"Biodiversity: Exploration, Exploitation, Conservation and Management – Vision and Mission"

Proceedings of the UGC Sponsored National Seminar

19-20th November, 2016

Editor-in- Chief

Dr. Sumana Saha

Associate Editors

Dr. Madhumita Manna, Dr. Jayati Ghosh,
Dr. Sanjoy Podder, Dr. Enamul Haque
Dr. Srikanta Guria, Sri Somaditya Dey

Organised by

Post Graduate Department of Zoology
Barasat Government College

In Collaboration with

The Zoological Society, Kolkata

West Bengal Biodiversity Board


HAPPY
TEACHERS
DAY


GO
GREEN

"Biodiversity : Exploration, Exploitation, Conservation and Management – Vision and Mission"

Proceedings of the UGC Sponsored National Seminar

19-20th November, 2016

Editor-in-Chief

Dr. Sumana Saha

Associate Editors

Dr. Madhumita Manna, Dr. Jayati Ghosh, Dr. Sanjoy Podder,
Dr. Enamul Haque Dr. Srikanta Guria, Sri Somaditya Dey

Organised by

Post Graduate Department of Zoology
Barasat Government College
Barasat, Kolkata – 700 124, India

In Collaboration with

The Zoological Society, Kolkata

West Bengal Biodiversity Board

Citation

S. Saha, M. Manna, J. Ghosh, S. Podder, E. Haque, S. Guria and S. Dey (Eds.). *Biodiversity : Exploration, Exploitation, Conservation and Management - Vision and Mission*. Proceedings of the UGC Sponsored National Seminar, Kolkata, India, 19-20th November, 2016. *World Scientific News* 71 (2017) 1-228

Reviewer

Prof. Jerzy Borowski
Department of Forest Protection and Ecology, SGGW,
Warsaw, Poland

Published On-line

03 May, 2017, WSN Volume 71 (2017), pp. 1-228
http://www.worldscientificnews.com/

Published By

Dr. Tomasz Borowski
Scientific Publishing House „DARWIN",
22/12 Adama Mickiewicza Street, 78-520 Złocieniec, Poland

ISBN 978-83-947896-2-6

ISSN 2392-2192

Technical Inputs

Ruby Das

Cover Design

Dr. Sumana Saha

CONTENTS

SECTION : I PAGE NO.

1. **Message** 6
2. **From the Convenor's Desk** 10
3. **About the Proceedings** 12
4. **Brief Report on the Seminar** 13
5. **A Few Moments of the Seminar** 15
6. **Department of Zoology – A Brief History** 18
7. **Organising Committee** 19
8. **Programme Schedule** 21

SECTION : II

9. **Key Note Address (Abstract only)** 24

SECTION : III

10. **Invited Lectures (Abstracts/Full Paper)** 25

SECTION : IV

11. **Presented Papers** 51

Message

It gives me immense pleasure to learn that the Department of Zoology, Barasat Government College in association with West Bengal Biodiversity Board is organising a Two- day- UGC – sponsored National Seminar on ***Biodiversity : Exploration, Exploitation, Conservation and Management – Vision and Mission*** at the Barasat Government College on November 19 - 20, 2016.

Biodiversity is relevant in all aspects and at all levels of socio-economics. India is rich in biodiversity and its preservation is of utmost importance. Drastic utilization of biodiversity to harness materials and profits for mankind will lead to an imbalance that will affect the overall environment. This must be checked. What we need is an optimal utilization of biodiversity for production of food and nutrition, pharmaceuticals, industrial raw materials and in applications for remediation of industrial pollutants and toxicants.

I hope the seminar will discuss all aspects of biodiversity mentioned above and will come up with positive recommendations so that biodiversity is protected, maintained and/or restored.

I wish the seminar all success.

Prof. Basab Chaudhuri

Vice-Chancellor
West Bengal State University

Kolkata
November 3rd, 2016

Message

I am glad to know that the Post Graduate Department of Zoology, Barasat Government College is going to organize the National Seminar on "***Biodiversity : Exploration, Exploitation, Conservation and Management – Vision and Mission***" during 19-20 November, 2016 in Barasat.

I am also happy to know that the seminar will bring out an "Abstract Book" containing the articles of the delegates and participants to commemorate the occasion.

The theme of the conference is very relevant in the present context and will surely address the key issues related to biodiversity. I congratulate the organizers for hosting the event.

I convey my best wishes for grand success of the conference.

Prof. Nimai Chandra Saha

Vice- Chancellor
University of Burdwan

Burdwan
October 24, 2016

Message

It gives me immense pleasure to know that the Department of Zoology, Barasat Government College, West Bengal is organising a UGC sponsored National Seminar on "**Biodiversity : Exploration, Exploitation, Conservation and Management – Vision and Mission**" during 19-20 November, 2016.

Biodiversity is the base of our sustainability. Conservation of biodiversity and rational use of the same, in the backdrop of expanding human population, is therefore a daunting task. The theme of the proposed seminar is very relevant in the present context and will surely help generating awareness among the younger generations, the ways and means to conserve the depleting biodiversity for sustenance of life system on the Earth.

I extend my best wishes to the organisers and the participants and hope that the deliberations and interactions in the seminar will help the scholars and students to become the successful custodian of our biodiversity heritage.

I wish grand success of the event.

Dr. Asok Kanti Sanyal

Kolkata ***Chairman***
November 4, 2016 ***West Bengal Biodiversity Board***

Message

Coming at a time when environmental concerns, world over, are gathering credence. The topic of the proposed seminar, '**Biodiversity : Exploration, Exploitation. Conservation & Management – Vision & Mission**' is very pertinent. The true inventory of biodiversity could be several times higher than what is known today. Lack of trained taxonomists, however, is a serious constraint to achieve this. Conserving what we have today is hampered by lack of management measures including outreach and our ability to predict what would live in India and lack of data relating changes in biodiversity to those of environment. So, the fact that the biodiversity in Indian perspective, its proper assessment and documentation, focus the gap areas for exploration and judicious utilization of bioresources are the main theme of the seminar. The deliberations at this seminar, coming as they will from eminent academicians and experts, are expected to shed light on various aspects of these issues and also offer valuable inputs on the proper harnessing of bioresources without disturbing ecological balances.

I am sure our students and teachers will appreciate and enjoy the proceedings of this seminar thoroughly.

I wish the organizers of this seminar all success in their endeavour to make this seminar worthwhile.

Dr. Subhasis Dutta
Principal
Barasat Government College

Kolkata
November 12, 2016

From the Convenor's Desk

People depend on the earth's living systems for both life and livelihood. Constant technological innovations ushered a radical change in the overall biodiversity and ecosystems with explosive speed. Such activities on our part have brought the entire human race to the brink of an ecological disaster. These deeds have also put even the survival of our future generation into great peril. India has a vast resource of biodiversity. It is a common knowledge that bioresources are important component of progress and the economic activities of a nation. At the same time we are aware that the impediment of a huge population explosion is working at draining resources. Efforts on the sustainable use of these resources also have much to be desired. This is perhaps the greatest challenge faced by the global scientific community.

Against this backdrop, the Department of Zoology, Barasat Government College arranged a two- day UGC – sponsored National Seminar entitled "**Biodiversity: Exploration, Exploitation, Conservation & Management-Vision & Mission**" during 19 – 20 November, 2016 to provide a platform to discuss various aspects about biodiversity, its proper assessment and documentation, focus the gap areas for exploration and judicious utilization of bioresources and hopefully generate the interest and awareness deserved. Not only that, there would be an appeal to the Conservationists, Scientists, NGOs, Civil Society Organisations especially people living close to forests, wetlands, sanctuaries, etc. to contribute their ideas, knowledge and efforts on nature and sustain the precious bioresources of our country which are of immense value and role in the human welfare. We have also aimed to make the seminar more accessible to students while retaining its authority and scope.

It is my proud privilege to extend my cordial thanks to the distinguished and celebrated Scientists and Professors, erudite researchers, scholars and students who have joined this National Seminar. I express my heartfelt thanks to Prof. Basab Chaudhuri, Vice-Chancellor, West Bengal State University (Patron), Prof. Namai Chandra Saha, Vice-Chancellor, Burdwan University (Patron & Chief Guest of the seminar), Dr. Asish Kumar Ghosh, Director, Centre for Environment and Development, Kolkata (Guest of Honour), Dr. Asok Kanti Sanyal, Chairman, West Bengal Biodiversity Board (Patron) for their kind help, valuable suggestions, active participation and cordial cooperation.

This seminar could not have been organised without significant input from various quarters. I take this opportunity to thank profusely to all the invited speakers, chairpersons and judges who agreed to spare their valued time for the seminar and deliberate in the proceedings. However, all the delegates – teachers, research scholars and students are the most important component without whom the seminar cannot reach to its success. Indeed it is my proud privilege to thank them all for their kind presence and constructive participation. We express our sincere gratitude to you all.

I on behalf of the department like to express our sincere gratitude to our Principal for his constant encouragement, advice and necessary assistance.

We consider it a pleasant duty to thank UGC for sponsoring the seminar and all the collaborators for agreeing to confederate in the seminar. Special thanks are due to all the vendors who extended contributions for seminar.

I owe to all my departmental colleagues, non-teaching members, and students for their effective support and cooperation rendered at various stages so as to make the seminar a grand success.

Last but not the least, thanks are also due to Prof. D. Raychaudhuri, External Expert member of Post Graduate Department of Zoology for his sincere support and untiring efforts for successful completion of the seminar as well as for bringing out the Proceedings of the Seminar which will be an important document in research in various aspects of biodiversity.

Dr. Sumana Saha
Head
Post Graduate Department of Zoology

Kolkata
April 4, 2017

About the Proceedings

Keeping in mind the importance of biodiversity, its exploration, sustainable utilization, conservation and proper documentation, the need of the day is to generate awareness as how to protect it for survival and sustainable development of humankind and how people's participation is needed to achieve the target. The UGC sponsored National Seminar of Biodiversity held during 19-20 November, 2016 organised by the Department of Zoology, Barasat Government College, Barasat, Kolkata in collaboration with The Zoological Society, Kolkata & West Bengal Biodiversity Board discussed some of the urgent issues and concerns of biodiversity and future strategies for conservation. The present Proceedings of the Seminar is a compendium wherein the invited lectures (abstracts/full Paper) as well as submitted papers (full length papers), presented both through oral and poster presentations have been accommodated along with the Messages from the well known dignitaries; From the Convenor's Desk; A Brief History of the Department of Zoology; Organising Committee; Programme Schedule, Report about Seminar, etc.

The papers have been arranged under four (4) sections viz., under Section II : Key Note Address (abstract only), Section III : Invited lectures (abstracts/full Paper), Section IV : Papers presented.

This compendium would provide very valuable and updated information on diverse aspects of biodiversity and its conservation and it is expected to shed light on future strategies to be adopted by policy makers, planners, researchers, etc. Though utmost efforts were made to make this proceedings error-free but yet if there are any, the Editor-in Chief urge the readers/users begging excuse.

The Editor-in-Chief takes the privilege of expressing her sincere thanks to the organising committee for various suggestions regarding the publication of the Proceedings. The financial support received from UGC is also gratefully acknowledged.

Dr. Sumana Saha
Editor-in-Chief

Brief report on the seminar

In lexical term, a seminar is a formal meeting of people with a shared interest. In the world of scientific endeavours, especially a titanic one like biodiversity with myriad interrelated topics, where one idea is explored by people having different perception, understanding and depth of knowledge, it is absolutely necessary for a person to share or discuss his or her idea with a fellow researcher. This national seminar, having practitioners of various fields in biodiversity in attendance, was surely a platform to that and we acknowledge our gratitude to Dr. Subhasis Dutta, Principal, Barasat Govt. College for his constant encouragement, advice and assistance, sponsorer – the UGC for funding the seminar, our collaborators, The Zoological Society & West Bengal Biodiversity Board, Kolkata, all the eminent invited speakers from different reputed institutes, across the country, the chairpersons, the young scientists for their oral/poster presentations, other faculty members, the non-teaching staffs, participants, distinguished guests and last but not the least, our research scholars and students for making the two-day seminar a grand success.

Dr. Subhasis Dutta, Principal, Barasat Govt. College, in his welcome address, pointed out the relevance of this seminar on biodiversity, particularly in Indian perspective, its proper assessment and documentation, especially when the irreversible loss of biodiversity & the massive floral & faunal extinctions, are major concerns for the biologists. Dr. Ashish Kumar Ghosh, Former Director, ZSI, in his keynote address, elaborated the present conservation strategy and the potentials of bio-resource for economic growth of the country through people's participation. Prof. (Dr.) Nimai Chandra Saha, Hon'ble Vice-Chancellor, Burdwan University, graced the occasion with his presence & delivered a special talk on key issues of biodiversity. The two- day seminar was comprised of eight invited lectures, arranged in four specific technical sessions, viz., 'Exploration of faunal diversity', 'Sustainable exploitation of faunal diversity', 'Conservation & Management of Wild Life' and 'Assessment & Documentation of Bioresources', chaired by the eminent personalities of those fields of research like, Dr. A.K. Sanyal, Chairman, West Bengal Biodiversity Board, Dr. R. Roy, Ex-HOD, P G Dept. of Zoology, Barasat Govt. College, Dr. J.R.B. Alfred, Ex-Director, ZSI & Dr. Amalesh Chowdhuri, Ex-Professor, Dept. of Marine Sciences, University of Calcutta, respectively.

Among the invited speakers, Dr. S.K. Gupta, Ex-Joint Director, ZSI, Kolkata, Dr. B.K. Mahapatra, Principal Scientist & O.I.C., ICAR-CIFE and, Dr. D. Ghose, Species & Landscape Programme, WWF-India, emphasized mainly on the following areas of their research like, Acarine Entomology, Fish biodiversity of West Bengal & it's status and Wildlife conservation at landscape scale- issues, respectively.

On the second day, we were fortunate enough to have Dr. G. K. Saha, Professor of Zoology, University of Calcutta, Prof. (Dr.) S. Sathyakumar, Scientist-G, WII-India and Prof. D. Raychaudhuri, Dept. of Agricultural Biodiversity, RMVU, Kolkata as the invited speakers. The major areas, discussed in those technical sessions were, conservation breeding, wildlife conservation & management in Himalayan regions & documentation of biodiversity and sustainable utilization of those potential bioresources.

Forty eight research papers (Oral presentations: 10 & Poster presentations: 38) were presented by the participants (Students : 76; Research Scholars : 28 , Faculties : 32), some of which were highly appreciated by the resource persons. The judges & experts, from different reputed Institutes, have selected four research papers two from each - as the best presentations. The best presenters were duly rewarded.

Lastly, although this conference is on *biodiversity*, but it doesn't mean that it caters exclusively to that subject. Knowledge surmised from this seminar can also be used to understand other threats & concerns regarding the biodiversity, and with the collective advice, guidance and help from the entire world, hopefully wouldn't be difficult to counteract the current problems.

A Few Moments of the Seminar

Day 1

Day 2

Day 2 (contd.)

Department of Zoology – A Brief History

Established in 1996 under University of Calcutta for undergraduate study with limited resources, the Department of Zoology, has taken giant strides to gain reputation of being one of the premiere Departments for undergraduate study with 49 seats under West Bengal State University (WBSU). It has also upgraded itself to Post Graduate status (with academic autonomy under WBSU) in 2009, adding to the prestige of the College. An updated course based on the UGC National curriculum for both undergraduate and postgraduate caters to the present needs of the students.

The Department has gradually become well equipped with spacious and modern e-classrooms and laboratories, an enriched zoological museum and a seminar library. Separate laboratories are available for the various specializations of M.Sc. curriculum while the faculties also have their own laboratories for research. In addition, an air conditioned computer laboratory is there to meet the requirements of the B.Sc. and M.Sc. curricula. The Department has a central instrumentation facility, well equipped with sophisticated instruments.

The Department, which has provision for nine teaching posts, including one Professor (vacant), is currently run by seven experienced and energetic teachers. Reputed retired teachers and scientists also impart quality education in the capacity of part-time and guest lecturers. Apart from giving emphasis on teaching, the Department has also consistently encouraged collaborative research programmes that will take it to new heights of excellence in the years to come. The teachers have a rich academic background with publications in reputed journals and keep themselves cognizant with the latest information and developments. Considerable research funding has been tapped from various national and state agencies for both major and minor projects and teachers provide guidance to research scholars pursuing their Ph.D. degree. The laboratory technicians and attendants are friendly and dutiful and work in tandem with the teachers to ensure smooth functioning of the Department.

The rate of success of the students is impressively high with many securing First Class and some procuring top positions in the University Merit List. They always maintain their high scholastic achievements throughout the country. Educational excursions are regularly organised not only to observe animals in their natural habitat and their biodiversity but also to strengthen the camaraderie between the students themselves and with the teachers. Warm relationships shared by the faculty and students add to the general richness of the academic environment of the Department.

Learning is an odyssey that never ends. Team Zoology of the Department is making this journey interesting and fruitful.

Dr. Rupendu Ray
(Former Head of the Department)

BIODIVERSITY: EXPLORATION, EXPLOITATION, CONSERVATION & MANAGEMENT – VISION & MISSION

Organized by
Post Graduate Department of Zoology, Barasat Government College

In collaboration with
Zoological Society, Kolkata
&
West Bengal Biodiversity Board

19th – 20th November, 2016

President	**Dr. Subhasis Dutta** Principal, Barasat Government College
Patrons	**Prof. (Dr.) Basab Chaudhuri** Vice-Chancellor, West Bengal State University
	Prof. Nimai Chandra Saha Vice-Chancellor, Burdwan University (Former Director of Public Instructions, Higher Education Department, Govt. of West Bengal)
	Dr. Kailash Chandra Director, Zoological Survey of India
	Dr. Asok Kanti Sanyal Chairman, West Bengal Biodiversity Board
	Dr. J. R. B. Alfred President, The Zoological Society, Kolkata
Advisory Committee	Dr. Madhusudan Ghosal, Dr. Salil Kumar Gupta, Dr. Rupendu Roy, Prof. Dinendra Raychaudhuri, Dr. Subhra Kumar Mukhopadhyay, Prof. Jukta Adhikary, Prof. Anilava Kaviraj, Prof. Subir Chandra Dasgupta, Prof. Sumit HomeChaudhuri, Prof. Goutam Kumar Saha, Prof. Narayan Ghorai, Prof. Shilanjan Bhattacharya, Prof. Chiranjib Pal
Convenor	Dr. Sumana Saha Head, Department of Zoology
Organizing Secretaries	Dr. Madhumita Manna & Dr. Sanjoy Podder

Treasurer Dr. Srikanta Guria & Sri Somaditya Dey

Steering Committee Dr. Jayati Ghosh, Dr. Enamul Haque, Dr. Srikanta Guria, Sri Somaditya Dey, Ms. Indrani Banerjee

Printing & Publication Committee

Convenors Dr. Sumana Saha & Dr. Jayati Ghosh
Members Dr. Enamul Haque, Dr. Srikanta Guria, Sri Somaditya Dey

Registration Committee

Convenors Dr. Srikanta Guria & Sri Somaditya Dey
Member Smt. Indrani Banerjee

Hospitality Committee

Convenors Dr. Madhumita Manna & Dr. Jayati Ghosh
Members Dr. Sumana Saha, Dr. Sanjoy Podder, Dr. Enamul Haque, Dr. Srikanta Guria, Sri Somaditya Dey

Decoration Committee

Convenors Dr. Jayati Ghosh & Sri Somaditya Dey
Members Dr. Sanjoy Podder, Dr. Enamul Haque, Smt. Indrani Banerjee

Technical Session Committee

Convenors Dr. Madhumita Manna & Dr. Jayati Ghosh
Members Dr. Enamul Haque, Dr. Srikanta Guria, Sri Somaditya Dey

Oral/Poster Session Committee

Convenors Dr. Enamul Haque & Sri Somaditya Dey
Members Dr. Sumana Saha, Dr. Madhumita Manna, Dr. Jayati Ghosh, Dr. Srikanta Guria, Smt. Indrani Banerjee

Refreshment Committee

Convenors Dr. Sanjoy Podder & Dr. Srikanta Guria
Members Dr. Sumana Saha, Dr. Madhumita Manna, Dr. Jayati Ghosh, Dr. Enamul Haque, Sri Somaditya Dey

BIODIVERSITY : EXPLORATION, EXPLOITATION, CONSERVATION & MANAGEMENT – VISION & MISSION

PROGRAMME SCHEDULE

19TH November, 2016
Venue: Rabindra Bhavan

9.30 am -10.00 am	**REGISTRATION**	
10.00 am – 11.00 am	**INAUGURAL SESSION**	
	Welcome Address	**Dr. Subhasis Dutta** Principal, Barasat Govt. College
	Key Note Address	**Dr. Ashish Kumar Ghosh** Director, Centre for Environment & Development, Honorary President, ENDEV(Former Director, Zoological Survey of India)
11.00 am – 11.15 am	**TEA BREAK**	
	TECHNICAL SESSION I :	**Exploration of Faunal Diversity**
	Chairperson	**Dr. Asok Kanti Sanyal** Chairman, West Bengal Biodiversity Board, Kolkata, West Bengal
11.15 am – 12.00 noon	**Invited Lecture 1**	**Prof. Nimai Chandra Saha** Vice-Chancellor, Burdwan University (Former Director of Public Instructions Higher Education Department, Govt. of West Bengal)
12.00 noon – 12.45 pm	**Invited Lecture 2**	**Dr. Salil Kumar Gupta** Former Jt. Director, Zoological Survey of India
12.45 pm – 1.45 pm	**LUNCH BREAK**	
	TECHNICAL SESSION II :	**Sustainable Exploitation of Faunal Diversity**
	Chairperson	**Dr. Kailash Chandra** Director, Zoological Survey of India
1.45 pm – 2.00 pm	**Invited Lecture 3**	**Dr. Sumit HomeChaudhuri** Professor, Department of Zoology. University of Calcutta, Kolkata, West Bengal, India

2.00 pm – 2.30 pm	**Invited Lecture 4**	**Dr. Bijoy Kali Mahapatra** Principal Scientist & Officer-in-charge ICAR- Central Institute of Fisheries Education, Ministry of Agriculture (GOI), Kolkata Centre
2.30pm – 3.15 pm	**Invited Lecture 5**	**Dr. Dipankar Ghose** Director, Species & Landscape Programme at WWF, India
3.15 pm – 3.30 pm	**TEA BREAK**	
3.30 pm – 5.30 pm	**ORAL PRESENTATION**	

20TH NOVEMBER, 2016

Venue **: Seminar Room, Annex Building, 2nd Floor,**
Barasat Government College

	TECHNICAL SESSION III :	**Conservation & Management of Wild Life**
	Chairperson :	**Dr. J.R.B. Alfred** President, The Zoological Society, Kolkata (Former Director, Zoological Survey of India)
10.00 am – 10.45 am	**Invited Lecture 6**	**Dr. Goutam Kumar Saha** Professor, Dept. of Zoology, Universityof Calcutta, Kolkata, West Bengal, India
10.45 am – 11.30 am	**Invited Lecture 7**	**Dr. S. Satyakumar** Scientist – G & Senior Professor WildLife Institute of India Dehradun, Uttarakhand, India
11.30 am – 11.45 am	**TEA BREAK**	
11.45 am - 1.00 pm	**POSTER PRESENTATION**	
1.00 pm – 2.00 pm	**LUNCH BREAK**	
	TECHNICAL SESSION IV :	**Assessment & Documentation of Bioresources**
	Chairperson :	**Prof. Amalesh Chowdhury** Former Professor, Dept. of Marine Science, University of Calcutta

2.00pm – 2.45 pm	**Invited Lecture 8**	**Prof. Dinendra Raychaudhuri** Hony. Professor, Dept. of Agricultural Biotechnology, IRDM Faculty Centre, Ramakrishna Vivekananda University (Former Professor, Dept. of Zoology, University of Calcutta)
2.45 pm – 4.30 pm	**ORAL PRESENTATION**	
4.30 pm - 4.45 pm	**VALEDICTORY SESSION**	
4.45 pm - 5.00 pm	**VOTE OF THANKS**	
5.00 pm onwards	**CERTIFICATE DISTRIBUTION**	

SECTION : II

Key Note Address

BIODIVERSITY: EXPLORATION, EXPLOITATION, CONSERVATION & MANAGEMENT - VISION & MISSION

A. K. Ghosh

Centre for Environment and Development, Kolkata
E-mail: cedkolkata@yahoo.com
www.cendev.org

ABSTRACT

Biological Diversity has sustained the human society since the origin of Homo sapiens and the days of hunter gathers. Interestingly, even in 21st Century, all major needs of human society are being largely met from living natural resources, be it food, fibre, pulses, spices, pulp and paper, textile, skin and hide, beverage, natural pigments, and aromatic or medicinal plants, etc. Industrial Revolution only helped to add value to biological products and generate extra wealth for human development. In the process, over exploitation of species of economic importance created a crisis of survival for many species which becomes vulnerable, threatened or extinct forever. The world leaders in the historic UN Conference on Environment and Development (UNCED) in June 1992, proposed for the first time a Convention on Biological Diversity (CBD) which has been signed by 193 countries. This Convention declared for the first time that all countries have a sovereign right over their biological resource, and henceforth access to bio-resource or transferring bio-resource from one country to the other, for commercial uses need prior informed consent; it also stipulates that if access and transfer is permitted, it should be on a principle of benefit sharing on mutually agreed terms. India, as a signatory, enacted its own Biological Diversity Act in 2002 and published the Rules in 2004. Indian Act provided a three tier system of governance, viz. a National Biodiversity Authority at the apex, a State Biodiversity Board in every state and a Biodiversity Management Committee (BMC) at the local level. The most distinctive feature of the Act is decentralization of power and empowering the local community to have control over its own resources. For this purpose, the major task of every BMC is to prepare a People's Biodiversity Register providing details of land, water, and the community as also current status of wild and domesticated biodiversity and their uses. This document will act as the basis of as how much bio-resource can be profitably utilized by the community either as raw material or as value added product. It also provides opportunity to promote conservation and propagation of the species within their area of jurisdiction which can help achieving higher economic growth. A local biodiversity fund to be set up by BMC, as per the law, can help to promote such activities and recognize the contribution of individual who might have acted as a pioneer. Over exploitation of resources from the wild need to be controlled to prevent future extinction; researches are urgently required to be conducted for cultivating or breeding those wild species which can provide better economic return to the community without endangering the wild species. The paper has discussed in details the present conservation strategy and the potential of bio-resource for economic growth of the country through people's participation.

SECTION : III

Invited Lectures

Lecture - I

Acari Diversity And Their Importance As Foes And Friends

Salil Kumar Gupta

Medicinal Plants Research and Extension Centre, Rama Krishna Mission Ashrama Narendrapur, Kolkata – 700103
E-mail: salil_zsidumdum@yahoo.com

ABSTRACT

The present paper reviews the acarine diversity of India focussing their early history, habits, habitats and economic importance of those relating to agricultural, veternary and public health aspects, This provides an up-dated data regarding status of Indian acarines.

Keywords: Acarine diversity, Foes & friends, Indian scenario

INTRODUCTION

Among the non-insect pests of agricultural crops, mites are gaining increasing importance throughout the world as some act as foes, being injurious pests of agricultural crops and do substantial economic loss to the growers, while some act as friends, being effective and potential predators, helping enormously to bring down the pest mite population below economic injury level. Likewise, there are many mites and ticks which are pests of veterinary animals, poultry birds and human beings and are responsible for causing various types of disease related to bacteria, virus, protozoa, rickettsia, spirochaete, etc. In addition, they also cause inconvenience, irritation, itching, inflammation, anaemia, paralysis, etc. to the hosts. Hence, those have tremendous importance in medical, veterinary and public health aspects. Some mites occur in house dust and are responsible for causing various types of respiratory allergic disorders. Mites also occur in water bodies (fresh water and salt water) and some act as indicator species for detecting water pollution. The mites inhabiting stored products including stored grains cause substantial damage to the grains making those unsuitable for human consumption and even for germination. Those mites which inhabit soil help enriching soil fertility by forming humus as well as act as indicator species for soil health and soil pollution. Gupta (1985, 2010, 2012), Gupta & Gupta (1999) summarized the available information on Indian Acarines.

Considering the above stated manifold importance, the Acari, comprising mites and ticks, have received world attention since last several hundred years and works on diverse aspects have been done. So far as India is concerned, a reasonably good amount of work has been done and the present paper provides an overview of that highlighting their importance as foes and friends.

EARLY HISTORY OF ACARINES

A tick transmitted fever was reported in ancient Egyptian papyrus in as early as 1550 BC. Homer mentioned in 850 BC the occurrence of a tick on dog of Ulyses. Aristotle described a parasitic mite collected from body of a locust. Hippocrates, Pliny and others reported mites/ticks several hundred years back. Until 1660, mites were referred as "lice" or "beetles" and it was only in 1860, the term "Acari" or "Akari" was used which meant headless creatures. After World War-II, the importance of acari increased further as many of those were related to transmission of diseases on one hand and also on the other hand due to random uses of broad spectrum pesticides like DDT, BHC, etc. which aggravated the agricultural mite problem further.

HABITAT AND SPECIES DIVERSITY OF ACARINES

Acari are rival to insects regarding habitat diversity. Hardly any habitat on earth is known where these creatures do not occur. Their occurrence has been reported from bottom of ocean to top of mountain and from hottest desert to arctic region as well as snow-clad mountains. Upto 1970, only 30,000 species were known from the world (Krantz, 1970). Upto 2000, as many as 55,000 species under 5500 genera were known (Walter & Proctor, 1999). As per guess estimate, presently about 0.5-1.0 million species exist. Of these, the estimated plant feeding mites are 0.4 million and vertebrate parasitic mites are 0.12 million. It is believed that if all possible habitats are explored, the number of Acari will exceed the number of insects.

ACARI AS FOES

Mites act as important pests of agri-horticultural crops, stored products and do enormous economic loss. Many ticks and some mites attack various veterinary animals, poultry birds as well as man causing a number of diseases besides causing inconvenience, nuisance, loss of blood, paralysis, scabies, mange etc. Many ticks cause protozoan, rickettsial, viral, bacterial, spirochaete diseases causing loss of life. All these invited world attention for conducting diverse studies on Acari.

ACARI AS FRIENDS

Some mites act as predators of crop pests and stored grain pests while some others like aquatic mites feed on mosquito larvae. Some parasitize insect pests of crops, house flies etc. By these, they contribute towards biological control. The soil mites help enriching soil fertility by forming humus. Some mites even help determining post-mortem interval. Even there are instances where the tribal people have been reported to use mites in preparing some traditional medicines for treatment of human ailments.

PROGRESS OF INDIAN ACARINE STUDIES IN FAUNAL EXPLORATION

Table 1. Indian Acarine Diversity

First report of Acarine from India (Tick)	One Tick species on Elephant (*Acarus elephanticus*)	Linnaeus, 1758
First report of Acarine from India (Mite)	One Mite species on tea (*Tetranychus bimaculatus)*	Peal, 1868
Known species up to 1899	3 spp.(Mites)	Prasad, 1982
Known species up to 1950	35 spp. (Mites)	Gupta & Gupta, 1999
Known species up to 1964	65 spp. (Mites)	Ghai 1964 Gupta & Gupta, 1999
Known species up to 1974	769 spp. (only Mites)	Prasad, 1974
Known species up to 1999	1800 spp. (Mites)	Gupta & Gupta, 1999
Known species up to 2012 Known species up to 2016	1400 spp. (Mites) 3365 spp. (Total Acari) 3255 (Mites) 110 (Ticks)	Gupta 2012 Updated Data

HABITAT-WISE STUDIES ON INDIAN ACARINES

1. Plant Mites –

Habitats-These mites occur in all kinds of agri-horticultural crops/ plants
Nature of damage- The mites damage plant tissues, suck plant sap and make the plants weak, causing retardation of growth and development and yield. Often they kill the plants. They produce different types of damage symptoms like chlorosis, blistering, russeting, curling, bronzing of leaves, defoliation, gall formation, deformation, of plant parts, and act as vectors of viral diseases. All these cause economic loss from 5-100%.
Number of spp. from India- 1490 spp.
Phytophagus- 1213 spp., 110 genera, 6 families, Predatory- 277 spp., 80 genera, 18 families.

2. Vertebrate associated mites –

Vertebrates attacked- These mites occur as ecto/endo parasites of all vertebrates from fish to mammals.
Nature of injury- Their biting and sucking of blood cause anaemia, itching, irritation, inflammation, dermatitis, rashes, scabies disease, scrub typhus disease, ricketttsial disease, etc.
Extent of mortality- 5-50%.
Total species known from India- 350 spp. , 110 genera, 40 families.
Some important spp.- *Sarcoptes scabiei*, *Neotrombicula deliense*, *Psoroptes* spp. etc.

3. Invertebrate associated mites –

Invertebrates attacked- These mites attack insects, millipedes, centipedes, mussels, slugs, snails, cray fish, scorpion, hermit crab, etc.
Nature of association- Phoretic, commensals, haemolymph feeder, parasitic, predators, often act as good bio-control agents of insect/ mite pests. Some cause virulent disease to honey bees.
No. of species known from India- 155 spp., 58 genera, 22 families.
Important species- *Acarapis woodi*, *Varroa jacobsoni*, *Eutrombidium trigonum*, etc.

4. Soil mites –

Habitat- These mites occur in soil, leaf litter under logs, etc.
Nature of association- They act as decomposer of soil organic matter to form humus for increasing soil fertility. They also help soil aereation/ dissemination of fungal spores and bacteria, while some feed on algae, mosses, etc.
No. of spp. known from India- 707 (Mesostigmata- 170, Prostigmata-17, Astigmata- 20, Cryptostigmata- 500).

5. Water mites –

Habitats- These mites occur in fresh water, marine water and oceanic bottom.
Nature of association- Some fresh water mites act as good bio-control agents of mosquito and house fly larvae
Number of spp. known from India- 245 spp., 60 genera, 25 families.

6. Stored product mites –

Stored Products attacked- These mites infest grains/ dried fish/ powder milk/ dry fruits/ various food & food products/ drugs/ farinaceous products/ cheese/ hide /seeds/ potato chips/ spices, etc.
Nature of damage- They make the infested articles unsuitable for human and animal consumption/ grains become unsuitable for germination. They also invite fungal attack.
Extent of damage- 5-20% loss.
Total species known from India- 93 species, 50 genera, 20 families.

Important species- *Acarus siro*/ *Tyrophagus putrescentiae*/ *Tyrolichus casei*/ *Caloglyphus berlesei*/ *Lardoglyphus konoi*/ *Rhizoglyphus echinopus*/ *Cheyletus eruditus*/ *C. malaccensis.*

7. Nest associated mites –

Habitats- These mites occur in bird and rodent nests. The nest acarine fauna shows succession of species in different nesting stages like- nest building/ egg laying/ hatchlings/ deserting of nest
Importance- These mites often invade human houses, bite man and cause irritation, itching, dermatitis and also may act as vectors of different diseases.
Number of spp. known from India- 92 spp.

8. Dust mite –

Habitats- These mites occur in both floor and bed dust, more in dampy and non-airy houses and also in those houses occupied by respiratory allergic patients
Importance- They cause respiratory allergic disorders (Asthma, Rhinitis), contract urticaria, etc. Some feed on human semen present in bed, if any, and are suspected to be carriers of Hepatitis-B, HIV, CMV, etc.
Number of spp. known from India- 123 spp., 43 genera, 25 families
(Gupta, 2010).

9. Ticks (Soft & Hard ticks) –

Habitats- These ticks occur in all vertebrates
Nature of association- These are exclusively blood feeders causing diseases like anaplasmosis, babesiosis, piroplasmosis, theileriasis, typhus, encephalitis, anaemia, paralysis, leucocytozoonosis, etc.
Number of spp. known from India- 110 spp., 12 genera, 2 families**.**

MAJOR GROUPS OF PLANT MITES

Spider mites (Family – Tetranychidae) :

These mites are exclusively plant sap feeders. They are variously coloured, 8 legged, occur on under-surface of leaves (some may occur on upper surface also), make colonies there and cover that with thin webs like spiders (hence called spider mites). Many species are important pests of agri-horticultural crops. Size – 350-450 microns.

False Spider mites (Family – Tenuipalpidae) :

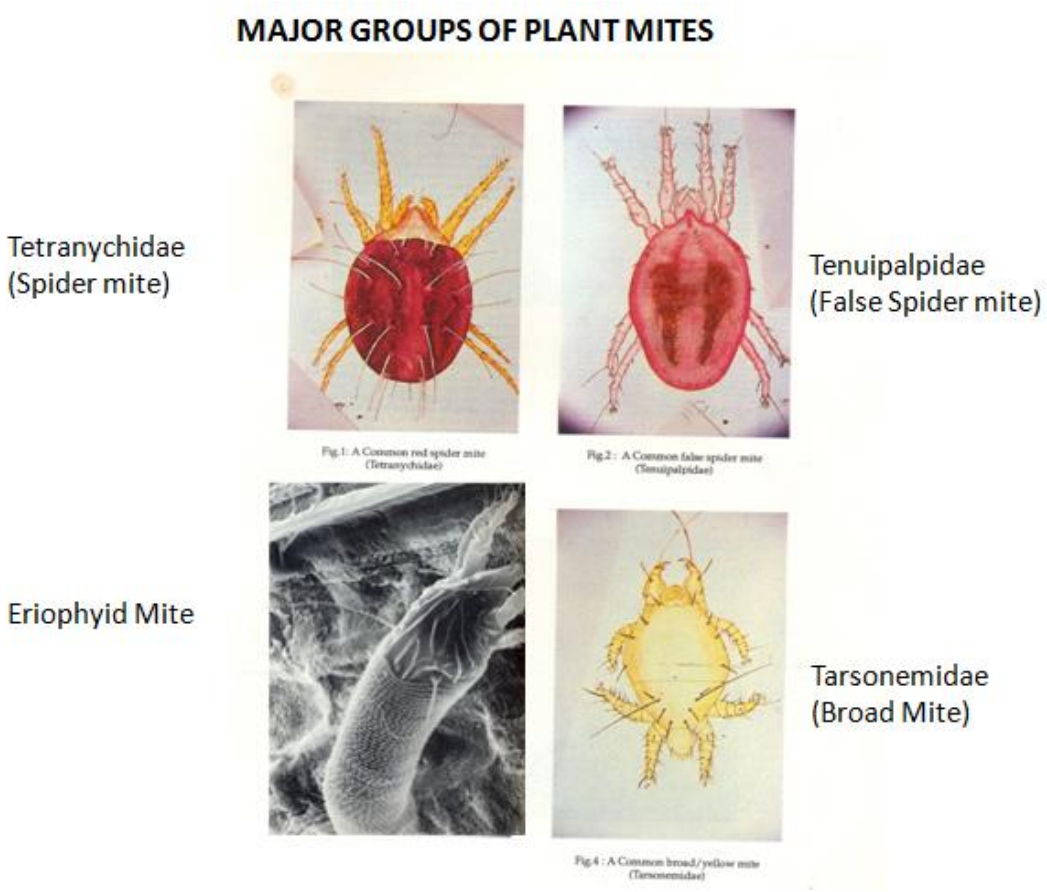
These mites are flat, pear shaped, 8 legged, brightly coloured, colonize on under-surface of leaves, also on twigs, fruits. These are plant sap suckers and some cause plant viral diseases. They never cover their colonies with webs (hence called false spider mites). Size – 300-350 microns.

Yellow mite/Broad mite (Family – Tarsonemidae) :

These tiny mites are yellowish white, move fast, 8 legged, plant sap suckers and occur on under-surface of leaves preferably on young apical leaves, causing curling of leaves. Size – 250-300 microns.

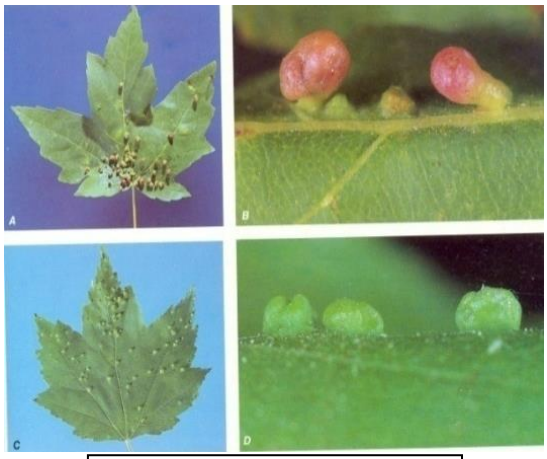
Gall mite / Erineum mite (Eriophyoidea) :

These mites are tiny, whitish, light brownish, 4 legged only, look worm-like and occur on under-surface of leaves/fruits, causing erineum/gall formation. Size – 200 microns.

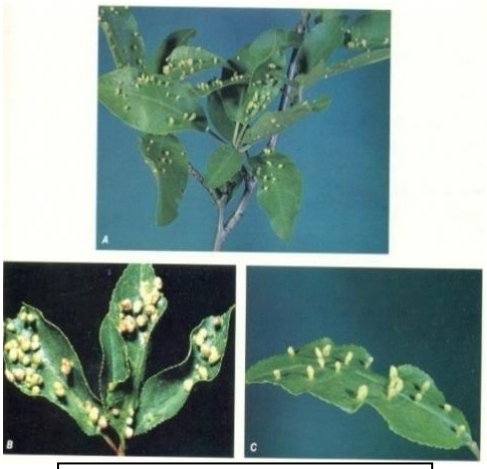


DIVERSITY OF DAMAGE SYMPTOMS CAUSED BY PLANT MITES

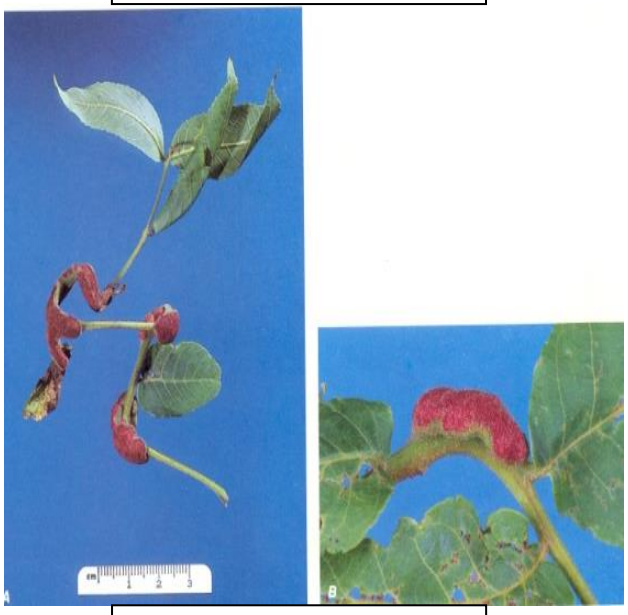
Since these mites are exclusively plant sap suckers, they puncture the leaves with their stylet-like chelicerae and suck plant sap. While feeding, they damage tissues, chlorophyll and due to this they produce various types of damage symptoms, the photographs of some of those are provided



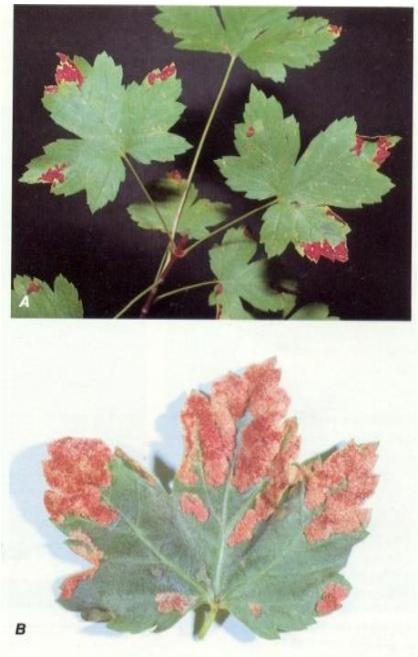
Gall on Red Maple



Gall on Plum



Gall on Black Walnut



Maple Erineum mite

Gall on Ash tree

Sterility mosaic disease of Arhar

Balooning of mites for Migration

Bhendi leaf damage

Litchi Erineum mite

Rice panicle mite : *Steneotarsonemus spinki*

Coconut Perianth mite : *Aceria guerreronis*

Citrus Rust mite: *Phyllocoptruta oleivora*

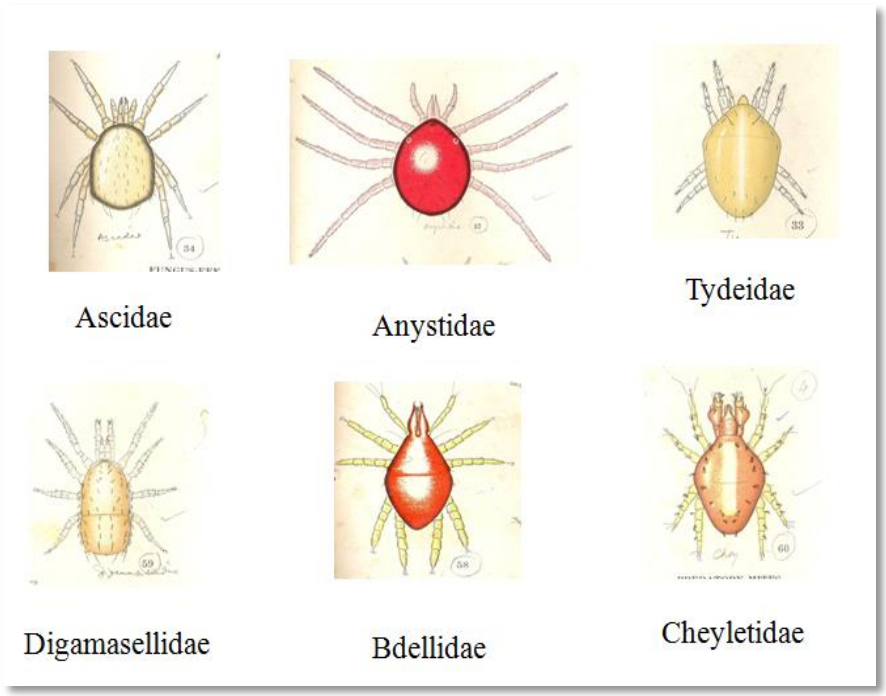
Grapevine gall mite: *Colomerus vitis*

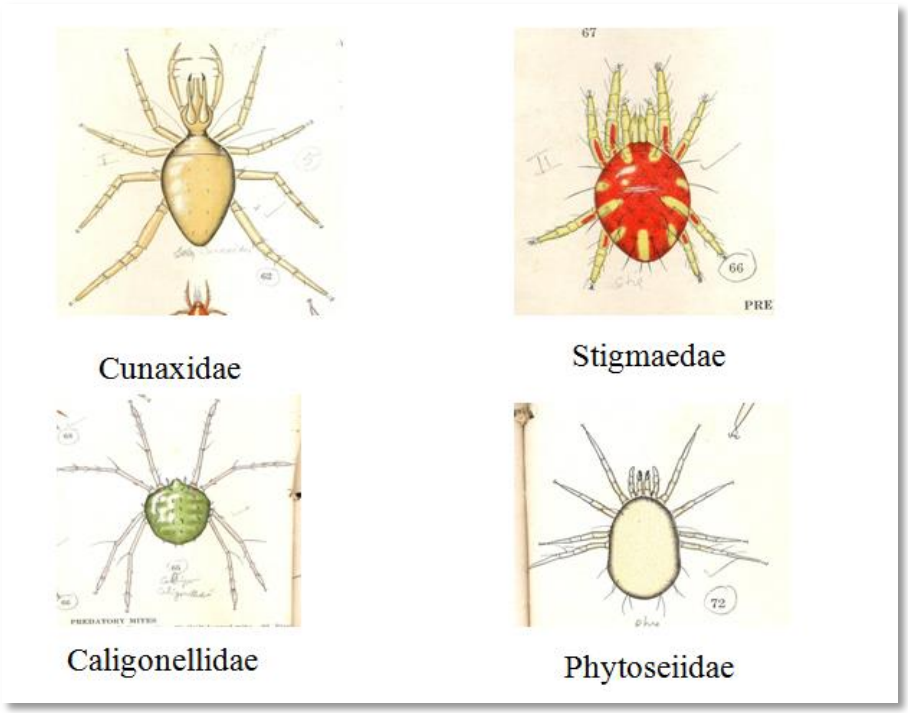
Citrus mite damage

Photographs showing damage symptoms caused by mites

DIVERSITY OF PREDATORY MITES

As there are pest mites, there are also predatory mites which belong to Phytoseiidae, Cunaxidae, Anystidae, Stigmaeidae, etc. And those contribute in biological control of pest mites. The photographs of some of the mites are given





Phytoseiulus persimillis feeding on different stages of two spotted spider mite, *Tetranychus urticae*

EXTENT OF CROP LOSS DUE TO MITE PEST ATTACK ON VARIOUS CROP LOSS

Information regarding extent of damage on various crops caused by mites is given below (Gupta 2012) -

- Mango malformation mite- 50-80%
- Litchi erineum mite- 30%
- Paddy white mite- 20-25%
- Sugarcane red mite- 20-30%
- PPSM –15-30%
- Cotton 2- Spotted spider mite- 20-30%
- Vegetable mite- 10-15%
- Tea Red Spider Mite- 5-11%
- Ber gall mite- 20-25%
- Brinjal Red mite- 13-31%
- Bhendi mite- 23-27%
- Chilly leaf curl mite- 27-29%
- Total crop failure- Mango malformation and PPSM
- Coconut 10-20%- 50-60%

Loss in terms of money-Rs. 8616.63/ ha in case of brinjal 2-spotted mite

HOST PREFERENCE AND VARIETAL RESISTANCE

Some of the information regarding studies on these aspects are given below (Gupta, 2012)-

Morphological

Leaf texture- Rough surface- more mite
Leaf venation- Deeper Midrib- more mite
Leaf thickness- Thick leaves- less mites
Leaf webbing- more webbing- more mite
Leaf age- Matured leaves- more mite

Biochemical factors

	Susceptible var.	Resistant var.
Starch content	higher	lesser
Free Amino Acid	more	lesser
N	more	higher
Na	more	lesser
K	lower	higher
Protein	lower	higher
Phenolics	higher	lesser

Plant volatiles- play important role in causing susceptibility/resistance of plants (not always true), (Gupta, 2012)

TICKS / MITES CAUSING DIFFERENT DISEASES OF MEDICAL , VETERINARY, AND PUBLIC HEALTH IMPORTANCE

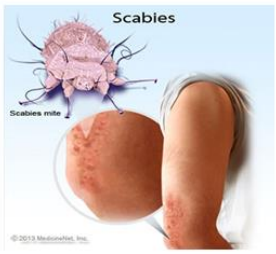
The ticks and mites are responsible for causing different diseases of medical, veterinary and public health importance and some of those are listed in the following tables – (as per Gupta, 2010)

Disease Man	Pathogen	Vector
Tick paralysis	Tick toxin	*Dermacentor andersoni*
Tularamia	Bacterial	*Dermacentor andersoni*
Rocky mountain spotted fever	Rickettsial	*Dermacentor andersoni*
Q fever	Rickettsial	*Dermacentor andersoni*
Relapsing fever	Spirochaetal	*Ornithodoros moubata*

Langet encephalitis	Viral	*Ixodes persulcatus*
CCHF	Viral	*Hyalomma marginata*
Tick borne Haemorrhagic fever	Viral	*Haemaphysalis spinigera*
Rickettsial pox	Rickettsial	*Allodermanyssus sanguineus*
Encephalitis	Viral	*Ornithonyssus sylviarum*
KFD	Viral	*Haemaphysalis spinigera*
Scabies/ Itch mite	Mite toxin	*Sarcoptes scabiei* *Pyemotes ventricosus*
Scrub typhus	Rickettsial	*Neotrombicula deliense*
Lyme disease	Spirochaetal	*Ixodes persulcatus*
Respiratory allergies	Mite toxin	*Dermatophagoides farinae* *D. pteronyssinus* Orchard mites

Veterinary Animals		**Poultry birds**	
Babesiosis	**Protozoan**	**Fowl spirochaetosis**	**Spirochaetes**
Anaplasmosis	***Anaplasma marginale***	**Scaly leg of fowl**	**Mite toxin**
Tick paralysis	**Tick toxin**	**Depluming mite**	**Mite feeding**
Bilary fever	**Protozoan**	**Tropical Fowl mite**	**Mite feeding**
Mange mite	**Mite toxin**	**Red mite of Poultry**	**Do**
Louping ill	**Viral**	**Relapsing fever**	**Spirochaete**
Tick typhus	**Rickettsial**		

Scabies



Acarine Diseases in Cattle

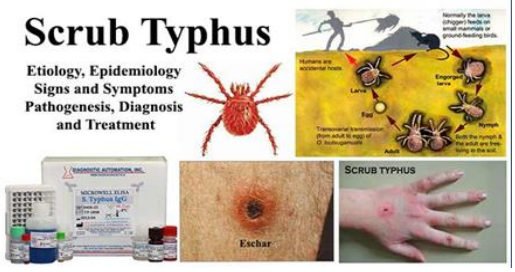
Anaplasmosis

Chorioptic Mange

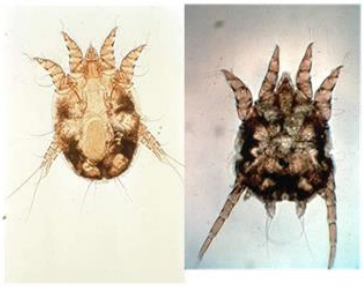
Theileriasis

Scrub typhus

Neotrombicula deliense



Psoroptic Mange in Cattle



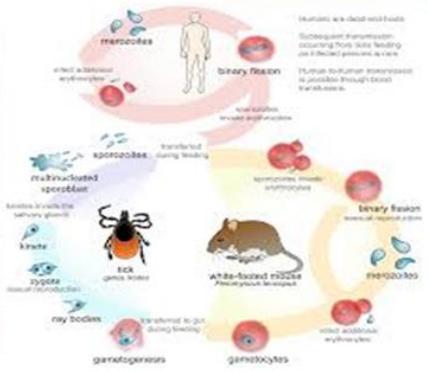
Some Tick Borne Diseases

Colorado Tick Fever

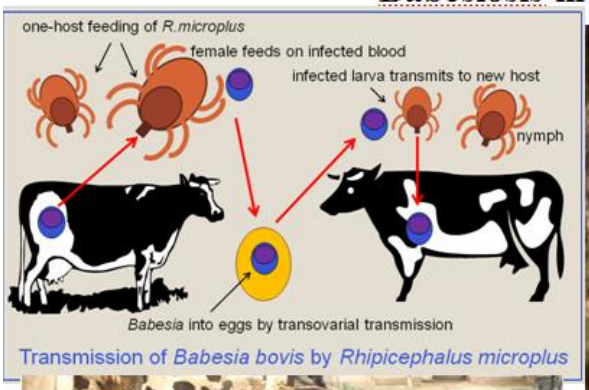
Rocky Mountain Spotted Fever (RMSF)

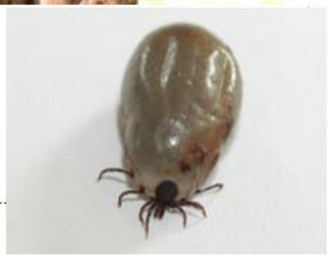
- ***Rickettsia rickettsii***
- Zoonosis –
- Reservoir: mammals
- Vector: ticks
- Characteristic hemorrhagic rash – maculopapular – starts on palms and soles (unlike measles!)
- Can damage vital organs

Tick Typhus



Babesiosis in Cattle





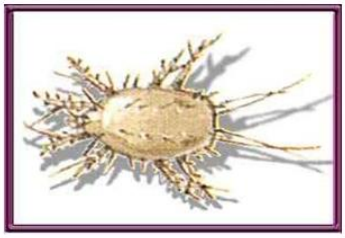
Sarcoptic Mange

Sarcoptic mange in cattle

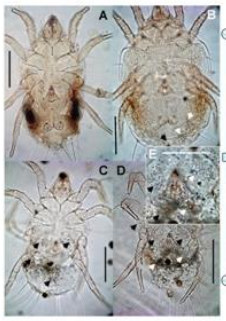
Sarcoptic mange in dog

MITES OCCURING IN DIFFERENT HABITATS

Stored Product Mites



Dust Mites



Reptile and Rodent Associated Acarines

Rodent Mites

Rodent Nest

Ticks on Snake

Insect Associated Acarines (Mites)

Mites in Different Habitats

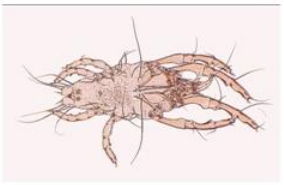
Aquatic Mites

Saprophagus Mite

Soil Mites

Nassal Passage Mite

Mites on Birds and Bird Nest



ACKNOWLEDGEMENTS

The author is thankful to anonymous authors for majority of the photographs borrowed from the internet, to the Secretary, Rama Krishna Mission Ashrama, Narendrapur for providing working facilities, to Ms. Sayani Bose, Project Assistant and Mr. Shantanu Pal, for helping in preparing the typescript, to Dr. Subhasish Dutta, Principal, Barasat Government College and Dr. (Ms.) Sumana Saha, Head, P.G. Department of Zoology, Barasat Government College, for extending invitation to the author for presenting this paper in the UGC sponsored seminar on "Biodiversity exploration, Conservation and Management-Vision and Mission" held in their college, 19-20 Nov 2016.

