**
Density (org./L)	16.5	14.125	25.5	18.37	13.375	25.5
Number of zooplankton genera (S)	10.75	9.625	12.25	10.87	9.00	12.00
Species Diversity Index(H′)	2.31	2.195	2.435	2.31	2.115	2.40
Species Evenness Index (J′)	0.976	0.974	0.977	0.9715	0.971	0.9705
Margalef's Species Richness Index (R)	3.495	3.275	3.635	3.31	2.98	3.41
Species Dominance Index (λ)	0.104	0.118	0.093	0.106	0.128	0.096

Table 6: Pearson's correlation coefficient matrix for zooplankton and air temperature and physico-chemical parameters of the river Teesta (n=48, d.f. 46).

	AT	WT	DW	pH	TSS	TDS	TS	EC	DO	FC	TA	TH	CL

DZ	-0.835**	-0.853**	-0.604**	0.143	-0.355*	0.604**	-0.011	0.661**	0.428**	-0.455**	0.829**	0.737**	0.507**
NZ	-0.648**	-0.681**	-0.641**	0.250	-0.419**	0.601**	-0.079	0.465**	0.439**	-0.636**	0.769**	0.709**	0.462**
DV	-0.621**	-0.652**	-0.638**	0.275	-0.418**	0.585**	-0.088	0.441**	0.404**	-0.656**	0.762**	0.687**	0.475**
EI	-0.149	-0.156	0.111	-0.062	0.061	0.043	0.086	0.005	-0.0081	-0.098	0.168	0.051	0.260
MI	-0.283	-0.318*	-0.393**	0.257	-0.246	0.200	-0.141	0.112	0.266	-0.596**	0.454**	0.429**	0.243
DM	-0.228	-0.211	-0.012	0.102	0.141	0.028	0.169	0.168	0.193	0.069	0.125	0.094	0.208

*** Correlation is significant at the 0.01level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).*

DZ=Density of zooplankton, NZ=Number of zooplankton Genera, DV=Shannon-Wiener diversity index, EI= zooplankton evenness index, MI=Margalef's species richness index, DM=Species dominance index AT=Air temperature, WT= Water temperature, DW=Depth of water, TSS= Total suspended solid, TDS=Total dissolved solid, TS=Total solid, pH=Power of hydrogen ion concentration, COND=conductivity, DO=Dissolved oxygen, FC= Free carbon dioxide, TA=Total alkalinity, TH= Total hardness and CL= Chloride.

4. ACKNOWLEDGEMENT

I declare that no part of the paper has been copied or taken from others paper. It is my own work.

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4 A Review on Endangered Flora of West Bengal

Adrija Mukherjee & Debraj Chakraborty

ABSTRACT

India is conferred with various agroclimatic conditions. It is one of the 12 mega-diversity rich centers which bears an extensive floristic diversity, among which many of wild and ornamental species are endangered. Any plant might get endangered, then ultimately become extinct when the rate of mortality will be more than the rejuvenation rate for an extended time interval. The causes might be natural or anthropogenic. Unwarranted anthropogenic activities have directed the destruction and fragmentation of vegetations with takeover of exotic aggressive species, were perceived as the major threats. Destructing forest lands for establishing agricultural fields, urban complexes, and industrialization have played a disparaging role against the survival of the various plant species. Replacement through creating natural forests and planting native plant species in large scale can help them from becoming rare and endangered in near future. The native plants should be carefully conserved in order to avoid genetic drift. The disappearance of their genes can be put to halt, if they are conserved both through in-situ and ex-situ ways. The present review focuses particularly about endangered flora in the state of West Bengal.

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INTRODUCTION

Biodiversity is a key component of the global ecosystem that contributes to ecosystem stability and ecological balance (Mehta et al., 2020). India is one of the world's 12 mega diversity countries and accounts for 2.4% of the world's land area and 8% of its biodiversity (Gowthami et al., 2021). West Bengal (WB), a state in eastern India, is located between latitudes of 21°5′ and 27°16′N and longitudes of 85°55′ and 89°56′ E. It covers 87, 676 sq. km land area, which is of one-third area of the Bengal state before partition of the India, when British ruled them. Presently, the state, WB is divided into 23 districts consisting of about 400 blocks and 4300 villages (Mitra, 2021). This state of India possess flora from the glittering littoral Mangrove Forest of Sundarban delta region to the rich vegetation of the foothills of Himalaya belonging to Terai region. Vegetation in northern part of the state crowns the temperate zone belonging to district of Darjeeling Himalayas (Bhattacharyya, 1997). WB can be further divided into 5 geographical regions, including the delta region at the confluence of the Ganges River and the Bay of Bengal, the Terai-Dooars, the Western Surging Highland Plateau, the North and Bengal Plains, and the Darjeeling. The Darjeeling-Himalayan zone, which is a part of the East- Himalayan Hotspot zone and is one of these five floral zones, is the richest and most abundant region of flora in the state of West Bengal (Chakraborty et al., 1999) In this state, plants were always being used medicinally since a long time back. Although, after drugs being discovered synthetically, usage of natural medicines has fallen immensely. A commonly used medicinal plant is *Curculigo orchioides* Gaertn. of family Hypoxidaceae (Mahato & Banerjee, 2019). Nature has been very generous in her gift to the Darjeeling district. Studies related to flora have become essential mainly in northern tip of WB (Mukherjee, 2009). *Gymnemasylvestre* R.Br. of family Apocynaceae is an endangered plant found in the hills of Darjeeling (Sharma &Thokchom, 2014). Also, an endangered carnivorous plant, *Drosera burmannii* Vahl. is found in the waste lands, playing fields and sides of small bodies of water belonging to Jalpaiguri district of sub-Himalayan part of WB (Chakraborty & Bhattacharya, 2013). Traditionally, *Drosera burmannii* Vahl. is used as an anticonvulsant drug (Hema et al., 2009). About 72% of dry deciduous forests belonging to WB are found in Paschim Medinipur district of WB and are surrounded by lateritic soil (Das & Mondal, 2012). An endangered plant named *Ipomoea pes-caprae* (L.) R.Br. is found here (Das & Manna, 2021).

The endangered species became one of the most productive substitute for identification of conservation preferences. When resources for their conservation are very less, identification of hotspots where their biodiversity is very much threatened is very critical in nature (Sarvalingam & Rajendran, 2016). Endangered plants can be preserved both in-situ and ex-situ ways. There are vast ranges of endangered plants which have now been properly propagated through in-vitro pathways. It had facilitated dispersal of materials from these plants to other near and far laboratories all over the world. This is because the plant cultures do not require to be within a quarantine procedure because of their non-fertile property (Fay, 1992). As these species are endangered in nature but used extensively, it is proposed that these species must be taken under special care for their conservation. Apart from this, the species which are belonging in the zone of higher risk for extinction should be listed and mapped in their specific distribution areas for their effective conservation (Mehta et al., 2020). The studies revealed that these plants are under threat due to following reasons, (i) Loss of habitat and fragmentation of land, (ii) Introduced species having new genotype, (iii) Over-exploitation of various threatened plant species, (iv) Heavy eroded areas, (v) Erratic use of natural resources, (vi) Large-scale deforestation and conversion of microclimate or much more area of our invaluable rare plants by unauthorized person from their natural habitat (Mukherjee, 2009).

Particularly, the main intention of this chapter is to summarize our current knowledge from various studies regarding the endangered flora of West Bengal as in Table 1 and pay proper attention to provide them natural and artificial habitats for their conservation. Also, at this very time, conservation of biodiversity and ecosystem is very essential and landscape of their habitats must be managed properly.

MEDICINAL USES OF DIFFERENT ENDANGERED PLANTS IN THE STATE OF WEST BENGAL

Gymnema sylvestre **R. Br.** is an importantherbaceous plant of the family Apocynaceae. It naturally works well against diabetes and is also utilized for treatment of arthritis and osteoporosis (Tiwari et al., 2014). The plant is known as gurmar, because when their leaves are being chewed, elimination of sweet taste occurs. This plant is also used for treating diabetes mellitus (Shanmugasundaram et al., 1990). Additionally, this plant has been proven to have multiple beneficial effects like it acts as a digestion tonic and has anti-inflammatory, diuretic, blood glucose lowering, and anti-helmentic qualities. Additionally, this herb is utilised to cure leukoderma, hyperbilirubinemia, indigestion, and constipation disorders (Saneja et al., 2010).

***Curculigo orchioides* Gaertn.** of family Hypoxidaceae is also commonly known as kalimusli and is a very important medicinal plant as shown in Fig. 1. It is utilized by tribal community for treating diseases like carbuncle and cancer (Mahato & Banerjee, 2019). It has property of curing cold and removing dampness, and is also utilized to treat severe back and knee pains, and paralyzed limbs (Wu et al., 2005). In India, the tuber-like root of this plant is taken as a tonic as it can also cure diuretics. It is also used in treatment of skin diseases (Garget al., 1989). Its rhizome extracts were tested for their anti-bacterial properties against strains of Gram positive (*Staphylococcus aureus* and *Staphylococcus epidermidis*) and Gram negative (*Escherichia coli*, *Pseudomonas aeruginosa* and *Salmonella typhimurium*) bacteria (Nagesh & Shanthamma, 2009).

***Pterocarpus marsupium* Roxb.** is a tree of family Fabaceae. Different plant parts have been used to treat many diseases like the leaves for sores, skin diseases and stomach pains and flowers for getting relieve fromfever. The gum-Kino is utilized to cure diarrhea and dysentery.Also, bark of the plant is utilized asan astringent (Katiyar et al., 2016). The decoctions from bark and resin both are traditionally utilized in treatingtumours of the gland anddischarges from urethra. Their heartwood is utilized as an astringent. It also has anti-inflammatory and anti-diabetic properties (Gairola et al., 2010). From a long time ago, the plant material had been utilized as an external cooling applicantfor inflammations and headache and is also used as an anti-pyretic and anti-helminthic (Badkhane et al., 2010).

***Nypa fruticans* Wurmb.** is a mangrove palm of family Arecaceae (as in Fig. 2) which has anti-hyperglycemic property (Reza et al., 2011). Its sap is richly constituted of sugar. The sap is thus utilized for making sweets, beverages, and for producing alcohol (Prasad et al., 2013). Their fruit is also enriched with carbohydrate, fiber, minerals, and retinol (Osabor et al., 2008). Its plant part like the leaves, stem, and rootare utilized in treatment ofvarious ailments like asthma, tuberculosis, sore throat and liver diseases. It also acts to relieve pain, and could be also used as sedative and carminative. The methanolic extract from its stem and leaves are also documented to possess anti-diabetic and analgesic effects (Prasad et al., 2013).

***Nardostachys jatamansi* DC.** is a small, eternal, hairy, herbaceous, rhizome-bearing, endangered and very primitive plant of family Valerianacae (Purnima et al., 2015). It is commonly named as Jatamansi. As per Ayurveda, this plant is used to treat psychopathy, sleeplessness, high blood pressure and heart disorders (Subashini, 2007). It is also effective against Parkinson's disease, epilepsy, cerebral ischemia, and liver disorders (Ali et al., 2000). It can even bring down the levels of norepinephrine and serotonin in brain (Ahmad et al., 2006). The jatamansi oil has an anti-arrhythmic activity. It is also utilized as a flavoring component during preparing process of some medicinal oil (Purnima et al., 2015).

***Mesua ferrea* L.** is a plant from Calophyllaceae family.It is used for treating various ailments including asthma, cough, dyspepsia, fever, nausea and renal disorders. Various pharmacological properties of *Mesua* are anti-oxidant, anti-microbial, anti-viral, anti-tumor and immunomodulatory (Asif et al., 2017).Resins are made using the polymers made from the oil of the plant's seeds (Chahar et al., 2013).

***Phoenix paludosa* Roxb.** is a thorn bearing palm with thin stems which are 6 - 7 meters in height as in Fig. 3. The extracts from its stems and leaves contain anti-oxidant, anti-bacterial, and analgesic properties. They can also be used to cure diarrhea and diabetes (Lima et al., 2010; Saha et al., 2012; Mondal et al., 2018).

***Swertia chirayita* (Roxb. *ex* Flem.) Karst.** isa plant in the family Gentianaceae having common name "Chiretta". It is widely used in traditional medicine, which has actually caused its over-exploitation from the natural habitat. Now, this plant is about to become extinct from its natural wild habitat (Kumar & Van Staden, 2016). The main components of *Swertia* are Xanthones. Other important components of *Swertia* are the secondary metabolites. They play a significant part in many biological processes. They have properties like hepatoprotective, gastrointestinal, astringent and purgative, and can cure inflammation and malaria. Thus, this plant has various active healing elements that will surely be very useful for the human population (Tabassum, et al., 2012). The extracts of *S. chirayita*have showed effects against anti-hepatitis B virus (anti-HBV) (Zhou et al., 2015).

***Rauvolfia serpentina* (L.) Benth. ex Kurz.** is an eternal and hairless herbaceous plant with a woody stem of family Apocynaceae as in Fig. 4. It is also commonly called as Sarpagandha or Snake root plant. According to Ayurvedia, its roots areutilized to cure higher blood pressure, sleeplessness, psychiatric issues, gastro-intestinal problems, epilepsy, various traumatic conditions, hallucinations, schizophrenia, and mentally ill patients. This plant is also utilized as an antidote against bites of snakes and various venomous insects. As many forms of alkaloids are present in it, thus this plant is also used to cure many circulatory problems (Kumari et al., 2013). Reserpine, an alkaloid found in the plant helps to cure hypertension and issues related to CNS (Bunkar, 2017). The plant also possesses anti-fungal, anti-oxidant, anti-proliferative and anti-cancerous properties. It can also be used to cure inflammation, dysentery and diarrhoea and can be used as a tranquillizer (Kumari et al., 2013).

***Ipomoea pes-caprae* (L.) R. Br.** is used as herbal treatment in various nations to treat inflammation, diuretics and gonorrhea (De Souza et al., 2000). It is also a sand binder and its leaves and roots are mainly used for medicinal purposes (Das & Manna, 2021). Infusions of its leaves are used for treatment ofhypertension and kidney disorders. The decoctions of this plant are used in treatment of digestive problems, internally and externally occurring pains, dysentery, fatigue, arthritis, and rheumatism. It is also utilized in certain rituals to get free from evil spirits (Akinniyi et al., 2022).

IMPACT OF EXTINCTION OF ENDANGERED SPECIES ON BIODIVERSITY

While going through extensive disturbance in their biodiversity, the species diversity naturally decreases. Moderate disturbances can also lead to it in the long term. The decrease in the diversity of species depends mainly on their geographical distribution and type of species. Thus, knowing the inter-relationship between disturbance and diverse nature of species is the main thing. This will help in projecting a stage for future research ofpolicies for developing sustainably among various different species of any specificregion. Currently, there is an increase in understanding the knowledge aboutthe structure of various communities and stabilization of ecosystems. This has raised the urge to make plant inventories of particular zonal areas. This is because, it has been found that vegetation play a critical role in controlling climate andconservation of biodiversity which provides livelihood to some people of certain regions (Bhattacharyya, 2021).

Due to global warming, the temperatures of our water bodies are rising and with pollution added to it, their salinity level is also increasing alarmingly. Both phenomena are causing harm to the endangered plants of the Sundarbans like *Heritiera fomes* Banks and *Nypa fruticans* Wurmb. Also, the competition from the invasive species is causing them more harm. The invasive species are changing the floristic data of the regions as well the microbial flora of the soil which is very detrimental for these endangered plants of the mangrove forests in the Sundarbans. Added to that the exploitation of these plants by the local population is causing them much harm for them to survive in the near future. Extinction of these endangered species will cause harm to the insects like honey bees which collect nectar from their flowers and some potential animals which feed on them, and with that effect, also some other genetically aligned species could also become endangered in the near future due to the changing climatic conditions of the Sundarbans mangrove forests in the delta of river Ganges (Chakraborty, 2019).

This will must have prominent adverse side-effects in the phyto-diversities of the nearby districts within West Bengal. Thus, until strict and fast actions are taken to change this present trend, a broad variety of species within the ecosystem, inside the biodiversity, might swiftly get lost in the near future (Bhattacharyya, 2021).

LIST OF DIFFERENT ENDANGERED PLANTS IN WEST BENGAL

Scientific names	Family	Common name in Bengali	Common name	References
Acer calcaratum Gagnep.	Aceraceae	-	Maple	Basnet, 2012
Gynocardia odorata R. Br.	Achariaceae	-	-	Biswas & Das, 2021
Tetrataenium wallichii (DC.) Manden.	Apiaceae	-	-	Mukherjee, 2009
Gymnema sylvestre R.Br.	Apocynaceae	Gurmara	Gurmar	Sharma &Thokchom, 2014
Rauvolfia serpentina (L.) Benth. exKurz.		Sarpagandha	Indian snakeroot	Yonzone et al., 2012; Yonzone&Rai, 2018; Biswas & Das, 2021
Panax pseudoginseng Wall. var. *angustifolius* (Burkill) Li	Araliaceae	-	Himalayan ginseng	Yonzone et al., 2012
Panax pseudoginseng Wall. var. *bipinnatifidus* (Seemab) Li		-	Himalayan ginseng	
*Nypa fruticans*Wurmb	Arecaceae	Golpata	Nipa palm	Dey et al., 2006
*Phoenix paludosa*Roxb.		Hetal, SamudraRai	Mangrove date palm	Sen &Bhakat, 2018
Streptocaulon sylvestre Wight	Asclepiadaceae	-	-	Dey et al., 2015; Das et al., 2020
*Asparagus racemosus*Willd.	Asparagaceae	Shatavari	Climbing *Asparagus*	Das &Mondal, 2012; Biswas & Das, 2021

Arnica montana L.	Asteraceae	-	Mountain *Arnica*	Purkait& Sharma, 2015
*Canarium strictum*Roxb.	Burseraceae	Raaldhup	Black dhup	Mallick, 2020
Mesua ferrea L.	Calophyllaceae	-	Ceylon ironwood	Sharma &Thokchom, 2014; Gowthami et al., 2021
Nardostachys jatamansi DC.	Caprifoliaceae	Jatamamsi	-	Yonzone et al., 2012
*Celastrus paniculatus*Willd.	Celastraceae	Malkangani	Intellect plant, Black oil tree	Das &Mondal, 2012; Biswas & Das, 2021
Ipomoea pes-caprae (L.) R.Br.	Convolvulaceae	Chagalkuri	Beach morning glory, Bayhops	Das & Manna, 2021
Cordia macleodii (Griff.) Hook.f. &Thoms.	Cordiaceae	Sitapatra	Macleod Cordia	Deb et al., 2018
*Dioscorea prazeri*Prain&Burkill	Dioscoreaceae	Bon alu	Yam	Biswas & Das, 2021
*Drosera burmannii*Vahl.	Droseraceae	-	Tropical Sundew	Chakraborty & Bhattacharya, 2013

Rhododendron anthopogon D.Don	Ericaceae	-	-	Mallick, 2020
Rhododendron campylocarpum Hook.f.		-	-	
*Rhododendron decipiens*Lacaita		-	-	
Rhododendron maddenii Hook.f.		-	-	
Rhododendron thomsonii Hook.f.		-	-	
Rhododendron triflorum Hook.f.		-	-	
Rhododendron vaccinioides Hook.f.		-	-	
Mallotus philippensis Muell.-Arg.	Euphorbiaceae	Dalguri, Kamala, Sindure	-	Das &Mondal, 2012
Chamae cristaabsus (L.) H.S. Irwin &Barneby	Fabaceae	Benar, Chaksi	-	Das & Manna, 2021
*Indigofera dendroides*Jacq.		-	-	
Mucuna pruriens (L.) DC.		Akalchi	Velvet bean	Biswas & Das, 2021
*Pterocarpus marsupium*Roxb.		-	Malabar Kino	Sharma &Thokchom, 2014
Sarac aasoca (Roxb.) Willd.		Ashok	Ashoka	Murthy et al., 2008
Swertia bimaculata (Siebold &Zucc.) Hook.f. & Thomson ex Clarke	Gentianaceae	Chirata	Bitter stick	Boral &Moktan, 2021
Swertia chirayita (Roxb. ex Flem.) Karst.				Yonzone et al., 2012; Sharma &Thokchom, 2014
*Curculigo orchioides*Gaertn.	Hypoxidaceae	Kalimusli, Talmuli	Black musli	Mahato& Banerjee, 2019

Cinnamomum glaucescens (Nees) Hand.-Mazz.	Lauraceae	SugandhiKokila	-	Sharma &Thokchom, 2014
*Cinnamomum tenuipile*Kosterm.		-	Japanese Cinnamon	Mallick, 2020
Litsea glutinosa (Lour.) C.B. Robins.		Leda, Kukurchita, Garur	Soft bollygum	Das &Mondal, 2012
Machilus glaucescens (Nees) Wight		-	Bay tree	Biswas & Das, 2021
Gloriosa superba L.	Liliaceae	Agnisikha	Glory lily	Maiti et al., 2007
Palhinhaea cernua (L.) Vasc. & Franco	Lycopodiaceae	-	-	Sharma &Thokchom, 2014
Sonneratia caseolaris (L.) Engl.	Lythraceae	Keora	Mangrove apple	Gowthami et al., 2021
*Sonneratia griffithii*Kurz.				Barik& Chowdhury, 2014
Magnolia globosa J.D. Hooker & Thomson	Magnoliaceae	Himchampa	Globe magnolia	Mallick, 2020
Heritiera fomes Banks	Malvaceae	Sundari	Sundri	Dey et al., 2006; Gopal & Chauhan, 2006; Barik& Chowdhury, 2014; Sen &Bhakat, 2018; Sen &Bhakat, 2020
Hibiscus fragrans Roxburgh		-	-	Ghosh et al., 2013

Stephania glabra (Roxb.) Miers.	Menispermaceae	-	Hairless Tape Vine	Yonzone et al., 2012; Yonzone&Rai, 2018
Tinospora cordifolia (Willd.) Hook.f. &Thoms.		Guduchi, Giloy	Heart-leaved moonseed	
Helminthostachys zeylanica (L.) Desv.	Ophioglossaceae	-	-	Das &Mondal, 2012; Biswas & Das, 2021
Ophioglossum reticulatum L.		-	Netted adder's-tongue	Biswas & Das, 2021
Bulbophyilum appendiculatum (Rolfe) J. J. Smith	Orchidaceae	-	-	Mitra, 2021
Bulbophyllum roxburghii (Lindl.) Reichb.f.		-	-	

Dactylorhiza hatagirea (D. Don) Soo	Orchidaceae	-	-	Yonzone et al., 2012; Yonzone&Rai, 2018
Dendrobium moschatum (Buch.-Ham.) Swartz		-	-	Kanjilal et al., 1999
*Dendrobium praecinctum*Reichenb.f.		-	-	Ghosh et al., 2017
Diplomeris hirsuta (Lindl.) Lindl.		-	-	
Paphiopedilum charlesworthii (Rolfe) Pfitzer		-	-	
Paphiopedilum fairrieanum (Lindl.) Stein		-	-	Ghosh et al., 2017; Mitra, 2021
Paphiopedilum insigne (Wall. ex Lindl.) Pfitzer		-	-	Ghosh et al., 2017
Paphiopedilum venustum (Wall. ex Sims) Pfitzer		-	-	
Pelatantheria insectifera Reichenb.f.		-	-	Mitra, 2021
Phaius tankervilliae (L'Her.) Blume		-	-	Thokchom et al., 2017
*Vanda coerulea*Griff. exLindl.		-	-	Ghosh et al., 2017
Zeuxine flava (Wall. ex Lindl.) Trim.		-	-	Mitra, 2021

Cleistanthus collinus (Roxb.) Benth. exHook.f.	Phyllanthaceae	-	-	Sen, 2019
Neopicrorhiza scrophulariiflora (Pennell) D.Y. Hong.	Plantaginaceae	-	-	Yonzone et al., 2012; Kunwar et al., 2021
*Picrorhiza kurroa*Royle ex Benth.		Katuki, Kutki	-	Sharma &Thokchom, 2014
*Podophyllum hexandrum*Royle	Podophyllaceae	Himalayan Mayapple	-	Yonzone&Rai, 2018
Podophyllum sikkimense Chatterjee & Mukherjee		-	-	Yonzone et al., 2012
Rheum acuminatum Hook.f. &Thoms.	Polygonaceae	-	-	Yonzone&Rai, 2018

Aconitum bisma (Buch-Ham.) Rapaics	Ranunculaceae	-	-	Yonzone et al., 2012; Yonzone&Rai, 2018
Aconitum ferox Wall. ex Seringe		-	-	Sharma &Thokchom, 2014
Aconitum spicatum (Bruhl.) Stapf.		-	-	Yonzone et al., 2012
Cotoneaster sandakphuensis G. Klotz	Rosaceae	-	-	Mallick, 2020
Luvunga scandens (Roxb.) Buch.-Ham. ex Wight &Arn.	Rutaceae	Lavanga-lata	-	Bhattacharyya, 2021
Zanthoxylum acanthopodium DC.		-	Andaliman	Yonzone&Rai, 2018

Viscum album L.	Santalaceae	-	European mistletoe	Yonzone et al., 2012; Yonzone&Rai, 2018
*Viscum liquidambaricolum*Hayata		-	-	Yonzone et al., 2012
Taxus baccata L. sub.sp. *wallichiana*Zucc.	Taxaceae	-	English Yew	
Boehmeria rugulosa Wedd.	Urticaceae	Dar	-	Mallick, 2020
Valeriana jatamansi Jones	Valerianaceae	-	Indian Valerian	Mukherjee & Chakraborty, 2014; Chakraborty et al., 2015; Maurya et al., 2017
Ampelocissus barbata (Wall.) Planch.	Vitaceae	-	Wild grape	Biswas & Das, 2021
Alpinia calcarata (Haw.) Roscoe	Zingiberaceae	-	Snap ginger	Biswas & Das, 2021
Amomum kingii Baker		-	King's ginger	Bhadra&Bandyopadhyay, 2017
Curcuma caesia Roxb.		Kaloholud	Black turmeric	Chowdhury et al., 2020

Table 1: Names of all documented endangered plants in the state of West Bengal (arranged in alphabetical order from their family names).

Figures:

Fig. 1: *Curculigo orchioides* Gaertn

Fig. 2: *Nypa fruticans* Wurmb

Fig. 3: *Phoenix paludosa* Roxb.

Fig. 4: *Rauvolfia serpentina* (L.) Benth. Ex Kurz.

CONCLUSION

Above studies directed various endangered plants from different regions of West Bengal. In the recent times, different primary and secondary metabolites synthesized by plants and various other complex chemical substances that are helpful to cure diseases and have other uses have been recognized for the use in the pharmaceutical industries and domestic purposes. Thus, currently the recent perception ofsurvival of these important valuable plantshave come into existence, which actually became the root cause for the need of plant tissue culture based techniques to further propagate theseendangered plant species in different parts of the world. This report can help in finding out and documenting the endangered plants spreading throughout the state of West Bengal and ways in which we can conserve them for future.

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5 Carbon Sequestration of Mangrove Trees Enhancing the Climate Change Mitigation

Suresh A. Palve and Ajit B. Telave

INTRODUCTION

Carbon is an element commonly found on earth in various forms which is essential element of all life forms. The bodies of living organisms and non-living things like oil, natural gas, coal, rocks and air contains large amount of carbon. Globally carbon is found in a variety of different stocks as oceans, fossil fuel deposits, terrestrial system and the atmosphere (Kiran *et al*., 2011). In the terrestrial system, carbon is stored in rocks, sediments, swamps, wetlands, forests, forest soils, grasslands and agriculture. About two-thirds of global terrestrial carbon is found in forests and forest soils (Alamgir, *et al*., 2007). In addition, there are some non-natural human-created carbon stocks like wood products and waste dumps. Carbon dioxide (CO_2) concentration has grown by 31% from 280 ppmv in 1850 to 380 ppmv in 2005, and is now growing at 1.7 ppmv yr^{-1}, or 0.46% yr^{-1} (WMO 2006; IPCC 2007). Methane (CH4) and nitrous oxide (N2O) concentrations have also continuously risen during the same time period (IPCC 2001, 2007; Prather et al. 2001; WMO 2006). Increasing carbon concentration in the earth's atmosphere led to an imbalance in the carbon budget and raising serious issue in the human life. Hence the needs to improve understanding of carbon sequestration within global ecosystems and investigate solutions to mitigate the effects of resulting climate change in nowadays (Howard *et al*., 2017).

Carbon sequestration is effective natural process of capturing, storing and removing atmospheric carbon dioxide (Sedjo, 2012).

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The carbon sequestration mechanisms point of view, there are different systems of carbon sequestration like biological, geological, and chemical system. The physical and chemical system are based on reactions and engineering techniques without involvement of living organisms. The physical and chemical strategy of carbon sequestration in oceanic and geological structures has received large attention (Freund & Ormerod 1997), because theoretically physical and chemical sequestration has a larger sink capacity than biotic sequestration (Kerr, 2001). But biological systems are one of the natural and cost effective technologies which gives solutions to the most dreaded problems of all times and important for formulating energy policies for future economic growth and development at national and global scales. Carbon is transported in complex form ($CO_{2)}$ in an ecosystem, it sinks in the form of biomass by plant photosynthesis, which uses sunlight to combine CO_2 from the atmosphere and water to form glucose a simple sugar that is stored directly in the tissue of living plants; and indirectly, by the microbial decomposition of the biomass of plant and animal tissue. Into other compounds like carbohydrates, amino-acids/proteins, organic acids, wax, coal, oil, and natural gas etc., (Atkin *et al*.,2012). The photosynthetic fixation of atmospheric CO_2 in plants and trees could be of great value in maintaining a CO_2 balance in the atmosphere (Trumper *et al.* 2009). The atmospheric carbon removing and storing in green plants, that's called sink. These sinks are aboveground biomass of living organisms and belowground biomass in soil, root system and microorganisms (Jina*et al*., 2008). Many reviews have been published various aspects of biotic carbon sequestration like forest, grasslands, microbes, wetlands and soil carbon sequestration (Bruce *et al.*, 1999; Lehmann 2007; Lal 2008).

Forests, soils and wetlands plays significant role in terrestrial carbon sequestration process in which wetlands play an important and complex role in the global carbon cycle. They contributing to the ecosystem service of greenhouse gas regulation through carbon sequestration (Mcleod*et al.*, 2011). Coastal wetlands are some of the most biologically and geochemically active regions within the biosphere (Gastusso*et al*., 1998). Coastal wetlands in particular are gaining increasing recognition as efficient carbon sinks (Bouillon *et al.*, 2008). Wetlands have unique biogeochemical characteristics, accreted sediment and organic matter which increase their potential for carbon storage as compare to other terrestrial ecosystems (Bridgham*et al*., 2006). Tidal and saline wetlands have continuously accreted and bury sediments that are rich in organic carbon while emitting negligible amounts of greenhouse gases such as CH_4 because of the saline and anaerobic environment (Pof-fenbarger*et al.* 2011). Mangroves, sea grasses and tidal salt marshes are highly productive ecosystems. They sequester carbon 10–50 times faster than terrestrial systems (McLeod *et al.*, 2011). A combination of high productivity, anaerobic conditions and high accumulation rates account for the high carbon storage capacity of particular mangrove ecosystems (Chmura *et al.*, 2003).

NEED OF CARBON SEQUESTRATION

The CO^2 concentration has rapidly increased in the past 50 years due to anthropogenic processes such as soil exploitation, land use change, deforestation, biomass burning, draining of wetlands and more use of fossil fuels (Lal, 2001). The atmosphere is being overloaded by fire, thermal power generation, logistics, transport, and many other humans made activities. The biggest environmental problem facing society in the twenty-first century is the need to stabilise atmospheric quantities of greenhouse gases (Smith, 2007). The average temperature of the earth is increasing as a result from increasing greenhouse gas concentrations, which is also disturbing the biological balance between animal and plant species. Climate change is one of the major risks on planets for survival of all living organisms. Sea levels are rising as oceans get warmer. Crops, biodiversity and freshwater resources are all at danger due to the ongoing, severe droughts. The diversity of life on our world is affected by the changing climate, from polar bears in the Arctic to marine turtles off the coast of Africa (Taj *et al.*, 2020). Human populations around the ocean, forest, and coral reefs are particularly vulnerable to climate change. The carbon dioxide is a main greenhouse gas. The main reason of carbon dioxide emission is industrial activities (O'Neill *et al.*, 2012). The majority of its emissions come from the burning of carbonaceous fuels. To reduce the effects of climate change or global warming to must be CO_2 emissions decreased. The requirement for electricity must be supplied by the production of energy from nuclear, hydro, fossil fuels, and coal in significant quantities, but CO_2 emissions must be decreased, clean coal technologies and efficient, clean coal combustion must be created. The different approach to helping in reducing the level of greenhouse gas. Capture and Storage Technologies are used to reduce the emission of Greenhouse gasses by capturing the CO_2 gas from the possible surface (Herzog, *et al.*, 2000). sequestration of atmospheric carbon dioxide as organic carbon in the biosphere attracts attention as an alternate way to help to reduce the rate of greenhouse gas and associated changes in our climate.

MANGROVE CARBON SEQUESTRATION

Mangroves are coastal forest ecosystems that may be found in the coastal intertidal zones of tropical, subtropical and warm temperate parts of the world. They grow on unconsolidated soil layers. Mangroves provide a multitude of benefits, such as the preservation of fisheries and biodiversity in coastal and estuarine water masses, as well as the defence of coastal regions against the force of wind and waves (Mazda *et al*., 2006). Over the last 20 years, research has confirmed that mangrove forests assist additional environmental function by carbon sequestration (Alongi, 2014). Twilley *et al*., (1992) reported that mangroves are the most productive ecosystems in world and also have one of the highest carbon storage capacities per unit area. Kathiresan *et al*., (2008) reported that greatest potential for mangroves to capture and store atmospheric carbon and this helps to keep the ecosystem's balance. National Geographic magazine (Feb, 2007) statement on the mangrove ecosystem is also known as a "carbon factory" because it has the highest net carbon productivity of any natural ecosystem. Mitra *et al*., (2011) Research has shown that coastal vegetation sequesters carbon more effectively and permanently than land forests. Donato *et al*., (2011) reported that world's mangrove forests carbon sequestration five times more than any other tropical forest. Alongi. (2014) studied the characteristics of mangrove carbon cycling and reported that mangroves carbon sequestration about 6 times more than other subtropical and tropical coastal ecosystem. According to IUCN (2009) mangroves store approximately 25.5 million metric tonnes of carbon annually and per hectare carbon sequester approximately 1.5 tonnes. This is comparable to the amount of carbon dioxide that a vehicle releases into the environment per year, (assuming that each car uses approximately 2,500 litres of fuel annually) by Spalding (2010). Alongi (2012) reported that mangroves allocate proportionally more carbon belowground, and have higher below- to above-ground carbon mass ratios than terrestrial trees and the most mangrove carbon is stored as large pools in soil and dead roots. Alongi (2014) observe that the Mangrove forests carbon store more than other ecosystems per unit area, particularly in soils; among a mean whole-ecosystem carbon stock of 956 tha^{-1}, soil organic carbon (SOC) constitutes 75% of the carbon pool.

INDIA MANGROVES CARBON SEQUESTRATION

In India, mangrove spreads over an area of 4,975.00 km^2 occupying only 0.15% of the geographical area of the country and 3% of globe and 8% in Asian mangrove cover (FAO, 2019). India with a long coastline of about 4,975.00 km^2, including the island territories (Anon, 2001), In India Mangroves occupy 4740 km^2, about 3 % of the world's mangrove cover. (Shedage*et al.,* 2018). These mangrove habitats (69°E89.5°E longitude and 7°N-23°N latitude) comprise three distinct zones: East coast habitats having a coast line of about 2700 km, facing Bay of Bengal, West coast habitats with a coast line of about 3000 km, facing Arabian sea, and Island Territories with about 1816.6 km coastline. According to FSI (2011) West Bengal has been covering the largest area (42.45%) under mangrove formations that includes Sundarbans Biosphere Reserve, followed by Gujarat (23.6%) and Andaman & Nicobar Island (12.39%) complex. Other state by Andhra Pradesh, Maharashtra, Odisha, Tamil Nadu, Goa, Karnataka and Kerala cover by Area under mangroves (8.12%), (5.04%) (6.44%), (0.90%), (0.52%) and (0.20%), (0.18%) respectively. Sundarbans in India is the largest man-grove site in the world, colonized with many threatened animal species (Shedage*et al.,* 2018). The long coastlines and their mangrove vegetation have massive role to protecting coastal biodiversity. The carbon sequestration of mangrove in India work has been done by some scientists. Singh *et al.,* (2005) reported the mangrove wetlands of are the important sources of biological diversity and world's second largest source of primary productive ecosystems next to rainforests. They have capacity to trap significant quantities of phosphorus which play a key role in biogeochemical cycle. Kathiresan and Khan (2010) they have observed coastal mangrove flora has higher biomass and carbon sequestration potential than other aquatic flora. But due to its extensive use, anthropogenic activities, climate change, storms etc. has lead to decreased area of mangrove (Banerjee *et al.* 2015). Patil *et al.,* (2012) reported mangroves to be good sequesters of carbon. But mangrove carbon sequestration is depending on numbers of factors such as physical (waves, tides, erosion, accretion etc.), biological (vegetation types and density) and anthropogenic (urbanization, barrage, discharge, nature of livelihood etc.) Noordwijik*et al.,* (1997) reported carbon sequestration in the mangrove forest depends on geographical location, mangrove species and their biomass. Mukherjee (2007) reported carbon sequestration in the mangrove shows variation as per age of plantation. A similar observation was reported by Mitra (2011). Carbon sequestration is highest in young forest and will tend to reduce as forest reach maturity. Sahu*et al.* (2016) did a comparative study on physico–chemical parameters, diversity, biomass and carbon stock potential of natural and plantation mangrove forest of Mahanadi Delta, Odisha. They reported carbon stock in plantation 60.9±13.9 tha^{-1} and natural mangrove forest 54.3±7.4 tha^{-1}. Kathiresan *et al.,* (2013) reported mangroves biomass depends on physicochemical parameters like rate of carbon sequestration, height, DBH, growth, net canopy photosynthesis, growth efficiency, leaf longevity and sediment. This parameter depending on season, type and age of the species. Banerjee *et al.* (2012) studied anthropogenic and natural effect on characteristics of soil. They observed the SOC, pH and salinity of the Sundarbans ranges between 1.02%, 7.47±0.071, 9.75 psu and 0.64%, 7.57±0.067, 13.85 psu in anthropogenic and natural forest region respectively. They reported that SOC is influenced by physical, biological and anthropogenic factors of the mangrove forest. Banerjee *et al.* (2012) studied salinity based allometric equations for biomass estimation of Sunderban mangrove. They observed the Salinity affects the growth of biomass negatively in the mangrove species such as *Sonneratia apetala*. Shinde (2018) studied on carbon sequestration in mangrove habitats of Mumbai region they observed mangrove parts show a different potential level for carbon sequestration. Mangrove leaves show second largest carbon stock, because leaves are absorbing atmospheric carbon through photosynthesis & carbon becomes a part of their biomass. Mangrove root exchange or uptakes carbon from their adjacent regions. Here roots show least amount of carbon stock than other parts which are probably due to polluted sediment quality.

Roy Chowdhury (2014) examined Indian Sundarbans they estimated the AGB of *S. apetala*, *E. agallocha*, *A. marina*, *A. alba* and *A. officinalis* of even age group of ≈12 years and reported the AGB of the selected species ranged between 12.37±1.39 to 73.09±6.88 tha^{-1} with an average value of 49.37 tha^{-1} and 38.32tha^{-1} in western and central sector of Indian Sundarbans respectively. Mitra *et al.,* (2011) studied the AGB and AGC of the *S. apetala, E. agallocha* and *S. alba*. They found that AGB and AGC varied significantly with stations due to salinity difference. The stored carbon in the AGB exhibited the trends stem > branch > leaf. Vinod Kavungal*et al.,* (2018) assess the biomass of mangroves in the Kadalundi wetland, south-west coast of India and evaluated the potential of *A. officinalis R. mucronata B. cylindrica S. alba and E. agallocha* mangroves to sequester and store carbon. The C-stocks of above-ground and root biomass were 83.32±11.06 t C ha^{-1}

and 34.96±4.30 t C ha^{-1} respectively, while the C-stock in sediment was estimated to be 63.87±8.67 t C ha^{-1}. Sankar *et al.*, (2014) estimated the biomass carbon and total SOC of Muthupet mangrove, Southeast Coast of India. They reported biomass carbon of leaf and stem ranged between 35.16% (*Suaedamonoica*) to 54.06% (*A. corniculatum*), 51.61% (*A. ilicifolius*) to 54.06% (*A. corniculatum*). Joshi and Ghose (2014) studied the diversity and AGB along with physicochemical characteristics of sediment in Indian Sundarbans. They found that AGB was low ranged from 8.9 tha^{-1} to 50.9 tha^{-1} high range in different communities, depending on the structural characteristics and tidal flood significantly affected the biomass. Manna *et al.,* (2014) studied the AGB and carbon stock of 5yearold*A. marina* plantation in India Sundarbans of an area approximately 190 ha using high resolution satellite data. They reported 236 tha^{-1} of biomass and 54.9 tha^{-1} of carbon stock in above ground. Pandey and Pandey (2013) have examined the carbon sequestration by mangroves of Gujarat. A total 8.116-million-ton carbon has been sequestered by mangroves of Gujarat. Vinod Kavungal *et al.,* (2018) assess the biomass of mangroves in the Kadalundi wetland, south-west coast of India and evaluated the potential of *A. officinalis, R. mucronata, B. cylindrica, S. alba and E. agallocha* man-groves to sequester and store carbon.

WORLD MANGROVES CARBON SEQUESTRATION

The world's total mangrove covers 15 million hectares, equivalent to 1% of the world's tropical forests. Mangroves are found mostly in 123 tropical and subtropical countries and territories. Asia has the world's largest mangroves. About 40% of the world's mangrove forests are in Southeast and South Asia, followed by South America, North and Central America, and West and Central Africa. Among the remaining six regions (South Asia, Australia/New Zealand, East and South Africa, Pacific Ocean, East Asia and Middle East), South Asia has the highest share at 6.8% and contains 10,344 km^2 of mangrove forest. India has about 3% of the total mangrove cover in South Asia. (Forest Survey of India, 2019). The last 20 years increasing interest in studying storage and flux of carbon or organic matter in mangrove ecosystems. In particular, the ''outwelling'' hypothesis, first proposed for mangroves by Odum (1968) and Odum and Heald (1972) suggested that a large fraction of the organic matter produced by mangrove trees and exported to the coastal ocean, where it should form the basis of a detritus food chain and they supporting to coastal fisheries.

The number of reports available on mangrove biomass from different regions in world. AGB of 460 tha^{-1} was reported from a forest dominated by *R. apiculata* in Malaysia (Putz and Chan, 1986). AGB of more than 300 tha^{-1} was documented in mangrove forests in Indonesia (Komiyama *et al.* 1988) and French Guiana (Fromard*et al.,* 1998). The AGB was less than 100 tha^{-1} in most secondary forests or concession areas. In high latitude areas (>24° 23`N or S), primary forests mostly have AGB of around 100 tha^{-1}, however, even at 27° 24′ S, an AGB of 341 tha^{-1} was reported for an *Avicennia marina* forest (Mackey, 1993). The lowest AGB reported was 7.9 tha-^{1} for a *Rhizophora mangle* forest in Florida, USA (Lugo and Snedaker, 1974). The canopy height of mangrove forests is generally lower at higher latitudes (Saenger and Snedaker, 1993) which is a justified reason for relatively lower AGB in higher latitudes. Alongi (2012) studied on Mangrove carbon stocks and they have been measured in 52 countries on world. It's reported that total ecosystem carbon stocks are, on average value, greatest on the Pacific Islands (987.4 Mg C ha^{-1}) of Kosrae, Yap and Palau, followed by mangroves in Southeast Asia (860.9 Mg C ha^{-1}), Central and North America and the Caribbean (777.7 Mg C ha^{-1}) and Africa (664.2 Mg C ha^{-1}). Total ecosystem carbon stocks were considerably lower in Australia and New Zealand (563.4 Mg C ha^{-1}), South America (424.0 Mg C ha^{-1}), South and East Asia (395.5 Mg C ha^{-1}) and the Middle East (248.4 Mg C ha^{-1}).

Mangroves carbon stock and sequestration in the aboveground biomass depend on mangrove forests age, dominant species, locality latitude, climatic parameters, physiographic types and age (Komiyama, 2008). According to Estrada*et al*., (2017) It was shown in this study that at the global/ regional scale, carbon stock increases towards the Equator and its variability is dependent on climatic parameters like primarily temperature of coldest periods, isothermality, annual precipitation and water balance. The highest aboveground biomass (460 tha^{-1}) was found in a forest dominated by *R. apiculata* in Malaysia (Putz and Chan, 1986). The lowest aboveground biomass reported was 7.9 tha^{-1} for a *Rhizophora mangle* forest in Florida, USA (Lugo and Snedaker, 1974). The canopy height of mangrove forests is generally lower at higher latitudes (Saenger and Snedaker, 1993). Therefore, in low latitudes, primary or mature mangrove forests generally have high aboveground biomass. The aboveground biomass is always low in temperate areas and may be related to different climatic conditions, such as temperature, solar radiation, precipitation and frequency of storms. Fromard*et al.*, (1998) estimated the aboveground biomass to be 180.0 and 315.5 tha^{-1}, respectively for *Avicennia* and *Rhizophora* stands in French Guiana. According to this studies aboveground biomass tends to be relatively low in stands near the sea and increases inland. Mangrove forests usually show ''zonation'' patterns. In Southeast Asia, *Sonneratia* or *Avicennia* stands are often found on the sea front, and *Rhizophora* or *Bruguiera* stands are distributed more inland (Watson, 1929), although Ellison *et al.*, (2000) questioned the concept of ''zonation''. Fromard*et al.*, (1998) estimated the aboveground biomass to be 180.0 and 315.5 tha^{-1}, respectively for *Avicennia and Rhizophora* stands in French. The number of scientist studies on pattern of biomass allocation to the aboveground organs of *Rhizophora* stands is shown results in all stands, stems and branches comprise the largest proportion of aboveground biomass. A tendency exists for the stem and branch portion to become larger as total aboveground biomass increases. The biomass of prop roots accounted for 15–17% of the aboveground biomass in mature stands. Cairns *et al.* (1997) reviewed root biomass studies conducted worldwide in upland forests, finding that root biomass is normally below 150 tha^{-1}. The prop roots formed a part of the root system of *Rhizophora* trees that was nearly equal to the branch biomass. Leaf biomass comprised the smallest portion of aboveground biomass and varied from 0.4 to 29.8 tha^{-1}. In mature forests, the leaf/woody biomass ratio was quite low.

CONCLUSION

The information provided here supports the idea that mangrove habitats are some of the most carbon rich ecosystems in the tropics. It was show in this study that at the mangroves are beneficial and chief alternative way to reduce the rate of greenhouse gas and associated changes in our climate. Mangroves carbon stock and sequestration in the aboveground biomass dependence on mangrove forests age, dominant species, locality latitude, climatic parameters, physiographic types and age. In this study that at the global/ regional scale, carbon stock increases towards the Equator and its variability is dependent on climatic parameters, primarily temperature of coldest periods, isothermality, annual precipitation, and water balance.

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6

Ecological and Cultural Aspects of Sacred Grove: A Study among the Santals of Odisha

Sk. Siraj Ali and Sk Md Abu Imam Saadi

ABSTRACT

Sacred Grove or Jahera is famous for nature worship and the concept of "sacred" implies that something maybe sacrificed in the name of religion. It is an animated component among the tribal society as well as the santal society. Sacred groves are covered of primary and natural forests, protected through socio-cultural lawsby the local communities near their villages and are always dedicated to certain deities. This practice of conserving such groves is linked to society since the beginning of the human settlement. Based on this evidence; this paper highlights the conservation and cultural values of the sacred grove of Keonjhar district in Odisha. The present study indicates the role of sacred groves in Ecological and Cultural aspects through faith, belief, religious activity and community participation.

Keywords: *Culture, Conservation, Sacred Grove, Odisha.*

1. INTRODUCTION

Traditionally protected areas are considered to be the cornerstones of the protection of biodiversity and the best wildlife habitat. Protection of natural resources has been a part of the world's different cultures since time immemorial. Sacred groves are culturally protected areas that are devoted to ancestral and tree spirits. These groves are of significance from anthropology, botany and ecology. Due to religious

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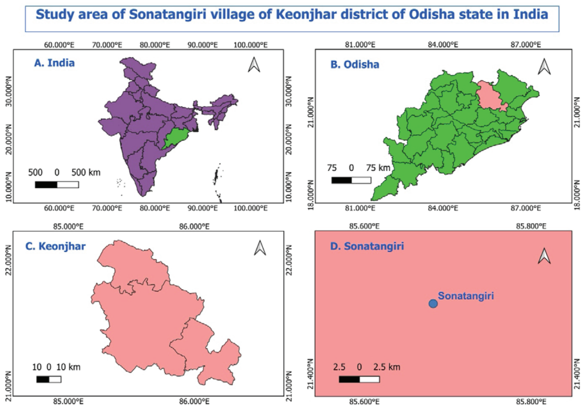
beliefs and traditional rituals indigenous practices are associated with them and have been running through several generations (Mulder & Coppolillo, 2005). Depending on the past, they can consist of multilayer, multispecies, very dense primary forests with semi-climax vegetation. Traditions of nature conservation formed around the world refer to specific examples from rich biodiversity countries where such traditions have been upheld, even today. Because of their long history, local tradition and the desire of local people to protect and preserve the natural sacred sites/groves; play a valuable role in the preservation of biodiversity (Doffana& Were 2019). A significant tradition of nature worship is that of dedicating and according protection of patches of forests to ancestral spirits/ deities. These vegetation patches have been designated as Sacred Groves (SGs). Such a grove may consist of a multi-species, multi-tier primary forest, a clump of trees belonging to one species, or even a single old tree, depending on the history of the vegetation and local culture (Malhotra *et al.* 2000). Although there is a variation in the way these groves have been defined/ described, most of the scholars emphasize the near natural nature of the vegetation and the preservation of vegetation and/or biodiversity through local taboos and sanctions that entail spiritual and ecological values (Malhotra *et al.* 2007). Thus, sacred groves are segments of landscape, containing vegetation and other forms of life and geographical features that are delimited and protected by human societies under the belief that to keep them in a relatively undisturbed state is an expression of important relationship to the divine or to nature (Hughes and Chandran 1998).

2. MATERIALS AND METHODS

2.1. Study Area

Keonjhar is a land locked district with an area of 8240 Sq. Km. It is situated in the northern part of Odisha. It is surrounded by Singhbhum district of Bihar in the North, Jajpur in the South, Dhenkanal and Sundargarh in the West and Mayurbhanj and Bhadrak in the East. It lies between 21°1′N and 22°10 and latitudes, between 35°11′ and 86°22′ longitude and 480-meter altitude.

For the purpose of the present research Santal tribal community residing at Sonatangiri village under Ghasipura police station of Anandapur sub-division, Keonjhar district of Odisha has been selected.



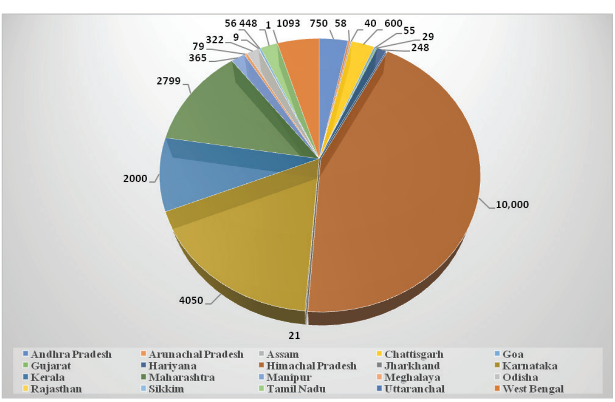
2.2. Standard Anthropological Methods

There are several methods and techniques for collecting ethnographic data. The data were collected by adopting all the standard anthropological methods like-

a) Participant observation method
b) Questionnaire method
c) Focus group discussion
d) Interview method
e) Case history

3. DISTRIBUTION OF SACRED GROVES IN INDIA

Malhotra *et al.* (2007) in their recently published book have provided State-wise distribution of reported sacred groves in India.



4. RELIGIOUS AND CULTURAL ASPECTS OF THE SANTALS TRIBE

The Santals are one of the largest tribes of India, spread over a wide area in Bihar, Odisha and West Bengal. Some of them also migrated to Tripura, Assam and Bangladesh as plantation labours in tea garden. Racially, the Santals show affinity to Proto-australoid; linguistically they belong to the Austro-Asiatic group of family. Their dialect has got some similarity with the Mundari speaking people. The Santals in general, are bi-lingual. Besides their mother tongue, they have adopted regional languages which are current in their habitation. Recently they have introduced their own script known as *Olchiki*. Numerically, the Santals accounts for more than 3.5 million and the same is constituting 9.5 percent of the total tribal population in India.Historically, the Santals have been migrating to long distances from their place of origin which is considered to be in the Dumka and adjoining hill areas of Chotonagpur, Bihar.

The Santals primarily eke out their living from agriculture. However, a significant amount of their cash income is earned by way of selling of Non-Timber Forest Produces (NTFP). In the recent years, with the intrusion of heavy and ancillary industries, a lot many of them have switched to the secondary sector. Very few of them are found to be engaged in the white-collar jobs. On the whole, their economic conditions are not very good and no wonder that a large many of their women folk are found earning their income by stealthily head-loading timber from the Government Forest. With the emergence of multi-cropping of paddy and different cash-crops a large number of them are found to work as seasonal migrant labourers.

The Santals have their own religion replete with the notion of supreme God ***Marangburu*** tutelary deity and a number of other subsidiary deities and spiritual forces benevolent and malevolent. Many of these deities are linked to natural elements like trees, animals, forests, stones, hills, water, stream, river etc. Sometimes they are also found to adopt the Hindu Gods and Goddesses. This identification however, is found to oscillate according to the political economic changes sweeping the area. Under the missionary influence, a few of the Santals have been proselytized into Christianity.

5. ENVIRONMENTAL AND SOCIO-ECONOMIC SIGNIFICANCE

5.1. Relationship between Sacred Grove and a Santal Village

The Santali word *Ato*comes closer to the English word village. The *ato* is one of the formally recognized territories of the Santals (Orans 1965). In 1887 an old Santal sage, Kolean*guru* described to Rev.L.O.

Skrefsurd about building and establishing a new village by the Santals (Bodding and Konow 1940). The description had special reference where there was forestland. Therefore, the present author conducted ethnographic fieldwork among the Santals living in the hill-forest environment of Ajodhya hills in the Puruliya district of West Bengal, where even today they build and establish new villages in the forest land (Chakrabarty, 1987).

The fieldwork revealed that whenever the Santals establish a new village they left standing a virgin patch of forest near the end of the newly prepared *kuli* or village road. This virgin patch is selected as sacred grove or *jahera by* a number of Santal men who become possessed by the national *bongas* or spirits of the Santals. It is noticed that the *jahera* so selected usually contains certain species of plants (Table.1). It was noticed by the present author that various portions of these plants were used during the socio-religious practices related either with the rites of passages or the economic activities of the community (Sen, Bhakat and Sanjeet, 2020). However, it is strictly prohibited to collect any portion of any variety of the trees, plants or grasses that are left standing or grown in the demarcated sacred grove. Similar prohibition is followed in the case of animals, birds or insects living within the *jahera* or sacred grove.

Table.1: Some Plant Species of Sacred grove and their Conservation status

Local Name	Scientific Name	Family	Conservation status
Sirom reeds	*Chrysopogon zizanioides* (L.) Roberty	Poaceae	Not Evaluate
Dhubi grass	*Cynodon dactylon* (L.) Pers.	Poaceae	Not Evaluate
Karam tree	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	Not Evaluate
Sarjom tree	*Shorea robusta* Roth	Dipterocar-paceae	Least Concern
Atnak tree	*Terminalia elliptica* Willd.	Combretaceae	Not Evaluate
Matkom tree	*Madhuca longifolia* (J.Konig) J.F.Macbr.	Sapotaceae	Not Evaluate
Murut	*Butea monosperma* (Lam.) Taub.	Fabaceae	Not Evaluate

Ichak	*Woodfordia fruticosa* (L.) Kurz	Lythraceae	Least Concern
Loa or fig	*Ficus racemose* L.	Moraceae	Least Concern
Gundli	*Panicum sumatrense* Roth ex Roem. & Schult.	Poaceae	Least Concern
Sama grass	*Echinochloa colona* (L.) Link	Poaceae	Least Concern
Sumtubukuchgrass	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Not Evaluate

The Santals define their particular village in terms of their allegiance to a particular sacred grove or *jahera* (Fig-1&2), which they believe to be the abode of their supreme deity — the *marangburu*. Culshaw has appropriately described this deity as a kind of "national spirit" for the tribe (Culshaw 1946). The other deities of the grove are *jaherera, lita, gosai era, moreko* and *tureko*. These deities are also nationally or ethnically shared by the Santals (Dutta Majumdar 1956). Centring on the *jahera*avillage or headman's council is formed. The head of this council is called *Manjhi*. The other office bearers of this council are namely *Naeke* (the village priest), *Kudam Naeke* (the priest of the outskirts), *Jog Manjhi* (in charge of the young boys and girls of the village) *Paranik* (the headman's assistant) *Jog Paranik* (assistant of the *jog manjhi*) *and Godet* (head man's messenger). All other households who show their allegiance to this particular *jahera*are also considered members of that *jahera* centric village council (Ali 2017). The council so formed, is also locally called *Shola Ana* by the Santals. However, despite the egalitarian nature of the village council, it is customary among the Santals that during the celebration of ritual and social feast in the Santal family, in connection with the birth, marriage and death (i.e., rites of passage), significant roles are attributed only to the office bearers of the village council. Thus, a number of Santal families who are socio-religiously connected to a particularly sacred grove and that grove-centric village council, - constitute an *ato*or Santal Village. Troisi (1978) mentions that the association of a village with a sacred grove expresses the unity of the group. No two Santal villages share the same sacred grove, and this serves as an important criterion to ascertain village membership and geographical boundary.

Fig. 1: Sacred Grove of Santal inside the village

The meeting of the sacred grove-centric village council is called *kulidurup* and it is presided by the village headman or *manjhi*. All the male head of the families of the *ato*or santal village assist the headman in resolving the matters related to the village affairs. All the people in the village will have to follow the resolutions adopted in the meeting of the village council or *Sholo Ana*. The resolutions may be related to hunting and gathering, horticulture and agriculture, community feasts and festivals, religious instruction and worship, marriage and divorce, disposal of dead and the final funeral ceremonies, witchcraft, strife and dispute, crime and misdeeds etc.

Fig. 1: Sacred Grove of Santal village alongside forest

6. RITUALS RELATED TO HUNTING-GATHERING

6.1. *Baha* or Festival of New Flowers

The Santals have one important ritual related to hunting gathering in the forest. One of them is *baha* (festival of new flowers) and the other is *disamsendra,* which is a symbolic hunt to define the *disham* (country) of the Santal. *Baha* festival is celebrated in the full moon night of the month of *Falgun* (February-March). In the first week of *Falgun* (February-March), a meeting of the village council is convened to work out the details of the programme related to this ritual and festival. In the morning of the day of ritual the *godet* goes round levying a toll comprising one fowl and one S*era* rice from each and every house of the village. The *yogamanjhi* along with the young men of the village remain busy to construct erect four platforms with the help of the branches and twigs of *Shal* tree. These platforms are considered as the temporary resting place of their deities. After building the platform the *yogmanjhi* leads the young men to the forest and collect the flowers of *sarjom* (*Shorearo busta*), *matkom* (*Madhuca longifolia*), *murut* (*Butea monosperma*), *ichak* (*Wood for diafruticosa*) (Table.1). These flowers are specially worshipped during *baha.* In the evening, in presence of the village council and young men of the village the priests perform the worship in the same manner as it was in case of *ero sim and maghi sim* rituals. So long *baha* festival does not take place, it is forbidden for the villagers to collect honey from beehives; sucking honey-like juice from *murut* and *ichak* flower. It is also forbidden to consume *matkom* flower and fruit of *loa* or fig (*Ficus racemosa*) and any kind of tender leaves. This prohibitory period lasts for fifteen days commencing from the first day of the new moon night of *Falgun* and ending on the full moon day when *baha* festivals take place.

7. ECOLOGICAL SIGNIFICANCE OF SACRED GROVE CENTRIC RITUALS

From the above description, it appears that economic activities are purely community affairs among the Santals and are conducted by the village priest under the overall supervision of the traditional village council, which is centered on the sacred grove, or *jahera* of the village. It is compulsory for every household of the village to contribute a fowl and a

handful of rice on the occasion of these rituals and festivals associated with the economic activities of the villagers. Moreover, in such occasions, the village council adopts some resolutions, which are integrally connected or functionally related to the economic activities of the village.It is only natural to conclude that *jahera* and the village council centered on it determines the agricultural cycle of a santal village. The conclusion is based on the fact after the *maghisim* festival, the individual farmers of the *jahera* centric village notionally surrender their lands and the farmers are discouraged to cultivate their lands and their cattle are allowed to graze freely owing to the fact that the village council relinquishes its guardianship.

The next question is why agricultural year ends in the month of *Poush* (December-January) but the next agricultural activities do not start before the month of *Jaistha* (May-June). The answer probably is that the Santals do not really have a functional concept of agricultural cycle. In fact, they have accepted that all agricultural activities within their habitat must remain closed between the end of *Pous h*and the second week of the month of *Jaistha* for the seasonal specificities of the climate of the region. What they have perceived through their long interaction with local ecology is the existence of an agricultural season, which is ushered in by the ritual of *erosim* in the second week of *Asar* (June-July) with the commencement of the monsoon. This ritual is essentially a village affair in that every family belonging to the *jahera* centric village is made to contribute to and participate in the ritual.It is only after this ritual that a Santal has the freedom to upturn the soil of maize field and is advised to transplant the paddy saplings as well as to employ someone to look after the grazing of cattle. The implications are manifold. If he opens the face of the soil of his maize field by upturning it before the onset of the monsoon, then he would only suffer by aiding the process of moisture loss through faster evaporation. Similarly, if he transplants his paddy, then he may suffer from a delayed onset of the rains; and if he leaves his cattle unguarded then it may destroy his crops as well as crop of his co-villagers.

One may wonder why some important agricultural activities like land preparation, sowing of maize, *gundli* millet and raising of nursery beds start even before the commencement of erosim, which is the institutionally accepted as beginning of the agricultural year. An interpretation may be that the overwhelming dominance of the rain-fed paddy in life, economy and culture of the Santals has prompted them to select paddy transplantation as a symbolic onset of the agricultural year in preference to all other crops of secondary importance possibly to be grown in his habitat. It is a ritual, which is possibly arranged at a convenient time to sanctify their activities during the planting season as a whole. In fact, as in the *maghisim*, the purpose of the *erosim* may be to provide social consent to all his individual activities already performed before the ritual, i.e., from the day of *rohin* which is the prevalent day to start sowing in the region (Chakraborty 1987).

The offering of first *gundli* (*Panicum sumatrense,* a commonly cultivated millet) by the village priest to the Santal deities inside the *jahera* or sacred grove and restriction of reaping as well as eating of new *gundli* before the commencement of *nawabad* indicate that *gundli* has a place in the core of the Santal culture of agriculture. This may be further substantiated by the Santal origin myth where it is mentioned that the Santal made his first *handi* or beer with the ears of *sama* and *sumtubukuch* grass (*Echinochloa colona* and *Dactyloctenium aegyptiacum* respectively)(Table-1) and in earlier days along with hunting they used to live on these two varieties of wild millets (Skrefsurd, 1887). It is important to mention in this context that even today, at the time of scarcity, the Santals collect and consume grains of *sumtubukuch* grass that grows largely in the surrounding forest. But gradually over time when the santals became more sedentary and conversant with rice culture, the millets became secondary and considered an inferior variety in the Santal scheme of food crops. This is indicated very subtly by his mode of observance of the rituals connected with *nawaabad*.

It is intriguing to observe that the village council meeting is not called to fix up a date for *nawaabad* and all the members of the village council do not remain present during this ritual. Although the village priest inside the *jahera* performs the *nawaabad* ritual, the fowl and *handi* (rice beer) are not offered to the deities, which is a deviation from the traditional Santal mode of worship. From the absence of intense social participation in *nawaabad* and the simple features of the ritual, one may be tempted to conclude that the functional importance of *gundli* millet as a food crop has become recessive to the rice among the Santals.In the initial period of their adaptation to the new home, the Santals probably depended more on short-duration varieties of paddy grown in *baid* lands (high land paddy fields which retain little moisture) that ripen and are harvested in the first half of the *kartik* (October- November) That is why they observe the festivities and rituals of the *soharai* in the full moon of this month. While the *nawaabad* does not call for any collective decision on the part of the villagers, the *sohari* with its elaborate observance is more intensively accepted by the community in the sense that the village council fixes the final dates in a way that the time of the festival become socio-economically convenient for all villagers to participate. In no other rituals and festivals of the Santal is the handi or rice beer so profusely taken, though the beer is made out of a *baid*rice which is only second in importance to the *baihar* rice in their economy. This is another indication that the initial emphasis of the Santals is on the shorter-duration paddy coming from relatively drier lands.

Many of the rituals associated with the *soharai* are centered around the cattle. This needs no special explanation because it is well established how important it is to possess draught animals for agricultural activities and the cattle to the Santal is more a functional entity than a sacred animal. It is interesting to note that the Santals are found to take beef not only frequently but also on the second day of *sohorai* – the same day on which the worship of cattle and cowshed is performed by them. They take beef baked with paste of rice powder and this cake is locally called *chaprapitha.*

As it is evident that after the *maghisim* agriculture in the village is considered an individual enterprise while between the periods of *erosim* and *maghisim* i.e., from the middle of *Asar* to the middle of *Magh* agriculture is considered as a community enterprise. Practically no villager is interested in cultivating his land during summer. So, for the period between *maghisim* and *erosim* (i.e., from *Falgun* to *Jaistha*, approximately 4/5 months) most of the cultivable lands in the village remain uncultivated and over tillage of soil is prevented which serves as a village common where grazing of cattle takes place. Through these rituals and consequently soil erosion is avoided to a large extent even in the face of food scarcity in the village. The cultural ecological school holds that it is the level of means of production, which puts certain constraints in the management of natural resources at the disposal of a specific community. It naturally follows that the rest of the socio-cultural formation ('periphery' in Julian Steward's Phraseology) would simply be governed by the dictums of production techniques and its associated behaviour patterns which are designated as he 'core' of a particular culture (Steward, 1955).

Finally, it appears from the above discussion that there is a complementary relationship between the management of natural resources, production techniques and sacred grove-based social organization. This, of course, does not imply that the means of production occupies a secondary position in the Santal village under study. But all the technological rationality, which strengthened the survival strategies of this community inhabiting an inhospitable terrain, assumed wider significance when viewed within the sacred grove-centric village-level social organization of the Santals. But here too, the relationship between agriculture and forest product utilization should not be viewedonly from its techno-economic perspective but also from the background of the wider sociopolitical and cultural ethos of the Santal society. At this juncture, the relationship between the sacred groves or *jahera* of the Santal village and the various socio-cultural institutions and festivals revolving around sacred groves gains much significance. The sacred grove of the Santals is not only a physical entity that characterizes a Santal self-assertion in miniature but also acts as a regulatory mechanism of their techno-economic activities.

The micro level and intensive field-based orientation of the present work has, therefore, attempted to yield some factual materials related to the sacred grove-centric Santal village council in connection with almost every aspect of the village economy, society and religion. In functional terms, the Santal village council (whose symbolic expression is embodied in the sacred grove or *jahera*) controls all the major ritual performances, which in turn, regulate the various natural resources management strategies related to the forest-agriculture interfaces.

8. CONCLUSIONS

Sacred natural areas, including sacred groves, are protected using conventional community-based conservation approaches. Conservation of sacred groves is imperative for many reasons: for preserving local and regional biodiversity; for preserving the socio-cultural integrity of local communities; and for the countless number of ecosystem services that these groves provide. Sacred groves, as community conserved areas, are significant and have contributed to biodiversity conservation, thus playing a key role in the ecosystem management. Understanding the total number, the expanse of the area, and the biodiversity of the groves, and the associated cultural beliefs and practices of local communities, can make it possible to appreciate the importance of conserving sacred forests and also to plan integrated approaches to biodiversity conservation at the landscape level. The wide distribution and abundance of sacred groves in the world's various ecosystems underlines the importance of inventory and research continuing. In numerous parts of the world there are still many secret sacred groves whose plant diversity needs to be registered in order to promote better protection and conservation of wild gene pools. To better understand the role of these forests in the conservation of biodiversity, further work on the ecology and underlying socioeconomic processes of sacred groves distributed in remote corners of the state is needed. Local societies have played a vital role in maintaining those forests for decades to come. Prioritizing the protection of these forests and funding for the indigenous communities that preserve them at this time is important.

9. ACKNOWLEDGEMENTS

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7

Diversity of Aquatic and Wetland Grasses in Cachar District, Assam

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ABSTRACT

The present study deals with the taxonomic enumeration of wetland grasses in Cachar district of Assam. In this attempt, a total of 21 species belonging to 7 different tribes and 14 genera of the grass family Poaceae were collected and documented. Among the tribes, Paniceae was found to be the most species rich tribe with 11 species, followed by Eragrostideae (3) and Andropogoneae (2). Detailed notes on distribution, growth form, life form, phenology, IUCN status for all the taxa enumerated here are provided. Taxonomic keys of the studied taxa were also made to ease the identification of taxa. The work will provide an important baseline data on the diversity and distribution of aquatic and wetland grasses of the region.

Keywords: *Barak Valley, Biodiversity, Gramineae, Monocotyledons, North-eastern India, Poaceae.*

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INTRODUCTION

Grasses (Poaceae, *nom. alt.* Gramineae) are cosmopolitan in distribution which covers *ca*. 25–45% of the total world flora (Stanley 1999). In India, the family is represented by 1506 species under 10 subfamilies (Kellogg *et al*. 2020). In Assam, a total of 295 species of grasses has been reported so far (Barooah & Ahmed 2014). Members of the Poaceae are very important due to its widespread economical uses (food, fodder, domestic & industrial goods) and ecological role towards development & stabilization of soil (Stanley 1999). In addition, Grasses not only act as indicators of water quality (Prasad *et al*. 2016) but also play chief role as primary producer in aquatic environment by providing shelter for other micro- as well as macro organisms (Palit *et al*. 2017).

A wetland is any area where water stagnant at least two weeks and saturation remains at least for 60 consecutive days (Cook 1996). Since wetland offer suitable environment for many floras and faunas, it is widely considered as one of the most dynamic ecosystems (Ghermandi *et al*. 2008). Therefore, a major portion of the species diversity as well as socio- economic condition of the human population relies upon the wealth of the wetland ecosystem (Sarkar *et al*. 2019).

District Cachar of the state Assam (southern part of the state) is blessed with low-lying wetland areas with numerous aquatic bodies. The district is flood-prone; river Barak and many other tributaries flow through the district. Since, wetlands are one of the major habitats for grasses; the district is the homeland for various grass species. Grasses play a key role in regulating wetland ecosystem structure and function (Prasad *et al*. 2016).

Different wetlands of Cachar district are very important for its biological diversity, aesthetic beauty and multipurpose features like fishing, boating etc. Apart from the water-spread area, their surrounding open landmass is also an integrated part of the lake ecosystem. All these low-lying areas play an active role in controlling water cycling and cleaning of the environment.

Some fragmentary works on the wetland vegetation of Barak valley particularly in Cachar district *viz*. Das *et al.* (2014), Prasad *et al*. (2016) & Sarkar *et al*. (2019) were done so far. Apart from that, Devi (2017) in her work on the taxonomic studies on Gramineae in Barak Valley enumerated a total of 121 species under 59 genera, 12 tribes and six subfamilies where 117 species were found to occur in Cachar district. Recently, it has been seen that the low-lying areas are filled up with soils for construction purposes. Since, grasses are one of the dominant members in aquatic bodies and have pivotal role in the overall ecosystem; we have attempted to enumerate grasses from the district which may protect different species from their further extermination.

MATERIALS AND METHODS

Study Area

The present study was undertaken in Cachar district of Assam. The district is situated between the coordinates $24^{0}20'$ - $25^{0}10'$ N latitudes and $92^{0}15'$ - $93^{0}15'$ E longitudes. The district is bounded by Manipur in the east, Hailakandi district (Assam) and Bangladesh in west and Mizoram state on the south (**Figure 1**). The main river flowing along the central part of the district is Barak and its tributaries *viz*. Rukni and Sonai. All the rivers are perennials in nature. The low-lying areas are usually characterized by the presence of natural lakes and swamps, locally known as 'haors'. The district is characterized with an average annual rainfall of 2717 mm. As per Census Report 2011, Cachar has a total population of 1,736,617. The district has warm & humid climate during summer and extremely heavy rainfall in pre-monsoon and monsoon seasons (Anonymous 2011).

The district has total 10419 ha wetland area which includes 46 small wetlands (<2.25ha). The major important wetland types are River/stream (55.48%), waterlogged-natural (29.91%) and lake/pond (14.61%). The area under aquatic vegetation is significantly more during pre-monsoon (1872 ha) compared to post-monsoon (137 ha). The turbidity of water is low to moderate (Anonymous, 2011).

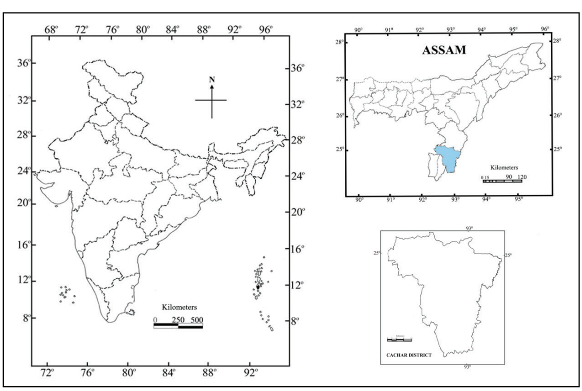

Fig. 1: Map showing study area

DATA COLLECTION

The species listed here were compiled mainly based on the conventional method of taxonomic study which includes collection, preservation and identification of species. The specimens were collected through extensive field studies in different wetlands of Cachar district during pre-monsoon to post-monsoon periods in three consecutive years. Photographs of the exploration sites are given in **Figure 2**. Specimens were collected randomly in its flowering and fruiting stages as well as in vegetative stage from their natural habitats. At least three to four specimens for all the species were collected. At the time of collection, the data like phenology, growth form, etc. were recorded with care and precision. The plant specimens were dried, processed and mounted following Jain & Rao (1977) and Singh & Subramaniam (2008). Specimens were identified with the help of regional floras like Cook (1996), Shukla (1996), Bor (1940).

Fig. 2: Wetland habitats: **a.** Baskandi–Anua Beel; **b.** Karbala Beel; **c.** Chatla Haor; **d.** Ramnagar wetland; **e.** Ramnagar – Anua Beel; **f.** Chatla Haor; **g.** Rosekandy wetland; **h.** Field trip at Baskandi – Anua beel

Specimens have been deposited in the Herbarium of Department of Life Science and Bioinformatics, Assam University, Silchar.

RESULTS

Poaceae Barnhart, *nom. cons.* (*nom. alt.* **Gramineae** Juss.)

Barnhart in Bull. Torrey Bot. Club 22: 7. 1895; GPWG in Ann. Missouri Bot. Gard. 88(3): 415. 2001. Gramineae Juss., Gen. Pl.: 28. 1789; Clayton & Renvoize in Kew Bull., Addit. Ser. 13: 29. 1986.

In the present study, a total of 21 taxa of Poaceae have been recorded from wetland habitats of Cachar district of Assam. Taxonomic enumeration of the taxa with an updated nomenclature, synonyms in some particular cases, distribution, growth form, life form, habitat, IUCN status and phenology were done. Clayton & Renvoize (1986) was followed to arrange the taxa. Bracketed key is provided for easy identification. Photographic plate (**Figure 3**) is also presented.

TAXONOMIC ENUMERATION

Tribe: Andropogoneae

1. **Imperata cylindrica** (L.) P.Beauv., Ess. Agrostogr. 8, 165, 177, pl. 5, f. 1. 1812. *Lagurus cylindricus* L., Syst. Nat. ed.2, 2: 878. 1759.

   Distribution: India: Throughout. Assam: Throughout.

   Growth form: Helophyte

   Habitat: Marshy bank

   Life form: Perennial

   Flowers & Fruits: July– April

   IUCN status: Least concern

   Specimen examined**:** *M. Devi* 10677; *L. M. Chanu* 30025

2. **Miscanthus fuscus** (Roxb.) Benth. in J. Linn. Soc., Bot. 19: 65. 1881. *Saccharum fuscum* Roxb., FI. Ind. 1: 241. 1820.

   Distribution: India: Arunachal Pradesh, Bihar, Manipur, Meghalaya, Uttar Pradesh, West Bengal. Assam: Southern Assam.

   Growth form: Helophyte

   Habitat: Marshy bank

   Life form: Perennial

   Flowers & Fruits: June – April

   IUCN status: Not evaluated

Specimen examined: *M. Devi* 10615, 10694, 10696; *L. M. Chanu* 30011, 30021

Tribe: Chlorideae

3. **Cynodon dactylon** (L.) Pers., Syn. Pl. 1: 85. 1805. *Panicum dactylon* L., Sp. Pl. 1: 58. 1753.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

Habitat: Marshy bank

Life form: Perennial

Flowers & Fruits: November – June

IUCN status: Not evaluated

Specimen examined: *M. Devi* 10681,10868, 10879 ; *L. M. Chanu* 30023

Tribe: Eragrostideae

4. **Eleusine indica** (L.) Gaertn., Fruct. Sem. Pl., 1: 8. 1788. *Cynosurus indicus* L., Sp. PI. 1: 72. 1753.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

Habitat: Marshy bank

Life form: Annual

Flowers & Fruits: June – April

IUCN status: Least concern

Specimen examined: *M. Devi* 10676, 10759, 10843; *L. M. Chanu* 30018, 30026

5. **Eragrostis atrovirens** (Desf.) Trin. ex Steud., Nomencl. Bot. ed. 2, 1: 562. 1840. *Poa atrovirens* Desf., F1. Atlant. 1: 73. t. 14. 1798.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

Habitat: Marshy bank

Life form: Perennial

Flowers & Fruits: April – December

IUCN status: Least concern

Specimen examined: *M. Devi* 10614, 10623, 10684; *L. M. Chanu* 30017

6. **Eragrostis unioloides** (Retz.) Nees ex Steud., Syn. Pl. Glumac.1: 264. 1854. *Poa unioloides* Retz., Observ. Bot. 5: 19. 1788.

Distribution: India: Throughout. Assam: Brahmaputra and Barak valley.

Growth form: Helophyte

Habitat: Marshy bank

Life form: Annual

Flowers & Fruits: Throughout the year

IUCN status: Least concern

Specimen examined**:** *L. M. Chanu* 30006, 30010

Tribe: Isachneae

7. Isachne globosa (Thunb.) Kuntze, Revis. Gen. Pl. 2: 778. 1891. *Milium globosum* Thunb., Syst. Veg. ed. 14: 109. 1784.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Hyperhydate

Habitat: Emergent aquatic

Life form: Perennial

Flowers & Fruits: August – November

IUCN status: Least concern

Specimen examined**:** *L. M. Chanu* 30019

Tribe: Oryzeae

8. Hygroryza aristata (Retz.) Nees ex Wight & Arn. in Edinburgh New Philos. J. 15: 380. 1833. *Pharus aristatus* Retz., Observ. Bot. 5: 23. 1789.

Distribution: India: Throughout. Assam: Brahmaputra and Barak valley.

Growth form: Hyperhydate

Habitat: Emergent aquatic

Life form: Perennial

Flowers & Fruits: September – April

IUCN status: Not evaluated

Specimen examined**:** *M. Devi* 10706

9. Leersia hexandra Sw., Prodr.: 21. 1788.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

Habitat: Bank Marsh

Life form: Perennial

Flowers & Fruits: Throughout the year

IUCN status: Least concern

***Specimen examined*:** *M. Devi* 10609

Tribe: Paniceae

10. Axonopus compressus (Sw.) P.Beauv., Ess. Agrostogr.: 12. 1812. *Milium compressum* Sw., Prodr.: 24. 1788.

Distribution: India: Throughout. Assam: Brahmaputra & Barak Valley.

Growth form: Helophyte

***Habitat*:** Bank Marsh

Life form: Perennial

Flowers & Fruits: July – November

IUCN status: Least concern

***Specimen examined*:** *M. Devi* 10636, 10717, 10726, 10747, 10753, 10787; *L. M. Chanu* 30003, 30020.

11. Digitaria ciliaris (Retz.) Koeler, Descr. Gram. 27. 1802. *Panicum ciliare* Retz., Observ. Bot. 4: 16. 1786.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

***Habitat*:** Bank Marsh

Life form: Annual

Flowers & Fruits: April – May

IUCN status: Not evaluated

***Specimen examined*:** *L. M. Chanu* 30005, 30024

12. Echinochloa colona (L.) Link, Hort. Berol. 2: 209. 1833. *Panicum colonum* L., Syst. Nat. ed. 10. 2: 870. 1759.

Distribution: India: Throughout. Assam: Throughout.

Growth form: Helophyte

***Habitat*:** Bank Marsh

Life form: Annual

Flowers & Fruits: June – February

IUCN status: Least concern

***Specimen examined*:** *M. Devi* 10639, 10687, 10689, 10762, 10841, 10851; *L. M. Chanu* 30022

13. **Echinochloa crus-galli** (L.) P.Beauv., Ess. Agrostogr. 1: 53. 169. pl. 11. f. 2. 1812. *Panicum crus-galli* L., Sp. Pl. 1: 56. 1753.

    Distribution: India: Throughout. Assam: Throughout.

    Growth form: Helophyte

    Habitat: Bank Marsh

    Life form: Perennial

    Flowers & Fruits: June – September

    IUCN status: Least concern

    Specimen examined**:** *L. M. Chanu* 30009

14. **Echinochloa crus-pavonis** (Kunth) Schult., Syst. Veg. 2, Mant. 269. 1824. *Oplismenus crus- pavonis* Kunth, Nov. Gen. Sp. 1: 108. 1816.

    Distribution: India: Andaman & Nicobar Islands, Uttar Pradesh, Uttarakhand. Assam: Throughout.

    Growth form: Helophyte

    Habitat: Bank Marsh

    Life form: Perennial

    Flowers & Fruits: May – August

    IUCN status: Least concern

    Specimen examined**:** *L. M. Chanu* 30008

15. **Echinochloa stagnina** (Retz.) P. Beauv., Ess. Agrostogr.: 53. 1812. *Panicum stagninum* Retz., Observ. Bot. 5: 17. 1789.

    Distribution: India: Throughout. Assam: Brahmaputra & Barak Valley.

    Growth form: Helophyte

    Habitat: Bank Marsh

    Life form: Perennial

    Flowers & Fruits: August – September

    IUCN status: Least concern

    Specimen examined**:** *L. M. Chanu* 30014

16. **Hymenachne aurita** (J. Presl ex Nees) Balansa in J. Bot. (Morot) 4: 144. 1890. *Panicum auritum* J. Presl ex Nees, Fl. Bras. Enum. Pl. 2(1): 176. 1829.

    Distribution: India: Andaman and Nicobar Islands, Bihar, Karnataka, Kerala, Nagaland, Sikkim, Tripura, West Bengal. Assam: Brahmaputra & Barak Valley.

Growth form: Hyperhydate

Habitat: Emergent Aquatic

Life form: Perennial

Flowers & Fruits: July

IUCN status: Not evaluated

***Specimen examined*: ** *M. Devi & D. Bhattacharyya* 10740

17. **Steinchisma laxum** (Sw.) Zuloaga in Amer. J. Bot. 90: 817. 2003. *Panicum laxum* Sw., Prodr. 23. 1788.

    Distribution: India: Assam. Assam: Barak Valley.

    Growth form: Helophyte

    Habitat: Bank marsh

    Life form: Annual-Perennial

    Flowers & Fruits: July – January

    IUCN status: Not evaluated

    ***Specimen examined*: ** *M. Devi* 10712, 10716

18. **Panicum dichotomiflorum** Michx., Fl. Bor.-Amer. 1: 48. 1803. *P. paludosum* Roxb., Fl. Ind. ed. 1820, 1: 310. 1820.

    Distribution: India: Not recorded (except Assam). Assam: Throughout.

    Growth form: Helophyte

    Habitat: Bank marsh

    Life form: Perennial

    Flowers & Fruits: June – May

    IUCN status: Not evaluated

    ***Specimen examined*: ** *M. Devi* 10698,10729, 10743, 10763; *L. M. Chanu* 30002

19. **Sacciolepis indica** (L.) Chase in Proc. Biol. Soc. Wash. 21: 8. 1908. *Aira indica* L., Sp. Pl. 1: 63, 1231. 1753.

    Distribution: India: Maharashtra. Assam: Throughout.

    Growth form: Helophyte

    Habitat: Bank marsh

    Life form: Annual – Perennial

    Flowers & Fruits: May - November

    IUCN status: Least concern

    ***Specimen examined*: ** *M. Devi* 10605, 10617,10627; *L. M. Chanu* 30013, 30007

20. Sacciolepis interrupta (Willd.) Stapf in Prain, Fl. Trop. Afr. 9: 757. 1920. *Panicum interruptum* Willd., Sp. Pl. 1: 341. 1797.

Distribution: India: Throughout. Assam: Brahmaputra & Barak Valley.

Growth form: Hyperhydate

Habitat: Emergent Aquatic

Life form: Perennial

Flowers & Fruits: June – December

IUCN status: Not evaluated

Specimen examined**:** *M. Devi* 10739, 10770; *L. M. Chanu* 30012

Tribe: Sporoboleae

21. Sporobolus diandrus (Retz.) P. Beauv., Ess. Agrostogr.: 26. 147 & 178. 1812 '*diandrus*'; Hook.f, Fl. Brit. India 7: 247. 1896 '*diander*'; Bor, Fl. Assam 5: 117. 1940 *et* Grasses Burma, Ceylon, India & Pakistan: 629. 1960. *Agrostis diandra* Retz., Observ. Bot. 5: 19. 1789.

Distribution: India: Bihar, NE India, Oddisa & West Bengal. Assam: Throughout.

Growth form: Helophyte

Habitat: Bank Marsh

Life form: Perennial

Flowers & Fruits: June – November

IUCN status: Not evaluated

Specimen examined**:** *M. Devi* 10685

Fig. 3: a. *Miscanthus fuscus*(Andropogoneae); **b.** *Axonopus compressus* (Paniceae); **c.** *Isachne globosa* (Isachneae); **d.** *Sacciolepis interrupta* (Paniceae); **e.** *Eleusine indica* (Eragrosteae); **f.** *Eragrostis atrovirens* (Eragrosteae); **g.** *Digitaria longiflora* (Paniceae); **h.** *Cynodon dactylon* (Chlorideae)

KEY TO SPECIES

1. Spikelets 1-flowered ……………………………………….......…..........**2**
1. Spikelets more than 1-flowered ………..……………………..……......**5**
2. Inflorescence digitate racemes ……...................**Cynodon dactylon**
2. Inflorescence open panicle ………………………………………........…**3**
3. Plant ceaspitose; stamens 3……….…..……......**Sporobolus diandrus**
3. Plant trailing; stamens 6 ….....…………………………........………**4**
4. Culms not spongy; spikelets unawned ....**Leersia hexandra**
4. Culms spongy below; spikelets awned …........**Hygroryza aristata**
5. Spikelets more than 2-flowered ..……………………....………**6**
5. Spikelets 2-flowered ……………………………...……...............**8**
6. Inflorescence of digitate racemes ………..…........**Eleusine indica**
6. Inflorescence an open panicle ……………………………........…**7**
7. Spikelets grayish-black ..…………..……..........**Eragrostis atrovirens**
7. Spikelets greenish with purple-tinge ….........**Eragrostis uniloides**
8. Spikelet disarticulating above glumes ....…**Isachne globosa**
8. Spikelets disarticulating with glumes like an entity ....….**9**
9. Spikelets paired, usually one sessile and other pedicelled; glumes as long as spikelets …...**10**
9. Spikelets single, or if paired both spikelets alike; lower glume shorter than spikelets or suppressed …..……………………......**11**
10. Panicle contracted or spike …..…...……..... .**Imperata cylindrica**
10. Panicle effuse ……………………...………..... . .**Miscanthus fuscus**
11. Inflorescence of unilateral racemes ..………………….……......**12**
11. Inflorescence an open, contracted or spikelike panicle ...…......**16**
12. Spikelets in 2-rows; lower glume absent .**Axonopus compressus**
12. Spikelets densely packed in 4-rows or congested into clusters; lower glume present...…..........**13**
13. Spikelets awnless ……………...……………......**Echinochloa colona**
13. Spikelets awned ……………...................................……........**14**
14. Ligule rim of hairs ……….................………..**Echinochloa stagnina**
14. Ligule absent …………..**15**

15. Racemes distinctly compound with many short branchlets ……. ....**Echinochloa crus-pavonis**

15. Racemes simple ……........................…......**Echinochloa crus-galli**

16. Panicle spikelike …...…………........**17**

16. Panicle open or digitate raceme ……...............................……......**18**

17. Culms slender, not spongy below; spikelets 2.2 – 3.5 mm long ………...**Sacciolepis indica**

17. Culms robust, usually spongy below; spikelets 4–5 mm long ....**Sacciolepis interrupta**

18. Upper glume length up to 2/3rd of the length of spikelet ....…........**Digitaria ciliaris**

18. Upper glume equal in length or slightly shorter than the spikelets ………..**19**

19. Stamens 2 ……..…......**Steinchisma laxum**

19. Stamens 3 ……...**20**

20. Ligule glabrous membrane; primary branches of panicle appressed to the axis …..............................…......**Hymenachne aurita**

20. Ligule ciliate membrane; primary branches of panicle spreading…..**Panicum dichotomiflorum**

DISCUSSION AND CONCLUSION

In the present investigation, a total of 21 species of aquatic and wetland grasses belonging to 7 different tribes and 14 genera was recorded from Cachar district, Assam out the of 117 species of grasses reported from the district. Among the tribes, Paniceae was found to be the most dominant species rich tribe with 11 species, followed by Eragrostideae (3 species), Andropogoneae & Oryzeae (2 species each), and Chlorideae, Isachneae & Sporoboleae (1 species each). On the basis of their response towards habitat, two types of growth forms (Cook, 1986) were found *viz*. helophyte and hyperhydates where most of the species (17) are helophytes and only 4 species are hyperhydates.

In India, about 50% wetlands were lost within last 100 years due to various anthropogenic activities (Sarkar *et al*. 2019). An urgent need for the conservation and sustainable management of such ecosystem is the call of the hour. Therefore, in order to sustain ecological management and restoration of wetland ecosystem, conservation of these wetland grasses are the urgent necessity.

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8 Conservation of an Endangered and Endemic Medicinal Tree *Kingiodendron pinnatum* (Roxb. ex DC.) Harms

D. Thangamani*, S. Poopathi Rajan*, O.M. Mohamed Nawas* & S. Lalitha*

ABSTRACT

Kingiodendron pinnatum (Roxb. ex DC.*) Harms is also known as Malabar mahogany belongs to the family Fabaceae, the third largest family of angiosperms contains more than 19400 species throughout the world and 730 genera approximately. IUCN red list plants considered K. pinnatum as an endemic and endangered plant species of southern Western Ghats. Resins are exuded from the stem as results of external injury of the stem. Oil is extracted from the K. pinnatum, however the oil extraction of K. pinnatum (Kulavuenna) is banned due to the fact that the tree has become very rare in the wild. Due to overexploitation and habitat degradation, the population of this species has been declined. Hence conservation of this species is very much important.*

INTRODUCTION

Kingiodendron pinnatum (Roxb. ex DC.*)* Harms *is* also known as Malabar mahogany belongs to the family Fabaceae, the third largest family of angiosperms contains more than 19400 species throughout the world and 730 genera approximately. IUCN red list plants considered *K. pinnatum* as an endemic and endangered plant

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species of southern Western Ghats. The *K. pinnatum* populations are distributed in evergreen/semi evergreen habitats with an altitudinal range of 176-680m elevation. The tree reached a first layer/canopy species with a height range from 24–30m. The flowering trees attained a height and DBH range of 10-30m and 85-320cm, respectively (Jose *et al*., 2018). Resins are exuded from the stem as results of external injury of the stem. Oil is extracted from the *K. pinnatum*, however the oil extraction of *K. pinnatum* (Kulavuenna) is banned due to the fact that the tree has become very rare in the wild; furthermore the extraction method of drilling the wood destroys the tree. But, illegal extraction is rampant. The highly inflammable resin has been leads to be the cause of some wildfire due to spillage of the resin when the drilled hole is left uncovered after extraction (Menon 2002).The oleo-gum-resin of this plant species is used to treat gonorrhoea, catarrhal conditions of genito-urinary and respiratory tracts. It is also used to curing sores of elephants. Due to over exploitation and habitat degradation, the population of this species has been declined. The scientific and pharmacological formulation of *K. pinnatum* is yet to be developed, though this species has been traditionally used for various purposes. Identification of relevant phytochemicals may add new knowledge in traditional medicinal practices. It is well-known fact that plant derived compounds provides numerous sources of antioxidant, antidiabetic, antiobesity and antimicrobial agent. Etnobotanical knowledge reveals use of many traditional herbs in treatment of various diseases, herbal medicines are usually free from side effects, are economical and also accessible to humans and provide significant potential for the development of novel biomolecules (Kumar *et al*., 2011). Asokarishta is prepared from the *Saraca asoca* which possess gynecological disorders. Alternative Arishta is prepared from *K. pinnatum* also possess similar pharmacological activity as that of Asokarishta (Shahid *et al*., 2018).

Fig. 1: & 2 Leaves and tree of *K. pinnatum*

Classification

Kingdom – Plantae

Division – Angiosperms

Order – Fabales

Family – Fabaceae

Genus – *Kingiodendron*

Species – *pinnatum*

DESCRIPTION

K. pinnatum is an evergreen tree, grow up to 30 m high, bark thickness ranges from 5-8mm, surface of bark is greyish-brown with green blotches, rough; it exuding a reddish sticky resin. Leaves of *K. pinnatum* is imparipinnate, alternate; leaflets are 5-9, alternate, Length ranges from 4.5-10.5 x width ranges from 2-4.5 cm, Leaves are ovate-lanceolate or oblong shape with acuminate apex, falcate or oblique, entire margin, glabrous, coriaceous; stipules minute, lateral, cauducous; rachis 10-15.2 cm, slender, pulvinate, glabrous; petiolule 5-10 mm, stout, grooved above, glabrous; lateral nerves are 8-13,pinnate, slender, prominent secondary laterals are present, intercostae reticulate, prominent. Flowers are bisexual, 2-3 mm across, white, in axillary and terminal panicled racemes. Flower has tubular calyx almost wanting, lobes 5, broadly ovate, imbricate. Petals are absent; disc very small. Stamens are 10, equal, filaments filiform, villous at base; anthers versatile. Flower has half inferior ovary, sessile, villous at base; ovules 2; style subulate; stigma minute, oblique. Fruit a pod, 4-5 x 2-2.5 cm, ovate-ellipsoid, turgid, obtusely beaked, prominently veined, dark brown, indehiscent; seed one, pendulous.

VERNACULAR NAMES

In Tamil Kodapalai, Kolavu and Madayan Samprani, in Kannada-Chou Paini, Enne Mara, Yenna Mara Malayalam it is known as – Churali, Chukannapayini, Kiyavu, Koda Pala, Kulavu.

DISTRIBUTION

K. pinnatum is distributed in southern Western Ghats, Kalakkadu and Mundanthurai of Tamil Nadu, Idukki, Kannur, Kasaragod, Kollam, Kozhikode, Palakkad, Thiruvananthapuram, Thrissur, Wayanad of Kerala.