LITERATURE CITED

[1] Ghai, S. 1964. Mites. In: Entomology in India , Ent. Soc. India, 385-396 pp.
[2] Gupta, S.K. 1985. Handbook. Plant Mites of India. Zoological Survey of India, Calcutta, 520 pp.
[3] Gupta, S.K. 2010 Medical, Veterinary and Public Health Important Mites and Ticks-A Handbook. Nature Books India, New Delhi, 334 pp.
[4] Gupta, S.K. 2012 Handbook. Injurious and Beneficial Mites infesting agri-horticultural crops in India and their management. Nature Books India, New Delhi, 362 pp.
[5] Krantz, G. W. 1970 A Manual of Acarology. Oregon State University, Corvallis, U.S.A., 335 pp.
[6] Peal, S.E. 1868. Letter for forwarding specimens and drawings of Red Spider. *J. Agric. Hort. Soc. India*, 1: 69
[7] Prasad, V. 1974. A Catalogue of mites of India. Indira Acarology Publishing House, Ludhiana, 320 pp.
[8] Prasad, V. 1982.History of Acarology. Indira Acarology Publishing House, Michigan, U.S.A., 472 pp.
[9] Walter, D. E. and Proctor, H. C. 1999. Mites, Ecology, Evolution and Behaviour. Willingford, U.K., CAB International, 561pp.

Lecture - II

EXPLAINING THE PROCESS AND PATTERN OF AQUATIC BIODIVERSITY –LINKING QUESTIONS OF HUMAN CARRYING CAPACITY BASED ON RESOURCE AVAILABILITY

Prof. (Dr.) Sumit Homechaudhuri

Aquatic Bio resource Research Laboratory, Dept. of Zoology,
University of Calcutta

ABSTRACT

Contrary to the theories that assess biodiversity and strategies for conservation, the fact indicates that biodiversity is rooted in precise points on earth at definite times. Precision to the concept makes its qualitative assessment for economic policy and planning applications more feasible. Process and pattern of biodiversity at temporal and spatial scales could be explained from contrasting views of assembly and unified neutrality. Competitive and dispersal ability of organisms therefore make of evolutionary advantage for coexisting and survival in a given region. In view of this, while concentrating on the taste of aquatic organisms, 3 different perspectives viz species-sorting, mass-effect and patch dynamics can be analyzed to explain fish meta community and regional pool of species. Management of bioresource productivity from aquatic systems, marine brackish water and freshwater largely depend on scientific data on the biological traits defining competitive and dispersal. The goal of conservation effort can be satisfactorily evaluated from current mathematical models. However, such information needs to be implemented through actions in reality for reaping benefits for human population of a given society at precise points of resource hotspots. To achieve this we view bioresource to remain at K, the carrying capacity in nature. However humans can increase the effective carrying capacity of resources, via technological breakthrough with deep questions about sustainability beyond optimum. Relevant questions include (1) Can we keep developing new technologies and abilities to use new reasons that enable increase in K? (2) Can we set human carrying capacity at a given region based on resource availability? And most importantly (3) Can we develop a science based economy for bioresource use for desired quality of life of humans. The purpose of my writing this is to provoke thoughts within young minds and intellect to shape on future in right direction following eco-ethics.

Lecture - III

FISH BIODIVERSITY OF WEST BENGAL: STATUS, POTENTIALS, THREATS AND CHALLENGES

Bijoy Kali Mahapatra

ICAR-Central Institute of Fisheries Education, Kolkata Centre,
Sector-V, Salt Lake City, Kolkata – 700 091
E-mail: bkmahapatra2007@yahoo.co.in

ABSTRACT

West Bengal is on the eastern bottleneck of India, stretching from the Himalayas in the north to the Bay of Bengal in the south. The state has a total area of 88,752 square kilometres (34,267 sq. m). The Ganga-Padma river artery divides the states in two parts, North and South Bengal. West Bengal's climate varies from tropical savannah in the southern portions to humid subtropical in the north. West Bengal is endowed with 7.5% of the water resource including rivers (1.72 Lakh ha), canals (0.80 Lakh ha), ponds/tanks (2.87 Lakh ha), reservoir (0.27 lakh ha), beel & Boar (0.41 Lakh ha) and Brackish water fishery (2.10 Lakh ha) of the country. The multifunctional wetland ecosystem consists of an area of 12,500 hectares. Kangsabati in West Bengal is the main reservoir on the Ganga (11,396 ha). 190 native freshwater fish species were recorded from the West Bengal contributing nearly 23% of the Indian freshwater fishes. Near about 403 species of marine fishes are available in the state. In West Bengal there are a wide range of shellfishes have been found which comprises different groups such as, Crustaceans (Shrimp, Prawn, Lobster, Crayfish and Crab), Molluscs (Clam, Mussel, Oyster and Scallop) and others (Octopus, Snails and Sea-urchins etc.). According to ZSI 64 fresh water and low saline water molluscs are present in the state. There are also 94 estuarine and marine water molluscs belonging to 65 genera and 42 families. 251 crustaceans species are also available in this state. Highest number of fresh water molluscs reported from Darjeeling and marine molluscs from South 24 Parganas. About 288 exotic ornamental fish species are popular in West Bengal among these 27 species are liver bearer and 261 species are egg layerer. *Tenualosa ilisha* is the state fish of West Bengal. The fish is commonly known at West Bengal as Ilish in Bengali. Total 14 cultured species have been adopted and presently available throughout the state among which *Catla catla, Labeo rohita, Cirrhinus mrigala, Clarias batrachus, Anabas testudineus, Labeo bata* are the main cultured species. Apart from these *Pangasius pangasius, Ompok pabda, Channa striata, Channa marulius, Notopterus chitala, Mugil cephalus, Lates calcarifer, Amblypharyngodon mola* are very much popular in fish culture farm and fetches high market value. Many exotic fishes are also very popularly cultured in the state. Silver carp, Common carp, Grass carp, Tilapia are common and valuable exotic food fish which play an important role in state fishery. It is reported that about 900 million seeds of *Penaeus monodon* are collected annually. Kolkata is the main place of ornamental fish trade contributed a major portion of the India's ornamental fish trade (85%). 90% of the export is based on natural wild collection. Out of the 140 potential native freshwater ornamental species available in different water bodies of the region, presently about 73 species are included in the export list. There are a number of species in threatened and endangered condition. The Critically Endangered species are: *Erethestis montana montana*, *Ompok bimaculatus*, *Pangasius pangasius*. Damming,

deforestation, diversion and withdrawal of water for irrigation, urban and industrial consumption has caused large scale changes in the channel bed and hydrology of the river in terms of flow, flow-rate, flood-rhythm and regime. Dam impedes upstream spawning migration of fishes and displaces populations from their normal spawning grounds. It may also result in separating a population into two smaller groups as in Hilsa (*Tenualosa ilisha*) above and below the Farakka barrage. The upland fast-moving habitat has been lost to reservoirs which are unfavourable for rheophylic species. Wanton killing by the use of dynamites, electric shocks and poisoning and brood fishes in spawning season and juveniles during post-monsoon periods have affected a number of food and game fishes of upland waters. Mass scooping of prawn seed in many Anicuts and Hilsa juveniles just below the Farakka barrage are examples of such destruction. Many alien species introduced have been found invasive and they have the ability to establish themselves, invade, out-compete native species and take over the new environments. Over-exploitation of fishery resources due to its higher economic value has exacerbated the vulnerability of the population in different ecosystems, viz. *Tor* spp. and *Schizothorax* spp. in upland waters, *Chitala chitala*, *Ompok pabda*, *Pangasius pangasius*, *Eutropiichthys vacha*, *Semiplotus semiplotus*, etc. in warm water, *Mugil cephalus*, *Liza tade*, *Nematolosa nasus*, *Lates calcifer*, etc. in brackish water and *Rhiniodon typhus*, *Polynumus indicus*, *P. heptadactylus*, *Pomadasy shassta*, some sharks, skates and rays etc. in marine ecosystem; they are declining at an alarming rate. Global climate change is likely to result in severe droughts and floods with major impact on human health and food supplies. Due to factors such as human modifications to the environment, overexploitation, habitat loss, exotic species and others, aquatic biodiversity is greatly threatened. In order to preserve these threatened areas and species for future generations, immediate action in the form of aquatic biodiversity conservation strategies are necessary. The conservation policy should promote the management practices that maintain integrity of aquatic ecosystem, prevent endangerment and enhance recovery of the threatened species. The conservation of the coldwater fishes in the upper stretches should be considered as the priority. Restoring the natural fish stocks should be a priority, which includes ensuring minimum flow requirements and thereby sustaining the recruitment process. In addition, restoration of floodplain and associated wetlands should be a priority for conservation because floodplains play an integral part of riverine ecosystem. Efforts should be made to check the sediment flow by extensive plantation of native trees, shrubs, etc. on the riverbank and adjoining catchment area. Effective construction of fish passage structure is necessary. Capacities for the assessment, study and systematic observation and evaluation of biodiversity need to be reinforced. Effective national action and international cooperation is required for the in situ protection of ecosystems, for the ex-situ conservation of biological and genetic resources and for the enhancement of ecosystem functions. The participation and support of local communities are elements essential to the success of such an approach. Although the state and central government have already taken several measures to conserve the fish biodiversity in the River Ganga basin, I feel more conservation is needed in order to retain as many of the natural ecological processes and functions of the Rivers and associated water bodies as possible. Since the River basin is undergoing drastic deterioration as a consequence of anthropogenic changes, the conservation strategies must be innovative and integrated. Success will depend on the extent to which conservationists, water commissions, corporations, and municipalities work cooperatively in these places to maintain or restore natural water habitats of the state. Moreover, there is need to improve knowledge on biodiversity by strengthening the taxonomic capacity using computer, image analysis, and molecular tools etc. There is also an urgent need to maintain the integrity of these aquatic ecosystems by restoring ecological processes of the natural waters.

Lecture - IV

WILDLIFE CONSERVATION AT LANDSCAPE SCALE – ISSUES REGARDING EXPLORATION, EXPLOITATION, CONSERVATION AND MANAGEMENT

Dipankar Ghose

Director – Species & Landscape Programme
WWF, India, New Delhi
E-mail: dipankarghose@gmail.com

ABSTRACT

Conservation of wild flora and fauna has been a culture in India, however, in the recent past, most of the efforts have been put in the Protected Areas, making them islands of wildlife conservation. It is time that one looks beyond the boundary of Protected Areas, and adopt the landscape approach for wildlife conservation. Landscapes include the Protected Areas, connecting sites or corridors and adjacent human dominated areas. This mosaic of differently used areas makes landscape conservation more challenging, and therefore, interesting. Exploration for wildlife at a landscape scale needs more resources, and on the other hand has the opportunity of involving more hands for the field surveys. Extrapolation of results could be done provided a study design is made properly and sampling from all the habitat mosaics is carried out. An example of this would be the recent efforts by the National Tiger Conservation Authority and Wildlife Institute of India with NGO partners and state governments in estimating the number of tigers in the country. Sampling is done in the Tiger Reserves, some other Protected Areas, Reserve Forests and interconnected sites, and then using statistical models, extrapolation is done to firstly come up with landscape wise numbers and then countrywide numbers. Exploitation at landscape level is the most challenging part, it is not just the flora and fauna, it is the minerals that also take a toll on wildlife conservation. Whereas the Forest Department is equipped to stop poaching of charismatic species like tigers, elephants and rhinos in a forest, or curb timber smuggling, they feel helpless when it comes to managing coal mining in a critical tiger movement corridor. It is the development prerogative of the state and country, that gets priority over tiger movement. Landscape scale conservation planning can ensure that these kind of development measures take into account conservation requirements and build the cost into the project. Landscape level management for wildlife conservation has not been picked up by the government at a large scale yet, however, there are indications that stakeholders are thinking about it. Some of the recent initiatives of the Government of India and state governments, like BCRLIP is a testimony of that. Landscape scale planning needs to be mainstreamed for wildlife conservation.

Lecture - V

CONSERVATION BREEDING – A NEW HOPE TOWARDS WILDLIFE CONSERVATION

Goutam Kumar Saha

Professor of Zoology, University of Calcutta, 35, B.C. Road, Kolkata – 700019

ABSTRACT

Wildlife conservation in India dates back to the prehistoric times and is deep-rooted in the ethos of Indian civilization through ages. In the past, the scenario of wildlife conservation in India was completely different and was traditionally conserved through love, respect and reverence for nature. Admiration and affection for wildlife was considered to be a part of their lifestyle and vividly reflected in Indian myths, rituals, folklores and ancient literatures, art and culture. Besides, several animals are associated with many deities and as a consequence, these animals have been traditionally conserved through religious belief. Several tribal rituals in our country also reflect the age-old respect for several wild flora and fauna. Even today, several forest patches exist in many villages where killing any life form is forbidden by several religious and traditional belief. These areas regarded as 'sacred groves' serve as a good refuge for a number of wild flora and fauna and are often found teeming with rich biodiversity. Present day conservation initiatives have been scientifically categorized as in-situ and ex-situ conservation, of which ex-situ conservation is the procedure of conserving a species as a whole outside its natural habitat (viz. zoological garden or botanical garden) or a part of it in the form of gene bank or seed bank. However, the major problem associated with ex-situ conservation is the increased rate of inbreeding depression due to loss of genetic heterozygosity. To overcome this situation a special type of ex-situ conservation, popularly known as "Conservation Breeding" has become the talk of the time. Conservation breeding can be described as a breeding program that protects genetic diversity within a breed. Hence, conservation breeding has become an emergent field of research in ex-situ mode, which has successfully saved several species from extinction throughout the globe. Conservation breeding in true sense means breeding of threatened species in captivity or semi captive condition for the purpose of maintaining optimum heterozygosity in the species in order to protect the genetic diversity within a breed to avoid inbreeding depression and the offspring are rehabilitated in the wild as and when appropriate and desirable. Recently, 61 species of endangered animal species have been identified for conservation breeding programme in different zoological gardens of India. During last twenty years, the present group has initiated scientific research in different regions of the Eastern Himalayas and its adjacent areas giving emphasis on higher vertebrates like birds and mammals. During twenties, a research project was initiated on 'Bio-ecological status of Red Panda (*Ailurus fulgens fulgens*) in the Singhalila National Park, West Bengal, India' to document the presence/absence status, distribution and abundance of the red panda in the Singhalila National Park and its adjoining areas. Red Panda is found in the temperate forests with bamboo understorey between 1500 m to 4000 m in Himalayas. In India, range of Red Panda distribution encompasses four states - West Bengal, Sikkim, Meghalaya and Arunachal Pradesh. In the state of West Bengal, Red Panda is present in the Singhalila

National Park and Neora Valley areas in the hilly district of Darjeeling. The study also included different aspects of ecology such as habitat use, feeding ecology and other ecological requirements of red panda in the park. Special emphasis was given to investigate the problems of conservation and management of red panda involving local people and using traditional knowledge and cultural practices. At the same time, Padmaja Naidu Himalayan Zoological Park, Darjeeling initiated a conservation-breeding program on red panda and the prospects for breeding in the captivity looked promising. As the red panda breeding program became successful, the problem of the surplus animals as well as the threat of inbreeding started to arise which gave birth to the idea of reintroduction of these captive animals in the wild. After in depth ecological assessment, Singhalila National Park in Darjeeling district was considered as a suitable site of reintroduction of those captive breeds in the wild. Out of the two female offsprings released in the park, one mated in the wild and produced next generation offsprings making the project a success story of conservation breeding. Although several measures have been taken from time to time to conserve wildlife, it is the fundamental duty of every Indian citizen to protect wild flora and fauna. Thus, peoples' awareness and their active participation is the only ray of hope for proper conservation of wildlife in this mega diversity country.

Lecture - VI

WILDLIFE CONSERVATION AND MANAGEMENT IN HIMALAYAN REGION

S. Sathyakumar

Scientist-G / Senior Professor,
Wildlife Institute of India, Chandrabani, Dehradun 248002, Uttarakhand, India
E-mail: ssk@wii.gov.in

ABSTRACT

The Himalaya is the most prominent mountain systems in India covering 10% of India's geographical area and is well recognized for its rich biological, ecological, hydrological, aesthetical and socio-cultural values. The Himalaya is home to >10,000 species of plants, over 300 mammals, 980 birds, 175 reptiles, 105 amphibians,251 fishes and several hundreds of species of invertebrate fauna. Many of these flora and fauna are endemic, rare, endangered and threatened including many that have global conservation significance. Over 100 wildllife protected areas covering approximately 10% of the Himalayan and Trans-Himalayan biogeographic zones and offer protection to wildlife species and their habitats. Human communities living in this region depend substantially on the natural resources for their sustenance. Conducting research or management of wildlife in the Himalaya poses serious challenges due to rugged terrain, cold climatic conditions and elusive behaviour of wildlife species. Conservation and management issues include poaching for meat and to cater to illegal wildlife trade, retaliatory killings to reduce negative human-wildlife interactions (conflicts), habitat loss, fragmentation and loss due to developmental activities, livestock grazing and other anthropogenic pressures, and the emerging threat from climate change. Wildlife research studies and management initiatives undertaken till date would be presented as case studies during the talk that range from single species approach to landscape approaches using modern tools and techniques. The way forward would be to address these using sound science based decision making that would include consolidation of protected area network, landscape level planning and management, reducing human-wildlife negative interactions through community participation and conservation education initiatives that illustrate the peculiarities and fragility of the local environment. There is an urgent need to increase trans-boundary co-operation between India and its neighbouring nations to ensure habitat connectivity and protection of species populations from poaching due to illegal trade in wildlife.

Lecture - VII

ASSESSING AND TRANSCRIBING BIODIVERSITY FOR BIORESOURCE !

Dinendra Raychaudhuri

Department of Agricultural Biodiversity, IRDM Faculty Centre,
Ramakrishna Mission Vivekananda University, Narendrapur, Kolkata- 700 103
E-mail: dinendrarccu@gmail.com

ABSTRACT

Recognition of potential, newer bioresources and their sustained use demand best possible output from biodiversity studies. Biodiversity studies on the other hand demand thorough and extensive knowledge on the species in question. Precisely Biodiversity demands 'knowing of a species' rather than merely describing or recording a species; contemporary taxonomy too. Sorry to say that a large segment of workers feel complacent with such data. To explain it further it would be relevant to cite few examples. Only 41 of the 2270 citations on *Hirudo medicinalis* Linnaeus in 2010 mentioned the presence of cryptic species and former misidentification of *H. medicinalis* and *H. verbena carena*. Hence, more than 95% of the analyses published explicitly dealt with *H. medicinalis* [covering a broad array of subjects, like genomes, proteomes, gene syntheses, medical novelties, etc] cannot be clearly assigned to this species nor to either of the two undescribed species within the *H. medicinalis* species complex nor to frequently misidentified *H. verbena* . Thus even well established species can become imprecise. We can expect more surprises during the era of molecular analyses, in various fields including human welfare. The recent findings of unknown subgroups within *Anopheles gambiae* Giles complex that exhibit a high susceptibility to infection with wild *Plasmodium falciparum* (Welch) must have to be cited in future analyses to acknowledge one's awareness of sympatric species with different ecological and behavioural strategies within the same strains. The finding of cryptic spitting cobras as well as the rearrangement of the large species complex of the Asian pit vipers into distinct genera has a direct bearing on categorization of their medical importance, also antivenin indication, prescription and research. Results are not restricted to small and cryptic living species but also comprise large animals like turtles, monitor lizards, antelopes or bovids with direct implications on conservation biology and related fields. May be it is the reason why some of the biodiversity and ecological studies focus on biomass production, CO_2 storage, functional groups or well known taxonomic groups like trees, birds as substitutes to alpha diversity measures. Workers involved in exploring Biodiversity &Bioresource are probably ignorant or unaware of the shortfalls of such study. Precisely short falls are Linnean, Wallacean, Prestonian, Hutchinsonian, Raunkiaeran, Eltonian and Darwinian. Despite the constraints, there is an increasing demand on the documentation of the Biodiversity and Bioresources as far as practicable. To be honest we are far behind the start up line. In fine, a country/state can prosper only when a collective effort could be made taking the shortfalls into serious considerations. Otherwise it would remain as a happy-go-lucky way.

SECTION : IV

Presented Papers

Coastal Eutrophication as a Cause of Elimination of Lugworms: First record of *Arenicola* (Linn., 1758) from coastal areas of Bay of Bengal at Chandipur, Odisha, India

Santanu Chakrabarti[1,*] and **Rupendu Ray**[2]

[1]Post-Graduate Department of Zoology, Krishnagar Government College, Krishnagar, Nadia, WB, India
[2]Post-Graduate Department of Zoology, Barasat Government College, 24 Parganas North, WB, India
*Email : scwbes@gmail.com

ABSTRACT

Arenicola marina (Linnaeus, 1758), a marine polychaete worm of the phylum Annelida is rarely seen but its coiled castings are a familiar sight on a beach at low tide of both northern and southern hemisphere. The genus *Arenicola* enjoys a wide distribution and in the tropical and sub-tropical regions *A. cristata* is the dominant species. Apart from a few records on the beaches of Indian Ocean and Arabian Sea the genus has not been known so far from any other part of India. In a study on the sandy as well as mudflats of Bay of Bengal at Chandipur in Odisha, India, we observed quite a big numbers of castings of *Arenicola* during the end of December, 2015 and accidentally found a full grown individual at the sandy beach. From that point of view it is the first report of its kind from this part of the globe, especially from Bay of Bengal

Key words: Lugworm, *Arenicola*, Bay of Bengal, Chandipur, India

INTRODUCTION

Lugworms, *Arenicola marina* (Linnaeus, 1758) is a large marine polychaete worm of the phylum Annelida. The animal itself is rarely seen without dig the worm out of the sand but its coiled castings are a familiar sight on a beach at low tide. Lugworms are burrow-dwelling annelid worms and can reach densities as high as 100-150 per square meter in certain areas (Fish, 1996). The lifespan of lugworms is estimated to be 5-6 years (Howie, 1984), and they can make up to 30% of the biomass of an average sandy beach, making them a very important part of the food web in their habitat. They bioturbate (re-oxygenate) the sand and serve as a food source for a wide variety of other animals such as flatfish and birds.

The genus *Arenicola* enjoys a wide distribution and is generally divided into cold water and warm water species. *Arenicola. marina* and *A. clapqredii* dominate the cold waters of the northern hemisphere and *A. assimilis* is more common in the southern hemisphere. In the tropical and sub-tropical regions *A. cristata* is the dominant species while *A. caroledna, A. glasselli, A. loveni and A. bombayensis* have also been reported. Bhatti and Soofi (1949) have

recorded *A. cristata* from Karachi and Ranade (1952) reported the occurrence of *Arenicola* from Bombay (later described as a new species *A. bombayensis* by Kewalramani *et al*. 1959). During a collection tour to the Andaman and Nicobar Islands in February-March 1960, Tampi and Rangarajan (1963) observed a few *Arenicola spp.*. Fauvel (1953) did not mention these in his compilation of the Polychaete Fauna of India and apart from these scanty records the genus has not been known so far from any other part of India.

In a study on the sandy as well as mudflats of Bay of Bengal at Chandipur in Odisha, India, we observed quite a big numbers of castings of *Arenicola cristata* during end of December, 2015 and accidentally found a full grown individual at the sandy beach. From that point of view it is the first report of its kind from this part of the globe and especially from Bay of Bengal.

MATERIALS AND METHODS

Physiography and climate of Chandipur

The area under study is Bay of Bengal at Chandipur in Odisha, India. Chandipur is situated between 860 .20' to 870 .29' East (Longitude) and 210 .3' to 210 .59' North (Latitude). The uniqueness of the beach lies in the fact that during a low tide the water recedes up to 5 km. into the sea exposing the golden sands.

The sea is very shallow and long distances in the sea bed from the coast become exposed (dissipative) during low tide. The beach becomes harder after the exposure due to the muddy soil mixed with sand. Annual rainfall ranges from 800 to 5500 millimetres which commences in April and lasts up to November. December rainfalls are rare. Though the average temperature at Chandipur is 35°C during December it ranges from 12-22°C. Ocean currents originating from the Indian Ocean flow along this coastline in two directions - from North to South during December to May and from South to North from June to November. During December-January there is a shift in current direction along the coast of the Bay when there is a northerly flow of warm water originating from Indian Ocean. Once again during the end December, when the study was conducted, there is a northerly flow reversal of the current, the direction shifting southwards. So, there is a gradual overlap of cold current from the north with the strong warm current from the south. For this reason, the upper strata of water remains cold and the lower one is warm during the end of the year.

Rivers in the Coastal plains near Chandipur

The Odisha Coastal Plains are the depositional landforms of recent origin and geologically belong to the Post-Tertiary Period. This region is the combination of several deltas of varied sizes and shapes formed by the major rivers of Odisha, such as the Subarnarekha, the Budhabalanga, the Baitarani, the Brahmani, the Mahanadi, and the Rushikulya. Therefore, the coastal plain of Odisha is called the "Hexadeltaic region". It stretches along the coast of the Bay of Bengal having the maximum width in the Middle Coastal Plain (the Mahanadi Delta), narrow in the Northern Coastal Plain (Balasore Plain) and narrowest in the Southern Coastal Plain (Ganjam Plain). Chandipur is in the North Coastal Plain comprises the deltas of the Subarnarekha and the Budhabalanga rivers and bears evidences of marine transgressions.

A unique phenomenon at Chandipur beach

A unique phenomenon rarely seen anywhere else, the sea recedes by as much as five kilometres every day on the Chandipur beach, not just enthralling the onlooker but also offering an opportunity to literally walk into the sea. The sea recedes massively from the beach during ebb and returns to fill the emptiness during high tide. This hide-

and-seek of the sea comes to play twice a day have significant bearing on the benthic lives on the beach. The study was conducted twice a day on the long stretch of the beach, covered by a mudflat followed by sandy beach towards the sea during low tide. This mudflat region is due to the presence of the deltas of the Subarnarekha and the Budhabalanga rivers. As this place is quite thickly populated, human interferences enrich the riverine discharges in this coastal delta region.

RESULTS

In Chandipur, when we observed quite a good numbers of castings of *Arenicola* during end of December, 2015 on the sandy beaches just following the mudflats during low tide we had undertaken this study to find out the species near the castings and holes beside. However, it was not possible to dig them out of the holes because of the presence of shallow sea water in the evening. At night the high tide swept the entire sand and the mudflat of the beach. We started our search in the same site in the following morning, once again when the sea receded due to low tide and found a few full grown individual at the sandy beach. All of the lug worms however were dead and only one complete organism could be observed. We were interested because this is the first report of *Arenicola* from this part of the globe and especially from any beaches of Bay of Bengal.

Biology of lugworm

1. Morphology (Fig. 1)

When fully grown, the lung worm of the coasts of Europe measures up to 23 cm long and 1.0 cm in diameter. Other species of North American coasts range from 7.6 to 30.5 cm. The specimen recorded by us from the coast of Bay of Bengal, Chandipur, Odisha measures 26 cm in length and 1.5 cm in diameter. The body is like that of an earthworm, metamerically segmented. The head end is blackish- red in colour and without any tentacles or bristles. The middle part is greenish-black, broader which terminates into a thinner yellowish red tail end. The middle part possesses bristles along the sides and also pairs of feathery gills. The anterior end also has a muscular eversible pharynx. There is a well developed system of blood vessels with red oxygenated blood.

2. Feeding behaviour

Lugworms are found on middle to lower shores in sand and muddy- sand and in sheltered, estuarine sediments. They live in J-shaped burrows, about 20 cm below the surface and can tolerate salinities down to 12 ppt (Fish, 1996). These worms feed on organic material such as micro-organisms and detritus present in the sediment. They ingest the sediment while in the burrow, leaving a depression on the surface sand. Once the sediment is stripped of its useful organic content it is expelled, producing the characteristic worm cast. The animal lives in the burrow head down and correctly orient themselves for feeding. It has been shown that if an aquarium is tilted they will compensate for the difference and change position (Ruppert & Barnes, 1991).

Arenicola is a burrower. They dig tunnel in the ground which may reach 50cm and are lined by brown mucus. The depth of the burrow depends on body size; the smaller live in the surface whereas the larger worms penetrate deeper. In the head down posture they continuously swallow the ground containing food particles such as detritus, small animals, diatoms and green algae with their eversible pharynx. The posterior part of the body is stuffed with ground food particles. Lugworms in the tide pool feed all day long but those living in the drying burrows feed only when the burrows are under water.

3. Life History

Lugworms have separate sexes with external fertilization and are known as 'broadcast' spawners, breeding several times in their life. In the wild they are sexually mature at 2-3 years. These worms live in separate burrows, and entirely separated populations will release their eggs and sperm at low tide just before the winter. Spawning in males is accompanied by intermittent muscular contractions of the body wall, causing ejaculation which continues for more than an hour until the worm is exhausted.

Females take much longer to spawn (up to 19 hours) and the process is less active, which reflects the fact that females keep eggs in their burrows whilst males must eject sperm onto the sand surface outside their burrows. Spawning occurs at low tide and as the tide comes in, the viscous sperm puddles are washed, diluted and enter the burrows of the females. The sperm puddles contain inactive sperm, the addition of seawater triggers them to become active and begin swimming.

Fertilization occurs in the female burrow and the larvae undergo early development here, later moving to the surface to be transported by the tide to settle on firmer areas. They then develop in mucous tubes attached to the substratum. Once developed, the worms are carried by the tide to more sandy/mud sediments where they can burrow (Fish, 1996).

DISCUSSION

Although Fauvel (1953) did not mention *Arenicola* in his compilation of the Polychaete Fauna of India later it was found that in the tropical and sub-tropical regions *A. cristata* is the dominant species while *A. caroledna, A. glasselli, A. loveni and A. bombayensis* have also been reported. Bhatti and Soofi (1949) have recorded *A. cristata* from Karachi and Ranade (1952) reported the occurrence of *Arenicola* in Bombay (later described as a new species *A. bombayensis* by Kewalramani *et al*. 1959). Apart from these records the genus has not been known so far from any other part of India especially from the beaches of Bay of Bengal.

Several reports are there on total or partial local extinction of many littoral forms like *Solen, Gastrana, Donax, Donacilla* among molluscs and *Arenicola* and *Ophelia* among worms, *Eriphia* and *Chtamalus* among crustaceans due to eutrophication in coastal areas. We observed the same is true for these lug worms of Chandipur beach as during this time, which is in the day time a high degree of eutrophication in the sea water. The water turned dark green and the effect of such bloom could be observed even on the shore as the receding sea left a dark green patch all along the beach. We could easily correlate the reason of such bloom as nutrient discharge in the coastal areas also favours exceptional algal blooms. The delta region receives huge amount of riverine discharge which might triggered such eutrophication. Though, in the littoral zones lug worms are generally adapted to be exposed at low tide for different periods of time, from a few minutes to more than five hours but the extent of eutrophication and the anoxic condition created due to that might have been the reason for their elimination.

ACKNOWLEDGEMENT

We sincerely acknowledge the alertness and skill of **Sourankur Chakrabarti**, a High School student of Aditya Academy, Kolkata, India in photo capturing the fauna on the beach during the field study.

LITERATURE CITED

[1] Bhatti, H.K. & Soofi, M. 1949. Arenicola- Polychaete from Karachi. Pakistan J. Sci. Res., 1: 76.

[2] Fauvel, P. 1953. The Fauna of India, including Pakistan, Ceylon, Burma and Malaya. The Indian Press, Allahabad, 375 pp.

[3] Fish, J.D. & Fish, S. 1996. A student's guide to the seashore. Second Edition. Cambridge University Press, Cambridge, 564 pp.

[4] Kewalramani, H. G., Wagh, P. V. & Ranade, M. R. 1959. Taxonomy of the lugworm found off Bombay. J. Zool. Soc. India, 11: 109.

[5] Ranade, M. R. 1952. Occurrence of Arenicola in Bombay. Curr. Sci, 21: 165.

[6] Ruppert, E. E. & Barnes, R.D. 1991. 'Invertebrate Zoology' 6th Ed. Saunders College Publishing, 928 pp.

[7] Tampi, P. R. S. & Rangarajan, K. 1963. On The Occurrence Of Arenicola brasiliensis Nonato (Family : Arenicolidae, Polychaeta) In Indian Waters. J. Mar. biol. Ass. India, 5 (1): 108-11.

Fig. 1. *Arenicola cristata* on the sandy beach of Chandipur, India

Study of Ant Faunal Diversity of Chintamoni Kar Bird Sanctuary, West Bengal, India

Samrat Bhattacharjee

Scottish Church College, 1 & 3 Urquhart Square Kolkata- 700 006
Email: samrat.scc@gmail.com

ABSTRACT

Ants are by far the most successful eusocial group of organisms. Present paper deals with ant survey in Chintamoni Kar Bird Sanctuary also called Narendrapur Bird Sanctuary, West Bengal, India. A total of 36 species under 18 genera and 6 subfamilies are recorded from the survey. Area A1 records maximum (27) species whereas area A7 records least (08) species. Premonsoon period of the year shows maximum ant activities and Subordinate Camponotini seems to be the predominant Functional group in the forest.

Keywords: Ant Diversity, Chintamoni Kar Bird Sanctuary, Premonsoon, Functional Groups

INTRODUCTION

Ants are by far one of the most successful eusocial group of organisms reigning the face of earth. They have colonised almost all the available habitats. They form about 15-25 % of any terrestrial biomass (Schultz, 2000) due to their ability to modify the habitat, resource mobilisation and their well defined social organisation which renders a strong protection to their colony. Ants have been in use for the study of evolution of polyphenism (Bonasio, 2014), as tools in biological control (Beth & Drummond, 2011) and as bioindicator organisms on the health of an ecosystem (Andersen *et. al*. 2004). Such role of ants have prompted scientists all over the world to study in great detail the ecology and diversity of the group. Till date estimates suggest worldwide around 22,000 ant species of which nearly 14,000 (Ohio State University, 2017) have been identified.

In Indian context the study of invertebrates in general remains poorly documented (Bharti *et. al*. 2016). India has approximately 828 valid ant species and subspecies belonging to 100 genera (op. cit.). This contributes about 6% of the total world species. Such a data prompt a thorough survey of ants at all the levels of biome.

The present paper deals with the study of diversity of ants in a protected area Chintamoni Kar Bird Sanctuary located at the outskirts of the city of Kolkata.

MATERIALS & METHODS

The work involves the assessment of ant diversity continually throughout the year. The yearly collection schedule is divided into three halves viz. premonsoon (March to June), monsoon (July to October) and postmonsoon (November to February). Ant samples were collected at regular periods by various methods viz. hand picking, pitfall traps, bush beating techniques. The entire forest was divided into seven broad areas namely A1 to A7. Area A1 being located at the extreme south of the sanctuary whereas area A7 towards north which is almost open land. In each area about 15 pitfall traps were placed diagonally at an interval of 5

metres. Plastic containers were placed in Pitfall traps which were filled 1/3rd by 70% alcohol and kept for a period of 24 to 26 hours. Collection during Monsoon is affected by torrential rain in the area. Also the sanctuary is accessible to visitors particularly bird watchers which confers anthropogenic interference in the forest.

Collected samples were put in 70% alcohol and brought to the laboratory. These were taxonomically evaluated with the help of stereo zoom binocular microscopes using relevant literatures viz. Bingham (1903), Bolton (1995), Tiwari *et. al*. (1998), Sheela (2008), Bharti *et. al* (2016) and AntWiki (2017).

Abbreviations used: Chintamoni Kar Bird Sanctuary (CKBS), Narendrapur Bird Sanctuary (NBS), India (IND), Tropical Climate Specialist (TCS), Subordinate Camponotini (SC), Opportunists (OPP), Generalised Myrmicinae (GM), Cryptic Species (CP), Specialised Predator (SP), and Dominant Dolichoderinae (DD).

The Study Area

Chintamoni Kar Bird Sanctuary (CKBS) also called Narendrapur Bird Sanctuary (NBS) is a small island located within the urban sprawl of Kolkata, in the state of West Bengal, India. Only 17 km. from the heart of Kolkata city, the sanctuary is a home to an astonishing diversity of flora and fauna. Total area of the sanctuary is only 10 hectares. But the plethora of its flora and fauna gives it a unique status.

The sanctuary is shaped like an elongated rectangle (Fig. 1). Its length lies in a north-south direction along the eastern bank of Adiganga Drainage Scheme Canal. Lengthwise it stretches to around 820 m, while its breadth is on an average 170m. Out of the total area of approximately 10 Ha, nearly 1/3rd at its northern end is now almost devoid of vegetal cover, though the rest remains thickly vegetated. Being drained by the Adiganga channel the sanctuary is rich in alluvial soil which supports rich floral and faunal diversity. The seasonal glimpses of the forest is shown in Fig. 2(A-F).

RESULTS

Total 36 species of ants under 18 genera were taxonomically identified which were collected from different parts of the sanctuary. These belong to 6 subfamilies viz. Dolichoderinae, Dorylinae, Ponerinae, Formicinae, Myrmecinae and Pseudomyrmicinae recording 1, 1, 8, 21, 3 and 2 species respectively (Fig. 3). The total number of individuals collected from the seven areas of the sanctuary is 793. Subfamily Formicinae recorded the highest number of individuals (488) while subfamily Dolichoderinae reported least number of individuals (15). 33 species were available during the premonsoon season of the year whereas only 13 and 23 species could be recorded during monsoon and postmonsoon period respectively [Fig.4]. Area A1 seems to be rich in species diversity recording 27 species followed by A2 & A4 each with 12 species and A3, A5, A6 with 10 species in each. Area A7 recorded least (08) species. Functional group status of the recorded 36 species show 18 species are Subordinate Camponotini, 6 species each are Tropical Climate Specialists and Opportunists, 3 species are Specialised predator and 1 species each belonging to Dominant Dolichoderinae, Generalised Myrmicinae and Cryptic species (Fig. 5 & 6). All the functional groups are present in the forest which reflects a stable ecosystem condition. Dominant Dolichoderinae is not really dominant in the forest with only 1 species in A1, A4, A6 & A7. Subordinate Camponotini is the predominant group in the forest which is present throughout the forest with highest species and individuals. It is interesting to note that Opportunists are present throughout the forest which indicates certain degree of disturbance in the forest which might be attributed to the anthropogenic interference/ location of forest in urban area or process of reclamation since September 2004. More species richness in area A1 and least in

A7 might be attributed to the more density of the forest & least disturbance due to the nature of its core area status.

Table 1 shows the different group of ant species recorded, their distribution and the functional group status. Figures 7-11 shows the different ant groups on the basis of their Functional Status recorded from CKBS.

ACKNOWLEDGEMENTS

The author wishes to acknowledge University Grants Commission, GOI. for funding the project (F. PSW-052/11-12 [ERO]); Teacher-in-Charge of Scottish Church College; Forest Department, Govt. of West Bengal; Sri. Supratim Laha, Research Fellow at University of Calcutta; Sri. Koushik Pal for their manifold assistance in the survey work. The author is immensely grateful for the overall guidance and support rendered by Prof. Dinendra Raychaudhuri of University of Calcutta. Also the assistance rendered by Dr. Alan Andersen, Chief Scientist, CSIRO Australia towards determining the functional groups of the ants is highly acknowledged.

LITERATURES CITED

[1] Andersen, A. N., Fisher, A., Hoffmann, B. D., Read, J. L. & Richards, R. 2004. Use of terrestrial invertebrates for biodiversity monitoring in Australian rangelands, with particular reference to ants. *Austral. Ecology*, 29: 87–92.

[2] http://www.antwiki.org/wiki/Welcome_to_AntWiki. [Last assessed on 05.02.2017].

[3] Beth Choate, B. and F. Drummond. 2011. Ants as biological control agents in agricultural cropping systems. *Terrestrial Arthropod Reviews*, 4(2): 157-180.

[4] Bharti, H., H. Benoit Guénard, Meenakshi Bharti, Evan P. Economo. 2016. An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). *ZooKeys*, 551: 1-83.

[5] Bingham, C.T. 1903. Ants and Cuckoo Wasps. The Fauna of British India including Ceylon and Burma. Hymenoptera II. Taylor and Francis, London: 1-506.

[6] Bolton, B. 1995. A New General Catalogue of the Ants of the World. Cambridge, Massachusetts, Harvard University Press: 512 pp.

[7] Bonasio, R. 2014. The role of chromatin and epigenetics in the polyphenisms of ant castes. Briefings in Functional Genomics, 13 (3): 235-245.

[8] Hymenoptera name server. Formicidae species count. Ohio State University. http://atbi.biosci.ohio-state.edu/hymenoptera/tsa.sppcount?the_taxon=Formicidae [Last assessed on 05.02.2017].

[9] Schultz, TR. 2000. In search of ant ancestors. *Proceedings of the National Academy of Sciences*, 97 (26): 14028–14029.

[10] Sheela, S. 2008. Handbook on Hymenoptera: Formicidae. Zoological Survey of India,: 1-55.

[11] Tiwari, R.N., Kundu, B.G., Roychowdhury, S. and Ghosh, S.N. 1998. Insecta : Hymenoptera : Formicidae: Fauna of West Bengal. State fauna Series 3. Zool. Surv. India: 211-294.

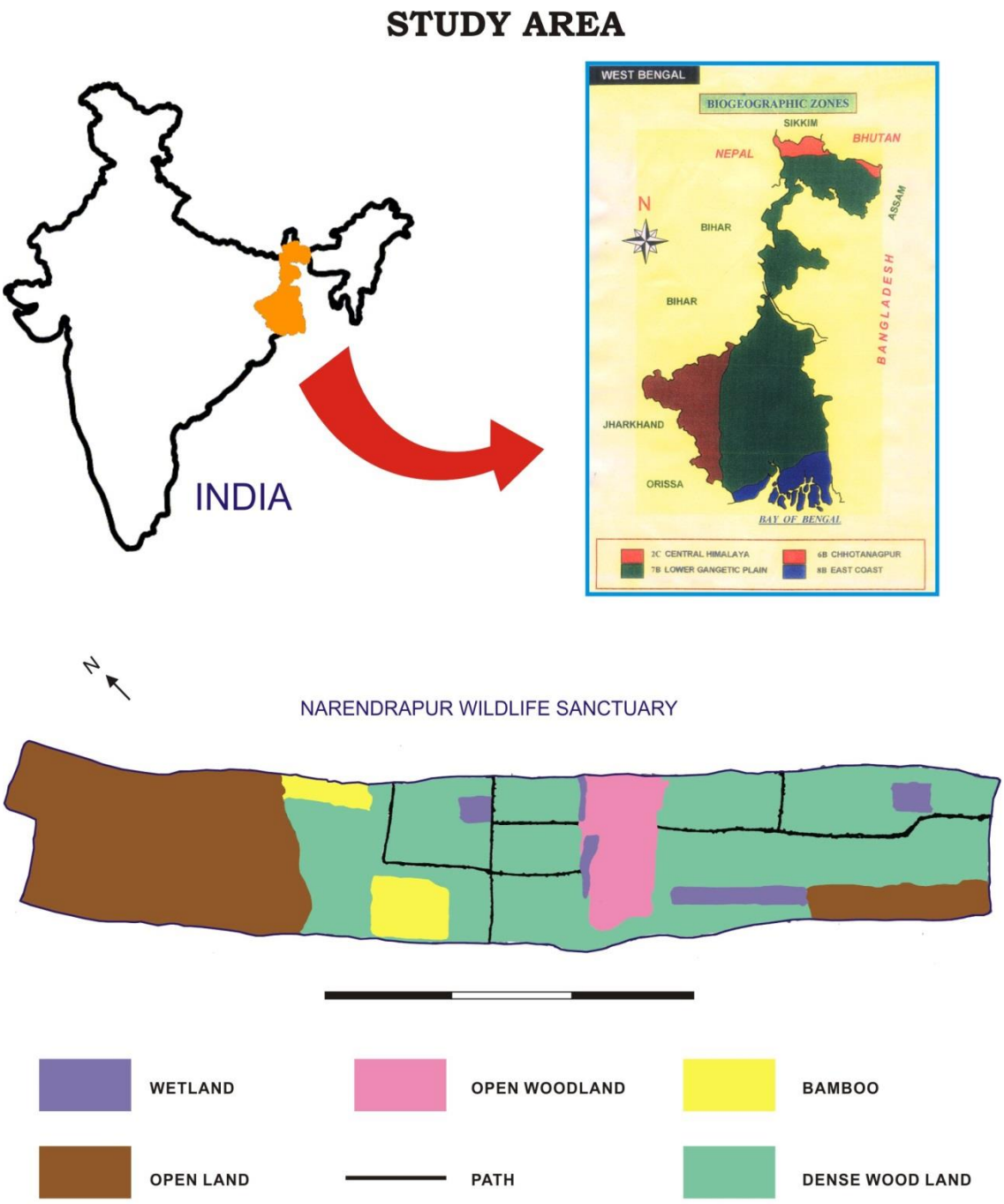
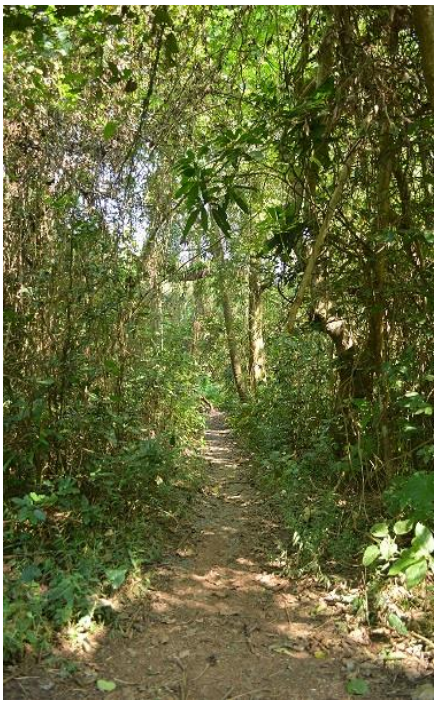


Fig. 1. Map of Chintamoni Kar Bird Sanctuary

A



B

C

D

E

Fig. 2 (A-E) (A-E). Seasonal Glimpses of different parts of the CKBS:
A&B- Premonsoon C- Monsoon D- Postmonsoon E- Water Pit for bird

Table 1: List of Ants Collected from Chintamoni Kar Bird Sanctuary

Subfamily	Species	DISTRIBUTION		Functional Status
		CKBS	IND	
Dorylinae	*Dorylus* (*Alaopone*) *orientalis* Westwood	A1	Arunachal Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand & West Bengal.	Tropical-Climate Specialist
Ponerinae	*Cerapachys aitkenii* Forel	A1 A6	Goa, Haryana, Karnataka, Kerala, Meghalaya, Punjab, West Bengal	Specialist Predator
	Leptogenys kitteli (Mayr)	A1	Arunachal Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Manipur, Meghalaya, Sikkim, Tripura, Uttar Pradesh, West Bengal	Specialist Predator
	Diacamma scalpratum (Smith)	A4	Arunachal Pradesh, Assam, Jammu & Kashmir, Karnataka, Kerala, Meghalaya, Sikkim, West Bengal [Burdwan, Darjeeling, Jalpaiguri)	Opportunist
	Diacamma vagans Smith	A1-A7	Assam, Maharashtra, Orissa, Sikkim, West Bengal	Opportunist
	Gnamtogenys bicolor (Emery)	A3	Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Mizoram, Sikkim, West Bengal	Opportunist
	Hypoponera confinis (Roger)	A1, A2	Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Mizoram, Nagaland, Punjab, Sikkim, Uttarakhand, West Bengal	Cryptic Species
	Pseudoneoponera rufipes (Jerdon)	A1, A4	Andaman & Nicobar Islands, Assam, Arunachal Pradesh, Goa, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal	Specialist Predator

	Brachyponera jerdoni (Forel)	A1, A2, A4, A5, A6	Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, kerala, Maharashtra, Manipur, Mizoram, Nagaland, Sikkim, Tripura, Uttarakhand, West Bengal	Opportunist
Formicinae	*Oecophylla smaragdina* (Fabricius)	A1-A7	Andaman & Nicobar Islands, Andhra Pradesh, Assam, Arunachal Pradesh, Assam, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Manipur, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal	Tropical Climate Specialist
	Plagiolepis longipes Jerdon	A7	Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Maharashtra,Punjab, Rajasthan, Uttarakhand, West Bengal	Opportunist
	Camponotus (Tanaemyrmex) variegates (Smith)	A3	Andaman & Nicobar Islands, Kerala, Maharashtra, Rajasthan, Tamil Nadu, Western India	Subordinate Camponotini
	Camponotus (Orthonotomyrmex) sericeus sericeus (Fabricius)	A1, A2, A5	Karnataka, Kerala, Tamil Nadu, Uttar Pradesh, West Bengal	Subordinate Camponotini
	Camponotus (Myrmosphincta) camelinus var *singularis* Smith	A1, A7	Arunachal Pradesh, Meghalaya, Sikkim, Tripura, West Bengal	Subordinate Camponotini
	Camponotus (*Myrmepomis*) *wasmani* Emery	A2, A4	Assam, Maharashtra, Meghalaya, Sikkim, Uttarakhand, West Bengal	Subordinate Camponotini
	Camponotus (Tanaemyrmex) compressus (Fabricius)	A1, A2, A3, A4	Andaman & Nicobar Islands, Assam, Arunachal Pradesh, Assam, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Manipur, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar	Subordinate Camponotini

			Pradesh, West Bengal	
	Camponotus (Myrmosericus) parius Emery	A1	Andaman and Nicobar Islands , Arunachal Pradesh, Assam, Goa, Haryana , Himachal Pradesh , Jammu & Kashmir , Karnataka, Kerala, Maharashtra , Meghalaya , Nagaland , Orissa, Punjab, Sikkim, Tamil Nadu , Uttar Pradesh , Uttarakhand , West Bengal	Subordinate Camponotini
	Camponotus misturus fornaronis Forel	A1	West Bengal, Kerala	Subordinate Camponotini
	Camponotus variegates infuscus Forel	A1, A5	Andaman, Karnataka, Uttar Pradesh, West Bengal	Subordinate Camponotini
	Camponotus (Tanaemyrmex) barbatus taylori Forel	A1, A6, A7	Kerala, Maharashtra , Orissa, Rajasthan , Sikkim , Tamil Nadu, West Bengal	Subordinate Camponotini
	Polyrhachis furcata Smith	A1, A3, A4, A5	Assam, Meghalaya, West Bengal	Subordinate Camponotini
	Polyrhachis affinis Smith	A1, A3, A4, A7	West Bengal	Subordinate Camponotini
	Polyrhachis tibialis Smith	A1	Andaman and Nicobar Islands , Arunachal Pradesh, Assam , Karnataka, Kerala, Meghalaya, Sikkim, Tamil Nadu , Uttarakhand , West Bengal	Subordinate Camponotini
	Polyrhachis armata defensa Smith	A1, A2, A5	Assam, West Bengal	Subordinate Camponotini
	Polyrhachis bicolor Smith	A1, A2, A5, A6	Andaman and Nicobar Islands, Arunachal Pradesh, Meghalaya, Sikkim, West Bengal	Subordinate Camponotini
	Polyrhachis laevissima Smith	A1, A4, A5	Andaman and Nicobar Islands , Arunachal Pradesh , Assam , Maharashtra, Meghalaya, Orissa, Sikkim, West Bengal	Subordinate Camponotini

	Polyrhachis gracilior Forel	A2, A4	Arunachal Pradesh , Assam , Karnataka, Kerala, West Bengal	Subordinate Camponotini
	Polyrhachis thrinax Roger	A3	Andaman and Nicobar Islands , Arunachal Pradesh , Assam, Karnataka, Kerala, Maharashtra, Sikkim, Tamil Nadu, West Bengal	Subordinate Camponotini
	Polyrhachis illaudata Walker	A1, A2, A5, A6, A7	Andaman and Nicobar Islands , Arunachal Pradesh, Assam , Goa, Himachal Prades, Jammu & Kashmir, Karnataka , Kerala, Meghalaya, Mizoram , Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal	Subordinate Camponotini
	Paratrechina longicornis (Latreille)	A1	Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Delhi, Goa, Gujarat, Himachal Pradesh , Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram , Nagaland, Orissa, Punjab, Rajasthan , Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, West Bengal	Subordinate Camponotini
Pseudomyrmecinae	*Tetraponera* (*Tetraponera*) *alloborans* (Walker)	A1, A3	Andaman and Nicobar Islands , Arunachal Pradesh, Assam, Goa, Gujarat , Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Meghalaya, Nagaland, Orissa, Punjab, Sikkim, Tamil Nadu, Uttarakhand , West Bengal	Tropical Climate Specialist
	Tetraponera (*Tetraponera*) *rufonigra* (Jerdon)	A3, A6	Andaman and Nicobar Islands, Arunachal Pradesh , Assam, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand , Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram , Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu , Tripura, Uttar Pradesh, Uttarakhand , West Bengal	Tropical Climate Specialist
Dolichoderinae	*Dolichoderus (Hypoclinea) affinis* Emery	A1, A4, A6, A7	Assam, Karnataka, Manipur, Meghalaya, Sikkim, West Bengal	Dominant Dolichoderinae
Myrmicinae	*Monomorium orientale* Mayr	A1, A6	Andaman and Nicobar Islands, Arunachal Pradesh , Assam , Himachal Pradesh, Jammu & Kashmir, Karnataka, Manipur, Orissa, Sikkim,	Generalised Myrmicinae

			Uttarakhand, West Bengal	
	Carerbara diversus (Jerdon)	A2	Arunachal Pradesh, Assam, Goa, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Mizoram, Sikkim, Tamil Nadu , Uttarakhand, West Bengal	Tropical Climate Specialist
	Meranoplus bicolor (Guérin-Meneville)	A1	Arunachal Pradesh, Assam, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram , Nagaland , Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand , West Bengal	Tropical-Climate Specialist

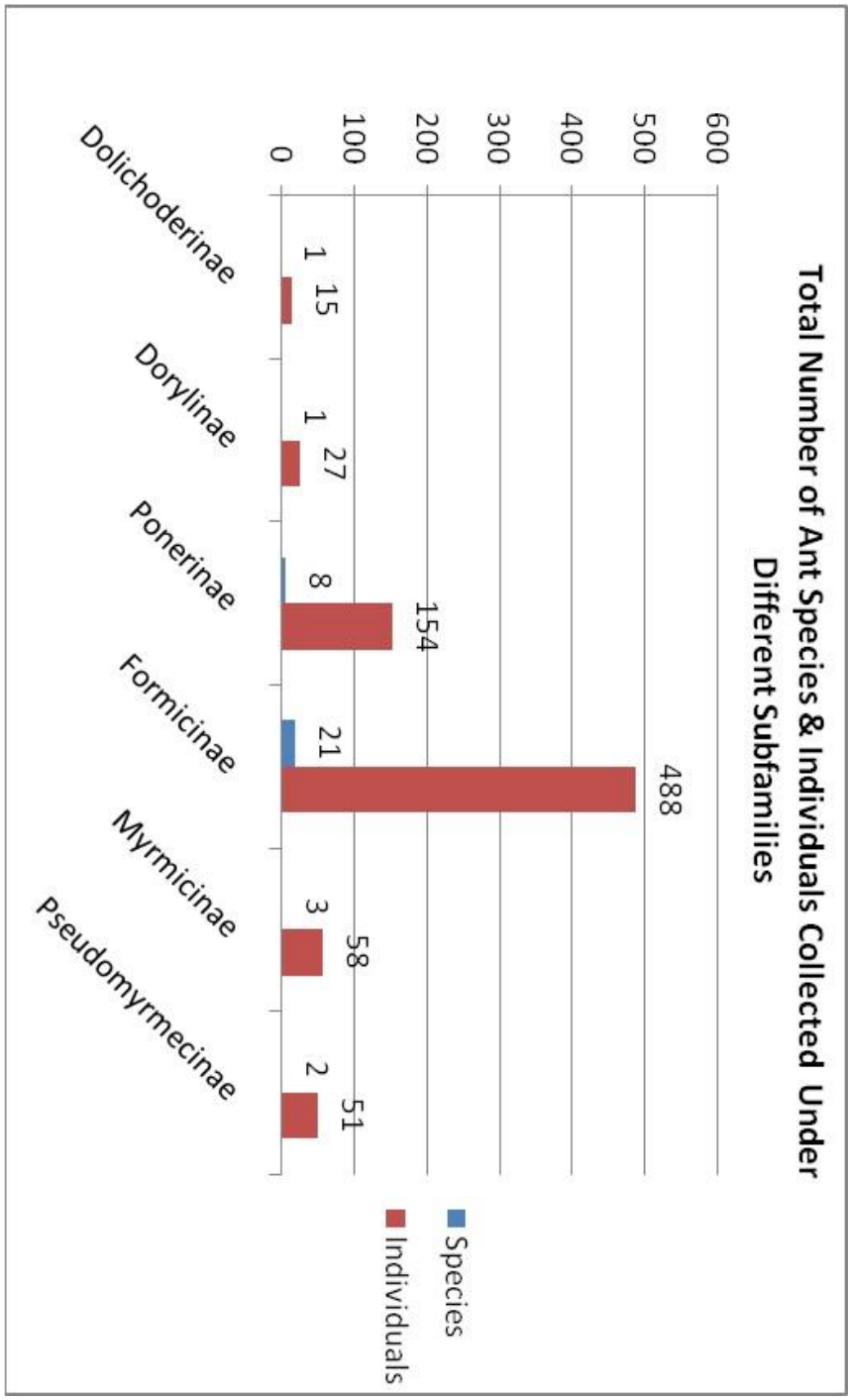


Fig. 3. Number of species and individuals of ants recorded from different parts of CKBS

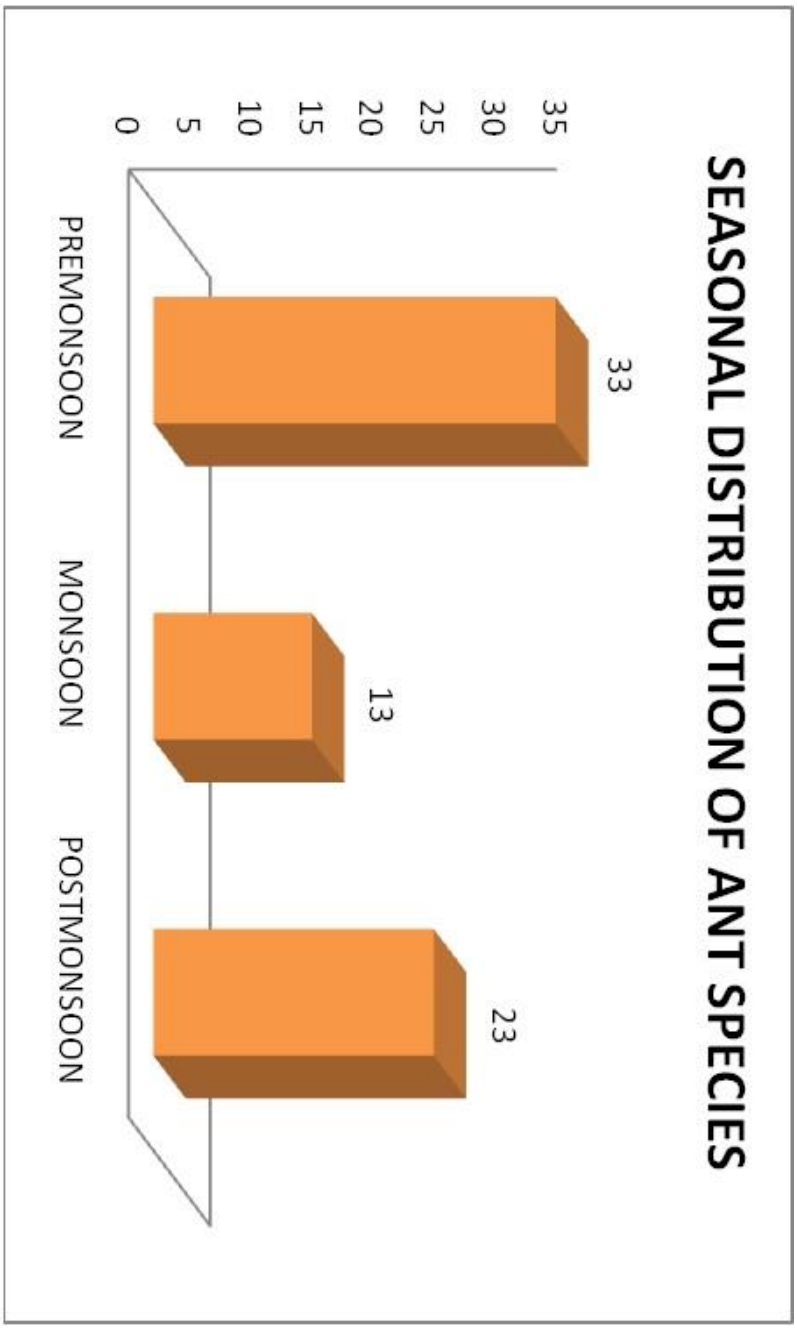


Fig. 4. Seasonal distribution of ant species

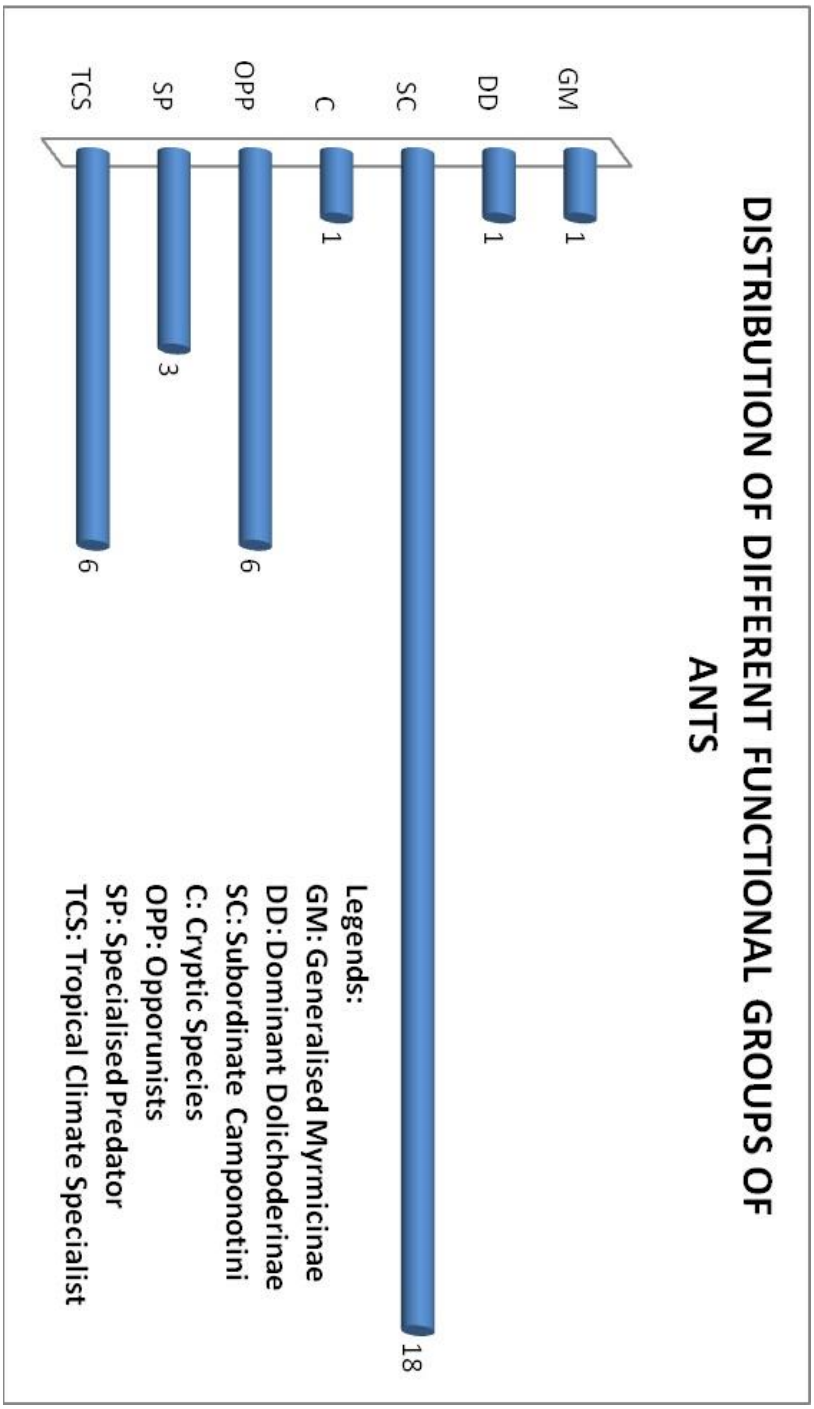


Fig. 5. Total number of ant species under each Functional Group

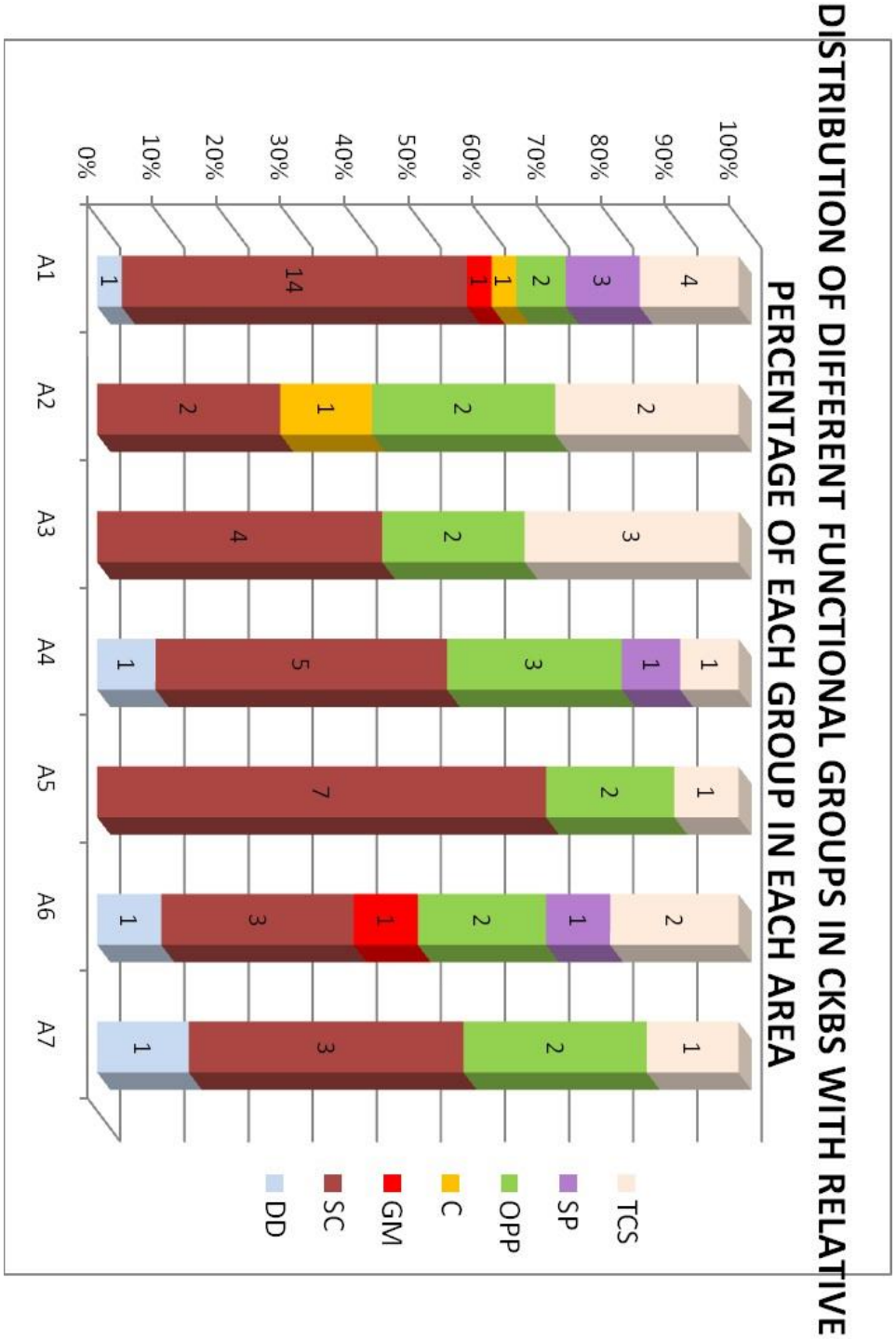


Fig. 6. Relative Ant Functional group distribution in each area of CKBS

DOMINANT DOLICHODERINAE

Dolichoderus (Hypoclinea) affinis Emery

GENERALISED MYRMICINAE

Monomorium orientale Mayr

Fig. 7

SUBORDINATE CAMPONOTINI

Camponotus (Tanaemyrmex) variegatus (Smith)

Camponotus (Orthonotomyrmex) sericeus sericeus (Fabricius)

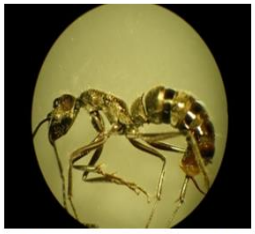
Polyrhachis mayri Roger

Polyrhachis gracilior Forel

Fig. 8

OPPORTUNISTS

Diacamma scalpratum (Smith)



Diacamma vagans Smith

Gnamtogenys bicolor (Emery)

Brachyponera jerdoni (Forel)

Plagiolepis longipes Jerdon

Fig. 9

CRYPTIC SPECIES

Hypoponera confinis (Roger)

Cerapachys aitkenii Forel

Leptogenys kitteli (Mayr)

SPECIALISED PREDATOR

Pseudoneoponera rufipes (Jerdon)

Fig. 10

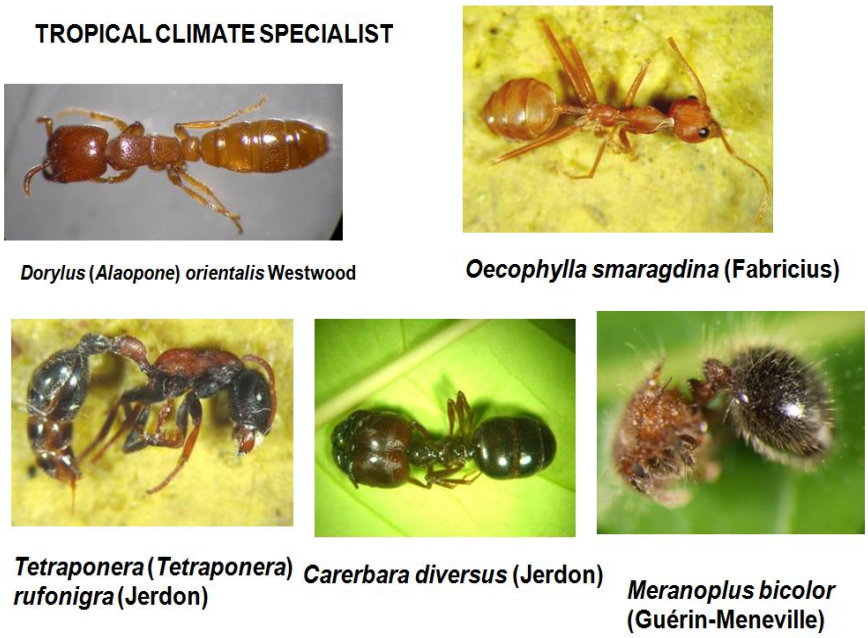


Fig. 11

Figs. 7-11. Functional Ant Groups

Documentation on the visiting profile of Quaker and Lime Blue to their native host plants as pollinating agents

Srinjana Ghosh[1] and **Sumana Saha**[2]

[1] Post Graduate Department of Zoology, Bethune College, Govt. of West Bengal, 181, Bidhan Sarani, Kolkata – 700006, West Bengal, India
E-mail: srinjanaghosh15@gmail.com

[2] Post Graduate Department of Zoology, Barasat Government College, Barasat, Kolkata - 700124, West Bengal, India
E-mail: sahasumana2010@gmail.com

ABSTRACT

The native host plants bearing wildflowers with overlapping blooming periods provide resource for the butterflies, the significant pollinators next to bees. Few of the behavioural features of these diurnal pollinators are co adapted to the phenology as well as fragrance chemistry or floral morphologies of their host plants establishing an ecological specialization state often maintained by stabilizing selection. Such specialization may lead to the considerable variation among reproductive success rates of the host plants. Thus, species specific pollinating attributes over the seasonal continuum of the pollinators towards their common host plants may provide idea about their pollinating potentiality. Lycaenids, with 443 Indian species, are commonly termed as 'blues'. Two representative species, the Quaker and Lime Blue are selected on the basis of their moderate to high abundance level in the study area. Few of their prominent ecological and ethological features concerned to their host plant visiting patterns are reported. The present study is important for highlighting the role of native pollinators to maintain the regional to landscape level floral diversity. The significance of conservation of such global bioindicators also cannot be neglected.

Keywords: butterflies, pollinators, wildflowers, lycaenids, conservation, bioindicators

INTRODUCTION

The diurnal lepidopterans are essential component of any natural terrestrial ecosystem. They are considered as relevant study group due to availability of existing standard tools. Sufficient information regarding their ecobiology is available. They could be considered as potential bioindicator for assessment of environmental health and hygiene (Pollard and Yates, 1993). Lycaenids are on the wing moderately throughout the year, frequently covering a wide range of habitat distribution.

Selection of host plants is based on the criteria of host preference (frequency of visits) and host dependence (on time spent basis). Throughout the study period, few of those plants topped the list with respect to habitat suitability prerequisites for butterflies. Among the climatic parameters, moisture content, rainfall and photoperiodic gradient act as the promoting factor for reproductive fitness. Being ectothermic, microhabitat determinants play crucial role for maintenance of delicate life history phases like oviposition, voltinism, diapauses, eclosion, etc. Latitudinal gradients affect the realized niche shifts on periodic basis to complete the life cycle. Often particular sets of host plants are optimized for different seasons by these poikilotherms, offering a kaleidoscopic assortment over native habitats

(Tiple *et al.* 2009). Floral units belonging to different plant families provide nectar pool with a gradient of sugar and other nutrients volume and concentrations. The nutritional value of consumed nectar promotes adult longevity and reproductive outputs like egg production and egg maturation. Switching of host plants occurs as a result of strong selection pressure to match its phenology with the temporal distribution. Thermal plasticity of host plant resource quality (e.g. Water and nitrogen content etc.) also act as key factor promoting shifting of host plant preference (Dronamraju, 1958; Weiss, 1997). Pollinator-host plant correlation co-evolved as highly diversified as well as unique ecologically sensitive balancing selection measure ensuring their survival. Psychophilic pollinators have established themselves as most effective natural pollinators, just next to the hymenopterans (bees). They are valuable pollinators for wild plants, thus serving key role for natural landscape sustainability (Tiple, 2012). Though the butterflies bear potentiality of playing role as flagship species, recently they are being threatened globally by the risk of habitat isolation, modification, fragmentation or habitat loss mainly due to the natural integrity deteriorating anthropogenic factors like industrialization, urbanisation or overexploiting agrobiological activities. Being extremely sensitive to subtle environmental changes they can act as efficient global bioindicator and the efficient value indicator of biotope quality (van Strien *et al.* 2009). Still a huge ratio of Indian species yet to be described with respect to their detailed ecological and behavioural functionality (Haribal, 1992). So, the present study is an observation based documentation on the visiting profile of the of two commonly found local Lycaenids, Quaker and Lime Blue to their native host plants. The later, interestingly, reported to attain the pest status during their developmental phases to their commonest local host plant, the lime plants. Various behavioural aspects concerned to their resource utilization pattern have been reported as a measure of qualitative description of environmental hygiene. Present study site, Taki, North 24 Parganas, comprising of multiple land use patterns, is presently threatened with huge anthropogenic interventions, particularly the tourism load. Scope exists there for assessing the role of ecological and anthropogenic parameters influencing habitat exploration abilities of native butterfly communities which may become significant from the conservation approaches in turn.

MATERIALS AND METHODS

Study area: Taki, 22.59°N and 88. 92°E. Taki-a municipality under Hasnabad P.S. of Basirhaat Subdivision in North 24 Pgs., West Bengal.. Global Positioning System (GPS; GPSMAP 76Cx, Garmin, Olathe, Kansas, USA) was used to record the geographic coordinates

Average elevation - 5 meters (16ft) at the bank of Ichhamati river

Climate: Subtropical with hot summer, from late March to Early June (avg. temp. range 25-40 °C). Monsoon dates from Mid-June to late August, receiving an average rainfall of 150 mm. A cool, dry winter ranges formulate Nov to early Feb (average temperature range 12-25 °C.

Duration of Study: April 2014 to March 2015

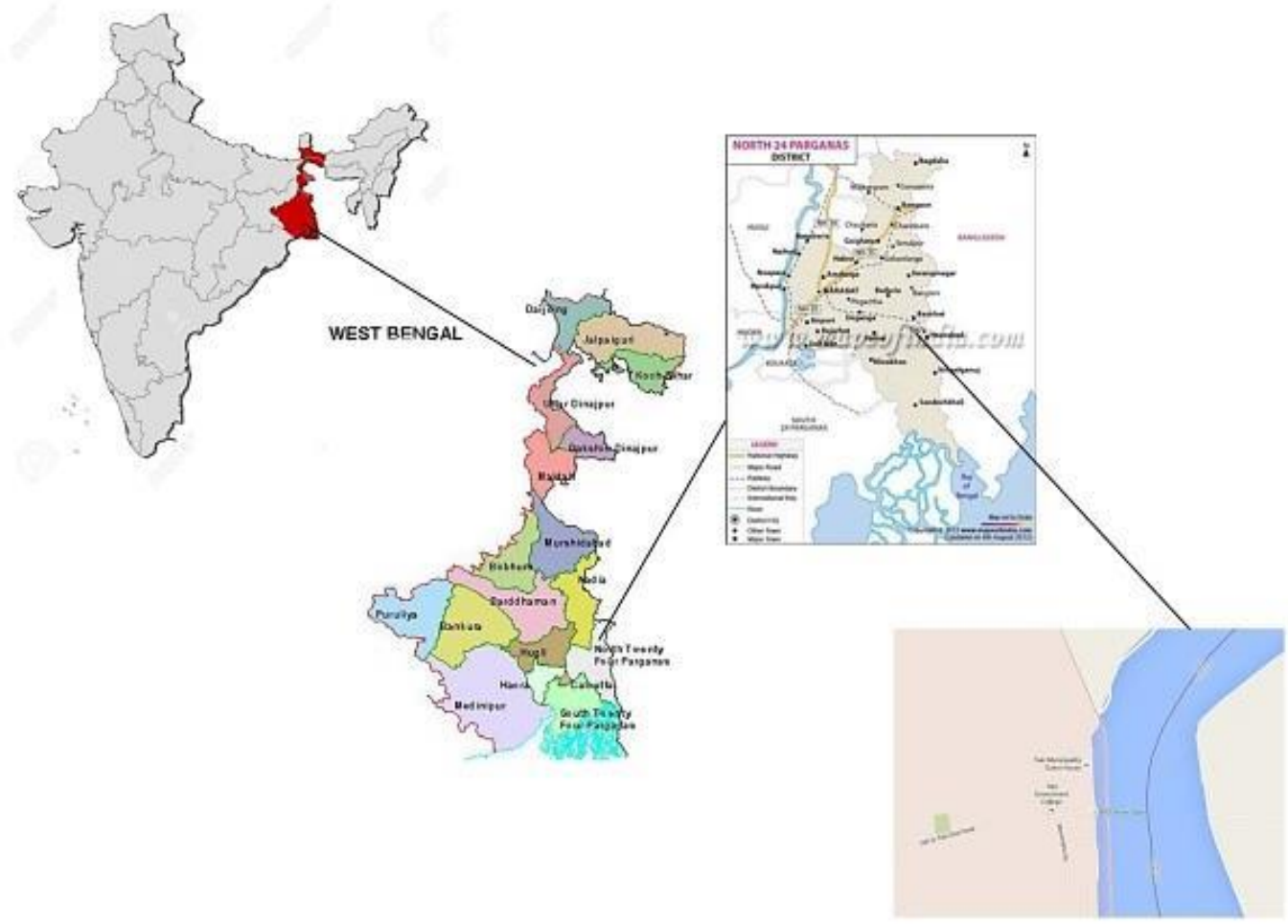
Survey Period: Monthly once; for thrice in a day : 9 am-11 am,12 noon to 2 pm, 3 pm to 5 pm.

Division of seasons (summer, monsoon, post monsoon and winter) based on the variation of rate of precipitation and temperature.

Sampling Techniques: Seasonal availability is reported by presence-absence scoring method. Four randomized transect walks performed for 12 minutes during each survey period through the study areas following "Pollard Walk" method with necessary modifications. Fixed transect routes (250 m long and 5m wide) followed for a particular habitat patch.

Approximately a uniform pace was maintained at each study site. Prominent host plant trails are selected on the basis of >70% of visiting frequencies of the respective butterflies. Nectar and non-nectar host plants randomly selected from the same transect. 5-10 numbers of each host plant species, depending on availability were focussed. Stationary observation time fixed for 15 minutes per survey period at three suitable locations to watch host plant based interactions. Minimum distance for minute observation was constantly maintained to be 1.5 metres between the observer and the host plant. For assuming the visiting profile by butterfly to host plant, 10 frequently encountered and easily observable landing sites, including the floral units and other suitable units were selected for individual host plants. The number of butterflies encountering each host plant and their behavioural specificity were temporarily scanned and reported; duration of specific behaviours noted with the help of a stopwatch. Microhabitat details like canopy layers, foliage surfaces, substratum profiles are also noted. Encountered butterflies were identified using suitable keys (Kehimkar, 2008; Varshney and Smetacek2015)Specific host plants were identified and recorded (Mukherjee, 1981).

Study sites:



RESULTS

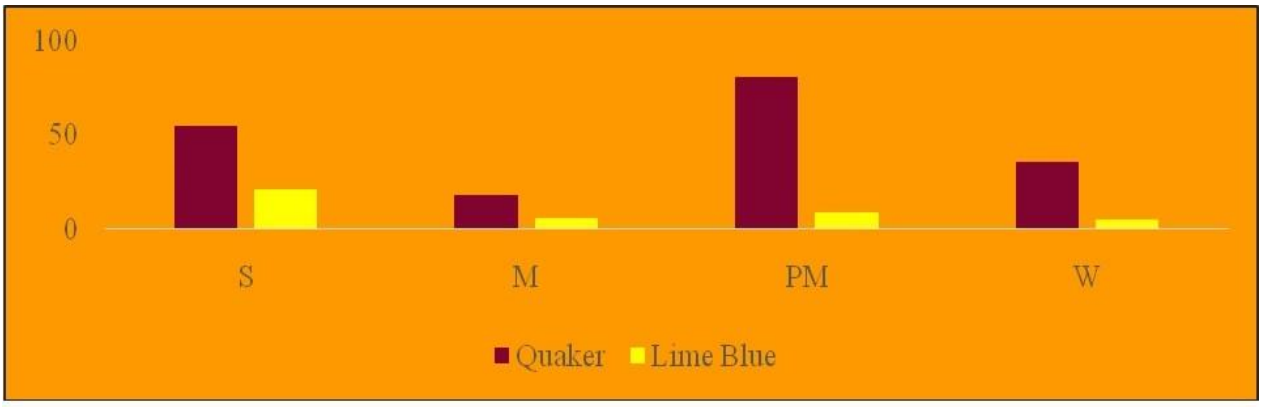


Fig. 1. Seasonal Abundance of the butterfly species

Table 1. Host Plant Profile

A. Quaker (*Neopithecops zalmora*, Butler)

Host plants	Type	Family	Habit and Habitat	Avg. height from ground level (m)	Blooming period	Description of the floral unit
Glycosmis pentaphylla (Ash - Sheora)	non nectar food plant; larval host plant	Rutaceae	wild evergreen Shrub; railway track, river bank, road side vegetation patches	1 -1.5	S, M, PM, W	Small, white flowers; compound inflorescence, racemose, 5 petals
Lantana camara (putush)	nectar plant	Verbenaceae	invasive evergreen shrub; railway tracks, river bank, uncultivated lands, roadside vegetation patches	2-2.5	S, M, PM, W	small white to yellow, orange to red, pink to violet; tubular, 4 petals
Tagetes erecta (taar gaanda)	nectar plant	Asteraceae	both wild and plantation variety; annual herb; garden, cultivated land	1	W	Yellow, orange flower; clustered, both ray and disc florets

B. Lime Blue (*Chilades lajus*, Stoll)

Host plants	Type	Family	Habit and Habitat	Avg. height from ground level (m)	Blooming period	Description of the floral unit
Murraya paniculata (kamini)	nectar plant,food plant, yearlong blooming	Rutaceae	evergreen; garden as well as wild flora	3-5	S, M, PM, W	White
Citrus limon (patilebu)	nectar plant,food plant, larval host plant, seasonal blooming	Rutaceae	evergreen; kitchen garden	upto 6	W, S	White

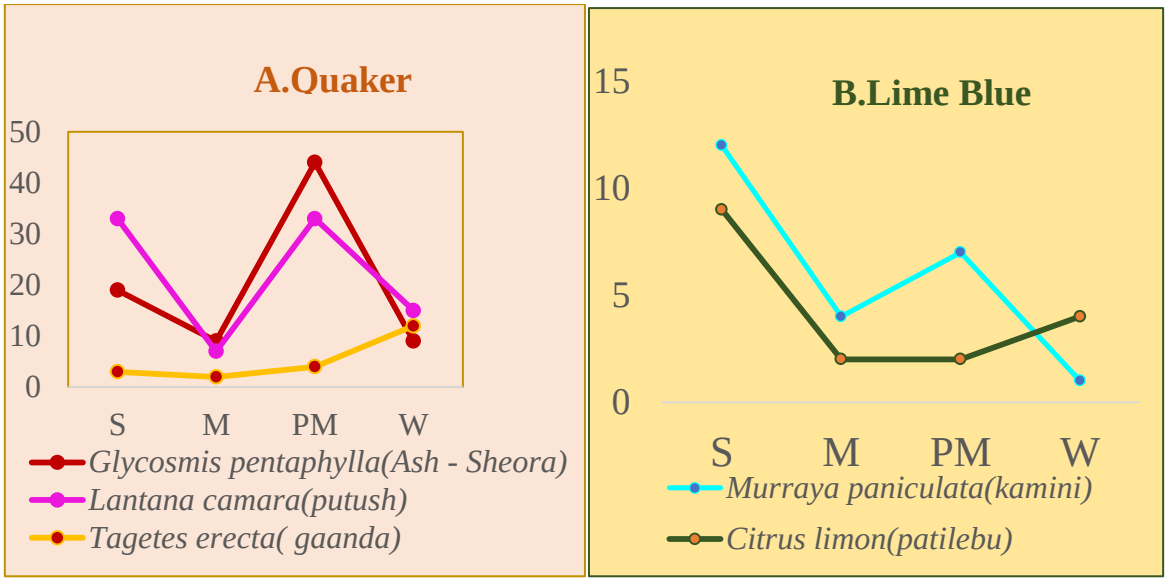


Fig. 2. Host plant based seasonal abundance pattern

Table 2. Seasonal profile of landing quotient on host plants

Landing on host plant includes both contacts and stoppages. Landing platforms provided by the floral units (blooming seasons) or other suitable parts (stem, leaves ,fruits) **landing quotient** is estimated as the number of pollinator landings /per avg. no of available landing sites on each plant/hour. It is considered as a qualitative assessment indicator for host preference.