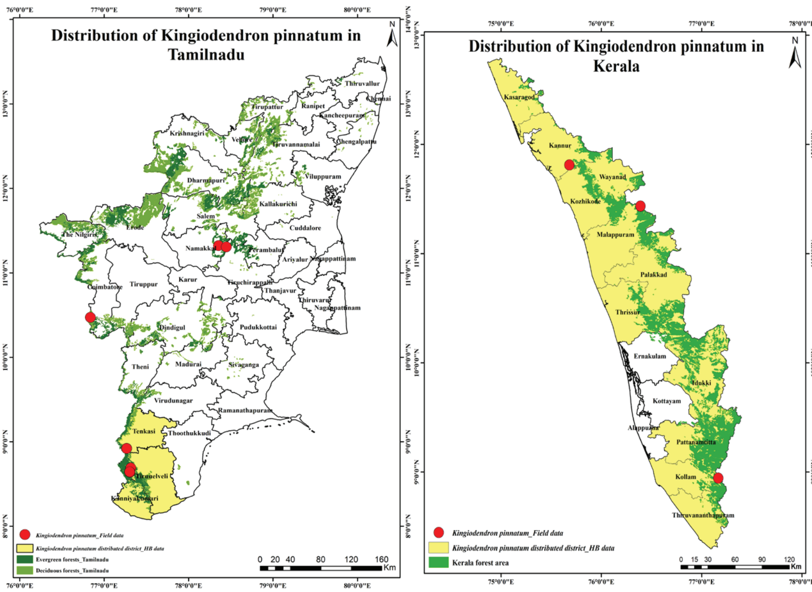

Fig. 3 & 4 : Distribution of K. *pinnatum* in Western Ghats of Tamil Nadu and Kerala

ASSOCIATED SPECIES

Major species associated with *K. pinnatum* is *Hopea parviflora* Bedd., *Dysoxylum malabaricum* Bedd. Ex Hiern, *Dipterocarpus indicus* Bedd., and *Vateria indica* L. which are common canopy associates reaching a height range of 26–35m. The members of the upper understorey include *Myristica beddomei* King, *Knema attenuate* (Hook. f. & Thoms.) Warb.,*Cinnamomum verum* Presl and *Garcinia Morella* (Gaertn.) Desv. with height range 15–25m. The lower understorey is composed of *Xanthophyllum arnottianum* Wight, *Schleichera oleosa* (Lour.) Oken, *Psydrax dicoccos* Gaertn., and *Baccaurea courtallensis* (Wight) Muell.-Arg. at a height range of 10–15m. The shrub layer is *Atalantia wightii* Tanaka, *Ixora nigricans* R. Br. ex Wight &Arn., *Mussa endafrondosa* L., *Lepianthes umbellate* (L.) Rafin, and *Leea indica* (Burm.f.) Merr.

Major herbs include *Asystasia dalzelliana* Sant., *Boesenbergia pulcherrima* (Wall.) O. Ktze., *Amorphophallus commutatus* (Schott) Engl., *Curcuma amada* Roxb., and *Begonia malabarica* Lam.

POLLINATION

Cross-pollination was recorded in *K. pinnatum*, with pollinators such as insects and, very occasionally,with small, long-beaked birds. The fruits are woody nature, with single pod. The seeds are heavy, and seed dispersal has been occurred through heavy wind, but over short distances.

CHEMICAL CONSTITUENTS

The *K. pinnatum* is rich with various active components like Phenols, Flavonoids, Glycosides and, Diterpenes. It also contains Tannins, Terpenes, Anthraquinones and, Phlobatanins that are responsible for different biological activities.

ANTIBACTERIAL ACTIVITIES

Ethyl acetate extract of *K. pinnatum* leaves contains diterpens, which showed antibacterial activity against the *Staphylococcus aureus* (Javarappa *et al*., 2016). Ethyl acetate and methanol extracts of *K. pinnatum* leaves have antibacterial activity against the *Staphylococcus aureus.* Ethyl acetate extracts of *K. pinnatum* leaves showed highest antagonistic activity against the S*acillus subtilis* (Sheik & Chandrashekar 2014).

ANTIOXIDANT ACTIVITY

Antioxidant activity of *K. pinnatum* is confirmed by phosphomolybdate assay using ascorpic acid as a standard. Methanol leaf extracts of *K. pinnatum* (500µg/ml) showed highest antioxidant activity (88%) (Kumar *et al*., 2011). The extract contains higher phenols and flavonoids showed a high antioxidant activity. Methanolic leaf extracts of *K. pinnatum* posses highest phenols and flavanoids when compared to aqueous and ethylacetate extracts. The phenolics show high ability to Scavenge free radicals due to the presence of phenolic hydroxyl groups. Methanolic leaf extract of *K. pinnatum* have DPPH radical scavenging activity where the hydrogen donors scavenge free radical DPPH (Sheik & Chandrashekar 2014).

TEN STEP PROTOCOL FOR THREATENED PLANT SPECIES

1. Population inventory, characterization and mapping through ecological niche modelling (ENM).
2. Metapopulation modelling of selected species populations to find out the conservation status, minimum viable population size and to assess extinction risk.

3. Identification of factors responsible for diminishing species populations and developing a species specific recovery strategy.
4. Molecular characterization of the selected species populations to find out those with greater diversity for genetic enrichment based on source–sink concept.
5. Characterization of active principles in selected species in different habitats/populations.
6. Standardization of the macro- and micro propagation techniques for mass multiplication.
7. Documentation of reproductive biology of the selected species to address the regeneration failure.
8. Production of planting materials for afforestation of the species in the areas identified through ENM.
9. Herbarium preparation and establishment of field gene banks at appropriate ecological zones.
10. MoU with Forest Department and communities, and reintroduction with post-introduction monitoring protocol (Barik *et al*., 2018).

CONCLUSION

The Western Ghats are rich with biological resources. The traditional knowledge from the tribal's is useful in the field of ethnobotany, taxonomy and pharmacology. According to red list details *K. pinnatum* is considered as an endangered species due to over exploitation. The populations of *K. pinnatum* were fragmented in distribution in the Kerala area of the Western Ghats. Fragmentation of populations and habitats often results in endangerment of local species leads to loss of diversity in forest ecosystems. The better survival and adaptability towards different environmental gradients and habitat conditions of *K. pinnatum* population was observed in medium high elevations when compared to low elevations. Furthermore, it is also observed that the flat terrain with gregarious seedlings and the seedlings were scattered in sloping terrain. The uniformity of moisture status might be a reason behind the gregarious nature of seedling emergence in flat terrain. The extended distribution pattern, number of individuals of different age classes among the populations, fare performance in natural seedling regeneration extends heal thier population stability and growth of the species as suggestive for reversion of conservation status from Endangered to Vulnerable in the Kerala area of the Western Ghats. However, the irregularities of flowering and fruiting, occurrence of fewer number of flowering individuals among populations warrants conservation and management of *K. pinnatum,* of the southern Western Ghats. Hence multiplication and conservation is very much essential for this species, because the leaf extract possesses bioactive compounds which have antioxidant, anti-obesity and anti-diabetic drugs and offers scope for development of potential crude drugs.

ACKNOWLEDGMENTS

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9 A Review of Ethnomedical Practices in Various Areas in Palghar of Maharashtra

Namdeo V. Mahale*

Ethnomedicine refers to the study of traditional medical systems and practices used by different cultural and ethnic groups around the world. This can include the use of plants, animals, minerals, and other natural substances for healing, as well as the cultural beliefs and practices that inform these medical systems. Ethnomedicine is an interdisciplinary field that draws on anthropology, botany, pharmacology, and other disciplines to understand the diversity of medical systems and practices around the world (Ghorbani, A., 2006). Some specific examples of ethnomedicinal practices include the use of traditional Chinese medicine, Ayurvedic medicine in India, traditional African medicine, and traditional Native American medicine (LeontiM. 2022). These practices often involve the use of plants and other natural substances to treat a wide range of conditions, including those related to mental health, respiratory health, and skin health. (Ibrahim Khan,2017). Ethnomedicine is a valuable field of study because it provides insight into the wide variety of medical systems and practices used around the world. By studying traditional medical systems, researchers can gain a deeper understanding of the cultural, historical, and ecological factors that shape these systems. This knowledge can then be used to develop new treatments and therapies, as well as to preserve traditional medical knowledge for future generations. Ethnomedicine also has a significant impact on the conservation of biodiversity, many traditional medicines are derived from wild plants and animals, therefore, the conservation of these species is crucial for the

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sustainability of these traditional medical systems (Kumar, M.2011). India is rich in ethanobotanical knowledge which is inherited from generation to generation among tribal people since ancient time. But the traditional knowledge system in India is rapidly neglecting and there is an urgent need of hour to record all ethnobotanical information from the diverse ethnic communities before they completely lost the ethnomedicinal information.

The Palghar district is western part of Maharashtra. It is spread between the west coast of the Arabian Sea and the Sahyadri Mountains rows that are east of the Northern District of Palghar. According to geographical structure the district generally falls in three departments. The first section of linear Sahyadri mountain is known by the name Jangalapatti. These mainly encompasses of Jawhar, Mokhada, Vikramgad talukas. The second section is known by Bandarpatti. These include Vasai,Palghar, Dahanu talukas. The third section is known by the plain land. These include Wada taluka. The forests in Thane district were bestowed with reputed faunaand wild game in the past. The rich wild life in those daysincluded important species like tiger, panther, leopard, hyena, spotted deer, barking deer, bear, blue bull, mouse deer monkeys, hare, flying squirrels, mongoose, poisonous and non-poisonous snakes and a number of species which the forest was replete. Today many rare and endemic plant and animal species in Palghar district have been recorded. Several ethnic groups which possess distinct social and cultural identities reside in this region and practice their own traditions. The various tribal community of Palghar district which have maintained their long followed tradition in medicine are seen to possess rich knowledge in the therapeutic use of plants and plant products. Their age old interaction with nature has brought them in possession of vast knowledge about the medicinal uses of plants. These knowledge needs to be preserved for the benefit of the future generations and also for the study and possible extraction of medicine at an industrial level.

The preparation of such medicine usually includes extracting the sap from the leaves, fruit or bark, and its application on the affected part or direct intake as whole fruit or leaves or as boiled. So far, very few studies have been conducted in order to properly document the identification, method of preparation, and application of such ethnomedicine.

The following review on Ethnomedicinal practices in various parts of Palghar was conducted to document some of the plants used as ethnomedicine by people in various parts of Palghar. Most of these plants are found in the household gardens and kitchen gardens and are easily accessible for use. The local names of the plants slightly vary in different places but the method and application mostly remain the same. Some of the commonly used ethnomedicinal pants in various regions of Palghar are as given below in the table.

Table 1. Ethnomedicinal pants in various regions of Palghar area.

Botanical Name of medicinal plants	Family	Local Name	Parts Used	Name of the Disease/Uses
Abrus precatorius	Fabaceae	Gunja	Roots	Scorpion bite, skin damage, swelling
Acacia catechu	Mimosaceae	Khair	Pods, leaves, bark and gum	Urinogenital disorder, diarrhea, dysen
Acacia nilotica	Fabaceae	Babul	Pods, leaves, bark and gums	Dental use
Achyranthes aspera	Amaranthaceae	Aghanda	Leaves	Fistula
Adathoa vasica	Acanthaceae	Adulsa	Leaves, roots, flowers and stem bark	Cough and cold
Aegel marmelos	Rutaceae	Bel	Leaves, root and fruits	Anti-dysentery
Allium sativum	Liliaceae	Lasun	Bulbs	Cough
Aloe vera	Liliaceae	Korphad	Leaves	Abortifacient
Alstonea scholaris	Apocyanaceae	Saptparni	Leaves	Snake bite
Amaranthus spinosus	Amarantaceae	Katemath	Leaves	kidney stone.
Annona squamosa	Annonaceae	Shitafal	Leaves, roots, fruits and seeds	Reducing weight

Argemone Mexicana	Papaveraceae	Dhatura	Leaves	Body heat
Azadiracta indica	Meliaceae	Kadunimb	Bark, leaves, flowers and seeds	Antibacterial
Bahunia reacemosa	Leguminosae	Apta	Leaves	Wound healer
Butea monosperma	Fabaceae	Palas	Barks, leaves, fruits, seeds and gums	Diabetes
Calatrophis procera	Asclepiadaceae	Rui	Whole plant	Cough
Carica papaya	Caricaceae	Papaya	Whole plant	Toothache, diabetes, dermatitis, hurt.
Centella asiatica	Apiaceae	Bramhi	Whole plant	Measles, jaundice
Chrysanthemum indicum	Asteraceae	Sevanthi	Flowers	Headache, hypertension
Cymbopogon citrates	Poaceae	Gawti chaha	Whole plant	Cough
Dendrocalamus strictus	Gamineae	Bambu	Culms	T.B., Cough
Diospyros melanoxylon	Ebnaceae	Tendu	Fruits	Antipreganancy
Eclipta prostrate	Asteraceae	Maka	Leaves and roots	Complexin, Laxative, Good for eyes, Brain tonic, Hair tonic, Dandruff,
Ficus bengalensis	Moraceae	Wad	Bark, leaves, fruits, seeds and latex	Anti-diabetic, wound
Ficus racemosa	Moraceae	Umbar	Fruits	Anthelmentic

Ficus religiosa	Moraceae	Pipal	Bark, leaves, fruits, seeds and latex	Treating skin disease
Gymnema sylvestre	Asclepiadaceae	Bedki	Fresh leaves	Diabetes
Hibicus rosa-sinesis	Malvaceae	Jaswand	Flowers	Leucorrhoea
Hibiscus cannabinus	Malvaceae	Ambadi	Leaves and fruits	Sunstroke
Lawsonia inermis	Lythraceae	Mehandi	leaves	Hair treatment
Mangifera indica	Anacardiaceae	Amba	Leaves, barks, fruits and seeds	Diarrhea, Dysentery
Michelia champaca	Magnoliaceae	Chamapa	Leaves and flowers	Expectorant, Purgative
Mimosa pudica	Mimociaceae	Lajalu	Whole plant	Stimulant
Momordica charantia	Cucurbitaceae	Karella	Fruits and seeds	Diabetes, blood purifier and antihelminthic
Moringa pterygosperma	Moringaceae	Sevaga	Seeds	Asthma, Diabetes, Diarrhea
Nerium indicum	Apocynaceae	Kaner	root	Diuretic and Cardiac tonic
Nyctanthes arboritristis	Oleaceae	Parijat	Leaves, flowers and seeds	Rheumatism
Ocimum sanctum	Lamiaceae	Tulas	Whole plant	Fever
Phyllanthus emblica	Euphorbiaceae	Awala	Leaves, fruits and seeds	Vitamin deficiency
Pithocellobium dulce	Fabaceae	Vilayati chinch	Fruits	Antioxidant

Pongamia pinnata	Fabaceae	Karanj	Leaves, flowers, seeds and bark	Wound healing
Psidium guajava	Myrataceae	Jam	Leaves, fruits and root	Anti- diarrhea
Sapindu emarginatus	Sapindaceae	Ritha	Bark, fruits and roots	Healthy hair, Antibacterial
Saraca indica	Fabaceae	Ashok	Leaf, bark	Tonic, nerve stimulant, dermatitis, menstrual irregularities.
Solanum nigrum	Solanaceae	Kamoni	Leaves	Antitumorigenic, Antioxidant
Solanum virginianum	Solanaceae	Bhuiringani	Fruits	Toothache
Tamarandus indica	Caesalpiniaceae	Chinch	Fruits, seeds and roots	Scorpion bites
Termanilia bellirica	Combretaceae	Behada	Bark and fruits	Vomiting, skin diseases
Tinospora cordifolia	Menispermaceae	Gulvel	Aerial parts	Fule
Trapa natans	Trapaceae	Singada	Fruits	Diarrhea, dysentery, fatigue
Tridax procumbems	Asteraceae	Kambarmodi	Leaves	Kraking foot
Vinca rosea	Apocynaceae	Sadafuli	Leaves and flowers	Leukemia
Vitex nigunda	Verbanaceae	Nirgudi	Flowers and roots	Anti-inflammatory Bone fracture
Zizyphus sp.	Rhamnaceae	Bor	Fruits	Vit-B

RESULTS

In the present study, a total of 48 species of medicinal plants were collected along with the documentation of significant information regarding their scientific names, families, common names and plant parts used by the local people for different purposes. These medicinal plants are used for common diseases like toothache, Skin infections, cough cold, fever, snake bite, kidney stone, blood purifier, hepatic protective, scorpion sting, dysentery, paralysis, laxative, jaundice, malarial fever, brain tonic, piles, leprosy, dandruff, chronic skin diseases, worms, ulcerations, cardiotonic, dyspepsia, etc. can be effectively cured with medicinal plants. It was noticed that no side effects were reported above ethnobotanical plants. Ethnomedicinal plant survey during observed in different regions the traditional knowledge has become extinct in some communities. There was none to carry the knowledge to the next generation it not documented properly. The knowledge shall be lost without any means for retrieval. It is still confused to the proper treatment of unknowingly and hence such as medicinally important plant species so now a day is needed proper identification and preservation for the future generation.

CONCLUSION

These ethno medicinal practices are appealed to be very effective and inexpensive and are therefore held to be highly beneficial for the society. However due to the lack of written recordssuch knowledge is seen to be slowly eroding away from the consciousness of the people. Moreover, the exact amount of plant extract to be used is seen to be uncertain in most of the cases. Proper studies need to be undertaken for the validation and documentation of such practices at the earliest. Also efforts must be made for the conservation of such beneficial plants and their cultivation at higher scale for the benefit of the society.

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10

In-situ and *Ex-situ* Strategy for Biodiversity Conservation

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ABSTRACT

Biodiversity conservation for in situ and ex situ strategy focuses on species diversity maintenance within or away from their natural habitats, respectively. This article provide outlines on techniques adopted for in situ and ex situ conservation through India and how diversity is maintained at the ecosystem, species, and genetic levels. Biodiversity conservation is presented which includes: selection of sites for conservation, concepts of Protected Areas, National Parks, Wildlife Sanctuaries, Bio reserve Forest, Botanic garden, Zoo garden, seed bank, cryopreservation etc., clarification of conservation objectives under the two basic conservation strategies (in situ and ex situ) and the range of conservation techniques, and ways of utilization.

Keywords: *Conservation, Biodiversity, Ex-situ, In-situ, Species, Ecosystem, Landscape.*

INTRODUCTION

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as land, forests and water. Through the conservation of biodiversity the survival of many species and their habitats which are threatened due to human activities can be ensured. Other reasons for conserving biodiversity include securing valuable Natural Resources for future generations and protecting the well-being of eco-system functions.

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Biodiversity conservation implies protecting all organisms and species within their natural habitats with the aim of ensuring intergenerational and intragenerational equity. The critical importance for conservation of biodiversity is vital now, because biodiversity is under threat of extinction and erosion, regardless it can be of direct and indirect benefit to humankind and is vital for human well-being. Human beings benefited from Biodiversity through the exploitation of animals and plants in agriculture and horticulture, the development of medicinal drugs, and the pivotal roles played by species in the functioning of all natural ecosystems. Biodiversity plays a fundamental role in maintaining the aesthetic value of the environment, the integrity of the natural environment, and promotes the overall well-being of all plant and animal life.

The Convention on Biological Diversity (CBD) is a landmark multilateral environmental agreement (MEA) opened for signature on the occasion of the historic UN Conference on Environment and Development held in Rio de Janeiro in June 1992, where representatives of 178 States (including 118 heads of state or government) gathered. Along with the CBD, two additional watershed MEAs were established: the UN Framework Convention on Climate Change and the UN Convention to Combat Desertification.

Human race depends on the ecosystems an essential part of biodiversity for fresh water and food, health, restoration and shelter from natural calamities. Its damage effects on cultural and divine ideals that are essential to human welfare. Recent progression in environmental degradation and damage of biodiversity can considerably lessen the capability of ecosystems to supply these crucial amenities (www.cbd.int).

Due to the immense range of physical and environmental situations, India nurtures diverse ecological community varying from grasslands, wetlands, the tropical rain forests, coasts and high alpine cold deserts due to the immense range of physical and environmental situations. India has a total of three primary biological areas namely, Eurasian, Afro-tropical and Indo-Malayan and ten bio-geographic zones together with 26 biotic regions (Rodgers andPanwar, 1990).

India being a mega diverse nation, contains an immense capability for the employment of biological sources from primary bionetworks along with various agro-climatic zones (Singh and Dukariya, 2021). India exhibit a remarkable variety of biodiversity and around 8% of the total biodiversity present in world India constitutes only

2.5% of the earth's land area which includes millions of species and subspecies (Bawa *et al*. 2021). Industrialization, urbanization and agriculture, increasing human population and extensive developmental plans such as highways, mining and dams resulting in degradation, fragmentation, over exploitation and habitat destruction of biological resources (Agnihotri *et al*. 2020). Coupled with these factors, unauthorized trade of high value wildlife products and unsustainable use of resources have seriously threatened many species of flora and fauna. Due to debut and encouragement of few crop varieties with 'high yield', the agro-biodiversity has also suffered critically. Even if, India has abundant practice of conserving nature and bio-resources but still minor efforts have been made to secure the traditional knowledge on biodiversity received by a huge number of local communities. Thus, it requires a combined attempt in the direction of education, scientific investigation and policy support for conservation of the biodiversity while providing economic and ecological security (Venkataraman, 2009; Singh and Dukariya, 2021).

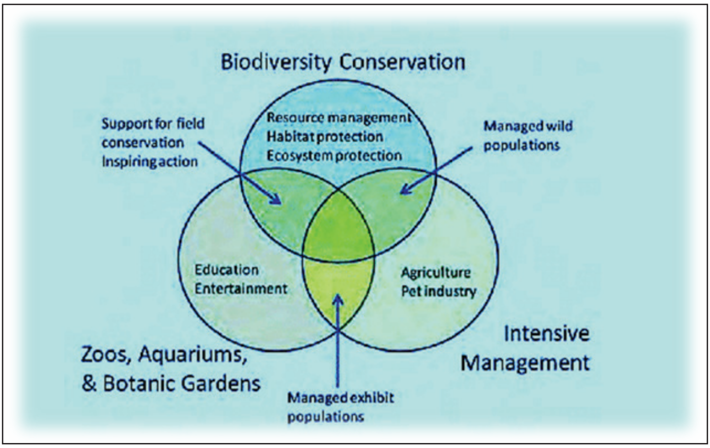
Biodiversity conservation demand efforts from various Ministries/ Departments at the Central and State Government levels thereby reprising the necessity for establishing of biodiversity affairs in development planning processes (www.nbaindia.org).

CONSERVATION OF BIODIVERSITY

Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains. India has undertaken a range of conservation measures to protect its biodiversity, including ex-situ and in situ measures. The cornerstone of in-situ conservation in the country is its vast protected area network. There are four main categories of protected areas, viz., National Parks, Wildlife Sanctuaries, Conservation Reserves and Community Reserves. Conservation of biodiversity and interactions between species and their natural surroundings will ensure an evolutionary potential for the earth planet, a sustainable capability to adapt changes and to maintain life on Earth.

Sustainable utilization of potential resources are assured by conservation of biodiversity is protected at its all level through the conservation and protection of whole ecosystem, thus, we save the entire forest to save the wild animals and plants. This approach is termed as in situ (on site) conservation. But the situation where animal or plant species are endangered or threatened needs urgent measures to save them from extinction through ex situ (off site) conservation.

The main objectives of biodiversity conservation may include sustainable use of ecosystem and species to maintain the diversity of species. Biodiversity conservation is essential tomaintain food chains and vital for ecological richness.



Biodiversity Conservation (source: https://prepp.in/news/e-492-biodiversity-conservation -environment)

BIODIVERSITY CONSERVATION: PURPOSES

India exhibit a remarkable variety of biodiversity but there is barely possibility for sense of security. In India, due to increasing human population, fast growth of industry, urbanization and agriculture and extensive developmental plans such as highways, mining and dams resulting in degradation, fragmentation, over exploitation and habitat destruction of biological resources (Agnihotri *et al*. 2020). Unauthorized trade of wildlife products and unsustainable use of natural resources have seriously threatened many species of flora and fauna. Due to debut and encouragement of 'high yield' crop varieties in the agricultural field, the agro-biodiversity has also suffered critically. Though, India has abundant practice of conserving nature and bio-resources but still minor efforts have been made to secure the traditional knowledge on biodiversity received by a huge number of local communities. Thus, it requires a combined attempt in the direction of education, scientific investigation and policy support for conservation of the biodiversity while providing economic and ecological security (Singh and Dukariya, 2021;Venkataraman, 2009). Biodiversity conservation is needed for the following purposes:

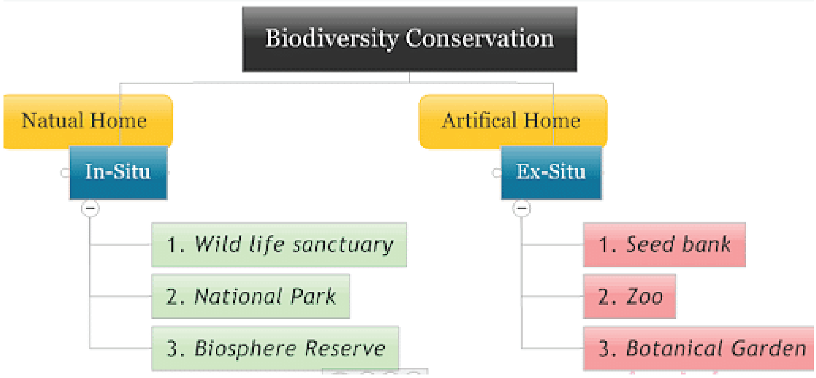
1. Awareness of the people to their surroundings and the diversity around them.
2. Implementation of environment friendly methods to achieve sustainable development.
3. Protect local flora and fauna from being endangered.
4. Resist overexploitation of natural resources.
5. Educate the people about biodiversity and its significance by establishment of institute and digital media.
6. To safeguard endangered species steps to be required to implement.
7. To keep species from becoming extinct careful planning and control measures should be required.
8. Protective measures planning for preservation of wild fauna and flora and their wild relatives before they become extinct.

BIODIVERSITY CONSERVATION PRACTICES

United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, focusedon the topic of conservation of biodiversity to the world and helped this critical issue on the agendas of world leaders. But concerning biodiversity seems to have diversified and increased, a basic understanding of what it is, what it means to mankind, and how it can be protected is still lacking.

There are various modes or ways of Biodiversity conservation practices is accomplished. Ex situ conservation and in situ conservation are two important strategies that are used to protect endangered animals and plants around the world. Ex-situ methods focus on species conservation in botanic gardens, zoos, gene banks, and captive breeding programs whereas in-situ methods use conservation areas as “warehouses” of biological information. According to many scientists and conservationists millions of species and varieties which will have economic value, through in-situ conservation protection of natural areas should be the primary means for the maintenance of these resources. In both cases, the intention is to give the endangered animals and plants a chance to increase their numbers and eventually repopulate their natural habitat.

Virtually, however impossible to implement a rigid preservation approach and even less likely to be maintained over time. In developing countries, considering trends in population growth and the urgency of economic developmenta more appropriate response would be to pursue proactive alternatives to high-impact development activities, and to implement carefully formulated strategies for in-situ methods that would include protected areas in the development mix.



In-Situ and Ex-situ Conservation Techniques (source: https://prepp.in/news/e-492biodiversity-conservation-environment)

IN-SITU CONSERVATION

"In situ" ('on site', 'in place') conservation, meaning on-site conservation of wild animals and plants in their natural habitats with "biodiversity conservation" which gives species a protected status to allow them to interact with and be shaped by the natural world's complex processes. In-situ conservation allow include the free choice of mate, food and territory selection (https://www.studysmarter.co.uk).The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties. Convention on Biological Diversity (CBD), 1992.

In-situ conservation techniques involving the designation, management and monitoring of biodiversity in the same area where it isencountered. The concept is best understood in contrast to ex-situ ('off site') conservation techniques are implemented away from the conservation target's natural habitat. In-situ conservation covers a broad spectrum of situations ranging from the establishment of a protected area to the design of a sustainable management strategy for a particular habitat.

In situ conservation protects endangered animals and plants from the threat of extinction by allowing them to live naturally and undisturbed. In-situ biodiversity conservation is sparked by the vulnerability status of a species. The International Union for Conservation of Nature (IUCN) is the largest independent body responsible for keeping records on animal species and deciding their protection and vulnerability statuses. IUCN often helps with biodiversity conservation efforts and provides guidelines for species reintroduction in their natural environments (B. Lausche, 2011).

Since ancient times, the in-situ conservation of biodiversity can be said to have been practiced in India. The Edicts of Ashoka are 2200-year-old pillar inscriptions ordered by the emperor Ashoka, which survive to this day as archaeological monuments preserved across the Indian subcontinent. He banned the hunting and slaughtering of certain wild species such as Indian rhinoceroses, bats, iguanas and tortoises, instituted no-logging or burning forest laws, built watering holes and established some veterinary facilities (Dhammika, 2001).

IN-SITU CONSERVATION: TECHNIQUES

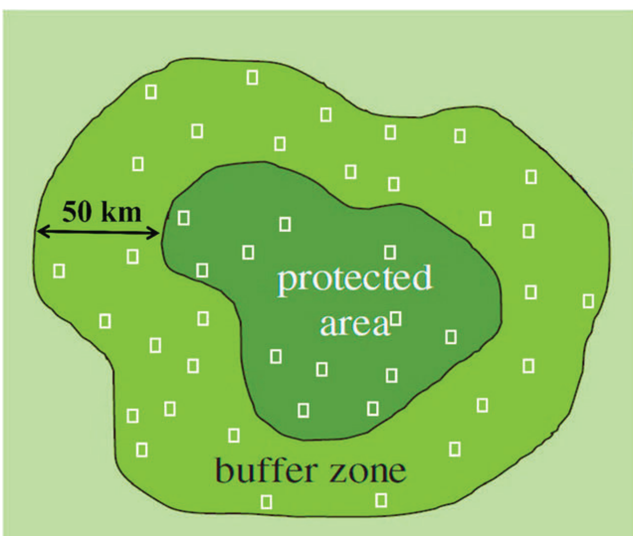
In situ conservation practices are typically more popular than ex situ methods because they don't require animals to be removed from their natural environment. This is often the best option for many species as it's the only type of conservation that can truly protect an ecosystem's biodiversity — in situ conservationists typically work to protect an entire habitat, instead of just one species.

In situ methods also work best for cases in which the ecosystem is stable. If the ecosystem is stable, there's a lower risk of the animals being negatively affected by human intervention and the environment can be allowed to heal itself without human interference. In situ conservation's primary goal is to preserve species and their natural habitats so they can continue to exist in their natural state. It is the conservation of a living organism in its natural habitat and is the only form of conservation that allows for the continued evolution and adaptation of a species.

A. PROTECTED AREAS

Protected areas are identified portions of land and water set aside for their unique physical and biological significance, managed to enhance biological diversity and protected against destructive human exploitation. Protected Area (PA) has been defined in the Wildlife (Protection) Act, 1972 (WLPA). Section 2(24A) says: "Protected Area" means a National Park, Sanctuary, Conservation / Community Reserve. These are notified under Chapter IV of the WLPA titled "Protected Areas".

At the global and regional level the most effective places to establish protected areas in order to conserve biodiversity, as well as locations that are relatively under protected (Ghosh-Harihar *et al*., 2019; Elsen *et al*., 2018; Pimm *et al*, 2018). Other works focus on the state of biodiversity in general (Pimm *et al*., 2014; Newbold *et al*., 2015) including evaluations of the extent to which 30 protected areas succeed in maintaining species (Gray *et al*., 2016; Newbold *et al*., 2015).



Protected area (source: Yang et al., 2019)

Ecological uniqueness and rich biodiversity regions of India legally protected as biosphere reserves, national parks and sanctuaries. From recent database, India now has 18 biosphere reserves, 106 national parks and 565 wildlife sanctuaries. Religious and cultural traditions of India emphasised protection of nature and natural resources andin many cultures tracts of forest were set aside, all the trees and wildlife within were venerated and given total protection. Such sacred groves are found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh.

India officially protects 5% of its area out of approximately 15% of the global protected land (Dinerstein *et al*, 2017). But it is a challenging issue in India regarding conservation, which differs from that of other large countries, such as the USA, Brazil, and China. In these countries, large protected areas are situated in sparsely populated regions, which in the USA and China are also of relatively low biodiversity (Pimm *et al*. 2018). In India, millions of people are live in and around a few kilometres of protected areas and perhaps 4 million reside within them (Narain *et al.*, 2005).The major challenges for those who manage India's biodiversity, both because the protected areas are used to some degree, and because major targets of conservation efforts, including elephants (*Elephas maximus*), tigers (*Panthera tigris*), leopards (*Panthera pardus*), bears (*Melursus ursinus*), wolves (*Canis lupus*), snow leopards (*Panthera uncia*) and prey species such as wild pigs (*Sus scrofa*), nilgai (*Boselaphus tragocamelus*), chital (*Axis axis*) and sambar (*Rusa unicolor*) pose threats to humans, livestock and crops. Such challenges are likely to become more pressing and more widespread across the world, as populations and wealth increase in the tropics (https://www.biodiversitya-z.org).

In Article no. 8 of the CBD, protected areas are the cornerstone of in-situ conservation. A protected area network may contribute to conservation targets through the maintenance of target species and their habitats, as well as the conservation of natural or semi-natural ecosystems. However growing awareness of the importance of extending in-situ conservation beyond protected areas is most important (Newmark, 2008; Primack, 2012). In context to the socioeconomic and political involvement around a threatened habitat may prevent the establishment or success of a protected area, and the development of alternative in-situ conservation management approaches may prove more useful.

The World Database of Protected Areas (WDPA)is a joint project between UN Environment Programme and the International Union for Conservation of Nature (IUCN). The compilation and management of the WDPA is carried out by UN Environment

Programme World Conservation Monitoring Centre (UNEP-WCMC), in collaboration with governments, non-governmental organisations, academia and industry. There are monthly updates of the data which are made available online through the Protected Planet website where the data is both viewable and downloadable.

PROTECTED AREA: INCLUDING CATEGORIES

1. **Strict Nature Reserve:** Natural Feature on pristine natural environment of unusual species and diversity,Main Management Objective-for science or wilderness protection,Allowable Human Activities limited scientific research activity, involving only measurements, counts and observation.
2. **Natural Park:** Natural Feature on an ecological community with minimum disturbance which illustrates the process of succession and restoration,Main Management Objective-for ecosystem conservation and recreation,Allowable Human Activities-regulated for recreation (ex. sight-seeing, bird watching and trekking), limited scientific research activity.
3. **Natural Monuments/Natural Landmarks:** Natural Feature-unique geological features of aesthetic or scientific values (ex. volcanoes, caves), Main Management Objective-for conservation of specific natural feature,Allowable Human Activities- regulated recreation (ex. controlled seasonal hunting and fishing).
4. **Wildlife Sanctuary:** Natural Feature- important wildlife species (unique, rare, threatened and endangered),Main Management Objective- for conservation of wildlife,Allowable Human Activities- scientific research involving small-scale manipulation experiments (ex. creation of artificial waterhole, habitat and population management- controlled recreation.
5. **Protected Landscapes and Seascapes:** Natural Feature- multiple use character (harmonious interaction of man, land and sea),Main Management Objective- for landscape or seascape conservation and recreation,Allowable Human Activities-socio-economic activities with emphasis on the development of compatible sustainable practices (ex. controlled collection of dead wood, wild fruits, traditional fishing/hunting- regulated recreation.
6. **Resource Reserve:** Natural Feature- extensive, isolated, uninhabited and inaccessible,Main Management Objective-

for protection of natural resources of the area for future use,Allowable Human Activities- scientific research involving only measurements, counts, and observations

7. **Natural Biotic Areas:** Natural Feature- ancestral domain (cultural sites),Main Management Objective- for preservation of Indigenous Cultural Communities (ICCs) and their culture and tradition,Allowable Human Activities- resources extraction in a traditional manner (ex. gathering food crops, medicines, dyes).

PROTECTED AREA: NIPAS ACT OF 1992

1. NIPAS Act of 1992 also known as Republic Act 7586.
2. This act is the classification and administration of all designated protected areas to maintain essential ecological processes and life-support systems, to preserve genetic diversity, to ensure sustainable use of resources found therein, and to maintain their natural conditions to the greatest extent possible.
3. It serves to "protect outstandingly remarkable areas and biologically important public lands that are habitats of rare and endangered species of plants and animals representative of biogeographic zones and related ecosystems."

   In the Andaman and Nicobar Islands over a hundred Protected Areas have been created top reserve their very special island ecosystems.

The need for an Integrated Protected Area System (IPAS):

Protected Areas, to be effective, must be established in every biogeographic region. A relatively larger representation must be included of highly fragile ecosystems, areas of high species diversity or high endemism. Protected Areas must also be integrated with each other by establishing corridors between adjacent areas wherever possible so that wildlife can move between them. The primary goal of protected areas is to conserve biodiversity to keep ecosystems healthy and secure, allowing them to continue providing essential ecosystem services like nutrient cycling, climate regulation, air and water purification, and pollination. Biodiversity conservation is critical for our economy, our values, and the natural value of species and ecosystems.

In our country, which has a rapidly growing human population, it is not easily feasible to set aside more and more land to create Protected Areas. The need to provide a greater amount of land for agricultural and other needs has become an increasing cause of concern in land and resource management. This forms a major impediment for creating new Protected Areas.

Accordingly, there is an urgent need to add to our Protected Areas to preserve our very rich biological diversity. Much of the natural wilderness has already undergone extensive changes. The International Union for Conservation of Nature and Natural Resources states that it is essential to include at least 10% of all ecosystems as Protected Areas if biodiversity is to be conserved in the long-term.

PURPOSES FOR PROTECTED AREAS

According to the World Congress on National Parks and Protected Areas (NCPPA):

1. Safeguard the world's outstanding areas of living richness, natural beauty and cultural significance as a source of inspiration and an irreplaceable asset.
2. Maintain the life-supporting diversity of ecosystems, species, genetic varieties, and ecological processes.
3. Protect genetic variation and species which are needed t met human needs, e.g., in food and medicine.
4) Provide homes to human communities with traditional cultures ad knowledge of nature.
5) Protect landscapes reflecting a history of human interaction with the environment.
6) Provide for scientific, educational, recreational and spiritual needs of societies.
7) Provide benefits to local and national economies and as models for sustainable development to be applied elsewhere.

PROTECTED AREA MANAGEMENT BOARD (PAMB)

1. It is organized by the Department of Environment and Natural Resources (DENR), as prescribed by the NIPAS Act undergoes three stages:
   a. ***Interim PAMB:-*** selection of members by the Regional Executive Director
      - processing of required documents
      - signing by the DENR of the official Certificate of Appointment

   b. **Proclamation PAMB:** exercise functions and powers given to it by the NIPAS Act.
   c. **XXXMB:**- establish a site as a protected area
      - may be called site-specific names (ex. Mt. Kanlaon Natural Park Management Board)

2. **Functions of the PAMB are:**
   a. Regulatory/Rule-making function
   b. Managerial function
   c. Policy-making/Monitoring function

PROTECTED AREA: SIZE AND DESIGN

According to the island biogeography model the design and the size of protected areas describe that large islands can accommodate more species and larger populations than small islands. Research on extinction rates of populations (Newmark, 1996; Woodroffe and Ginsberg, 1998) and species richness (Harcourt *et al*., 2001; Brashares *et al*., 2001) has shown that protected areas function very much like islands. Specifically, because large protected areas contain greater habitat diversity than small protected areas, larger protected areas can accommodate (a) more species, (b) a larger range of ecosystem processes, and (c) viable populations of large species that range over large areas and live at low densities. Large protected areas are generally preferred over small ones because they can support a greater variety of ecosystems and larger wildlife populations.

On concern of costs and benefits of establishing large protected areas, conservation biologists have debated whether creating a single large reserve or several small reserves of the same total area—known as the SLOSS (Single Large or Several Small) debate—is better. Habitat fragmentation is currently one of the main drivers of species extinctions; it divides large populations into more vulnerable subpopulations, leads to undesirable edge effects, creates barriers to dispersal, and provides entry points for invasive species. These negative impacts are also of concern for protected areas, especially those that are small and fragmented (leading to larger perimeter: area ratios). For example, fragmentation concentrates elephants (Vanak *et al*., 2010) and apex predators (Cozzi *et al*., 2013) in the core of protected areas, greatly limiting the effective protected area for these taxa. However, these same impacts do not alter ungulate foraging (Kiffner *et al*., 2013), leading, potentially, to overgrazing near reserve borders. Studies have also shown how wildlife experience higher levels of mortality near protected area boundaries (Balme *et al*., 2010). Ignoring such edge effects could disrupt the long-term conservation value of a protected area, particularly small ones that could effectively function as edge habitat in its entirety. Because one big fragmented reserve has many of the characteristics of several small protected areas, conservation planners should aim to establish properly-placed large protected areas and to keep them as intact as possible. It is thus good practice to restrict and even remove highways, fences, farms, logging operations, and other human activities inside protected areas because of how they fragment habitats and reduce habitat availability overall.

Ultimately, optimal size depends on the area over which important natural processes take place, which varies depending on the ecosystem. In some cases, the functional size may be quite small, such as a desert spring, a mountain bog, or a rocky outcrop. In contrast, the functional size of tropical forests, seasonal drylands, and desert communities are typically quite large, possibly spanning across country borders. Understanding and planning for protecting these different targets thus requires a familiarity with the functioning and ecology of each ecosystem.

When considering the size of a proposed protected area, conservation managers must also consider how well the area can be monitored and defended from threats. In some instances, an entire community may be incorporated into a relatively small protected area that is easy to monitor and defend against pollution, invasive species, and so forth. More often however, only a portion of the target community can be protected. In such cases it is important to consider how secure the conservation target will ultimately be. For example, if an aquatic organism needs protection, clearly the protection of its immediate habitat is critical. However, if a major threat is upstream from its habitat, then protection of the immediate habitat alone will be insufficient. Instead, managers would need to find ways to prevent outside threats from impacting populations inside the protected area. One option could be to discuss the threats and how to mitigate them with surrounding landowners, perhaps by facilitating their adoption of sustainable land-use practices. If the magnitude of the threats cannot be reduced to acceptable levels, a prioritization program might be used to identify critical sub-components of a larger ecosystem that will still accomplish the necessary protection. These kinds of considerations can become very complex and involved. But they are also very important to consider as options, especially when dealing with ecosystems situated between a varieties of stakeholders.

PROTECTED AREA NETWORK IN INDIA

A National Board for Wildlife (NBWL), chaired by the Prime Minister of India provides for policy framework for wildlife conservation in the country. The National Wildlife Action Plan (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation. India's conservation planning is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. The Indian Constitution entails the subject of forests and wildlife in the Concurrent list. The Federal Ministry acts as a guiding torch dealing with the policies and planning on wildlife conservation, while the provincial Forest Departments are vested with the responsibility of implementation of national policies and plans.

A network of 987 Protected Areas (PAs) has been established, covering an area of 1,73,053.69sq km or 5.26% of India's land area, comprising 106 National Parks, 564 Wildlife Sanctuaries, 99 Conservation Reserves and 218 Community Reserves(***Source: National Wildlife Database, Wildlife Institute of India, As on December, 2021***). UNESCO has designated 5 Protected Areas as World Heritage Sites.

As the ecosystems and species do not recognise political borders, the concept of Trans boundary Protected Areas has been initiated for coordinated conservation of ecological units and corridors with bilateral and/or multilateral cooperation of the neighbouring nations. There are 4 categories of the Protected Areas viz, National Parks, Sanctuaries,Conservation Reserves and Community Reserves.

India had 589 Protected Areas in 2004,however much of this includes plantations of Sal or teak, which were developed for timber in the past and are thus relatively poor in diversity and have a low level of 'naturalness'. There are only a few good grass lands left in our country that are notified as Protected Areas. Some are overgrazed wastelands in areas that were once flourishing grasslands. Most of these areas have a low biological value and need careful management to allow them to revert to a more 'natural' state, with their full complement of plants and animals. A major strategy to reduce impacts on the biodiversity of the PAs should be to provide a sustainable source of resources for local people living around them. A Protected Area curtails their traditional grazing practices and access fuel wood sources. These resources must be provided by developing them in buffer areas. Plantations of fuel wood and good grassland management in areas outside Protected Areas can help reduce the pressure on the habitat of wildlife in the Protected Area. Management must ensure that local people derive a direct economic benefit from the presence of the PA. Involving local people in Protected Area management and developing tourist facilities that support the income generation for local people helps in involving their support for the Protected Area. A carefully designed management plan which incorporates an 'Eco development' component aimed at providing a source of fuel wood, fodder and alternate income generation for local people, is an important aspect of PA management.

There are several species of plants and animals that survive without protection outside our current network of PAs. As it is not practical to notify more PAs without affecting the lives of people, alternate strategies such as Community Reserves or Community Conserved Areas need to be created. These should be managed by local people to bring about the conservation of biodiversity while using the area's resources in an equitable and sustainable way.

State Wildlife Administration Structure (Source: Praveen Bhargav)

B. NATIONAL PARKS

National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National

Park is declared forthe purpose of protecting, propagating or developing wildlife or its environment. India has some of the world's most scenic and diverse national parks, from the Hemis and Valley of Flowers in the north to the Namdapha in the East, Ranthambore and Gir in the west to the Periyar in the south. These national parks in India safeguard the natural habitats of land and marine animals from human encroachment.

According to the Indian Ministry of Environment &Forests (MOEF), a national park is that "an area, whether within a sanctuary or not, can be notified by the state government to be constituted as a National Park, by reason of its ecological, faunal, floral, geomorphological, or zoological association or importance, needed to for the purpose of protecting, propagating or developing wildlife there in or its environment. No human activity is permitted inside the national park except for the ones permitted by the Chief Wildlife Warden of the state under the conditions given in CHAPTER IV, WPA 1972"(wiienvis.nic.in. Retrieved 3 September 2019).The state government cannot change the boundaries of a National Park in India unless the National Board recommends it.

In India National Parks are under IUCN category II protected areas where the primary goal is to protect the area's natural environment and to conserve biodiversity. Recently, there are 106 existing national parks in India, covering an area of 44,372.42 km^2, or 1.35 percent of the country's geographical area (National Wildlife Database, May. 2022). In addition to the above 75 National Parks covering an area of 16,608 km^2 are proposed in the Protected Area Network Report (Rodgers and Panwar, 1988). The network of parks will go up 181 after full implementation of the above report. (https://wii.gov.in/nwdc_national_parks, 2022). India's first national park was established in 1936 as Hailey National Park is now known as the Jim Corbett National Park in Uttarakhand. India enacted the Wildlife Protection Act in 1972 and Project Tiger in 1973 to safeguard the habitats of conservation reliant species. Kaziranga National Park is the most famous which has elephant, wild buffalo, gaur, wild boar, swamp deer, and hog deer, in large numbers, as well as tiger and leopard. Its bird life is extremely rich and includes ducks, geese, pelicans and storks. In the Thar Desert, the wild life is protected in the Desert National Park. Here large numbers of black buck, neelgai and chinkara can be seen. The Great Indian Bustard lives in these arid lands.

National Parks: Characteristic Features

1. A relatively large area of one or more ecosystems that have not been significantly altered by human exploitation and occupation.
2. It is an area with sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance.
3. A National Park is established for the purpose of protecting, propagating, or developing wildlife or its environment.
4. The primary objective of a National Park is the vesting of rights of those who live within.
5. No rights are granted in a National Park.
6. Within a National Park no livestock grazing shall be permitted.
7. Removal or exploitation of wildlife or forest produce from a National Park requires the National Board for Wildlife's approval.

National Parks: Provisions

A. Notification by the State Government

1. Through notifications the State Government may declare its intention to establish a national park in any area within or outside of any reserve forest if it believes that such an area is of sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance for the purpose of protecting, propagating, or developing wild life or its environment.
2. The State Government may issue a notification specifying the boundaries of the national park and declaring that the said area shall be a national park as of the date specified in the notification after the initial notification has been issued and the period for filing claims has expired.

B. Notification by the Central Government

The Central Government by notification may declare a national park in any area if it is satisfied that an area is of sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance for the purpose of protecting, propagating, or developing wild life or its environment.