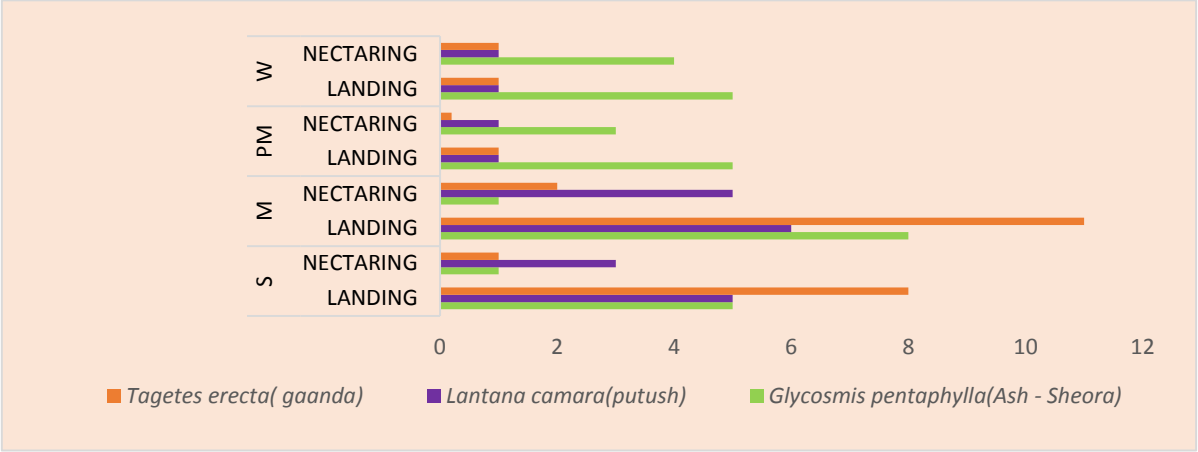
A. Quaker

Host plants	Landing quotient (no. of pollinator landings/available sites)			
	S	**M**	**PM**	**W**
Glycosmis pentaphylla (Ash - Sheora)	0.7	0.7	0.8	0.4
Lantana camara (Putush)	1.2	0.7	1	0.8
Tagetes erecta(Gaanda)	1.1	0.2	0.2	1.5

B. Lime Blue

Host Plants	Landing quotient (no. of pollinator landings/available sites)			
	S	**M**	**PM**	**W**
Murraya paniculata(kamini)	0.27	0.32	0.25	0.21
Citrus limon(patilebu)	0.5	0.4	1.1	0.43

A. Quaker



B. Lime Blue

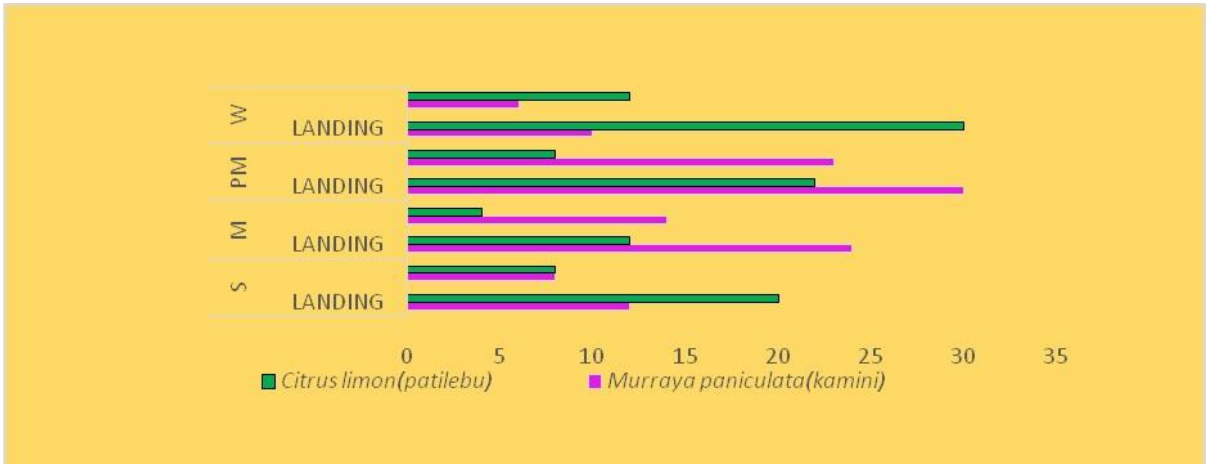


Fig. 3. Landing vs. nectaring profile: (addresses the overall tendency of host dependence for nutrient and other resources)

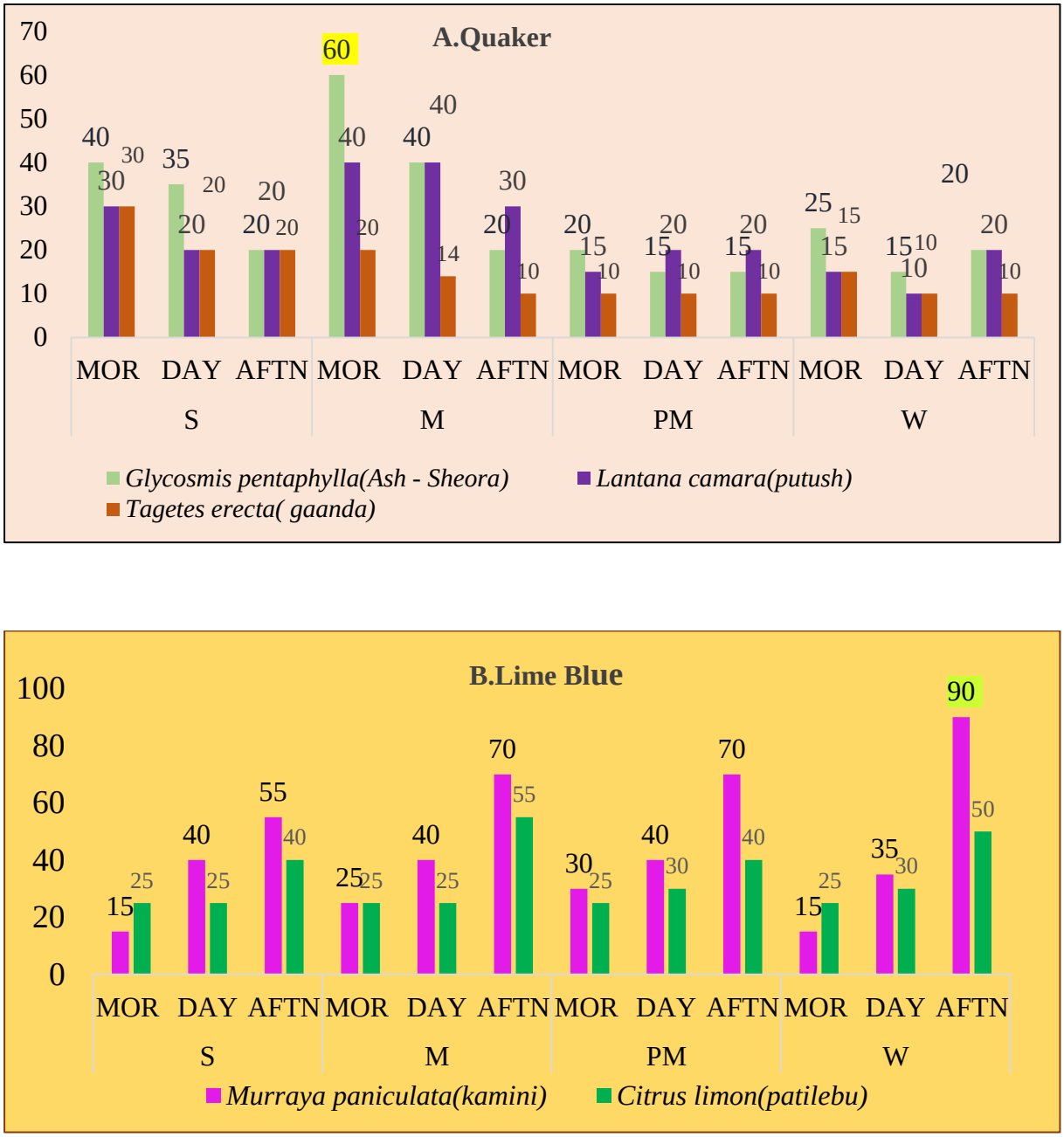
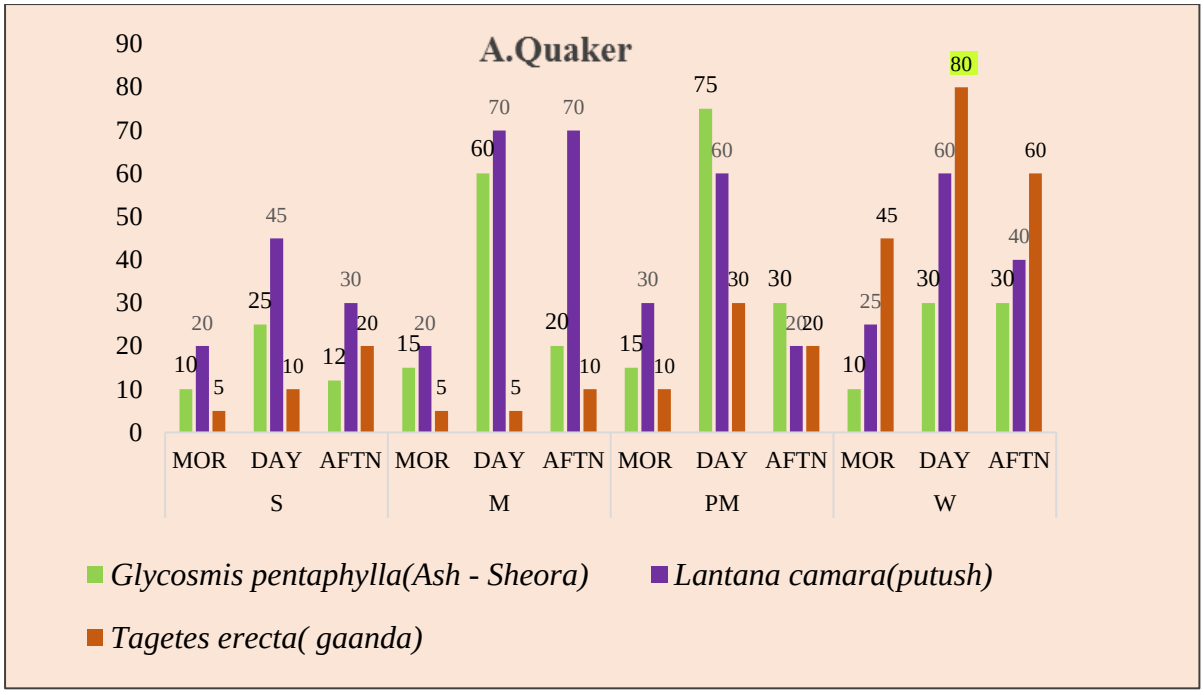


Fig. 4a. Foraging (a. perching b. nectaring) duration (secs);
Perching: sitting folded wing on floral unit or other plant parts to standardize the resource availability; [Avg. perching time /single visit to a single landing site (sec) recorded]



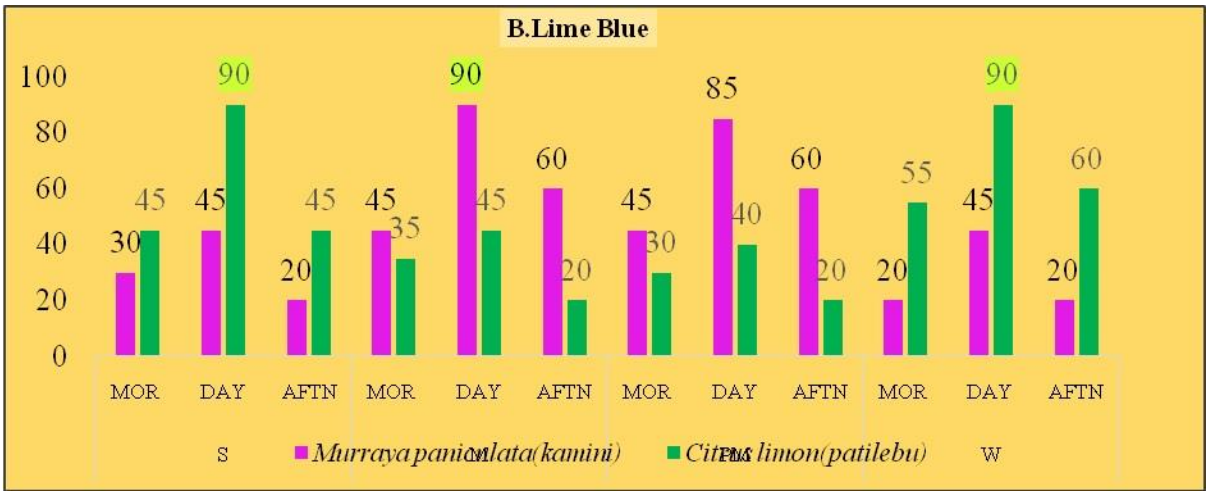
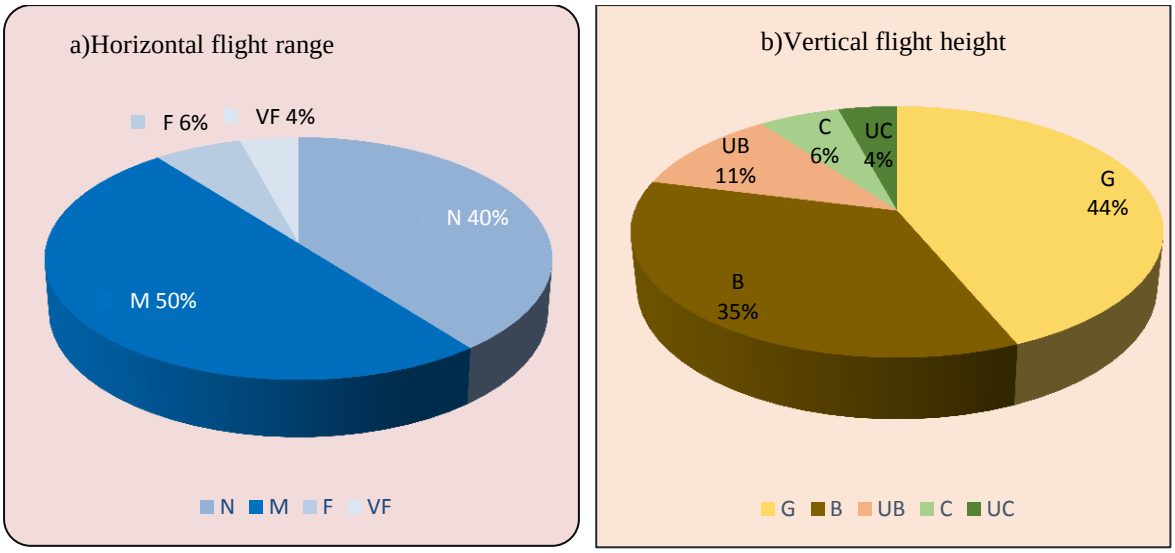


Fig. 4b. Nectaring; Nectaring duration recorded from the moment of dipping butterfly proboscis in the flower corolla till the moment of its withdrawal
[Avg. nectaring duration/single floral unit (secs)

A) Quaker



B) Lime Blue

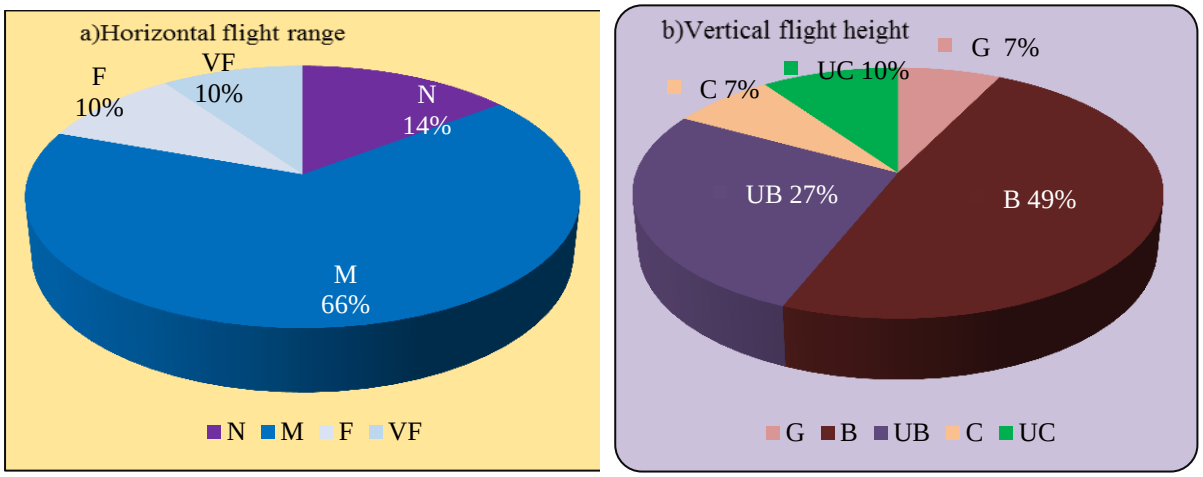


Fig. 5a. Horizontal flight range
Flight range; N- 1.5 m from observation point; M-4.5 m from observation point;
F-7.5 m from observation point- >7.5 m from observation point
b) Vertical flight height
Flight -height – Ground (Ground – 1.5m); B-Bush level (Ground-3. 5m);
UB-Upper Bush level (Ground – 5m); C-Canopy level (Ground to 7.5m);
UC-Upper Canopy level (Ground to >7.5 m)

DISCUSSION

Quaker and Lime Blue both are common visitors to the habitats near human colonisations like railway trackside, urban roadsides, river bank and also in open meadow patches. Lime Blues are likely to visit lime plants in kitchen gardens , orchards and in wild, particularly in summer months. Their larvae being fruitborer they sometimes attain pest level

due to higher infestation rates to the fruits. The instars feed on the fruit pulp. Fig. 2 shows the graphical representation of the overlapping blooming period of the host plants and the annual abundance ratios of the butterflies. It also reflects the temporal correlation between host plant flowering and butterfly oviposition. They are on the wing mostly during summer and post monsoon, followed by that in winter. In Table 2, the landing quotients are listed as the qualitative indicator for host preference varying on seasonal basis. Highest (1.5) is for *Tagetes*, during winter by Quaker and lowest (0.2) is for the same plant during monsoon and post monsoon, which is the blooming period for other two nectar source options *i.e. Lantana* and *Glycosmis* .For Lime Blue ,it is highest (1.1)for *Citrus* during post monsoon and lowest (0.21) for *Murraya* during winter. The host plant switching tendency is also reflected from this table. In Fig. 3, landing vs. nectaring ratios are displayed to address the overall tendency of host plant dependence for nutrient and other resources. For individual host plants, it can act as a measure of exclusive resource provision ability. In Fig. 4, an idea about foraging profile with respect to perching (4a) and nectaring proper (4b) is outlined. Perching is considered to be a behavioural strategy for standardizing resource availability. Sometimes the perching span equivalents to the average temporal spacing between the consecutive visits over a single floral unit.For Quaker ,it is of maximum duration (60 secs) at monsoon morning on *Glycosmis pentaphylla*. Highest perching period for Lime Blue, (90 secs) is reported at winter afternoon on its wild host plant *Murraya paniculata*. Maximum nectaring duration (80 secs) for Quaker is reported at daytime in winter on blooming *Tagetes*. Significant nectaring span (85-90 secs) is reported for Lime Blue, mostly during the daytime throughout the year on both the host plants.

Lepidopteran flight may be categorized according to different functional aspects like: searching flight to locate the nutritional resources or appropriate egg laying site, patrolling flights with the scanning purpose, chasing flights, often displayed by males to maintain territory and last but not the least, the courtship(including the contesting) flights. Our study concentrates on the horizontal and vertical level flight patterns observed during regular foraging on host plants. Specific vertical flight patterns observed during foraging ,territory maintainace (chasing) etc. Lack of any specific defensive measures against their enemies, such type of aerial displays sometimes make them highly vulnerable to predation. As per the horizontal flight range is considered, Quaker found to avail mostly the near (40%) to moderate (50%) ranges whereas Lime Blue avails the moderate range most frequently (66%). Considering the vertical flight height distribution, Quaker commonly occurs G (44%) to B (35%) levels, whereas Lime Blue frequents mostly the B (49%) level.

On the basis of findings from the present study, it can be concluded that, presence of series of host plant species flowering over all seasons may turn favourable for native butterfly species. Retention of wild floral den with at least few blooming all times provides sites for foraging, nesting, basking, resting and hiding purposes. These suitable conditions, if fulfilled, a spatio temporal mosaic of pollinator assemblage may generate. Presence of mud patches as water source and maintenance of suitable soil salinity level also the role of essential survival factors. Damaging anthropogenic activities like grazing, pesticidal over- exposure, excessive tourism load must be restricted to maintain the undisturbed ecological functioning of these insect pollinators (Dover and Settele, 2009).

Ecological outcomes of host-specificity and habitat association of these native pollinating agents encompass the local dispersion to metapopulational expansion. Often the species with narrow dietary breadth show higher larval advancement rates. Mechanical type of floral isolation, maintenance of allopatric speciation mechanisms and prevention of interbreeding between sympatric populations have been made possible by such type of coevolved host-pollinator interactions (Dronamraju, 1958).

Psychophyly helps framing of a pollination network by the polyphagous species in nature. Their ecological functionality could be justified for selecting them as focal indicator for climatic change and urbanization (Clark, Reed and Chew, 2007).

Pre-requisites for their conservation should cover their protection both at the levels of adult and developmental phases**.** Awareness about adult and larval habitat and mode of optimisation of the natural resources by the individuals over a spatial and temporal scale should be created. Conservation both at habitat and landscape level are equally important. Restoration approaches to be adopted keeping in mind that the habitat specialist species are vulnerable to habitat area isolation whereas generalists are more sensitive to landscape values. Sustainable microhabitat management is essential. Finally, minute and detailed information regarding species autecology would be of major help to improvise their conservation scheme.

ACKNOWLEDGEMENTS

The authors express thanks to Smt Bidisha Ray, Faculty, Department of Zoology, Taki Government College, for her cooperation during field visits. Authors remain obliged to Dr. Santanu Saha, Associate Professor, Dept. of Botany, Bidhannagar Govt College for his valuable suggestions. Necessary logistic support extended by the respective Principals of the colleges is thankfully acknowledged. First author (SG) expresses sincere thanks to The Officer-in-charge & Head, Department of Zoology, Taki Government College for their support and encouragement. Sincere thanks are also due to Prof. Dinendra Raychaudhuri for his valuable suggestions during preparation of the manuscript.

LITERATURE CITED

[1] Clark, P.J. & Reed, J.M. & Chew, F.S. 2007. Effects of urbanization on butterfly species richness, guild structure, and rarity. *Urban Ecosystem*, 10: 321-337

[2] Dover, J. & Settele, J. 2009. The influences of landscape structure on butterfly distribution and movement: a review. *Insect Conservation*, 13: 3-27

[3] Dronamraju, K. R. 1958. The visits of insects to different coloured flowers of *Lantana camara* L. *Current Science*, 27: 452-453.

[4] Haribal M. 1992. Butterflies of Sikkim Himalaya and their natural history. Gangtok: *Nature Conservation Foundation*, 217 pp.

[5] Kehimkar, I. (2008). The book of Indian butterflies. Mumbai. Bombay Natural History Society, 520 pp.

[6] Mukherjee, M. 1981. Plant Groups. New Central Book Agency (P) Ltd., 727-1117 pp.

[7] Pollard, E. & Yates, T. J. 1993. Monitoring butterflies for ecology and conservation. Publ. Chapman and Hall, London, 292 pp.

[8] Tiple, A. D., Khurad, A. M. & Dennis, R. L. H. 2009. Adult butterfly feeding-nectar flower associations: constraints of taxonomic affiliation, butterfly, and nectar flower morphology. *Journal of Natural Hist*ory, 43(13), 855-888.

[9] Van Strien, A. J, van Duuren, L., Foppen, R. P. B. & Soldaat, L. L. 2009. A typology of indicators of biodiversity change as a tool to make better indicators. *Ecooical Indicators*, 9: 1041–1048

[10] Varshney, R. K. & Smetacek, P. (Eds.) 2015. A Synoptic Catalogue of the Butterflies of India. Butterfly Research Center, Bhimtal and Indinov Publishing, New Delhi, ii +261 pp.

[11] Weiss, M. R. 1997. Innate colour preferences and flexible colour learning in the pipevine swallowtail. *Animal Behav*iour, 1; 53: 1043-1052.

[12] Suryanarayanac, K. & Venkata Ramanad, S. P. 2015. Ecobiology of the Spot Swordtail *Graphium nomius* (Esper) (Lepidoptera:Rhopalocera:Papilionidae) from the Eastern Ghats of Southern Andhra Pradesh. *International Journal of Plant, Animal and Environmental Sciences*, 5(3): 77-87.

Faunistic Record of Click Beetles (Elateridae : Coleoptera) from Tea Gardens of Darjeeling, West Bengal, India

Sutirtha Sarkar[1a], **Sumana Saha**[2,b] and **Dinendra Raychaudhuri**[1,c]

[1]Department of Agricultural Biotechnology, IRDM Faculty Centre, Ramakrishna Mission Vivekananda University, Narendrapur, Kolkata -700103, India
[a,c]E-mails: sutirthaento@gmail.com, dinendrarccu@gmail.com

[2]Department of Zoology, Barasat Govt. College, Govt. of West Bengal, Kolkata- 700124, India
[b]E-mail: sahasumana2010@gmail.com

ABSTRACT

Eleven species are recorded from six tea gardens of Darjeeling namely Badamtam T.E., Ging T.E., Happy valley T.E., Namring T.E., Selimhill T.E. and Thurbo T.E. of Darjeeling. Out of these six are recorded for the first time from Darjeeling. It is to mention that one species of *Melanotus* Eschscholtz is considered as new to science.

***Keywords*:** Elateridae, Click beetle, Tea Garden, Darjeeling, West Bengal, India

INTRODUCTION

Elaterids are commonly called click beetles. They are one of the important group of insects having considerable significance as pests, predators and pollinators. These beetles are one of the classical example of insects exhibiting a wide range of diversity by virtue of their occurrence in the entire zoogeographical region. Nearly 16,740 species under 840 genera of elaterids are present globally (http://insectoid.info/beetles/click-beetles/). And in India about 527 species under 102 genera present (http://insectoid.info/checklist/elateridae/india/). In 1979, Stibik proposed the higher classification of elaterids. He (op.cit.) dealt up to tribes and provided keys and diagnosis for each of the higher taxa. In the past few decades several authors Vats & Chauhan (1991a,b,c; 1992a,b,c,d,e,f,g,h; 1993); Vats & Kashyap (1992a,b,c,d,e,f; 1995a,b; 1996); Vats & Vasu (1993a,b,c,d,e,f); Punan *et.al* (1995; 1997a,b,c); Punam & Saini (1996); Punam & Vasu (1996a,b); Garg & Vasu (1997; 1998; 1999a,b); Garg *et.al* (1998); Vasu & Garg (1998a,b; 1999); Chakraborty & Chakraborty (2000, 2006); Schimmel (2007); Patwardhan & Athalye (2008; 2010a,b; 2012); Patwardhan *et. al* (2008, 2009a,b); Schimmel & Tarnawski (2012); Sarkar *et.al* (2012; 2015a,b,c; 2016a,b) have enriched our knowledge on Indian Elateridae. In order to explore other available habitats, attempt is made to unveil the diversity spectrum of the said beetles in tea ecosystem of Darjeeling. The species are considered sensu http://insectoid.info/beetles/click-beetles/.

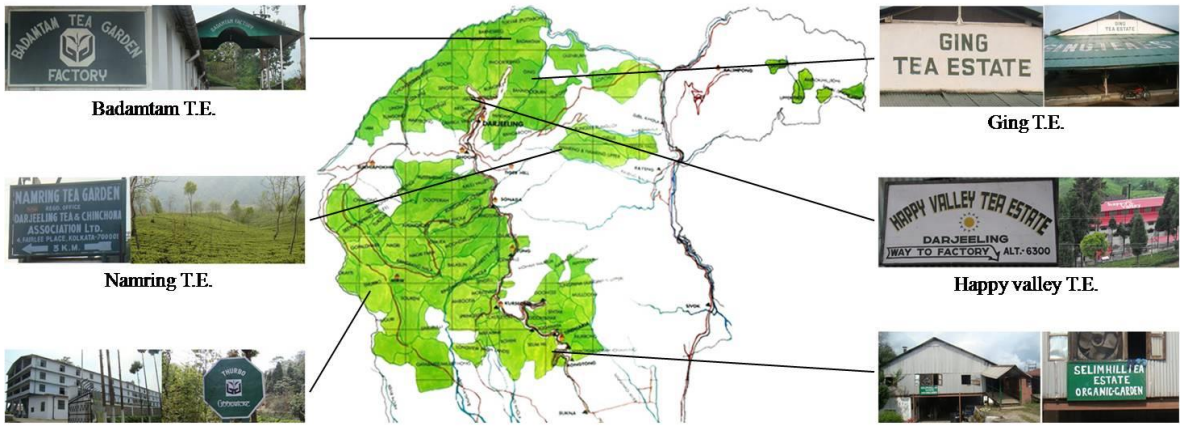
MATERIAL & METHODS

Click beetles were mainly collected during April, 2012 to March, 2014 by visual search, hand picking and UV light trap. Collected samples were preserved following Chakraborty & Chakrabarti (2006). The recorded samples were studied under Stereo Zoom Binocular Microscopes Olympus SZX7 and SZX 16.

Materials are in the deposition of Department of Agricultural Biotechnology, Ramakrishna Mission Vivekananda University.

Abbreviations and symbol used
T.E.- Tea Estate.
* New to Darjeeling.

Study Area



RESULTS

A. Subfamily : Agrypninae

I. Tribe : Agrypnini

1. *Agrypnus costicollis* (Candeze)
[Plate: 1, Fig. a]

1857. *Lacon costicollis* Candeze, *Mem. Soc. r. Sci. Liege,* 12 : 116.
1971. *Agrypnus costicollis* Ohira, *Annls. Hist. Nat. Mus. Natn. hung,* 63 : 205.
1973. *Agrypnus costicollis* von Hayek, *Bull. Br. Mus. Nat. Hist. (Ent.) Suppl.*, 20 : 144.
1979. *Agrypnus costicollis* von Hayek, *Bull. Br. Mus. Nat. Hist. (Ent.)*, 38(5) : 216.

Material Examined: 2♀♀, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: Assam, Sikkim, Uttar Pradesh, West Bengal (Kolkata & Darjeeling); Cambodia, Nepal, Tonkin, Yunnan [Chakraborty & Chakrabarti, 2006; Ohira, 1971; Vats & Kashyap, 1992c; http://insectoid.info/insecta/coleoptera/elateridae/agrypnus_costicollis/ accessed on 18.01.2017].

II. Tribe : Oophorini

2. *Aeoloderma brachmana* (Candeze) *
[Plate: 1, Fig. b]

1859. *Aeolus brachmana* Candeze, *Mon. Elat., II* : 283, 345.
1929. *Aeoloderma brachmana* Fleutiaux, *Ency. Ent., Coleoptera*: 34.
1934. *Aeo1oderma brachmana* Miwa, *Fauna Elat. Japan*: 192.
1967. *Aeloderma brachmana* Ohira, *Ent. Rev., Japan, XIX (2)*: 41.

1970. *Aeloderma brachmana* Ohira, *Annls. Hist. Nat. Mus. Natn. hung, 62* : 211.
1972. *Aeloderma brachmana* Ohira, *Pacific Insects,14(1)*: 5.

Material Examined: 1♀, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: West Bengal (Kolkata, North 24 Parganas & Darjeeling); Borneo, China, Formosa, Java, Myanmar, Philippines, Sri Lanka, Sulawesi, Sumatra, Taiwan, Vietnam [Chakraborty & Chakrabarti, 2006; Ohira, 1972; http://insectoid.info/insecta/coleoptera/elateridae/aeolus_brachmana/ accessed on 18.01.2017].

III. Tribe : Monocrepidiini
3. *Conoderus longipenis* Vats & Chauhan *
[Plate: 1, Fig. c; Plate: 2, Fig. l]
1992. *Conoderus longipenis* Vats & Chauhan, *Uttar Pradesh J. Zool.,* 12 (1): 33.

Material Examined: 2♂♂, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: Uttarakhand, West Bengal (Darjeeling) [Vats & Chauhan, 1992f; http://insectoid.info/insecta/coleoptera/elateridae/conoderus_longipenis/ accessed on 18.01.2017]

B. Subfamily : Cardiophorinae
IV. Tribe : Cardiophorini
4. *Cardiophorus flexus* Vats & Chauhan *
[Plate: 1, Fig. d; Plate: 2, Fig. m]
1991. *Cardiophorus flexus* Vats & Chauhan, *Res. Bull. (Sci.) Panjab University,* 42 (I-IV) : 15.

Material Examined: 2♂♂ & 1♀ , Ging T.E., Darjeeling, West Bengal, India, Coll. D. Raychaudhuri, 17.v.2013; 2♀♀ & 1♂ , Ging T.E., Darjeeling, West Bengal, India, Coll. S. Sarkar, 17.v.2013; 1♀, Ging T.E., Darjeeling, West Bengal, India, Coll. D. Dhali, 17.v.2013; 1♂, Ging T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.v.2013; 2♂♂ & 1♀ , Ging T.E., Darjeeling, West Bengal, India, Coll. T. K. Roy, 17.v.2013; 1♂, Namring T.E., Darjeeling, West Bengal, India, Coll. T. K. Roy, 18.v.2013; 1♀, Namring T.E., Darjeeling, West Bengal, India, Coll. D. Raychaudhuri, 18.v.2013; 1♀, Namring T.E., Darjeeling, West Bengal, India, Coll. S. Sarkar, 18.v.2013.
Distribution: India: Haryana, West Bengal (Darjeeling) [Vats & Chauhan, 1991b; http://insectoid.info/insecta/coleoptera/elateridae/cardiophorus_flexus/ accessed on 18.01.2017].

5. *Phorocardius moorii* (Candeze)
[Plate: 1, Fig. e; Plate: 2, Fig. n]
1860. *Cardiophorus moorii* Candeze, *Mon. Elat.,* 3 : 206.
1971. *Phorocardius moorii* Ohira, *Annls. Hist. Nat. Mus. Natn. hung,* 63 : 215.

Material Examined: 1♂, Ging T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 25.iv.2013; 1♂, Ging T.E., Darjeeling, West Bengal, India, Coll. D. Dhali, 26.iv.2013; 1♂ & 1♀ , Ging T.E., Darjeeling, West Bengal, India, Coll. S. Sarkar, 26.iv.2013; 1♂, Ging T.E., Darjeeling, West Bengal, India, Coll. D. Raychaudhuri, 14.v.2013; 1♂, Ging T.E.,

Darjeeling, West Bengal, India, Coll. D. Raychaudhuri, 17.v.2013; 2♂, Ging T.E., Darjeeling, West Bengal, India, Coll. S. Sarkar, 17.v.2013; 2♂, Ging T.E., Darjeeling, West Bengal, India, Coll. T. K. Roy, 17.v.2013.
Distribution: India: Sikkim, Tamil Nadu, West Bengal (Darjeeling); Bhutan [Chakraborty & Chakrabarti, 2006; Ohira, 1971; http://insectoid.info/insecta/coleoptera/elateridae/phorocardius_moorii/ accessed on 18.01.2017]

6. *Horistonotus spatulatus* Vats & Chauhan *
[Plate: 1, Fig. f]
1993. *Horistonotus spatulatus* Vats & Chauhan, *J. ent. Res.*, 17(1): 37.

Material Examined: 1♀, Badamtam T.E., Darjeeling, West Bengal, India, Coll. T. K. Roy, 24.iv.2013.
Distribution: India: Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Uttar Pradesh, West Bengal (Darjeeling) [Vats & Chauhan, 1993]
http://insectoid.info/insecta/coleoptera/elateridae/horistonotus_spatulatus/ [accessed on 18.01.2017]

C. Subfamily : Elaterinae

V. Tribe : Ampedini
7. *Melanotus cribriventris* Blatchley
[Plate: 1, Fig. g; Plate: 2, Fig. o]
1860. *Melanotlus longicornis* Candeze, *Mon. Elat.* III : 332.
1910. *Melanotus cribriventris* Blatchley, An illustrated descriptive catalogue of the Coleoptera or beetles (exclusive of the Rhynchophora) known to occur in Indiana: 747.

Material Examined: 1♂, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: Assam, Sikkim, West Bengal, (Darjeeling & Kolkata); China, Sri Lanka, USA [Chakraborty & Chakrabarti, 2006; Ohira, 1971; Quate & Thompson, 1967; http://insectoid.info/insecta/coleoptera/elateridae/melanotus_cribriventris/ accessed on 18.01.2017]

8. *Melanotus fuscus* (Fabricius)
[Plate: 1, Fig. h; Plate: 2, Fig. p]
1801. *Elater fuscus* Fabricius, *Syst. Eleuth*, II : 228.
1860. *Melanotus fuscus* Candeze, *Mon. Elat*., III : 335.

Material Examined: 2♂♂, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012; 1♀, Namring T.E., Darjeeling, West Bengal, India, Coll. S. Sarkar, 18.v.2013.
Distribution: India: Sikkim, Tripura, West Bengal. (Darjeeling, Jalpaiguri, Kolkata & Murshidabad); Ambon, Cambodia, Indonesia, Laos, Mayanmar, Sri Lanka, Taiwan, Thailand, Vietnam, Yunnan. [Chakraborty & Chakrabarti, 2006; Ohira 1970; http://insectoid.info/insecta/coleoptera/elateridae/melanotus_fuscus/ accessed on 18.01.2017].

9. *Melanotus kumaunensis* Vats & Chauhan *
[Plate: 1, Fig. i]

1991. *Melanotus kumaunensis* Vats & Chauhan, *J. ent. Res.,* 15(3): 188.

Material Examined: 1♀, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: Uttarakhand, West Bengal (Darjeeling) [Vats & Chauhan, 1991a; http://insectoid.info/insecta/coleoptera/elateridae/melanotus_kamaunensis/ accessed on 18.01.2017].
[mis spelt in Vats & Chauhan,1991;
http://insectoid.info/insecta/coleoptera/elateridae/melanotus_kamaunensis/ accessed on 18.01.2017; Type locality : Almora that falls within Kumaun Himalaya; for further detail see Final Technical Report, L.K. Vats, 1991]

10. *Melanotus bifoveatus* Vats & Chauhan *
[Plate: 1, Fig. j]

1991. *Melanotus bifoveatus* Vats & Chauhan, *J. Ent. Res.,* 15(3):192.

Material Examined: 2♀♀, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: Uttrakhand, West Bengal (Darjeeling) [Vats & Chauhan, 1991a; http://insectoid.info/insecta/coleoptera/elateridae/melanotus_bifoveatus/ accessed on 18.01.2017].

11. *Melanotus* n. sp. (to be communicated elsewhere)
[Plate: 1, Fig.: k; Plate: 2, Fig. q]

Material Examined: 2♂♂, Happy valley T.E., Darjeeling, West Bengal, India, Coll. S. Saha, 17.vii.2012.
Distribution: India: West Bengal (Darjeeling).

DISCUSSION

First ever attempt to explore elaterids in tea ecosystem of Darjeeling has lead to the recognition of 11 species of which a *Melanotus* species is considered new to science. Six more species viz., *Aeoloderma brachmana* (Oophorini), *Conoderus longipenis* (Monocrepidiini), *Cardiophorus flexus*, *Phorocardius moorii*, *Horistonotus spatulatus* (Cardiophorini) and *Melanotus kumaunensis* (Ampedini) are additions to the list of recorded species from Darjeeling. It is probable that such habitat is conducive for the click beetles to sustain. However, further data may conclude on their regular occurrence and exploitation of the habitat.

ACKNOWLEDGEMENTS

Authors are indebted to Tea Board (Sanction no. RL-33(167)/2010/Part-VI) for sponsoring the project, The Head, Dept. of Zoology, University of Calcutta and The Hon'ble Vice Chancellor, Ramakrishna Mission Vivekananda University for necessary support.

LITERATURE CITED

[1] Chakraborty, P. & Chakraborty, S. 2000. Agrypninae (Coleoptera: Elateridae) of India: A taxonomic review and checklist. Records of the Zoological Survey of India, 98(3): 71-83.

[2] Chakraborty, P. & Chakrabarti, S. 2006. A contribution to the fauna of click-beetles (Coleoptera: Elateridae) of West-Bengal. Records of the Zoological Survey of India, Occasional Paper no. 254: 1-220.

[3] Garg, P. & Vasu, V. 1997. New additions of genus *Silesis* candeze (Insecta: Coleoptera: Elateridae: Adrastinae) to the indian fauna. The Raffles Bulletin of Zoology, 45 (1): 53-59.

[4] Garg, P & Vasu, V. 1998. Studies on Indian species of *Cardiorhinus* Eschscholtz (Coleoptera : Elateridae : Cardiorhininae). Journal of the Bombay Natural History Society, 95(1): 96-98.

[5] Garg, P. & Vasu, V. 1999a. A new species of *Sericus* Eschscholtz (Coleoptera : Elateridae : Ludiinae) from India. Journal of the Bombay Natural History Society, 96(1): 111-112.

[6] Garg, P. & Vasu, V. 1999b. A new species of *Agonischius* Candeze (Coleoptera : Elateridae : Ludiinae) from India. Journal of the Bombay Natural History Society, 96(2): 281-284.

[7] Garg, P., Saini, M. S. & Vasu, V. 1998. New species of *Silesis* Candeze (Coleoptera: Elateridae: Adrastinae) from India. Journal of the Bombay Natural History Society, 95 (3): 460-464.

[8] Ohira, H. 1970. A List of the Elaterid-Beetles from South Asia Preserved in the Hungarian Natural History Museum (Coleoptera) Parts I.-V. Annales Historico-Naturales Musei Nationalis Hungarici, 62: 207-243

[9] Ohira, H. 1971. A List of the Elaterid-Beetles from South Asia Preserved in the Hungarian Natural History Museum, Part VI. (Coleoptera). Annales Historico-Naturales Musei Nationalis Hungarici, 63: 205-216

[10] Ohira, H. 1972. Elaterid-Beetles from Taiwan in Bishop Museum (Coleoptera). Pacific Insects, 14(1): 1-14.

[11] Patwardhan, A. & Athalye, R.P. 2008. Genera of Click Beetles (Coleoptera : Elateridae) from Maharashtra. Proc. Sem. "Wonderful World of Insects": 47-50.

[12] Patwardhan, A. & Athalye, R.P. 2010a. New records and two new species of Cardiophorine Elateridae from Maharashtra, India (Insecta: Coleoptera). Genus, 21(4): 505-511.

[13] Patwardhan, A. & Athalye, R.P. 2010b. Two new species of Dicrepidiini from Maharashtra, India with note on structure of hind wing and genitalia of some previously described species (Coleoptera: Elateridae). Genus, 21(1): 43-52.

[14] Patwardhan, A. & Athalye, R.P. 2012. *Plectrosternus* Lacordaire, 1857 (Coleoptera: Elateridae); genus new to northern Western Ghats, India with a description of one new species. Zootaxa, 3193: 53-61.

[15] Patwardhan, A., Schimmel, R. & Athalye, R.P. 2008. A new species of *Xanthopenthes* Fleutiaux 1928 from Maharashtra, India (Coleoptera: Elateridae). Genus, 19(4): 675-678.

[16] Patwardhan, A., Platia, G. & Athalye, R.P. 2009a. A new species of *Metriaulacus* Schwarz, 1901 from Maharashtra, India. Bionano Frontier, 2(1): 15-17.

[17] Patwardhan, A., Schimmel, R. & Athalye, R.P. 2009b. A new genus *Punctodensus* from North Western Ghat, Maharastra, India (Coleoptera: Elateridae: Agrypninae: Hemirrhipini). Genus, 20(1): 53-60.

[18] Punam & Saini, M.S. 1996. Three new species of *Ctenicera* Latreille (Colepotera: Elateridae: Ctenicerinae) from India. Journal of Entomological Research, 20 (4): 317-323.
[19] Punam & Vasu, V. 1996a. Two new species and a revised key to genus *Neodiploconus* Hyslop (Coleopteira, Elateridae, Melanotinae) from India. Journal of the Bombay Natural History Society, 9: 260-262.
[20] Punam & Vasu, V. 1996b. A new spceies of *Megapenthes* Kiesenwetter (Coleoptera: Elateridae : Ampedinae) frorn India. Journal of Entomological Research, 20 (4): 345-347.
[21] Punam, Vasu & Vats. 1995. A new species of *Monadicus* Candeze (Coleoptera : Elateridae : Hypnoidinae) together with a key to Indian species. Journal of Entomological Research, 19 (4): 363-365.
[22] Punam, Saini, M.S. & Vasu, V. 1997a. New additions to genus *Cardiophorus* Eschscholtz (Coleoptera: Elateridae : Cardiophorinae) frorn India. Journal of Entomological Research, 21 (1): 65-70.
[23] Punam, Saini, M.S. & Vasu, V. 1997b. New elaterid fauna or *Melanotus* Eschscholtz (coleoptera : Elateridae : Melanotinae) from India. Journal of Entomological Research, 21 (2): 99-105.
[24] Punam, Saini, M.S. & Vasu, V. 1997c. New additions to the Indian fauna of *Agrypnus* Eschscholtz (Coleoptera : Elateridae: Agrypninae). Journal of Entomological Research, 21 (3): 283-289.
[25] Quate, L. W & Thompson, S.E. 1967. Revision of click beetles of genus *Melanotus* in America North of Mexico (Coleoptera: Elateridae). Proceedings of the United States National Museum, 121(3568): 1-83.
[26] Sarkar, S., Saha, S. & Raychaudhuri, D. 2012. On the elaterid fauna (Coleoptera) of Buxa Tiger Reserve (BTR), West Bengal, India. Munis Entomology & Zoology, 7 (2): 1195-1198.
[27] Sarkar, S., Saha, S. & Raychaudhuri, D. 2015a. Conoderinae (Elateridae) of Buxa Tiger Reserve, West Bengal, India. Munis Entomology & Zoology, 10 (2): 328-332.
[28] Sarkar, S., Saha, S. & Raychaudhuri, D. 2015b. Click beetle diversity of Buxa Tiger Reserve, West Bengal, India. World Scientific News, 19: 120-132.
[29] Sarkar, S., Saha, S. and Raychaudhuri, D. 2015c. Cardiophorine Click Beetles (Elateridae) of Buxa Tiger Reserve, West Bengal, India. Romanian Journal of Biology-Zoology, 60(1): 3–11.
[30] Sarkar, S., Saha, S. & Raychaudhuri, D. 2016a. A new *Ampedus* Dejean (Elateridae : Elaterinae) from Buxa Tiger Reserve, West Bengal, India. Species, 17(54): 1-5.
[31] Sarkar, S., Saha, S. & Raychaudhuri, D. 2016b. Five new click beetles of *Melanoxanthus* Eschscholtz (Elateridae: Elaterinae) from Buxa Tiger Reserve, West Bengal, India. World Scientific News, 50: 1-19.
[32] Schimmel, R. 2007. New records on Elateridae, and description of a new species from Westghats in India (Insecta: Coleoptera). Genus, 18(2): 221-238.
[33] Schimmel, R. & Tarnawski, D. 2012. Negastriinae Studies: Species of the Genus *Arhaphes* Candèze, 1860 (Insecta: Coleoptera: Elateridae). Zoological Studies, 51(4): 536-547.
[34] Stibick, J. N. L. 1979. Classification of the Elateridae (Coleoptera) Relationships and classification of the subfamilies and tribes. Pacific Insects, 20 (2-3): 145-186.
[35] Vasu, V. & Garg, P. 1998a. Male reproductive organs of *Campsosternus gigas* Vats & Kashyap (Coleoptera : Elateridae : Chalcolepidinae). Insect Environment, 4(1): 7.
[36] Vasu, V. & Garg, P. 1998b. Host plants of Indian species of *Heteroderes* Latreille (Coleoptera : Elateridae). Insect Environment, 4(2): 54-55.

[37] Vasu, V. & Garg, P. 1999. Flight Records for the Indian Conoderin Click Beetles (Coleoptera : Elateridae: Conoderinae). Environment & Ecology, 17 (1): 233-235.
[38] Vats, L.K. & Chauhan, R.L. 1991a. Species of *Melanotus* Eschscholtz (Elateridae: Coleoptera). Journal of Entomological Research, 15 (3): 187-196.
[39] Vats, L.K. & Chauhan, R.L. 1991b. The species of *Cardiophorus* from North India (Elateridae: Coleoptera). Research Bulletin (Science) of the Panjab University, 42(I-IV): 11-29.
[40] Vats, L.K. & Chauhan, R.L. 1991c. Species of Hypnoidinae from North India (Coleoptera: Elateridae). Journal of Entomological Research, 15 (4): 294-300.
[41] Vats, L.K. & Chauhan, R.L. 1992a. Two new species of Ampedinae (Coleoptera: Elateridae). Journal of Entomological Research, 16 (1): 20-23.
[42] Vats, L.K. & Chauhan R.L. 1992b. Description of species of *Anchastus* LeConte from North India (Coleoptera: Elateridae). Journal of Entomological Research, 16(3): 185-188.
[43] Vats, L.K. & Chauhan R.L. 1992c. Two new species of *Adiaphorus* Candeze from North India (Coleoptera : Elateridae). Journal of Entomological Research, 16(3): 177-180.
[44] Vats, L.K. & Chauhan R.L. 1992d. New species of *Glyphonyx* Candeze (Elateridae : Coleoptera) from north India. Journal of Entomological Research, 16(3): 177-180.
[45] Vats, L.K. & Chauhan R.L. 1992e. New species of Ludiinae (Coleoptera : Elateridae). Journal of Entomological Research, 16(3): 189-192.
[46] Vats, L.K. & Chauhan R.L. 1992f. Species of *Conoderus* Esch. with notes on genus (Conoderinae, Elateridae: Coleoptera). Uttar Pradesh Journal of Zoology, 12(1): 28-36.
[47] Vats, L.K. & Chauhan R.L. 1992g. Two new species of *Adrastus* Eschscholtz (Coleoptera: Elateridae). Journal of Entomological Research, 16(3): 181-184.
[48] Vats, L.K. & Chauhan R.L. 1992h. New species of *Ctenicera* Latreille from northern India (Coleoptera: Elateridae). Journal of Entomological Research, 16(1): 24-32.
[49] Vats, L.K. & Chauhan R.L. 1993. Four new species of Elateridae (Coleoptera) from North India. Journal of Entomological Research, 17(1): 35-41.
[50] Vats, L.K. & Kashyap, S.L. 1992a. Seven new species of *Adelocera* Latreille from North-West India (Coleoptera: Elateridae). Journal of Entomological Research, 16 (1): 1-12.
[51] Vats, L.K. & Kashyap, S.L. 1992b. Four new species of subfamily Hemirrhipinae (Coleoptera: Elateridae). Journal of Entomological Research, 16 (3): 193-200.
[52] Vats, L.K. & Kashyap, S.L. 1992c. Forty-eight species of *Agrypnus* Eschscholtz including forty new additions from North-West India (Coleoptera:Elateridae). Journal of Entomological Research, 16 (2): 87-154.
[53] Vats, L.K. & Kashyap, S.L. 1992d. A new genus with a description of new species of Crepidomeninae (Coleoptera: Elateridae) from North India. Journal of Entomological Research, 16 (4): 252-254.
[54] Vats, L.K. & Kashyap, S.L. 1992e. Description of three species including two new species of subfamily Denticollinae (Coleoptera: Elateridae) from North India. Journal of Entomological Research, 16 (4): 247-251.
[55] Vats, L.K. & Kashyap, S.L. 1992f. Four new species of *Lacon* Castelnau from North India (Coleoptera: Elateridae). Journal of Entomological Research, 16 (1): 13-19.
[56] Vats, L.K. & Kashyap, S.L. 1995a. A new species of *Octocryptus* Candeze (Coleoptera: Elateridae: Octocryptinae) with notes on the genus. Journal of Entomological Research, 19 (3): 215-217.
[57] Vats, L.K. & Kashyap, S.L. 1995b. A new species of the genus *Tetralobus* Lepel. and Serv. (Coleoptera: Elateridae). Journal of Entomological Research, 19 (2): 171-173.

[58] Vats, L.K. & Kashyap, S.L. 1996. Species of *Meristhus* Candeze from North India (Coleoptera: Elateridae: Agrypninae). Journal of Entomological Research, 20 (1): 67-72.
[59] Vats, L.K. & Vasu, V.1993a. Studies of internal organs of reproduction in *Ampedus* Germar (Coleoptera: Elateridae: Ampedinae). Journal of Entomological Research, 17 (2): 137-140.
[60] Vats, L.K. & Vasu, V. 1993b. Taxonomic significance of the internal organs of reproduction in *Melanotus* Esch. (Coleoptera: Elateridae: Melanotinae). Journal of Entomological Research, 17 (2): 121-124.
[61] Vats, L.K. & Vasu, V. 1993c. Taxonomic importance of internal organs of reproduction in Agrypninae (Coleoptera: Elateridae). Journal of Entomological Research, 17 (1): 65-70.
[62] Vats, L.K. & Vasu, V. 1993d. Internal organs of reproduction in *Cardiophorus* Esch. (Coleoptera: Elateridae: Cardiophorinae). Journal of Entomological Research, 17(3): 159-162.
[63] Vats, L.K. & Vasu, V. 1993e. Comparative studies on the internal organs of reproduction in Conoderinae (Coleoptera: Elateridae). Journal of Entomological Research, 17(3): 163-168.
[64] Vats, L.K. & Vasu, V. 1993f. A comparative account to evaluate the taxonomic importance of the male reproductive organs of click beetles (Coleoptera: Elateridae). Journal of Entomological Research, 17(4): 233-238.

Plate : 1

Fig. Dorsal habitus of **a.** *Agrypnus costicollis* (Candeze); **b.** *Aeoloderma brachmana* (Candeze); **c.** *Conoderus longipenis* Vats & Chauhan; **d.** *Cardiophorus flexus* Vats & Chauhan; **e.** *Phorocardius moorii* (Candeze); **f.** *Horistonotus spatulatus* Vats & Chauhan; **g.** *Melanotus cribriventris* Blatchley; **h.** *Melanotus fuscus* (Fabricius); **i.** *Melanotus kumaunensis* Vats & Chauhan; **j.** *Melanotus bifoveatus* Vats & Chauhan; **k.** *Melanotus* n. sp.