National Park: Boundary Area

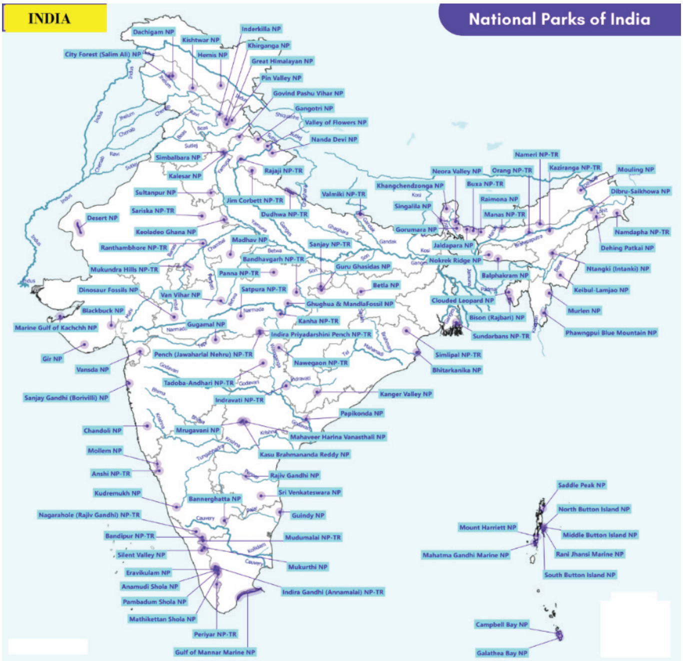
1. Description of the situation and boundaries of the area must be clearly notified as precisely as possible.
2. The limits in cases where territorial waters are included shall be determined in consultation with the Central Government's Chief Naval Hydrographer, after adequate measures to protect the occupational interests of local fishermen have been taken.
3. Unless recommendation of the National Board for Wild Life the boundaries of a national park may not be changed.

National Park: Settlement of Rights and Claim

1. The State Government shall make alternative arrangements for making available fuel, fodder, and other forest produce to those affected in accordance with their rights.
2. The State Government under this act can appoints an officer as a 'Collector' to investigate and determine the existence, nature, and extent of any person's rights in or over the land comprised within the national park that is to be notified.
3. After the issuance of a notification for declaration of the Protected Area, no right shall be acquired in, on, or over the land comprised within the limits of the area specified in such notification, except by succession, testamentary or intestate.
4. In the event of a claim to a right in or over any of the aforementioned lands, the Collector shall issue an order admitting or rejecting the claim in whole or in part.
5. If such claim is accepted in whole or in part, the Collector may either:
   a. exclude such land from the proposed sanctuary's boundaries or
   b. proceed to acquire such land or rights, unless, by agreement between the owner of such land or holder of such rights and the Government, the owner or holder of such rights has agreed to surrender his rights in or over such land to the Government in exchange for such compensation, as provided in the Land Acquisition Act, 1894.
   c. allow, in consultation with the Chief Wild Life Warden, the continuation of any person's right in or over any land within the national park's boundaries.

National Park: Permission for Entry

1. No one else have permitted to enter National Park, except:
   a. A public servant on the job.
   b. A person who has been granted permission to reside within the boundaries of the National Park by the Chief Wild Life Warden or an authorised officer.
   c. A person who has any right to immovable property within the national park's boundaries.
   d. A person travelling on a public highway through the national park.
   e. The dependents of the person referred to in clause (a), (b), or (c) above
2. No one is permitted to enter or reside in the national park, except under and in accordance with the terms of a permit granted.
3. On application, the Chief Wild Life Warden may grant any person a permit to enter or reside in a National Park for all or any of the following purposes:
   a. scientific study investigation of wildlife and related purposes
   b. purpose for photography
   c. activities for scientific research
   d. purposes of tourism
   e. transaction of lawful business with any person residing in the boundaries
4. The Chief Wild Life Warden is the authority in charge of controlling, managing, and maintaining all Protected Areas.
5. The National Board for Wild Life may make recommendations on the establishment and management of national parks, as well as on matters relating to activity restrictions in those areas.
6. The State Board for Wild Life shall advise the State Government on the designation and management of protected areas.



National Parks of India (106 National Parks in India in 2022;https://www.pmfias.com/national-parks/)

National Park: Importance

1. Helps to perpetuate, manage the area through natural means. These are examples of physiographic regions, biotic communities, genetic resources, and natural processes that are unaltered.
2. Contributes to the preservation of diverse species, regional ecological processes, and migration routes.
3. Keeps population viable and ecologically functional. In the long run, this assemblage of native species at densities is done to preserve the ecosystem's integrity and resilience.
4. Helps manage visitor use so that it does not cause significant biological or ecological degradation to natural resources for inspirational, educational, cultural, and recreational purposes.
5. It considers indigenous peoples' and local communities' needs, including subsistence resource use. So far, these will have no negative impact on the primary management goal.

6. Contributes to local economies through tourism.
7. Category II areas are usually quite large and preserve a functioning "ecosystem." To accomplish this, the protected area may need to be supplemented by sympathetic management in the surrounding areas.

National Parks: Restrictions of Activities

1. Human activity is not permitted in National Parks. Furthermore, livestock grazing and private tenurial rights are prohibited.
2. The species listed in the Schedule to the Wildlife Act are also prohibited from hunting or capturing.
3. No one may take, exploit, or destroy wildlife in a National Park.
4. No one shall allow any wild animal's habitat to be damaged or destroyed, or deprive any wild animal of its habitat within a National Park.
5. They also cannot be demoted to the status of "sanctuary."
6. National Parks can be established by both the federal government and state governments.
7. However, no changes to the boundaries of a national park may be made unless authorised by a resolution passed by the State legislature.

National parks contain thousands of plants that benefit our environment by providing us withfresh air, clean water, and other services that help to protect biodiversity. National Park in Gujarat protects shallow areas in the sea, islands, coral reefs and extensive mudflats.

C. WILDLIFE SANCTUARY

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Wildlife sanctuary is a geographical territory where wildlife is conserved or preserved to protect wildlife species from hunting, predation, competition, and poaching. In 1972, The Wild Life (Protection) Act authorised the State Government to designate certain areas as wildlife sanctuaries if they were deemed to be of sufficient ecological, geomorphological, and natural significance. India's wildlife sanctuaries are IUCN Category IV protected areas. There are 565 existing wildlife sanctuaries in India covering an area of 122560.85 km2, which is 3.73% of the geographical area of the country (National Wildlife Database, May. 2022). Another 218 sanctuaries are proposed in the Protected Area Network Report covering an area of 16,829 km^2 (https://wii.gov.in/nwdc_national_parks, 2022). The Great Himalayan National Park is the largest sanctuary in this ecosystem and is one of the last homes of the beautiful snow leopard. Dachigam Sanctuary is the only place where the rare Hangul or Kashmir stag is found.

India-- Wildlife Sanctuaries

Wildlife Sanctuary: Characteristic Features

1. A sanctuary has sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance.
2. It was established to protect, propagate, or develop wildlife or its environment.

3. Certain rights of people living within the Sanctuary may be granted.
4. These areas are enhanced by dense forests, large rivers, and high mountains.
5. Wildlife Sanctuaries of India have a unique global status because they have the world's second-largest biodiversity base. These tranquil and peaceful wildlife preserves are home to a variety of rare animals and bird species.
6. Furthermore, before finally notifying the Sanctuary, the Collector may, in consultation with the **Chief Wildlife Warden**, allow the continuation of any person's right in or over any land within the Sanctuary during the settlement of claims.

Wildlife Sanctuary: Provisions

Notification by the State Government

1. Through notifications the State Government may declare its intention to establish a sanctuary in any area within or outside of any reserve forest if it believes that such area is of sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance for the purpose of protecting, propagating, or developing wildlife or its environment.
2. The State Government may issue a notification specifying the boundaries of the Sanctuary and declaring that the said area shall be a Sanctuary as of the date specified in the notification after the initial notification has been issued and the period for filing claims has expired.

Notification by the Central Government

The Central Government by notification may declare a Sanctuary in any area if it is satisfied that an area is of sufficient ecological, faunal, floral, geomorphological, natural, or zoological significance for the purpose of protecting, propagating, or developing wild life or its environment.

Wildlife Sanctuary: Boundary Area

1. Description of the situation and boundaries of the area must be clearly notified as precisely as possible.
2. The limits shall be determined in cases where territorial waters are included in consultation with the Central Government's Chief Naval Hydrographer, after adequate measures to protect the occupational interests of local fishermen have been taken.

3. Unless recommendation of the National Board for Wild Life the boundaries of a national park may not be changed.
4. The Amendment Act of 1991 included territorial waters in areas designated as sanctuaries for the protection of off-shore marine flora and fauna.

Wildlife Sanctuary: Settlement of Rightsand Claim

The State Government shall make alternative arrangements for making available fuel, fodder, and other forest produce to those affected in accordance with their rights.

1. The State Government under this act can appoints an officer as a 'Collector' to investigate and determine the existence, nature, and extent of any person's rights in or over the land comprised within the national park that is to be notified.
2. After the issuance of a notification for declaration of the Protected Area, no right shall be acquired in, on, or over the land comprised within the limits of the area specified in such notification, except by succession, testamentary or intestate.
3. In the event of a claim to a right in or over any of the aforementioned lands, the Collector shall issue an order admitting or rejecting the claim in whole or in part.
4. If such claim is accepted in whole or in part, the Collector may either:
    a. exclude such land from the proposed sanctuary's boundaries or
    b. proceed to acquire such land or rights, unless, by agreement between the owner of such land or holder of such rights and the Government, the owner or holder of such rights has agreed to surrender his rights in or over such land to the Government in exchange for such compensation, as provided in the Land Acquisition Act, 1894.
    c. allow, in consultation with the Chief Wild Life Warden, the continuation of any person's right in or over any land within the sanctuary's boundaries.

Wildlife Sanctuary: Permission for Entry

1. No one else have permitted to enter Wildlife Sanctuary, except:
    a. A public servant on the job
    b. A person who has been granted permission to reside within

the boundaries of the sanctuary by the Chief Wild Life Warden or an authorised officer.

c. A person who has any right to immovable property within the sanctuary's boundaries.
d. A person travelling on a public highway through the sanctuary.
e. The dependents of the person referred to in clause (a), (b), or (c) above

2. No one is permitted to enter or reside in the sanctuary, except under and in accordance with the terms of a permit granted.
3. On application, the Chief Wild Life Warden may grant any person a permit to enter or reside in a sanctuary for all or any of the following purposes:
   a. investigation or study of wildlife and related purposes
   b. photography purposes
   c. scientific research purposes
   d. tourism purposes
   e. transaction of lawful business with any person residing in the sanctuary
4. The Chief Wild Life Warden is the authority in charge of controlling, managing, and maintaining all Protected Areas.
5. The National Board for Wild Life may make recommendations on the establishment and management of Sanctuaries, as well as on matters relating to activity restrictions in those areas.
6. The State Board for Wild Life shall advise the State Government on the designation and management of protected areas.

Wildlife Sanctuaries: Importance

1. Help to Preserve or Conserve Wildlife

As relocating endangered animals is time-consuming and expensive, these animals are protected in their natural environment where they can be monitored, reproduce, and grow in number while being under the strict protection of the sanctuary. By visiting these sanctuaries, biologists and other researchers can study the animals' behaviours and characteristics. Furthermore, because they are in their natural habitat, they are free to roam and move around without being confined in a cage.

2. **Landscape Protection and Preservation**

   Forests are disappearing. Once upon a time, all we could see around us were trees; now, all we see are buildings. These forests were cleared to make way for villages, towns, and cities. However, because these are protected areas, the forests cannot be cut down; instead, they are preserved and allowed to grow naturally. This also aids in the preservation of landforms such as hills and mountains, rivers, valleys, and waterfalls. They are safe from destruction, development, and pollution because they are protected.

3. **Preservation of Culture and History**

   The forests that these sanctuaries occupy are also home to some tribes who have lived there for centuries. Tribes such as the Saaraadivasis in Odisha also contribute to the conservation of the forests in which they live. The tribes who live in these sanctuaries are also protected because they do not have to fight developers who would otherwise destroy the forest. This also aids in the preservation of their culture and habits.

4. **Protection of Endangered Species**

   Because of our habits and needs, many plant and animal species are on the verge of extinction. Sanctuaries provide us with a safe space where human activities do not interfere with nature and where nature can grow without interference from humans.

5. **Biodiversity Conservation**

   It refers to the abundance of habitats, ecosystems, and species diversity on the planet, which has been decreasing due to human activity. Sanctuaries aid in the conservation of all biodiversity in an area by keeping it free of humans and their activities that could harm the ecosystem. It is also a type of conservation known as in-situ conservation, which preserves the ecosystem in its natural state and form.

6. **Ecotourism**

   Ecotourism is the tourism of ecologically interesting areas in order to support wildlife conservation and to observe wildlife. The general public can see animals in their natural habitat, free of cages, with their young, and without fear for their safety. One of the major advantages of ecotourism is that the fees collected for entering the sanctuary can be used to raise funds. This money can then be used to develop the sanctuary.

7. Education and Public Use

The general public is not well informed about sanctuaries and their benefits. However, more and more people are becoming educated about sanctuaries and serving on committees that aid in the adoption of sanctuaries. Celebrities also contribute to raising awareness by adopting animals and establishing charities on behalf of sanctuaries not only in India but worldwide.

Wildlife Sanctuaries: Protection

The government passed the **Indian Wildlife Act in 1972** to protect plant and animal species.

1. This Act prohibited the hunting and poaching of animals, as well as the legal protection of their habitats.
2. To protect forests and wildlife, the federal and state governments have established numerous wildlife sanctuaries and national parks.
3. The government has launched a number of projects aimed at conserving endangered species such as the tiger and the one-horned rhino.
4. The government has implemented a programme of joint management. This has involved local communities in forest management.
5. The **Wetland (Conservation and Management) 2010 Rules** have been proposed to protect India's wetlands. It has been launched by the central government to **preserve the Aquatic Ecosystem**, which provides assistance to various states in order to preserve the wetlands.
6. Another significant step taken by the Indian government to combat the international illegal trade in animal skins and organs was the establishment of the **Wildlife Crime Control Bureau**.
7. The **Wildlife Institute of India** was established in 1982 by the Ministry of Environment, Forests, and Climate Change. The institute is important in wildlife research, with areas of specialisation including Biodiversity, Wildlife Management, Eco-development, and Wildlife Forensics, to name a few.
8. The Bombay Natural History Society, founded in 1883, is still actively involved in wildlife preservation and research.
9. In Tamil Nadu, an ornithological centre named after Dr. Salim Ali conducts extensive research on bird migration and habitats.

10. State governments in India have also emphasised the importance of strengthening field formations and patrolling around animal preservation areas.
11. The **National Tiger Conservation Authority** was established in December 2005 to give new life to the Tiger project in India, preserving the dwindling number of tigers and their ecosystem.

    India's wildlife sanctuaries (including bird sanctuaries) are situated Ladakh in Himalayas to Southern tip of Tamil Nadu with its rich bio-diversity and heritage. Wildlife sanctuaries in India attract people from all over the world as the rarest of rare species are found where the range and diversity of India's wildlife heritage is unique.

    Bharatpur is one of the most famous water bird sanctuaries in the world. Thousands of ducks,geese, herons, and other wading birds can be seen here. This is the only home of the very rareSiberian crane which migrates to India every winter. During the last 20 years, the 30 or 40Siberian cranes have dwindled to only 2 or 3. During 20023 no cranes were seen and it is possible that this beautiful bird will never again come to India.

    Ranthambor was the most well-known sanctuary for observing tigers in the wild till about 3or 4 years ago. Since then many tigers have been killed by poachers. The Great and the Little Rann of Kutch have been made into sanctuaries to protect the veryrare wild ass, the flamingo, the star tortoise and the desert fox.

    In Gujarat, the Gir Sanctuary protects the last population of the majestic Asiatic lion. This thornand deciduous forest is also the home of large herds of chital, sambhar, and nilgai.The Sanctuaries of the Western Ghats and associated hill ranges protect some of the mostdiverse forest types in the country. The few examples of highly threatened species include the Malabar giant squirrel, the flying squirrel and a variety of hill birds, several species of amphibians, reptiles and insects. These regions are also rich in highly endemic plant life. Sanctuaries such as Bhimashankar, Koyana, Chandoli and Radhanagari preserve this rich flora in Maharashtra, Bandipur, Bhadra, Dandeli, Nagarhole, etc. in Karnataka, and Eraviculum, Perambiculum, Periyar, Silent Valley, in Kerala.

    In the Nilgiri Hills the rich forest Sanctuaries protect some of the last pockets of the Indian elephant in South India. Examples include Bandipur, Madhumalai, Wynad and Bhadra. During the last 10 years, a large number of the great tusker elephants of this region have beenruthlessly killed for their ivory. Now very few of these magnificent animals are left in these jungles. Two important sanctuaries meant for preservation of coastal ecosystems are the Chilka Lakeand Point Calimere.

The Manas Sanctuary, in addition to the above Terai species, also includes the rare golden langur and the very rare pygmy hog, the smallest wild boar in the world. The florican is found only in a few undisturbed grasslands in the Terai sanctuaries.

D. BIOSPHERE RESERVES IN INDIA

Biosphere reserves are sites established by countries and recognized under UNESCO's Man and the Biosphere (MAB) Programme to promote sustainable development based on local community efforts and sound science. The programme of Biosphere Reserve was initiated by UNESCO in 1971.

UNESCO designated Biosphere Reserve is an area of land and/or sea as being of outstanding universal value because of its ecological features are important for the conservation of biological diversity and the sustainable use of natural resources. In India Biosphere reserves were first notified by the Indian government to protect and preserve them, and later some of them were recognized by UNESCO under UNESCO's Man and the Biosphere (MAB) Programme to promote sustainable development based on local community efforts and sound science. In India, there are 18 Biosphere Reserves, among which 12 Biosphere reserves find their place in UNESCO's List of Man & Biosphere Reserves Programme (MAB). These are representative parts of natural and cultural landscapes extending over large areas of terrestrial or coastal/marine ecosystems which are internationally recognized within UNESCO's Man and the Biosphere Programme Thirteen biodiversity- rich representative ecosystems, largely within the forest land (total area – 53,000 sq. km.) have been designated as Biosphere Reserves in India.

UNESCO, in 1971initiated the Biosphere Reserve Programme to conserve in situ all forms of life, may serves as a referral system for monitoring and evaluating changes in Organic ecosystems. The first biosphere reserve of the world was established in 1979. Since then the network of biosphere reserves has increased to 631 in 119 countries across the world (Read more at https://

en.unesco.org/biosphere/Last Updated: June 23, 2021/ https://wii.gov.in/nwdc_biosphere_reserves).There are 738 biosphere reserves, including 22 transboundary locations in 134 nations. They are allocated in the following manner:

- In Africa: 90 Biosphere reserves in 33 countries.
- In the Arab States:36 Biosphere reserves in 14 countries.
- In Asia and Pacific: 172 Biosphere reserves in 24 countries.
- In Europe and North America: 308 Biosphere reserves in 41 countries.
- In Latin America and Caribbean: 132 Biosphere reserves in 22 countries

Biosphere Reserve: Criteria

1. A site must contain a protected and minimally disturbed core area of value of nature conservation.
2. The core area must be a bio-geographical unit and should be large enough to sustain a viable populations representing all trophic levels.
3. The involvement of local communities and use of their knowledge in biodiversity preservation.
4. Area's potential for preservation of traditional tribal or rural modes of living for harmonious use of the environment.

World Network of Biosphere Reserves (WNBR)

The UNESCO World Network of Biosphere Reserves (WNBR) created as part of the Man and the Biosphere Programme (MAB), comprises globally recognised protected areas referred to as biosphere reserves, which are intended to illustrate a balanced link between people and the environment (e.g. encourage sustainable development).

The World Network of Biosphere Reserves is a unique instrument for international collaboration through information sharing, experience exchange, capacity building, and the promotion of best practices facilitates collaboration between the northern and southern hemispheres.Under UNESCO's MAN AND BIOSPHERE PROGRAM, the World Network of Mountain Biosphere Reserves is a new initiative.

The Government of India has been implementing a programme known as Biosphere Reserve since 1986, which provides financial assistance in the proportions of 90:10 to the North-eastern Region

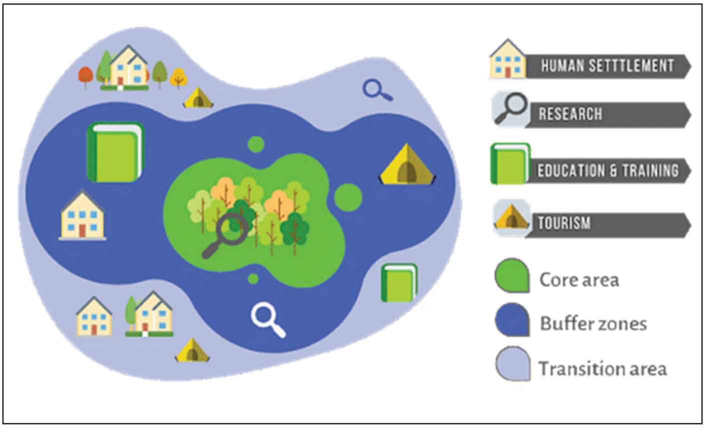
States and three Himalayan states and 60:40 to other states for the upkeep, improvement, and advancement of certain components. The Central MAB Committee reviews and approves the Management Action Plan drafted by the State Government.

Biosphere Reserves: Functional Role

For planning and management Biosphere Reserves involves the local communities and all other interested stakeholders. Biosphere Reserves in India or any part of the world are formed to achieve three main "functions":

1. Conservation of biodiversity and cultural diversity inside the reserve.
2. Socio-culturally and environmentally sustainable economic development of the reserve.
3. Logistic support and achieve development through research, monitoring, education and training.

Biosphere Reserves: Zoning Schemes



A Biosphere Reserve[https://prepp.in/news/e-492-in-situ-conservation-environment]

Biosphere reserves aim to attain integrated management of land, marine and fresh waters and living resources by placing bioregional planning schemes based on incorporating conservation to development through proper zoning of the reserve areas into three parts.

While countries maintain flexibility at the federal levels concerning the definition of zones, through integrated zonation and collaborative management, the zonation needs to ensure that biosphere reserves effectively unite these three components:conservation,sustainable utilization of tools and knowledge generation.

The zonation of each biosphere reserve in India or any other Biosphere reserve should include:

A. Core area

1. Human interference in the core area is restricted.
2. The core area of Biosphere Reserves generally consists of national parks and sanctuaries protected under the wildlife protection act 1972.
3. Core areas of the biosphere reserve are securely protected sites for conserving biological diversity. Monitoring these minimally disturbed ecosystems and undertaking non-destructive research and other low-impact uses such as education.
4. In addition to its conservation function, the core area of the reserves contributes to a range of ecosystem services, e.g. carbon sequestration, supply of clean water and air, soil stabilization.

B. Buffer zone

1. Buffer zone generally surrounds or adjoins the core regions and can be used for activities compatible with sound environmental practices, such as: environmental education, recreation, ecotourism, applied and basic research.
2. The buffer zone of the biosphere reserve also has a critical connectivity function in a larger spatial context as they connect biodiversity components within core areas with those in transition areas.
3. Buffer zones also have intrinsic functions of maintaining anthropogenic, biological, and cultural diversity in the biosphere reserves.

C. Transition area

1. It is the outermost area of the Biosphere Reserves.
2. Transition Area plays a central function in sustainable development. Transition Areas may contain a variety of agricultural activities, settlements, and other uses.

3. Local communities, management agencies, scientists, NGOs, cultural groups, and other stakeholders work together to manage and sustainably develop the area's resources.

The Advantages of a Biosphere Reserve

1. Ecological, economic, and social sustainability in an area may be maintained by promoting the prudent use of natural and human resources in the biosphere reserves established thereBiological diversity and land-use problems may be resolved using these methods.
2. National and international networks allow a biosphere reserve to receive knowledge, experience, assistance, and financing.
3. Biosphere reserves help rejuvenate rural communities by promoting a variety of local businesses.
4. The biosphere idea may serve as a framework for programmes that improve people's lives.
5. Biosphere reserves magnetise government and academic study into local concerns and difficulties.
6. Biosphere reserves are educational laboratories where conservation and sustainable development strategies may be tested and refined for use in other parts of the world.
7. Biosphere reserves assist locals and tourists develop a feeling of place by highlighting the uniqueness of the location.
8. The designation of a biosphere reserve may help increase awareness of environmental and development concerns among local people, residents, and government officials.
9. Stakeholders and volunteers may work together in a biosphere reserve.

Biosphere reserves in India and the various zones can be safely deduced that conservation and sustainable usage may be reconciled via biosphere reserves. More than 250 million people's lives are being impacted as they learn about sustainable development in various ecological, social, and economic circumstances.The World Network of Biosphere Reserves now includes 738 biosphere reserves in 134 nations, including 22 transboundary sites.

E. CONSERVATION RESERVES AND COMMUNITY RESERVES:

Conservation reserves and community reserves are terms used to describe protected areas in India that serve as buffer zones, connectors, and migration corridors between established national parks, wildlife sanctuaries, and reserved and protected forests. These categories of protected areas were first introduced in the Wildlife (Protection) Amendment Act of 2003, which amended the Wildlife Protection Act of 1972.

Conservation Reserves: Features

1. It is a state-owned area adjacent to National Parks and sanctuaries for the protection of the landscape, seascape, and habitat of fauna and flora. It is overseen by a Conservation Reserve Management Committee.
2. After consulting with local communities, the State Government may declare any area owned by the Government as a conservation reserve.
3. Tiruppadaimarathur conservation reserve in Tirunelveli, Tamil Nadu is the country's first conservation reserve.
4. The village community made an effort to protect the birds that nest in their village and acted to establish a conservation reserve.
5. The rights of people who live within a Conservation Reserve are unaffected.
6. There are 100 existing conservation reserves in India, covering an area of 4927.28 km2, or 0.15 percent of the country's geographical area.

Community Reserves: Features

1. The State Government may designate any community land or private land as a Community Reserve if the members of that community or individuals involved agree to offer such areas for the protection of fauna and flora, as well as their traditions, cultures, and practises.
2. The designation of such an area aims to improve the socioeconomic conditions of the people who live in such areas while also conserving wildlife.
3. A Community Reserve Management Committee oversees the Reserve.
4. Where a community or an individual has volunteered to conserve wildlife and its habitat, the State Government may declare the area as community land by notification.
5. There shall be no change in land use pattern within the Community Reserve unless authorised by a resolution passed

by the Management Committee and approved by the State Government.

6. There are 219 existing community reserves in India, covering an area of 1446.28 km2, or 0.043 percent of the country's geographical area.

Conservation/Community Reserves: Importance

1. Community Reserves and Conservation Reserves are protected area systems in India that bring together local communities and private organisations to manage protected areas.
2. Amendments to the Wildlife Protection Act in 2003 provided a mechanism for community-led wildlife protection efforts to be recognised and legally supported.
3. It offers a flexible system for wildlife conservation without jeopardising community needs.
4. These categories were created in response to decreased protection in and around existing or proposed protected areas as a result of private land ownership and land use.

Community Conserved Areas in India

A Community Conserved Area must have specific conservation goals that can be achieved without compromising the area's utilitarian potential. A major drive for conservation of biological diversity can only come from a mass environmental education program on the value of protecting our dwindling biological resources.

1. Gondtribals in Mendha (Lekha) village, Maharashtra, have been protecting 1800ha of reserved and protected forest for more than two decades. This is an offshoot of the struggle for tribal self-government.
2. The villagers of Jardhargaon village in Uttaranchal have been responsible for the regeneration and protection of 600-700ha of Reserved Forests and grasslands, as well as the fight against limestone mining and the in-situ conservation of hundreds of varieties of indigenous crops.
3. Protection of sea turtle eggs, hatchlings, and nesting sites by the Kolavipalam fisherfolk community in Kerala.
4. Villagers in Kokkare Bellur village, Karnataka, have traditionally conserved Painted Stork and Spot-billed Pelican nesting sites.
5. Ronmei tribe in Tokpa Kabui village, Manipur, have regenerated 600ha of village forest in the Loktak Lake catchment. The hunting

ban on the endangered Sangai deer (Brow antlered deer) in this area is self-imposed.

6. Thousands of sacred groves are being preserved by local communities across the country, despite their rapid depletion.
7. Forest regeneration, revival of traditional water harvesting structures, regulated use of water and forest resources; ban on hunting of wild animals by villagers in and around Rajasthan's Sariska National Park, is led by the NGO Tarun Bharat Sangh.

Conservation areas are designated if they are uninhabited and entirely owned by the Government of India, but are used for subsistence by communities, and community areas if a portion of the lands is privately owned. These categories were created in response to decreased protection in and around existing or proposed protected areas as a result of private land ownership and land use. People living within a Community Reserve have the same rights as those living within a Conservation Reserve.

F. SACRED FORESTS AND SACRED LAKES:

A traditional strategy for the protection of biodiversity has been practiced in India in the form of sacred forests. These are small forest patches protected by tribal communities due to religious sanctity. These have been free from all disturbances. Sacred forests are located in several parts of India i.e. Karnataka, Maharashtra, Kerala, Meghalaya, Similarly, several water bodies for example, Khecheopalri lake in Sikkim, have been declared sacred by the people, leading to protection of aquatic flora and fauna.

G. SPECIES-ORIENTED PROJECTS

Certain species have been identified as needing a concerted and specifically directed protection effort. Project Tiger, Project Elephant and Project crocodile are examples of focusing on single species through conserving their habitats.

In Situ Conservation: Advantages and Disadvantages

Similar to ex situ conservation, in situ conservation has a number of advantages and disadvantages and may make more sense in certain situations. The main advantage is that in situ conservation is a much more natural way of protecting a species. This is because the species is able to live in its natural habitat, do what it would do naturally, and breed with other members of its species. Conversely, the main disadvantage is that it's getting harder and harder to conserve a species in the wild because of human interference.

In situ conservation: Advantages

1. The animal is in its natural environment and can live as it would in the wild.
2. In most cases, both the animal and its habitat are conserved.
3. It is more humane than removing organisms from their natural habitats.
4. The odds of the population recovering are greater than ex situ methods.
5. Nature is conserved in its natural state.
6. Biodiversity can be permanently preserved and protected.
7. Natural and cultural heritage is protected and preserved for surrounding areas.
8. The ecosystem is properly managed.
9. Opportunities may emerge for environmentally conscious land uses (which come with economic benefits).
10. Establishes a framework for coordinated scientific research.
11. If the area has been damaged by poaching, it may be possible to improve its ecological integrity and restore it.

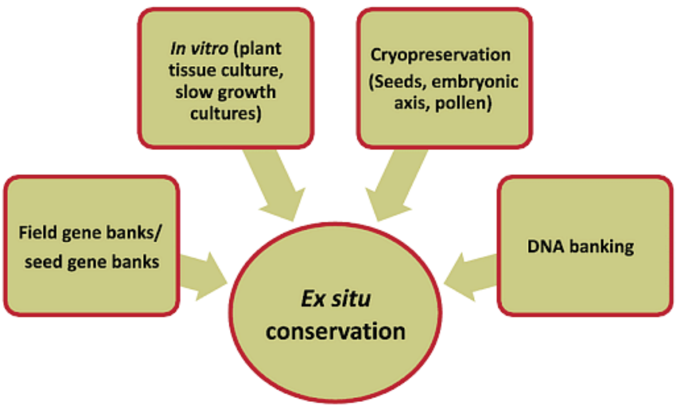
In situ conservation: Disadvantages

1. The animals are more likely to be affected by natural threats like poaching and predation.
2. When a species' population is threatened, it can be difficult to control some of the factors that are harming it. For example, disease and climate change.
3. Habitats may be small and fragmented, so the area may not be large enough to ensure the survival of these species.
4. Genetic diversity may have already been dramatically decreased.
5. Environmental conditions that threatened the organisms in the area may still be present, e.g., disease or interspecific competition.

Ex-Situ Conservation

Ex-Situ conservation refers to the conservation of biodiversity outside of the normal habitatscan take place both inside and outside of a species' native range. Similar to some conservation methods used for cultural heritage, ex situ conservation protects endangered animals and plants from the threat of extinction by keeping them in a controlled environment.

In this method threatened animals and plants are removed from their native environment and relocating them to a designated location where they can be protected and special care should be given.Ex-Situ conservation accomplished by zoological parks, botanical gardens, wildlife safari parks, and seed banks etc. Many species of animals are nevertheless kept alive in zoological parks despite going extinct in the wild.



Ex-situ Conservation (source:https://prepp.in/news/e-492-biodiversity-conservation-environment)

Recently ex-situ conservation has gone beyond the preservation of vulnerable species through utilizing cryopreservation technology, gametes of endangered species can be kept in viable and fertile form for extended periods of time. For propagation of plants *in vitro* fertilization of eggs and tissue culture techniques are also possible whereas,seeds of several genetic strains of commercially significant plants can be preserved for a long time through seed banks. The national gene bank at the National Bureau of Plant Genetic Resources (NBPGR), Delhi, focuses on the long-term preservation of rare accessions as base collections for future generations, particularly in the form of seeds.

The degree of natural dynamics varies greatly due to people influence the managed populations and this may involve changing living conditions, reproductive cycles, resource access, and protection from mortality and predators. Zoos, aquariums, botanical gardens, seed banks, and captive breeding programmes are a few examples of ex-situ conservation techniques.

Ex-situ Conservation - Facilities

Ex situ conservation can lead to the reintroduction of species into their natural habitats, but it's not a perfect solution and there are no guarantees. So, depending on the species of animal or plant, ex situ conservation may not make sense and may actually hinder the survival of the species. In some cases, ex situ conservation may be more or less a permanent solution, while in others, it may be a stepping-stone toward reintroduction to the wild.

1. For endangered species, new reproductive technologies will maximize the probability of reproductive success.
2. Monitoring the health of organisms is possible due to human interventions and help is always near when needed.
3. To conserve endangered species, there are many zoos, botanical gardens, parks, and gene banks etc., all of which are working throughout the world.
4. Organisms are well-attended to and provided with everything they need to thrive. This results in a longer and more productive life.

Ex Situ Conservation: Purposes

Ex situ conservation has several purposes:

1. Threatened germplasm of threatened species rescued.
2. Documentation for reintroduction, translocation, reinforcement, habitat, and landscape restoration and management.
3. Documentation for conservation biology research.
4. Bulk up germplasm for storage in various forms of ex situ facility.
5. Supply material for various purposes to remove or reduce pressure from wild collecting.
6. Grow those species with recalcitrant seeds that cannot be maintained in a seed store.
7. Generate skills and knowledge to support wider conservation aims.
8. Make available material for conservation education and display.

Ex-Situ Conservation: Techniques

Ex situ conservation methods are typically more proactive than in situ conservation methods, with the focus being on protecting species that are at risk of becoming extinct in their natural habitat before they are lost completely. The ex situ species are protected in a controlled environment, so their protection is not dependent on external factors such as natural predators or weather conditions. This allows conservationists to make decisions based on the species' best interest, rather than considering how the species may be affected by outside influences.

A. BOTANICAL GARDENS

A Botanical garden is an educational institute that aims to awaken and enlighten scientific workers as well as the general public or layperson's interest in plant life. Botanists, home gardeners, nurserymen, horticulturists, landscape gardeners, and foresters benefit greatly from the botanical gardens, as do millions of national and international tourists. A botanical garden is an institution for botanical research, particularly on the region's native flora.

This is a technique for ex-situ conservation of endangered and threatened species in their local habitats. Governments at various levels, educational institutions, and international assistance are all involved in maintaining this. More than 80,000 species can be found in more than 1500 botanic gardens and arboreta around the globe. There are currently tissue culture labs, seed banks, and other ex-situ technologies at many of these botanical gardens.

Colonel Robert Kyd, an army officer of the East India Company, established India's first botanical garden in 1787.The primary goal of establishing the garden was to identify new plant species with high economic value, such as teak, and to grow them on a commercial scale for trade. It was then known as the Royal Botanic Garden, Calcutta. The name was later changed to Calcutta Botanical Garden and then to Indian Botanic Garden. On June 25, 2009, the name was finally changed to Acharya Jagadish Chandra Bose Botanic Garden in honour of Acharya Jagadish Chandra Bose, a Bengali botanist-physicist and early science fiction writer.The 109-hectare garden houses over 12,000 rare plant specimens.The Botanical Survey of India (BSI) manages the centre under the Ministry of Environment and

Forests of India.The world's first university botanical garden was established in Padua in 1545.

Botanical gardens, zoos, etc. Ex-situ conservation is being undertaken through setting up botanical gardens, zoos, medicinal plant parks, etc by various agencies. The Indian Botanical Garden in Howrah (West Bengal) is over 200 years old. Other important botanical gardens are in Ooty, Bangalore and Lucknow. The most recent one is The Botanical Garden of Indian Republic established at NOIDA, near Delhi in April, 2002.

Botanical Garden - Purpose

1. To research plant taxonomy and growth.
2. To research the introduction and acclimatization of exotic plants.
3. It aids in the creation of new hybrids.
4. It contributes to the conservation of rare and threatened species.

   Serve as germplasm banks or gene pools for wild relatives of economically important plants.
5. Create nature centres and youth museums to draw attention to the destruction of tropical and temperate ecosystems, as well as environmental degradation.
6. Keep less appealing and abandoned ornamental plants.
7. Botanic gardens have a strong educational component that allows them to communicate the importance of plant conservation to a wide range of audiences while also demonstrating how this can be accomplished.
8. Linking plants to human well-being, as well as assisting in the conservation of indigenous and local knowledge.
9. To encourage the sustainable use of plant resources for the benefit of all, as part of sustainable development.

Botanical Garden - Criteria

1. A reasonable level of permanence.
2. A scientific basis for the collections.
3. Proper documentation of the collections, including the wild origin.
4. Plant collection monitoring.

5. Plants are appropriately labelled.
6. The public is welcome to attend.
7. Communication of information to other gardens, institutions, and the general public.
8. Exchange of seed or other materials with other botanic gardens, arboreta, or research institutions.
9. Conducting scientific or technical research on plants in the collections.
10. Maintenance of plant taxonomy research programmes in associated herbaria.

Botanical Garden - Importance

1. It is a protected area for a variety of endangered flora.
2. It aids in taxonomic study and research.
3. It informs the public about both local and exotic plant species.
4. A botanical garden conserves and propagates rare species and genetic diversity.
5. Botanic Garden Conservation International (BGCI)
6. Botanic Gardens Conservation International (BGCI) is a membership organisation that represents botanic gardens in over 100 countries worldwide.
7. It is an independent UK charity founded in 1987 with the goal of connecting the world's botanic gardens in a global network for plant conservation.
8. The mission is to mobilise botanic gardens and engage partners in ensuring plant diversity for the well-being of people and the planet.
9. Botanic gardens, seed banks, and botanical institutions that are being established or created have an interest in developing their activities for the purpose of plant conservation and wish to take advantage of the benefits that BGCI membership provides.

Plant Conservation: Global Strategy

1. Botanic gardens have collectively built up centuries of resources and abilities of individuals that now play a crucial component in plant upkeep and monitoring.
2. Many of these accomplishments contribute to ex-situ maintenance, but botanic gardens also play an important role in sitting maintenance.

3. Botanical gardens must adhere to international policies and guidelines such as the Convention on Biological Diversity and the Convention on International Trade in Endangered Species of Wild Animals and Plants.
4. These rules are required to avoid the rapid loss of biodiversity. In the botanical garden, there is research and scientific management.
5. Plant diversity is maintained in botanical gardens. These strategies focus on how plant species save the world and how plant species save life on Earth.
6. There is a significant variation in the size and type of botanic garden in all areas of the biosphere, with facilities set up to share proof and effectiveness.

Botanical gardens are used to study and conserve plant species. Along with local plant species, it also features plant species from around the world. These gardens play an important role in meeting human needs and providing well-being. Botanical gardens are frequently run by universities or other scientific research organisations, and many have associated herbaria and botanical science research programmes.This is a method of ex-situ conservation of threatened and endangered species in their respective regions. This is maintained by governments at different levels, educational institutions and with the international assistance as well. There are more than 1500 botanic gardens and arboreta in the world containing more than 80,000 species. Many of these botanic gardens now have seed banks, tissue culture facilities and other ex-situ technologies.

B. ZOOLOGICAL GARDENS (ZOOS)

Around the world, there are more than 800 professionally run zoos that house around 3000 different species of mammals, birds, reptiles, and amphibians. These zoos frequently feature advanced captive breeding programmes. Breeders and genetic engineers have a ready source of genetic material thanks to the protection of crop plants', animals', or microbes' wild ancestors. Many tropical islands have a large number of indigenous animal species, and they also have a highly spectacular record of agro-biodiversity.

A Zoological Park or zoo is a stationary or mobile establishment where captive animals are kept for public exhibition and includes a circus and rescue centres but does not include a licenced dealer in captive animals. Zoos were originally intended to provide entertainment; however, over time, they have evolved into centres for wildlife conservation and environmental education. Zoos, in addition to saving individual animals, play an important role in species conservation (through captive breeding). In this article, we will discuss Zoological Parks which will be helpful for UPSC exam preparation.

A zoological garden, zoological park, or zoo is a place where living animals are kept in enclosures and usually displayed to the public.Zoos perform research, education, and conservation (such as breeding endangered animals and sometimes reintroducing them into the wild) in addition to recreation. While some domesticated animals may be kept for display, wild animals are the main focus.Aquariums are places where marine invertebrates, fish, and marine mammals are kept separately.

Role of Zoological Park: Critical for Wildlife Conservation

1. Zoological parks are special parks or large land areas with special confinements where zoological entities can live in a man-made natural environment while being cared for.
2. A zoological park can be either government or private, and it is maintained by special autonomous bodies in India such as the Zoological Society of India.
3. Zoological parks are necessary in order to conserve the genotype of a specific organism, so that even if the organism becomes extinct from this world due to man-made or ecological factors, the scientific community that works on zoological research can recover such organism in order to maintain a region's fauna.
4. Different regions of a country have different types of zoological parks with a wide variety of animals. We have organisms that are native to hilly regions, and the entire zoological park is built in this manner.
5. Zoological parks provide all of the requirements for animals that are found in the forest, as well as proper veterinary services to ensure that the animals do not contract any disease.
6. The veterinary hospital also oversees animal nutrition, ensuring that animals receive adequate nutrition at all times of the day.

Indian Zoos (2021-2031): Vision Plan

1. The Union Environment Minister released the Vision Plan (2021-2031) for Indian zoos by Central Zoo Authority (CZA) to upgrade them to global standards and strengthen Central Zoo Authority.
2. The comprehensive 10-year vision plan was developed following a rigorous data mining and stakeholder consultation process, and it is expected to steer India towards ex-situ conservation approaches.
3. The objective of this vision document is dedicated to making CZA and Indian zoos a more powerful conservation force by providing unparalleled animal care, cutting-edge research, and immersive visitor experience that resonates with people of all ages.

Central Zoo Authority (CZA)

1. The Central Zoo Authority is a statutory body whose primary goal is to enforce minimum standards and norms for animal upkeep and health care in India's zoos.
2. Zoos are governed by the provisions of the Wild Life (Protection) Act of 1972 and the National Zoo Policy of 1992. In 1991, the Wild Life Protection Act was amended to create the Central Zoo Authority.
3. Objective: To supplement and strengthen the national effort in the conservation of the country's rich biodiversity, particularly the fauna, as outlined in the National Zoo Policy of 1998.
4. Functions: It enforces minimum standards and norms for the upkeep and healthcare of animals in Indian zoos. Every zoo in the country must obtain CZA recognition in order to operate. It can also de-recognize zoos.

   Nandankanan, which literally means "The Garden of Heaven," is located near Bhubaneswar, Odisha. Unlike other zoos in the country, Nandankanan is built right inside the forest and is set in a completely natural environment. Nandankanan is one of six zoos involved in the White-backed vulture conservation breeding programme. It is also the world's first zoo to breed white tigers and melanistic tigers.

   The White Tiger is a rare form of Bengal Tiger that has a unique (recessive) gene that causes it to be white. A white tiger is not a tiger subspecies. White tigers are only born when two Bengal tigers with recessive genes (genes that affect coat colour) mate.

Melanistic tigers are black-striped tigers born solely due to genetics. Black stripes are caused by an increase in the production of melanin pigment in the body. Melanistic tigers are extremely rare in the wild. The only conservation breeding centre for Indian pangolins in the world. The only zoological park in India to become an institutional member of the World Association of Zoos and Aquariums (WAZA). Gharials bred in captivity for the first time in the world at Nandankanan Zoological Park in 1980.The first zoo in India where endangered Ratel was born in captivity.

Odisha's second largest heronry for Open-Billed Storks. A number of zoos have been developed in the country. These zoological parks have been looked upon essentially as centres of education about animal species and recreation. They have also played an important role in the conservation of endangered animal species such as the Manipur Thamin Deer (Ceruseldieldi) and the White winged Wood Duck (Cairinascutulata). Notable successful examples of captive breeding are those of Gangetic gharial (Gavialisgangeticus), turtles and the white tiger.

Birds and animals at a Zoological Park live in an environment that is similar to their natural habitat in many ways. The Zoological Park not only houses endangered species, but also assists them in reproducing in captivity. They may eventually be able to thrive in the wild again. Many animals in the world, including the Black Panther, have become endangered as a result of indiscriminate hunting.

There are more than 800 professionally managed zoos around the world with about 3000 species of mammals, birds, reptiles and amphibians. Many of these zoos have well-developed captive breeding programmes.

The conservation of wild relatives of crop plants, animals or cultures of microorganisms provides breeders and genetic engineers with a ready source of genetic material. Many of the tropical islands are rich in the number of endemic faunal species it possesses, while its record in agro-biodiversity is very impressive as well.

C. WILDLIFE SAFARI PARKS

A safari park, sometimes known as a wildlife park, is a zoo-like commercial is an ex-situ conservation technique. A zoo-like establishment frequently referred to as a "wildlife park," a safari park is an example of ex-situ conservation. It is a drive-in tourist attraction where visitors can ride in vehicles provided by the establishment or drive their own cars while watching animals roam freely. A safari park is bigger than a zoo and smaller than a game reserve. For instance, the 750-acre African Lion Safari in Hamilton, Ontario, Canada (3.0 km2).

D. SEED BANKS

Seeds are kept in seed banks in order to protect genetic variety for the future. They often contain jars of seeds from various plant species and are vaults that are bomb, flood, and radiation proof. Seeds must be kept in storage for a variety of reasons. In order to boost crop output, disease resistance, drought tolerance, nutritional quality, flavour, and other traits, plant breeders need certain genes to be preserved. Another is to prevent the genetic diversity of rare or threatened plant species from being lost in an effort to ex situ conserve biodiversity. The seeds are normally stored in low humidity and cold (about -20°C) conditions.

The preservation of seeds in a setting with controlled humidity and temperature is called seed banking. For taxa with conventional seeds that can withstand desiccation, this method is employed. Facilities for seed banks range from climate-controlled walk-in freezers or vaults to sealed boxes. Normally, taxa with resistant seeds that cannot tolerate desiccation aren't kept in seed banks for a very long time.

E. CRYOPRESERVATION

Seeds, pollen, tissue, and embryos are all stored in liquid nitrogen during plant cryopreservation. Compared to all other methods of ex situ conservation, this method allows for practically unlimited storage of the material without deterioration over a far longer time frame. Through cryoconservation of animal genetic resources, cryopreservation is also employed to conserve livestock genetics. Many species cannot be cryopreserved due to technical limits, but plants are the subject of several studies in the discipline of cryobiology, which is an area of ongoing research.

This type of in vitro conservation is done in liquid nitrogen at a temperature of −196°C. This is particularly useful for conserving vegetative propagated crops, for example, potato. Cryopreservation is the storage of material at ultralow temperature (−196°C) either by very rapid cooling, as used for storing seeds, or by gradual cooling and simultaneous dehydration, as being done in tissue culture. In cryopreservation, the material can be stored for a considerable long period of time in compact low maintenance refrigeration units.

For instance, the Zoological Society of San Diego has created a "frozen zoo" to retain such samples from more than 355 species, including mammals, reptiles, and birds, using cryopreservation techniques. Interspecific Pregnancy: Interspecific pregnancy is one such method that could help endangered species reproduce. It involves implanting embryos of an endangered species into a female of a related species and allowing to bring the embryo to term. For the Spanish ibex, it has been done. Cryopreservation: ("freeze preservation") is particularly useful for conserving vegetative propagated crops. Cryopreservation is the storage of material at ultra-low temperature of liquid nitrogen and essentially involves suspension of all metabolic processes and activities. Cryopreservation has been successfully applied to meristems, zygotic and somatic embryos, pollen, protoplasts cells and suspension cultures of a number of plant species.

F. FIELD GENE BANKING/ GENE BANKS

Ex-situ collection and preservation of genetic resources is done through gene banks and seed banks. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi preserves seeds of wild relatives of crop plants as well as cultivated varieties; the National Bureau of Animal Genetic Resources at Karnal, Haryana maintains the genetic material for domesticated animals, and the National Bureau of Fish Genetic Resources, Lucknow for fishes.Field Gene Banking refers to a sizable open-air planting used to preserve the genetic variety of wild, domesticated, or forest species.In most cases, field gene banks conserve species that are either impossible or difficult to conserve in seed banks. Field gene banks can be used to cultivate and pick offspring of species preserved via various ex situ methods.

Similar methods are used to protect endangered animal species and breeds. In gene banks, which are composed of cryogenic facilities used to store living sperm, eggs, or embryos, animal species can be conserved.

G. CULTIVATION COLLECTIONS

Cultivation Collections refers to plants that are cared for horticulturally in a built landscape, usually a botanic garden or arboretum. Although plants are kept in their natural habitat, this method is comparable to field gene banks in that collections are often not as large or genetically varied. These collections are vulnerable to disease spread, genetic drift, artificial selection, and hybridization. Frequently, cultivated collections contain species that cannot be preserved using other ex situ methods.

H. INTER SITU

This method is mainly applied to uncommon taxa or those that are found in severely degraded habitats. Horticulture is used to take care of the plants, but the surroundings are kept as close to natural as possible. This happens in both semi-natural and restored habitats.

I. TISSUE CULTURE

In tissue culture, somatic tissue can be kept in vitro for a short while. This is carried out in a setting with controlled lighting and temperature to manage cell development. Tissue culture is mostly utilized for clonal growth of vegetative tissue or immature seeds as an ex situ conservation strategy. This makes it possible for clonal plants to grow from a tiny amount of parent tissue.

Ex situ conservation methods for vegetative propagated woody species traditionally relied on field or glasshouse collections. Such collections are expensive to maintain, are susceptible to environmental changes, and do not present a safe long-term option. Consequently, some 25 years ago, alternative in vitro approaches were considered. Shoot tip culture methods were modified to slow down growth rates and hence reduce maintenance costs. This was achieved most conveniently by employing reduced temperatures and was carried out initially with herbaceous crops. One major advantage of restricted growth techniques is that they utilize the same basic facilities as micro-propagation. Cultures can be readily switched to rapid multiplication regimes when required. Restricted growth techniques have been used for a number of temperate woody species, including apple (*Malus pumila*) and pear (*Pyruscommunis*). However, they do not alleviate some of the main problems associated with the culture of plant tissue in vitro, such as high costs of labour and space, and risks of somaclonal variation.

Ex-Situ Conservation: Advantages and Disadvantages

Ex situ conservation in any way is a useful tool for the conservationist's arsenal but the advantages and disadvantages must be weighed carefully before making a decision to pursue it.

Ex-situ Conservation: Advantages

1. Endangered organisms are completely protected from predators and poachers.
2. Healthy and cared for offspring is carried out in artificial environments, thus adding additional supervision.
3. Individual species health can be tracked and medical assistance can be provided whenever necessary.
4. During the case of a disaster populations can be managed more effectively.
5. It has the potential to reintroduce several organisms back into their natural habitat.
6. Genetic diversity of the population can be measured.
7. Selective breeding programmes can be implemented.
8. Modern reproductive technology can increase the chances of reproductive success.
9. Animals and plants can be bred to increase their numbers if they are in danger of extinction.
10. Research on an endangered species' reproductive physiology, way of life, and ecology is made simpler.
11. Funds for additional conservation efforts might be raised by using conservation sites as attractions.
12. Educational activities can take place at conservation areas.

Ex-situ Conservation: Disadvantages

1. Interbreeding among plants or animals can happen and hybridization of animals and plants is sometimes required.
2. In captive population genetic diversity is minimal.
3. Nutritional related problems could occur as the creatures are residing outside of their normal habitat.
3. Animals can be prone to a wide variety of diseases as artificial environment is not natural and is not as suitable.
4. Animals might not behave normally as suffer from stress, boredom, and a lack of room.

5. Attempting to reproduce at times may become difficult.
6. Appropriate environmental conditions for survival could be challenging to attain.
7. Acceptance by the species' current wild members may present challenges.
8. It takes species away from their natural habitat and is seen as a last resort.

Ex-situ conservation requires regular assessments on the materials' viability and prompt regeneration, which vary depending on the crop species and their reproductive systems. Ex Situ conservationists will have to face and strive to resolve these issues in the upcoming ten to fifty years, much alone the entire new millennium. They will be important for the advancement of humanity. To ensure that the world's natural resources are accessible to everyone who needs them, we must work to preserve sections of the natural, or at least the semi-natural environment, not just for living and leisure, but also to ensure that they are preserved for future generations.

CONCLUSION

In the past National Parks and Sanctuaries in India were notified to preserve major wildlife species such as tigers, lions, elephants, and deer. The objective of these areas should be expanded to the preservation of relatively intact natural ecosystems, where biological diversity – from microscopic unicellular plants and animals, to the giant trees and major mammals – can all be preserved.

However species cannot be protected individually as they are all inter dependent on each other. Thus the whole ecosystem must be protected. The biologist's view point deals with areas that are relatively species rich, or those where rare, threatened or endangered species are found, or those with 'endemic' species which are not found elsewhere. As rare endemic species are found only in a small area these easily become extinct due to human activity. Such areas must be given an added importance as their biodiversity is a special feature of the region. Animals such as elephants require different types of habitat to feed in during different seasons. They utilize open grasslands after the rains when the young grass shoots are highly nutritious. As the grasses dry, the elephants move into the forest to feed on foliage from the trees. A Protected Area that is meant to protect elephants must therefore be large enough and include diverse habitat types to support a complete complement of inter linked species.

There are Protected Areas, National Parks and Wildlife Sanctuaries include a variety of ecosystems and habitats. Some have been created in order to protect highly endangered species of wild plants and animals found nowhere else in the world. There are several Sanctuaries in the Terai region, the Sundarbans protect the largest mangrove delta in India. The residual areas that have high levels of species richness, endemism or endangered plants and animals must be notified as National Parks and Wildlife Sanctuaries. Other areas can be made into Community Conserved Areas which are managed by local people.

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11 Contribution of different Components of Biodiversity in Ecosystem

J. K. De

INTRODUCTION

India is recognised as one of the 12 Mega bio-diversity Country of the world due its unique geographical location and diversity of climate. India has only 2% land mass of the world, but has nearly 89,500 no. of animal species which is more than 7% of the total animal species in the world (1). India is home to have more than 50,000 species of plants, which constitute some 6-7 percent of the total plant species in the world (2) & (3). India has approx. 329 million Hectare of land and its coastal line stretches about 7500 km. Forest Survey of India reported the total forest and Tree cover in India is 80.9 million hectre which is 24.62 % of the geographical area and forests constitute about 12% of the total land surface (24). Out of 89,500 nos. of animal species 66% of species belong to Insects group only.

Highest biological diversity is observed in India like China, Peru, Brazil, Madagascar, Ecuador, Australia, Mexico, Indonesia, Colombia, Malaysia and Zaire. Almost all the world's major ecosystems viz., 1) Forests, 2) Mountains, 3) Deserts, 4) Grass lands, 5) Fresh water, 6) Marine, 7) Wet lands, 9) Estuaries & Backwater, 10) Islands are found in India (4). Indian faunas are distributed in its 10 bio-geographical regions ranging from temperate to arctic in the Himalaya to tropical & sub-tropical in the Indo-Gangetic plains & the peninsular India. Vegetative cover consists of all types of forests and vast expanse of grass lands.

* Former Office Zoological Survey of India, New Alipore, Kolkata

Services provided by the Biodiversity in the Ecosystem

Biodiversity is the variety of life in the world or in a particular habitat or ecosystem. Biodiversity brings together the different species and forms of life (animal, plant, entomological and other) and their variability. Ecosystems provide services is extensive and it includes in cleaning air and water, supply oxygen, regulating climate, decomposing and cycling organic matter, maintenance of soil structure, soil detoxification, formation of soil and plant growth control, gaseous exchange, pollination of plants, production of food, fibre for textiles and shelter, fuel and energy and medicines, pest control, wastewater treatment, suppression of pests and human diseases. It may be said that more than 90 % of the calories consumed by people worldwide are produced from plant species and almost 30 % of medicines are developed from plant and animal.

A healthy biodiversity offers many natural services viz., Protection of water resources, Soils formation and protection, Nutrient storage and recycling, Pollution breakdown and absorption, Contribution to climate stability, Maintenance of ecosystems and Recovery from unpredictable events.

TYPE OF BIODIVERSITY

There are three type of biodiversity viz., Species diversity i.e. every ecosystem contains a unique collection of species, all interacting with each other.

Genetic Diversity i.e. describes how closely related the members of one species are in a given ecosystem. Genetic diversity within a species not only is necessary to maintain diversity among species,but also contributes to the diversity of food, fibre, and medicines available from nature.

Ecosystem diversity deals with the variations in ecosystems within a geographical location and their overall impact on human existence and the environment.

ROLE OF BIODIVERSITY

The mother earth gives us raw materials for our shelter and dresses. Even traditional medicine and a large number of drugs are derived from the plant extracts. The ecological services provided by biodiversity are vital to our everyday life. We depend on nature for air to breathe, water to drink, foods and nutrients for survival. Insects, worms, bacteria, and other tiny organisms enrich soils by breaking down wastes and decomposing of dead plants and animals. Role of some components of biodiversity are discussed here:-

A. Plants as producer

In fact all of the oxygen on earth is produced through photosynthesis. The rainforests are responsible for 28 percent of earth's oxygen and 70 percent is produced by marine plants called phytoplankton (5).

B. Insects &Butterflies as consumer

Insects are found everywhere and are the most common animals. At present more than 1.5 million species of insects have been discovered. They are important because of their diversity, ecological role, and influence on agriculture, human health, and natural resources. They are important for a healthy ecosystem. Like micro-organism Insects also play a vital role in releasing of nutrients for utilisation of the growing plants and also help in maintaining soil and fertility. Many insects help in pollination of crops and fruit trees, dispersal of seeds and exert biological control on those insects, which are harmful. They control populations of other organisms, and provide a major food source for other taxa. Insects pollinate many of our fruits, flowers, and vegetables. We would not have much of the produce without the pollinating services of insects, not to mention honey, beeswax, silk, and other useful products that insects provide. Our lives would be different without insects.

They are omnivorous i.e. that they can eat a variety of foods including plants, fungi, dead animals, decaying organic matter, and nearly anything they encounter in their environment and others may rely only on one particular plant or even one specific part of one particular plant to survive. Many insects are predatory or parasitic, either on plants or on other insects or animals, including people. Such insects are important in nature to help keep pest populations (insects or weeds) at a tolerable level. We call this the balance of nature. Predatory and parasitic insects are very valuable when they attack other animals or plants that we consider to be pests. They are the sole food source for many amphibians, reptiles, birds, and mammals. Insects themselves are harvested and eaten by people in some cultures. They are a rich source of protein, vitamins, and minerals, and are prized as delicacies in many third-world countries. In fact, it is difficult to find an insect that is not eaten in one form or another by people.

Among the most popular are cicadas, locusts, mantises, grubs, caterpillars, crickets, ants, and wasps (7).

Our life would become dull without having butterflies or lightning beetles. They are regarded as central pollinators to many agricultural crops. Additionally, their ecological function is also a food source to predators like birds, spiders, lizards and other animals. Butterfly's beauty is like a flower, which displays attraction wherever it flies. They add aesthetic value to the ecosystem due to their elegance and beauty (8).

C. Amphibian as consumer

Amphibians play a pivotal role in ecosystem as secondary consumers in many food chains**.** Tadpoles have significant impact in nutritional cycling. They are herbivorous to omnivorous and are the prey items for both invertebrates and vertebrates. Adult amphibians are the best biological pest controllers. Amphibians are viewed as indicators of wetland ecosystem health. Amphibians contribute to regulating services by reducing mosquito recruitment from ephemeral wetlands, potentially controlling other pest species, and indirectly through predation of insect pollinators. Amphibians can affect ecosystem structure through soil burrowing and

Aquatic bioturbation and ecosystem functions such as decomposition and nutrient cycling through waste excretion and indirectly through predatory changes in the food web. They also can control primary production in aquatic ecosystems through direct consumption and nutrient cycling (15). Amphibians and reptiles are both important members of aquatic and terrestrial ecosystems. Both groups serve as both predators and prey, and species that inhabit both ecosystems serve to transfer energy between the two systems. Both of them represent a high proportion of global species diversity and include species that are widely distributed throughout the world and play a variety of roles that benefit humans. Amphibians and reptiles contributed directly and indirectly to the four types of ecosystem services: provisioning, regulating, cultural, and supporting (16).

D. Reptiles as consumer

Reptiles play a critical role both as predator and as prey species in most ecosystem. They are the most important components of the food webs in many ecosystem. They control the numbers of serious rodent and insect agricultural pests by consuming. Lizards have ecological functions such as dispersing seeds, controlling insect populations like ants, and providing food for other animals (13). As one part of the greater food chain, they prevent overpopulation and provide food for hungry predators, especially when they are young. According to Sinervo, an evolutionary biologist, a herpetologist and ecologist, insect populations would "explode" with the disappearance of lizards, because lizards prey on insects as their major food source.

Crocodiles and alligators also prevent overpopulation of fish species in coastal regions and wetlands keeping these aquatic ecosystems healthy and balanced (14). They also help in carrion control. For any reptile a rotting carcass, a carrion is an easy meal. So reptiles such as the infamous Komodo dragon are one of many organisms that play a role in clearing dead animals from the environment. Reptiles themselves are often used for food. Birds of prey will eat anything from boas to lizards. Young turtles are preyed upon by all manner of animals. Sea turtle hatchlings that face a perilous journey back to the water provide a veritable feast for hungry animals.

Turtles, for instance, are a delicacy and play a role in traditional Chinese medicine. In addition, the venom of a snake is used often to derive vaccines, and reptile scales are considered fashionable in many cultures.

E. Birds as consumer

Birds have also important role in ecosystem. Some birds prey on small rodents and other group of animals. They control insect and rodent reducing and maintaining populations of insects and other prey species in natural systems. Their role in plant pollination and seed dispersal is highly worth mentioning. They bring plants back to ecosystem that has been destroyed and also carry them in new islands. They also play a role of predators, scavengers and ecosystem engineers. Without birds, insect population may be increased rapidly. Because insectivorous birds eat insects, they are also known as environment cleaners, like vultures they eat decayed bodies, which can harm environment. Humans are benefited by these natural processes of "Ecosystem services" rendered by birds (9). Out of the more than 9,000 bird species of the world, the Indian subcontinent contains about 1300 species or over 13 % of the world birds. An enormous variation in climatic conditions within the Indian limits has helped birds to colonise throughout the country in huge numbers spread over various habitats (10). Many bird species predate on smaller rodents and animals (which pollute the environment) to sustain themselves.

F. Mammal as consumer

Mammals may be herbivores, carnivores, insectivorous, or omnivores i.e., they can feed at various levels of food chains. With their four types of teeth, they can eat wide range of foods. They can maintain a constant body temperature with high range of tolerance whether in Antarctica or in the Sahara desert (https://www.topperlearning.com). Mammals are important members of food chains and food webs of practically every ecosystem, as grazers and predators. The significance of mammals in an ecosystem is to modify vegetation structure, altar pathways of nutrients, and thereby change species composition. The structuring role of mammals in maintaining species diversity is evident not just in vegetation, but also in birds, other mammals, and invertebrates. This role make them prime candidates as 'umbrella species' for conservation. Such mammals become the 'indicator species 'for the health of the ecosystem. Some mammals especially carnivores as highest consumers in ecosystem (11). Mammals provide dairy products and much of the meat eaten by the human population, whether farmed or hunted. They also yielded leather and wool for clothing and equipment. Until the arrival of mechanised transport, domesticated mammals provided a large part of the power used for work and transport (12).

G. Micro-organisms as decomposer

Their activities are vitally important to virtually all processes on Earth. They are found in every part of the earth and can live even in the most heated areas as well as in most cold environment. These microbes /Bacteria play key roles in nutrient cycling within ecosystem, biodegradation/bio deterioration, climate regulation, carbon sequestration, food spoilage, the cause and control of disease, and biotechnology. They help in decomposition by breaking down organic matter of dead plants and animal and helps the soil to generate vital elements that are taken up by plants. They play important roles in balancing the ecosystem of the earth by the process. They also help in oxygen production, evolution, and symbiotic relationships with higher organism. Decomposition also helps in the removal of disease-causing organisms in carcasses. Some bacteria living on the ocean floor feed on oil that seeps from the ground (6).

BIODIVERSITY IS NOW AT STAKE

In spite of so many importance, these biodiversity are being lost at a greater extent due to human interference stated below (17). They are under severe threats owing to various anthropogenic activities. Human- wildlife conflict between wild animals and people is the result of human interference. It is because of growing human populations overlap with established wildlife habitat.

1). The valuable faunal wealth is severely affected for over exploitation and habitat destruction. Due to pressure of human population, mass scale encroachment of forest lands are made. Developmental activities such as construction of roads, construction of rail lines within forests clearing vegetation and excavating can destroy wildlife and its habitats. Construction needs land and the use of land can have direct impacts in terms of destruction of habitats .This can influence population dynamics especially for mobile species which rely on large habitats (18). All the environmental problems are due to increase of population in the world. Real estate construction causes both air and water pollution. The noise and light from ongoing construction can disrupt species' feeding or breeding behaviours (19).

2). In spite of introduction of several Laws and Acts, the animals are being indiscriminately poached for illegal export/import of wildlife and its derivatives. Endangered plant species are also illegally felling besides many valuable trees.

3). Animals targeted by smugglers

Tiger & big cats (skins & bones).

Elephant (ivory).

Rhino (horns)

Pangolin (scales), mongoose (hairs), otter (skins)

Snakes (skins), Monitor lizards & Crocodile (skins).

Monkeys, Lories, Hoolock (live)

Deer species (musk, antler & pelts).

Turtles and tortoises

4). Military/defence activities: Setting up of military camps, Air base, roads for military movements etc., within forests resulting deforestation and habitat loss for the faunas.

5). Socio-economic situation of the fringe villagers also forced them to fell tree for their fire woods collection etc.

6). Cattle grazing is one of the burning issues for spreading of diseases among wild animals of forests.

7). Introduction of exotic species in natural habitat also affect food chain of the native species. They compete with native species for food and habitat. Interbreeding of native and non-native species declines the population of native species. Accidentally (from lack of knowledge of the general public) introduced pest species to area causes severe damage to native species. It may be said that the conversion of forests, wetlands, grasslands, and other natural areas to urban and agricultural uses and invasive species are the primary drivers of biodiversity loss.

8). Abiotic factors: Temperature, pH, moisture levels are the non-living factors in ecosystem. Any of the extreme abiotic factors can reduce the biodiversity of the ecosystem.Extremes of an abiotic factor can reduce the biodiversity of the ecosystem. For example, ecosystems with a very low temperature tend to have low biodiversity (20).

IMPACTS

Over exploitation of animals and plants and their habitats have led to dwindling of both their diversity and population. Habitat, foraging areas, host plants of wild animals are decreasing day to day for human interference. Most of the animals are in critical condition due to deforestation, pollution, excessive use of pesticides, poaching and hunting etc. About 70% of animals are negatively affected due to these. If we do not think of these creatures, we will loss many more animals in the near future. Already we have lost some species for ever from our country and some are in the verge of extinction. The hunting leopard, *Acinonyx jubatus venaticus* Griffith, 1821 a fastest runner was last recorded in India during 1952. About 90% of forest land areas have been destroyed over 100 years age. It is presumed that at the end of this century there would be no forests left outside the reserve and protected areas, if this situation goes on.

To protect the different components of biodiversity, we, the human being has to take initiative specific measures in spite of different

Laws and Acts introduced by nationally and internationally. We can provide them some chance to survive.

As for example for birds:-

1). Windows may be kept visible to avoid death as because birds can see them as obstruction to hit the windows.

2). We should restrict ourselves from purchasing any endangered species of birds an animal as pets. Because their rarity, black marketers demands high price. If such animals are purchased, it will attract illegal traders to provide high incentive to the poachers to continue decimate the already fragile species.

3). We should keep our pets indoor, because our pets Cats and Dogs are fond of hunting small animals especially birds resulting decreasing of bird's population.

4). To control rodent pests on the ground, we use pesticides like boric acid, glyphosate and DDT (Dichloro diphenylt richloro ethane). Acephate-anorganophosphate insecticide $C_4H_{10}NO_3PS$ is also used to control insects (such as aphids and thrips) on cultivated crops and ornamental plants. These are very effective to control pests and they do not organically decomposed and passed from pests to some birds who also feed on these food grains/ crops/ seeds or come in contact with these chemical pesticides on the ground resulting death.

5). Global warming increase pest numbers such as ticks and mites which can lead to weakened of bird population and to kill them (21).

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CONSERVATION

Conservation is the act of protecting the world's resources, whether it is wildlife, plants or land. It's the act of saving as well as the wise use of all natural resources. As the world's population grows and as more people live at a higher standard, there is a greater demand for resources. These resources must be conserved to assume that these will be enough for the future.

Conservation measures

Conservation may be achieved partially through legislation and or by declaring any area having adequate ecological, faunal, floral, geo morphological , natural or zoological significance as a sanctuary for the purpose of protecting, propagating or developing wild life or its environment.

The followings are some of the measures taken by Government to protect biodiversity of our country:-

A). International Union for Conservation of Nature and Natural Resources (IUCN)

The IUCN has already categorized 367 Indian animal species in Red list Category. Status or categorization of Indian species have been done on the basis of the population size or the degree of threat within Indian origin and according to the latest criteria of International Union for Conservation of Nature and Natural Resources (IUCN) and Conservation Assessment and Management Plan of biodiversity conservation prioritization project (CAMP) workshop, 1998.

B). Introduction of Convention on International Trade on Endangered Species of wild flora and fauna (CITES)

To monitor and to restrict international trade on endangered species, to inspect the imports and export permit, no. of animals of different group are placed in different appendices (provided below) of Convention of International Trade on Endangered Species of Wild Flora and Fauna (CITES).

C). Introduction of Wildlife (Protection) Act, 1972

It has 66 sections and all the animals are placed under Schedule 1 to 5 and plant in Schedule 6. Several Sections under this law restrict any person to destroy, to exploit, to remove any wildlife from sanctuary or damage or destroy the habitat of any animal, to hunt or to make any products from the wildlife.

In chapter iv, WPA 1972, it empowers the competent authorities to declare any forests as national park, reserve forests, sanctuary including the marine environment for the purpose of protecting, propagating or developing wildlife or its environment.

Under the Protected Areas Management System there are nearly a total of 103 National Parks in India covering an area of 40,500.13 km^2 which is 1.23% of the geographical area of the country (National Wildlife Database, July, 2017) (22). There are 543 existing wildlife sanctuaries in India covering an area of 1, 18,918 km^2, which is 3.62 % of the geographical area of the country (National Wildlife Database, June, 2017) (23) and 12 Biosphere Reserves covering about 3, 12,921.97 km^2.

D). Community Conservation Programme

Community participation has given a fruitful result in conserving the wildlife. Local Communities become an integral parts of the conservation efforts. Now the traditional tribal realises and inherits the responsibility regarding the conservation and substances of the Biodiversity, instead of being a mere a watchman of the forests. It benefits both the natural environment as well as the communities living in and around also through participatory management programme.

E). Introduction of Environmental (Protection) Act, 1986

It empowers the union government to take all measures to improve and protect the quality of the environment.

F). Constitution of India:

Our constitution also empowers the state to protect and to improve the environment and to safeguard the forest and wildlife of the country. As per our constitution vide article no. 51(G), it is the fundamental duty of every citizen to protect and to improve the natural environment including forests, lakes and wildlife.

G). Member in a International Forum

India has become the member in almost all the International conservation, *viz.*, convention on CITES, the convention on wetlands of International importance (the Ramasar convention), the convention of migratory species of wild animals, the international convention for the regulation of whaling and the convention of bio-diversity.

H). The CBD (Convention on Bio-diversity) declare the biological resources are the sovereign right of a country where the species belong. Main objectives are: –

i. Conservation of biological diversity

ii. Sustainable use of its components

iii. Fair and equitable sharing of the benefits arising out of the utilization of genetic resources

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12 Soft Stratum Mangrove Pools of Indian Sundarbans: A Potential Nursery Ground for Estuarine Juvenile Fish

Shrayan Bhattacharjee*, Pradipta Kumar Ghosh*, Banani Mandal, Joydev Maity***, Arunava Mukherjee*[1]**

ABSTRACT

Structural complexity of soft stratum habitats in mangrove ecosystem may provide nutritional benefits and juvenile fish friendly habitat which in turn helps them to escape from predators. Tidal flows influence the recruitment of estuarine juvenile fish within root integrated soft stratum tidal pools of Indian Sundarbans. The present study reports occurrence of 25 juvenile fish species from different tidal pools at Ishwaripur near Saptamukhi river, West Bengal. Analysis of habitat utilization pattern in juvenile fish shows four different type of recruitment dynamics (CNU, FER, IP, DR) whereas,recruitment of few fish are not established well. Among these four designated recruitment mode; majorityof juvenile fish shows facultative presence (FER) in tidal pools. Along with this, seasonal occurrence study supports facultative recruitment by identifying juvenile fish availability in different seasons.

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Various environmental parameters like salinity and temperature probably help the growth and development of juvenile fish in mangrove habitats. In Indian Sundarbans, the tidal pools are being indiscriminately destroyed for agriculture and aquaculture expansion, thereby threatening the nursery habitat of juvenile fish. The present work is trying to draw a special attention to tidal pool conservation and address further research arena on ecosystem dynamics of juvenile fish in mangrove tidal pools.

INTRODUCTION

Mangroves are well known for its ecosystem services and undoubtedly unique in their function as nursery ground for various juvenile fishes, crustaceans and other invertebrates. The fish-nursery roles of mangroves are widely accepted for tropical and temperate mangrove habitats in the North and South America, Australia, Africa and Asia (Austin 1971, Thayer et al. 1987, Robertson and Duke 1987, Little et al. 1988, Chong et al. 1990). Among several habitat pattern, tidal pools with mangrove prop roots are widely recognized as a significant nursery habitat (Laegdsgaard and Johnson 1995). Previous studies showed that the increasing fish assemblages in mangrove region has a direct relation with increasing root densities (Nanjo et al. 2014). The quality of nursery habitat is determined through their function that optimizes growth, reproductive and survival potential (Gibson 1994). Tidal pool, also designated as soft stratum habitat sustains several invertebrates and algal communities those are colonized in integrated root structures, provides nutritional resources to juvenile fishes (Lugendo *et al.* 2007).Various fish species enter estuary at during their post-larval stages after completing larval stages in offshore waters where the adults reproduces majorly (Bell et al. 1984, Little et al. 1988). Characteristically, tidal pools are over flooded during high tide and fish assemblage are seems to be highly influenced with tidal and diel changes in small intertidal mangrove creeks of northern Brazil(Krumme et al. 2004). Earlier studies showed that juvenile fish assemblages may not be influenced by presence and absence of mangrove flora (Nip & Wong 2010) but their diversity may get get influenced by eradication of mangrove patches and this effects are short-lived (MacKenzie and kryss 2010). In contrast with the above mentioned study, Laegdsgaard et al. 2001 showed that, the sustainability of juvenile stage of fishes in mangrove habitats are because of maximum food availability and minimum predation risk. Similarly, the relevance of effective juvenile habitat (EJH) regardless to their unit area contribution to adult fish populations has also be acknowledged (Dahlgren et al. 2006).

Mangrove forest of Indian Sundarbans, consisting of huge mangal flora diversity, are enlisted as endangered forest (Sievers et al. 2020) under Red List of Ecosystems (RLE)from International Union for the Conservation of Nature (IUCN) and harbours a great diversity (92 species) of juvenile fishes (Mukherjee et al. 2012).Total 15-20% fish requirement of eastern metropolis of Kolkata are provided by Indian Sundarbans where 98.33% of resource area are designated as brackish water fishery (Mahapatra et al. 2014). However, root integrated tidal pools are common but still less explored habitats of Indian Sundarbans. Considering the nursing function, this is highly desirable to document the juvenile fish diversity from mangrove tidal pools.

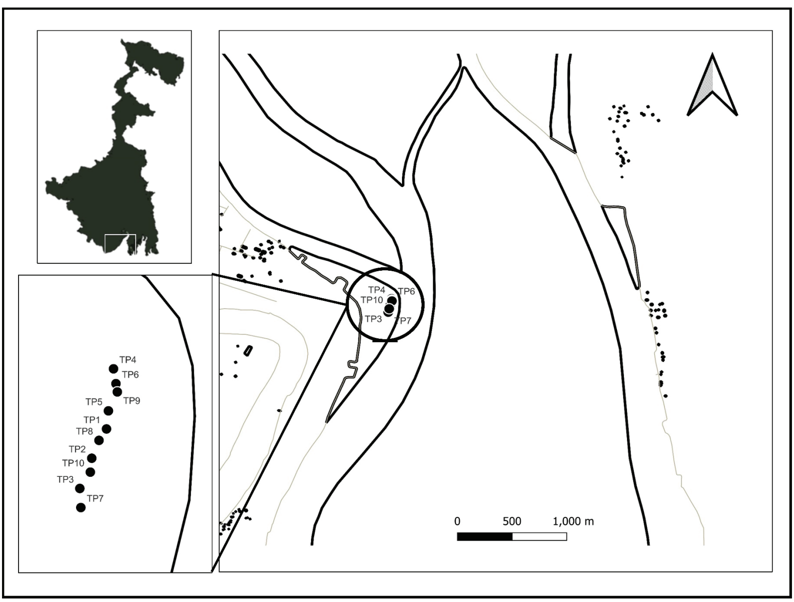

Figure 1: Representative GIS map of the studied tidal pools in Iswaripur, Namkhana, West Bengal, India using QGIS 3..22.11

MATERIALS AND METHODS

Fish sampling:

Juvenile fish samples were collected from various tidal pools of Ishawaripur, Namkhana adjacent to Saptamukhi river of Indian Sundarbans from July to December months of 2022 (twice in a month). Total 10 tidal pools were selected for juvenile fish collection. The juveniles were sampled using standard plankton net (Muzaki et al. 2019), dragging approximately 5 times in each pools. All samplings were performed during low tide only because of accessibility of tidal pools for fish juvenile collection (Figure 1). Fishing activities were conducted by four people, among them two persons were dedicated for sampling and rest were involved in sample storage. After sample collection, individual of juvenile fishes were photographed by using cell-phone devices with GPS tags. Some physical characteristics like salinity and water temperature were also measured on the spot of sampling. Sample of water was collected in a glass beaker and then 2-3 drops of water was taken in refractometer for determination of water salinity. The *infrared thermometer* was directly pointed toward pool water and measurement value was noted. The pools were mainly surrounded by *Avicennia offcinalis, Avicennia alba, Excoecaria agallocha, Acanthus ilicifolius, Brugeira gymnorhyza. Porteresia coarctata* and *Suaeda maritima*. Variety of roots had been observed in the pools which were mostly pneumatophore types- pencil roots, cone roots, cable roots. The sampling locations are highly threatened by uncontrolled prawn farming industries, facing habitat destruction and soil erosion by several anthropogenic interventions.

Fish preservation and documentation:

Just after collection juvenile fishes were transferred into icebox and transferred into laboratory. In laboratory, all samples were preserved in -20°C deep freezer for further analysis. Each individual fish were separated and identified by using standard identification materials such as-Talwar and Kacker 1984; Talwar and Jhingran 1991, Neira et al. 1998 and Fish Base. Each juvenile fishes were observed under stereo-zoom microscope (Leica EZ4) with LAS-EZ software and documented accordingly.

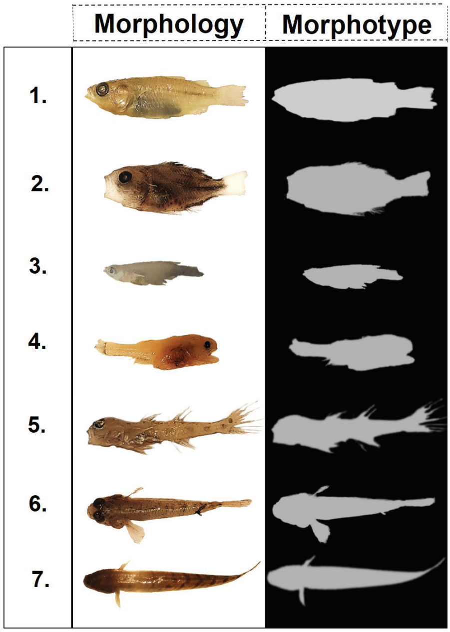

Figure 2. Representative pictures of juvenile fishes collected from tidal pools of Indian Sundarbans showing their morphotypes. The juvenile fish species are- 1. *Mugil parsia, 2. Terapon jarbua, 3. Oryzius melastigma, 4. Polynemus paradiseus , 5. Glossogobius guiris , 6. Periophthalmus weberi , 7. Boleophthalmus dussimieri*

RESULTS AND DISCUSSION

A total of 25 different species of juvenile fishes belonging to 13 different families (Sciaenidae, Gobiidae, Oxudercidae, Mugilidae, Terapontidae, Sillaginidae, Scatophagidae, Toxotidae, Hemiramphidae, Clupeidae, Adrianichthyidae, Belonidae and Polynemidae) and 4 different orders were identified (Table 1) . The species were –*Gobiopterus chuno , Boleophthalmus dussimieri, Periophthalmus weberi, Bathygobius ostreicola, Acanthogobius gobiceps, Bathygobius fuscus, Glossogobius biocellatus, Brachygobius nunus, Otolithoides pama, Mugil cephalus, Mugil oligolepis, Mugil parsia, Rhinomugil corsula, Silla gosihama, Scatophagus argus, Terapon jarbua, Toxotes chatereus, Stolephorus commersonnii, Corica soborna, Oryzius melastigma, Strongyluras trongylura, Hemiramphus far, Rhynchorhamphus malabaricus, Glossogobius guiris, Polynemus paradiseus.* The representative pictures of seven juvenile fish along with their morphotypes are shown in Figure 2. Most of the Juvenile fish enter tidal pools through water currents, usually during high tide.They stay there for different periods depending on their growth and development. Then they leave the pool at the next round of high tide. But few of them remained there even after the water level of the pools have dropped. They use the resources available in the pool and continue their growth as classical nursery users. Mukherjee, 2014, identified nursery use patterns of various juvenile fishes in the Indian Sundarbans. Total four different habitat utilization patterns were designated- 1. Classic nursery utilization (CNU), i.e., cyclical recruitment of juvenile fishes followed by their growth and dispersal, 2. Interrupted persistence (IP), i.e., classified by recruitment of juveniles in one season and fully or partially absence in another season, 3. Delayed recruitment (DR), i.e., juveniles are found exclusively as advanced or post-larval fish, 4. Facultative estuary residents (FER), i.e. recurrence of early and late stage juveniles in year round fashion and 5. Undesignated (UD), i.e., their recruitment pattern is not well understood. According to the above mentioned work, *G. chuno, S. argus* are designated as major classic nursery utilizer whereas *B. dussimieri, P. weberi, O. pama, M. cephalus, T. jarbua, S. commersonnii, C. soborna* are the typical facultative estuary residents. *M. oligolepis, S. strongylura, G. guiris* were showing interrupted persistence and *S. sihama* is recruited in delayed fashion. Still no proper decision could be taken regarding the recruitment of the rest of the juvenile fishes. Fish availability in mangroves varies significantly with season. Recent studies on fish assemblages in small Mangrove System on Príncipe Island, Gulf of Guinea showed that the distribution of fish is significantly varied with season where the capture quantity of fishes is three times higher in rainy season than dry season (Cravo et al. 2021). The study of Mukherjee et al. 2012 documented the season wise availability of juvenile fishes in different habitats around selected rivers of Indian Sundarbans. The highest availability of juvenile fishes in different seasonal periods, i.e., pre-monsoon, monsoon and post-monsoon are observed. With due help from this work the authors are trying to develop an idea of season wise availability of juvenile fishes in mangrove tidal pools. In Saptamukhi river, *G. chuno, B. dussimieri, P. weberi, B. nunus* and *T. chatereus,*were found significantly abundant during monsoon season. Along with that *G. biocellatus, M. oligolepis, S. argus, S. commersonnii, C. soborna, R. malabaricus* were collected in higher quantities in pre-monsoon and *B.ostreicola, A. gobiceps, B. fuscus,* *O. pama, M. parsia, R. corsula, O. melastigma,S. Strongylura* and *H. far* were exclusively prevalent during post-monsoon, respectively. Few juveniles fishes were encountered in multiple seasonal periods like *M.cephalus, G.guiris* were mostly observed during pre and post-monsoon, *S. sihama* in monsoon and post-monsoon and *P. paradiseus* was ubiquitously available in all seasonal periods. By analysing the patterns of occurrence of juvenile fish in Saptamukhi river, it can be hypothesized that same trends of recruitment of juvenile fishes in tidal pools might be expected as they enters into the pool from riverine system for better nourishment and shelters. Various previous studies have shown that various factors in mangrove ecosystems can potentially influence fish recruitment and habitat selection. Availability of food resources and shelter form predators are well known selective criteria for juvenile fishes to enhance their developmental functions (Nagelkerken, 2008). The unique structural peculiarities of semi-submerged root systems of mangrove plants create an ideal shallow shelter sanctuary for juvenile fishes while the same structure might create a structural hindrance for large piscivorous fishes (Nagelkerken and Faunce, 2008). As these tidal pools are designated as soft stratum bed and due to presence of the soft soil and extensive high tannin leaf litter, the water colour becomes mostly cloudy and turbid. This kind of shallow water environment provides ambient countershading for juvenile fish to hide themselves from predatory adult fish and other potential predators (Ellis and Bell 2004, Verweij et al. 2006). With the help of regular tidal cycle, tidal pools are periodically overflowed during high tide water, which also deliver different juvenile fishes that can exploit the tidal pool niches. A study in mangrove forests from Andaman and Nicobar Islands, India shows that inundate areas in mangrove creeks are mostly preferred by fishes than other regions (Sridharan and Namboothri 2015). The most effective factor that effects juvenile fish assemblages is salinity (Wright, 1986) which may changes juvenile fishes survival , growth (Vo and True 2021) and distribution of fishes (Bhat 2012).The present study measured the salinity and temperature of mangrove tidal pools of Indian Sundarbans throughout the study period exclusively in low tide and the results shows the salinity was in range of 21-23 ppt(parts per thousand) and the temperature ranged between 32-26°C . The changes of salinity can alter the ion-exchange phenomenon (Schwarz et al. 2014), modify gill morphology (Shirangi et al. 2016) and also influence feed utilization pattern (Likongwe et al. 1996) in juvenile fishes. In association with salinity, temperature is another influencing factor in growth of juvenile fishes. Abnormal lowering of water temperature can reduce the growth, metabolic processes and feeding rates of juvenile reef fishes (Djurichkovic et al. 2019). Indian Sundarbans is an iconic detritus based ecosystem that can provide a better nutritional value for aquatic organisms. During tidal fluxes, huge amount of leaf litter enters and get deposited in tidal pools might be due to the amount of fallen leaf litter. Salinity induced high protein content (Wu et al. 2021) and nutritional components (Alam et al. 2021) present in leaf litter of Sundarbans which is stimulated by high rate of decomposition, helps in growth and colour of shrimp larvae. Other than feeding resources, the juvenile fishes like *Mugil liza* use mangrove leaves as a floating raft to escape from predators (Sazima, 2017).

Similar with mangrove deforestation and habitat loss, tidal pools of Indian Sundarbans also faced severe anthropogenic threats. Large prawn industries are rapidly expanding in Indian Sundarbans following destruction of river embankments and mangrove vegetation. During prawn seed collection by local people constant treading on mangrove trees readily destroyed root integration and use of small mesh sized fine net deliberately capture and destroyed a huge diversity of fish juveniles by segregating them into labeling them trash fish or by-catch. Through this practices, tidal pools becomes very soft targets for capturing prawn seeds and can get easily encroached for developing aquaculture farms. Indian Sundarbans surrounded with many fresh water river also act as a sink for huge amounts of plastics that floats and accumulates in mangrove bed. Plastic garbage from Bay of Bengal is also deposited here thus making it one of the largest delta plastic cesspit (Adyel and Macreadie 2021, Kumar et al. 2022). Recent studies from Bangladesh part of Sundarbans reports trophic transfer of microplastic (size >5 mm) from zooplankton to sea turtle (Sarkar et al., 2022) and significant presence of microplastic in gut and tissue of fish (Sultan et al. 2023). Study of Zhang et al., 2022 shows tidal fluctuations can able to regulate the microplastic distribution in mangrove habitat. Since, tidal pools are periodically filled with high tide water; we can assume that tidal pools of Indian Sundarbans get significantly infiltrated by microplastic pollution. Microplastic potentially deposited in the body of juvenile fishes and able to inhibits their growth by increasing oxidative stress (Xie et al. 2021). Although no data has found regarding microplastic availability in juvenile fishes from tidal pools of Indian Sundarbans, we recommend future research on microplastic study from juvenile fishes from Indian Sundarbans. Therefore, as a key nursery habitat of estuarine fishes, tidal pools certainly need more serious attention in regarding their restoration and conservation of the fish production.

Table 1: Different nursery utilization pattern and seasonal occurrence of 25 juvenile estuarine fishes from tidal pool (developed with due help of Mukherjee, 2014). CNU- Classic nursery utilization, FER- Facultative estuary residents, IP- Interrupted persistence, DR- Delayed recruitment, UD- Undesignated and PM- Pre monsoon, M- Monsoon, POM- Post monsoon.

Sl. No	Species name	Vernacular name	Order	Nursery utilization pattern	Seasonal occurrence
1.	*Gobiopterus chuno*	Amtachuno	Perciformes	CNU	M
2.	*Boleophthalmus dussimieri*	Daku	Perciformes	FER	M
3.	*Periophthalmus weberi*	Menu	Perciformes	FER	M
4.	*Bathygobius ostreicola*	Bele	Perciformes	UD	POM
5.	*Acanthogobius gobiceps*	Bele	Perciformes	UD	POM

6.	*Bathygobius fuscus*	Bele	Perciformes	UD	POM
7.	*Glossogobius biocellatus*	Bele	Perciformes	UD	PM
8.	*Brachygobius nunus*	Kalochhapbele	Perciformes	UD	M
9.	*Otolithoides pama*	Jhatbhola	Perciformes	FER	POM
10.	*Mugil cephalus*	Gol parse	Perciformes	PM	PM,POM
11.	*Mugil oligolepis*	Parse	Perciformes	IP	PM
12.	*Mugil parsia*	Chota parse	Perciformes	UD	POM
13.	*Rhinomugil corsula*	Korsula	Perciformes	UD	POM

14.	*Sillago sihama*	Tulbele	Perciformes	DR	POM, M
15.	*Scatophagus argus*	PairaChanda	Perciformes	CNU	PM
16.	*Terapon jarbua*	Kat koi	Perciformes	FER	PM
17.	*Toxotes chatereus*	Gotipoa	Perciformes	UD	M
18.	*Stolephorus commersonnii*	Gab chuno	Clupeiformes	FER	PM
19.	*Coricas oborna*	Nadichuno	Clupeiformes	FER	PM

20.	*Oryzius melastigma*	Baishnabchuno	Cyprinodontiformes	UD	POM
21.	*Strongylura strongylura*	Bak	Cyprinodintiformes	IP	POM
22.	*Hemiramphus far*	Bak	Beloniformes	UD	POM
23.	*Rhynchorhamphus malabaricus*	Bak	Beloniformes	UD	PM
24	*Glossogobius guiris*	Bele	Perciformes	IP	PM, POM
25.	*Polynemus paradiseus*	Topse	Perciformes	UD	PM, M, POM

Conflicts of interest:

Authors have no conflict of interest.

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Biodiversity of Aquatic Macro Invertebrates Associated with Macrophytes in the Sewage Fed Ponds of East Kolkata Wetlands

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ABSTRACT

Maiti and Bhattacharya (2016, 2017) carried out faunal survey in the macrophytes infested bheries of East Kolkata wetlands. Diversity of macroinvertebrates was recorded to be higher inthe Pistia, Lemna and Eichhornia bed. Among insects the Coleopterans and Hemipterans are abundant. Among these Canthydrus, Anisops, Laccophilus, Diplonychus, Paraplea, Anisops tahitiens are the common ones. The mollucan population was dominated by Lymnae, Bellamya, Bithynia, Tarebia, Gabbia, Melanoides and Indoplanorbis, while among the spiders, Pardosa sp., Lycosa sp., Harmochirus sp and Spingius sp. were widely sampled. Spiders tend to aggregate more among the Eichhornia whereas insects and molluscans are abundant in Pistia /Lemna bed. The macro-invertebrate assemblage appeared to be quite similar in the two macrophytic beds but their abundance is higher in Pistia /Lemna .

Keywords: *East Kolkata Wetlands, Macrophytes, Sewage fed, Insects, Mollusca, Functional feeding groups.*

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INTRODUCTION

The East Kolkata Wetlands (22° 27′ N 88° 27′ E) are designated Ramsar Site (August, 2002) that stretch over an area of e 12,741hectares. This low lying spill area of the former Bidyadhari river, daily receive city sewage, storm water runoff and effluents of thousands of industries, the organic load of which is used as nutrients for fish. The wetlands being the largest of its kind in Asia is employed in commercial pisciculture in about 170 bheries (Mandal *et al*., *2001*).

The wetlands support rich faunal diversity among which the aquatic macroinvertebrates need special reference, as any temporal change in their number and population composition is indicative of the change in water quality. Therefore, the distribution, abundance and diversity of invertebrates is determined by the hydrological parameters besides pond size, macrophyte coverage, type of substrate and water depth. (Bauernfeind and Moog, 2000).

Aquatic macrophytes provide an array of stable microhabitats for the macroinvertebrates. These shelter them from predators and also act as spawning and attachment sites for eggs and nymphs. Plants increase habitat heterogeneity and affect richness and composition of invertebrate assemblages (Ohtaka*et al*. 2011). Macrophytes and the associated periphyton are important oxygen and food source for aquatic organisms providing both living and dead organic matter. So, any change in macrophytic composition modifies phytophilous macro-invertebrate community composition and biomass (Allan and Castillo, 2007).

The macrophytes are structurally and functionally significant because of their diverse role in primary production, nutrient cycling and improvement of water quality. Macrophytes alter the substrate and detritus type, of water bodies increasing the heterogeneity of the habitat for macroinvertebrates besides these reduce current velocities that influence the invertebrate distribution by providing a stable habitat. (Allan and Castillo, 2007) So the macroinvertebrate density tends to increase when both macrophyte biomass and habitat complexity increases (Habib and Yousuf, 2014).

Maiti and Bhattacharya (2016, 2017) designed a study to determine the observed pattern of distribution of macroinvertebrates, associated with the various aquatic macrophytes of the sewage fed ponds of East Kolkata Wetlands. The study can be used as a basis for biological assessment of the wetlands where the faunistic survey provides crucial information about the ecology and food web pattern of the ecosystem.

Functional feeding group analyses have been also done for water quality assessment, energy transfer studies and food chain modeling at the community level (Uwadiae, 2010).

Site of Study: Sampling was carried out in the various stocking ponds, nursery ponds and even unmanaged derelict water bodies and open sewage canal located at Anandapur, Baishtala, Bamunghata, Bantala and Choubhaga of the East Kolkata Wetlands. The sites were surveyed for rapid biodiversity assessment method where open water and aquatic macrophytes were sampled at each pond.

MATERIALS AND METHODOLOGY

Animals inhabiting the aquatic macrophytes were collected by kick method (Bath and Kaur, 1997) whereby the vegetations were disturbed and a circular net (mesh size 60μm) was dragged around the vegetation for collection of specimen.

Besides, collection of macrophytes was done in plastic containers. (20x20x40cm). Collected plants were submerged in water after which these were rinsed vigorously. The water is then filtered through a sieve (0.5mmmesh). The sorted animals were retained in the sieve. Molluscan specimens were handpicked from the macrophyes, and stored in vials. (Pal and Nandi, 1997) Molluscs were fixed in 5% formaldehyde while insects and spiders were stored in 76%-80% ethyl alcohol. The alcohol was changed every 2-3 days. Trapped specimens were sorted by habitat, species and age (juvenile, penultimate, or adult). Total number of species and their relative abundance were then calculated.

Specimen was identified to the lowest possible taxonomic category by standard taxonomic keys and by the experts by Zoological Survey of India. Macrophytes were identified by the experts from Botany department. Entomofaunal identification was done following the manual of Subramanian and Sivaramkrishnan (2007).