Plate : 2

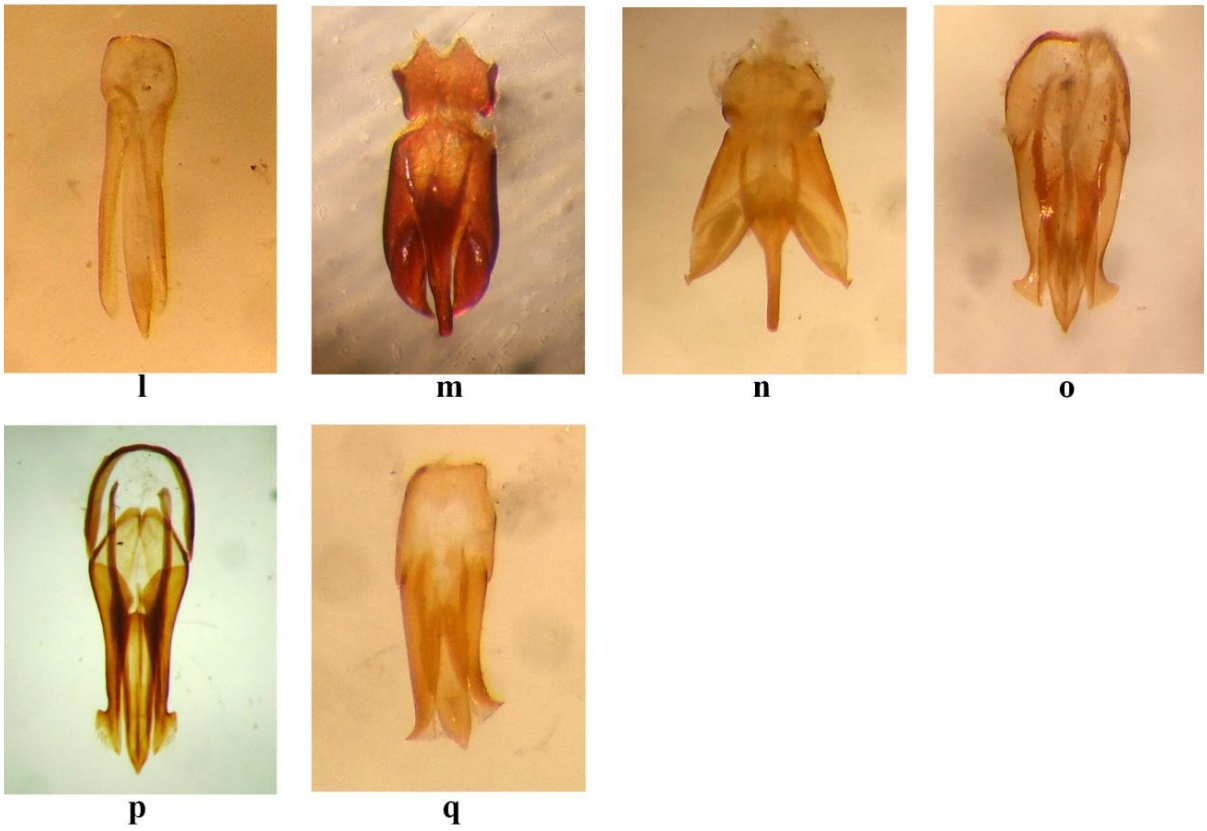


Fig. Male genitalia of **l.** *Conoderus longipenis* Vats & Chauhan; **m.** *Cardiophorus flexus* Vats & Chauhan; **n.** *Phorocardius moorii* (Candeze); **o.** *Melanotus cribriventris* Blatchley; **p.** *Melanotus fuscus* (Fabricius); **q.** *Melanotus* n. sp.

A Study on Nectar Plant Preference of Butterflies at Juvenile Detention Center, Barasat

Upasana Chattopadhyay

Post Graduate Department of Zoology, Barasat Government College,
Barasat (North 24 Parganas), Kolkata 700124, India
E-mail: upasana.chatterjee27@gmail.com

ABSTRACT

Nectar is the primary nutrient source for adult butterflies. Plant species vary in their nectar content that may influence the biological attributes of the dependent life forms. Butterflies too differ in the range of available nectar resources for exploitation. Seven flowering plant species were selected in the study area, Kisholoy, Juvenile Detention Center, Barasat, where butterflies visit the most. Data was generated from three individual plants of each of the seven plant species. Each plant individual was observed for scheduled time period in the morning to record the encounters of butterfly species. Thirty eight [38] butterfly species of five [5] families were recorded during the study period. It was found that, the encounter frequencies of butterfly species varied for different nectar plant species. It was also observed that butterflies of a particular family preferred a specific nectar plant species or even a particular plant of a selected species. None of the seven nectar plants did attract members of all the five butterfly families. Lycaenids were found to be the most frequent visitors in different nectar plants like *Aerva lanata*, *Acmella uliginosa* and *Sida* sp. In case of *Mikania micrantha*, nymphalids were frequent visitors following lycaenids.

***Keywords*:** Butterfly, Nectar, Plant Preference

INTRODUCTION

Lepidoptera is the second largest order in the class Insecta and constitutes an important component of terrestrial biodiversity (New and Collins, 1991). In entire life cycle, butterflies mostly depend on two types of plants: host plants and nectar plants. Caterpillars feed on the foliage of their particular host plant species and adult butterflies feed on nectar from flowers of certain plants (Nimbalkar *et al*., 2011). However, caterpillars are often limited to a single host plant, but adult butterflies utilize a wide variety of plant species for their nectar resources. Nectar, the primary nutrient for adult butterfly varies in plant species both in its carbohydrates and constituent components that may affect fecundity (Romeis and Wäckers, 2002). Therefore, both quality and quantity of nectar has direct bearing on the occurrence, distribution and density of different butterfly species (Fothergill and Vaughn, 2009).

Butterflies are the potential taxa for biodiversity conservation. They have enormous ecological importance. After bees, butterflies are the second category of insects which are very specific to their food plants. Presence of butterflies indicates healthy habitat enriched with flowering plants whereas diminishing number of butterflies indicates disturbed habitat (Roy *et al*., 2012; Mukherjee *et al*., 2015) and the presence of grass butterflies indicates complete conversion of forests into an agricultural ecosystem

(Borges *et al*., 2003). Hence, documentation of butterfly species, their occurrence and characteristics may provide crucial information on the ecology of a particular region. The present study was carried out in a suburban area [Kisholoy, Juvenile Detention Center, Barasat] to understand nectar plant preference of some butterflies and to find out if nectar plant choice for a particular butterfly family is similar or not.

MATERIALS AND METHODS

Study Area

The overall study was carried out in Kisholoy (Juvenile Detention Center), near Vidyasagar Krirangan, Barasat (22.72° N, 88.48° E). The area is a mixed habitat comprising different types of marshy plants, shrubs, trees and scattered human settlements.

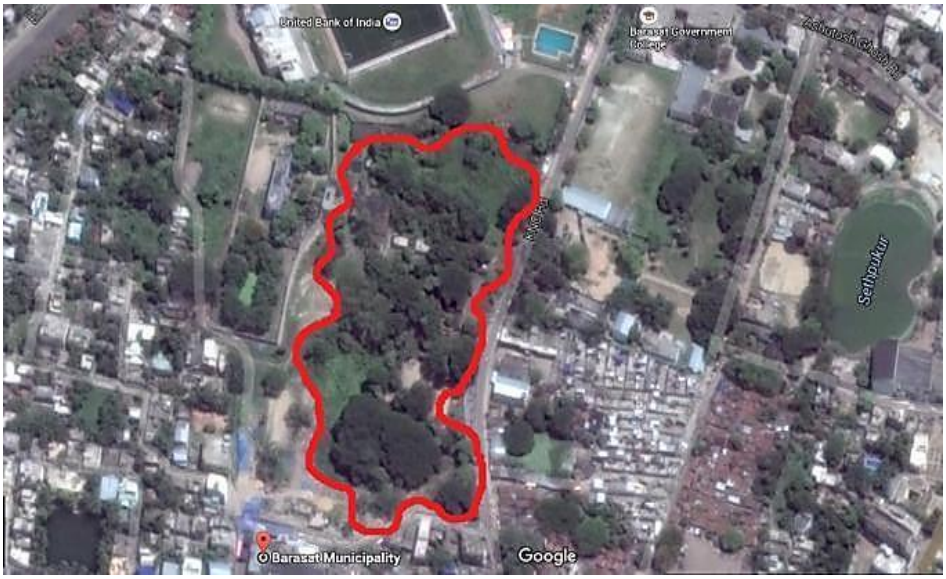


Figure 1. Map of the study site: Kisholoy, Barasat

Study Period

The study was conducted from November 2015 to April 2016. The data was recorded by personal observation for three [3] hours in the morning from 8:00 AM to 11:00 AM.

Methods of Study

Seven flowering plant species were selected from the entire study area (10,400 m^2), where butterflies visit the most. Three [3] individuals of each plant species were tagged. A single plant was observed for 5 minutes followed by a 5 minutes interval. Every single visit of each butterfly species was counted within the 5 minutes observation time. The butterfly species were identified by visual observations and photo shots. The identification of butterfly species was confirmed with the help of "The Book of Indian Butterflies (Kehimkar, 2008)". The nectar plant species were identified by Botanical Survey of India, Kolkata.

RESULTS

Altogether sixteen [16] types of plant species (excluding trees) were found in the study area. Among those plants some were important host plants for butterflies like *Ricinus communis* (host: Common Castor), *Cassia sophera* (host: Mottled Emigrant), *Glycosmis pentaphylla* (host: Common Mormon, Lime butterfly) etc. However, for the present study, seven [7] flowering plant species namely *Luffa* sp. (NP1), *Urena lobata* (NP2), *Mikania micrantha* (NP3), *Aerva lanata* (NP4), *Acmella uliginosa* (NP5), *Sida* sp. (NP6), *Clerodendrum infortunatum* (NP7) were selected where butterfly visits were more. Total of thirty eight [38] butterfly species of five [5] families were recorded from the area. It was found that the encounter frequencies of the butterfly species vary for different nectar plant species. It was also observed that butterflies belonging to a particular family preferred a specific nectar plant species or even a particular plant of a selected species.

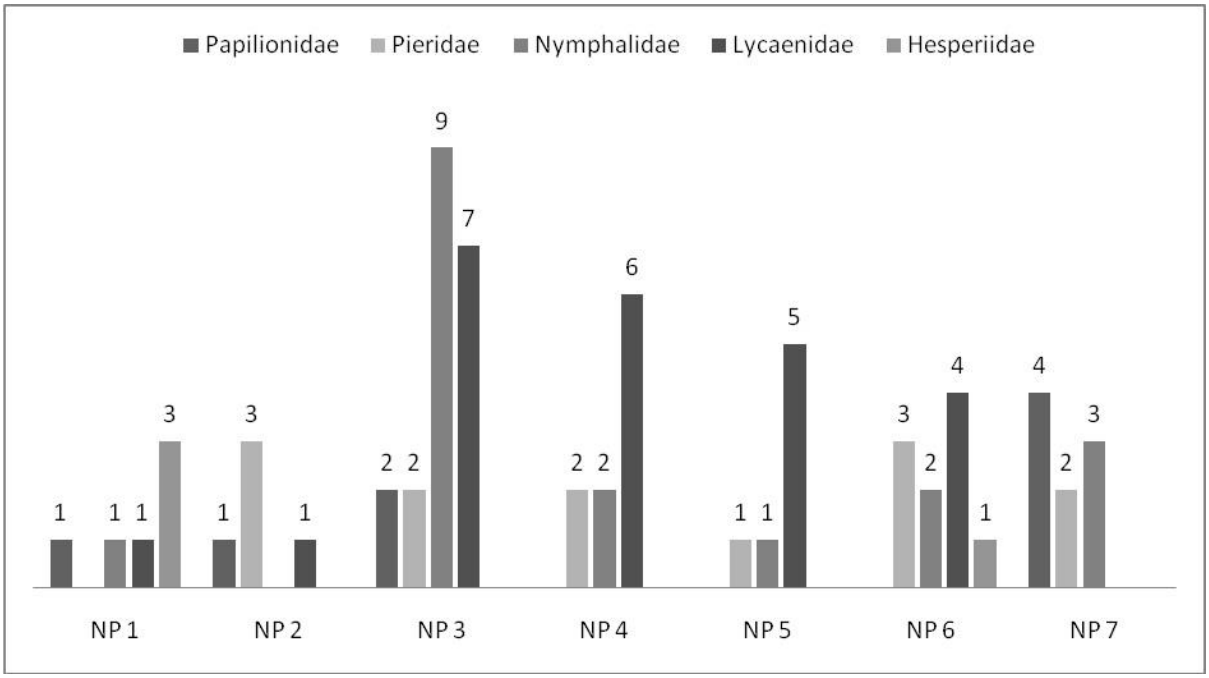


Figure 2. No of Butterfly species of the five families on the seven nectar plant under study

Table 1. Butterfly species found on the seven nectar plant and their visit number

Sl. No.	Species	*Luffa* sp.	*Urena lobata*	*Mikania micrantha*	*Aerva lanata*	*Acmella uliginosa*	*Sida* sp.	*Clerodendrum infortunatum*
1.	Common Pierrot		1	15	3	27	4	
2.	Plains Cupid			31	6	8		
3.	Eastern Striped Albatross		13	3	1		7	7
4.	Common Jezebel		12					19

5.	Plain Tiger			5	2	6	9	6
6.	Mottled Emigrant		19	2			6	
7.	Parnara Swift spp.	4						
8.	Common Silverline			24				
9.	Tawny Coster			7	11		5	
10.	Common Mormon							21
11.	Pale Grass Blue				2			
12.	Common Grass Yellow					4	13	
13.	Tailed Jay	6	2	5				
14.	Grey Pansy			13				
15.	Common Castor			11				
16.	Blue Tiger	4						5
17.	Gram Blue				4		4	
18.	Common Crow			5				2
19.	Lime Blue			4		3		
20.	Common Mime							6
21.	Tiny Grass Blue						6	
22.	Common Rose							4
23.	Slate Flash			4				
24.	Pierrot *(Tarucus* sp.)					4		
25.	Small Branded Swift	10					16	
26.	Lime Butterfly							3
27.	Great Eggfly			3				
28.	Peacock Pansy			3				
29.	Commander			3				
30.	Common Ciliate Blue	3						
31.	Common Leopard			2				
32.	Psyche				2			
33.	Pointed Ciliate Blue			2				
34.	Pea Blue				2			
35.	Dark Grass Blue				8	2	9	
36.	Common Dartlet	2						
37.	Common Jay			1				
38.	Common Red Flash			1				

Nectar Plant Species:

A total of seven [7] nectar plant species were identified in the study area. Most of them were shrubs like *Urena lobata* (1.5 m height) and *Clerodendrum infortunatum* (maximum

4 m in height). Some were climbers like *Luffa* sp. and Mikania *micrantha.* Others were herbs like *Sida* sp., *Acmella uliginosa* and *Aerva lanata.*

Luffa sp., *Aerva lanata* and *Clerodendrum infortunatum* belong to family Cucurbitaceae, Amaranthaceae and Lamiaceae respectively. *Urena lobata* and *Sida* sp. are under the family Malvaceae, while *Mikania micrantha* and *Acmella uliginosa* are under Asteraceae. *Urena lobata* and *Mikania micrantha* are invasive plant species whereas others are native.

DISCUSSION

Butterflies do not feed indiscriminately. They show preference for certain nectar flowers with specific chemical composition (Tiple *et al*., 2006, Nair *et al*., 2014; Mukherjee *et al*., 2015). Flowers with a narrow corolla tube and flat rim characterize typical butterfly flowers. Although butterflies utilize both tubular and non tubular flowers, they show a strong preference for tubular flowers. Further, most of the plant species produce trace amount of nectar but produce numerous flowers on daily basis at plant level (Tiple *et al*., 2006; Nimbalkar *et al*., 2011). Butterflies need carbohydrates and low level of some other compounds such as amino acids, lipids and fats for their fertility, longevity and daily oviposition (Romeis and Wäckers, 2002). The diversity of butterflies for particular habitat is associated with the availability of larval host plants and adult nectar plants (Kunte, 2000). Many of the flowering plants are used by butterflies as nectar plants and support a rich diversity of butterflies.

In the present study, it was found that the encounter frequencies of butterfly species varied for different nectar plant species. It was also observed that butterflies belonging to a particular family preferred a specific nectar plant species raven a particular plant of a selected species. None of the seven necta plants attracted members of all the five butterfly families. Nymphalids were encountered most (with maximum number of butterfly species) on *Mikania micrantha*. The number of visit of butterfly pecies of Lycaenidae was found to be highest in three nectar plants, *Aerva lanata*, *Acmella uliginosa* and *Sida* sp. *Clerodendrum infortunatum* attracted various butterfly species of three families (Papilionidae, Pieridae, Nymphalidae) almost equally. Members of Hesperiidae was found to be an abundant visitor of *Luffa* sp. Common Red Flash butterfly appears to be first record from the area (Mukhopadhyay *et al*., 2015).

ACKNOWLEDGEMENTS

I owe to The Principal and Head of the Post Graduate Department of Zoology, Barasat Government College for providing infrastructure facilities and all the faculty members for constant encouragement. I am extremely thankful to Dr. Kuladeep Roy, Assistant Manager, WWF, for his expert guidance and valuable suggestions. I express my sincere gratitude to Priyanka Das, Sagari Chaudhury, Anirban Chakraborty and Shiladitya Mukhopadhyay for their manifold assistance and cooperation during the course of study.

LITERATURE CITED

[1] Borges, R. M., Gowda, V. and Zacharias, M. 2003. Butterfly pollination and high contrast visual signals in a low density distylous plant. *Oecologia*. 136: 571-573.

[2] Fothergill, K. and Vaughn, A. 2009. Butterfly Nectar Plants at Big Oak Tree State Park and Towosaghy State Historic Site, Mississippi County, Missouri. *Midsouth Entomologists*, 3: 33-38.

[3] Kehimkar, I. 2008. Book of Indian Butterflies. Bombay Natural History Society. Mumbai and Delhi: *Oxford University Press*., 513 pp.
[4] Kunte, K. 2000. *Butterflies of Paninsular India*. *University Press* (Hyderabad) and Indian Academy of Sciences (Bangalore), 254 pp.
[5] Mukherjee, S., Banerjee, S., Saha, G. K., Basu, P. and Aditya, G. 2015. Butterfly diversity in Kolkata, India: An appraisal for conservation management. *Journ. Asia-Pacific Biodiversity*, 8: 210-221.
[6] Mukhopadhyay, S., Chattopadhyay, U., and Sarkar, D. 2015. Diversity of Butterfly Fauna in Barasat, West Bengal. *Bionotes.*, 17(2): 47-49.
[7] Nair, A. V., Mitra, P. and Aditya (Bandyopadhyay), S. 2014. Studies on the diversity and abundance of butterfly (Lepidoptera: Rhopalocera) fauna in and around Sarojini Naidu College campus, Kolkata, West Bengal, India. *Journ. Ent. Zool. Stud.*, 2(4):129-134.
[8] New, T. R. and Collins, N. M. (and the IUCN/SSC Lepidoptera Specialist Group). *Swallowtail butterflies An action plan for their conservation.*, 36 pp.
[9] Nimbalkar, R. K., Chandekar, S. K., and Kunte, S. P. 2011. Butterfly diversity in relation to nectar food plants from Bhor Tahsil, Pune District, Maharashtra, India. *Journ. Threatened Taxa*, 3: 1601-1609.
[10] Tiple, A. D., Deshmukh, V.P. and Dennis, R.L.H. 2006. Factors influencing nectar plant resource visits by butterflies on a university campus: implications for conservation. *Nota Lepidopterologica* 28(3/4): 213-224.
[11] Romeis, J., and Wäckers, F. L. 2002. Nutritional suitability of individual carbohydrates and amino acids for adult *Pieris brassicae*. *Physiological Entomology* 27: 148-156.
[12] Roy, U. S., Mukherjee, M. and Mukhopadhyay, S. K. 2012. Butterfly diversity and abundance with reference to habitat heterogeneity in and around Neora Valley National Park, West Bengal, India. *Our Nature*, 10: 53-60.

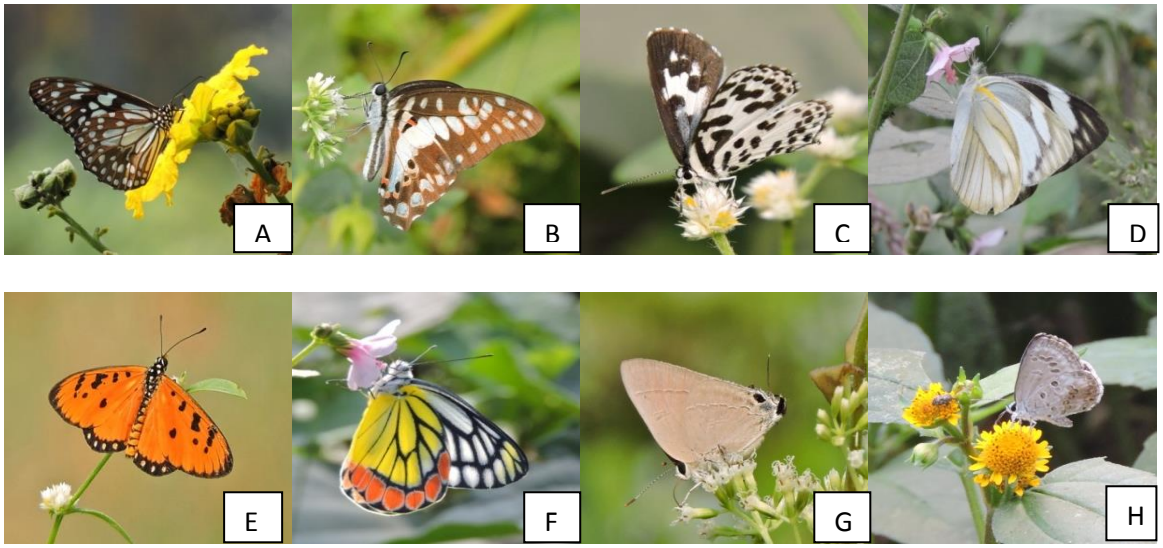


Figure 3. Some of the representative butterfly species encountered during the study period: A. Blue Tiger; B. Common Jay; C. Common Pierrot; D. Eastern Striped Albatross; E. Tawny Coster; F. Common Jezebel; G. Common Red Flash; H. Lime Blue.

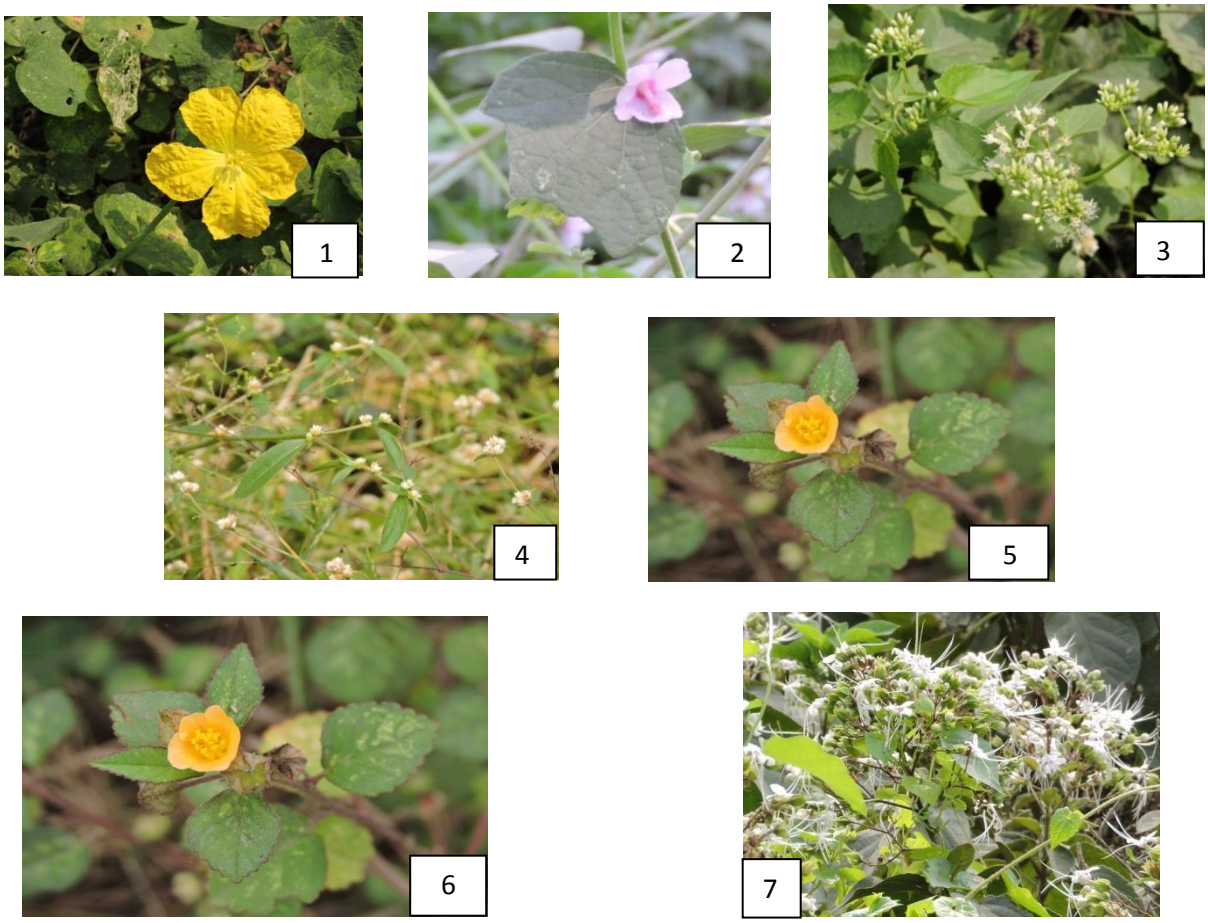


Figure 4. Nectar plant species under study: 1. *Luffa* sp.; 2. *Urena lobata*; 3. *Mikania micrantha*; 4. *Aerva lanata*; 5. *Acmella uliginosa*; 6. *Sida* sp.; 7.*Clerodendrum infortunatum.*

Spider Fauna of Meghalaya, India

Tapan Kumar Roy[1], **Sumana Saha** [2] and **Dinendra Raychaudhuri** [1]

[1]Department of Agricultural Biotechnology, IRDM Faculty Centre,
Ramakrishna Mission Vivekananda University, Narendrapur, Kolkata - 700103,
[2]Post Graduate Department of Zoology, Barasat Govt. College, Barasat, Kolkata - 700124
E-mails: tapanroycal1@gmail.com, sahasumana2010@gmail.com, dinendrarccu@gmail.com

ABSTRACT

The present study is on the spider fauna of Nongkhylem Wildlife Sanctuary (NWS), Sohra (Cherrapunji) [included within East Khasi Hill District], Umsning (Ri Bhoi District) and their surrounding tea estates (Anderson Tea Estate, Byrnihat Tea Estate and Meg Tea Estate) of Meghalaya, India. A total of 55 species belonging to 36 genera and 13 families are sampled. Newly recorded taxa include four genera and 11 species of Araneidae, six genera of Salticidae, each represented by single species. The species recorded under *Tylorida* Simon and *Tetragnatha* Latreille of Tetragnathidae and *Camaricus* Thorell and *Thomisus* Walckenaer of Thomisidae are found to be new from the state. Also, three oxyopids and one miagrammopid are new. So far, Linyphiidae, Pisauridae, Sparassidae and Theridiidae were unknown from the state. Out of 55 species, 13 are endemic to India and thus exhibiting a high endemicity (23.6%). A family key of the State Fauna is provided along with relevant images of the newly recorded species.

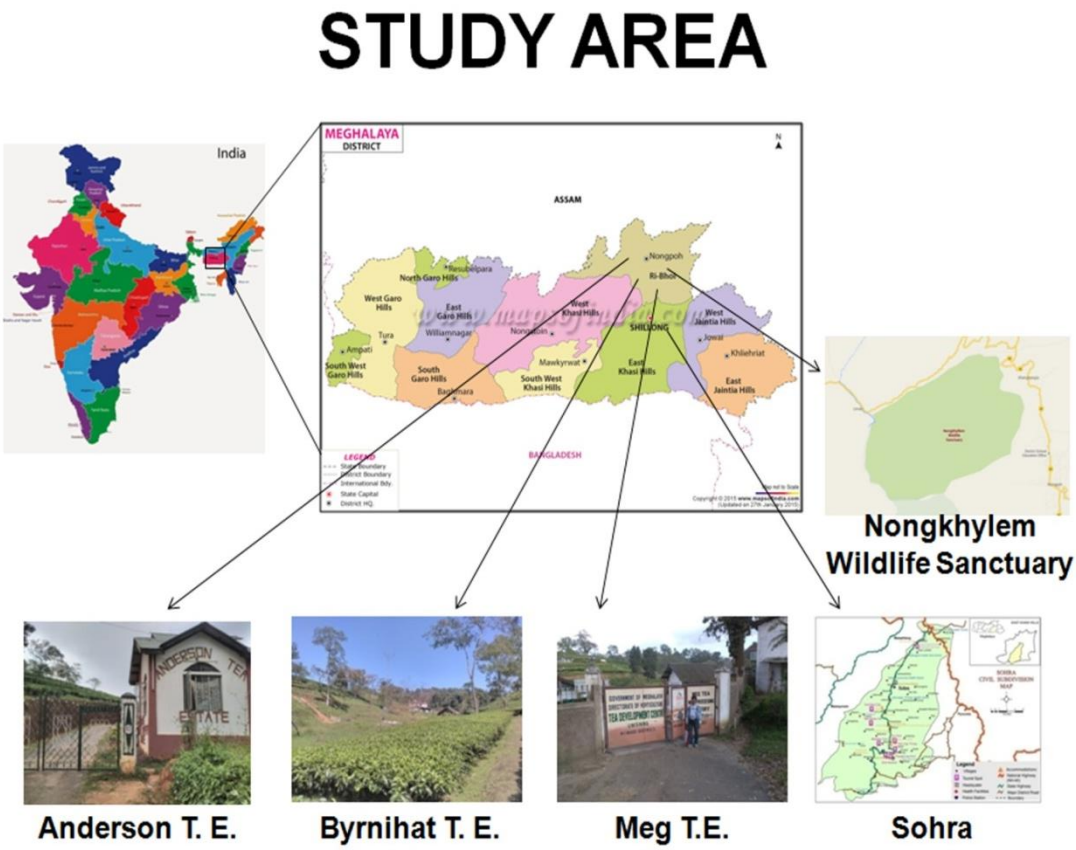
Keywords: Spiders; New Records; Endemicity; Nongkhylem Wildlife Sanctuary; Sohra; Umsning; Tea Ecosystem; Meghalaya.

INTRODUCTION

Spiders are amongst the most omnipresent, numerous, generalist predators in both agricultural and natural ecosystem. They are nature's master spinners of silken webs. They exert considerable top down effect and have the potential to both lower and stabilize pest population making themselves excellent biological pest management candidates. They are also utilized as ecological indicators in many communities. Their abundance is being proved by the current world spider catalogue (2017) which includes 46433 species under 4029 genera distributed over 113 families. In India, there are 1686 species distributed over 438 genera of 60 families (Keswani *et al.*, 2012), while from Meghalaya, 92 species belonging to 38 genera and 10 families are known (Biswas & Majumder, 1995). However we have initiated a survey since 2015 for the spiders of Meghalaya with emphasis on the untouched areas. The study area (vide Map) included Nongkhylem Wildlife Sanctuary (NWS), Sohra (Cherrapunji) [included within East Khasi Hill District], Umsning (Ri Bhoi District) and their surrounding tea estates (Anderson Tea Estate, Byrnihat Tea Estate and Meg Tea Estate). So far we could record 55 species belonging to 36 genera and 13 families. Among the recorded taxa, four genera and 11 species of Araneidae, six genera of Salticidae, two species each of Tetragnathidae and Thomisidae, three species of Oxyopidae and one species of Uloboridae are new records from the state. Find of members of four families viz. Linyphiidae, Pisauridae, Sparassidae and Theridiidae are as such new. A family key of the State Fauna is provided along with relevant images of the newly recorded species.

MATERIAL AND METHODS

Samples are collected from different area of the NWS and non reserve areas such as Sohra, Umsning and their surrounding tea estates (Anderson Tea Estate, Byrnihat Tea Estate and Meg Tea Estate) mainly by bush beating; inverted umbrella; hand picking; visual search and foliage, trunk & branch sampling methods. But in case of tea estates we had to rely mainly on hand picking; visual search and foliage, trunk & branch sampling methods. The survey was conducted during the period of October to November 2015 in different areas of the study sites.



Spider specimens thus sampled were preserved following Tikader (1987) and Barrion & Litsinger (1995). They were studied under Stereo Zoom Binocular Microscopes, model Olympus SZX-7 & and SZX-16.
Materials are in the deposition of Department of Agricultural Biotechnology, IRDM Faculty Centre, Ramakrishna Mission Vivekananda University, Narendrapur, Kolkata.

Abbreviations used: NWS= Nongkhylem Wildlife Sanctuary, ATE= Anderson Tea Estate, BTE= Byrnihat Tea Estate, MTE= Meg Tea Estate, J= Juvenile, S= Sub adult, ® = New record from Meghalaya, € = Endemic to India.

RESULTS : TAXONOMIC ACCOUNT

Order: Araneae
Suborder: Araneomorphae

Key to families:

1. Cribellum and calamistrum present, sometimes absent or reduced in male; femora with rows of long trichobothria; metatarsi IV compressed and curved under the line of calamistrum

--------Cribellate, **Uloboridae** Thorell

- Cribellum and calamistrum absent

---------- Ecribellate

2. Tarsi with 2 claws and claw tufts

----------3

- Tarsi with 3 claws, claw tuft absent

---------- 6

3. Eyes usually in 3 rows, occupying the entire cephalic area, 1st row of eyes large on vertical face with anteromedians largest, anterolaterals smaller, in some genera moved into separate row behind anteromedians, posteromedians of 2nd row minute, located between anterolaterals and medium sized posterolaterals of 3rd row

----------**Salticidae** Blackwall

- Eyes in 2 rows

---------- 4

4. Legs usually prograde; posterior spinnerets 2 segmented with distal segment distinctly conical; male palp with expanded retrotibial apophysis

---------- **Eutichuriidae** (Lehtinen)

- Legs I and II usually laterigrade, in few less evident or never; posterior spinnerets not 2 segmented; male palp not so

---------- 5

5. Metatarsal apex with soft trilobate membrane; epigynum with paired lateral lobes, often with a median piece; all metatarsi and tarsi with dense scopulae

---------- **Sparassidae** Bertkau

- Metatarsal apex without any such membrane; epigynum otherwise, usually with hood or guide pocket; metatarsi and tarsi III and IV never scopulate

---------- **Thomisidae** Sundevall

6. Eyes hexagonal, anterior row strongly procurved and posterior row strongly recurved; clypeus very high; leg spines long and prominent

---------- **Oxyopidae** Thorell

- Eyes never hexagonal, if approximately close then clypeus narrow

---------- 7

7. Trochanters ventrally with a curved notch

---------- 8

- Trochanters not so

---------- 9

8. Eyes arranged in 2 rows, often stalked; median tarsal claw with 2-3 teeth, anterior piece of lorum with a notch into which posterior piece fits

----------**Pisauridae** Simon

- Eyes arranged in 3 rows, not stalked; median tarsal claw smooth or with a single tooth, anterior piece of lorum rounded behind and fits into a notch of the posterior piece

---------- **Lycosidae** Sundevall

9. Tarsus IV ventrally with a distinct comb of strong, curved serrated bristles, in male may be poorly developed; labium not rebordered

---------- **Theridiidae** Sundevall

- Tarsus IV without such comb; labium rebordered

---------- 10

10. Eyes heterogenous with anteromedians dark; clypeus usually as high as or higher than median ocular area; chelicerae with stridulating ridges

---------- **Linyphiidae** Blackwall

- Eyes homogenous; clypeus usually lower than the height of median ocular area; chelicerae without stridulating ridges

---------- 11

11. Epigastric furrow procurved; chelicerae usually very large and powerful, devoid of boss; anterior and posterior spinnerets similar, epigyne without scape

---------- **Tetragnathidae** Menge

- Epigastric furrow nearly straight; chelicerae moderate, usually with a boss; anterior and posterior spinnerets dissimilar; epigyne with scape

---------- 12

12. Cephalothorax usually longer than wide; trichobothria present on tibiae only; male paracymbium usually flat and rectangular

---------- **Nephilidae** Simon

- Cephalothorax flat, variable; trichobothria present on all leg segments except tarsi; paracymbium usually with a sclerotised hook

---------- **Araneidae** Clerck

Family 1: **Uloboridae** Thorell

1. ***Miagrammopes* sp. nr. *kirkeensis*** ® € Tikader

(Fig. 1)

Miagrammopes kirkeensis Tikader, 1971, *J. Asiat. Soc. Calcutta*, 213: 176.

Material examined: 1♀ (J), ATE, 30.X.2015, coll. T. K. Roy; 1♀ (J), Umsning, 28.X.2015, coll. D. C. Dhali

Distribution: India: Maharashtra, Meghalaya, West Bengal (New record) (Tikader, 1971; Roy, 2013; WSC, 2017).

2. ***Uloborus khasiensis*** € Tikader

Uloborus khasiensis Tikader, 1969, *Proc. Indian Acad. Sci.*, 70(B): 127.

Material examined: 1♀, BTE, 03.XI.2015, coll. T. K. Roy; 2♀♀, NWS, 02.XI.2015, coll. D. C. Dhali

Distribution: India: Assam, Meghalaya, West Bengal (New record) (Tikader, 1969; Dhali *et al*., 2010b; Roy 2013; WSC, 2017).

Family 2: **Salticidae** Blackwall

3**. *Rhene decorata*** ® € Tikader

(Fig. 2)

Rhene decorata Tikader, 1977, *Proc. Indian Acad. Sci.*, 85(B): 276.

Material examined: 1♀, MTE, 28.X.2015, coll. S. Sen
Distribution: India: Assam, Maharashtra, Meghalaya, West Bengal (Tikader & Biswas, 1981; Biswas & Biswas, 1992; Majumder, 2005; Prószyn'ski, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

4. ***Thiania bhamoensis*** ® Thorell
(Fig. 3)
Thiania bhamoensis Thorell, 1887, *Ann. Mus. Civ. Stor. Nat. Genova*, 25: 357.

Material examined: 1♀, MTE, 28.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Andaman Islands, Kerala, Meghalaya, West Bengal; Burma, China, Krakatau, Malacca, Malaysia, Myanmar, Singapore, Sumatra, Vietnam (Sebastian & Peter, 2009; Dhali *et al*., 2010a; Prószyński, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

5. ***Telamonia dimidiata*** ® (Simon)
(Fig. 4)
Viciria dimidiata Simon, 1899, *Ann. Soc. Ent. Belg.*, 43: 118.
Telamonia dimidiata (Simon) Prószyński, 1984, *Annls Zool. Warsz.*, 37: 428.

Material examined: 2♀♀ (J), BTE, 03.XI.2015, coll. S. Sen; 1♀, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Assam, Gujarat, Kerala, Maharashtra, Meghalaya, West Bengal; Bhutan, Indonesia, Singapore, Sumatra (Sebastian & Peter, 2009; Dhali *et al.*, 2010a; Prószyński, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

6. ***Hyllus semicupreus*** ® (Simon)
(Fig. 5)
Thyene semicuprea Simon, 1885, *Bull. Soc. Zool. Fr.*, 10: 4.
Hyllus semicupreus (Simon) Prószyński, 1990, *Wyzsza Szkola Rolniczo-Pedagogiczna W Siedlcach*: 177.

Material examined: 1♀, Umsning, 28.X.2015, coll. S. Saha
Distribution: India: Assam, Meghalaya, West Bengal; Sri Lanka (Sebastian & Peter, 2009; Dhali *et al.*, 2010a; Prószyn'ski, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

7. ***Plexippus paykullii*** (Audouin)
Attus paykullii Audouin, 1826, *Explication sommaire des planches d'arachnides de l'Egypte et de la Syrie publiées ... in "Description de l'Egypte..."* : 409.
Plexippus paykullii (Audouin) Peckham & Peckham, 1886, *Trans. Wiscons. Acad. Sci. Arts Let.*, 6: 296.

Material examined: 1♀, Umsning, 30.X.2015 coll. S. Sen
Distribution: India: Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, West Bengal; Afghanistan, Algeria, American Samoa, Australia, Bermuda, Brazil, Canary Islands, Celebes, China, Costa Rica, Crete, Cuba, Egypt, Ethiopia, Fiji, France, French Polynesia, Galapagos Islands, Gambia, Greece, Hawaii, Hispaniola Island, Indochina, Iran, Italy, Japan, Java, Kenya, Krakatau, Lao, Libya, Malaysia, Malta, Marquesas Islands, Marshall Islands, Nepal, New Hebrides, Palmyra Atoll, Panama, Papua New Guinea, Paraguay, Philippines, Saudi Arabia, Senegal, Singapore, Society Islands, South Korea, Sri Lanka, Sudan, Suriname,

Taiwan, Tonga, Trinidad, Tuamotu Islands, Tunisia, United Arab Emirates, USA, Venezuela, Vietnam, Yemen (Tikader & Biswas, 1981; Biswas & Biswas, 1992, 2004, 2006; Barrion & Litsinger, 1995; Majumder, 2005, 2007; Sebastian & Peter, 2009; Dhali *et al.*, 2010a; Prószyn'ski, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

8. ***Phintella vittata*** ® (C. L. Koch)
(Fig. 6)
Plexippus vittatus C. L. Koch, 1846, *Die Arachniden*, Nürnberg: 125.
Phintella vittata (C.L. Koch) Zabka, 1985, *Annls Zool. Warsz.*, 39: 429.

Material examined: 1♀ (J), MTE, 28.X.2015, coll. D. Raychaudhuri
Distribution: India: Nicobar Islands, Meghalaya, West Bengal; China, Indonesia, Malaysia, Penang Island, Philippines, Singapore, Sri Lanka, Sumatra, Vietnam (Sebastian & Peter, 2009; Dhali *et al*., 2010a; Prószyński, 2016; Roy *et al*., 2016; Metzner, 2017; WSC, 2017).

9. ***Myrmarachne caliraya*** ® Barrion & Litsinger
(Fig. 7)
Myrmarachne caliraya Barrion & Litsinger, 1995, *CAB International in association with the International Rice Research Institute, Philippines:* 56.

Material examined: 4♂♂ (J), ATE, 30.X.2015, coll. D. C. Dhali; 2♀♀ (J), Umsning, 28.X.2015, coll. T. K. Roy;
Distribution: India: Meghalaya, West Bengal; Philippines (Barrion & Litsinger, 1995; Dhali *et al*., 2010a; Keswani *et al*., 2012; Sen *et al*., 2015; Roy *et al.*, 2016; Metzner, 2017; WSC, 2017).

Family 3: **Eutichuridae** (Lehtinen)

10. ***Cheiracanthium melanostomum*** (Thorell)
Eutittha melanostoma Thorell, 1895, *Descriptive catalogue of the spiders of Burma*. Lond.: 44.
Cheiracanthium melanostomum (Thorell) Simon, 1901, *Proc. Zool. Soc. Lond.*, (2): 67.

Material examined: 1♀ (J), BTE, 03.XI.2015, coll. T. K. Roy; 2♀♀, NWS, 02.XI.2015, coll. D. C. Dhali; 1♀, ATE, 30.X.2015, coll. D. Raychaudhuri; 1♀ (J), Umsning, 03.XI.2015, coll. S. Saha; 10♀♀ (J), Sohra, 31.X.2015, coll. T. K. Roy
Distribution: India: Andaman & Nicobar Island, Assam, Bihar, Goa, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Mysore, Rajasthan, Tamil Nadu, West Bengal; Bangladesh, Bhutan, Burma, Myanmar, Sri Lanka (Majumder & Tikader, 1991; Biswas & Biswas, 1992; Majumder, 2007; Sebastian & Peter, 2009; WSC, 2017).

Family 4: **Sparassidae** ® Bertkau

11. ***Olios tener*** ® (Thorell)
(Fig. 8)
Sparassus tener Thorell, 1891, *Kongl. Svenska. Vet.-Acad. Handl.*, 24(2): 80.
Olios tener (Thorell) Gravely, 1931, *Rec. Indian Mus. Calcutta*, 33: 244.

Material examined: 1♀ (S), BTE, 03.XI.2015, coll. D. C. Dhali

Distribution: India: Bihar, Karnataka, Maharashtra, Meghalaya, Tamil Nadu, West Bengal; Burma, Myanmar, Pakistan (Sethi & Tikader, 1988; WSC, 2017).

Family 5: **Thomisidae** Sundevall

12. ***Camaricus formosus*** ® Thorell
(Fig. 9)
Camaricus formosus Thorell, 1887, *Ann. Mus. Civ. Stor. Nat. Genova*, 25: 262.

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Saha; 1♀, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Andaman & Nicobar Island, Arunachal Pradesh, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Orissa, West Bengal; Burma, China, Indonesia, Philippines, Sumatra (Tikader, 1980; Tikader & Biswas, 1981; Biswas & Biswas, 1992, 2004, 2006; Barrion & Litsinger, 1995; Majumder, 2005, 2007; Sebastian & Peter, 2009; Sen *et al.*, 2009b; WSC, 2017).

13. ***Thomisus andamanensis*** ® € Tikader
(Fig. 10)
Thomisus andamanensis Tikader, 1980, *Fauna of India* (Araneae), 1: 39.

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Sen; 2♀♀ (J), NWS, 02.XI.2015, coll. D. Raychaudhuri
Distribution: India: Andaman Island, Meghalaya, West Bengal (New record) (Tikader, 1980; Roy, 2013; WSC).

Family 6: **Oxyopidae** Thorell

14. ***Oxyopes shweta*** Tikader
Oxyopes shweta Tikader, 1970, *Rec. Zool. Surv. India*, 64: 78.

Material examined: 2♀♀, BTE, 03.XI.2015, coll. S. Sen; 2♀♀ (J), NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Andhra Pradesh, Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Sikkim, Tripura, West Bengal; China (Tikader, 1970; Biswas & Biswas, 1992, 2004, 2006; Hazarika & Chakraborti, 1998; Majumder, 2005, 2007; Gajbe, 2008; Sebastian & Peter, 2009; Dhali *et al.* 2010b; WSC, 2017).

15. ***Oxyopes matiensis*** ® Barrion & Litsinger
(Fig. 11)
Oxyopes matiensis Barrion & Litsinger, 1995, *Riceland Spiders of South and Southeast Asia*: 329. (Figs. 195a-h, 196a-g)

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Saha; 2♀♀ (J), NWS, 02.XI.2015, coll. T. K. Roy; 1♀ (J), ATE, 30.X.2015, coll. T. K. Roy; 1♀, Umsning, 28.X.2015, coll. S. Sen
Distribution: India: Assam (New record), Madhya Pradesh, Meghalaya, West Bengal (New record); Philippines (Barrion & Litsinger, 1995; Roy, 2013; WSC, 2017).

16. ***Oxyopes kamalae*** ® € Gajbe
(Fig. 12)
Oxyopes kamalae Gajbe, 1999, *Rec. Zool. Surv. India*, 97(3): 56.

Material examined: 1♀ (J), BTE, 03.XI.2015, coll. D. C. Dhali; 1♀, NWS, 02.XI.2015, coll. D. Raychaudhuri
Distribution: India: Madhya Pradesh, Meghalaya, West Bengal (New record) (Gajbe, 2008; Roy, 2013; WSC, 2017).

17. ***Oxyopes javanus*** ® Thorell
(Fig. 13)
Oxyopes javanus Thorell, 1887, *Ann. Mus. Civ. Stor. Nat. Genova*, 25: 329.

Material examined: 1♀, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Assam (New record), Kerala, Madhya Pradesh, Meghalaya, Nicobar Island, West Bengal; Bangladesh, China to Java, Malaysia, Myanmar, Philippines, Singapore, Sumatra, Thailand (Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Majumder, 2005; Gajbe, 2008; Roy, 2013; WSC, 2017).

Family 7: **Pisauridae** ® Simon

18. ***Dendrolycosa* sp. nr. *gitae*** ® € (Tikader)
(Fig. 14)
Pisaura gitae Tikader, 1970, *Rec. Zool. Surv. India*, 64: 59.
Dendrolycosa gitae (Tikader) Jäger, 2011, *Zootaxa*, 3046: 13.

Material examined: 1♀ (J), BTE, 03.XI.2015, coll. D. Raychaudhuri; 2♀♀ (J), NWS, 02.XI.2015, coll. T. K. Roy; 1♀ (J), MTE, 28.X.2015, coll. D. C. Dhali; 1♀ (J), Umsning, 28.X.2015, coll. S. Sen
Distribution: India: Assam, Andaman Island, Kerala, Meghalaya, Sikkim, West Bengal (Tikader, 1970; Biswas & Biswas, 1992; Sebastian & Peter, 2009; WSC, 2017).

Family 8: **Lycosidae** Sundevall

19. ***Pardosa sumatrana*** (Thorell)
Lycosa sumatrana Thorell, 1890, *Ann. Mus. Civ. Stor. Nat. Genova*, 30: 136.
Pardosa sumatrana (Thorell) Hogg, 1919, *J. Fed. Malay St. Mus.*, 8(3): 100.

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Saha; 2♀♀, NWS, 02.XI.2015, coll. T. K. Roy; 1♀, ATE, 30.X.2015, coll. S. Sen; 1♀, MTE, 28.X.2015, coll. T. K. Roy; 1♀ (J), Umsning, 28.X.2015, coll. D. C. Dhali
Distribution: India: Andaman & Nicobar Island, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujrat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Rajasthan, Tamil Nadu, Tripura, West Bengal; Bangladesh, China, Indonesia, Japan, Nepal, Pakistan, Philippines, Sri Lanka, Sulawesi, Sumatrana (Tikader & Malhotra, 1980; Tikader & Biswas, 1981; Biswas & Biswas, 1992, 2004, 2006; Barrion & Litsinger, 1995; Gajbe, 2004; Majumder 2005, 2007; Saikia & Baruah, 2009; Sebastian & Peter, 2009; Dhali *et al*., 2012; WSC, 2017).

20. ***Pardosa birmanica*** Simon
Pardosa birmanica Simon, 1884, *Ann. Mus. Civ. Stor. Nat. Genova*, 20: 333.

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Sen; 2♀♀, NWS, 02.XI.2015, coll. S. Saha; 2♀♀, ATE, 29.X.2015, coll. D. Raychaudhuri; 1♀, MTE, 28.X.2015, coll. D. C. Dhali
Distribution: India: Andaman & Nicobar Island, Andhra Pradesh, Assam, Bihar, Gujrat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttaranchal, Uttar Pradesh, West Bengal; Bangladesh, Burma, China, Indonesia, Java, Myanmar, Pakistan, Philippines, Sumatrana (Tikader & Malhotra, 1980; Tikader & Biswas, 1981; Biswas & Biswas, 1992, 2004, 2006; Barrion & Litsinger, 1995; Gajbe, 2004; Majumder 2005, 2007; Sebastian & Peter, 2009; Dhali *et al*., 2012; WSC, 2017).