Results and Discussion: About 106 aquatic plants belonging to 70 genera and 36 families have been recorded in the East Kolkata Wetlands. (Bhattacharya *et al* 2012).In a comprehensive study by Maiti and Bhattacharya, (2016,2017) a total of 2978 individuals of macroinvertebrates have been collected from 15 different observations from the macrophyte infested fish culture ponds of East Kolkata Wetlands.(Table1,2,3) Observations reveal that, the abundance and biomass of macroinvertebrates is higher in vegetated areas than in the non-vegetated or open water of the bheries. Their density is proportional to macrophyte biomass and habitat complexity. However, among the various floating macrophytes, *Pistia* /*Lemna* and *Eichhornia* harbour rich faunal assemblage that includes arthropods, mollusks, spiders and others. The macroinvertebrate assemblage appeared to be quite similar in the two macrophytic beds as these shows strong species similarity but their abundance varied.

Insects are secondarily adapted to the aquatic system and aquatic forms represent only 3% of the total insect fauna. (Majumder *et al*., 2013) Aquatic insects comprise about 8600 species, under 12 orders, 150 families. Among these 5,000 species occur in India. (Elango *et al* 2012) Higher abundance, high birth rate, short generation time and large biomass make insects, model organisms that define the structure and function of aquatic system.

Aquatic insects affect wetland function, but form the most heterogeneous and disharmonic assembly (Susheela, 2014). **True aquatic insects remain associated with water, part of their life-cycle.** Ephemeroptera, Coleoptera, Hemiptera, Odonata and Dipterans are dominant fauna of the freshwaters of south eastern West Bengal. (Subramanian and Sivaramakrishnan, 2007). Several species of Orthoptera are found in association with aquatic habitats. *Collembola* ***is*** the oldest **insect order**, that occur seasonally **among vegetations or organic detritus.** Among the members of Order *Ephemeroptera,* only *Cloeon*sp, has been recorded. The **larvae of Diptera are** abundantly present in the shallow margins of water bodies**, among which only** chironomids that endure higher pollutant level are abundantamong the *Eichhornia* strands. Both the adult and larval stages of Coleoptera, Heteroptera and Hemiptera are aquatic. However, the latter are species rich. Among these *Canthydrus, Anisops* and *Laccophilus* are abundant. All the species of *Diplonychus, Paraplea* are abundant. *Anisops tahitiensis* Lundblad has been first recorded by the authors from the Indian mainland. (Jehamalar *et al*., 2014). *Micronecta* and *Ranatra* however, favours open water. Larvae of Odonata, Lepidoptera, Hymenoptera, Isopoda, Dermaptera, besides members of Chrysomelidae, Bruchidae, Curculionidae, Histeridae have been sampled in the wetlands. (Maiti and Bhattacharya, 2016) Some species may be specialized for certain microhabitats, allowing resource partitioning in a community (Hann, 1995). Linhart *et al.,* (1998) suggested that the association of insects with macrophytes can either be trophic, spatial or both.

When functional feeding group analyses was done, it was observed that the resident insect community is dominated by predators (38 species) as most of the coleopterans, hemipterans and odonate larvae are generalist predators. The collectors/gatherers were represented by Collembola, Ephemeroptera, members of the family Corixidae (hemiptera) and dipteran larva. Shredders were represented by the lepidopteran larva only. Hydrophilidae (coleopterans) are scavengers.

Species with similar functional feeding group reflects both convergent and parallel evolution leading to functionally similar organisms which form guilds in a community (Rawer-Jost*et al.*, 2000). Various ratios of the functional groups are used as surrogates for ecosystem attributes that focus on the nutritional status of the wetlands(Cummins and Klug, 1979), further it focusses on their morphological and behavioral mechanisms of acquisition of food.

Structurally complex wetlands habitat of dense macrophyte beds allows greater refuge for the predators. In stagnant water, predation regulates aquatic insect communities although predatory effects are related to habitat complexity. Higher abundance of predators is indicative of top down control where slow turnover of predatory taxa is dependent on fast turnover of non predator or prey taxa. Dense macrophytic infestations and higher abundance of non-predatory carps, paved the way to dominance of predatory insects. (Khan and Ghosh, 2001)

The relative proportion of each functional feeding group of the macroinvertebrate communities generally determine ecosystem functioning. Some invertebrates graze and decompose macrophytes while others process leaf litter, recycle nutrients by shredding aquatic macrophytes and grazing on algae. The predators control the population of prey species. Aquatic insects are also a primary source of food for fishes and amphibians. Intense and selective grazing leads to disruption of one type of macrophytes making the other plant species to be dominant (Carlsson and Lacoursiere, 2005).

With 50,000 living species, (Rao, 1989) molluscs forms the most diverse and dominant group that help in recycling of nutrients, (Waghmare *et al.* 2012) besides, are widely consumed as food (Mangare *et at.* 2016). Among the living eight classes, six are exclusively marine with the exception of gastropoda and bivalves or Pelecypoda. In the study, *Pistia*, *Lemna beds* harbor higher abundance of *Lymnae, Bellamya, Bithynia, Tarebia* and *Gabbia*, compared with that of *Eichhornia*. However, *Melanoides* and *Indoplanorbis* have been recorded to be high among *Eichhornia* bed. (Maiti and Bhattacharya, (2017). The latter being a very adaptable species. *Bellamya bengalensis is* also found in the vegetations as well as in the pond bottom. *Melanoides tuberculatus* is a browser on microalgae besides being a detritivore, it can thrive in aquatic habitats strongly impacted by human activities and are tolerant towards pollutants. *Lymnae* and *Gyraulus* are habitat generalist freshwater species, found among aquatic weeds of the littoral zones. (Miller 1970).

Functional feeding group analyses revealed that gastropods are scrapers (grazers), which are generally found attached to submerged vegetations. The benthic bivalves are filter collectors that consume decomposing fine particulate organic matter (FPOM) (Ramkrishna and Dey, 2007). Shallowness of water body and presence of abundant sunlight is congenial for periphyton growth (Lindstrom *et al.,* 2004) that allow greater abundance of grazers.

Molluscan species richness is generally correlated with pH and hardness of water besides pollutant level influence the occurrence of this group. Most species were found in the sampled floating vegetations that support similar invertebrate assemblages, suggesting relatively little habitat specificity. It has been observed that abundance of both insects and molluscs are higher in *Pistia/ Lemna* beds. Downing and Cyr (1985) opined that phytophilous invertebrates are not equally abundant on all plant species as they exhibit preferences for only certain aquatic plants,. However, according to Wilson and Ricciardi, (2009), the magnitude of macroinvertebrate density and diversity is higher in the combined mixed vegetation than in single species dominant beds.

Spiders are also generalist predators that are ubiquitous in terrestrial ecosystems. They depend on arachnids, fish, tadpoles and small invertebrates especially insects, as food and are thus highly effective in controlling insect populations. Moreover, these also attack members of their own species, thereby maintaining ecological equilibrium of the prey species. (Archana, 2011)

In the study it was observed that spiders are represented in 16 families, 47 genera and 92 species. In the present study, *Pardosa* sp is by far the most abundant genus. *Lycosa sp*, *Harmochirus* sp and *Spingius* sp are also common. The presence of commendable number of spiders in the wetlands suggests the presence of higher diversity of prey species including the insects.

It was observed that floating macrophyes such as *Pistia* / *Lemna* and *Eichhornia* are habitat for aquatic spiders, although their abundance is more among the later.

Seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity influence population structure of spiders. (Rosenzweig 1995).

In the littoral region, water hyacinth with its long, floating stems, form dense vertical strands structure that provides microhabitat for spider assemblage that also aid for web attachment. (Agostinho *et al*. 2007). These provide shelter and increase the availability of their prey thereby reducing intraguild predation. Besides, vegetations, environmental factors like temperature, humidity and rainfall affect the araneid populations.

Aquatic plants play an important role in moderating phytoplankton growth and reducing turbidity of water as these compete with phytoplanktons, algae and bacteria, for nutrients and sunlight. Excess of macrophytes also prevent solar energy for phytoplanktonic growth. In eutrophic waters, the grazing invertebrates may prevent algal blooms, thereby allowing submersed macrophytes to persist. Irvine *et al.* (1990)

The morphology of the plants plays an important role in determining invertebrate community assemblage. Feldman, (2001) opines that macrophyte structural design shape up macroinvertebrate communities because design influences a plant's surface-to-biomass ratio. The abundance of invertebrates per unit macrophyte biomass may vary with plant species and the degree of leaf dissection. Besides, temporal changes in the architecture of macrophytes influence habitat use by macroinvertebrates.

Macrophytes with finely dissected leaves, support more macroinvertebrates as these offer a higher surface area to volume ratio per unit of biomass. Moreover, these support greater biomass of epiphytic growth for grazing aquatic invertebrates (Cheruvelli *et al*. 2001). Hence, Pistia and *Lemna* bed with highly dissected leaves harbor greater abundance of invertebrates.

Cyr and Downing (1988) proposed that larger plants support heavy crawling invertebrates which has been evidenced by the higher abundance of giant water bugs and spiders among the strands of *Eichhornia*. Similarly, molluscs and chironomids assemble more around its roots.

The functional performance of any organism is determined by its physiological, behavioral and morphological response to variable environmental factors. Release of allelochemicals by macrophyte also influences the associated organisms.

As macrophyte-epiphyte complexes are the most important primary producers in the littoral zone, significant alteration of these plant assemblages could cause trophic cascades in higher trophic levels of the food web by altering phytophilous macroinvertebrate and fish communities that feed on them (Downing, 1986). On the other hand, herbivory by aquatic insects reduce plant biomass by 50-95 %. Macrophyte piercers, make tunnel in the stems and decompose macrophytes. Gastropods feed on the succulent vegetations. So, these organisms may inhibit excess growth of plants in water. Thus, invertebrate communities can be used as biological control agents to prevent the nuisance growth of invasive macrophytes.

Conclusion: Both macrophytes and aquatic macroinvertebrates serve as a reliable indicator of ecological characteristics of water and are used as environmental biomonitoring tool. As an integral part of the aquatic biota, insects act as model organisms that define the structure and function of the inland waters. More plants provide more feeding groups and that is indicative of healthier environment. Aquatic plants support higher local diversity that provides redundant species which help to recover a community after a disturbance. Thus decreasing plant biomass lead to decreased diversity of macroinvertebrates.

Molluscs are 'ecosystem engineers' that help in improving the water quality, (Pasupuleti and Subba Rao, 2015) .Several species of snails such as *Lymnae, Melanoides* are highly stenotopic or habitat specific hence they may be considered as bio-indicators of biologically diverse aquatic habitats. Spiders play an important role in stabilizing insect pests that complement the effect of insecticides. (Bukhari and Naeem 2012)

Aquatic macroinvertebrates are now threatened with extinction because of their reduced ranges resulting from habitat loss and invasive species. Wetlands are subject to reclamation due to widespread anthropogenic activities such as clearance of aquatic macrophytes, increase in pollutants, sedimentation, reclamation and overexploitation. (Ramkrishna and Dey, 2007) Thus, ensuring their conservation are a necessity. Weeding out of aquatic macrophytes if prevented may help to restore macroinvertebrates assembly. Conservation can be supported when the vital role of invertebrates within aquatic ecosystems will be realized and appreciated.

Table 1.Insect Species collected from Macrophytic bed of East Kolkata Wetlands.

Order	Family	Genus	Food	Feeding habit	Stage	Habitat
Coleoptera	**Dytiscidae** Predaceous diving beetles	*Canthydrus angularis* Sharp	Fish spawn	Predators	Adult	Wetlands species
		Canthydrus laetabilis (Walker)	Fish spawn	Predators	Adult	Wetlands infested with macrophytes
		Canthydrus luctuosus (Aube)	Fish spawn	Predators	Adult	Sewage fed wetlands with high organic load
		Neohydrocopt ssubvittulus Mots	Fish spawn	Predators	Adult	Lentic waters
	Dytiscidae	*Hydrovatus sp*	Invertebrates, fish eggs, fry	Predators	larvae	Fresh macrophytes near bottom along the littoral zone
		Laccophilus anticatusanticatus Sharp	Invertebrates, fisheggs, fry	Predators	Adult	Macrophytes ofshallow wetlands Adults are good swimmers, jumper, climber and diver.

		Laccophilus parvulus	Invertebrates, fishBggs, fry	Predators	Adult	Small numbers in wetlands
		Laccophilus clarki Sharp	Invertebrates, fish eggs, fry	Predators	Adult	Wetlands
		Laccophilus sp.	Invertebrates, fish eggs, fry	Predators	Nymph	Sub submerged vegetations of wetland
		Guignotus flammulatus Sharp	Invertebrates, fish eggs, fry	Predators	Adult	Large sized beetles common in most wetlands
		Hydrocoptus subvittulus Motsch	Invertebrates, fish eggs, fry	Predators	Adult	common in most wetlands
		Cybister sp	Invertebrates, fish eggs, fry	Predators	Larva	Largest species, found in still waters with less vegetations.
	Hydrophilidae Water Scavenger Beetles					
		Berosus fairmairi Zaitev	Detritus,algae and decaying vegetative matter	Scavengers	Adult	Shallower region of the wetland with abundant submerged macrophytes,

		Amphiop spedestris Sharp	Detritus,algae and decaying vegetative matter	Scavengers	Adult	Occur in water bodies with submerged vegetations
		Hydrophilus rufocinctus (Bede)	Detritus,algae and decaying vegetative matter	Scavengers	Adult	Wetland species
		Enochrus esuriens Walker	Detritus,algae and decaying vegetative matter	Scavengers	Adult	Natural wetlands and fish culture ponds
		Helochares ancholaris Sharp	Detritus,algae and decaying vegetative matter	Scavengers	Adult	Uncommon species, occurs in macrophyte strands from the littoral zones. Occur in ox -bow lake and freshwater wetlands
		Helochares pallens (Macleay)	Detritus algae and decaying vegetable matter	Scavengers	Adult	Shallow natural wetlands, among macrophytes
		Helochares sp	Detritus algae adecaying vegetable matter	Scavengers	Larva	

Hemiptera	**Nepidae** Water scorpions Sluggish insect, prefers still water					
		Ranatra filiformis (Fabr)	Live on nymphs of dragon flies,pupae of mosquito	Predators	Adult	Shallow part of the water bodies near submerged vegetations. Also live in trash and mud
		Ranatra varipes Stal	Insects and nymph of dragon fly	Predators	Adult	Clings to vegetations in shallow water
		Ranatra sp	Small invertebrates	Predators	Nymph	In all types of wetlands
		Laccotrepes sp	Insects and nymph	Predators	Nymph	Edges of littoral zones
		Laccotrepes maculates Fabricius	Feed on adult insects and their nymphs.	Predators	Adult	Found in all types of wetlands.

	Gerridae Water strider or Pond skater These skate across the water surface. The adults are incapable of flight	*Limnogonus* (L.) *nitidus* (Mayr)	Micro-crustaceans below the water surface	Predators	Adult	Microcrustacea and insects available just below the water surface
		Limnogonus Fossarumfossarum (Fabricius)	Micro -crustaceans below the water surface	Predators	Adult and Nymph	Abundant in sewage fed ponds in small group
		Aquarius adelaidis (Dohrn)	Micro -crustaceans below the water surface	Predators	Adult	Prevalent in natural wetlands
		Rhagadotarsus kraepelini Breddin	Micro -crustaceans below the water surface	Predators	Adult	Rarely found in ox bow lake
	Notonectidae, Backswimmers .	*Anisops breddini*Kirkaldy	Aquatic insects, other invertebrates, fish eggs, fry. Nymph microcrustacean zooplankton.	Predators	Adult	Swimmers on surface water, cling to submerged vegetations. Abundant in ponds.

		Anisops sardeussardeus Herrich – Shaffer	Fish eggs, invertebrates, aquatic insects and microcrustacean zooplankton.	Predators	Adult	All types of wetlands
		Anisops sp	Fish eggs, invertebrates, aquatic insectsand microcrustacean zooplankton.	Predators	Nymph	All types of wetlands
		*Anisops tahitiensis*Lundblad	Fish eggs,invertebrates, aquatic insects and microcrustacean zooplankton. own larvae, fish larvae and amphibian tadpoles	Predators	Adult	Slow moving waters, sewage fed wetlands.
		Anisops bouvieri Kirkaldy	Fish eggs, invertebrates, aquatic insects and microcru-stacean zoop-lankton.	Predators	Adult	Wetland species
		Anisops kuroiwae Matsumura	Fish eggs,invertebrates, aquatic insects and microcrustacean zooplankton.	Predators	Adult	Wetland species

		Enithares indica	Aquatic insects, fish eggs	Predators	Adult	Wetland species
		Nychi marshalli (Scott)	Aquatic insects	Predators	Adult	Wetland species
		Nychi sp.	Aquatic insects, microcrustaceans	Predators	Nymph	Wetland species
	Vellidae	*Microvelia leveillei* (Lethierry)	Micro-invertebrates	Predators	Adult	Wetland species
		Microvelia douglass Scott	Micro-invertebrates	Predators	Adult	Wetland species
		Microvelia sp	Micro-invertebrates	Predators	Nymph	
	Pleidae Pigmy Backswimmers Smallest aquatic hemiptera , Creeps through macrophytes.	*Paraplea frontalis* (Fieber)	Micro-invertebrates	Predators	Adult and Nymph	Dense submerged vegetation remain attached to stem and leaves
		Paraplea sp (Fieber)	Micro-invertebrates	Predators	Larva	Cling to Macrophytes
		Plea sp	Micro-invertebrates	Predators	Nymph	Cling to Macrophytes

	Belostomatidae Giant Waterbugs	*Diplonychus rusticus* (Fabricius)	Invertebrates and Fish fry, eggs	Predators	Adult and nymph	Pond bottom in the shallow littoral zones with emergent vegetations
		Diplonychus molestus (Dufour)	Invertebrates and Fish fry	Predators	Adult	Pond bottom in the shallow littoral zones with emergent vegetations
		Diplonychus annulatus (Fabr)	Invertebrates and Fish fry	Predators	Adult	Pond bottom in the Shallow littoral zones with emergent vegetations
		Diplonychus sp	Invertebrates and Fish fry	Predators	Nymph	Pond bottom in the Shallow littoral zones with emergent vegetations
	Mesoveliidae Pond weed bugs or Water Treaders	*Mesovelia horvathi* Lundblad	Small dead or alive insects	Predators	Adult	Edge of water bodies among emergent vegetation

		*Mesovelia vittigera*Horvath	Small dead or alive insects	Predators	Adult + nymph	Edge of water bodies among emergent vegetation
	Corixidae . Water Boatman . Largest family of aquatic hemiptera.	*Micronecta scutellaris* (Stal)	Debris,algae, protozoa and other microscopic organisms	Gatherers	Adult	Swimmers near bottom of wetlands
Odonata Damselflies and Dragonflies,	**Coenagrionidae**	*Pseudagrion* sp	Feed on molluscs, other insects, crustaceans, worms, and small fish, eggs and fry.	Predators	Nymph	Top layer of pond bottom near littoral zones, submerged macrophytes
	Libellulidae		Feed on smaller organisms	Predators	Nymph	Top layer of pond bottom near littoral zones
Ephemer-optera Mayflies	Baetidae	*Cloeon* sp. Small Minnow Mayflies	Fine detritus	Collector-Gatherers/ Collector-filterers/ Scrapers	Nymph	Macrophytes in the littoral zones

Diptera	Chironomidae (Larvae) (Meigen, 1803)	*Chironomus sp*	Algae. Collect fine particles of detritus from the bottom or from the water, shredding dead leaves, and preying on other invertebrates.	Collectors	Larva	Pond bottom

Fig. 2. Number of insect species in each Functional Feeding Groups .

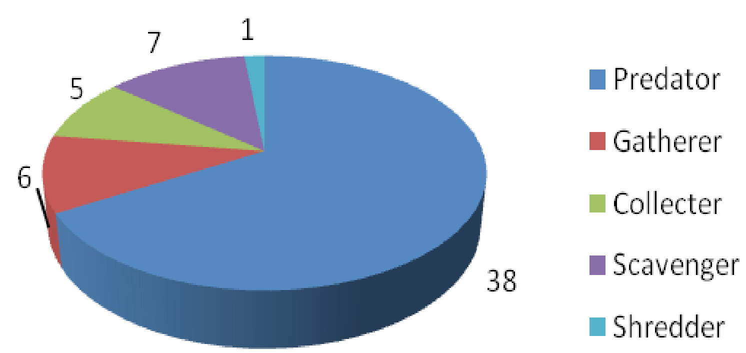

Table 2. Diversity of Molluscs collected from Macrophytic bed East Kolkata wetlands.

.	Order	Family	Species	Feeding Groups	Habitat	Conservation Status
	Trigoinoida	**Unionidae**	*Lamellidens marginalis* (Lamarck)	Collector /Filterer	Benthic Clinger/burrower	Least Concern
	Mesogastro-poda	**Viviparidae**	*Bellamya bengalensis f. typica-*	Scrapper. Feed on succulent vegetation	Freshwater pools, streams. feeds on detritus. Clinger/crawler	Least Concern
		Bithyniidae	*Bithynia* (Digoniostoma) *cerameopoma* (Benson)	Scrapper.	Freshwater pools, streams. Clinger/crawler.	Least Concern
			Gabbia orcula var. *producta*	Scrapper	Freshwater pools, streams even of paddy fields. Clinger/crawler;	Least Concern
		Thiaridae	*Melanoides tuberculata-* (Mueller)	Filter feeders collector and gatherer	Inhabits both freshwater and brackish water. Fine sediment Clinger/crawler;	Least Concern
			Tarebia granifera (Lamarck, 1822	Scrapper	Lotic and lentic system	Least Concern

	BASOMMA-TOPHORA	**Planobridae**	*Gyraulus convexiusculus* (Hutton)	Scrapper	Shallow littoral zone of ponds and lakes. Clinger/burrower	Least Concern
		Lymnaeidae	*Lymnae (Pseudosuccinea) luteola f. typical Lamark*	Scrapper Habitat generalist	Freshwater habitat with or without vegetations. Clinger	Least Concern
		Bullinidae	*Indoplanorbis exustus* (Deshayes)	Scrapper	Common in pools, canals, ditches with or without vegetations.Clinger	Least Concern

Table 3. Diversity of Spiders collected from the Macrophytic bed East Kolkata Wetlands.

	Order	**Suborder**	**Family**	**Species**
	Araneae	Araenomorphae	Lycosidae	*Pardosa*
	Araneae	Araenomorphae	Lycosidae	*Lycosa*
		Araenomorphae	Lycosidae	*Arctosa*
	Araneae	Araenomorphae	Tetragnathidae	*Leucauge pondae*
		Araenomorphae	Tetragnathidae	*Tetragnatha sp*
	Araneae	Araenomorphae	Liocranidae	*Sphingius*

	Araneae	Araenomorphae	Araneidae	*Araneus*
	Araneae	Araenomorphae	Araneidae	*Neoscona bengalensis*
	Araneae	Araenomorphae	Salticidae	*Telamonia dimidiaata*
	Araneae	Araenomorphae	Salticidae	*Harmochirus*
	Araneae	Araenomorphae	Salticidae	*Plexipus calcutanaensis*
	Araneae	Araenomorphae	Tetragnathidae	*Leucauge decorata*
	Araneae	Mygalomorphae		Unidentified

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14 Observation on Spider Fauna of Central Academy for State Forest Service Campus, Burnihat, Assam, North East India

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ABSTRACT

The study is focused on the diversity of spiders in the Central Academy for State Forest Service Campus located in Burnihat, Assam. The conservation-friendly non-destructive photographic identification was the survey method in the human-dominated environment of the campus. During the study period, 21 families and 73 genera are recorded, among them 16% are rare, 18% are abundant, 33% are common and 33% are occasional in terms of their occurrence status. In this paper, occurrences status and guild types of spider are discussed. The study is the first scientific documentation of the spider fauna in the academy campus area.

Keywords: *Spider genera, Occurrences status, Guild types, CASFoS, Burnihat, Assam.*

INTRODUCTION

Spiders are air-breathing Arthropods,also known as Arachnids and belong to the order Araneae. Spiders are an important component of the world's biodiversity, with about 50,800 species belonging to 4,308 genera and 132 families (WSC V. 24).They occupy the seventh position in terms of total species diversity and are found all over

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the world. In India, 1923 species under 492 genera in 61 families are known (WSC V. 24, Mondal et al. 2020).

Spiders play a vital role in the ecosystem as apex predators in the food web. Their small size allows them to thrive in small areas and they are an integral part of the food web, feeding on small insects and in turn being eaten by birds and other carnivores. Spiders also help to transmit energy from ground-dwelling prey to higher levels of the food chain. In addition to their role in the food web, spiders are also considered as potential biological control agents (Riechert and Bishop, 1990). They help to maintain the trophic balance of nature, and their diversity can serve as an indicator of the health of the ecosystem (Churchill, 1997; Hore and Uniyal, 2008). Changes in vegetation can affect the distribution and abundance of other species of insects, birds, and mammals, and therefore also the distribution and diversity of spiders.

Most studies on spiders have focused on their evolution (Coddington and Levi, 1991; Oxford and Gillespie, 1998; Kulkarni et al. 2020) and biology (Ford, 1977; Foelix, 1996; Oxford and Gillespie, 1998). Some studies have also investigated the mechanism of web construction (Tso et al., 2006) and their role in the ecosystem (Wise, 1993).

Spiders have also been studied in various agro-ecosystems in India, such as irrigated rice fields (Sebastian et al., 2005), cashew orchards, tea plantations, coffee plantations, and soybean agro-ecosystems. Similarly, research has been conducted on the distribution of spiders in the natural forests, such as Shola forests (Sudhikumar et al., 2005), mangrove forests (Sebastian et al., 2005), terai vegetations (Hore and Uniyal, 2008), and semi-evergreen forests (Chetia and Kalita, 2012). The ecological role of spiders has been less studied, but there are some researches under taken on their role as natural pest control agents (Nyffeler and Benz, 1987) and other ecological functions (Turnbull, 1973; Wise, 1993). Studies have also been conducted on the distribution of spiders in highly urban areas, such as Kolkata and its vicinity (Tikader and Biswas, 1981).

The diversity of spiders in India has been well documented by various researchers (Tikader, 1987; Siliwal et al., 2005; Keswani et al., 2012). However, the site-specific distribution and diversity have been more thoroughly studied in South India (Sebastian et al., 2005). In Northeast India, studies have been conducted in Sikkim (Tikader, 1966; Biswas and Biswas, 2003), Tripura (Biswas and Majumder, 2000a), Manipur (Biswas and Biswas, 2004), Arunachal Pradesh (Biswas and Biswas, 2006), Mizoram (Biswas and Biswas, 2007), Assam (Chetia and Kalita, 2012; Singh et al., 2012) and Meghalaya (Barman, 1975; Biswas and Majumder, 2000b).

Since spiders are top predators in the invertebrate food chain, it is important to properly explore different ecological niches in primary and disturbed human-dominated environments to catalog their spider fauna. The object of the present studies is to understand the variety of spider genera at the CASFoS campus in the human-dominated environment of Burnihat, Assam. This is the first scientific documentation of the spider fauna from this college campus. Increased urban characteristics, such as congested roads, structure and human activity, pose a danger to these significant apex predators in Assam and Meghalaya. To carry out the proper management of this degraded ecosystem, this baseline survey is conducted and this faunal list may be helpful for the future conservation of spiders in the area.

MATERIALS AND METHODS

Study Area

The academy is located between the state of Assam and Meghalaya about 21 km away from Guwahati town. The academy campus is spread over an area of about 24 hectares which is spread on either side of NH-40. The Assam side land measuring about 19 hectares, falls in Kamrup district which is located between latitudes 26°04′94″N to 26°03′47.47″N and longitudes 91°52′20.54″ E to 91°52′36.42″ E and elevation 68 m, above MSL. The study area is situated in the valley area of Assam side surrounded by the mountain ranges of Kamrup and Khasi hills on the opposite side (Fig. 1).

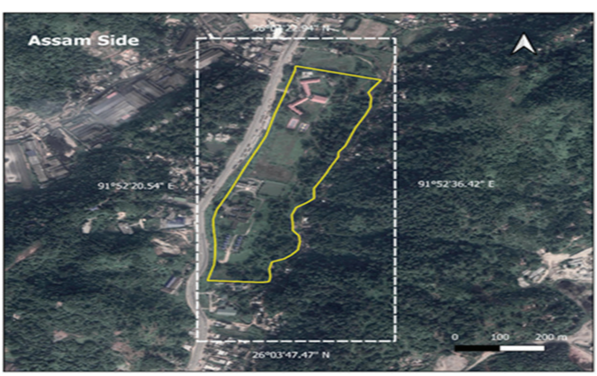

Fig. 1: Map of the Main Campus of Central Academy for State Forest Service, Burnihat, Assam

The climate is mostly tropical wet with hot summers and cold winters. The soil is clay-loam, alluvial and red-alluvial. The soil is highly porous in hilly areas and moisture retention capacity is less. The vegetation of this campus is mostly tropical. The original vegetation surrounding the academy campus has been disturbed due to the development of national highway road construction, land encroachments and the construction of houses. This campus has academic buildings, playgrounds, residential areas and a variety of ecosystems such as grassland, forest, garden area, pond, canal, and bushy areas. This particular ecosystem is rich in diversity of arthropods group and bird species which keep humming around this area.

Sampling Method

A survey is carried out for a period of one year, starting from July 2021 to June 2022, at the grassland, bushy area, adjacent to a hill stream, mud puddle patches, open college campus, wildflower, seasonal flower garden and residential area too. The survey sites are selected randomly and 20 by 20-meter squares are demarcated. Standard sampling methods like visual inspection, manual picking, and pitfall trapping are utilized. The surveys took place once a week between 6:00 am to 6:00 pm, and whenever possible a survey was also carried out during the night period. The collected spiders were captured in images so that we can identify them up to the genus level (Mondal et al. 2020). From a conservation point of view, the collected specimens are not damaged. This non-destructive identification approach (Mukherjee and Mondal, 2020; Mondal et al. 2020) of specimens led us to keep the documentation level up to the genera which have been promoted to adopt in such fragile habitats. Photographs have been taken with the Digital SLR camera (Cannon 90D) in the study area **(Plate: I- III, Fig. a to f).** The identification of spiders with photographs was confirmed by the renowned specialist as and when required. Species-level identification of such specimens can be ascertained in the future with standered taxonomic methodology.

Table 1: List of Spider genera of Central Academy for State Forest Service Campus, Burnihat, Assam (from July 2021 to June 2022)

Sl. No.	Name of Genus	Occurrence Status	Guild types
1. Infraorder: - Mygalomorphae			
1.1 Family :- Nemesiidae			

1.	*Gravelyia* sp.	Rare	Burrow living
1.2 Family :- Theraposidae			
2.	*Chilobrachys* sp.	Rare	Burrow living
2. Infraorder: - Araneomorphae			
2.1 Family :- Scytodidae			
3.	*Scytodes* sp.	Occasional	Nocturnal stalker
2.2 Family :- Pholcidae			
4..	*Belisana* sp.	Occasional	Space web builder
5.	*Crossopriza* sp.	Abundant	Space web builder
6.	*Pholcus* sp.	Common	Space web builder
2.3 Family :- Hersiliidae			
7.	*Hersilia* sp.	Abundant	Surface-web builders
2.4 Family :- Uloboridae			
8.	*Miagrammopes* sp.	Abundant	Cribellate orb weaver
9.	*Zosis* sp.	Common	Cribellate orb weaver
2.5 Family :- Agelenidae			
10.	*Tamgrinia* sp.	Occasional	Funnel web builder
2.6 Family :- Cheiracanthiidae			
11.	*Cheiracanthium* sp.	Occasional	Nocturnal runner
2.7 Family :- Ctenidae			
12	*Ctenus* sp.	Common	Ground wanderer
13.	*Anahita* sp.	Occasional	Ground wanderer
2.8 Family :- Oxyopidae			
14.	*Hamadruas* sp.	Common	Dirunal foliage hunter
15.	*Oxyopes* sp.	Abundant	Dirunal foliage hunter
2.9 Family :- Pisauridae			
16.	*Nilus* sp.	Rare	Ambush hunter

2.10 Family:- Lycosidae			
17.	*Lycosa* sp.	Rare	Ground runner
18.	*Margonia* sp.	Abundant	Funnel web builder
19.	*Pardosa* sp.	Abundant	Ground runner
20.	*Wadicosa* sp.	Abundant	Ground runner
2.11 Family:- Clubionidae			
21.	*Clubiona* sp.	Common	Nocturnal runner
22.	*Matidia* sp.	Occasional	Nocturnal runner
2.12 Family:- Corinnidae			
23.	*Castianeira* sp.	Occasional	Cryptic stalker
24.	*Corinnomma* sp.	Occasional	Cryptic stalker
2.13 Family:- Sparassidae			
25.	*Gnathopalystes* sp.	Occasional	Active runner
26.	*Heteropoda* sp.	Abundant	Active runner
27.	*Olios* sp.	Occasional	Active runner
28.	*Pseudopoda* sp.	Common	Active runner
2.14 Family:- Philodromidae			
29.	*Philodromus* sp.	Common	Ambush hunter
2.15 Family:-Thomisidae			
30.	*Bomis* sp.	Rare	Ambush hunter
31.	*Camaricus* sp.	Occasional	Ambush hunter
32.	*Oxytate* sp.	Occasional	Ambush hunter
33.	*Thomisus* sp.	Abundant	Ambush hunter
34..	*Tmarus* sp.	Common	Ambush hunter
35.	*Xysticus* sp.	Common	Ambush hunter
2.16 Family:-Salticidae			
36.	*Burmattus* sp.	Occasional	Foliage hunter
37.	*Carrhotus* sp.	Occasional	Foliage hunter
38.	*Chrysilla* sp.	Common	Foliage hunter
39.	*Hyllus* sp.	Common	Foliage hunter
40.	*Menemerus* sp.	Abundant	Foliage hunter
41.	*Myrmarachne* sp.	Common	Cryptic stalker
42.	*Pancorius* sp.	Common	Foliage hunter

43.	*Phintella* sp.	Common	Foliage hunter
44.	*Plexippus* sp.	Abundant	Foliage hunter
45.	*Portia* sp.	Rare	Cryptic stalker
46.	*Rhene* sp.	Occasional	Foliage hunter
47.	*Siler* sp.	Occasional	Foliage hunter
48.	*Telamonia* sp.	Common	Foliage hunter
49.	*Bavia* sp.	Occasional	Foliage hunter
2.17 Family:-Theridiidae			
50	*Achaearanea* sp.	Occasional	Messy web builders
51..	*Argyrodes* sp.	Occasional	Kelptoparasite
52..	*Chrysso* sp.	Common	Messy web builders
53.	*Parasteatoda* sp.	Occasional	Messy web builders
54.	*Rhomphaea* sp.	Rare	Messy web builders
55.	*Theridion* sp.	Occasional	Messy web builders
56.	*Thwaitesia* sp.	Rare	Messy web builders
2.18 Family:-Tetragnathidae			
57.	*Leucauge* sp.	Common	Orb-web builders
58.	*Opadometa* sp.	Rare	Orb-web builders
59.	*Tetragnatha* sp.	Common	Orb-web builders
60.	*Tylorida* sp.	Common	Orb-web builders
2.19 Family:- Araneidae			
61.	*Acusilas* sp.	Rare	Orb-web builders
62.	*Argiope* sp.	Common	Orb-web builders
63.	*Araneus* sp.	Common	Orb-web builders
64.	*Chorizopes* sp.	Rare	Orb-web builders
65.	*Cyrtarachne* sp.	Occasional	Orb-web builders
66.	*Cyslosa* sp.	Common	Orb-web builders
67.	*Cyrtophora* sp.	Abundant	Orb-web builders
68..	*Eriovixia* sp.	Common	Orb-web builders
69.	*Gasteracantha* sp.	Occasional	Orb-web builders

70.	*Neoscona* sp.	Abundant	Orb-web builders
71.	*Parawixia* sp.	Occasional	Orb-web builders
72.	*Nephila* sp.	Common	Orb-web builders
73.	*Herennia* sp.	Rare	Surface-web builders

OBSERVATION AND RESULT

The present study represented the spider community structure of Central Academy for State Forest Service, Burnihat campus which depicted the presence of 73 genera spiders belonging to 2 infra orders and 21 families (Table -1). Different guild types are found, like orb-web builders, scattered line weavers, stalkers, foliage hunters, ambushers, ground runners, and burrow living. Two families Nemesiidae and Theraposidae are under infra order Mygalomorphae spider while the rest of the other 19 families are under infra order Araneomorphae.

Some of the genera are exclusively found in the residential habitat. Members of the family Pholcidae, genera like *Plexippus* and *Menemerus* of the family Salticidae, and *Neoscona* of the family Araneidae fall under this category.

Family Salticidae (14) and Araneidae (13) contain the highest number of genera, followed by Therididae (7) and Thomisidae (6). Family Lycosidae, Sparassidae and Tetragnathidae harbour (4) genera each (Fig. 2). A large variation in the diversity of spider genera among the families is observed, which can be explained through the great variety of microhabitats and niches present in the study area.

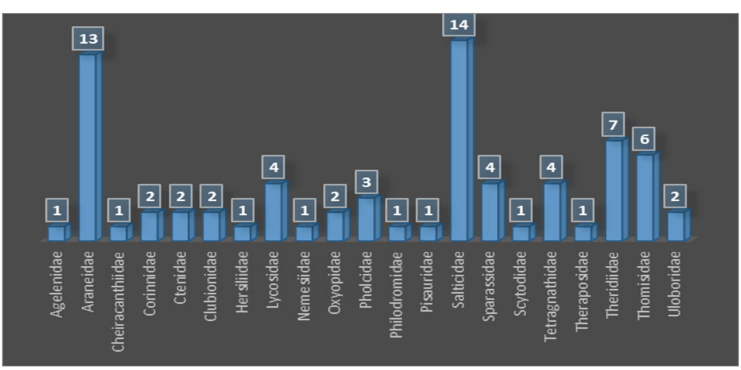

Fig. 2: Number of genera on each spider family in Central Academy for State Forest Service Campus, Burnihat, Assam.

In accordance to occurrence status, 24 occasional, 24 common, 13 abundant, and 12 rare spider genera, have been recorded (Fig. 3). 33% of the total observed and recorded spider genera fall under both common as well as occasional categories, 18% of them are abundant and 16% are rare. The Maximum number of rare spider genera belongs to the family Theridiidae and Araneidae. Both the Mygalomorphae family genera are single representative and rare occurrence like previous work (Mirza and Mondal, 2018).

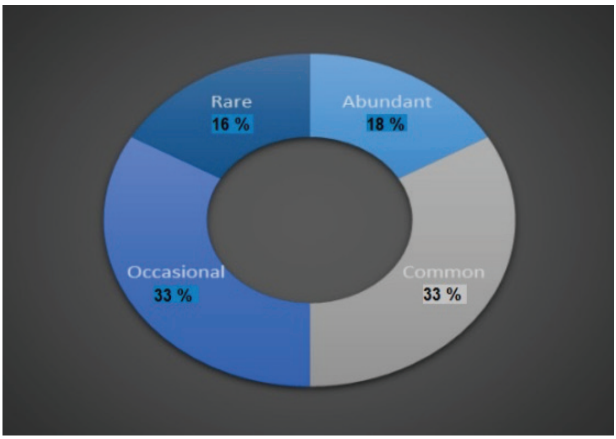

Fig. 3: Occurrence status of spider genera in Central Academy for State Forest Service Campus, Burnihat, Assam.

Although a large portion of the diversified spider population in India's North eastern hilly area is yet undiscovered, the variety of spiders in North East India has been the subject of a few surveys (Biswas and Biswas, 2007), but they are scarce or details fall short given the region's prominence as a hotspot for biodiversity. The findings of the present study support the existence of a rich and varied population of spiders in the CASFoS environment campus in North eastern India. Due to minute variations in habitat structure, complexity, and microclimate, spider species diversity, and distribution frequently differ from one geographic location to another (Downie et al., 1999). High species diversity allows healthier and more complex interactions among the members of the community and is hence considered an indicator of good environmental conditions (Hill, 1973). The present study made a significant contribution toward preliminary knowledge of spider distribution in this area.

Plate-I (a-f)

Plate-I(a-e): a. *Nephila* sp., b. *Heteropoda* sp., c. *Neoscona* sp., d. *Pancorius* sp., e. *Burmattus* sp., f. *Hyllus* sp.

Plate –II (a- f)

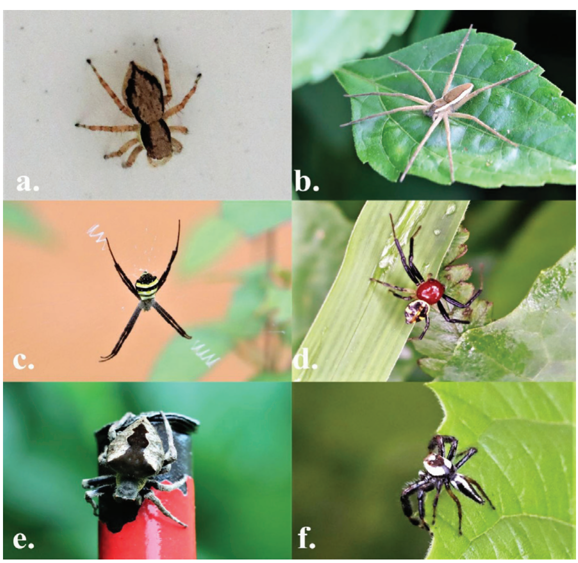

Plate-I(a-e): a. *Menemerus* sp., b. *Nilus* sp., c. *Argope* sp., d. *Camaricus* sp., e. *Parawixia* sp., f. *Telamonia* sp.

Plate –III (a- f)

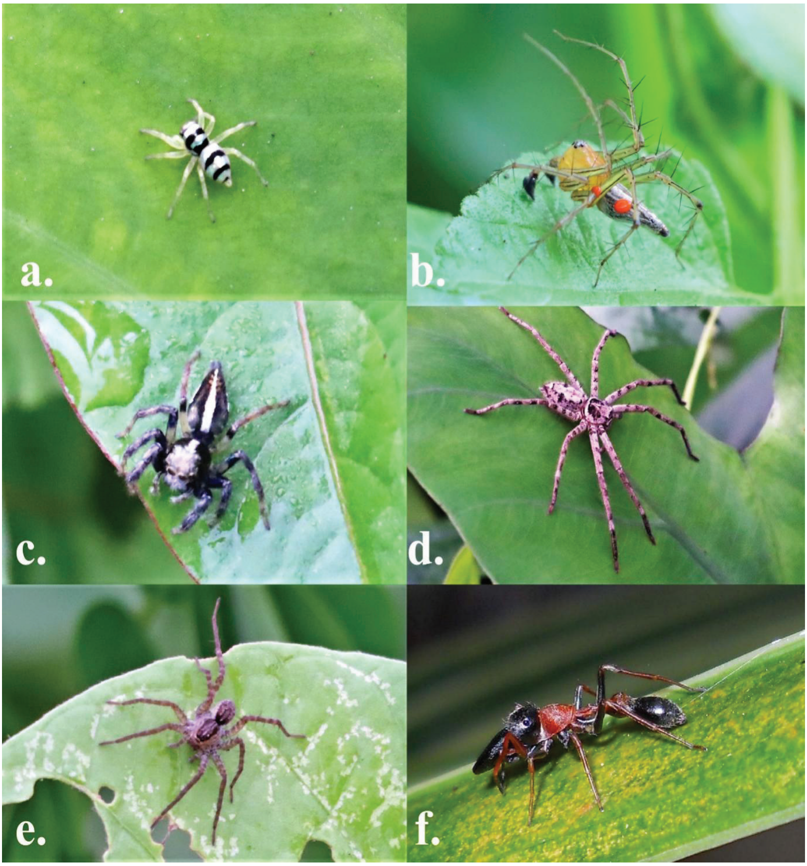

Plate-III (a-e): a. *Phintella* sp., b. *Oxyopes* sp., c. *Pancorius* sp., d. *Heteropoda* sp., e. *Pardosa* sp., f. *Myrmarachne* sp.

CONCLUSION

In the study, it has been observed that the family Araneidae and Salticidae spider diversity is dominating over other spider families in the CASFOS campus. All spiders are predators that mostly consume other arthropods, particularly insects. They are the top predator in the tiny world and reserve the same place as a tiger or large carnivores in an invertebrate food web. Usually "charismatic" groups like birds, mammals, and butterflies receive the greatest attention in conservation efforts, whereas ecologically significant groups like spiders are frequently overlooked. This study is the pavement for further research to reveal the spider diversity up to the species level and their role in this particular habitat. To carry out the proper management of the specified degraded ecosystem, this base line survey is conducted and this faunal list maybe helpful for the future conservation of spiders in the area, helping the stakeholders to build up the much-needed and relevant sustainable conservation policies.

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15 Biodiversity of Coral Reefs of Andaman and Nicobar Islands, India

Hemen Biswas*

ABSTRACT

Globally coral reefs are spread over an area of 600000 sq. k. in 100 countries. In India, major coral reefs are in Andaman and Nicobar Islands, Gulf of Mannar, Gulf of Kachchh and Lakshadweep. Excepting Lakshadweep, which has Atoll, all others have fringing reefs. The total area of India, based on satellite data, was estimated to be about 2300 sq. km. of which about 953 sq. km. is in Andaman and Nicobar Islands forming about 43.3% of the total coral reef area in India. But according to another estimate Andaman and Nicobar Islands alone have a coral reef of about 2000 sq. km. Many of the islands are surrounded by fringing reefs, while some islands have formed out of coral pinnacles. There are also channel reefs and coral knolls especially in the Ritchie's Archipelago. A few kilo metres away from the shore, there are coral banks in deeper waters. In Andaman group, the reefs are about 500 m wide with erosion channels up to 20 m wide and with thick growth at reef edge. In the Nicobar group, the reefs are about 1000 m wide and have surge channels of 1 m deep at reef edge.

Keywords: *Coral reefs, Andaman and Nicobar Islands, Atoll, Fringing reefs, Coral banks, Erosion channels, Surge channels*

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INTRODUCTION

The word coral may mean to some, especially women, an item of jewellery. Indeed the commercial red coral, which is used in jewellery, is part of the skeleton of a coral animal. Coral is a common term for a group of animals, scientifically known as Cnidaria, which are capable of secreting calcareous skeleton. This skeleton-secreting cnidarians belong to two classes, namely Hydrozoa and Anthozoa. The word Anthozoa means "Flower animals". In the Andaman and Nicobar islands corals are called Patthar Phul or stone flowers.

There are different types of corals: stinging corals, soft corals, organ-pipe coral or red coral, blue coral, horny corals or sea fans and stony corals. The stony corals are hermatypic and build reefs. Concerted growth of corals in localised habitat along with a variety of coralline algae, molluscan shells, echinoid debris, etc. gives rise to a coral reef. In simple terms, the colony of stony corals along with other animals associated with them is called a coral reef.

Coral reefs have been classified into four well-known categories: the fringing reef, the Barrier reef, the Atoll and Platform or Patch reef. Fringing reefs are the most common and they develop adjacent to the shore. Isolated and discontinuous fringing reefs are Patch reefs. Barrier reefs develop far away from coastline and separated from the adjacent land mass by deep channel. Atolls are circular of oval formations with a central lagoon.

FACTORS CONTROLLING THE GROWTH OF CORALS

The growth and extent of coral reefs are governed by physico-chemical parameters in the sea. Some of the physico-chemical variables that influence the growth of corals are given below:

Temperature: Coral reefs grow where the annual mean minimum temperature is between 18^0 C and 36^0 C with a optimal range of 26^0 C to 28^0 C. However, some corals can tolerate temperatures between 36^0C to 46^0 C. That is why, coral reefs exist only between Latitudes 30^0 N and 30^0 S. In Andaman and Nicobar Islands, sea surface temperature fluctuates between 27^0 C to 30^0 C which is slightly higher than the optimum level of coral growth.

Salinity: Corals are true marine organisms and grow well in oceanic salinities ranging between 32 to 35 parts per thousand (ppt). Many species however can endure salinities as low as 75% of normal value, but only for a few hours. However, heavy and long lasting rains associated with hurricanes and typhoons adversely affect corals, killing or at least whitening them, which is called bleaching, owing to the release of Zooxanthellae. In Andaman and Nicobar Islands, sea surface salinity varies between 31.2 ppt and 33 ppt, which are well within the tolerable limits for corals.

Depth and light: Normally reefs do not develop in waters deeper than about 50 to 70 m. Maximum species diversity is observed at depths between 10 m and 30 m. Maximum rates of reef accretion and productivity takes place in a 5 m to 10 m depth range. In the absence of sufficient light, the photosynthetic rate is reduced and with it the ability of corals to secret calcium carbonate and to produce reefs. The islands experience 180 to 232 rainy days a year. The available light for photosynthesis in the islands is thus limited. The secchi disc readings to measure transparency of water ranged between 3 to 9 m.

Water exposure: Coral reefs grow well in areas with strong wave action, because it provides a constant source of fresh and oxygenated sea waters renews the plankton food supply and prevents sediment from settling on the colony. Although, polyps can eliminate sand or silt particles by ciliary movements, the coral has to spend additional energy.

Emergence or exposure to air: Most corals are killed by long exposure to air. They cannot endure long term emergence at low tide.

Turbidity: Increased turbidity or sediment in water reduces transparency and curtails the penetration of light. For that region, coral reefs are absent in areas where sedimentation accumulates from discharges of rivers or streams.

Reproduction and growth: Coral exhibit both sexual and asexual reproduction. In sexual reproduction the larva attaches to the substratum, and the polyp becomes the parent and produces the colony by asexual budding. The colonies continuously grow by the addition of calcium carbonate deposit. Massive corals grow slowly by 0.5 to 2.0 cm a year by vertical r radial deposition of calcium carbonate. Some branching corals grow rapidly in linear direction by 10cm to 20 cm a year. The whole reef system may register from 0.2 mm to 8 mm upward growth per year.

Corals draw their nourishment by the capture of zooplankton and the receipt of translocated photosynthetic product from their Zooxanthellae. Corals also take up dissolved organic compounds from sea water. Corals require very little external nutrient supply and are adapted to waters containing very low levels of nutrients.

They have effective internal mechanisms to recycle nutrients. High nutrient levels in the ambient waters are actually detrimental to reef heath.

THE VALUE OF CORAL REEFS

Coral reefs generate economic and environmental goods and services that sustain human needs and development. The economic value can be calculated on the basis of direct uses, but it is not easy to comprehend the environmental services offered by the reef ecosystem. Green economists are in the process of developing a methodology to capture Total Economic Value of Coral Reefs Ecosystem. The environmental services offered by the coral reefs are many:

1. A healthy fringing reef acts a natural breakwater and prevents coastal erosion and storm surge. Corals provide sand for beach nourishment as they disintegrate.
2. Coral reefs play important role in bio-geo-chemical cycles. They are compared to tropical rainforest. Just as tropical forests are reservoirs of carbon, coral reefs also play important role carbon cycle through reef calcification. Coral reefs precipitate substantial quantities of calcium carbonate from the over line water and modify the chemical balance of the local marine CO_2 system. Calcium carbonate state of surface waters in the sea gets reduced when CO_2 is added to the atmosphere. It reduces calcification tare, resulting in weak coral skeleton.
3. Coral reefs provide information on climate changes over geographical periods.
4. Coral reefs are aesthetically pleasing and excitingly interesting, proving scope for adventure tourism and recreation. Island tourism sustains on coral reefs.

BIODIVERSITY VALUES AND BIO-RESOURCES

1. Reef organisms contain bioactive substances with important pharmaceutical properties, which can be tapped for the benefit of humanity. Sponges, soft corals, sea whips and the sea fans have yielded bioactive compounds with antiviral and anticancer properties.
2. Coral reefs provide biotic services by maintaining the habitat and by establishing linkages with mangroves and sea grass ecosystems. Coastal and mangrove forests constitute about 13%

of the total forest area in the island. Mangrove forest of Andaman and Nicobar Islands is the third largest after Sunderbans and Gujarat on the mainland. The flora of this ecosystem consists of 50 species of mangroves and associates. The faunal diversity is the highest for Indian mangrove. About 838 species of macrofauna and 53 species meiofauna were reported. These include two rare species of insects, endemic species of birds and mammals and a species of mangrove frog. The endangered salt water crocodile and water monitor occur in the mangrove ecosystem.

Sea grass ecosystem is spread over 100 to 200 hectares. Nine out of 14 species of sea grasses known from India occur in the islands. The high profile and charismatic species, sea cow or dugong depends on sea grasses for its food. This slow breeding mammal is sighted very rarely in the islands. From anecdotal information it is evident that there is only a small population at present. The islands are also rich in marine sea weeds, which grow on the rocks and in the reef ecosystem. As many as 184 species of marine algae, 16 species of crustose coralline algae and 8 species of articulated coralline algae are recorded from the islands.

Coral reefs in the islands have highest biodiversity in India. A total 250 species of corals are estimated to occur in the islands. But a recent inventory lists 196 species belonging to 69 genera and 16 families. The most recent underwater survey estimates about 400 species in the best preserved reefs of the islands. Of the 34 animal phyla known 30 are reported to occur in the coral reefs worldwide. In the islands, 20 animal phyla are reported so far. About 4500 marine species are reported from the islands and 50% of these occur in the reef ecosystem. The important fauna of the reef ecosystem include 580 species of fishes, 500 species of mollusks (snails, slugs, clams, etc.), 500 species of crustaceans (crabs, shrimps, lobsters, etc.), 220 species of echinoderms (star fishes, sea urchins, sea cucumbers, etc.), 120 species of soft corals and 40 species of sponges. For many species the islands form the western limit of their distribution in Indo-Pacific and do not occur on the inland mainland coast.

3. The islands' coral reefs are a rich store house of bio-resources. Although exploitation is prohibited, sea cucumbers attract a number of poachers, mainly foreign nationals and a few locals. The fishery potential in the islands is estimated to be around 0.24 million tonnes, but the present annual exploitation is about 28000

tonnes. Among reef fishes, groupers and snappers are much in demand in the world market. The fishermen population is about 12000; they use mostly non-mechanised, and mechanised boats. There are only a few trawlers in the islands. There is no long term fishing policy and the fishery suffers from "tyranny of small decisions". The prerequisite for an effective fisheries management is to develop a scientific data base on fisheries resources.

Unplanned or ill-planned exploitation of reef organisms may pose a significant threat to reef ecosystem. In the islands coral reefs were not much disturbed or damaged till 1970. From the mid 1980s impact of human pressure on the reefs was more discernible than ever before. Corals were collected as curios and sold in the market. Commercial exploitation of corals was banned in 1978, but it goes on clandestinely in remote and uninhabited islands. The organ pipe coral locally known as red coral (*Tubipora musica*) was once very common in the near shore waters of Great Nicobar. It is collected and smuggled. As a result it has become a rare species now. Targeted species fishing is unsustainable in the long run. In the islands sharks, crabs and lobsters are collected heavily and exported. In the year 1999, 18.2 tonnes of crabs and 4.5 tonnes of shark fins and 10.2 tonnes of lobsters were exported from the islands.

In 1995, shells constituted and important resource of the islands with large-scale socio-economic implications. About 100 to 150 persons were engaged in shell collection. More than 60 persons were employed in the shell craft industry. About 10 shops were engaged in marketing of shell products. Out of 52 shell craft units registered with Department of Industries only 18 were functioning. It was estimated that the total shell business in the islands is worth Rs. 20 million per year.

In spite of Shell Fishing Rules and Regulations, shell resources have shown a decline. Turban Shell (*Turbo mannoratus*) has come down from 210 kg in 1994 to 1995 to 20 kg in 1998 to 1999. Similarly Trochus (*Trochus niloticus*) which is the mainstay of shell craft industry has recorded 1955 kg in 1994 to 1995 and 515 kg in 1998 to 1999. Similarly other shells have also registered declining trends. Many of the shells are under threatened category of IUCN. Shell fishing rules have to be reviewed to introduce protective measures for the depleting shell populations of the following species. However, these species are recently declared protected under Wildlife Protection Act, 1972.

Turban shell (*Turbo mannoratus*), Sacred Chank (*Turbinella pyrumfusus*), Giant Clams (*Tridacna maxima*, *T. crocea* and *T. squamosa*), Horse's Hoof Clam (*Hippopus hippopus*), Pearl Oyster (*Pinctada margaritifera*), etc. are those species are not protected under Wildlife Protection Act, 1972.

The islands have rich potentials of marine resources and an effective management plan for sustainable utilisation of these resources may go a long way in improving the economy of the islands.

THREATS

The surveys conducted for rapid assessment of reef health revealed that reefs at many places are in damaged condition. Most of the exposed reefs have been destroyed. The live coral coverage varied between 30 and 60%. The reefs around little Andaman and Car Nicobar, which are unprotected, are under severe pressure. Even in the protected areas like Mahatma Gandhi Marine National Park live coral coverage is around 30% only. Some of the good reefs are found around North Reef in Ritchie's Archipelago and in Nancowry region. Damage has been noticed mostly in case of fragile branching corals. But overall the condition of reefs in the islands is better than in other coral reefs in India and is best in the Indian Ocean.

The rich coral reef bio-wealth, our natural heritage, is under threat. Reefs in the islands are living under suboptimal conditions. Besides, the natural causes such as storms, predation by star fish, bleaching etc, main threats to the reef ecosystem are poaching and sedimentation. Sedimentation is caused due to coastal erosion. Although it is attributed to logging there is no qualified data on the subject. Sedimentation smothers the coral surface, causes abrasion, shedding and inhibition of recruitment. Fortunately, water quality assessment has not indicated any oil pollution so far. Poaching a major threat to biodiversity and poachers often resort to blasting.

CONCLUSION

The geographical distribution and population abundance of many benthic taxa such as foraminiferans, sponges, soft corals, snails, crabs and fish families are closely co-related with the distribution and development of hermatypic corals. Hence, the degradation of coral reefs results in the disappearance of most of the associated fauna. The coral reef complex, if destroyed or damaged, requires a very long time for recovery. This million year's work of nature maybe lost forever.

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16

Appraisal of Phytodiversity on Coastal Sand Dunes of West Bengal, India

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ABSTRACT

This study is an attempt to document the nature of phyto diversity on coastal sand dune complex of Digha and adjoining areas in the Indian state of West Bengal. Simple quadrat sampling has been employed to collect relevant primary data regarding floral diversity. The collected data has been analyzed by applying Average Density, Shannon Diversity and Simpson Index. Findings of this study show that the floral diversity varies from small herbs to woody plants. The diversity and average density of floral species is almost same at New Digha Coast and Digha Mohona. Pandanus sp., Lantana camara, Opuntea dillenii, and Calotropis gigantea are the four important dominant dune scrubs along the Digha coast. Results of this study will be beneficial to conservation scientists for appropriate policy making related to coastal management based on the local context.

Keywords: *Coastal sand dune, Phyto diversity, Shannon Diversity Index, Simpson Index, West Bengal.*

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INTRODUCTION

Coastal area is considered as one of the most eco-sensitive habitat in the global environment. This area is dotted with many outstanding topographical features like coastal plains, wetlands, beaches and dunes, reefs, mangrove forests, lagoons and other coastal features (Hewawasam, 2002; Paul, 2002; Sigren et al. 2014). Coastal sand dunes are a ridge, or a series of ridges, that form at the rear of a beach and differ from most other constructional coastal landforms in that they are formed by the movement of air (Aeolian transport) rather than by tidal, wave, or current action (Kurz et al. 1942; Inman et al. 1966; Kriebel, 1986; Hesp, 1999; Marques et al. 2001; Psuty, 2004; Paul et al. 2023). Sand dunes serve an important purpose by protecting inland areas from coastal water intrusion (McEwan and Willetts, 1999). They are able to absorb the impact and protect inland areas from high energy storms and act as a resilient barrier to the destructive forces of wind and waves (Paul, 2002). The importance of sand dune and their floral diversity in the coastal ecosystem has been emphasized by environmentalists and researchers time and again from global to local scale (Kamila et al. 2021).

The tropical coastal track of West Bengal is dotted with virgin beaches and series of sand dunes especially along the shoreline of Contai (Kanthi) Coastal Plain. Sand dunes are very critical to the coastal areas and sand dune flora have specific role in maintaining the ecological balance (Das, 2007; Das, 2014, Das et al. 2017; Jana and Mondal, 2020). Apart from having medicinal properties, they act as sand binders, protecting the coast from natural hazards and also help maintain coastal aquifers (an underground layer of water-bearing permeable rock from which groundwater can be extracted using water well) (McGwynne and McLachlan, 1992; Chaudhuri and Das, 2009; Arulmoorthy and Srinivasan, 2015; Das, 2023).

Plants establishing on the coastal sand dunes are subjected to several environmental fluctuations which affect their growth, survival and community structure. The most important factors include temperature, desiccation, low moisture retention, soil erosion, sand accretion, soil salinity, salt spray, changes in organic matter and pH (Arun et al. 1999; Paul et al. 2021). Shore dune, fore dune, main dune with wind ward and lee ward slopes, wet dune slacks and back dunes with plateaus, holes supports grasslands scrub forests, thus portraying complex ecosystem diversity (Dey et al. 2005). In areas like Digha-Shankarpur coastal track, some plant species like *Ipomoea* *pes-caprae* and *Spinifex littoreus* are degrading gradually from the last few decades (Paul and Bandyopadhyay, 1987; Padmavathy et al. 2010; Chakraborty, 2010; Chakraborty et al. 2012; Chakraborty, 2013; Das, 2014). The reasons behind this are anthropogenic activities like tourism, recreational projects, road constructions, and other disturbances (Das and Manna, 2021). The other factor leading to loss of native species are natural disasters like cyclones, storm surges and coastal flooding (Sahoo et al. 2014, Biswas and Das, 2014; Das et al. 2017). In this background this study has taken to know the state of situation of dune ecology (especially plant ecology) along the coast of Digha in West Bengal.

AIM AND OBJECTIVES

The prime focuses of this study is to enhance our knowledge and understanding regarding the state of situation of floral diversity on coastal sand dunes of the study area. Specifically, this study has two interrelated objectives: (i) to know the floral diversity, and (ii) to assess the floral density on coastal sand dunes of the study area.

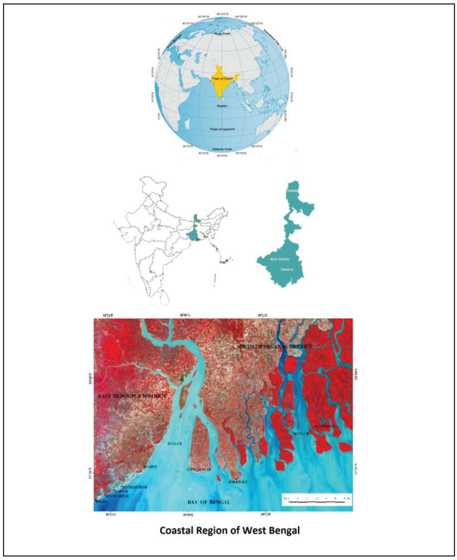
MATERIALS AND METHODS

Sources of data

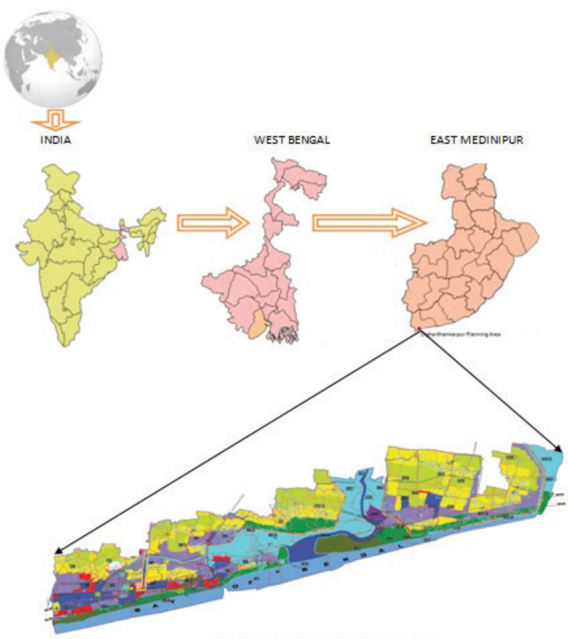
This study is based on primary data that has been collected through in depth field survey during the period from 8th February to 10th February, 2021.

Selection of study area

To fulfill the objective of this study, Digha coastal track under the administrative area of Digha-Shankarpur Development Authority (DSDA) of Purba Medinipur district in the state of West Bengal have been selected purposively as the dominance of sand dunes are maximum in this area. Coastal area of Digha is a part of Contai (Kanthi) Coastal Plain. Beaches, casuarinas groves along with fishing harbours are main components of coastal environment in this area. Today this area is one of the most famous coastal tourism sites in the state of West Bengal.



Map 1. Coastal Region of West Bengal.



Map 2. Location of the Study Area (Digha Coast).

Selection of samples

The information related to floral diversity on coastal sand dunes have been collected through in depth field survey. Only New Digha sector and Digha-Mohona sector along the Digha-Shankarpur Coastal tract have been considered in the present study for collecting relevant information. Altogether, seven quadrats[1] (Five quadrats from New Digha sector and three quadrats from Digha-Mohona sector) were randomly selected for the measurement of floral diversity in the study area. Photographic evidences were also collected during primary survey.

Analytical tools

Density and diversity of floral species on coastal sand dunes in the study area have been calculated by using the following formulas:

Average Density of Floral Species: The average density is obtained by summing the numbers and dividing by the number of quadrats in each plot.

$$\mathbf{X} = \frac{\mathbf{S\ (x)}}{\mathbf{n}}$$

Where,

X = Average density of plant species; S(x) = Total number of species; n = Number of Quadrats.

Shannon Diversity Index: The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled.

$$\text{Shannon Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

In the Shannon index, ***p*** is the proportion (***n*/*N***) of individuals of

1 A quadrat is a frame, traditionally square, used in ecology, geography and biology to isolate a standard unit of area for study of the distribution of an item over a large area.

one particular species found (***n***) divided by the total number of individuals found (***N***), ***ln*** is the natural logarithm, **Σ** is the sum of the calculations, and ***s*** is the number of species.

3.4.3 Simpson Index: The Simpson index is a dominance index because it gives more weight to common or dominant species.

$$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^{\,2}}$$

In this case, a few rare species with only a few representatives will not affect the diversity. In the Simpson index, ***p*** is the proportion (***n***/***N***) of individuals of one particular species found (***n***) divided by the total number of individuals found (***N***), **Σ** is still the sum of the calculations, and ***s*** is the number of species.

RESULTS AND DISCUSSION

Phyto density on coastal sand dunes along the Digha coast

Five quadrats at New Digha (Quadrat Plot - 1 to 5), and two quadrats at Digha-Mohona (Quadrat Plot - 6 to 8) on the coastal sand dunes were selected for sampling of floral species in quadrat measures to test of comparison. Sampling sites area selected on the basis of abundance of plant species to obtain all the required information from one set of quadrates. A set of quadrats contains 5 square meter area with 1 sq. meter of each sub-quadrat.

The average density is obtained by summing the numbers and dividing by the number of sub-quadrats in each plot is presented in Table 1.

Table 1. The average density of plant species in each quadrat plot of the study area.

Sl. No.	Plot No.	Total No. of Individual	No of Sub Plots	Average Density S(x)/n
1	P1	66	25	66/25 =2.64
2	P2	201	25	201/25=8.04
3	P3	320	25	320/25=12.8

4	P4	256	25	256/23=10.24
5	P5	179	25	179/25=7.16
6	P6	93	25	93/25=3.72
7	P7	481	25	481/25=19.24
8	P8	64	25	64/25=2.56

Source: Calculation based on primary data, 2021.

The value of average density of floral species is near about same at New Digha Coast (8.176) and Digha-Mohona (8.51), which is presented in Table 2.

Table 2. The average density of plant species at New Digha coast and Digha-Mohona.

Sl. No.	Plot No.	Total No. of Individual	No of Sub Plot	Average Density S(x)/n
1	P1-P5 (at New Digha)	1022	125	1022/125=8.176
2	P6-P8 (at Digha-Mohona)	638	75	638/75=8.51

Source: Calculation based on primary data, 2021.

4.2 Phyto diversity on coastal sand dunes along the Digha coast

Phyto diversity (richness, evenness and dominance) on the coastal sand dunes along the coastal track of Digha has been measured by Shannon Diversity Index and Simpson Index. Quadrat Plot-wise values of Shannon Diversity Index and Simpson Index have been presented in Table 3.

Table 3. Measurement of species (plant) diversity index on coastal sand dunes.

Sl. No.	Area	Plot No.	Shannon Diversity Index (H)	Simpson Index (D)
1	New Digha	Plot - 1	1.8121	4.56
2		Plot - 2	0.926	2.030
3		Plot - 3	1.081	2.146
4		Plot - 4	1.1749	3.159
5		Plot - 5	1.155	2.594

6	Digha-Mohona	Plot - 6	1.73	4.406
7		Plot - 7	3.299	1.48
8		Plot - 8	1.384	3.155

Source: Calculated based on primary data, 2021.

Nature of dune vegetation

Coastal and inland dunes of the study area have wide ranging structures of vegetation. Vegetation varies from a small herb (about 2 centimeter) to a woody plant or tree (20 feet or more). The sandy shores, flats, embryonic dune ridge of the coastal sides are dominated by herbs and grasses. Dry slacks of the coast and inland areas are generally dominated by long grasses. The list of plant species found in the study area during survey is presented in Table 4.

Table 4. Ecological status of plant species in New Digha Coast to Digha-Mohona.

Species No.	Scientific Name	Family	Characteristics
S1	*Glycosmis pentaphylla*	Rutaceae	It is an evergreen shrub or small tree. It is grows up to 1 meter in height and leaves are compound.
S2	*Opuntia* sp.	Cactaceae	It is a species of cactus thus has long been a domesticated crop plant grown in agricultural economies. It is the most widespread and most commercially important.
S3	*Bulbostylis barbata*	Cyperaceae	It is a good sand binding species. The annual grass-like plant has a tufted habit and typically grows to a height of 2 to 35 centimeters.
S4	*Casuarina equisetifolia*	Casuarianaceae	They are evergreen shrubs and trees growing to 35 m tall. The apetalous flowers are produced in small catkin like inflorescences.

S5	*Hydrophylax maritima*	Rubiaceae	It is a good sand binder and helps to protect coastal erosion.It consists of terrestrial trees, shrubs, lianasthat are recognizable by simple, opposite leaves.
S6	*Croton bonplandianum*	Euphorbiaceae	Alternatively arranged leaves. 3-5 cm long, are lance-shaped, with a toothed margin. Flowers have 5 sepals and 5 petals and humorous long stamens protruding out.
S7	*Cassia* sp.	Fabaceae	It is a medium shied deciduous or semi deciduous tree, 10 to 15 m tall with a straight trunk to 5m in height and 1 m in diameter. It has spending branches.
S8	*Lantana camara*	Verbenaceae	*Lantana camara* is a theory shrub upright, half climbing or sometimes more or less hanging, reaching 2-3 m in height. The stems and bran chess are angular, bearing curved spines, arranged along the edges.
S9	*Cyanthillium cinereum*	Asteraceae	It is an annual herb up to 120 cm (4 feet) tall. It produces felt topped arrays of numerous flower heads, each with pinkish or purplish disc florets but no ray florets.
S10	*Tridax procumbens*	Asteraceae	It is a species of flowering plant and is best known as a widespread weed and pest plant. The branches are more abundant near the soil surface..

S11	*Sesuvium portulacastrum*	Aizoaceae	It grows on the ocean side of the dunes down to the high tide mark.These plants help build the dunes by catching sand in between stems and leaves.
S12	*Azadirachta indica*	Meliaceae	It is a tree in the mahogany family Meliaceac. It is typically grown in tropical and semi-tropical regions.
S13	*Launaea sarmentosa*	Astaraceae	It is a perennial herb species that has been used as a dietary plant. It is a hairless whip-shaped, procumbent perennial herb, rooting and leaf-bearing at the nodes and arching between them.
S14	*Calotropis gigantea*	Asclepiadaceae	It is a large shrub growing to 4 m tall. It has clusters of waxy flowers that are either white or lavender in colour.
S15	*Ziziphus mauritiana*	Rhamnaceae	Rhamnaceae is a spiny, evergreen shrub or small tree up to 15 m height, with trunk 40 cm or more in diameter, spreading crown. Stipular spines and many drooping branches. The fruit is of variable shape and size.
S16	*Alstonia scholaris*	Apocynaceae	It is an evergreen tropical tree in the family Apocynaceae. It is from the flowers of the saptaparni tree that are small greenish-white, growing in light cluster.

S17	*Argemone mexicana*	Papaveraceae	An extremely hardy pioneer plant, it is tolerant ofdrought and poor soil, often being the only cover or new road cuttings or verges. It is poisonous to grazing animals, and it is rarely eaten, but it has been used medicinally by many peoples, including those in its native area, as well as the natives of the western US and many parts of India.
S18	*Cynodon dactylon*	Poaceae	They are the conspicuous ring of write hairs of the ligules, the fringe of white hairs of the ligulae along with the gray-green appearance of the foliage.
S19	*Pandanus faecicularis*	Pandanaceae	It grows in the coastal lowlands typically near the edge of ocean. Long linear, sword-shaped, spiny-margined, light green leaves (to 2-6' long) are spirally arranged at the branch ends.
S20	*Glycosmis pentaphylla*	Rutaceae	A medium-sized shrub found in the Indian subcontinent to southeast Asia. Leaves are compound, consist of 5-7 leaflets and smell like lemon.
S21	*Guilandina bonduc*	Caesalpinieae	It is a species of flowering plant in the senna tribe.
S22	*Jacquemontia paniculata*	Convolvulaceae	It is a very vigorous, creeping, or scrambling, evergreen, perennial plant with a large, thick root that can be 3m long and 5 cm in diameter. The plant quickly forms a dense mat of low growth, completely covering the soil.

S23	*Ipomoea pes-caprae*	Convolvulaceae	It is a prostrate perennial often covering large area. It has pink petals with a darker center.
S24	*Chromolaena odorata*	Asteraceae	*C. odorata* is a bushy plant with woody stem, and spread much branched, which is dense stands. It is entirely covered with a clean pubescence, the leaves are simple and opposite characteristics in their sub-rhombic shape and venation.
S25	*Datura stramonium*	Solanaceae	The common name of Datura is throb apple, stinker, angles trumpet, and Jamestown weed. It is a vegetable delirium type of cerebral poison.
S26	*Ceiba pentandra*	Malvaceae	It is a species of flowering plant in the mallow filmily. This is a decumbent perennial herb producing a white-hairy stem up to about 40 cm long.
S27	*Mimosa pudica*	Mimosaceae	They are typically featured by having radially symmetric flowers, with petals that are twice divided in bud and with numerous showy, prominent stamens.

Source: Field Survey (2021) Report

Dunes along the Shoreline

Dune Ridge

Back dune Complex

Fore dune Complex

Photo Plate 1. Morphology of coastal sand dunes in the study area.

Source: Clicked by the authors, 2021.

Casuarina equisetifolia

Lantana camara

Glycosmis pentaphylla

Azadirachta indica

Calotropis gigantea

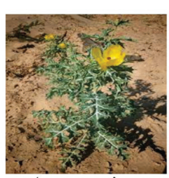
Pandanus tectorius

Datura stramonium

Veronica cinerea

Chromolaena odorata

Croton bonplandianus



Argemone mexicana

Ipomoea pes-caprae

Photo Plate 2. Some important plant species on coastal sand dunes of the study area.

Source: Collected by the authors, 2021.

CONCLUSION

This study identifies the state of situation of dune ecology especially floral diversity along the Digha coast in West Bengal. The nature of vegetation varies from a small herb to a woody plant as well as long grasses. The creeper plants (dune heaths) are developed on the dune ridges. *Pandanus* sp., *Lantana camara, Opuntia dillenii, and Calotropis gigantea* are the four important dune scrubs of the Digha coast. The shoreline vegetation characterized by Ipomoea and wooded scrubs and coastal forest with casuarinas as well as cashew nut trees. The diversity of plant species is almost same in the entire study area. The field observation shows that the distribution of plant species on the dune is also sparse. Here dune scrubs are important colonizer.

LIMITATIONS OF THE STUDY

(i) Sample area was only limited in the Digha coast of Purba Medinipur district in Indian state of West Bengal and thus the result may not represent the entire state or nation. (ii) Sample size (only seven quadrat plots) of the study was very limited to acquire a more reliable and relevant data. (iii) Lack of previous information on relevant topic, only small amount of data available for reference.

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17 Role of Biodiversity in Human Life and Living

Prabir Mukherjee

Biological diversity, or biodiversity, is the term used to denote the variety of life on Earth. Broadly speaking, biodiversity does have influences not only on living species but also to surrounding ecosystems. And it is most relevant to mention that every living being, including the so-called powerful human beings, is involved in these complex networks of interdependent relationships by way of living together and depends on one another which form the intricate network of ecosystem.

Biodiversity is a key indicator of the health of ecosystem. A wide range of species, even if smaller in number, will have the capacity to counter extinction threats if they exist in large populations of ecosystems. And it becomes possible by the influences of existing diverse ecosystem that will ultimately help them to adapt and survive. But the extinction of a single or a few species will have unintended consequences and lead to the destruction of species within the system and ultimately the entire ecosystem.

Diversity in eco-system makes the system and the species more resilient to environmental stress. A large number of species may control a certain level of functional redundancy while, contrary to it, the loss of one or a few species may affect the diverse system and cause damage to the resistance to epidemics. Consequently, it is clear that the increasing frequency of disease outbreaks is linked to climate change and biodiversity loss.

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In favor of diversity, the Victorian biologist Charles Darwin made a powerful observation in which he remarked that a mixture of species planted together often grew more vigorously than species planted separately and he proposed that species diversity due to fragmentation could increase ecosystem productivity. The role of labour within species suggests that each species is unique in how it exploits its environment. It thus follows that species-rich systems can exploit resources more efficiently than species-poor systems.

Thus, the importance of diversity in ensuring the functioning of biological systems suggests that the loss of diversity in natural ecosystems can cause a sudden disaster and eventually disrupt our ability to maintain sustainable lives and livelihoods.

Incidentally, it has become imperative to seriously consider the need for biodiversity for sustainable life and living. Needless to say, the presence of biodiversity in ecosystems regulates the climate, recycles nutrients to provide us with food and drink and provides resources for medicines and more. Thus, biodiversity plays a pivotal role in maintaining civilizations and sustainable economies.

Another important aspect of biodiversity is to stop deforestation because it primarily drives wild animals and birds out of their natural habitats and forces them to move closer to human populations, creating ground for zoonotic diseases, i.e., diseases that spread from animals to humans. Furthermore, climate change due to deforestation accelerates the transmission patterns of infectious diseases and as a result, people become more vulnerable to diseases like Ebola, Zika, Nipah and eventually the Corona Virus.

Biodiversity is not a limited concern. It is something that affects all living things, be it plants, humans or animals. Here, for obvious reason, the issue of migration comes to the fore which affects biodiversity vis-a-vis ecosystem processes at regional and global scales.

Animals and birds use predictable environmental cues for migration timing and navigation. A change in these signals affects phenology and the extent of migration. Arrival dates and hatching dates are phenological markers in migratory birds that are strongly affected by global warming.

Migratory birds are an integral part of global biodiversity and have great ecological and economic value. They aid in seed dispersal, which maintains biodiversity along their routes. Migration of birds facilitates the movement of other species, such as eco-parasites including ticks and lice, which in turn may carry microorganisms with concerns for human health.

Biodiversity is crucial to our health, safety and livelihoods. But as a result of human ignorance, diversity within species, between species and within ecosystems is declining globally at an alarming rate.

But at the same time, it is quite promising that the requirements of maintaining the ecosystem are being realized by larger sections of the society and it is developing promisingly.

BIODIVERSITY DAY 22 MAY

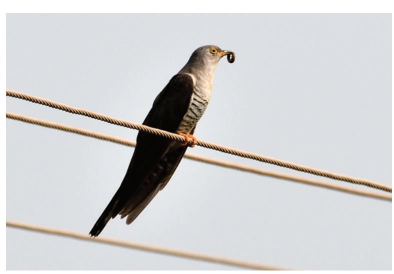
In line with this growing trend and to raise awareness among people globally, The United Nations General Assembly, in 2000, officially declared 22 May as the International Day for Biodiversity (IDB) and in 2022, this day was observed with the slogan "Building a shared future for all life".

I hereunder submit 14 photos of fauna who are integrated parts of our diverse eco-system

Adult Saras Crane feeding to Juvenile

Black-throated Prinia with nesting material

Browsing of Spotted Deer



Common Cuckoo with food

Dark-Eyed Himalayan Grey Langur

European Roller with a catch

Himalayan Palm Civet

Indian Gray Mongoose

Little Owl

Marsh Crocodile

26 days old tiger cubs at Tadoba

Neel Gai

Savannah Nightjar

The Royal Bengal Tiger of the Sunderbans

18

Host Plants and Host Specificity of the Roundhead Timber Wood Borers (Cerambycidae: Coleoptera) of Andaman & Nicobar Islands

Bulganin Mitra*

ABSTRACT

Among the wood boring insects of the freshly felled timber wood, the long-horned beetles or roundhead borers belonging to the order Coleoptera and family Cerambycidae are found in large varieties and abundance in the tropics and are very successful in colonising most of the tropical islands of the world including the islands of Andaman & Nicobar, India. 78 freshly felled timber wood species from 24 families were identified as the hosts of the 44 species of cerambycid borer from three subfamilies (Lamiinae-27, Cerambyciane-13, Prioninae-4). Of them, host plants of 26 cerambycid borer species have been documented for the first time from these islands. New additions of 12 species of host plants of cerambycid borers have also been made during this investigation from these islands. Halme caerulescens and Remphan hopei are the only monophagous species from these islands that were reported during this study. With 36 host plant species, Stromatium barbatum appears to be the most devastating pest of the freshly felled logs while Canarium euphyllum was observed to be the most susceptible host plant (13 borer species) in the Andaman and Nicobar Islands.

Keywords: *Roundhead borer, Andaman & Nicobar Islands, Host Plants, Timber wood*

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INTRODUCTION

The Andaman & Nicobar Islands, located in the Bay of Bengal, possess a tropical climate that is conducive to the growth of numerous timber-yielding plant species. The freshly felled logs of these plants, in turn, offer distinctive habitats to cerambycid borers. The family Cerambycidae is a fascinating group of insects due to their diurnal and nocturnal activities, adult phytophagous behaviour, immature xylophagous behaviour, and significant impact on wood damage as a means of survival. The field of forest entomology in India witnessed a significant surge in literature production during the period spanning from the mid-nineteenth century to the mid-twentieth century. The current understanding of the biology and ecology of cerambycid borers in the Indian subcontinent is insufficient, considering the enormous scope of studying the vast magnitude of fauna of great economic importance.

The year 1914 saw the publication of a masterly volume on forest beetles titled "Indian Forest Insects of Economic Importance - Coleoptera" by Stebbing. Additionally, the monumental work authored by C.F.C. Beeson, titled "The Ecology and Control of the Forest Insects of India and the Neighbouring Countries," which was published in 1941, is considered the most comprehensive and authoritative work on tropical forest insects. In 1919, Beeson compiled an extensive catalogue of food plants consumed by forest insects in India. Furthermore, Linseley (1959) has produced extensive literature on the ecology of cerambycids. Moreover, Khan (1985, 1989) and Khan and Maiti (1983) have published monographs on the bio-ecology of cerambycid beetles in the Bay Islands. This work is considered pioneering in the field of bio-ecology of cerambycid borers in the Andaman and Nicobar Islands. Afterwards nothing has been communicated on bio ecology of cerambycid fauna from these islands except some taxonomic publications made by Mitra (2013, 2014 & 2020), Ghate & Bharathimeena (2014), Majumder et al. (2019).

This communication deals with the 44 species of roundhead borers and their host plants, host range and host specificity recorded on the freshly felled logs or timber wood from the forest, timber extraction and logging centres, timber depots of Andaman & Nicobar Islands.

Study Area

The Andaman and Nicobar Islands, which constitute a Union territory of the Indian Union, are situated atop a lengthy underwater mountain range spanning approximately 1125 km. across the Bay of Bengal and Indian Ocean. This range is contiguous with the Cape Negrais and extends from the Arakan-Yomah range of Myanmar in the North to the Achin Head (the Mentawei groups) of Sumatra in the south. The archipelago in question comprises 572 islands, islets, and rocks, and is located between latitudes 6˚ 45'N and 13˚45'N and longitudes 90˚15'E and 94˚0'E. Its total area measures 8249 sq.km., which accounts for 0.25 percent of the Indian landmass. The archipelago boasts a total coastline of approximately 1962 km. and a continental shelf spanning 34,965 km., Mitra (2020). According to the Forest Survey of India’s State of Forest Report 2005, the forest cover in Andaman and Nicobar Islands accounts for 80.36% of the total geographical area. According to Mitra (2020), the tropical rain forests of Andaman and Nicobar Islands exhibit a dense and verdant vegetation that spans from the water’s edge to the mountain peaks, harbouring numerous distinctive plant species. As per Census 2011, the UT is divided into 3 districts, namely: i) North and Middle Andaman, ii) South Andaman, and iii) Nicobar.

METHODOLOGY

The study employed a random sampling technique to gather beetle borers from the freshly felled logs of various locations such as natural forest areas, timber extraction and logging centres, timber depots, and wood-based industries across multiple islands spanning from North Andaman to Great Nicobar (1980-2010). Choppers and axes were utilized to sever the felled timber for the purpose of gathering both immature and mature specimens, regardless of their location. The method of handpicking was utilised for the gathering of under bark borers. The study on insectary was carried out in Port Blair, utilising infested materials gathered from various field locations.

The specimens were examined using a Leica EZ4 HD binocular microscope in order to facilitate identification. The identification of the specimens was conducted through a thorough review of published literature on Cerambycidae from India, and subsequently verified by cross-referencing with the reference collection of the National Zoological Collection at the Zoological Survey of India, Kolkata and Forest Research Institute, Dehradun. The material that was examined has been archived in the National Zoological Collection, which is managed by the Zoological Survey of India, Kolkata.

RESULTS

The present study has identified the host plants of 44 species of cerambycid borers in the Andaman and Nicobar Islands. Of them, 27 species are under the subfamily Lamiinae, 13 species of subfamily Cerambycinae and rest 4 species under the subfamily Prioninae.

Out of the 44 species of cerambycid borers, only two exhibit monophagous behaviour. These two species are *Halme caerulescens*, which is typically found on *Terminalia manni,* and *Remphan hopei,* which is typically found on *Dipterocarpus* sp. (Table 1). *Stromatium barbatum* is the most prevalent polyphagous species among the remaining 42 species, and it infests approximately 36 timber wood species on the Islands, as indicated in Table-1. *Acalolepta rusticatrix* is the second most polyphagous borer species in the islands, with a total of 16 host plants. This is followed by *Aeolesthes holosericea* and *Neoplocaederus obesus* (15 host plants each), *Olenecamptus biobus* and *Pelargoderus niger* (12 host plants each), *Batocera andamana* (10), *Palimna annulata* and *Xystrocera globosa* (8 host plants each), *Epepeotes luscus* and *Glenea (Stiroglenea)* and *andamanica* (6 host plants each), and lastly, *Ceresium andamanicum*, *Epepeotes andamanicus, Stibara (Stibara) suturalis*, and *Pharsalia (Cycos) subgemmeta* have been infested on 5 host-plant species each, as shown in table-1.

Among the rest, 11 species are having 04 host plant species each, specifically, *Aeolesthes basicornis, Apomecyna histrio, Apomecyna saltator, Batocera molitor, Dorysthenes (Lophosternus) huegelii, Macrochenus atkinsoni, Nepoides sulcipennis, Olenecamptus sexplagiatus, Ropica honesta, Xenolea tomentosa,* and *Xylotrechus buqueti* (Table- 1).

The distribution of 07 borer species, namely *Acalolepta nivosa, Ceresium geniculatum, Chloridolum (Chloridolum) alcmene, Demonax andamanicus, Desisa subfasciata, Parorsidis nigrospersa*, and *Pterolophia (Hylobrotus) beesoni,* is limited to a narrow range of 03 host-plant species in the islands (Table 1).

Rest 9 species of borers, namely *Acanthophorous serraticornis, Cacia (Pericacia) cretifera, Ceresium flavipes, Dorysthenes (Lophosternus) indicus, Gnoma nicobarica, Marmaroglypha nicobarica, Mimabryna nicobarica, Oberea posticata*, and *Serixia andamanica* have been found to inhabit 02 host plant species in the islands, as shown in Table 1.

Considering host plants of cerambycid borers, a total of 44 borer species were found to have infested 78 distinct plant species belonging to 24 families (Table-2.). Among the 24 plant families, Fabaceae, Moraceae and Anacardiaceae are the most preferred host plants of cerambycid borers of these islands (Fig.1).

Among the host plants studied, *Canarium euphyllum* was found to be the most vulnerable to borer infestation (13 host plants). *Ficus carica* followed with 11 borer species, while *Mangifera andamanica, Lannea coromandelica, Mangifera indica*, and S*almalia insignis* were attacked by 10, 09, 09 and 09 borer species respectively. *Pongomia pinnata* and *Terminalia procera* were infested by 08 borer species, while *Semecarpus kurzii* was attacked by 07 borer species. *Artocarpus chaplasha, Dipterocarpus sp., Pterocymbium tinctorium,* and *Salmalia malabarica* were found to be infested by 06 borer species each, while *Garuga pinnata* and *Samanea saman* are having 05 borer species (Table- 2).

The current study has revealed that there are 09 host plants, namely *Aegle marmelos, Artocarpus lakucha, Murraya exotica, Murraya paniculata, Pterocarpus dalbergioides, Pterygota alata, Terminalia bellirica, Terminalia bialata,* and *Tectona grandis*, each of which is infested by 04 borer species. Additionally, it was found that eight other host plants, namely *Acacia pennata, Anacardium occidentale, Casuarina equisetifoia, Ficus religiosa, Lagerstroemia hypoleuca, Parishia insignis, Spondias pinnata,* and *Tetrameles nudiflora* were infested with 03 borer species (Table-2).

Plants like, less susceptible host plants found during this study are: *Albizzia lebbek, Albizzia procera, Albizzia chinensis, Artocarpus integrifolia, Barringtonia asiatica,Calophyllum soulattri,Carallia brachiata, Cassia fistula, Citrus maxima, Dalbergia volubilis, Dracontomelum mangiferum, Duabanga sonneratioides, Ficus bengalensis, Ficus rumphi, Hopea odorata, Planchonia andamanica, Pterospermum acerifolium, Rhizophora apiculata, Sterculia villosa, Sonneratia alba* and *Teminalia manni* with 02 borer species each (Table-2).

The following 25 species of plants, viz., *Alstonia kurzii, Amoora wallichi, Bauhinia retusa, Bridelia griffithii, Barringtonia racemosa, Barringtonia pendula, Carapa moluccensis, Cassia nodosa, Cassia siamea, Citrus aurantium, Citrus medica, Desmodium umbellatum, Excoecaria agallocha, Erythrina variegata, Ficus hispida, Ficus infectoria, Ficus retusa, Heritiera littoralis, Mallotus philippinensis, Mangifera sylvatica, Manilkara littoralis, Myristica andamanica, Myristica longifolia, Sterculia colorata* and *Xylocarpus granatum* were found to be attacked by single borer species each (Table-2).

DISCUSSION

Host selection and host specificity, although interrelated, is not necessarily the same thing. The host selection depends on the availability of food plants, suitable place for oviposition, protection of immature stages and less number of competitors. Therefore, selection of the appropriate host is one of the most vital issues for the successful development and proper growth of borer larvae. According to Kennedy (1953), the host plant is not merely something fed on, it is something lived on. Moreover, it will be a suitable place for oviposition. Ovipositing adults are influenced to a greater degree by the nature and condition of the host plant (i.e., thickness of bark, stage of decay, moisture content, other microclimatic conditions and identity of the host species). According to Peyerimhoff (1933) host selection involves a combination of factors, including the attractiveness and condition of the host, internal factors of the plant feeder (including mutation), as well as environmental conditions.

Khan and Maiti (1981), in their experiment showed that the host selection of *Acalolepta rusticatrix* in these islands depends primarily upon the condition of the host material (i.e., stage of decay) and secondarily upon the host identity. In another experiment, Khan (1987) showed that, pupal development and survival in *Neoplocaederus obesus* are greatly depend on high relative humidity and darkness of the surrounding (microclimatic conditions). According to J. Henri Fabre (Teale,1991), ovipositing females possess a 'botanical instinct' that helps them to recognize their host plants. The facility with which host selection is accomplished by the females is undoubtedly a result of high development of special sense organ. Most of these organs are found in cerambycid antenna. Loss of the antenna greatly impairs of inhibits the host selection.

The current investigation has documented the host plants of 44 species of cerambycid borers from the aforementioned islands, as presented in table- 1. Earlier, Khan & Maiti (1983) documented the host plants of 29 borer species with one unidentified species. Among these 44 borer species, 18 species were already dealt by Khan & Maiti (1983). Therefore, 26 borer species and their host plants are the new addition in this communication (marked with * in table-1). In addition, the present study has documented a total of 78 host plant species. Notably, 12 of these species (*Alstonia kurzii, Amoora wallichii, Bridelia griffithii, Barringtonia asiatica, Barringtonia racemosa, Calophyllum soulattri, Desmodium umbellatum, Heritiera littoralis, Hopea* *odorata, Manilkara littoralis, Pongamia pinnata, Sonneratia alba)* have been identified as host plants of cerambycid borers for the first time from this region (marked with * in table -2).

The feeding habit of the borer species is a determining factor in host specificity, as has been widely acknowledged. In the realm of entomology, certain insect species exhibit either monophagy, wherein they subsist on a solitary host plant species, or polyphagy, wherein they rely on a diverse array of host plant species for sustenance. Bernays and Graham (1988) stated that host- plant specialization is the rule rather than the exception. As per their assertion, a minority of herbivorous species, specifically less than 10%, consume plants from over three different plant families. Monophagy, which refers to the consumption of a single type of food, is a prevalent characteristic observed in various insect taxa, and in some groups, it is the prevailing behaviour.

But during the course of this investigation, it was observed that the majority of cerambycid borers exhibit polyphagous behaviour, with 95% of species displaying this trait. Only two species, specifically *Halme caerulescens* and *Remphan hopei,* were found to be monophagous, as indicated in table- 1. The findings of the current study do not corroborate the observations reported by Bernays and Graham (1988). The observed phenomenon can be attributed to the fact that the principle of host-plant specialisation in felled logs or under storage conditions deviates from the conventional rule applicable to living trees.

According to Linsley's (1959) findings, the more primitive groups of cerambycids such as Parandrinae, Prioninae, and Lepturinae exhibit a higher degree of polyphagy. However, certain specialised forms with a limited host range, such as *Remphan hopei* in the current investigation, is also present among them. Further, the polyphagous species are usually associated with such wood which has been dead for some time or is actually decomposing (Linsley, 1959). In general, those species which develop as larvae in living trees are usually the most narrowly host specific (Linsley, 1959).

When considering the number of host plants as a measure of pest destructiveness, it can be observed that *Stromatium barbatum*, with a total of 35 host plant species, appears to be the most destructive pest in these islands, as indicated in table- 1. Previous research has also indicated that this species is the primary wood borer in India (Beeson and Bhatia, 1939) as well as in the Andaman & Nicobar

Islands (Khan and Maiti, 1983). Probably, the unique capability of ovipositing by *Stromatium barbatum* in excessively dry wood and its ability to retain body moisture in the dry microclimatic conditions leads this cerambycid insect to be the predominant wood borers in all the situations. The present study also highlights the prevalence of various borer species, including *Acalolepta rusticatrix, Aeolesthes (s.str) holosericea, Neoplocaederus obesus, Pelargoderus niger, Olenecamptus biobus, Batocera andamana, Palimna annulata, Xystrocera globosa, Coptops rufa, Epepeotes luscus, Glenea (Stiroglenea) andamanica, Ceresium andamanicum, Epepeotes andamanicus, Pharsalia (Cycos) subgemmeta,* and *Stibara (Stibara) suturalis,* which are known to infest a significant number of host plants after *Stromatium barbatum* in the Andaman and Nicobar Islands (Table- 1).