21. ***Lycosa shillongensis*** € Tikader & Malhotra
Lycosa shillongensis Tikader & Malhotra, 1980, *Fauna of India* (Araneae), 1: 403.

Material examined: 1♀, BTE, 03.XI.2015, coll. D. C. Dhali; 2♀♀, NWS, 02.XI.2015, coll. T. K. Roy; 1♀, ATE, 29.X.2015, coll. D. Raychaudhuri
Distribution: India: Manipur, Meghalaya, West Bengal (Tikader & Malhotra, 1980; Biswas & Biswas, 1992; Sebastian & Peter, 2009; Dhali *et al*., 2012; WSC, 2017).

Family 9: **Theridiidae** ® Sundevall

22. ***Argyrodes gazedes*** ® Tikader
(Fig. 15)
Argyrodes gazedes Tikader, 1970, *Rec. Zool. Surv. India*, 64: 11.

Material examined: 1♀, BTE, 03.XI.2015, coll. S. Sen; 1♀, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Assam, Kerala, Meghalaya, Sikkim, West Bengal (New record); Krakatau, Myanmar to Japan (Tikader, 1970; Sebastian & Peter, 2009; WSC, 2017).

23. ***Chrysso urbasae*** ® € (Tikader)
(Fig. 16)
Linyphia urbasae Tikader, 1970, *Rec. zool. Surv. India*, 64(1-4): 19-20.
*Chrysso urbasae (*Tikader) Breitling, 2015, *Contributions to Natural History* 30: 1-7.

Material examined: 1♀, BTE, 03.XI.2015, coll. T. K. Roy; 1♀, NWS, 02.XI.2015, coll. T. K. Roy; 7♀♀, ATE, 29.X.2015, coll. D. C. Dhali
Distribution: India: Kerala, Meghalaya, Sikkim, West Bengal (Tikader, 1970; Sebastian & Peter, 2009; Breitling, 2015; WSC, 2017).

24. ***Theridion indicum*** ® € Tikader
(Fig. 17)
Theridion indicum Tikader, 1977, *Rec. Zool. Surv. India*, 72: 168.

Material examined: 3♀♀, BTE, 03.XI.2015, coll. T. K. Roy; 3♀♀ & 3♀♀ (J), NWS, 02.XI.2015, coll. D. C. Dhali; 4♀♀ & 2♀♀ (J), ATE, 30.X.2015, coll. D. Raychaudhuri; 1♀, MTE, 28.X.2015, coll. S. Sen; 1♀ (J), Umsning, 28.X.2015, coll. T. K. Roy; 4♀♀ & 1♀ (J), Sohra, 31.X.2015, coll. T. K. Roy

Distribution: India: Andaman & Nicobar Island, Assam, Meghalaya, West Bengal (Tikader, 1977; Biswas & Biswas, 1992; Majumder, 2005, 2007; WSC, 2017).

25. ***Achaearanea budana*** ® € Tikader
(Fig. 18)
Achaearanea budana Tikader, 1970, *Rec. Zool. Surv. India*, 64: 16.

Material examined: 1♀ (S), BTE, 03.XI.2015, coll. D. C. Dhali; 1♀ (J), NWS, 02.XI.2015, coll. T. K. Roy; 1♀ (J), ATE, 30.X.2015, coll. S. Sen; 1♀ (J), Sohra, 31.X.2015, coll. T. K. Roy
Distribution: India: Assam, Meghalaya, Sikkim, West Bengal (Tikader, 1970; WSC, 2017).

Family 10: **Linyphiidae** ® Blackwall

26. ***Nereine sundaica*** ® (Simon)
(Fig. 19)
Linyphia sundaica Simon, 1905, *Mitteilungen aus dem Naturhistorischen Museum in Hamburg 22:* 59.
Nereine sundaica (Simon) van Helsdingen, 1969, *Zoologische Verhandelingen* 105: 191.

Material examined: 3♀♀, BTE, 03.XI.2015, coll. S. Sen; 3♀♀ & 1♂ (J), NWS, 02.XI.2015, coll. T. K. Roy; 2♀♀ & 1♀ (J), ATE, 30.X.2015, coll. D. Raychaudhuri
Distribution: India: Kerala, Meghalaya; Java, Lombok (WSC, 2017)

Family 11: **Tetragnathidae** Menge

27. ***Tetragnatha ceylonica*** ® O. P.- Cambridge
(Fig. 20)
Tetragnatha ceylonica O. P.-Cambridge, 1869, *J. Linn. Soc. Lond. (Zool.)*, 10: 394.

Material examined: 1♀, Sohra, 01.XI.2015, coll. T. K. Roy
Distribution: India: Assam, Kerala, Meghalaya, West Bengal; Africa, Japan, New Britain, New Guinea, Seychelles to Philippines, Southeast Asia, Taiwan, Thailand (Okuma, 1988; Barrion & Litsinger, 1995; Sen *et al*., 2009c; WSC, 2017).

28. ***Tylorida nicobarensis*** ® € (Tikader)
(Fig. 21)
Linyphia nicobarensis Tikader, 1977, *Rec. Zool. Surv. India*, 72: 166.
Tylorida nicobarensis (Tikader) Breitling, 2015, *Contributions to Natural History* 30: 5.

Material examined: 2♀♀, BTE, 03.XI.2015, coll. S. Sen; 3♀♀, NWS, 02.XI.2015, coll. T. K. Roy; 1♀, MTE, 28.X.2015, coll. D. C. Dhali; 1♀ (J), Umsning, 28.X.2015, coll. T. K. Roy
Distribution: India: Assam, Nicobar Islands, Meghalaya, West Bengal (New record) (Tikader, 1977; Roy, 2013; WSC, 2017).

29. ***Leucauge celebesiana*** (Walckenaer)
Tetragnatha celebesiana Walckenaer, 1841, *Histoire naturelle des Insects. Aptères. Paris* 2: 222.
Leucauge celebesiana (Walckenaer) Hogg, 1919, *J. Federated Malay States Museums*, 8(3): 89.

Material examined: 11♀♀ (J) & 3♂♂, Sohra, 01.XI.2015, coll. S. Saha
Distribution: India: Assam, Maharashtra, Meghalaya, Sikkim, TamilNadu, West Bengal; India to China, Burma, Japan, Korea, Laos, New Guinea, Russia, Sri Lanka, Sulawesi, Vietnam (Tikader, 1970, 1982; Biswas & Biswas, 1992, Barrion & Litsinger, 1995; Sen *et al.*, 2009c; WSC, 2017).

30. ***Leucauge decorata*** (Blackwall)
Tetragnatha decorata Blackwall, 1864, *Ann. Mag. Nat. Hist.*, (3) 14: 44.
Leucauge decorata (Blackwall) Simon, 1906, *Ann. Soc. Ent. Fr.*, 75: 282.

Material examined: 1♀, ATE, 30.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Pondicherry, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal; Burma, Myanmar, Pakistan, Paleotropical, South and South east Asia, Sri Lanka, (Tikader, 1970, 1982; Biswas & Biswas, 1992, Barrion & Litsinger, 1995; Hazarika & Chakraborti, 1998; Saikia & Baruah, 2009; Sebastian & Peter, 2009; Sen *et al.*, 2009c; WSC, 2017).

31. ***Leucauge tessellata*** (Thorell)
Callinethis tessellata Thorell, 1887, *Ann. Mus. civ. stor. nat. Genova*, 25: 135.
Leucauge tessellata (Thorell) Gravely, 1921, *Rec. Ind. Mus., Calcutta*, 22(4): 455.

Material examined: 3♀♀, ATE, 30.X.2015, coll. T. K. Roy
Distribution: India: Assam, Arunachal Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Sikkim, West Bengal; Bhutan, China, Laos, Moluccas, Myanmar, Taiwan (Tikader, 1982; Biswas & Biswas, 1992,'04,'06; Biswas *et. al*., 1997; Majumder, 2007; Sebastian & Peter, 2009; Sen *et. al.*, 2009c; WSC, 2017).

Family 12: **Nephilidae** Simon

32. ***Nephila pilipes*** (Fabricius)
Aranea maculata Fabricius, 1793, *Ent. Syst*., 2: 425.
Nephila pilipes (Fabricius), Harvey, Austin & Adams, 2007, *Invertebr. Syst*., 21: 422.

Material examined: 1♀ & 3♀♀ (J), ATE, 30.X.2015, coll. D. C. Dhali
Distribution: India: Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Gujarat, Kerala, Maharashtra, Madhya Pradesh, Meghalaya, Sikkim, Uttar Pradesh, West Bengal; China,
Philippines to Australia (Tikader, 1982; Biswas & Biswas, 1992,'06; Sebastian & Peter, 2009;
WSC, 2017).

Family 13: **Araneidae** Clerck

33. ***Gasteracantha diadesmia*** Thorell
Gasteracantha diadesmia Thorell, 1887, *Ann. Mus. Civ. Stor. Nat. Genova*, 25: 225.

Material examined: 2♀♀, BTE, 03.XI.2015, coll. D. Raychaudhuri; 2♀♀, NWS, 02.XI.2015, coll. S. Saha

Distribution: India: Andaman & Nicobar Island, Assam, Meghalaya, Sikkim, West Bengal; Burma, Myanmar, Philippines, Thailand (Tikader, 1970, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Saha *et al.*, 1995; Kundu & Raychaudhuri, 1997; Saha & Raychaudhuri, 2004; Roy *et al*., 2009, 2010; Sen *et al*., 2009a; WSC, 2017).

34. ***Gasteracantha kuhlii*** C.L. Koch
Gasteracantha kuhlii C.L. Koch, 1837, *Die Arachniden*: 20.

Material examined: 4♀♀, ATE, 30.X.2015, coll. D. C. Dhali
Distribution: India: Andaman & Nicobar Island, Assam, Bihar, Kerala, Meghalaya, Sikkim, West Bengal; Bhutan, Burma, Hongkong, Indo- Malaysia, Japan, Myanmar (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Hazarika & Chakraborti, 1998; Saha & Raychaudhuri, 2004; Roy *et al*., 2009, 2010; Sebastian & Peter, 2009; Sen *et al.*, 2009a; WSC, 2017)
.

35. ***Gasteracantha hasseltii*** ® C. L. Koch
(Fig. 22)
Gasteracantha hasselti C. L. Koch, 1837, *Die Arachniden*: 29.

Material examined: 2♀♀, BTE, 03.XI.2015, coll. S. Sen; 1♀, NWS, 02.XI.2015, coll. T. K. Roy; 2♀♀, ATE, 30.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Kerala, Meghalaya, Sikkim, West Bengal; China to Moluccas (Tikader, 1982; Biswas & Biswas, 1992; Majumder, 2007; Sebastian & Peter, 2009; Sen *et. al*., 2009a; WSC, 2017).

36. ***Argiope aemula*** ® (Walckenaer)
(Fig. 23)
Epeira aemula Walckenaer, 1841, *Hist. Nat. des Ins. Aptères*. *Paris*, 2: 118.
Argiope aemula (Walckenaer) Thorell, 1877, *Ann. Mus. Civ. Stor. Nat. Genova*, 10: 364.

Material examined: 2♂♂, BTE, 03.XI.2015, coll. T. K. Roy; 1♂, NWS, 02.XI.2015, coll. D. C. Dhali
Distribution: India: Andaman & Nicobar Island, Assam, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Meghalaya, Tamil Nadu, West Bengal; Burma, China, Indonesia, Indo and Austro- Malaysia, Myanmar, New Hebrides, Philippines, Sri Lanka, Taiwan, Thailand (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Majumder, 2007; Roy *et al*., 2009, 2010; Sebastian & Peter, 2009; WSC, 2017).

37. ***Argiope pulchella*** Thorell
Argiope pulchella Thorell, 1881, *Ann. Mus. Civ. Stor. Nat. Genova*, 17: 74.

Material examined: 2♀♀ (J), BTE, 03.XI.2015, coll. D. Raychaudhuri; 2♀♀, NWS, 02.XI.2015, coll. T. K. Roy; 1♀ & 3♀♀ (J), ATE, 30.X.2015, coll. S. Saha.
Distribution: India: Andaman & Laccadive Islands, Assam, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Tamil Nadu, West Bengal; Burma, Java, Malaya Peninsula, Myanmar, Pegu Moulmein (Tikader, 1982; Biswas & Biswas, 1992; Kundu & Raychaudhuri, 1997; Hazarika & Chakraborti, 1998; Saha & Raychaudhuri, 2004; Majumder, 2007; Roy *et al.*, 2009, 2010; Sebastian & Peter, 2009; Sen *et al*., 2009a; WSC, 2017, 2017).

38. ***Cyrtarachne inequalis*** ® Thorell
(Fig. 24)
Cyrtarachne inequalis Thorell, 1895, *Descriptive catalogue of the spiders of Burma*. Lond.: 201.

Material examined: 1♀, NWS, 02.XI.2015, coll. T. K. Roy;
Distribution: India: Andhra Pradesh, Assam, Madhya Pradesh, Meghalaya, West Bengal; Burma, Japan (Tikader, 1982; Biswas & Biswas, 1992; Roy *et al*., 2010; WSC, 2017).

39. ***Eriovixia excelsa*** ® (Simon)
(Fig. 25)
Glyptogona excelsa Simon, 1889, *J. Asiat. Soc. Bengal*, 58: 337.
Eriovixia excelsa (Simon) Grasshoff, 1986, *Zool. Wetensch.*, 250: 118.

Material examined: 1♀ (J), BTE, 03.XI.2015, coll. D. C. Dhali; 1♀ (J), NWS, 02.XI.2015, coll. T. K. Roy; 2♀♀, ATE, 30.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Bihar, Gujarat, Maharashtra, Meghalaya, West Bengal; China, Indonesia, Pakistan, Philippines, Taiwan (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Majumder, 2007; Roy *et al*., 2009, 2010; Sebastian & Peter, 2009; WSC, 2017).

40. ***Chorizopes quadrituberculata*** ® € Roy, Sen, Saha & Raychaudhuri
(Fig. 26)
Chorizopes quadrituberculata Roy et al, 2014, *Rom. J. Biol. – Zool.*, 59 (1): 3–9

Material examined: 1♀ (S), MTE, 28.X.2015, coll. T. K. Roy; 1♀ (J), Umsning, 28.X.2015, coll. S. Sen
Distribution: India: Meghalaya, West Bengal (WSC, 2017)

41. ***Acusilas coccineus*** ® Simon
(Fig. 27)
Acusilas coccineus Simon, 1895, *Hist. Nat. des Araign. Paris*, 1: 785.

Material examined: 1♀, ATE, 29.X.2015, coll. T. K. Roy
Distribution: Assam, Meghalaya, West Bengal; China to Moluccas (Sebastian & Peter, 2009; Roy *et al*., 2010; Roy *et al*., 2017; WSC, 2017).

42. ***Cyclosa krusa*** ® Barrion & Litsinger
(Fig. 28)
Cyclosa krusa Barrion & Litsinger, 1995, *Riceland Spiders of South and Southeast Asia*: 596.

Material examined: 1♂, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Meghalaya, West Bengal; Pakistan, Philippines (Barrion & Litsinger, 1995; Mukhtar & Mushtaq, 2005; Raychaudhuri *et al*., 2016; Saha *et al*., 2016; WSC, 2017).

43. ***Cyclosa moonduensis*** ® Tikader
(Fig. 29)
Cyclosa moonduensis Tikader, 1963, *J. Univ. Poona* (Sci. Tech.), 24: 46.

Material examined: 1♂ (S), NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Gujrat, Madhya Pradesh, Maharashtra, Meghalaya, West Bengal (Tikader, 1982; Roy *et al*., 2017; WSC, 2017).

44. ***Cyclosa bifida*** (Doleschall)
Epeira bifida Doleschall, 1859, *Acta Soc. Sci. Ind.-Neerl.*, 5: 38.
Cyclosa bifida (Doleschall) Simon, 1895, *Hist. Nat. des Araign. Paris*, 1: 779.

Material examined: 4♀♀, BTE, 03.XI.2015, coll. D. Raychaudhuri; 3♀♀, NWS, 02.XI.2015, coll. D. C. Dhali; 10♀♀, ATE, 30.X.2015, coll. T. K. Roy; 1♀ (J), MTE, 28.X.2015, coll. S. Sen; 1♀ (J), Umsning, 28.X.2015, coll. T. K. Roy; 1♀, Sohra, 31.X.2015, coll. S. Saha
Distribution: India: Assam, Meghalaya, Sikkim, West Bengal; Malaysia, New Guinea, Philippines, Sri Lanka (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Saha & Raychaudhuri, 2004; Roy *et al*., 2009, 2010; Sebastian & Peter, 2009; Sen *et al*., 2009a; WSC, 2017).

45. ***Cyclosa mulmeinensis*** ® (Thorell)
(Fig. 30)
Epeira mulmeinensis Thorell, 1887, *Ann. Mus. Civ. Stor. Nat. Genova*, 25: 221.
Cyclosa mulmeinensis (Thorell) Simon, 1909, *Bull. Sci. Fr. Belg.*, 42: 104.

Material examined: 1♀ (J), BTE, 03.XI.2015, coll. T. K. Roy; 1♀, NWS, 02.XI.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Maharashtra, Meghalaya, West Bengal; Africa to Japan, Arabia, Burma, Malacca, Malaysia, Philippines, Taiwan (Tikader, 1982; Barrion & Litsinger, 1995; Hazarika & Chakraborti, 1998; Roy *et al.*, 2009, 2010; WSC, 2017).

46. ***Cyclosa quinqueguttata*** ® (Thorell)
(Fig. 31)
Epeira quinque-guttata Thorell, 1881, *Ann. Mus. Civ. Stor. Nat. Genova*, 17: 113.
Cyclosa quinqueguttata (Thorell) Roberts, 1983, *Zool. J. Linn. Soc.*, 77: 261.

Material examined: 3♀♀, BTE, 03.XI.2015, coll. D. C. Dhali; 3♀♀, NWS, 02.XI.2015, coll. D. Raychaudhuri; 13♀♀, ATE, 30.X.2015, coll. T. K. Roy; 1♀, MTE, 28.X.2015, coll. T. K. Roy; 1♀ (J), Umsning, 28.X.2015, coll. S. Saha
Distribution: India: Assam, Meghalaya, Sikkim, West Bengal; Bhutan, China, Myanmar, Taiwan (Tikader, 1982; Kundu & Raychaudhuri, 1997; Hazarika & Chakraborti, 1998; Saha & Raychaudhuri, 2004; Roy *et al*., 2009, 2010; Sen *et al*., 2009a; WSC, 2017).

47. ***Cyclosa spirifera*** ® Simon
(Fig. 32)
Cyclosa spirifera Simon, 1889, *J. Asiat. Soc. Bengal*, 58: 337.

Material examined: 1♀, BTE, 03.XI.2015, coll. T. K. Roy; 1♀, NWS, 02.XI.2015, coll. D. C. Dhali; 14♀♀, ATE, 30.X.2015, coll. S. Sen; 1♀ (J), MTE, 28.X.2015, coll. T. K. Roy; 1♀, Umsning, 28.X.2015, coll. T. K. Roy; 1♀, Sohra, 31.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Chhattisgarh, Madhya Pradesh, Meghalaya, West Bengal; Pakistan (Tikader, 1982; Biswas & Biswas, 1992; Kundu & Raychaudhuri, 1997; Hazarika &

Chakraborti, 1998; Saha & Raychaudhuri, 2004; Roy *et al*., 2009, 2010; Sen *et al*., 2009a; WSC, 2017).

48. ***Parawixia dehaani*** ® (Doleschall)
(Fig. 33)
Epeira dehaanii Doleschall, 1859, *Acta Soc. Sci. Ind.-Neerl.*, 5: 33.
Parawixia dehaani (Doleschall) Tikader, 1982, *Fauna of India* (Araneae), 2: 212.

Material examined: 2♀♀ (J), BTE, 03.XI.2015, coll. T. K. Roy; 1♀, NWS, 02.XI.2015, coll. T. K. Roy
Distribution: India: Assam, Karnataka, Meghalaya, Sikkim, West Bengal; Burma, Indo & Austro- Malaysia, Japan, Java, New Guinea, Philippines, Polynesia, Sumatra (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Saha & Raychaudhuri, 2004; Majumder, 2007; Roy *et al.*, 2009, 2010; Sebastian & Peter, 2009: Sen *et al*., 2009a; WSC, 2017).

49. ***Neoscona bengalensis*** € Tikader & Bal
Neoscona bengalensis Tikader & Bal, 1981, *Rec. Zool. Surv. India, Occ. Pap.*, 24: 15.

Material examined: 1♀, BTE, 03.XI.2015, coll. T. K. Roy; 1♀, NWS, 02.XI.2015, coll. D. C. Dhali
Distribution: India: Assam, Meghalaya, West Bengal (Tikader, 1982; Biswas & Biswas, 1992; Kundu & Raychaudhuri, 1997; Majumder, 2005; Roy *et al*., 2009, 2010; Sebastian & Peter, 2009; Sen *et al*., 2009a; WSC, 2017).

50. ***Neoscona nautica*** (L. Koch)
Epeira nautica L. Koch, 1875, *Aegyptische und abyssinische Arachniden gesammelt von Herrn C. Jickeli*. Nürnberg: 17.
Neoscona nautica (L. Koch) Petrunkevitch, 1930, *Trans. Connect. Acad. Arts Sci.*, 30: 320.

Material examined: 1♀, Sohra, 01.XI.2015, coll. T. K. Roy
Distribution: India: Andhra Pradesh, Assam, Gujarat, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, West Bengal; Burma, North America, Pakistan, Philippines (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Saha & Raychaudhuri, 2004; Majumder, 2007; Roy *et al.*, 2009; Sebastian & Peter, 2009; WSC, 2017).

51. ***Neoscona punctigera*** ® (Doleschall)
(Fig. 34)
Epeira punctigera Doleschall, 1857, *Nat. Tijdschr. Neder.-Ind.*, 13: 420.
Neoscona punctigera (Doleschall) Roberts, 1983, *Zool. J. Linn. Soc.*, 77: 275.

Material examined: 1♀, ATE, 30.X.2015, coll. D. Raychaudhuri
Distribution: India: Assam, Gujarat, Maharashtra, Meghalaya, West Bengal; Austro-Malaysia, China, Japan, Reunion, South New Guinea (Tikader, 1982; Roy *et al*., 2010; Roy *et al*., 2017; WSC, 2017).

52. ***Neoscona yptinika*** ® Barrion & Litsinger
(Fig. 35)
Neoscona yptinika Barrion & Litsinger, 1995, *Riceland Spiders of South and Southeast Asia*: 620.

Material examined: 1♂, ATE, 30.X.2015, coll. T. K. Roy
Distribution: India: Meghalaya, West Bengal; Philippines (Barrion & Litsinger, 1995; Roy *et al.*, 2010; Sen *et al.*, 2011; WSC, 2017).

53. ***Neoscona theisi*** (Walckenaer)
Epeira theis Walckenaer, 1841, *Hist. Nat. des Ins. Aptères*. *Paris,* 2: 53.
Neoscona theisi (Walckenaer) F. O. P.-Cambridge, 1904, In *Biologia Centrali-Americana, Zool . Lond*., 2: 470.

Material examined: 2♀♀, BTE, 03.XI.2015, coll. S. Saha; 1♀, NWS, 02.XI.2015, coll. D. C. Dhali; 2♀♀, ATE, 30.X.2015, coll. S. Sen; 1♀ (J), MTE, 28.X.2015, coll. D. C. Dhali; 1♀, Umsning, 28.X.2015, coll. T. K. Roy; 1♀, Sohra, 31.X.2015, coll. D. Raychaudhuri
Distribution: India: Gujarat, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, West Bengal; China to Pacific Island, New Guinea (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Majumder, 2007; Roy *et al*., 2009; Saikia & Baruah, 2009; WSC, 2017).

54. ***Neoscona shillongensis*** Tikader & Bal
Neoscona shillongensis Tikader & Bal, 1981, *Rec. Zool. Surv. India, Occasional Paper* 24: 34.

Material examined: 7♀♀, Sohra, 01.XI.2015, coll. T. K. Roy
Distribution: India: Meghalaya; China, Pakistan (Tikader, 1982; WSC, 2017).

55. ***Araneus mitificus*** ® (Simon)
(Fig. 36)
Epeira mitifica Simon, 1886, *Act. Soc. Linn. Bord.*, 40: 150.
Araneus mitificus (Simon) Simon, 1909, *Bull. Sci. Fr. Belg.*, 42: 109.

Material examined: 10♀♀, ATE, 30.X.2015, coll. T. K. Roy; 3♀♀ (J), MTE, 28.X.2015, coll. D. C. Dhali; 3♀♀ (J), Umsning, 28.X.2015, coll. S. Sen
Distribution: India: Assam, Chhattisgarh, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, West Bengal; Bangladesh, Burma, Hongkong, Malaysia, Myanmar, New Guinea, Pakistan, Philippines, Singapore, Thailand, Vietnam (Tikader, 1982; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Kundu & Raychaudhuri, 1997; Hazarika & Chakraborti, 1998; Majumder, 2007; Roy *et al.*, 2009, 2010; Sebastian & Peter, 2009; Sen *et al.*, 2009a; WSC, 2017).

DISCUSSION

In fine, total catch of spiders reveals 55 species belonging to 36 genera distributed over 13 families. A comparative account of the spider taxa recorded from different study area shows that diversity is maximum in Nongkhylem Wildlife Sanctuary, followed by Byrnihat Tea Estate, Anderson Tea Estate, Umsning, Meg Tea Estate and Sohra. Species diversity is maximum in Araneidae (23), followed by Salticidae (7), Tetragnathidae (5), Oxyopidae (4),

Theridiidae (4) and Lycosidae (3). Both Thomisidae and Uloboridae are represented by two species. Nephilidae, Linyphiidae, Pisauridae, Sparassidae and Eutichuridae are represented single species. Out of 55 species, 13 are endemic to India, thus exhibiting a high endemicity (23.6%). Based on this, the decreasing order of family is Uloboridae > Pisauridae > Theridiidae > Thomisidae > Lycosidae > Oxyopidae > Tetragnathidae > Salticidae > Araneidae. Analysis of zoogeographical distribution reveals that ¼ th and 1/6 th Palaearctic and Australian elements contribute in composition of the fauna.

ACKNOWLEDGEMENTS

We thank MOEF & CC, GOI, (AICOPTAX) [22018/02/2010-CS (Tax) dt. 28.7.2014] for sponsoring the project and the officials of the concerned Tea Estates, Dept. of Forest, Govt. of Meghalaya, the Hon'ble Vice-Chancellor, Ramakrishna Mission Vivekananda University, Narendrapur for necessary support. Sincere thanks are also extended to Dr. Souvik Sen and Dr. Dhruba Chandra Dhali for their manifold assistance during the study.

LITERATURE CITED

[1] Barrion, A. T. & Litsinger, J. A. 1995. Riceland Spiders of South and Southeast Asia, CAB International, Wallingford, UK, xix + 700 pp.

[2] Biswas, B. K. & Biswas, K. 1992. State Fauna Series 3: Fauna of West Bengal, Araneae: Spiders, part 3. Zool. Surv. India, 357-500.

[3] Biswas, B. K. & Biswas, K. 2004. State Fauna Series 10: Fauna of Manipur, Araneae: Spiders. Zool. Surv. India, 25-46.

[4] Biswas, B. K. & Biswas, K. 2006. State Fauna Series 13: Fauna of Arunachal Pradesh, Araneae: Spiders, part 2. Zool. Surv. India, 491-518.

[5] Biswas, B. K. & Majumder, S. C. 1995. State Fauna Series 3. Fauna of Meghalaya, Araneae: Spiders, Zool. Surv. India, 95-128.

[6] Biswas, V., Saha, S. & Raychaudhuri, D. 1997. Araneidae and Theridiidae of Buxa Tiger Reserve, West Bengal; genera *Leucauge* White, *Cyrtophora* Stoliczka and *Theridula* Emerton. Entomon., 22 (3 & 4): 229-233.

[7] Breitling, R. 2015. *Linyphia bilobata* Roy & al., 2015, is a junior synonym of *Chrysso scintillans* (Thorell, 1895) (Araneae: Linyphiidae, Theridiidae). Contributions to Natural History 30: 1-7.

[8] Dhali, D. C., Sen, S., Saha, S. & Raychaudhuri, D. 2010a. Jumping spiders (Araneae: Salticidae) of four Reserve Forests of Duars, West Bengal. Bionotes, 12(1): 24-25.

[9] Dhali, D. C., Roy, T. K., Saha, S. & Raychaudhuri, D. 2010b. Spiders of the Gibbon Wildlife Sanctuary, Assam. Bionotes, 12 (4): 122 .

[10] Dhali, D. C., Roy, T. K., Sen, S., Saha, S. & Raychaudhuri, D. 2012. Wolf spiders (Araneae: Lycosidae) of the reserve forests of Dooars, West Bengal, India. Mun. Entomol. Zool., 7(2): 1199-1213.

[11] Gajbe, U. A. 2004. Studies on some spiders of the family Lycosidae (Araneae: Arachnida) from Madhya Pradesh, India. Rec. Zool. Surv. India, Occas. Pap., 221: 1-40.

[12] Gajbe, U. A. 2008. Fauna of India and the adjacent countries: Spider (Arachnida: Araneae: Oxyopidae). Zool. Surv. India, Kolkata, 3: 1-117.

[13] Hazarika, L. K. & Chakraborti, S. K. 1998. Spider complex of tea ecosystem in Assam. Assam Agric. Univ., Jorhat, Res. Bull. No. AAU/DA/EI.

[14] Keswani, S., Hadole, P. & Rajoria, A. 2012. Checklist of Spiders (Arachnida: Araneae) from India-2012. Indian J. Arachnol., 1(1): 129 pp.
[15] Kundu, M. & Raychaudhuri, D. 1997. Araneid Spiders (Araneidae: Araneae) from Buxa Tiger Reserve, Jalpaiguri, West Bengal. Ins. Env., 2(4): 133-134.
[16] Majumder, S. C. 2005. Studies on some spiders from eastern coastal region of India. Mem. Zool. Surv. India, 20(3): 1-57.
[17] Majumder, S. C. 2007. Pictorial handbook on spiders of Sunderbans, West Bengal, Zool. Surv. India, 138 pp.
[18] Majumder, S. C. & Tikader, B. K. 1991. Studies on some spiders of the family Clubionidae from India. Rec. Zool. Surv. India, Occ. Pap., 102: 175 pp.
[19] Metzner, H. 2017. Jumping spiders (Arachnida: Araneae: Salticidae) of the world. Available at: http://www. jumping-spiders. com. (Accessed on 2nd February, 2017).
[20] Mukhtar, M. K. & Mushtaq, S. 2005. Spiders of the genus *Cyclosa* (Araneae: Araneidae) from Punjab, Pakistan. Pak. J. Zool., 37: 199-204.
[21] Okuma, C. 1988. A revision of the Genus Tetragnatha Latreille (Araneae: Tetragnathidae) of Asia, Part I. J. Fac. Agric., Kyushu Univ., 32(3-4): 165-181.
[22] Prószyński, J. 2016. Monographs of the Salticidae (Araneae) of the world 1995 – 2015. Available from: http://www.peckhamia.com/salticidae, version October 30th, 2016. (accessed on 2nd February, 2017).
[23] Raychaudhuri, D., Saha, S. & Roy, T. K. 2016. Spiders: A proficient candidate in practicing IPM for Darjeeling Tea. World Scientific News 38: 62 pp.
[24] Roy, T. K., Dhali, D. C., Saha, S. & Raychaudhuri, D. 2009. Typical Orb-weaving Spiders (Araneidae: Araneae) of Tea Ecosystem of Dooars, West Bengal. *Ins. Env.*, 15 (3): 116-117.
[25] Roy, T. K., Dhali, D. C., Saha, S. & Raychaudhuri, D. 2010. Orb-weaving spiders (Araneae: Araneidae) in the Tea Ecosystem of Assam. Bionotes, 12(4): 113-114.
[26] Roy. T. K. 2013. Spiders (Araneae: Arachnida) of Tea Ecosystem of Dooars, West Bengal. Ph.D. thesis submitted to University of Calcutta, 488pp.
[27] Roy, T. K., Saha, S. & Raychaudhuri, D. 2016. A Treatise on the Jumping Spiders (Araneae: Salticidae) of Tea Ecosystem of Dooars, West Bengal, India. World Scientific News, 53(1): 1-66.
[28] Roy, T. K., Saha, S. & Raychaudhuri, D. 2017. On the Araneid Fauna (Araneae: Araneidae) of the Tea Estates of Dooars, West Bengal, India. World Scientific News, 67(1): 1-67.
[29] Saha, S. & Raychaudhuri, D. 2004. A survey of spiders (Araneae: Araneidae) of Jaldapara Wildlife Sanctuary, West Bengal, with description of a new *Zilla* species. Entomon, 29: 245-252.
[30] Saha, S., Biswas, V., Majumder, S. C. & Raychaudhuri, D. 1995. Araneidae of Buxa Tiger Reserve, West Bengal. Acta Arachnol., 44: 11-14.
[31] Saha, S., Roy, T. K. & Raychaudhuri, D. 2016. Survey on spider faunal diversity of Darjeeling Tea Plantations. Munis Entomology & Zoology, 11 (2): 622-635.
[32] Saikia, P. & Baruah, M. 2009. Diversity of spiders in Deep Water Rice Ecosystem of Assam. Ins. Env., 14 (4): 173-174.
[33] Sebastian, P. A. & Peter, K. V. 2009. Spiders of India, University press (India) private limited, 614 pp.
[34] Sen, S., Saha, S. & Raychaudhuri, D. 2009a. Typical Orb weavers (Araneidae: Araneae) of Mahananda Wildlife Sanctuary, West Bengal. Ins. Env., 15(1): 30-31.
[35] Sen, S., Saha, S. & Raychaudhuri, D. 2009b. Crab Spiders (Thomisidae: Araneae) of the Reserve Forests of Dooars, West Bengal. Ins. Env., 15(1): 32-33.

[36] Sen, S., Saha, S. & Raychaudhuri, D. 2009c. Long-jawed Orb Weaving Spiders (Tetragnathidae: Araneae) in the Reserve Forests of Dooars, West Bengal. Ins. Env., 15(3): 118.
[37] Sen, S., Roy, T. K., Dhali, D. C., Saha, S. & Raychaudhuri, D. 2011. First record of the genus *Tukaraneus* Barrion and Litsinger and *Neoscona yptinika* Barrion and Litsinger (Araneae: Araneidae) from India. J. Asia-Pacific Entomol., 14: 367-371.
[38] Sen, S., Dhali, D. C., Saha, S. & Raychaudhuri, D. 2015. Spiders (Araneae: Arachnida) of Reserve Forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. World Scientific News, 20: 1-339.
[39] Sethi, V. D. & Tikader, B. K. 1988. Studies on some giant crab spiders of the family Heteropodidae from India. Rec. Zool. Surv. India, Misc. Publ. Occ. Pap., 93: 1-94.
[40] Tikader, B. K. 1969. Two new species of the genus Uloborus of the family Uloboridae from India. Proc. Indian Acad. Sci., 70(B): 127-130.
[41] Tikader, B. K. 1970. Spider fauna of Sikkim. Rec. Zool. Surv. India, 64: 1- 83.
[42] Tikader, B. K. 1971. Descriptions of some little known spiders from India of the genus *Miagrammopes* Cambridge (Uloboridae). J. Asiat. Soc. Calcutta, 213: 172-177.
[43] Tikader, B. K. 1977. Studies on spider fauna of Andaman and Nicobar islands, Indian Ocean. Rec. Zool. Surv. India, 72: 153-212.
[44] Tikader, B. K. 1980. Thomisidae (Crab-spiders): Fauna of India (Araneae). Zool. Surv. India, 1: 247pp.
[45] Tikader, B. K. 1982. The Fauna of India, Spider: Araneae (Araneidae & Gnaphosidae). Zool. Surv. India, Calcutta, II (1): 533 pp.
[46] Tikader, B. K. 1987. Hand Book of Indian Spiders. Zool. Surv. India, Calcutta, 251 pp. Tikader, B. K. & Biswas, B. 1981. Spider fauna of Calcutta and vicinity. Rec. Zool. Surv. India. Occ. Pap., 39: 149 pp.
[47] Tikader, B. K. & Malhotra, M. S. 1980. Lycosidae (Wolf-spiders): Fauna of India (Araneae) 1. Zool. Surv. India, 248-447.
[48] World Spider Catalog. 2017. World Spider Catalog. Natural History Museum Bern. Available at http://wsc.nmbe.ch, version 17.5 (Accessed on 2nd February, 2017).

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

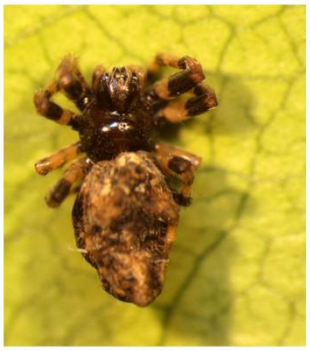
26

27

28

29

30



31

32

33

34

35

36

Affirming Length of Body or Part/s and Weight There of as a Determinant of Capture Area of Spider Web

Priyankar Sanphui[1,a], **Subhabrata Dey**[2], **Dipsmita Mukherjee**[2] and **Sumana Saha**[3,b]

[1]Department of Zoology, Sree Chaitanya College, Habra, West Bengal,
[a]E-mail: psanphui@gmail.com

[2]Post Graduate Department of Zoology, Darjeeling Government College, Darjeeling, West Bengal

[3]Post Graduate Department of Zoology, Barasat Government College, Barasat, Kolkata,West Bengal,
[b]E-mail: sahasumana2010@gmail.com

ABSTRACT

A spider web is a device created by a spider out of proteinaceous silk extruded from its spinnerets, primarily to trap its prey. Among spiders, members of orb weavers (Families Araneidae, Nephilidae and Tetragnathidae) are unique for their webs of geometric precision. Web size and design may vary with the prey size, food availability and body dimensions. However, not all body dimensions are equally relevant to web design. Present study was conducted in the Happy Valley Tea Estate Darjeeling, West Bengal in order to affirm the query, does length of body or part/s and weight govern the capture area of spider web. Measures of the web structure were noted using a slide calipers. Equally several individuals of the orb weaving species that were taken into consideration were brought to the laboratory not only to measure the body/leg length under microscope but also for taxonomic evaluation. Present discourse is on the data generated during May –August, 2016. Our study was limited to the webs of *Neoscona rumpfi* (Thorell) (Araneidae) and *Leucauge decorata* (Blackwall) (Tetragnathidae). A total of 19 and 21 webs of the respective species were analyzed. Capture areas were calculated following Herberstein and Tso (2000). The result suggests that body length relates positively with the capture area of both the spider webs. However leg length, 4th leg plays a significant role in determining the capture area. Thus the present study once again confirms the fact that the capture area of spiders' web is largely dependent on the body dimensions. However it is also important to remember that capture area of a particular species depend on dimension of specific body part/parts.

Keywords: Capture area, orb web, Araneidae, Tetragnathidae

INTRODUCTION

Spider web is a device created by a spider by the proteinaceous silk extruded from its spinnerets, mainly for prey capture. The webs of spider can be of different types like orb web, tangle or cob web, funnel web and tubular web. The orb web spiders mainly belong to the family Araneidae, Nephilidae and Tetragnathidae. Orb webs are more appropriately distinguished from other types of spider webs by their round, 'wagon wheel'-shaped architecture. Orb –Weaving spiders are excellent models for studying various questions in behavior and ecology. By measuring the architectural features of the web many aspect of

spider behavior can be compared. In nature organisms compete for food and space. The orb web spiders usually do not compete for food (Wise,1993), as different species use different predatory strategies (Henaut *et. al.*, 2006). One such strategy to reduce competition is construction of webs for prey capture.

The webs of orb-web weaving spiders shows great variations in their designs, on which depends the prey capturing specificity (Eberhard, 1986). Orb web design may vary both intra and inter specifically in response to prey size , food availability, web site etc. (Sandoval, 1994).

The web design (capture area) can relate to various measures of the body size like body length (Waldorf, 1976), carapace width (Olive, 1980), leg length and spider weight (Eberhard, 1988). However there are other studies which failed to find any such relationship (Leborgne & Pasque,t 1987). Similarly, not all body dimensions may be equally relevant to web design.

The present study was aimed to understand the correlation of the body dimensions, weight of orb web spider with the capture area of their webs.

MATERIALS AND METHODS

Study area:

For this study specimens were collected form Happy Valley Tea Estate (Fig.1). Happy Valley Tea Estate is a tea garden in Darjeeling, West Bengal, India. Established in 1854, it is Darjeeling's second oldest tea estate. Spread over 437-acre, it is situated (27.0514° N, 88.2586°E) at a height of 2,100 m above sea level. The bushes in the garden are very old — the minimum age is 80 years, and some are 150 years old. Very little re-plantation has been done in the recent past.. Present discourse is on the data generated during May –August, 2016.

Web characteristics and calculation of capture area of web :

Only the webs of adult individuals were used for the study. Before recording the web data, each web was sprayed with flour to improve the resolution. The measurements of the web structure were done using slide calipers and scale and noted in the field note book. Capture areas were calculated following Herberstein and Tso (2000).

$$\textbf{Capture area: } [\tfrac{1}{2}\pi r_{au}^2 - \tfrac{1}{2}\pi(Hr_u)^2] + [\tfrac{1}{2}\pi r_{al}^2 - \tfrac{1}{2}\pi(Hr_1)^2]^*$$

$$^* r_{au} = (r_u + d_h/2)/2 \text{ and } r_{al} = (r_1 + d_h/2)/2.$$

The specimens were studied under Stereo Binocular Microscopes (Olympus SZX7) and identification was done following standard literatures.

Collection and identification of spider samples

Spiders were collected by hand picking or by holding the tube close to the webs from their respective webs as described earlier (Sen, *et. al*. 2010). The collected specimens are killed and preserved in 70% alcohol in a number of plastic tubes, each with a definite sample number. The measurements of body parts like body length, leg length, carapace width, abdomen length were taken (in mm) and the wet weight was also estimated (in mg).

Statistical analysis

The relationships of all body size measures (carapace width, body length, abdomen length, leg length) and wet weight to capture area of those webs were calculated using Pearson Correlations. Students t test was performed to check the level of significance.

RESULTS

For the study a total of 40 webs were taken into consideration. Out of these 19 were of *Neoscona rumpfi* (Thorell) (Araneidae) and 21 were of *Leucauge decorata* (Blackwall) (Tetragnathidae) (Fig. 3). The body length , leg length (4^{th} leg), abdomen length, carapace width and wet weight were measured and the correlation with the capture area was checked. The measurements of *N. rumpfi* and *L. decorata* are given in Tables 1and 2 respectively. The correlation between the body length, leg length (4^{th} leg), abdomen length, carapace width and wet weight and capture area were calculated (Figs 4 and 5)

Our result shows that the mean capture area of the studied .*N. rumpfi* were 853.6 ± 186 cm^2 . The capture area shows correlation with body length, leg length, abdomen length, carapace width and wet weight. The calculated correlation coefficient were 0.39, 0.52, 0.22, 0.497, 0.244 respectively (Table 3). However the correlation was statistically significant only in case of leg length (0.0189) and carapace width (0.0288). This indicate that at least for the population of *N. rumpfi* studied, the capture area shows a significantly positive correlation with leg length and carapace width.

In case of *Leucauge decorata* the mean of capture area of the studied webs was less than that of *N. rumpfi* that is 476.7 ± 45.56. The correlation coefficient of capture area to body length, leg length, abdomen length, carapace width and wet weight was respectively 0.45, 0.46, 0.45, 0.43 and 0.33. Out of all the parameters used capture area showed significant positive correlation with body length (0.04), leg length (0.028), abdomen length (0.037) and carapace width (0.049). However the correlation between capture area and wet weight was not significant statistically (Table. 3).

DISCUSSION

The web design in adult spiders related differently with the various body size measures. Our study was to affirm the query whether the lengths of body parts, weight correlates with the capture area of the spider web.

Our result shows that for *Neoscona rumpfi* the leg length and carapace width are significantly correlated with capture area. The capture area is positively correlated with leg length and carapace width. However body length, abdomen length and wet weight were not significantly correlated with the capture area of the spider. Interestingly Heiling and Herberstein (1998) also reported that *Nuctenea sclopetaria* (Araneae, Araneidae) also show the positive correlation between carapace width and capture area. They didn't find any correction between leg length and capture area. This indicates that even within the same family of spiders the capture area of the web of different species correlates differently to different body parameters.

Like *Neoscona rumpfi, L. decorata* also show significant positive correlation with leg length and carapace width and there was no correlation between capture area and wet weight. However in case of *L. decorata* unlike the *N. rumpfi* the correlation between capture area and body length, abdomen length was also statistically significant. Our result corroborate a with the report by Tahir *et. al.*, 2010 on *L. decorata* where the authors report a positive correlation between capture area and carapace width.

It has been previously shown that the capture area only increases with carapace width (Olive, 1980; Murakami 1983). In our present study we found the capture area is not only dependent on carapace width but also leg length and other body parameters. It will probably be correct to postulate that the body parameter that determines the capture area is specific for each species of orb web spider. A more detailed study with different species of spiders will enlighten this aspect.

ACKNOWLEDGEMENTS

The authors express sincere thanks to The Officer-in-charge & The Principals of respective colleges for necessary logistic support and encouragement. Sincere thanks are also due to Prof. Dinendra Raychaudhuri for his valuable suggestions during preparation of the manuscript.

LITERATURE CITED

[1] Eberhard, W.G. 1986. Effects of orb-web geometry on prey interception and retention . pp. 71-100, In Spiders: Webs, Behavior and Evolution (W.A.Shear, ed). Stanford Univ. Press, Stanford, California.

[2] Eberhard, W.G. 1988. Behavioral flexibility in orb web construction: effects of supplies in different silk glands and spider size and weight. J. Arachnol 16: 295-302.

[3] Heiling, M. A. and M. E. Herberstein. 1998. The web of *Nuctenea sclopetaria* (Araneae, Araneidae): Relationship between body size and web design. J. Arachnol 26:191–96.

[4] Henaut, Y., Garcia-Ballinas, J.A. and Alauzet, C., 2006. Variation in web construction in *Leucauge venusta* (Araneae, Tetragnathidae). *J. Arachnol.*, 34: 234-240.

[5] Herberstein M E and Tso I M. 2000: Evaluation of formulae to estimate the capture area and mesh height of orb webs (Araneoidea, Araneae). J . Arachnol 28: 180-184.

[6] Leborgne, R. and Pasquet, A. 1987: Influences of aggregative behaviour on space occupation of the spider Zygiella x-notata (Clerck). Behav. Ecol. Sociobiol. 20: 203–208.

[7] Murakami, C.M., 1983. Factors determining the prey size of the orb-web spider, *Argiope amoena* (L. Koch) (Argiopidae). Oecologia, 57: 72-77.

[8] Olive, C .W 1980. Foraging specializations in orbweaving spiders. Ecology, 61: 1133-1144.

[9] Sandoval, C. P. 1994. Plasticity in web design in the spider *Parawixia bistriata*: a response to variable prey type. Funct . Ecol, 8: 701-707.

[10] Sen, S, Saha, S. & Raychaudhuri, D. 2010: Estimation of capture area and mesh height of the webs of two orb weaving spider species. (Arachnida: Araneae). Bionotes, 12(3): 84-85.

[11] Tahir, H.M , Butt, A. & Alam, I. 2010: Relationship of web characteristics and body measures of *Leucauge decorata* (Araneae: Tetragnathidae). Pakistan J. Zool., 42(3): 261-265.

[12] Waldorf, E. S. 1976. Spider size, microhabitat selection and use of food. American Nat, 96: 77-87.

[13] Wise, D. H., 1993. *Spiders in ecological webs*. Cambridge Studies in Ecology, Cambridge University Press, Cambridge, UK: 328 pp.

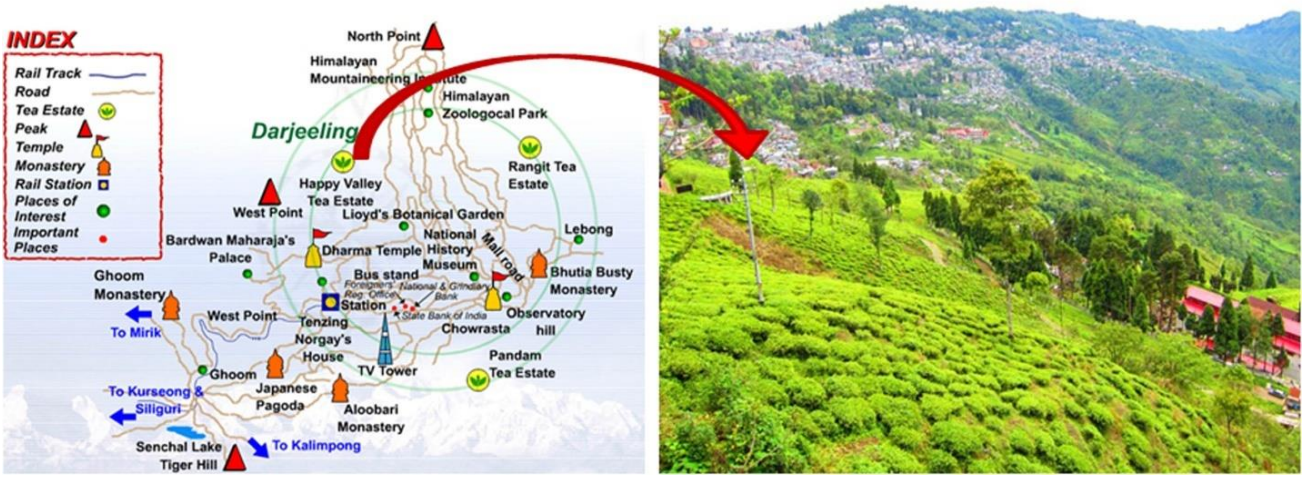


Figure 1. Happy Valley tea estate.