There is no doubt that the survival potentiality of all the wood-boring insects including the cerambycid beetles has increased by the characteristic biological features and unique ecological adjustment with the physico-chemical changes of wood-hosts. So, those host plants would attract the wood borers more who can fulfill all the prerequisite conditions for them. In the course of the current investigation, it was determined that the logs of *Canarium euphyllum* serve as a suitable ecological niche for cerambycid wood borer species indigenous to the islands under study. Specifically, the logs of this particular host plant were found to harbour a total of 13 distinct species of borers, as outlined in table- 2. The soft wood of *Canarium euphyllum* allowed easy penetration and thick bark of this host plant retains the moisture content for longer span of time, making it a susceptible host plant for wood borers in these islands. Additional host plants that were found to be susceptible include *Ficus carica, Mangifera andamanica, Salmaliainsignis, Lannea coromandelica, Mangifera indica, Pongomia pinnata, Terminalia procera, Pterocymbium tinctorium, Semecarpus kurzii, Dipterocarpus sp., Salmalia malabarica, Samanea saman*, among others in Andaman & Nicobar Islands (Table- 2).

This study identified 25 host plant species that were found to be less susceptible to borer infestation, with each plant species being attacked by a single borer species, as indicated in table- 2. Thus, it can be inferred that a significant proportion (68%) of the host plant species identified in this investigation exhibited attraction to multiple borer species. The observed phenomenon could potentially be attributed to the presence of a high concentration of host plant species within a limited spatial area, as may be the case in logging centres or storage facilities.

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Tables

Table- 1: Cerambycid borer species and their host plants in Andaman & Nicobar Islands

No	Borer species	Subfamily	Host plant species
*1	*Acalolepta nivosa* (White 1858)	Lamiinae	*Acacia pennata, Aegle marmelos, Carallia brachiata*
2	*Acalolepta rusticatrix* (Fabricius 1801)	Lamiinae	*Aegle marmelos, Anacardium occidentale, Artocarpus chaplasha, Artocarpus integrifolia, Canarium euphyllum, Citrus maxima, Erythrina variegata, Ficus religiosa, Ficus carica, Pterocymbium tinctorium, Salmalia insignis, Samanea saman, Semecarpus kurzii, Tectona grandis, Terminalia procera, Barringtonia asiatica*
*3	*Acanthophorous serraticornis* (Olivier,1975)	Prioninae	*Garuga pinnata, Parishia insignis*
4*	*Aeolesthes basicornis* Gahan 1893	Cerambycinae	*Lannea coromandelica, Mangifera indica, Salmalia insignis, Mangifera andamanica*
5	*Aeolesthes holosericea* Fabricius 1787	Cerambycinae	*Aegle marmelos, Dracontomelum mangiferum, Duabanga sonneratioides, Dipterocarpus sp., Lannea coromandelica, Mangifera andamanica, Mangifera indica, Pterospermum acerifolium, Rhizophora apiculata, Rhizophora candelaria, Salmalia insignis, Salmalia malabarica, Terminalia bellirica, Terminalia procera, Tectona grandis*
*6	*Apomecyna histrio* (Fabricius 1793)	Lamiinae	*Semecarpus kurzii, Calophyllum soulattri, Terminalia bellirica, Mangifera andamanica*
*7	*Apomecyna saltator* (Fabricius 1781)	Lamiinae	*Dracontomelum mangiferum, Lannea coromandelica, Parishia insignis, Canarium euphyllum*
*8	*Batocera molitor* Newman 1915	Lamiinae	*Terminalia procera, Mangifera andamanica, Barringtonia racemosa, Canarium euphyllum*

9	*Batocera andamana* Thomson 1878	Lamiinae	*Artocarpus chaplasha, Dipterocarpus sp., Canarium euphyllum, Ficus bengalensis, Mangifera indica, Parishia insignis, Pterocymbium tinctorium, Salmalia insignis, Semecarpus kurzii, Pterocarpus dalbergioides*
*10	*Cacia (Pericacia) cretifera* (Hope 1831)	Lamiinae	*Ficus carica, Planchonia andamanica*
11	*Ceresium andamanicum* Gahan 1906	Cerambycinae	*Artocarpus lakoocha, Ficus carica, Planchonia andamanica, Canarium euphyllum, Terminalia procera*
12	*Ceresium flavipes* (Fabricius 1793)	Cerambycinae	*Casuarina equisetifoia, Rhizophora apiculata*
13	*Ceresium geniculatum* White 1855	Cerambycinae	*Artocarpus lakoocha, Lagerstroemia hypoleuca, Terminalia manni*
*14	*Chloridolum alcmene* Thomson 1865	Cerambycinae	*Ficus carica, Pterocymbium tinctorium, Samanea saman*
*15	*Demonax andamanicus* Gahan 1906	Cerambycinae	Semecarpus kurzii, Pongamia pinnata, Pterocymbium tinctorium
*16	*Desisa subfasciata* (Pascoe 1862)	Lamiinae	*Semecarpus kurzii, Pongamia pinnata, Pterocarpus dalbergioides*
*17	*Dorysthenes (Lophosternus) huegelii* (Redtenbacher 1848)	Prioninae	*Murraya paniculata, Mangifera indica, Ficus carica , Murraya exotica Linn.,*
*18	*Dorysthenes (Lophosternus) indicus* (Hope 1831)	Prioninae	*Ficus carica, Pongamia pinnata*
*19	*Epepeotes andamanicus* Gahan 1893	Lamiinae	*Anacardium occidentale, Artocarpus chaplasha,Lagerstroemia hypoleuca, Tetrameles nudiflora, Canarium euphyllum*

*20	*Epepeotes luscus* (Fabricius 1787)	Lamiinae	*Canarium euphyllum, Dipterocarpus sp, Hopea odorata, Pongamia pinnata, Semecarpus kurzii, Terminalia procera*
21	*Glenea (Stiroglenea) andamanica* Breuning 1958	Lamiinae	*Alstonia kurzii, Calophyllum soulattri, Dipterocarpus sp.Pterospermum acerifolium, Salmalia insignis,Terminalia procera*
*22	*Gnoma nicobarica* Breuning 1936	Lamiinae	*Desmodium umbellatum , Terminalia bialata*
23	*Halme caerulescens* Gahan 1906	Cerambycinae	*Terminalia manni*
*24	*Macrochenus atkinsoni* Gahan 1893	Lamiinae	*Salmalia insignis, Salmalia malabarica , Hopea odorata, Lagerstroemia hypoleuca*
*25	*Marmaroglypha nicobarica* Redtenbacher 1868	Lamiinae	*Terminalia bialata, Barringtonia pendula*
*26	*Mimabryna nicobarica* Breuning 1937	Lamiinae	*Semecarpus kurzii, Sterculia villosa*
*27	*Nepoides sulcipennis* (White 1853)	Cerambycinae	*Ficus carica, Sonneratia alba, Terminalia procera, Canarium euphyllum*
28	*Neoplocaederus obesus* (Gahan 1890)	Cerambycinae	*Artocarpus chaplasha, Canarium euphyllum, Garuga pinnata, Lannea coromandelica, Mangifera andamanica, Mangifera indica, Pterocymbium tinctorium, Heritiera littoralis, Pterygota alata, Salmalia insignis, Salmalia malabarica, Spondias pinnata, Sterculia colorata, Sterculia villosa, Tetrameles nudiflora*
*29	*Oberea posticata* Gahan 1894	Lamiinae	*Amoora wallichi, Terminalia bellirica*

30	*Olenecamptus bilobus* (Fabricius 1801)	Lamiinae	*Artocarpus chaplasha, Artocarpus integrifolia, Canarium euphyllum, Ficus bengalensis, Ficus carica, Ficus infectoria, Ficus religiosa, Mangifera andamanica, Mangifera indica, Pterocymbium tinctorium, Salmalia insignis, Salmalia malabarica*
*31	*Olenecamptus sexplagiatus* (Breuning 1936)	Lamiinae	*Garuga pinnata, Lannea coromandelica, Mangifera andamanica, Mangifera indica*
*32	*Palimna annulata* (Olivier 1792)	Lamiinae	*Artocarpus chaplasha, Canarium euphyllum, Pterygota alata, Salmalia insignis, Salmalia malabarica, Spondias pinnata, Sterculia villosa, Tetrameles nudiflora*
*33	*Parorsidis nigrospersa* (Pic 1929)	Lamiinae	*Ficus rumphii, Pterygota alata, Salmalia insignis*
*34	*Pelargoderus niger* Thomson 1878	Lamiinae	*Acacia pennata, Atrocarpus lakoocha, Casuarina equisetifoia, Dalbergia volubilis, Ficus carica, Lannea coromandelica, Murraya exotica Linn.,Murraya paniculata, Pongomia pinnata, Pterygota alata, Canarium euphyllum, Pterocarpus dalbergioides*
35	*Pharsalia (Cycos) subgemmata* (Thomson 1857)	Lamiinae	*Canarium euphyllum, Garuga pinnata, Mangifera andamanica, Mangifera sylvatica, Spondias pinnata*
*36	*Pterolophia (Hylobrotus)* beesoni Breuning 1937	Lamiinae	*Albizzia lebbek. Manilkara littoralis, Samanea saman*
37	*Remphan hopei* Waterhouse 1836	Prioninae	*Dipterocarpus sp.*
38	*Ropica honesta* Pascoe 1927	Lamiinae	*Lannea coromandelica, Pongomia pinnata, Salmalia malabarica, Samanea saman*
39	*Serixia andamanica* Gardner 1930	Lamiinae	*Myristica andamanica, Terminalia bialata*

*40	*Stibara (Stibara) suturalis* Gahan 1890	Lamiinae	*Mangifera andamanica, Mangifera indica, Murraya exotica, Murraya paniculata, Pongomia pinnata*
41	*Stromatium barbatum* (Fabricius1775)	Cerambycinae	*Acacia pennata, Anacardium occidentale, Aegle marmelos, Atrocarpus lakoocha, Carallia brachiata, Albizzia chinensis , Carapa moluccensis, Albizzia procera, Bridelia griffithii, Cassia fistula, Cassia nodosa, Cassia siamea, Casuarina equisetifoia, Citrus aurantium, Citrus maxima, Citrus medica, Dalbergia volubilis, Dipterocarpus sp., Excoecaria agallocha, Ficus carica, Ficus hispida, Ficus retusa, Ficus rumphi, Garuga pinnata, Lannea coromandelica, Mallotus philippinensis, Mangifera andamanica, Mangifera indica, Murraya exotica Linn.,Murraya paniculata, Pongomia pinnata, Pterygota alata, Terminalia bellirica, Terminalia bialata, Terminalia procera, Xylocarpus granatum*
42	*Xenolea tomentosa* (Pascoe 1864)	Lamiinae	*Ficus carica, Ficus religiosa, Lannea coromandelica, Tectona grandis*
43	*Xylotrechus buqueti* (Laporte & Gory 1841)	Cerambycinae	*Cassia fistula, Duabanga sonneratioides, Myristica longofolia, Tectona grandis*
44	*Xystrocera globosa* (Olivier 1795)	Cerambycinae	*Albizzia lebbek, Albizzia chinensis, Albizzia procera, Bauhinia retusa, Pterocarpus dalbergioides, Salmalia malabarica, Samanea saman, Sonneratia alba*

Table-2: Plant species and their cerambycid borers in Andaman & Nicobar Islands

Sl. No.	**Plant species**	**Plant Family**	**Borer species**
1	*Acacia pennata (L.)* Willd.	Mimosaceae	*Acalolepta nivosa, Pelargoderus niger, Stromatium barbatum*

2	*Aegle marmelos* Linnaeus	Rutaceae	*Acalolepta rusticatrix, Aeolesthes holosericea , Acalolepta nivosa, Stromatium barbatum*
3	*Albizia lebbeck* Benth.	Mimosaceae	*Pterolophia (Hylobrotus) beesoni, Xystrocera globosa*
4	*Albizia procera* Benth.	Mimosaceae	*Stromatium barbatum, Xystrocera globosa*
5	*Albizia chinensis* (Osb.)	Mimosaceae	*Stromatium barbatum, Xystrocera globosa*
6*	*Alstonia kurzii* Hook.f.	Apocyanaceae	*Glenea (Stiroglenea) andamanica,*
7	*Anacardium occidentale* Linnaeus	Anacardiaceae	*Acalolepta rusticatrix, Epepeotes andamanicus, Stromatium barbatum*
8	*Artocarpus chaplasha* Roxb.	Moraceae	*Acalolepta rusticatrix, Batocera andamana, Epepeotes andamanicus, Neoplocaederus obesus, Olenecamptus bilobus, Palimna annulata*
9	*Artocarpus integrifolia* Linn.	Moraceae	*Acalolepta rusticatrix, Olenecamptus bilobus*
10	*Artocarpus lakucha* Roxb.	Moraceae	*Ceresium andamanicum, Ceresium geniculatum, Pelargoderus niger, Stromatium barbatum*
11*	*Amoora wallichii* King	Meliaceae	*Oberea posticata*
12	*Bauhinia retusa* Roxb.	Fabaceae	*Xystrocera globosa*
13*	*Bridelia griffithii* Hook.f.	Euphorbiaceae	*Stromatium barbatum*
14*	*Barringtonia asiatica* L. Kurz	Lecythidaceae	*Acalolepta rusticatrix, Marmaroglypha nicobarica*
15*	*Barringtonia racemosa* (L.) Roxb.	Lecythidaceae	*Batocera molitor*
16	*Barringtonia pendula*	Lecythidaceae	*Marmaroglypha nicobarica*

17	*Canarium euphyllum* Kurz	Burseraceae	*Acalolepta rusticatrix , Apomecyna saltator, Batocera molitor, Batocera andamana, Ceresium andamanicum, Epepeotes andamanicus, Epepeotes luscus, Nepiodes sulcipennis, Olenecamptus bilobus, Palimna annulata, Pelargoderus niger, , Pharsalia (Cycos) subgemmeta, Neoplocaederus obesus*
18*	*Calophyllum soulattri* Burm.f.	Calophyllaceae	*Apomecyna histrio, Glenea (Stiroglenea) andamanica*
19	*Carallia brachiata (Lour.)* Merr.	Rhizophoraceae	*Acalolepta nivosa, Stromatium barbatum*
20	*Carapa moluccensis* Lam.	Meliaceae	*Stromatium barbatum*
21	*Cassia fistula* Linn.	Fabaceae	*Stromatium barbatum, Xylotrechus buqueti*
22	*Cassia nodosa* Ham	Fabaceae	*Stromatium barbatum*
23	Cassia siamea Lam.	Fabaceae	*Stromatium barbatum*
24	*Casuarina equisetifolia* Linnaeus	Casuarinaceae	*Ceresium flavipes, Pelargoderus niger, Stromatium barbatum*
25	*Citrus aurantium* Linn.	Rutaceae	*Stromatium barbatum*
26	*Citrus maxima* (Burm.)Merrill	Rutaceae	*Acalolepta rusticatrix, Stromatium barbatum*
27	*Citrus medica* Linn.	Rutaceae	*Stromatium barbatum*
28	*Dalbergia volubilis* Roxb.	Fabaceae	*Pelargoderus niger, Stromatium barbatum*
29	*Dipterocarpus* sp.	Dipterocarpaceae	*Aeolesthes holosericea, Batocera andamana, Epepeotes luscus, Glenea (Stiroglenea) andamanica, Remphan hopei, Stromatium barbatum*
30	*Dracontomelum mangiferum* Blume	Anacardiaceae	*Aeolesthes holosericea, Apomecyna saltator*

31	*Duabanga sonneratioides* (Roxb. Ex DC) Walpers	Lythraceae	*Aeolesthes holosericea, Xylotrechus buqueti*
32*	*Desmodium umbellatum* (L.) DC	Fabaceae	*Gnoma nicobarica*
33	*Excoecaria agallocha* Linnaeus	Euphorbiaceae	*Stromatium barbatum*
34	*Erythrina variegata* Linn	Fabaceae	*Acalolepta rusticatrix*
35	*Ficus bengalensis* Linn.	Moraceae	*Batocera andamana, Olenecamptus bilobus*
36	*Ficus carica* Linn.	Moraceae	*Acalolepta rusticatrix rusticatrix, Cacia (Pericacia) cretifera, Ceresium andamanicum, Chloridolum alcmene, Dorysthenes (Lophosternus) huegelii, Dorysthenes (Lophosternus) indicus, Nepiodes sulcipennis, Olenecamptus bilobus, Pelargoderus niger, Stromatium barbatum, Xenolea tomentosa*
37	*Ficus hispida* Linn. F.	Moraceae	*Stromatium barbatum*
38	*Ficus infectoria* Roxb.	Moraceae	*Olenecamptus bilobus*
39	*Ficus religiosa* Linn.	Moraceae	*Acalolepta rusticatrix, Olenecamptus bilobus, Xenolea tomentosa*
40	*Ficus retusa* Linn.	Moraceae	*Stromatium barbatum*
41	*Ficus rumphii* Blume	Moraceae	*Parorsidis nigrospersa, Stromatium barbatum*
42	*Garuga pinnata* Roxb.	Burseraceae	*Acanthophorous seraticornis, Olenecamptus sexplagiatus , Pharsalia (Cycos) subgemmeta , Neoplocaederus obesus, Stromatium barbatum*
43*	*Heritiera littoralis* Dryand., Aiton	Malvaceae	*Neoplocaederus obesus*

44*	*Hopea odorata* Roxb.	Dipterocarpaceae	*Epepeotes luscus, Macrochenus atkinsoni*
45	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	*Aeolesthes basicornis, Aeolesthes holosericea, Apomecyna saltator, Olenecamptus sexplagiatus , Pelargoderus niger, Neoplocaederus obesus, Ropica honesta, Stromatium barbatum, Xenolea tomentosa*
46	*Lagerstroemia hypoleuca* Kurz.	Lythraceae	*Ceresium geniculatum, Epepeotes andamanicus, Macrochenus atkinsoni*
47	*Mallotus philippinensis* Mull. Arg.	Euphorbiaceae	*Stromatium barbatum*
48	*Mangifera indica* Linn.	Anacardiaceae	*Aeolesthes basicornis, Aeolesthes holosericea, Batocera andamana, Dorysthenes (Lophosternus) huegelii, Olenecamptus bilobus, Olenecamptus sexplagiatus , Neoplocaederus obesus , Stibara (Stibara) suturalis, Stromatium barbatum*
49	*Mangifera andamanica* King	Anacardiaceae	*Aeolesthes basicornis, Aeolesthes holosericea, Apomecyna histrio, Batocera molitor, Olenecamptus bilobus, Olenecamptus sexplagiatus, Pharsalia (Cycos) subgemmeta , Neoplocaederus obesus, Stibara (Stibara) suturalis, Stromatium barbatum*
50	*Mangifera sylvatica* Roxb.	Anacardiaceae	*Pharsalia (Cycos) subgemmeta*
51*	*Manilkara littoralis* Kurz.	Sapotaceae	*Pterolophia (Hylobrotus) beesoni*

52	*Murraya exotica* Linn.,	Rutaceae	*Dorysthenes (Lophosternus) huegelii, Pelargoderus niger, Stibara (Stibara) suturalis, Stromatium barbatum*
53	*Murraya paniculata* (Linn.) Jack.,	Rutaceae	*Dorysthenes (Lophosternus) huegelii, Pelargoderus niger, Stibara (Stibara) suturalis, Stromatium barbatum*
54	*Myristica andamanica* Hook.f.	Myristicaceae	*Serixia andamanica*
55	*Myristica longifolia* Wall.	Myristiaceae	*Xylotrechus buqueti*
56	*Parishia insignis* Hook.f	Anacardiaceae	*Acanthophorous seraticornis, Apomecyna saltator, Batocera andamana*
57	*Planchonia andamanica* King.	Lecythidaceae	*Cacia (Pericacia) cretifera, Ceresium andamanicum*
58*	*Pongamia pinnata* (Linn.) Pierre	Fabaceae	*Demonax andamanicus, Desisa (Desisa) subfasciata, Dorysthenes (Lophosternus) indicus, Epepeotes luscus, Pelargoderus niger, Ropica honesta, Stibara (Stibara) suturalis, Stromatium barbatum*
59	*Pterocarpus dalbergioides* Roxb.	Fabaceae	*Batocera andamana, Desisa (Desisa) subfasciata, Pelargoderus niger, Xystrocera globosa*
60	*Pterocymbium tinctorium* Merr.	Sterculiaceae	*Acalolepta rusticatrix, Batocera andamana, Chloridolum alcmene, Demonax andamanicus, Olenecamptus bilobus, Neoplocaederus obesus*
61	Pterospermum acerifolium Willd.	Sterculiaceae	*Aeolesthes holosericea, Glenea (Stiroglenea) andamanica*
62	*Pterygota alata* (Roxb.) R. Br.	Sterculiaceae	*Pelargoderus niger, Parorsidis nigrospersa, Neoplocaederus obesus, Stromatium barbatum*

63	*Rhizophora apiculata* Blume	Rhizophoraceae	*Aeolesthes holosericea, Ceresium flavipes*
64	*Salmalia insignis* Scott & *Endl.*	Bombaceae	*Acalolepta rusticatrix, Aeolesthes basicornis, Aeolesthes holosericea, Batocera andamana, Glenea (Stiroglenea) andamanica, Macrochenus atkinsoni, Olenecamptus bilobus, Parorsidis nigrospersa, Neoplocaederus obesus,*
65	*Salmalia malabarica* (Decand.)Scott & Endl.	Bombaceae	*Aeolesthes holosericea, Macrochenus atkinsoni, Olenecamptus bilobus, Neoplocaederus obesus, Ropica honesta , Xystrocera globosa*
66	*Samanea saman* (Jacq.) Merr.	Fabaceae	*Acalolepta rusticatrix, Chloridolum alcmene, Pterolophia (Hylobrotus) beesoni, Ropica honesta, Xystrocera globosa*
67	*Semecarpus kurzii* Engler	Anacardiaceae	*Acalolepta rusticatrix, Apomecyna histrio, Batocera andamana, Demonax andamanicus, Desisa (Desisa) subfasciata, Epepeotes luscus , Mimabryna nicobarica*
68	*Spondias pinnata* (Linn.f.) Kurz.	Anacardiaceae	*Palimna annulata , Pharsalia (Cycos) subgemmeta, , Neoplocaederus obesus*
69	*Sterculia colorata* Roxb.	Sterculiaceae	*Neoplocaederus obesus*
70	*Sterculia villosa* Roxb.	Malvaceae	*Mimabryna nicobarica, Neoplocaederus obesusa*
71*	*Sonneratia alba* Sm.	Sonneratiaceae	*Nepiodes sulcipennis, Xystrocera globosa*
72	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	*Aeolesthes holosericea, Apomecyna histrio, Oberea posticata, Stromatium barbatum*

73	*Teminalia bialata* (Roxb.) Steud.	Combretaceae	*Gnoma nicobarica, Marmaroglypha nicobarica, Serixia andamanica, Stromatium barbatum*
74	*Terminalia manni* King	Combretaceae	*Ceresium geniculatum, Halme caerulescens*
75	*Terminalia procera* Roxb.	Combretaceae	*Acalolepta rusticatrix, Aeolesthes holosericea, Batocera numitor, Ceresium andamanicum, Epepeotes luscus, Glenea (Stiroglenea) andamanica, Nepiodes sulcipennis, Stromatium barbatum*
76	*Tectona grandis* Linn.	Verbenaceae	*Acalolepta rusticatrix, Aeolesthes holosericea, Xenolea tomentosa, Xylotrechus buqueti*
77	*Tetrameles nudiflora* R. Br.	Tetramelaceae	*Epepeotes andamanicus, Neoplocaederus obesus, Palimna annulata*
78	*Xylocarpus granatum* Koening	Meliaceae	*Stromatium barbatum*

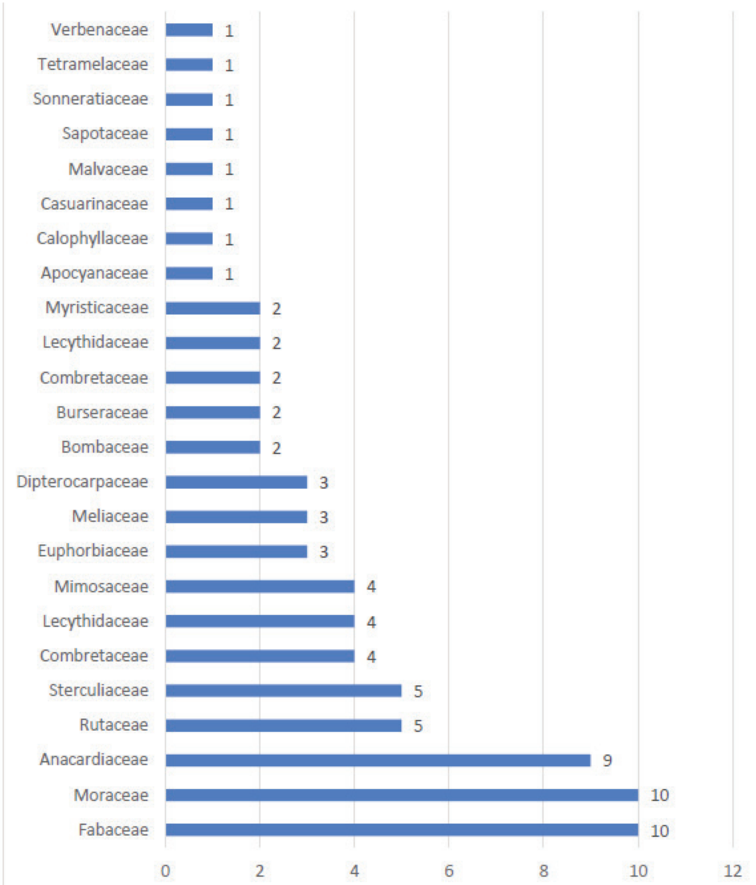

Fig.1. Number of plant species (Familywise)

19 Biodiversity and Its Components –A General Discussion

Dr. Debabrata Das

ABSTRACT

Biodiversity is the diversity of all biological components in an environment. It goes to gene and spreads over ecosystem or landscape. In general, all the organisms with diverse colour, size, shape, orientation, variations of all parts as a whole under the head biodiversity. We see colourful fishes, plants, animals and so on but under microscope a huge number of small and tiny microorganisms are under this category. So, biodiversity and its components are versatile which are available in different environments and has predictive use value. Food, flosses, fibers, resins, tannins, saponins of plants; fars, bones, teeth, skin, fleshes and so on from animals are used by us that are available from nature and regarded as components of biodiversity. It is better to use micro-organismal diversity, phytodiversity, zoodiversity for all microbes, plants and animals respectively. Researchers have their own view on biodiversity while common people have another vision on biodiversity. Different pet birds, ornamental fishes, colourful indoor plants, lawn grasses, shrubs, trees, herbs and medicinal plants have their own beauty. Small to smaller and big to bigger plants and animals are used potentially for their values. It may be extrinsic or intrinsic. Ecosystem services and energy flow in the ecosystem is also run by the presence of biodiversity. The producer's and consumer's interactions are also governed by the versatile organisms in ecosystem which are under biodiversity. The primary and secondary products of all natural kinds are due to presence of

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biodiversity. In this communication author is trying to discuss on biodiversity and its components.

Keywords: *Biodiversity, components, examples, Citizen's view, conservation.*

INTRODUCTION

The term biodiversity was proposed by Walter G Rosen in the year 1985. Diversity of plants, animals and microbes are all together called biodiversity. Biodiversity term is very meaningful as it depicts many diverse aspects like colour, varieties, size, shape and more (Ghosh, 2021). Fanciful color plants, ornamentals, breeds, crop types in the species, species in the genus and genus in the family are under this category. The genetic components and its distribution among the traces are also called diverse items which is called biodiversity but under the category of gene. Similarly ecological and or landscape diversity is fall under a separate category. Biodiversity is a term applied for diverse kind of biological organisms and its habitat also which is diverse as landscape but in a small unit to smaller unit as gene is within this term (Das, 2022).

So, biodiversity is the variations of organisms in its ecological habitats, its meaningful shape, size, appearance that vary from one to another group or from one habitat to another even from one gene level to another. Therefore it's sphere is from gene to species to ecosystem. The form biodiversity applied everywhere but its tune and applications is very shy because we use daily a large number of terms in every sphere but unfortunately no terms applied as biodiversity (Das, 2021). Subject and discipline wise its use and componential concept is different.

Rich biodiversity is due to action of fertile environment, this means every components play a crucial role and increasing the quality of environment and its s congenial for all types of organisms. But altered environment make arrangement to loss of biodiversity and therefore species, ecosystem components and it's loss is a common phenomenon. It is accelerated by the global warming and climate change. Loss of habitats and loss of environmental positive factors accelerate the species loss.

The most important direct drive of biodiversity loss in terrestrial system in the last several decades has been land use change, primarily the conversion of pristine native habitats (forests, grasslands, and mangroves) into agricultural system; while much of the oceans have been overfished (De and Dey, 2022). Paradigm –shift is needed in agriculture to stop the large scale loss of biodiversity in the agricultural landscape and soil, but even more than that to rethink the use of the role of soil life, landscape elements and biodiversity in sustainable agriculture.

Some plants and animals are threatened due to various reasons among them human activities is dominant one. Now except protected areas other sites have no populations of *Rauvolfia serpentina.* Bramha kamal in the Himalayan region is vanishing. Species and number of different Primulas in the Himalayan regions are decreasing. Population of high altitude birds are deceasing.

Common bird sparrow is also decreasing though in rural areas some pockets have sparrow population. Crick et al. (2002) and Summer-Smith (2003) explained that the sparrow population has decreased. Survey conducted by ICAR in the year 2010 noticed that the house sparrow population has declined beyond 90% in the state of Andhra Pradesh (Bhattacharya et al. 2010; Jawale, 2012 and Khera and Das, 2010). Most of the studies revealed that habitat loss is the main threat for the existence of sparrow. Several studies suggest that there is more demand for breeding spaces (Bhattacharya, 2010 and Balaji, 2014). In his study Balaji (2014) has opined that by providing nest boxes one can resolve the problem of habitat loss. Still there is need to improve the nest boxes design for house sparrow (Crick et al. 2002). Recently workers (Veers and Lanka, 2022) have prepared a protective nest design with some modifications to the model suggested by British Trust Ornithology to suit to local climatic condition (2021a, b).

It is true that like Himalayas and Western Ghats, Terai-Duars belt is also important for biodiversity components. Diverse and varied habitats of Terai-Duars belt of West Bengal are home to the unique vegetation and a number of rare, endemic, and threatened elements (Biswas and Das, 2021). It is the Sub-Himalayan region of the Indian State that extends from Nepal to Assam. Geographically this land mass is unique because its location from 26° 16′ 00″ N to 27° 00′ 00″ N latitudes and from 87° 59′ 30″ E to 89° 53′ 00″ E longitudes. It is bounded by hilly regions of Darjeeling district and Bhutan to the North, by Cooch Behar, North Dinajpur and Bangladesh to the South. In this region, endemic, endangered, near threatened, vulnerable and critically endangered category species were recorded. *Alpinia calcarata, Ampelocissus barbata, Asperagus racermosus, Celastrus* *paniculatus, Dioscorea prazeri, Helminthostachys zeylanica, Mucuna pruriens, Gynocardia odorata, Ophioglossum reticulatum and Rauvolfia serperntina* are endangered species. Species like *Aglaia spectabilis, Ailanthus integrifolia, Ampelocissus sikkimensis, Argyreia roxburghii, Baccaurea ramiflora, Capparis olacifolia, Caseartia vareca, Castanopsis lancefolia, Garuga floribunda, Gynocardia odorata, Leea aequata, Leea indica, Litsea panamanja, Litsea salicifolia, Piper chuvya, Piper sylvaticum, Polyalthia simiarum, Psychortia erratica, Pueraria sikkimensis, Saurops quadrangularis, Syzygium kurzii* and *Tetrastigma campylocarpum* are endemic species. *Aristolochia indica* and *Gloriosa superba are vulnerable species.* Near threatened species is *Tylophora indica*. Critically endangered species is *Persea glaucescens*. As the site is facing a large number of threats so their population size is declining day by day at an alarming rate. This is not only confined for plants, it's for animals also.

BIRD STUDIES- A CASE STUDY IN BUXA TIGER RESERVE (BTR)

BTR in Dooars is a rich biodiversity area. Its vegetation, flora –fauna and people's perception on biodiversity conservation is amazing. Research and extension programme going on time to time at that area by Govt. and NGOs which develop the knowledge time to time (Fig. 1-6). Like plant diversity, animal diversity in BTR was versatile.

The same tracts in Dooras boost many avian species. Ghosh (2021) in a 3-day field study in Jayanti Range, BTR revealed 113 bird species. The avian checklist showed that the bird composition in BTR was completely different from that of Teesta Barage, Gajoldoba, comprising of 16 orders. According to the author's report relative diversity of various families at Jayanti range, BTR was given below:

Galliformes- 0.88, Pelecaniformes- 1.77, Phalacrocoraciformes- 0.88, Falconiformes- 0.88, Accipitriformes- 3.54, Charadriformes- 3.54, Columbiformes- 3.54, Psittaciformes- 3.54, Cuculiformes- 1.77, Strigiformes- 0.88, Apodiformes- 1.77, Bucerotiformes- 0.88, Coraciiformes- 6.19, Passeriformes- 61.06. He opined that BTR is a good place to study passerine birds. Therefore like plants and birds, other components of biodiversity need to study in a research based way for conservation of biodiversity.

CONCLUSION

It is highly recommended that specialist should start their research at that place round the year. Seasonal study and repeated year wise study is essential to know the diversity of species even their loss or rate of loss. Citizens should take initiative to conserve common bird species, common plants etc. because these are the ready indicators for our environmental health. Regular discussion, seminar and field research should be organized by local NGOs, Stack holders and Nature's club including Schools, Colleges and Wildlife Institutes to know the actual status of each species and ecological amplitude. Lastly, more projects on specific species should be released from Govt. sectors to study the species in a specific level. Nutshell our duty is to protect our species and ecosystem for our purpose. So, start your best practice now.

Fig. 1 Jayanti River at BTR-During Medicinal Plants Conservation Area (MPCA) study

Fig. 2 During MPCA Study at BTR with experts

Fig. 3 *Abroma augusta* in the Medicinal plants Garden at BTR

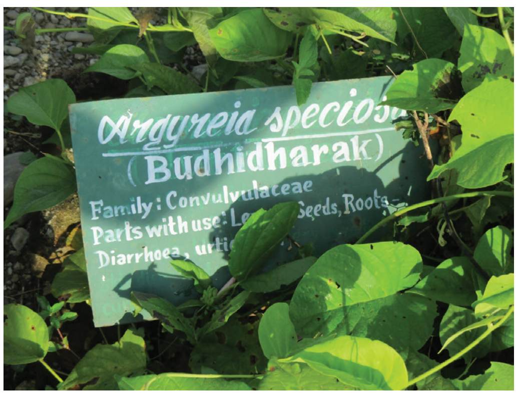

Fig. 4 Important Medicinal Plant in the Conservatory at BTR

Fig. 5 Orchidarium at BTR

Fig. 6 Entrance of BTR

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20 VAM study and Inoculum Production for Sustainable Use

Dr. Pampi Ghosh

ABSTRACT

Vesicular Arbuscular Mycorrhiza (VAM) is regarded as mutually persistent association in combination with fungal mycelium and fine rootlets of plants. Almost all land plants are mycorrhizal except few plants belonging to families like Brassicaceae, Chnopodiaceae, Amaranthaceae, Polygonaceae, Papaveraceae and Boraginaceae. Within soil and in fine feeder roots fungal mycelia shows their presence but in soil huge number of fungal spores are available which are regarded as potent source of new infection on hosts. Many studies revealed that natural but unaltered soils like forests and meadows are the best suit soil may be used as new inoculums in the experiment as well isolation of fungal spores that may be used as mycorrhizal inoculum starter. So, in a situation, inoculums production and local strain development may be a boon to fungal bio-fertilizer production. It could be used in agriculture, forestry, horticulture and many different branches of plant science. A short method and easy production of AM inoculum have been presented here for reference study.

Keywords: *VAM, Spores, Mycelium, Inoculums, Fungal biofertilizer.*

INTRODUCTION

Vesicular Arbuscular Mycorrhiza (VAM) is a mutual association between soil fungi and the majority of land plant species found ubiquitously in nature. Where no vesicles are formed the said

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mycorrhiza is called AM. Its presence found in rhizosphere soil. It is considered to be the most widespread inter kingdom symbiosis on Earth. Scientists argued that AM fungi have been on earth since 470 million years ago (Shadi, 2022). The AM fungi are obligate biotrophs, completely dependent on the carbon supply from the host plant for their life cycle and reproduction. Germination of spores and mycelia form may be started on in-vitro as well as in vivo condition under experimental condition as per the record but their growth and development need immediate fine feeder roots of plants. Through establishment of extensive hyphal networks in the soil, the fungi efficiently gather poorly mobile soil nutrients such as phosphorus and zinc, which they trade for carbon with the host plant (Wyatt et al. 2014). During monsoon soil shows good number of colonization as the feeder roots extend over the area and rhizosphere soil contain less number of AM spores. Most often, the extent of root colonization by AM fungi is assessed as the fraction of root length colonized by mycorrhizal hyphae, arbuscules or other structures. A positive relationship between the extent of root colonization and mycorrhizal contribution to plant growth has been demonstrated across a number of glasshouse and field trials (Treseder, 2013) and references therein time to time, although other factors such as the identity of the symbiotic partners obviously contribute another large share of the variability (Jakobsen et al. 1992; Munkvold et al. 2004; Jansa et al. 2008; Lendenmann et al. 2011 and Thonar et al. 2011). On the other hand, when environmental conditions change, the colonization levels of the roots also often change, indicating a dynamic regulation of the size of the symbiotic interface (Duke et al. 1994; Treseder and Allen, 2002; and Schroeder and Janos, 2005). But so far, the mechanisms behind the regulation of symbiotic interface establishment have not been characterized till dates which need further study. With critical study scientists argued spores and mycelia may be used as starter and the substratum used by these cultures may be soil. So, locally people can collect soil from natural habitats and after isolation large mass may be produced for fungal biofertilizer production. Study revealed that many plants may be used as host plants during culture but sudan, leek, maize etc. are common and used widely. In some cases researchers from Bangladesh used mango plant for inoculation study and showed 100% colonization. But for readymade use weed plants may be used for mass culture. Remembering the theme in mind the present article has been prepared to study more in different areas for mass culture of AM spores.

MATERIALS AND METHODS

Root Colonization Study

Field studies in Monsoon, summer; winter from 2016 to 2022 were taken into consideration for AM study. Random sampling was done following statistical methods. The root samples were collected from uprooting of study plants was taken and root samples were preserved in FAA for 7-8 days. Samples were stained following certain modifications of original method of Phillips and Hayman (1970). Sample roots were cleaned thoroughly in running tap water and then alkaline hydrolysis of root sample was done with 10 percent potassium hydroxide (KOH) solution. The root samples were then dipped in 10% KOH solution and placed in a water bath at 60 degree centigrade for about 10-15 minutes depending upon thickness of root. KOH solution was decanted and the root was rinsed with water till no brown colour appeared in the water. Roots which were dark coloured even after KOH treatment for 10-20 minutes or until the roots were completely bleached. The roots were then washed with several changes of water thoroughly and then treated with 1 (N) 1% hydrochloric acid for five minutes. Subsequently, roots were stained with 0.1% Trypan blue in lactophenol. 100 small pieces of 1m root length of each was studied and % of colonizatio was recorded following the formula given below:

% of colonization= (No. of root segments having AM infection/No. of root segments studied) x 100

Spore density Study

Similarly Rhizosphere soils from different areas were collected and kept in a laboratory for spore number study. Moisture content and pH in each sample was calculated. Arbuscular Mycorrhizal Fungal (AMF) spore density was calculated from the rhizosphere soil samples using 100g soil samples for each sample. Three replicas were used and then mean was taken to determine the number month wise. SD value was calculated using software. From the month wise data mean was calculated to draw a final conclusion following multiplication by 10 as the soil was 100g. Wet sieving and decanting technique was used (Gerdemann and Nicolson, 1963) and direct count was used for quantification using the “stereomicroscope”. Results were expressed as mean of three replicates for each sample. The abundance of spores determined for each sample was expressed as the number of AM fungal spores per 10g of soil for all the samples studied after that it was multiplied by 10 to get 100g soil sample because a large number get so many number of spores might be problematic during counting. Intact spores and sporocarps were mounted in lacto-phenol glycerol and identified according to their spore morphology by using taxonomic key (Schenck and Perez, 1990; Brundrett, 2004). The qualitative estimation was expressed as percentage frequency occurrence of AM fungal species.

RESULTS AND DISCUSSION

Study revealed that spore density of earlier study indicates natural sites have high spore density in compare to other study site(s). Here, Hatidhara in West Midnapore district showed 653 spores per 100g rhizosphere soil during winter while Kanipal area distantly located from Kansai River in Jhargram District showed 375 spores per 100g rhizosphere soil (Table 2) in which moisture content and pH value was 13-26% and 6.6 respectively (Table 1). It is interesting to note that potato cultivation field uses chemical fertilizers round the year but they use organic manure also hence the spore density during winter in that field is 375. So, during inoculum related spore density study, natural field selection is better which is unaltered.

Colonization % of weeds available in various sites showed different colonization%. During colonization study it was found that colonization % was highest in case of *Jatropha gossypifolia* and *Scoparia dulcis* (99%) while lowest in *Sida acuta* (17%) (Table 3). So, during selection of locally available weeds for host, highest % of colonization study is essential. In case of previous study, *Jatropha* and *Sida* may be used as hosts to prepare local inoculums. As weeds are easily available and seed production rate is high so they may be used as good host species. But selection should be on the basis of highest % of root colonization.

Table 1.

Moisture content and soil p^H of study soil samples of Hatidhara and Kanaipal, West Bengal, India

Name of the study sites (Abbreviations used for study sites name)	Range of soil moisture Content (%)	Mean Soil p^H During Winter
Hatidhara (HC)	7% to 16%	6.6
Kanaipal Potato cultivated land (Nearer to Kansai River) (KPCLNK)	12% to 24%	7.1
Kanaipal Potato cultivated land (KPCLDK) (Distantly located from Kansai River)	13%-26%	6.6

Table 2.

Arbuscular Mycorrhizal Fungal (AMF) spore number in Rhizosphere soil of cultivated land

Type	Sample No.	100 BSS Mess Sieve	<100 BSS Mess Sieve	VAM Spore in 100 gm Rhizosphere soil	
				Spore no. in samples	Mean spore number
Hatidhara	1.	380	220	600	653 ±112.64
	2.	200	350	550	
	3.	410	400	810	
Kanaipal (KAL) River side	1.	110	300	410	453±47.84
	2.	180	250	430	
	3.	160	360	520	
Kanaipal Away from River (KAL)	1.	073	193	266	375±77.31
	2.	130	300	430	
	3.	120	310	430	

N.B.: *Per 100 gram rhizosphere soil therefore contains 653±112.64, 453±47.84, and 375±77.31 number of AMF spores during winter at Hatidhara, Kanaipal (river side) and Kanaipal (away from river) respectively. This indicates aman rice cultivated field shows maximum spore density than station at river side of Kanaipal than station away from river at Kanaipal.*

Source: Das, D and Ghosh, P. 2017. AMF Spore Density in Three Agricultural Sites in Two Districts of West Bengal, IJSART, 3(5): 140-146.

Table 3. VAM fungal colonization and arbuscule-vasicle ratio of some weeds grown in W.B.

Sl. No.	Host species	Colonization %	Arbuscule/ vesicle ratio	Host Family
1.	*Atylosia scarabaeoides* (L.) Benth.	42±0.08	1:2	Fabaceae
2.	*Sida acuta* Burm. f.	17±0.08	1:2	Malvaceae
3.	*Tephrosia purpurea* (L.) Pers.	67±0.05	1:2.76	Fabaceae
4.	*Scoparia dulcis* L.	99±0.0	1:0.28	Scrophulariaceae
5.	*Triumfetta rhomboidea* Jack.	70±0.06	1:0.86	Tiliaceae

6.	*Clereodendrum infortunatum* L.	60±0.04	1:0.42	Lamiaceae
7.	*Anisomeles ovata* R.Br.	42±0.04	1:0.15	Lamiaceae
8.	*Jatropha gossypifolia* L.	99±0.05	1:1.47	Euphorbiaceae
9.	*Ludwigia perennis* L.	95±0.08	1:0.2	Onagraceae
10.	*Crotalaria pallida* Aiton	20±0.02	1:0.25	Fabaceae

Source: Own study in Laboratory

CONCLUSION

In normal cases people use sudan grass or maize but the plants selected by me are *Jatropha* and *Scoparia* sp. During May to June seeds are available. In case of Scoparia, seeds available round the year. So, isolate the spores from soil and culture in earthen pot filled with sterilized soil and inoculate by selected spores. Same time put your selected seeds and grow them on the same site to grow seedlings slowly. Keep it free from any kind of contaminants. Wait 3 months and after that chop the aerial parts and crust the soil and keep it in a jar for further use. Inoculum may be used for further use.

PHOTOGRAPHS

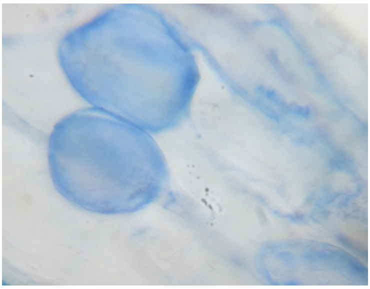


Fig. 1 Vesicle of VAMF

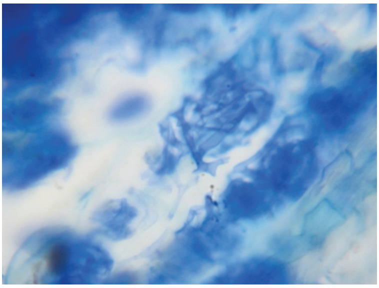
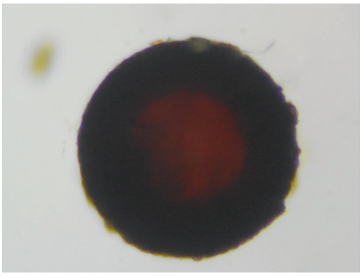


Fig. 2 Arbuscule of VAMF



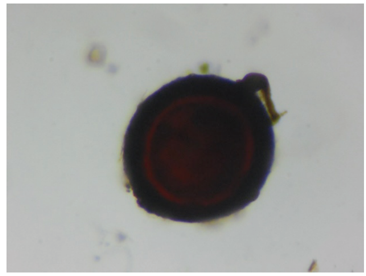


Fig. 3-4 Isolated AM spores from forest soil (W.B.) for inoculums preparation

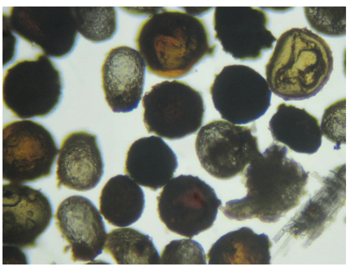


Fig. 5 AM Spores in the inoculums after Mass culture

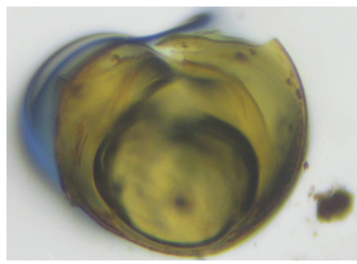


Fig. 6 A single spore isolated from mass culture as starter for pure culture

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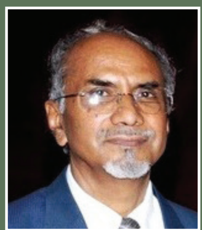

Prof. (Dr.) Mammen Daniel is an internationally acclaimed Phytochemist and Taxonomist. He received his Ph. D. in Botany from M. S.University, Baroda in 1976 and thereafter joined the same Department as Lecturer. He was promoted as a reader in 1987 and Professor in 1997. He served as The Head of Department of Botany and Dean, Faculty of Science of the same University. He retired from University services in 2012 and with his students, started his own pharmaceuticals named "Dr. Daniel's Laboratories" in Baroda which now manufactures more than 15 well-acclaimed herbal medicines.

Prof. Daniel has published more that 180 research papers in the fields of Chemotaxonomy, Phytochemisry, Phytoalexins, Allelopathy and Medicinal plants and authored 18 books of which 5 are international publications. He has guided 18 students for their Ph.D and more than 50 for M. Sc. projects. Known for his oratorical skills, he had travelled far and wide and gave more than 150 lectures and about 30 webinars during Covid times. He has conducted about 5 major research projects and five national/international seminars. He is serving as a Mentor for Life Sciences in Navrachana University of Baroda and Member, Board of Studies of a number of Universities.

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