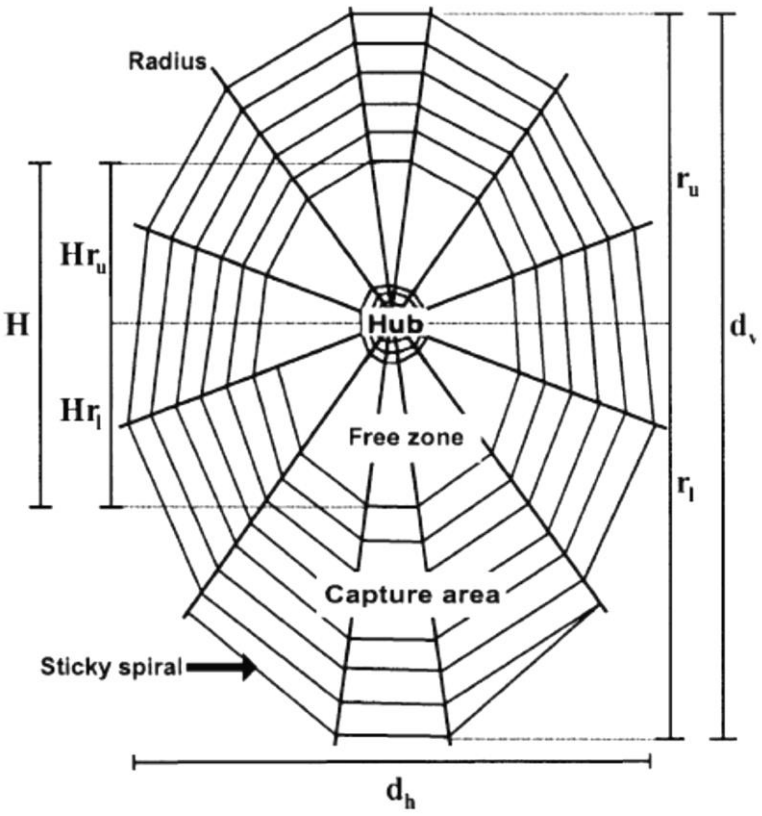


Figure 2. Schematic diagram of orb web, showing different measuring parameter. (after Herberstein and Tso (2000))

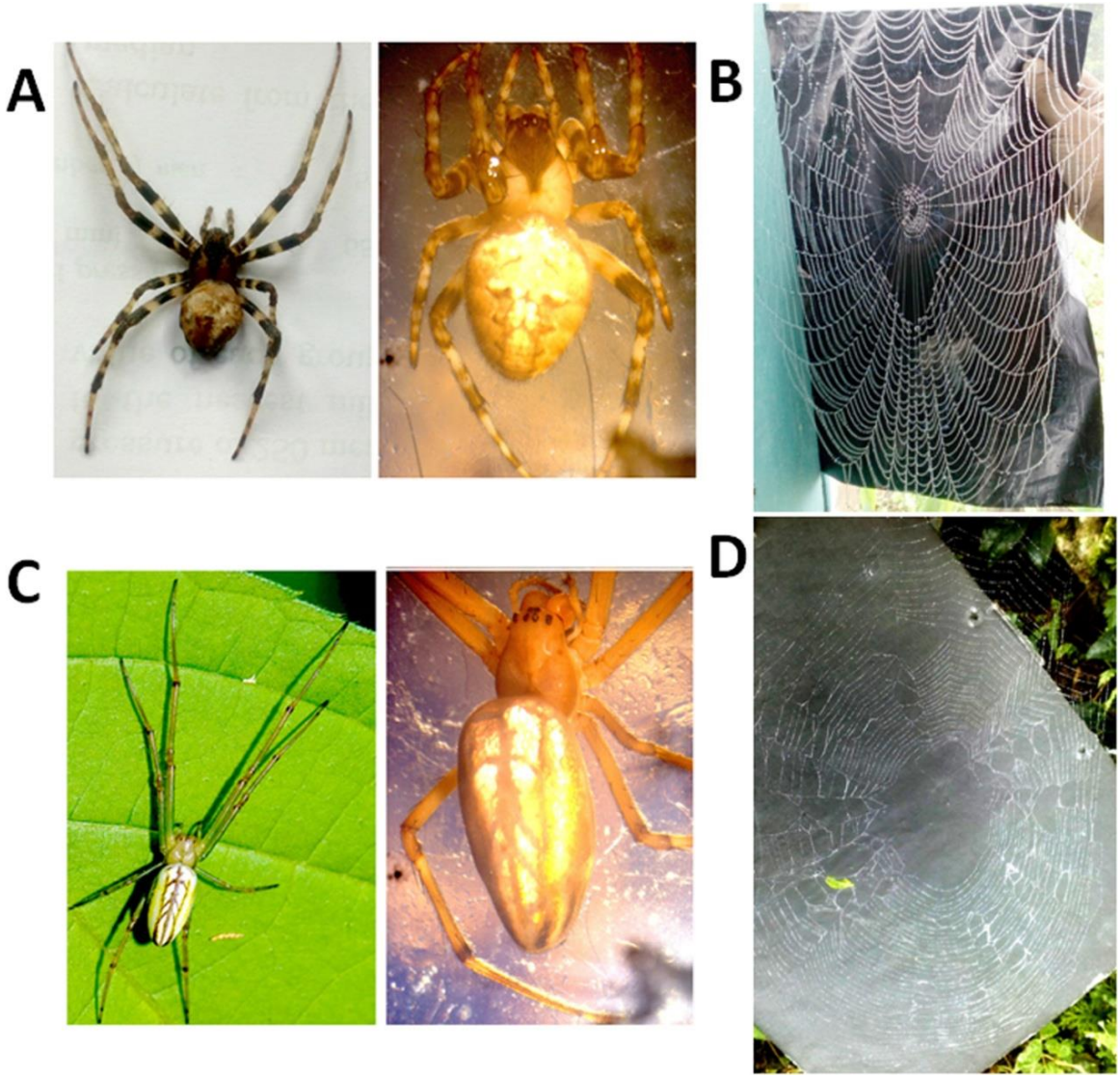


Figure 3. A. *Neoscona rumpfi* B. Web of *N.rumpfi* C. *Leucauge decorata* D. Web of *L. decorata*

Table 1. Web parameters, wody dimension, weight and capture area of *Neoscona rumpfi*

Secimen no.	Hr_u (Cm)	Hr_l (Cm)	r_u (Cm)	r_l (Cm)	d_h (Cm)	Body length (Cm)	Leg Length (Cm)	Abdomen length (Cm)	Carapace width (Cm)	wet weight (Gm)	Capture area (Cm^2)
1	5	4.3	18	18.7	34.2	1	2.9	1	0.5	0.506	917.39
2	3.1	3.2	11.9	11.8	21.4	0.8	1.3	0.6	0.3	0.138	366.98
3	1.8	3.5	8.6	13.5	18	0.81	1.2	0.5	0.5	0.157	290.22
4	3.5	7	23	32	44	0.8	1.5	0.5	0.3	0.074	1813.15
5	1.8	2.1	5.8	6.5	9	0.6	0.8	0.4	0.3	0.021	74.96
6	2	6.8	23	33	40	0.8	1.7	0.5	0.5	0.088	1697.61
7	6	10	23	34	40	0.8	1.5	0.55	0.3	0.158	1588.84
8	3	4	8.5	13.5	19	0.5	0.7	0.3	0.1	0.02	289.67
9	5.8	9.6	18.2	32.2	35.9	1.4	2.1	0.9	0.6	0.365	1234.18
10	1.4	1.8	3.3	6	7.4	0.6	0.8	0.35	0.15	0.019	45.99
11	1.9	3.8	9.4	15.6	16.5	0.6	0.9	0.4	0.2	0.03	298.31
12	4	6.8	15.9	19.1	26.8	1.6	2.2	0.6	0.3	0.245	644.77
13	1.7	3.6	9.3	11	15.7	0.7	0.7	0.4	0.15	0.024	228.14
14	1.5	3.5	9.6	14	19	0.7	0.8	0.4	0.3	0.025	332.37
15	2	3	11.5	12	16	0.65	0.85	0.5	0.15	0.026	275.54
16	2.5	5	22	27	33	0.8	0.99	0.3	0.2	0.046	1225.19
17	4.4	7.4	25	36.2	70.6	1.1	2	0.5	0.5	0.138	3282.46
18	2	4	13.5	21	24	0.55	0.9	0.3	0.15	0.034	621.72
19	3	6	17	25	32	0.75	0.9	0.5	0.15	0.045	991.46
Mean ± SEM						0.82 ±0.06	1.30 ± 0.14	0.5 ± .04	0.297 ± 0.035	0.114 ± 0.03	853.62 ± 186.5

Table 2. Web parameters, body dimension, weight and capture area of *Leucauge decorata*

Specimen no.	Hr_u (Cm)	Hr_l (Cm)	r_u (Cm)	r_l (Cm)	d_h (Cm)	Body length (Cm)	Leg Length (Cm)	Abdomen length (Cm)	Carapace width (Cm)	Wet weight (Gm)	Capture area (Cm^2)
1	2.6	4.12	6.3	14.2	13.3	0.13	1.2	0.5	0.15	0.017	179
2	2.1	3.9	10.7	12.1	28.6	0.8	1.7	0.6	0.2	0.094	484
3	2.4	3.7	11.2	13.9	23	0.8	1.6	0.4	0.2	0.041	424
4	2.6	3.4	15.5	13.9	25.7	0.9	2	0.6	0.2	0.085	565
5	1.9	2	13.9	19.5	25	0.6	1.1	0.9	0.15	0.012	644
6	2.5	4.3	16.5	27.6	33.7	1	2.2	0.6	0.3	0.074	1130
7	2.5	3.2	11.3	12.9	26	0.9	1.3	0.6	0.3	0.058	468
8	2.9	4.1	13	17.3	25.6	0.9	1.6	0.6	0.2	0.075	570
9	2.1	2.3	8.4	10.2	16.9	0.8	1.4	0.5	0.2	0.055	232
10	2.8	2.3	17.8	9.8	30	1	1.5	0.5	0.2	0.045	630
11	2.4	2.9	10.2	15.7	28.4	0.9	1.7	0.7	1.5	0.06	555
12	3.2	3	10.5	11	25	0.9	1.6	0.5	2.5	0.033	392
13	2	3.5	15.5	11.8	26	0.7	1.5	0.6	0.2	0.068	533
14	2.3	3.6	6.4	8.4	20.4	0.8	1.6	0.5	0.1	0.044	210
15	1.9	3	9	12	23.9	0.8	1.5	0.5	0.15	0.049	375
16	2.5	2.7	8.8	8.8	20.2	0.9	1.6	0.5	0.2	0.05	258
17	2.7	3.6	10.1	14.5	23.3	0.7	1.4	0.5	1.5	0.046	419
18	2.5	2.4	8.5	19	29.5	0.9	1.6	0.5	0.1	0.022	618
19	2.4	3	9	10.4	21.5	0.7	1.5	0.5	0.2	0.048	305
20	3	2.9	12	10.8	23	0.6	1.5	0.5	0.2	0.026	384
21	1.9	1.9	7.2	12.3	21.9	0.9	1.9	0.3	0.15	0.02	324
Mean ± SEM						0.791± 0.04	1.57 ± 0.05	0.54 ± 0.02	0.42 ± 0.13	0.048 ± 0.004	461.79 ± 45.6

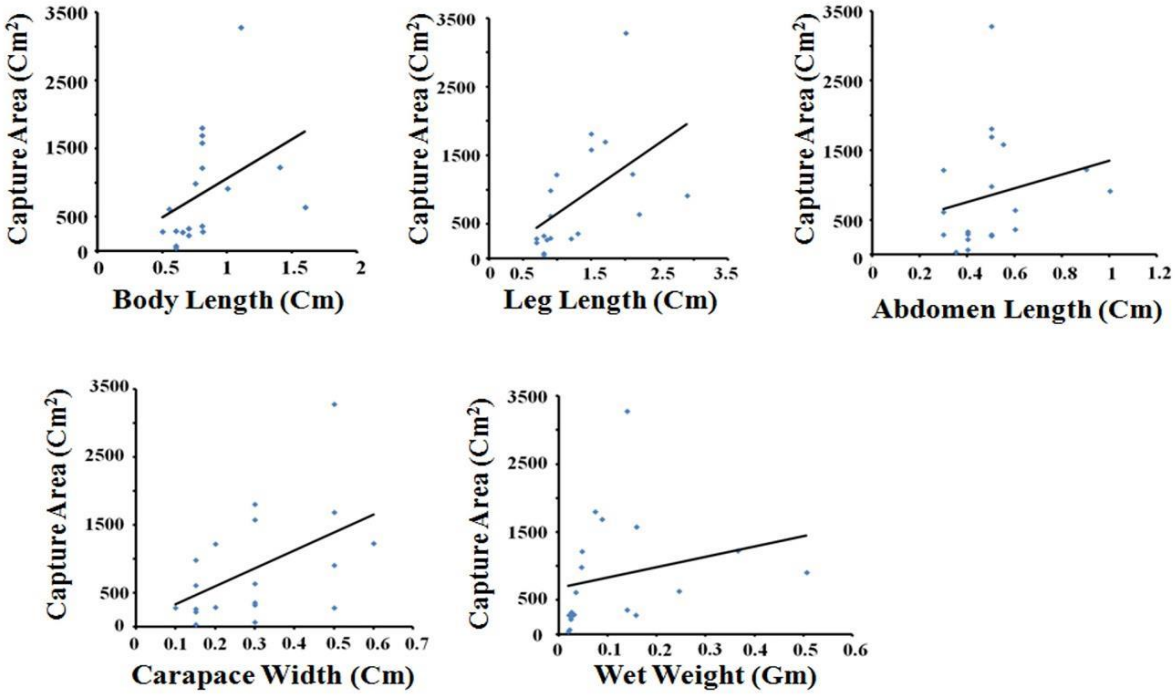


Figure 4. Graph showing correlation between body length, leg length, abdomen length, carapace width, wet weight and capture area of web of *Neoscona rumpfi*

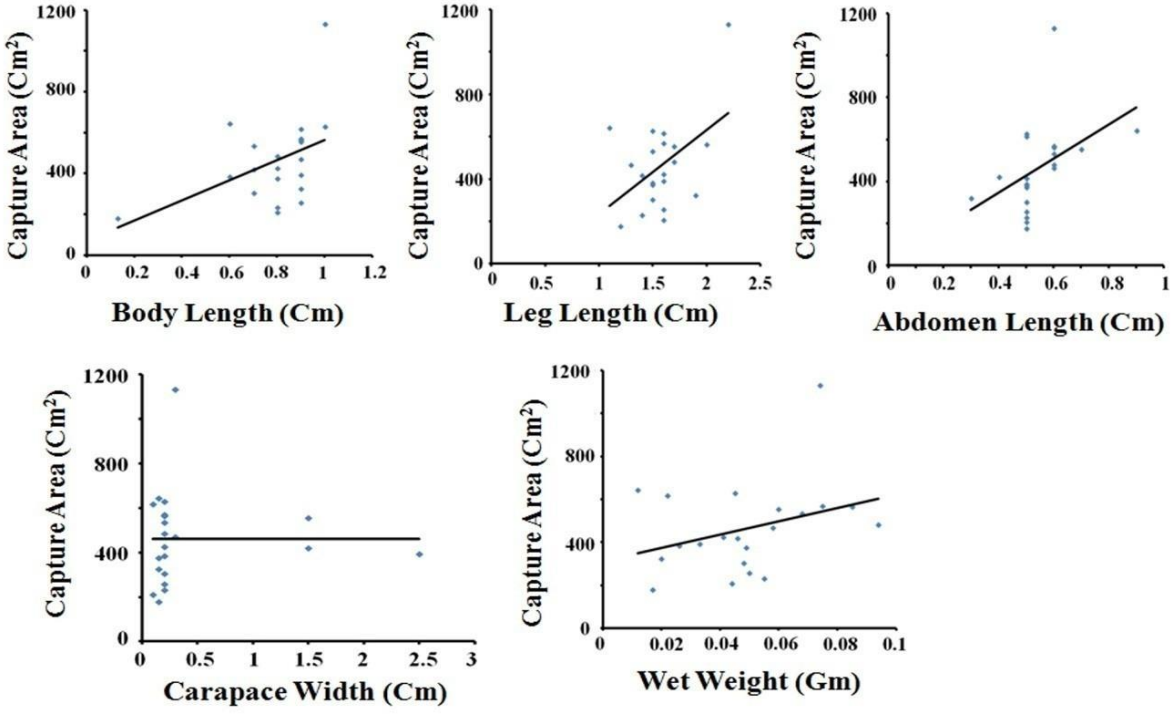


Figure 5. Graph showing correlation between body length, leg length, abdomen length, carapace width, wet weight and capture area of web of *Leucauge decorata.*

Table 3. Comparative account of r and p values.
[* denote statistical significance]

	Correlation between Body length and Capture area		Correlation between Leg length and Capture area		Correlation between Abdomen Length and Capture area		Correlation between Carapace width and Capture area		Correlation between Wet weight and Capture area	
	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value
Neoscona rumpfi	0.39	0.09	0.53	0.018*	0.22	0.35	0.49	0.02*	0.244	0.31
Leucauge decorata	0.45	0.04*	0.48	0.02*	0.45	0.03*	0.43	0.04*	0.33	0.138

Araneidae: A Remarkable Orb-weaving Group in the Rice Land Ecosystem of South 24 - Parganas, West Bengal, India

Debarshi Basu[1] and **Dinendra Raychaudhuri**[2]

Department of Agricultural Biotechnology
Faculty Centre of Integrated Rural Development and Management
Ramakrishna Mission Vivekananda University
Narendrapur, Kolkata – 700 103, India
[1,2]E-mails: dbasumk@gmail.com ; dinendrarccu@gmail.com

ABSTRACT

As a potential predator the importance of spiders, especially dwelling in rice land, needs to be properly addressed. Till date the information gathered in this field isinsufficient. Due to various reasons, members of the family Araneidae Clerck, 1757, exhibit striking variability particularly in Gangetic delta. After sampling for two years, it is found that, *Neoscona theisi* (Walckenaer, 1841) is the most dominant group in the fields of South 24 Parganas, West Bengal, India, amongst araneids and their average sex ratio increases during kharif session due to multiple environmental factors including reproductive strategies.

***Keywords*:** Orb-weavers, Araneidae, Rice Land, South 24 Parganas, West Bengal, India

INTRODUCTION

Spiders inhabiting rice land ecosystem necessarily demand serious consideration because of their fascinating adaptability and remarkable predatory efficiency (Nyffeler & Benz, 1987). In India, their role as a proficient bio-control agent is yet to be evaluated.(Sebastian & Chacko, 1994). Interestingly, the coastal ecosystem in the Gangetic Delta at the southern part of West Bengal, India, exhibits a wide variety of predatory spider population because of climatic fluctuation, soil quality and several other factors. Orb-weaving spiders appear to be of special importance in this context, as much more is entrapped than their actual consumption volume.

The present study is aimed at unfolding the diversity of the family Araneidae Clerck, 1757, the remarkably predominant group amongst many other orb-weavers found in rice fields of South 24 Parganas, West Bengal, India. As a result of a two-year sampling, from February 2014 to February 2016, it is found that spiders belonging to the families Tetragnathidae Menge,1866 and Araneidae Clerck, 1757, (or typical orb-weaving spiders) are predominant. Considering richness and distribution, tetragnathids come before araneids and it is just the reverse when the species diversity is concerned. It is worthwhile to mention that Basu & Raychaudhuri, 2016 have elaborately dealt with the tetragnathids of the said ecosystem.

Being never on the ground, most of the araneids construct webs in the foliage, either high upon the trees or in shrubs, herbs or grass, with considerable geometrical precision and beauty. Many of them build a nest like retreat by folding a leaf or bunch of leaves which is little away from the web but directly connected with the web-centre by threads. Generally the

male araneids are much smaller than females and are not commonly found in the webs unlike females (Tikader, 1982 & Barrion *et.al.*, 1995).

Out of the 16 araneid species under 7 genera so far recorded from the study site, interestingly, the members of the genus *Neoscona* Simon, 1864, is found to be the dominant group.Altogether, 6 discrete species of the genus are observed to be rotated through the two cropping sessions of paddy, of which, *N. theisi* (Walckenaer, 1841) is identified as the predominant member. Moreover, in terms of abundance, three genera, *Eriovixia* Archer, 1951, *Argiope* Audouin, 1826 and *Cytrophora* Simon, 1864, come immediately after. In spite of varying environmental condition in the Gangetic delta, these four genera also exhibit a wide range of distribution. However, *Larinia* Simon, 1874 and *Gasteracantha* Sundevall, 1833, are considered as rare. Further, almost for all the genera, sex ratio increases typically during kharif session.

Study area:

South 24 Parganas (22.1352° N, 88.4016° E), a district of West Bengal, is located near the confluence of the river Ganges sharing a considerable part of the largest delta of the world. From 6 different blocks, 7 discrete areas are selected as sites for sampling. Fields in different locations are identified in such a manner so that they can provide a pen-picture of the faunal diversity of spiders of the district as a whole. Of them, 3 study areas are located at 3 different regions of Sundarbans where due to the proximity of Bay of Bengal, salinity and nutrient structure of soil vary to a considerable extent affecting the growth and distribution pattern of the agro-ecosystems. The study areas are as follows – 1. Narendrapur [NPUR] (Block-Sonarpur) (22.4391°N and 88.3968°E), 2. Arapanch[ARPH] (Block - Sonarpur) (22.4491°N and 88.3915°E), 3. Sarisha [SRSH] (Block - Diamond Harbour) (22.1987°N and 88.2023°E), 4. Manasadwip [MSDP] (Block - Sagar) (21.753° N and 88.106°E.), 5. Nimpith [NMPT] (Block - Jaynagar II) (22.1772°N and 88.4258°E), 6. Kakdwip [KKDP] (Block – Kakdwip) (21.8760°N and 88.1853°E), 7. Gosaba [GSBA] (Block - Gosaba) (22.1652°N and 88.8079°E) (for further details see Basu & Raychaudhuri, 2016).

Time of study :

Field visits were carried out in every month of any calendar year during the crop seasons. It was continued for two consecutive years,February 2014 to February 2016. The annual rainfall (average) in the district was 1796 mm.Temperature in the study areas varied from 10^0C to 35^0C during the course of study.

MATERIALS & METHODS

For collection of spiders, sweep nets, bush beating and collection in inverted umbrella, hand picking techniques were used. Several pit fall traps were laid in the collection localities to trap ground dwelling spiders. Samples after collection [collector: D. Basu] were preserved in 70% alcohol and later transferred to glass vials filled with Audman's fixative. Necessary labels were used to mark each of the samples. Data regarding locality, date of collection, collector's name were noted in a note book in the field itself. The samples were then studied under Stereo zoom Binocular Microscopes Olympus SZX 10 and SZX 16.

Deposition :

All materials are in the collection of Department of Agricultural Biotechnology, IRDM Faculty Centre, RKM Vivekananda University, Narendrapur.

RESULTS AND DISCUSSION

A total number of 557 araneid individuals distributed over 16 species under 7 genera is recorded of which 6 species belong to the genus *Neoscona* Simon, 1864. Genus *Eriovixia* Archer, 1951, contains 3 species while genera *Cytrophora* Simon, 1864 & *Argiope* Audouin,1826, have 2 species each. Rest 3 genera i.e. *Areneus* Clerck, 1757, *Larinia* Simon,1874 and *Gasteracantha* Sundevall, 1833, have single species in each (vide Table 1, Plate 1 & Figure 1). Maximum number i.e. 7 araneid species are found form Narendrapur area and diversity wise Nimpith area is lowest (Figure 2). Moreover, Narendrapur also includes maximum of number of rare species (Figure 4). It is also evident that *Neoscona theisi* (Walckenaer, 1841) is the most dominant group amongst all araneids present in the rice land (Figure 3).

It is found that almost for all the genera, sex ratio increases typically during kharif session (October) while the number of male considerably reduces during Februray-March. In rabisession, the sex ratio in totality (male: female) is calculated as 1:32 which increases upto 1:7 during late monsoon. The possible reason may be the consumption of males by female individuals immediately after mating to fulfill the protein demand in their bodies; the presence of humidity in the environment and the upsurge of pests including other insects in agroecosystems at post rainy season (Figure 5).

Table 1. Details of the araneid taxa recorded

Family	Genus	Species
Araneidae, Clerck, 1757	(i) *Neoscona* Simon,1864	(1) theisi (Walckenaer,1841)
		(2) punctigera (Doleschall, 1857)
		(3) bengalensis Tikader & Bal, 1981
		(4) yptinica Barrion & Litsinger, 1995
		(5) nautica (L. Koch, 1875)
		(6) vigilans (Blackwall, 1865)
	(ii) *Eriovixia* Archer, 1951	(7) excelsa (Simon, 1889)
		(8) poonaensis (Tikader & Bal, 1981)
		(9) laglaizei (Simon, 1877)
	(iii) *Areneus* Clerck, 1757	(10) ellipticus (Tikader & Bal, 1981)
	(iv) *Larinia* Simon,1874	(11) phthisica (L. Koch, 1871)
	(v) *Cyrtophora* Simon,1864	(12) cicatrosa (Stoliczka, 1869)
		(13) moluccensis (Doleschall, 1857)
	(vi) *Gasteracantha,* Sundevall, 1833	(14) kuhlii C. L. Koch,1837
	(vii) *Argiope* Audouin,1826	(15) pulchella (Thorell, 1881)
		(16) catenulata (Doleschall, 1859)

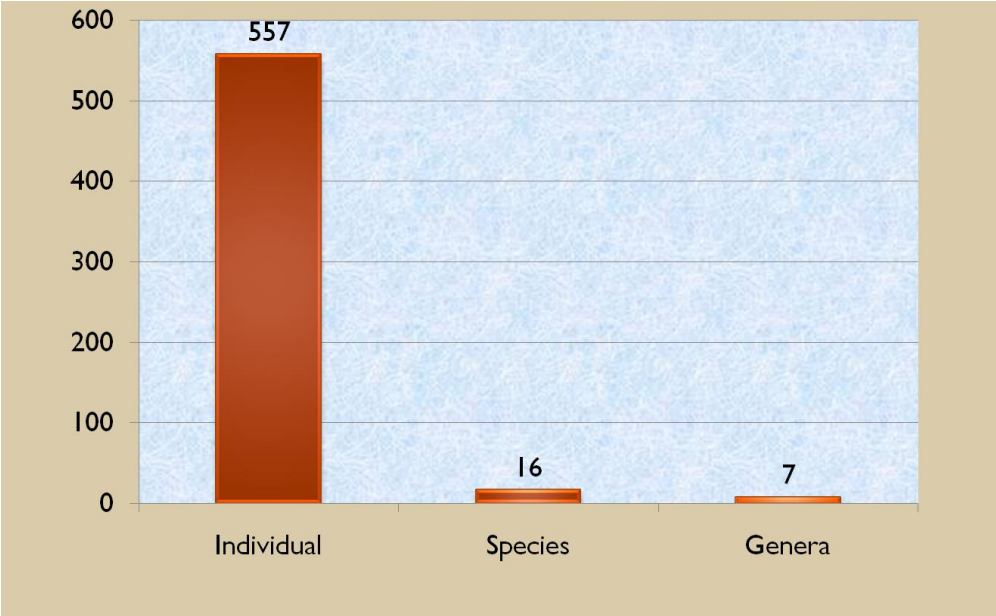


Fig. 1. Critical appraisal of the data showing total no. of araneid spiders Recorded from rice lands of South 24 Parganas

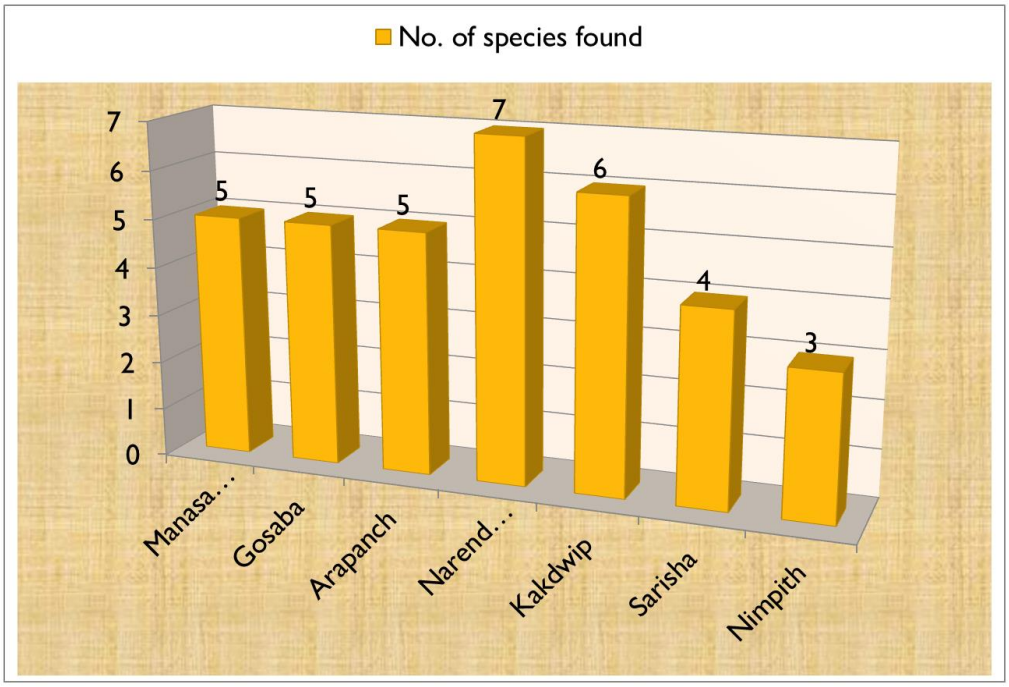


Fig. 2. Showing total no of species recorded from each study site

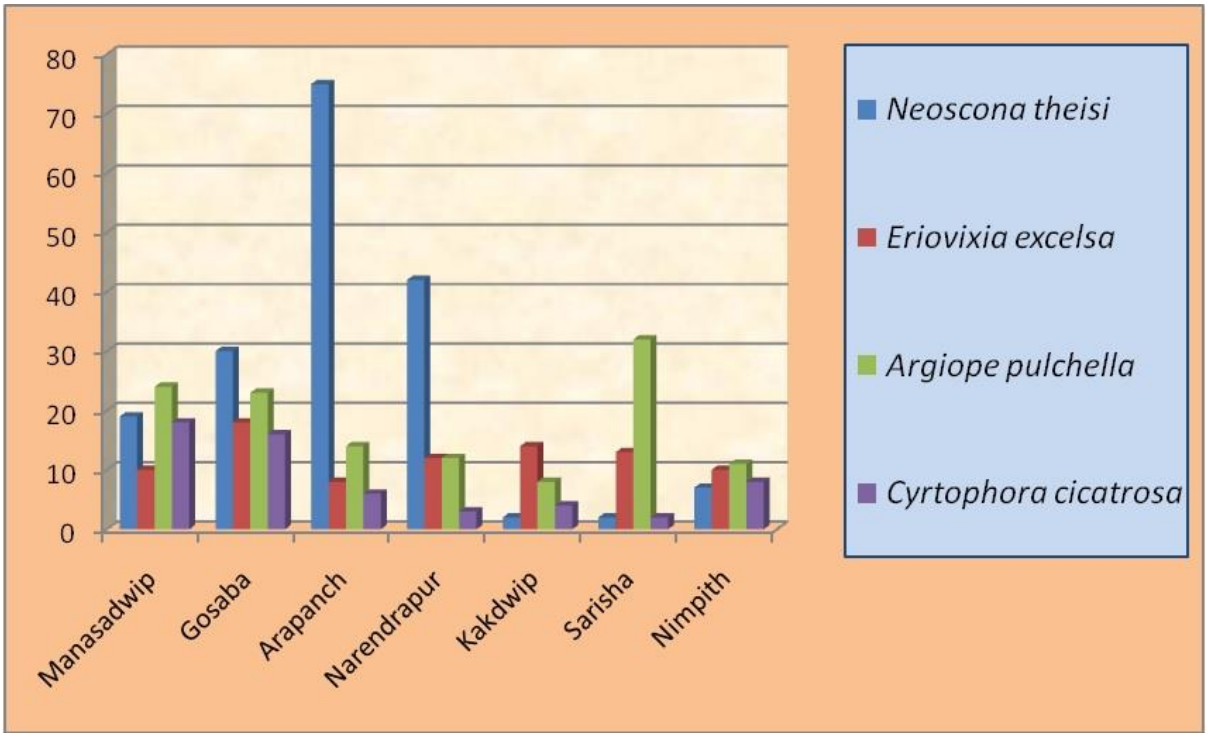


Fig. 3. Showing dominant species in the study sites

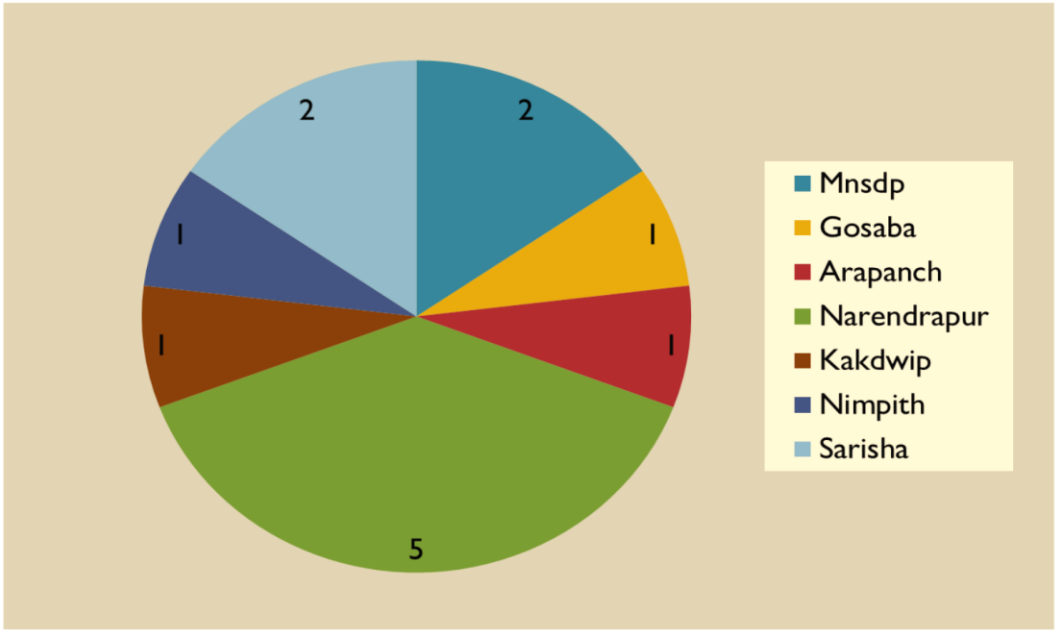


Fig. 4. Showing no of rare species in each of the study site

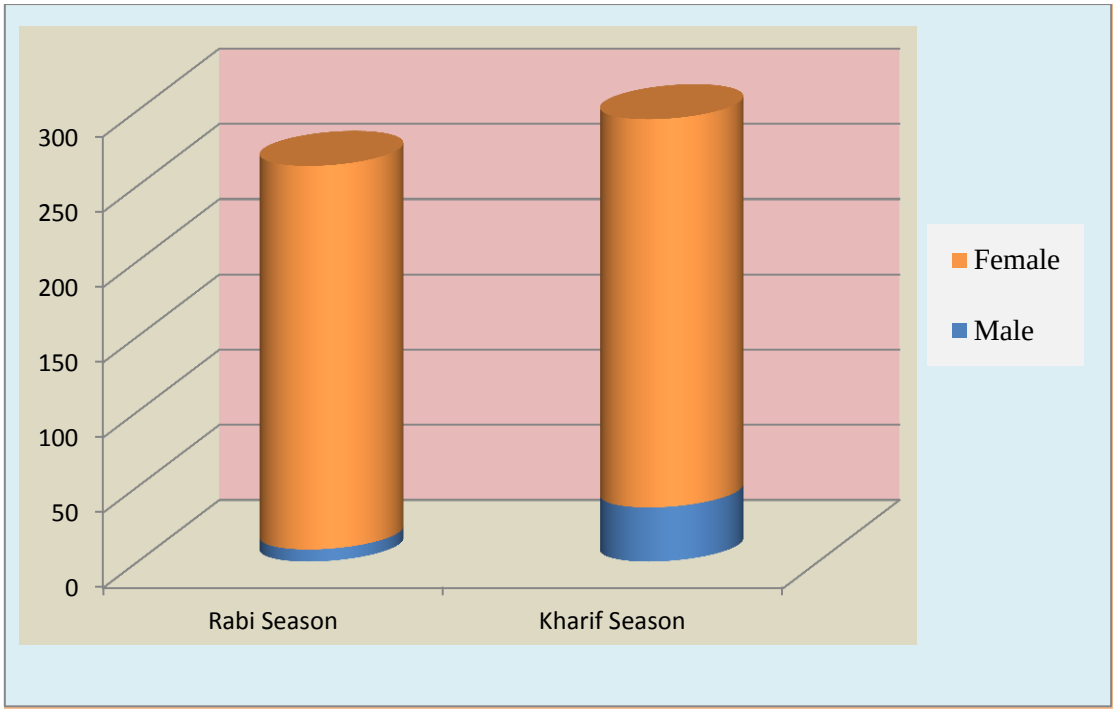


Fig. 5. Showing the ratio of male & female araneids in 2 cropping sessions

ACKNOWLEGEMENTS

Authors express deep sense of gratitude to Swami Atmapriyananda, Vice-Chancellor, Ramakrishna Mission Vivekananda University, for providing the opportunity to undertake this endeavour. Authors remain indebted to Dr. Sumana Saha, Dr.Tapan Kumar Roy and Dr. Sutirtha Sarkar, Research colleagues, IRDM Faculty Centre, Narendrapur, for manifold assistance. Sincere thanks are due to Dr. Manas Ghose, Dean and other staff members of Centre for Integrated Rural Development and Management, Narendrapur, for their necessary support.

LITERATURE CITED

[1] Barrion, A.T. & Litsinger, J.A., 1995. *Riceland Spiders of South and Southeast Asia*, CAB International, Wallingford, Oxon OX10 8DE, UK, 548 pp.

[2] Basu, D. & Raychaudhuri, D., 2016. Rice land inhabiting long jawed orb weavers, *Tetragnatha*Latreille, 1804 (Tetragnathidae: Araneae) of south 24-parganas, West Bengal, India, *World Scientific News* 55, 210-239.

[3] Nyffeler, M. & Benz, G., 1987. Spiders in natural pest control – a review. *Journal of Applied Entomology*, 103: 321-339.

[4] Sebastian, P.A. & Chacko, E., 1994. Studies on the predatory spiders of paddy field from Kuttanad. *Proc 6th Kerala Sci Cong*, 1: 377.

[5] Tikader, B.K., 1982. *The Fauna of India, Volume II*, Zoological Survey of India, Calcutta, 293 pp.

Plate 1. Representatives of Orb-weaving genera recorded

***Neoscona nautica* (L. Koch)**

***Eriovixia excelsa* (Simon)**

***Cyrtophora cicatrosa* (Stoliczka)**

***Gasteracantha kuhii* C. L. Koch**

***Argiope catenulata* (Doleschall)**

***Araneus ellipticus* (Tikader & Bal)**

***Larinia phthisica* (L. Koch)**

A Preliminary Report on Diversity of Mites (Acari) in Different Plants from Campus of Barasat Government College, West Bengal

Piu Banerjee, Priti Mondal, Sanjoy Podder[1] and **Salil Kumar Gupta**[2]

Post Graduate Department of Zoology, Barasat Govt. College,
10, K. N. C Road, Kolkata - 700124
[1,2]E-mails: skpzoo2@rediffmail.com , salil_zsidumdum@yahoo.co.in

ABSTRACT

The present paper reports the occurrence of phytophagous and predatory mites from the campus of Barasat Govt.College, Dist. North 24 Parganas, West Bengal. A total of 38 species under 25 genera, 11 families and 2 orders are listed. Among which included 4 species of phytophagous mites under 3 genera, 2 families and 33 species of predatory mites under 21 genera and 8 families. This also includes one fungus feeding mite species, *Acarus* sp. of the family Acaridae. Hosts/habitats/economic importance of the listed species are also provided.

***Keywords*:** Phytophagous mites, Predatory mites, Fungivorous mite, Economic importance Barasat Government College Campus, West Bengal

INTRODUCTION

Mites and insects are most important and significant pests of agri-horticultural crops causing serious damages and crop losses. Though insect pests have received adequate attention in India but unfortunately mites have remained neglected probably due to their microscopic size and nature of exploiting concealed niches within plants. Information regarding phytophagus and predatory mites from India was given by Gupta (1985; 1992, 2012). Barasat Govt. College campus which is situated in North 24 Parganas, very rich with diverse array of vegetation, was found to have been infested with various types of mites. Since no survey was conducted earlier on mites occurring on different vegetation of the college campus, it was thought necessary to undertake a preliminary survey of the plants for occurrence of mites and to document those for the first time from this campus.

MATERIAL & METHODS

Collection of mites was made from diverse types of plants present within the campus of Barasat Govt. College during July- October, 2016. Leaves of different types of plants collected from campus were examined under stereo-binocular microscope (MSZ-TR70T0842) and mites were collected with fine brush moistened with alcohol and preserved in 70% ethanol. Samples after mounting in Hoyer's medium followed by gentle heating for proper stretching of appendages, were examined under stereo-research microscope (OLYMPUS CH-20iTr). Mites were identified following the literature of Gupta (2002, 2003).

RESULTS AND DISCUSSION

Identified mites are listed in Table 1 along with their hosts, habitats, and economic importance, if any. Altogether 38 species, under 11 families, 25 genera and 2 orders could be

recorded. This includes mites of both phytophagous and predatory groups. The former is represented by 4 species, under 3 genera and 2 families and the latter by 33 species, under 21 genera and 8 families. In addition, there is one fungivorous mite species, *Acarus* sp.. Among the phytophagous mites, the dominant species are *Tenuipalpus leptadinae and Brevipalpus deleoni* of the family Tenuipalpidae. It may be mentioned here that *Tenuipalpus leptadinae* was so far unknown from West Bengal. The predatory group is represented by four dominant species under Phytoseiidae_*viz*. *Amblyseius largoensis, Phytoseius kapuri, Phytoseius minutus* and *Typhlodromus homalii*.

As far as their economic importance is concerned, *Brevipalpus deleoni* is found to cause brownish patches on Basak leaves, especially towards the margin and hundreds of mites could be seen on a single leaf. The mite was found to be readily fed by *Amblyseius largoensis*, the dominating predatory mite. The infested jarul (*Lagestroemia speciosa*) leaves when examined under microscope, *Euseius ovalis* was found actively feeding on *Eutetranychus maximae*. *Tenuipalpus leptadinae* is found to cause severe chlorosis on jarul and tulsi leaves.

This preliminary report indicates more abundance of predatory mites mostly of Phytoseiidae as compared to phytophagous ones. This is evident from the fact that predatory mites are represented by 33 species compared to only 4 species of phytophagous mites. Hence, the abundance and generic diversity is more among predatory mites than that of the phytophagous mites.

Since, this is a preliminary study conducted for a short duration, the observations presented here need not be considered as final result and for that more intensive study is needed.

ACKNOWLEDGEMENTS

The authors are very grateful to Dr. Subhasis Dutta, Principal and Dr. Sumana Saha, Head of the Postgraduate Department of Zoology, Barasat Government College for providing infrastructure facilities and constant encouragement and to the Department of Science and Technology, Govt. of West Bengal [Sanction no.: 1170(Sanc.)/ST/P/S&T/1G-4/2016 dt. 02.03.2016] for financial assistance.

LITERATURE CITED

[1] Gupta, S.K. 1985 Handbook Plant Mites of India. Zoological Survey of India, 520 pp.
[2] Gupta, S.K.1992 Arachnida: Plant Mites (Acari) In:Fauna of West Bengal,State Fauna Series 3(Part3): 61-211
[3] Gupta, S.K. 2002. A Monograph on Plant Inhabiting Predatory Mites of India: Part I : Orders: Prostigmata, Astigmata and Cryptostigmata. Publ.: Zool Surv. India, 19(2): 183 pp.
[4] Gupta, S.K. 2003. A Monograph on Plant Inhabiting Predatory Mites of India: Part I I: Order : Mesostigmata. Publ. Zool Surv. India, Kolkata, 20(1), 185 pp.
[5] Gupta, S.K. 2012. Handbook Injurious and Beneficial Mites Infesting Agri-horticultural Crops In India and their Management. Publ. Nature Books India, New Delhi: 362 pp.

Table 1. List of mites collected from the campus of Barasat Govt. College during July, 2016 - October, 2016

Sl. No.	Order/Family/Genus/Species	Host & Habitat	Remarks
	A. PHYTOPHAGOUS GROUP		
	ORDER I : PROSTIGMATA		
	FAMILY 1 : Tenuipalpidae		
1.	*Brevipalpus deleoni* (Pritchard & Baker)	Jarul and Basak leaf.	Produced brownish spot at points of feeding.
2.	*Tenuipalpus leptadeniae mohansundaram*	Jarul, Basak and Tulsi leaf.	Produced chlorosis of leaves, huge population earlier unreported from West Bengal.
	FA MILY 2 :Tetranychidae		
3.	*Eutetranychus maximae* (Nassar & Ghai)	Mussaenda and Basak leaf	
4.	*Eutetranychus orientalis* (Klein)	Jarul and Basak leaf.	New record from West Bengal, poor population. Huge population on Jarul and Basak form new record.
	B. PREDATORY GROUP		
	FAMILY 3 : Bdellidae		
5.	*Bdella* sp.	Jarul and tekoma leaf.	Poor population, new habitat recorded.
6.	*Cyta* sp.	Kath-Tagar leaf.	Poor population, new habitat recorded.
	FAMILY 4 : Cheyletidae		
7.	*Bak* sp.	Mussaenda leaf.	Interesting species, genus earlier unknown from West Bengal.
8.	*Chelacarosis* sp.	Mango leaf.	New genus record from West Bengal.
9.	*Hemicheyletia bakeri* (Ehara)	Arjun and Champak leaf.	New habitat recorded.
	FAMILY 5 : Cunaxidae		
10.	*Cunaxa capreolus* (Berlese)	Jarul and Mussaenda leaf.	New habitat recorded.
11.	*Cunaxa cynodonae* (Gupta)	Jarul and Mussaenda leaf.	New habitat recorded.
12.	*Cunaxa mangiferae* (Gupta)	Mango leaf.	
13.	*Cunaxa setirostris* (Hermann)	Kath-Tagar leaf.	Very good predator of Tenuipalpid mites.
14.	*Cunaxoides croceus* (Koch)	Shiuli leaf.	New habitat recorded, rare occurrence.
15.	*Dactyloscirus machairodus* (Oudemans)	Jarul and Arjun leaf.	New habitat recorded, rare occurrence.
	FAMILY 6 : Raphignathidae		
16.	*Exothorhis* sp.	Mango and Lemon leaf.	May be new species, new habitat recorded.
	FAMILY 7 : Stigmaeidae		
17.	*Agistemus fleschneri* (Summers)	Jarul and rangan leaf.	Known to be good predator but such behaviors not observed
18.	*Eryngiopus* sp.	Mussaenda leaf.	Interesting species but appear to be un-described.
19.	*Stigmaeus* sp.	Jarul and champak leaf.	New habitat recorded genus unreported from West Bengal.
	FAMILY 8 : Tydeidae		
20.	*Parapronematus* sp.	Shiuli and Nut leaf	
21.	*Pronematus fleschneri* (Baker)	Guava and lemon leaf.	Abundantly available.
	ORDER II : MESOSTIGMATA.		
	FAMILY 9 : Ascidae		
22.	*Asca* sp.	Guava and Nut leaf.	
	FAMILY 10 : Phytoseiidae		
23.	*Amblyseius largoensis* (Muma)	Mango and Guava leaf.	Abundantly available, good predator of tenuipalpid mites.
24.	*Amblyseius paraaerialis* (Muma)	Shiuli leaf.	Rare occurrence.
25.	*Amblyseius channabasavannai* (Gupta &	Kath-Tagar leaf.	Rare occurrence.
26.	Daniel)	Jarul and Basak leaf.	Rare occurrence.
27.	*Amblyseius herbicolus* (Chant)	Hibiscus and jarul leaf.	Frequently available, good predator of spider mite.
28.	*Euseius ovalis* (Evans)	Mussaenda and jarul leaf.	New habitat recorded.
29.	*Euseius rhododendronis* (Gupta)	Guava and lemon leaf.	
30.	*Euseius coccineae*(Gupta)	Rose and Champak leaf.	Abundantly available.
31.	*Paraphytoseius bhadrakaliensis* (Gupta)	Jarul leaf	Abundantly available.
32.	*Phytoseius kapuri* (Gupta)	Nut and Arjun leaf.	Rare occurrence, earlier unknown from West Bengal.
33.	*Phytoseius namdaphaensis* (Gupta)	Arjun and Jarul leaf.	
34.	*Phytoseius minutus* (Narayanan, Kaur &	Hibiscus and Rose leaf.	Rare occurrence earlier unknown from West Bengal.
35.	Ghai)	Guava leaf.	Common occurrence.
36.	*Phytoseius mizoramensis* (Gupta)	Tekoma And Jarul leaf.	Earlier unknown from West Bengal.
37.	*Scapulaseius suknaensis* (Gupta)	Mussaenda leaf.	Common occurrence.
	Typhlodromus himalayensis (Gupta)		
	Typhlodromus homalii (Gupta)		
	C**. FUNGIVOROUS**		
	ORDER III : ASTIGMATA		
	FAMILY 11 : Acaridae		
38.	*Acarus* sp.	Mango, Jarul, Rose leaf.	Associated with fungus.

PLATE

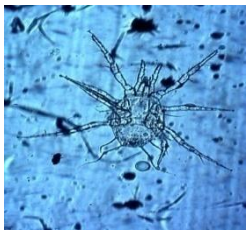
Photographs of some of the phytophagous and predatory mites collected from Barasat Government College Campus.

Acaridae
(*Acarus* sp.)

Ascidae
(*Asca* sp.)

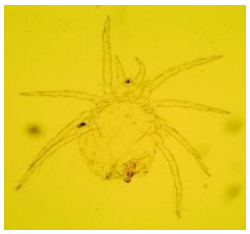
Cheyletide
(*Cheletogenes* ornatus)

Cunaxidae
(*Cunaxa setirostris*)



Phytoseiidae
(Amblyseius largenesis)

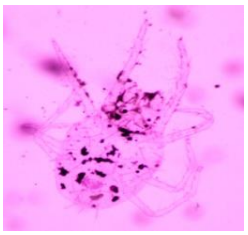
Phytoseiidae
(Euseius coccineae)



Stigmaeidae
***(Agistemus* sp.)**

Raphignathida
***(Exothorhis* sp.)**

Tenuipalpidae
(*Tenuipalpus leptadeniae*)



Tetranychidae
(*Eutetranychus orientalis)*

Study of Changes in Genetic Diversities and Hepatic Histological Structures of Two Ichthyofauna as a Consequence of Water Pollution in Two Different Areas of West Bengal

Annesha Lahiri, Sohini Das and **Rahul Kumar Datta***

Department of Zoology, Bethune College
181, Bidhan Sarani, Kolkata 700 006
***E-mail : dattarahulkumar@gmail.com**

ABSTRACT

Water pollution affects biodiversity harshly. An attempt was made to find out the effect of aquatic pollution on the tissues of the fish, taking two different types of carps from two different areas of West Bengal (Barrackpore in North 24 Parganas and Raiganj in North Dinajpur). The carps used were *Labeo rohita* (major carp) and Labeo *bata* (minor carp) and were sampled from two different ponds within 1 km of each locality. The physicochemical parameters of the respective ponds were estimated from which the fishes were collected and comparisons were made. Liver tissues were taken from the fishes for histological and molecular analysis. From histological studies, it was found that there were some irregularities in the liver tissue structures which might be due to water pollution. DNA isolation from fish liver followed by gel electrophoresis was done to check whether water pollution affect the integrity of the extracted genomic DNA of the fish samples.

***Keywords*:** Water pollution, ichthyofauna, physicochemical parameters, fish liver, histopathology, DNA gel electrophoresis

INTRODUCTION

In recent years, water pollution is one of the major environmental concerns, which implies several threats to biodiversity. Water is synonymous to life and is a primary driving force for major physical, chemical and biological changes all over the world. Water resources are declining day by day at a faster rate due to rapid urbanization and population load. Deterioration of the water quality is now a global problem (Mahananda *et al*., 2010). From ancient times the rain water is being stored in small water body like ponds in most of the area in India. Several anthropogenic activities and interventions on pond as well as water bodies ultimately deteriorate the water quality, including accumulation of toxic chemicals and sediments, shrinkage of catchment area, loss of aesthetic value and biodiversity of the aquatic body. The accumulation of various kinds of pollutants and nutrients through the domestic sewage, municipal effluents, and agricultural runoff into the ponds leads to changes in the physico-chemical characteristics of fresh water. These physico-chemical parameters help us assess the quality of water and provide information regarding its being suitable for drinking and aquaculture. Fish is one of the most important constituent of the aquatic fauna. It provides a good source of animal protein in diet for humans and is widely used as a model organism for different biological studies and researches. Aquaculture is thus gaining importance day by day at national and international level. A good number of pesticides and fertilizers are used in aquaculture for eradication of enemies of fish as well as for growth of

plankton, the natural food of herbivorous fishes. However, the assessment of the ecotoxicological hazards caused by pesticides and fertilizers to ecosystems is based on the data on the toxicity and effects to non-target organisms. Fishes are among the group of non-target aquatic organisms. Histological changes provide a rapid method to detect effects of irritants, especially chronic ones, in various tissues and organs (Bernet *et al*., 1999). The organs where changes can be adequately observed are the liver, kidney, gills etc in the fish (Bernet *et al*., 1999). In the present study, the histopathology of the liver of *Labeo rohita* and *Labeo bata* has been studied. The histology of the liver varies among species, but there are general features that are found in the majority of species. The hepatic structure normally varies (and considerably) in direct relationship to gender, age, available food - especially with regard to glycogen and fat content, or temperature, and with endocrine influences strongly connected to the environmentally regulated breeding conditions (Genten *et al.*, 2009). Moreover, another objective of the study was to determine whether the integrity of DNA is by any way affected by the aquatic pollution.

MATERIAL AND METHODS

Water samples were collected from the two ponds of Barrackpore area and are referred as S1 and S2 and two ponds from Raiganj in the North Dinajpur area which are referred to as S3 and S4 (Fig. 1). Samples were collected in glass containers previously cleaned by distilled water. During sampling, water taken from a depth of 30 centimeter below the surface of each pond and from four sites. The samples were labeled and transported to the laboratory, stored at 4 °C in the refrigerator for analysis of selected parameters including temperature, pH, dissolved oxygen, dissolved free carbon dioxide, total hardness and total alkalinity using different methods. Temperature was measured by digital thermometer; pH was measured by portable pH meter and the rest were calculated by chemical methods (APHA, 1995; Michael, 1984). To study the hepatic histology, liver tissues were dissected out and cut into small pieces for preservation in Bouin's fixative for 18 hours. It is followed by dehydration, sectioning (Microtome machine used Leica RM 2125RTS) and lastly routine staining by Haematoxylin and Eosin stain and were observed under a compound light microscope with high resolution and eventually photographed with a digital camera attached to the microscope. Fish samples were collected from previously mentioned water bodies. Genomic DNA was isolated from the liver of the fishes collected from two water bodies. The genomic DNA extraction was carried out following the method of Shiozawal *et al*., 1992 and Adriane *et al*., 2003. The extracted genomic DNA was run in 0.8% agarose gel (prestained with 0.5µg/ml ethidium bromide) and electrophoresis was carried out at constant voltage and current (Horizontal Gel Apparatus GeNei Catalogue No. 106470GB), and followed by visualization of the gel in UV transilluminator and photographs were taken with a digital camera.

RESULT AND DISCUSSION

Data on the physicochemical parameters of water are shown in Table I. It was found that the pond in Site 2 (S2) and Site 4 (S4) are polluted as it has high level of biological oxygen demand (BOD) and low level of dissolved oxygen (DO) compared to the Site 1 (S1) and Site 3 (S3). The greenish colour of the water is due to the presence of green algae and cyanobacteria. The hardness of the water is also high compared to Site 1, suggesting the presence of carbonate and bicarbonate in the water due to the regular household runoffs by local inhabitants. BOD is highest in case of Site 4 and algal bloom was evident.

The histological sections are presented in Fig. 2. The histological sections of the liver of *Labeo rohita* and *Labeo bata* collected from the Site 1, has normal hepatocytes (Fig. 2a, 2c,2e and 2f). But the fishes collected from Site 2 , necrosis of hepatocytes and large void area was observed in section of *Labeo rohita* (Fig. 2b); and necrosis and cirrhosis of hepatocytes was observed in liver section of *Labeo bata* (Fig. 2d). Thus, it is evident from the histopathological studies that the water pollution might be an important factor for the histological tissue changes in the liver of the fishes.

The integrity of the genomic DNA of the fishes collected from the Site 2 was greatly affected due to water pollution compared to the less polluted Site 1 (Fig. 3). The genomic DNA is found to form smear (Fig 3b) in the agarose gel compared to the clear visible band in the samples collected from pollution free Site 1 (Fig 3a). The smear formation of the DNA extracted from the liver of the fish collected from polluted water body (Site 2) may be due to the fact of necrosis that occurs in the hepatocytes due to pollution.

CONCLUSIONS

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollutants can be either foreign substances or naturally occurring contaminants. The adverse effect of aquatic pollutants can be well determined by observing the changes in the histopathology of the liver of the two most commonly found and consumed carps. The physicochemical parameters of the water of the two ponds clearly show that differences in the water quality of the aquatic bodies are responsible for the abnormal changes in fishes like the necrosis, cirrhosis and pyknosis of the hepatocytes. Since liver is the primary organ for detoxification of organic xenobiotics therefore any toxic by-products tend to accumulate in it and the organ suffers harmful effects (Hawkes, 1980). Hence, observation of the histological section of the liver can prove very useful indicator as any toxic effect will be reflected by the abnormalities of the liver cells. The smear formation of the extracted genomic DNA in the agarose gel is greatly related to the water pollution that affects the hepatocytes of the fish liver. Therefore, it can be concluded that pollution is related to abnormality of the hepatocytes in the fish. Moreover, a comparative molecular analysis like RAPD can be carried out with the fishes from different water bodies covering a large region, to further clarify and establish the relation of pollution with the tissue abnormalities in the aquatic organisms and the relation between same and the different species of fishes.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge UGC and DST-FIST for their financial assistance. The authors are also thankful to Shri Samiran Ghosh, Assistant Professor of Zoology, Bethune College for the study of histology of liver for the carps. The authors duly acknowledge Shri Tanmay Mukhopadhay, Research Scholar of North Bengal University for helping in giving the informations about the physicochemical parameters in Raiganj ponds. Thanks are due to Shri Abhishek Dey, Assistant Professor of computer Science for processing of photography of the same during preparation of manuscript.

LITERATURE CITED

[1] Adriane, P., Wasko, C.M., Claudio, O. & Fausto, F. 2003. Non-destructive genetic sampling in fish. An improved method for DNA extraction from fish fins and scales. *Hereditas.* 138: 161–165

[2] American Public Health Association (APHA). 1995. *Standard methods for the examination of water and wastewater*. 19th ed. American Public Health Association,

American Water Works Association and Water Pollution Control Federation. Washington, DC, USA.
[3] Bernet, D., Schmidt, H., Meier, W., Burkhardt-Holm, P. & Wahli, T. (1999). Histopathology in fish: proposal for a protocol to assess aquatic pollution. *J. Fish Dis*. 22: 25-34.
[4] Chatterjee, N. & Bhattacharjee, B. 2015. Salient alterations in hepatic and renal histomorphology of an Indian minor carp, *Labeo bata* (Hamilton, 1822) owing to ZnS nanoparticle induced hypoxia and environmental acidification. The International Journal of Earth & Environmental Science. 1(1): 1-9.
[5] Genten F., Terwinghe, E. & Danguy, A. 2009. *Atlas of Fish Histology*. CRC Press, Florida, 224 pp.
[6] Hawkes J.W. 1980. The effect of xenobiotics on fish tissues: Morphological studies. *Fed. Proc.* 39: 3230-3236.
[7] IS 13891 1994. *Indian Standard Quality Tolerances for Fresh water for Fish culture.* Bureau of Indian Standards, New Delhi, 1-4.
[8] Mahananda, M.R. Mohanty, B.P. & Behera, N.R. 2010. Physico-chemical analysis of surface and ground water of Bargarh district, Orissa, India. *Indian Journal of Research and Review in Applied Sciences*. 2(3): 284-295.
[9] Michael, P. 1984. *Ecological method for field and laboratory Investigation*. Tata McGraw Hill Publ. Comp, New Delhi,, 404 pp.
[10] Sambrook. J., Fritsch, E.F. & Maniatis, T. 1989. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press, CSH, New York, 1626 pp.
[11] Shiozawa1, D.K., Kudo, J., Evansl, R.P., Woodward, S.R. & WiUiams, R.N. 1992. DNA extraction from preserved trout tissues. *Great Basin Naturalist.* 52(1): 29-34.
[12] Thapa, G.B. & Pal, J. 2015 Role of physicochemical factors of pond water on the outbreak of epizootic ulcerative syndrome and histopathology of affected fishes from eastern Nepal. *International Journal of Fisheries and Aquatic Studies*. 2(5): 1-8.

Table 1. The physico-chemical parameters of various ponds (mean value)

Parameters	**Sampling sites**				**Tolerance limit for freshwater fish culture Standards- BIS**
	S1	**S2**	**S3**	**S4**	
pH	8.1	6.4	7.5	7.9	6.5 – 8.5
Total alkalinity (mg/l)	210	240	256	400	100-300
Hardness (mg/l)	146	264	152	356	80-150
Dissolved Oxygen(mg/l)	4.6	3.8	5.2	3.2	4 (minimum)
Biochemical Oxygen Demand (mg/l)	1.8	2.2	1.0	2.5	
Free carbon dioxide (mg/l)	2	6	1.7	1.2	12 (at sunrise) [maximum]
Colour	Grayish	Greenish	Clear	Greenish	
Temperature (°C) [average]	25.77	26.43	21	21.2	2-35 (range)
S1 = Barrackpore railway side pond, S2 = Barrackpore Andandapuri (Sumangalapuri) pond, S3 = Rajpukur Raiganj, S4 = Kasba in Raiganj					

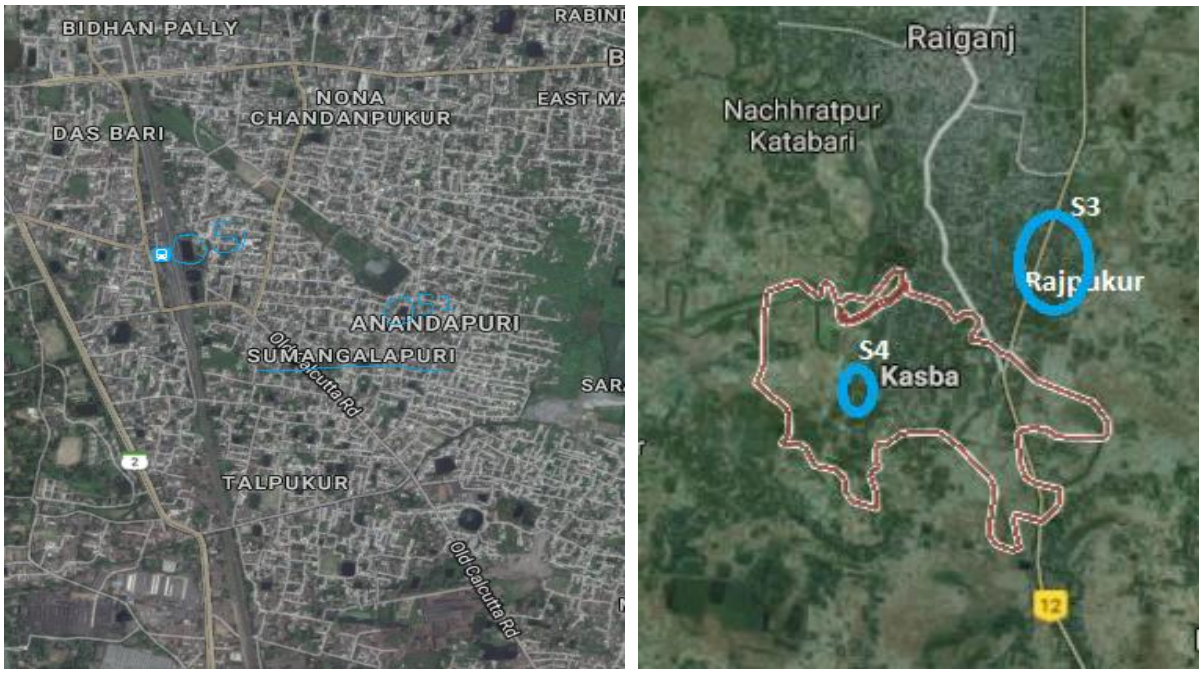


Fig. 1. Map showing two collection spots. S1 = Barrackpore railway side pond, S2 = Barrackpore Andandapuri (Sumangalapuri) pond, S3 = Rajpukur Raiganj, S4 = Kasba Raiganj

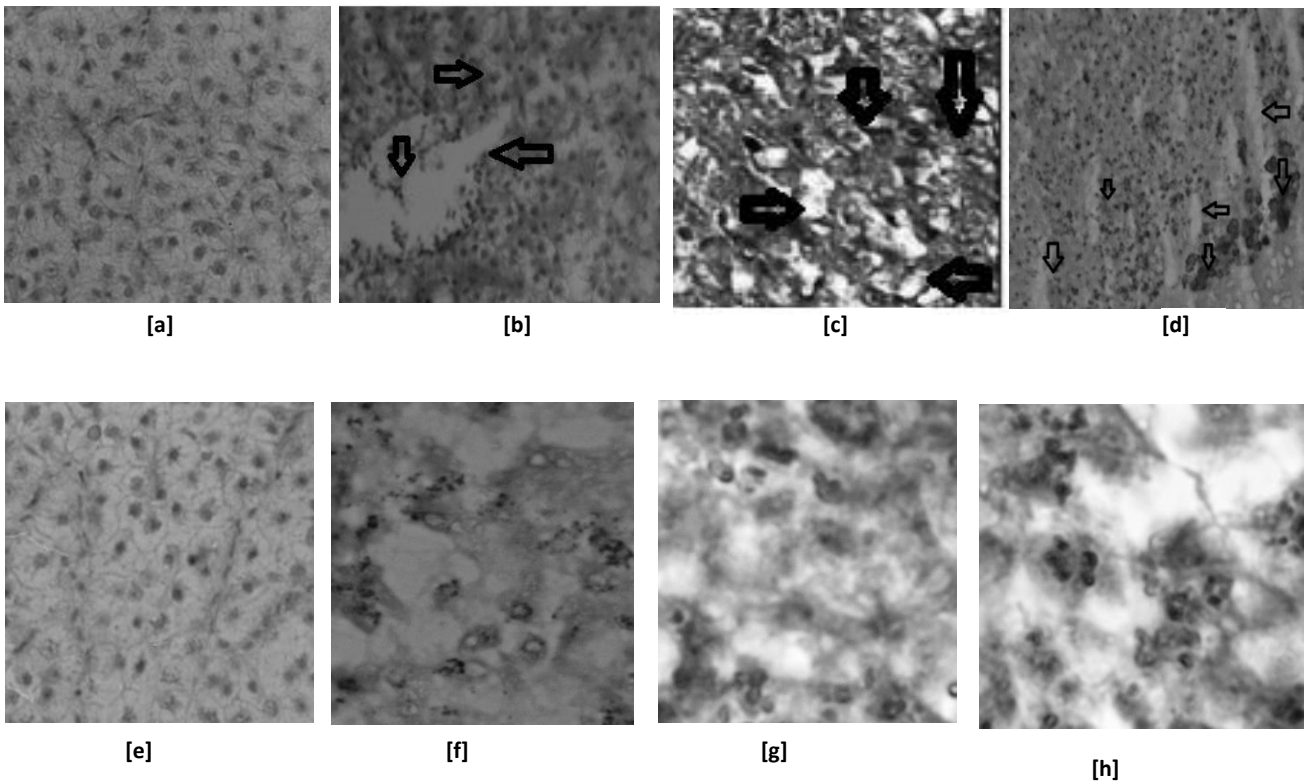
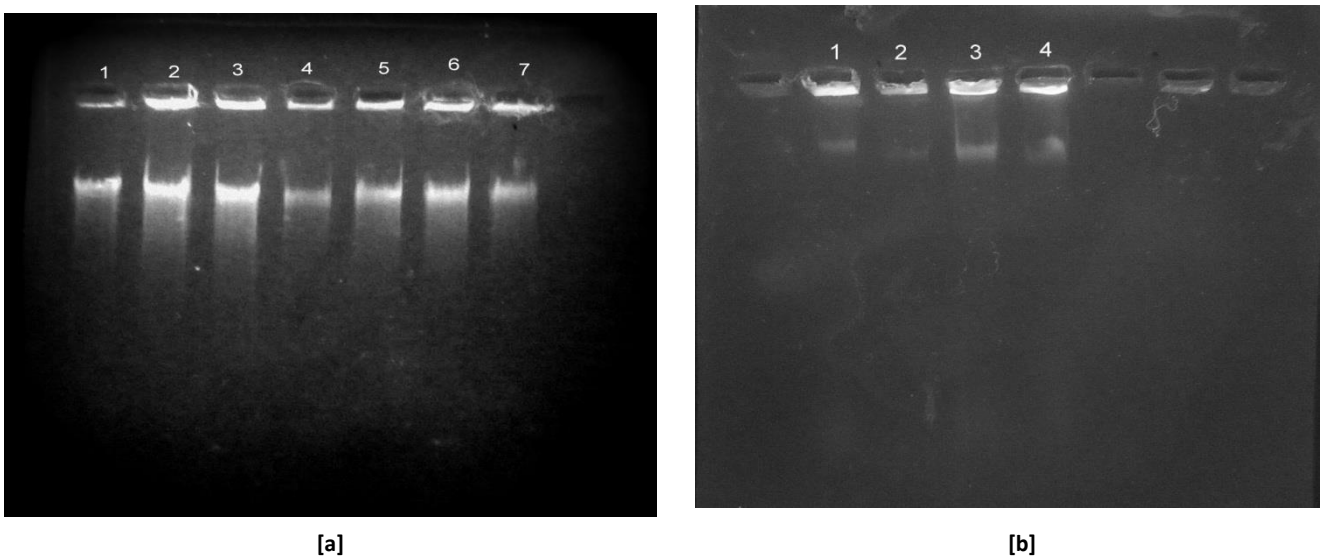


Fig. 2. Histological sections of fish liver from different location.a. *Labeo rohita* collected from S1 having normal hepatocytes, b. *Labeo rohita* collected from S2 with huge space and necrotic hepatocytes, c. *Labeo bata* collected from S1 showing normal hepatocytes, d. *Labeo*

bata collected from S2showing abnormality in the hepatocytes, e. *Labeo rohita* collected from S3 having normal hepatocyte, f. *Labeo rohita* collected from S4 showing necrosis in hepatocyte, g.*Labeo bata* collected from S3 having ablesion and pyknosis in the hepatocytes , h .*Labeo bata* collected from S4 having void space in the hepatocytes.



[a] **[b]**

Fig. 3. 0.8% agarose gel of extracted DNA from fish liver of different locations.[a] DNA gel electrophoresis of extracted DNA from liver of Labeo rohita of S1 (Lane -1), S2 (lane-2,3), S3 (lane-4,5), S4 (6,7) [b] DNA gel electrophoresis of extracted DNA from liver of Labeo bata from S1 (lane 4), S2 (lane-3), S3 (lane-1), S4 (lane 2)

Food diversity and feeding preference of Black Molly (*Poecilla sphenops* (Valenciennes, 1846)), a common ornamental fish- A preliminary study

Mandakranta Dasgupta[1], Gargi Sarkar[1], Ankur Bhowal[1], Gautam Kundu[1], Gobinda Chandra Sadhukhan[2], Debasish Karmakar[3,*]

[1]Department of Zoology (UG+PG) Vidyasagar College,
39 Sankar Ghosh Lane, Kolkata - 700006
[2]UGC-HRDC, Jadavpur University, LB-8, Sector-III, Salt lake City, Kolkata - 700098
[3]Department of Zoology, City College, 102/1 Raja Rammohan Sarani, Kolkata - 700009
*E-mail: neeldebasish@gmail.com

ABSTRACT

Black mollies are one of the most popular ornamental fishes in the aquarium hobby. Most People have had at one time at least one of these gentle and attractive fishes in their fish tank. They are one of the most popular feeder fishes due to high growth rate, birth size, reproduction and brood number. During fish development, supply of suitable food during culture period is the most vital factor to achieve good growth ratio. Present study aims at unfolding the feeding preference of Black Molly for which eggs of Pomfret, Carp and *Tenualosa* sp. and semolina and poppy seeds were provided as food of animal and plant sources respectively. It was observed that food with more protein contents (i.e. food from animal sources) were mostly preferred by Black Molly. It is concluded that food from animal sources could be beneficial to get good growth and survival of Black Molly.

***Keywords*:** Ornamental fish, Black Molly, Fish egg, Food preference, Feeding behavior

INTRODUCTION

Ornamental fish keeping is one of the most popular hobbies in the world including India (Nayar, 1996). Ornamental fishes are the important part of aquaculture providing aesthetic requirement and up keeping of the environment. Ornamental fish industry also has made an amazing progress in the areas of spawning and breeding, larval nutrition and health management which is directly related to fish-food production (Hardy, 2003). Among the various ornamental fishes, Black Molly (*Poecilia sphenops*) is the most popular one throughout the world and also frequently considered to be the first species reared by many ornamental fish enthusiasts because of its hardness. Taste preferences in ornamental fishes are highly species specific and even vary between the individuals of the same species (Carlberg *et al*., 2015). The knowledge of nutritional requirements along with their acceptability is important for improving the productive development. Therefore, attempt is made to study the feeding preference of Black Molly (*Poecilia sphenops*) between foods from animal sources and plant sources,

MATERIALS AND METHODS

Collection and Acclimatization of Fish

Black Mollies of 6 months age group (35-40 mm) were collected from local pet store in Calcutta and were brought to the laboratory with oxygen packs. At first the fishes were kept in rearing tanks (18"X10"X10") at a density of 5 fishes per tank with proper aeration and temperature (27 ±2 °C). They were then acclimatized to laboratory condition for one week and were supplied commercial feed.

Experimental Set up

The experiment was set up to know the food preference of Black Molly for individual food items when both animal and plant food items were given separately. For this experiment 5 Black Mollies were taken from the rearing tank and each was kept in 5 separate 5L tanks. The fishes were allowed to starve for 24 hours prior to the commencement of the experiment to standardize hunger level (Gupta and Banerjee 2009). Each fish was then provided with 50 Pomfret eggs, 50 carp eggs, 50 *Tenualosa* sp. eggs, 50 Poppy seeds, and 50 *Semolina* seeds for 20 days respectively. After 30 minutes, the number of left over unit food was recorded to calculate the intake number by the Black Molly.

Statistical Analysis

Feeding preference was calculated by counting the food unit (Number of fish egg/Number of plant seed) left in the aquarium after each experiment and subtracting the number from the introduced food units (i.e 50 units/experiment). The number was averaged and SE was calculated. (Table 1). One way ANOVA (Table 2:A) was performed to find out the significant difference in food preference among the different food types. Tukey's multiple comparison test (Table 2:B) was also performed to compare the food items in all possible pair with the help of Graph Pad Prism software.

RESULTS AND DISCUSSION

Table 1. The table shows the average food consumed as unit (Pomfret Egg, Carp Egg, *Tenualosa* Egg, Poppy Seed and *Semolina* Seed) by the Black Molly fishes.

	Pomfret Egg	Carp Egg	*Tenualosa* Egg	Poppy Seed	Semolina Seed
Average food unit consumed ± SE	34.4±1.47	29.7±0.94	33.1±0.87	21.65±1.00	19.65±1.02

Table 2:A

P value	P<0.0001
P value summary	***
Are means significantly Different? (P < 0.05)	Yes
Number of groups	5
F	25.46
R squared	0.5174

ANOVA Table	SS	df	MS
between columns)	3589	4	897.3
within columns	3348	95	35.24
Total	6937	99	

Table 2:B

Tukey's Multiple Comparison Test	Mean Diff.	q	Significant? P < 0.05?	Summary
Pomfret Egg vs Poppy Seed	12.75	9.605	Yes	***
Pomfret Egg vs Semolina Seed	14.75	11.11	Yes	***
Carp Egg vs Poppy Seed	8.050	6.064	Yes	***
Carp Egg vs Semolina Seed	10.05	7.571	Yes	***
Tenualosa Egg vs Poppy Seed	11.45	8.626	Yes	***
Tenualosa Egg vs Semolina Seed	13.45	10.13	Yes	***
Pomfret Egg vs Carp Egg	4.700	3.541	No	ns
Pomfret Egg vs *Tenualosa* Egg	1.300	0.9793	No	ns
Carp Egg vs *Tenualosa* Egg	-3.400	2.561	No	ns

Table 2A. Table shows the result of one way ANOVA to compare different food consumed by the molly. The mean unit food consumption are significantly different (P<0.0001) for the different food types **Table 2B**: Tukey's Multiple Comparison Test performed to compare the food items in all possible pair.

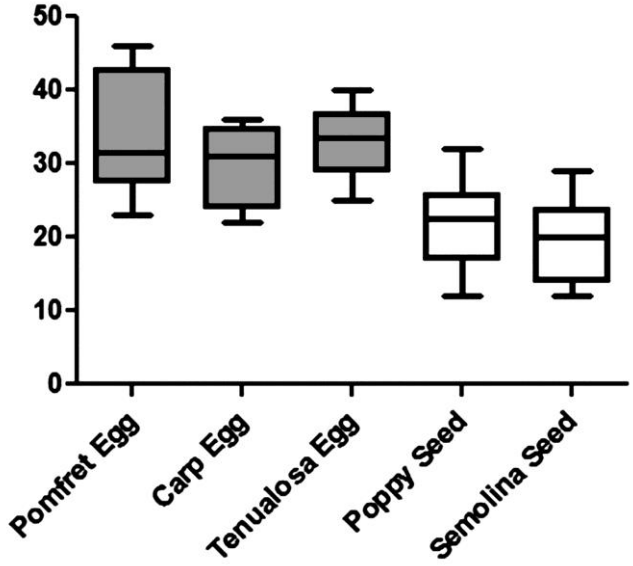


Figure 1. Vertical box and whiskers plot showing the minimum and maximum feeding of each food type by the molly. The pair-wise significant differences are shown as ($P<0.0001$)

Data obtained from one way ANOVA leads to infer that food acceptance of Black Molly differs significantly among the food types ($P<0.0001$). Tukey's multiple comparison test is suggestive of the fact that all the fish eggs (Pomfret, Carp and *Tenualosa* sp.) were consumed more frequently than all the food materials from the plant sources ($P<0.05$). No significant difference was found when comparing the feeding preference among different fish egg type. A vertical Box and Whisker plot summarizes the outcome of the entire study (Fig. 1).

ACKNOWLEDGEMENTS

Authors are thankful to Dr. Indrani Sarkar, Mr. Prantik Ghosh, Dr. Minakshi Mazumdar, Dr. Sajal Dey and Mr. Arijit De, faculties of Department of Zoology, Vidyasagar College, Kolkata, for their enormous support and necessary arrangements to conduct the work properly and Mr. Jay Mondal, student of M. Sc. in Zoology (IIIrd Semester), Vidyasagar College, Kolkata, for the collection and maintenance of fishes and food in proper time.

LITERATURE CITED

[1] Carlberg, H. Cheng, K. Lundh, T. & Brannas, E. 2015. Using Self-selection to evaluate the acceptance of a new diet formulation by fired fish. *Applied Animal Behaviour Science,* 171: 226-232

[2] Hardy, R. 2003. Introduction to the special issue on 'Ornamental fish'. *Aquaculture Research*. 34(11): 903-974

[3] Gupta, S. & Banerjee, S. 2009. Food preference of Goldfish (*Carassius auratus* (Linnaeus,1758)) and its potential in mosquito control. *Electronic Journal of Ichthyology*, 2: 47-58

[4] Nayar, S.,1996. Ornamental fishes- A booming trade. *Fishing Chimes.* 16(9): 17.

Short-term Impact of Chromium on Erythrocytic Profiles of *Channa punctatus* (Bloch)

Samudra Gupta, Jaysmita Saha, Swagata Hazra and **Rajarshi Ghosh***

Post Graduate Department of Zoology, Maulana Azad College,
8 Rafi Ahmed Kidwai Road, Kolkata-700013, West Bengal, India
***E-mail: rajarshighosh3077@gmail.com**

ABSTRACT

The tannery industries add chromium as one of the heavy metals to the aquatic environment and tannery waste waters continue to cause negative effects on the aquatic fauna. In the present study, the erythrocytic alterations produced on short-term exposure to sub-lethal concentration of chromium (20 mg/L) were investigated in fresh water air-breathing fish, *Channa punctatus* (Bloch) for 24h, 48h and 72h respectively. The 96h LC_{50} of chromium salt, potassium dichromate was determined to be 33.125 mg/L. The results revealed statistically significant decrease in Total Erythrocytic Count (TEC), Haemoglobin (Hb) and Haematocrit (Hct %) in all experimental animals when compared to the control with an increase in exposure periods. The absolute corpuscular values like Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC) also exhibited significant increase in fishes of experimental groups. However, the Mean Cell Volume (MCV) contrarily exhibited a fluctuating pattern. The depression of erythrocytic parameters clearly indicates that the fishes have become anaemic due to sublethal exposure of chromium.

***Keywords*:** heavy metals, chromium, *Channa punctatus*, erythrocytic parameters

INTRODUCTION

Water pollution by heavy metals has become a health hazard in recent years. With industrialization, heavy metals are released into natural waters in large quantities. Due to their high toxicity even in low concentrations, harmful effects may be produced in aquatic organisms, including teleosts. Chromium is extensively used in chrome plating, tanning and as a corrosion inhibitor in cooling tower operations. The wastewater generated by tanneries is a major source of chromium which contains Chromium (Cr^{6+}) and their indiscriminate introduction in the aquatic ecosystem pose a serious threat to the growth and survival of the fish population. A considerable amount of experimental data on chromium toxicity to aquatic life was reviewed (Irwin *et al.*, 1997) but the data on chromium toxicity to Indian teleosts are scarce and are mostly restricted to the effects on biochemical or enzymological profiles (Sastry & Tyagi, 1982; Vutukuru, 2003). The present work was undertaken to examine the short-term acute toxicity of this heavy metal to a freshwater murrel, *Channa punctatus* and deals with alterations in the erythrocytic parameters viz.TEC (Total Erythrocytic Count), Hb (Haemoglobin), Hct% (Haematocrit) and absolute corpuscular values like Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC).

MATERIAL & METHODS

Live specimens of adult *Channa punctatus* (Family: Channidae) of length 13.78 ±0.33 cm and 39.36 ±2.35 g weight, were procured from clean and unpolluted local freshwater sources of the fish market. They were acclimatized in laboratory glass aquaria in clean tap water for 5 days prior to experimentation. Water used in the aquaria had a pH: 7.2 ± 0.05, water temperature: 23 ±2 °C, DCO_2: 3.4 ± 0.05 mg/L, DO: 7.5 ±1 mg/ L. APHA (2005) method was followed for the water quality determination. Fish were fed, *ad libitum*, with live *Tubifex* sp. and commercial dry pellets during the acclimatization period only. Two-third of the water was renewed every day to avoid accumulation of unutilized food or metabolic waste products. Analytical grade Potassium dichromate ($K_2Cr_2O_7$) by BDH (India) was used as a metal toxicant throughout the experiment and for the determination of LC_{50} of chromium. The LC_{50} value was determined according to the arithmetic method of Karber as adopted by Dede & Kaglo (2001) using the daily renewal bioassay system. Five test concentrations of narrow range viz. 30, 35, 40, 45 and 50 mg/L respectively and a control (without chromium) were selected to find the 96 h LC_{50} value of the chromium. Eight fish were placed in each of the aquarium and duplicates were maintained for the each of the treatment as well as for control. In this experiment, no distinction was made between the sexes and no feeding was allowed. Dead fishes were removed from the aquaria immediately. The whole exposure medium was monitored on a regular basis with a view to maintain the desired concentration of chromium.

The percentage of mortality was recorded at 96 h interval for each of the test concentrations which was used to estimate LC_{50} value of the $K_2Cr_2O_7$ at 96h. The fishes were divided into four groups each containing 8 individuals, one group was taken as control, with no chromium added to the water, and other 3 groups were exposed to chosen sublethal dose of chromium (20 mg/L) for 24, 48 and 72 h respectively after determining LC_{50} value at 96h. During the exposure, mortality of the fish, if any, was monitored. Different blood parameters viz., TEC, Hb and Hct were measured following the methods earlier described (Hesser, 1960). Some modifications were made following the methods of Blaxhall & Daisley (1973), Dacie & Lewis (1984). After stipulated exposure periods, the control and experimental fishes were wiped dry before collecting the blood samples. Free flowing blood was collected by severing the caudal peduncle of fish without using anesthesia. TEC and TLC were analyzed following by standard clinical method, with the help of improved Neubaur double haemocytometer (Fein-OPTIK, Blankenburg, G.D.R.) using Hayem's solution as diluting fluid. The haemoglobin content (g %) of blood was determined with the help of Sahli's Haemometer. The Hct and Lct values were estimated by microhaematocrit method (Wintrobe, 1967) using microhaematocrit capillary tubes and a microhaematocrit centrifuge (3000 g for 25 min). The values of MCV, MCH and MCHC were calculated from the red cell count (TEC), haemoglobin (Hb) and haematocrit (Hct %) values using standard formulae. The results were presented as mean and standard error (mean ± SE). Independent sample t-test was used to distinguish between means of significant differences. Treatments were taken to be significantly different where $P < 0.05$ and highly significant where $P < 0.01$.

RESULTS

The 96h LC_{50} of chromium salt, $K_2Cr_2O_7$ for *C. punctatus* was determined to be 33.125 mg/L. The fish exposed to sublethal dose of chromium (i.e. 20 mg/L) exhibited erratic swimming and loss of equilibrium gradually. The exposure of *C. punctatus* to sublethal concentration of chromium for 24h, 48h and 72h caused remarkable and significant alterations in erythrocytic parameters as represented in Tables 1 and 2. As shown in Table 1,

the values of TEC ($\times 10^6$ /cmm) and haemoglobin concentration (g %) were found to be significantly decreased ($p < 0.01$) especially after 48 h and 72 h exposures of chromium when compared with control. A sharp decline ($p < 0.01$) of haematocrit count (Hct %) was observed from the first day onwards compared to control (Table 1).

Table 1. Changes in few erythrocytic parameters (TEC, Hb and Hct) of control and experimental freshwater fish, *Channa punctatus* exposed to sublethal dose of chromium (20 mg/L)

Erythrocytic parameters	Control	Experimental fish groups		
		24h	48h	72h
TEC ($\times 10^6$) /cmm	3.07 ± 0.11	2.66 ± 0.41	2.15 ± 0.03 **	1.43 ± 0.13**
Hb (g %)	11.3 ± 0.35	10.12 ± 0.47	8.63 ± 0.46**	7.5 ± 0.11**
Hct (%)	24.43 ± 0.04	15 ± 0.73**	14 ± 0.57**	14.25 ± 0.65**

Values are expressed as Mean ± S.E., n = 6. ** = significant at p < 0.01 level.

In Table 2, MCV values were found to be significantly low ($p < 0.05$) after initial exposure but gradually increased later on. MCH were found to be significantly different in chromium exposed groups (72h) when compared with control. MCHC values were significantly high ($p < 0.01$) in treated fish groups especially during 24h and 48h of exposure.

Table 2. Changes in absolute corpuscular values (MCV, MCH and MCHC) of control and experimental freshwater fish, *Channa punctatus* exposed to sublethal dose of chromium (20 mg/L)

Erythrocytic parameters	Control	Experimental fish groups		
		24h	48h	72h
MCV (fl)	79.91 ± 2.25	63.21 ± 3.02*	65.16 ± 9.02	102.88 ± 7.58*
MCH (pg)	37.09 ± 2.08	45.53 ± 6.86	40.22 ± 2.47	54.92 ± 5.41*
MCHC (g/L)	46.28 ± 1.42	68.55 ± 5.0**	61.81 ± 2.79**	53.24 ± 2.81

Values are expressed as Mean ± S.E., n = 6. * = significant at p < 0.05 level, ** = significant at p < 0.01 level.

DISCUSSION

Haematology is used as an index of fish health status in a number of fish species to detect different stress conditions like disease, hypoxia, and exposure to metals and pollutants etc (Blaxhall, 1972). In general, the results of the present study revealed that hexavalent chromium induces effects on erythrocytic parameters of the fish. The significant reduction in

TEC coupled with low Haemoglobin content may be due to destructive action of heavy metal on erythrocytes which was also reported by earlier workers (Karuppasamy, 2000; Bela Zutshi *et al.*, 2010). The decreased Haemoglobin count indicates the inability to provide sufficient oxygen to the vital organs in fish. The erythrocytic fragility following exposure to heavy metals might explain the initial anaemic condition observed in this short-term study. Prolonged reduction in haemoglobin content is harmful to oxygen transport and degeneration of the erythrocytes could be described as pathological condition in fishes exposed to heavy metals (Pamila *et al.*, 1991). The anemic condition of this experimental fish groups were further detected by haematocrit study. A distinct decrease in the level of Haemoglobin and Hct % after exposure to heavy metal chromium clearly suggests a haemodilution mechanism possibly due to gill damage or impaired osmoregulation. This study is in line with Smit *et al.* (1979) that heavy metal exposure exerts the decrease in RBC count, Hb and Hct values and that may be due to the impaired intestinal absorption of iron. Significant changes were recorded in the mean MCV, MCH, MCHC values and similar results have been reported in *Labeo rohita*, exposed to chromium (Venkatachalam & Natarajan, 2014). Cells released from the affected spleen, an erythropoietic organ in fish, would have lowered MCV values initially. A similar observation was reported in *C. carpio* after cadmium exposure (Koyama & Ozaki, 2002).

In conclusion, the present study clearly indicates that chromium in the form of $K_2Cr_2O_7$, a toxic heavy metal, experimentally introduced into aquatic environments induces severe anaemia and alterations in erythrocytic indices in the fresh water air-breathing fish, *Channa punctatus* at short-term exposures.

ACKNOWLEDGEMENT

The authors would like to thank Prof. Subir C. Dasgupta, Head of the Department of Zoology, Maulana Azad College for providing infrastructural facilities.

LITERATURE CITED

[1] American Public Health Association. 2005. Standard methods for the Examination and Water and Wastewater, 21st ed., Washington DC.

[2] Bela Zutshi, S., Raghu Prasad, G. & Nagaraja, R. 2010. Alteration in Hematology of *Labeo rohita* under stress of pollution from lakes of Bangalore, Karnataka, India. Environmental Monitoring & Assessment, 168: 11-19.

[3] Blaxhall, P.C. 1972. The haematological assessment of the health of freshwater fish. Journal of Fish Biology, 4: 593-605.

[4] Blaxhall, P.C. & Daisley, K.W. 1973. Routine haematological methods for use with fish blood. Journal of Fish Biology, 5: 771-781.

[5] Dacie, J.V. & Lewis, S.N. 1984. Practical Haematology, 6th Edition. Edinburg, Churchill Livingstone, pp. 112.

[6] Dede, E.B. & Kaglo, H.D. 2001. Aqua-toxicological effects of water soluble fractions (WSF) of diesel fuel on *O. niloticus* fingerlings. Journal of Applied Sciences & Environmental management, 5: 93-96.

[7] Hesser, E.F. 1960. Methods for routine fish haematology. The Progressive Fish-Culturist, 22: 164-171.

[8] Irwin, R.J., Van Mouwerik, M., Stevens, L., Seese, M.D. & Basham, W. 1997. ChromiumVI (Hexavalent chromium). Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado, 43 pp.

[9] Karuppasamy R. 2000. Impact of Phenyl mercuric acetate on the bimodal respiration in an air-breathing fish *C. punctatus.* Journal of Environmental pollution, 7: 287-293.
[10] Koyama, J. & Ozaki, H. 2002. Haematological changes of fish exposed to low concentrations of cadmium in the water. Bulletin of the Japanese Society for the Science of Fish, 50: 199-203.
[11] Pamila, D. & Subbaiyan, P.A., Ramaswamy, M. 1991. Toxic effect of chromium and cobalt on *Sartherodon mossambicus* (Peters). Indian Journal of Environmental Health, 33: 218-224.
[12] Sastry, K. V. & Tyagi, S. 1982. Toxic effects of chromium in a freshwater teleost fish, *Channa punctatus*. Toxicology Letters, 11: 17-21.
[13] Smit, G. L., Hatting, J. & Burger, A. P. 1979. Haematological assessment of the effects of the anaesthetic MS222 in natural and neutralized form in three fresh water fish species: Interspecies differences. Journal of Fish Biology, 15: 633-643.
[14] Venkatachalam, T. & Natarajan, A. V. 2014. Haematological investigation on freshwater teleost *Labeo rohita* (Ham.) following aquatic toxicities of Cr (III) and Cr (VI). International Journal of Research in Biosciences; 3(3): 1-14.
[15] Vutukuru, S.S. 2003. Chromium induced alterations in some biochemical profile of the Indian major carp *Labeo rohita* (Hamilton). Bulletin of Environmental Contamination & Toxicology, 70: 118–123.
[16] Wintrobe, M. M. 1967. Clinical haematology. 6th Edition, Lea and Febiger, Philadelphia, Library of Congress, Print USA.

Avifaunal Diversity of Bibhutibhushan Wildlife Sanctuary, West Bengal, India

Shiladitya Mukhopadhyay[1,*] and **Subhendu Mazumdar**[2]

[1]Post Graduate Department of Zoology, Barasat Government College, North 24 Parganas, India
[2]Department of Zoology, Shibpur Dinobundhoo Institution (College), Shibpur, Howrah, India
*E-mail: s21mukherjee@gmail.com

ABSTRACT

Birds are found in a variety of habitats, performing various functions. They are highly sensitive to even minor perturbation in ecosystems. Documentation of avian assemblages in different ecosystems is, therefore, becoming increasingly important from environmental monitoring perspective. In absence of comprehensive account of birds of Bibhutibhushan Wildlife Sanctuary, West Bengal, India, we made an attempt to document the birds thriving in this protected area. A total of 102 species of birds belonging to 13 orders and 46 families were recorded during the study period (June 2013 – May 2016). Maximum number of species belong to the order Passeriformes (49 species) and minimum under order Anseriformes (1 species). Among the total bird species, 83 species (81.37%) were resident, 15 species (14.71%) were winter visitor, three species (2.94%) were summer visitor and one species (0.98%) was passage migrant. We noted 38 species of birds (including 36 residents and two summer visitors) to breed within the sanctuary. Analysis of feeding guild data revealed that 46.08% were insectivore, 22.55% were carnivore, 15.69% were omnivore, 6.86% were granivore, 5.88% were frugivore, 1.96% were nectarivore and 0.98% were herbivore. Grey-headed Fish Eagle (*Icthyophaga ichthyaetus*) and Red-breasted Parakeet (*Psittacula alexandri*) are two Near Threatened (NT) species designated by IUCN. Present study is the first scientific documentation of avian assemblage of this protected area and will serve as a baseline data for future avifaunal research, as well as, will be useful in the preparation of Peoples' Biodiversity Register (PBR) of this area.

Keywords: Avifauna, species richness, feeding guild, *Bibhutibhushan* Wildlife Sanctuary, *Parmadan*

INTRODUCTION

Birds are ubiquitous, execute varied functional roles and provide many ecosystem services (Wellan *et al.*, 2008). Indian subcontinent, a part of the vast Oriental Bio-geographic regions, is very rich in biodiversity. With highly varied climatic conditions, diverse habitat and long stretch of vegetation, this region supports over 13% of the world's birds (Grimmett *et al*., 1998, Ali, 2002). Despite of being present worldwide in nearly all habitats, they are very sensitive to environmental changes (Taper *et al*., 1995; Olechnowski, 2009). Therefore, avian species assemblages are considered as key indicators for assessing the status of ecosystem health and

functioning (Turner *et al*., 1990; Newton, 1995; Padoa-Schioppa *et al*., 2006). Thus, exploration of richness and diversity of bird communities have been considered as an efficient tool to monitor various habitats, both qualitatively and quantitatively (Bilgrami, 1995).

Unfortunately global diversity of birds is decreasing incessantly primarily due to anthropogenic disturbances (Rapoport, 1993) and climate change (Chen *et al*., 2011; Sekercioglu *et al*., 2012). IUCN Red List of endangered birds has already recognized 1226 bird species as threatened globally and India with 88 threatened bird species (Bird Life International, 2010). Forests attract a large number of avifauna because they provide suitable habitats for most birds. But, even in tropical forests 1800 individuals of birds are decimated per hour while 16 million are killed annually on an average (Hughes *et al*., 1997). In such an alarming situation, protected areas are also known to serve as important refuge for many avian communities and increasingly recognized as critical in supporting biodiversity. They also play key roles in essential ecological functions, such as ecosystem services, climatic stabilization, carbon sequestration, groundwater recharge, nutrient retention, and natural disaster prevention (Heal, 2000; DeFries *et al*., 2007). So, understanding the diversity and structure of bird communities is essential to delineate their importance in avian conservation (Kattan & Franco, 2004). Therefore, documentation of avian assemblages along with the diversity of other key taxa of various protected areas has become very important. Although, avian species richness of some of the well known protected areas of West Bengal is documented (Inglis 1919; Mukherjee, 1959; Spillett 1967; Shahi, 1983; Allen *et al*., 1992; Anonymous 1993; Kumar, 1998; Prakash *et al*., 2001; Delany & Scott, 2002; Sanyal, 2002; Lobo, 2003; Shivakumar & Prakash, 2004; Gopal & Chauhan, 2006; Pramanik *et al*., 2010; Roy *et al*., 2012), yet studies on avian diversity of Bibhutibhusan Wildlife Sanctuary is almost non-existent. In view of these, the objective of the study was to prepare an up to date checklist of birds of this protected area for monitoring and conservation planning.

MATERIAL & METHODS

Study Area

Bibhutibhusan Wildlife Sanctuary (23.18°N, 88.77°E; 0.64 sq km, henceforth BBWLS), locally known as *Parmadan* forest, is located in North 24 Parganas Forest Division, West Bengal, India on the banks of the *Ichhamati* river (Fig. 1). The forest land is bounded on all its three sides (i.e. north, south and east) by *Ichhamati* river while the eastern side is bounded by rural settlements (namely *Parmadan* and *Jhupa* villages). Natural vegetation of this protected area is comprised of varied assemblage of deciduous and non-deciduous trees, while the undergrowth is thick and dense, comprising mostly ferns, tall grasses and bushes. Floral biodiversity of the study area includes about 209 species of angiosperms including 59 trees, 98 herbs, 34 shrubs, 15 climbers and 3 creepers (Talukdar & Sanyal, 2013). Main trees of this forest are *Terminalia arjuna*, *Albizia saman*, *Senna siamea*, *Morus* sp., *Bombax ceiba*, and several species of bamboo. This forest is known to harbour more than 200 deer, birds, rabbit and a large number of langurs. The core area of the forest is fenced off and visitors are permitted to walk along the road by the fence. The climate is tropical, dry during winter (mid - November to mid-February) and humid during summer. Annual rainfall is 1,579 mm, temperature ranges between 41 °C (in May) and 10 °C (in January) and relative humidity varies between 50 % and 90 % (Talukdar & Sanyal, 2013).

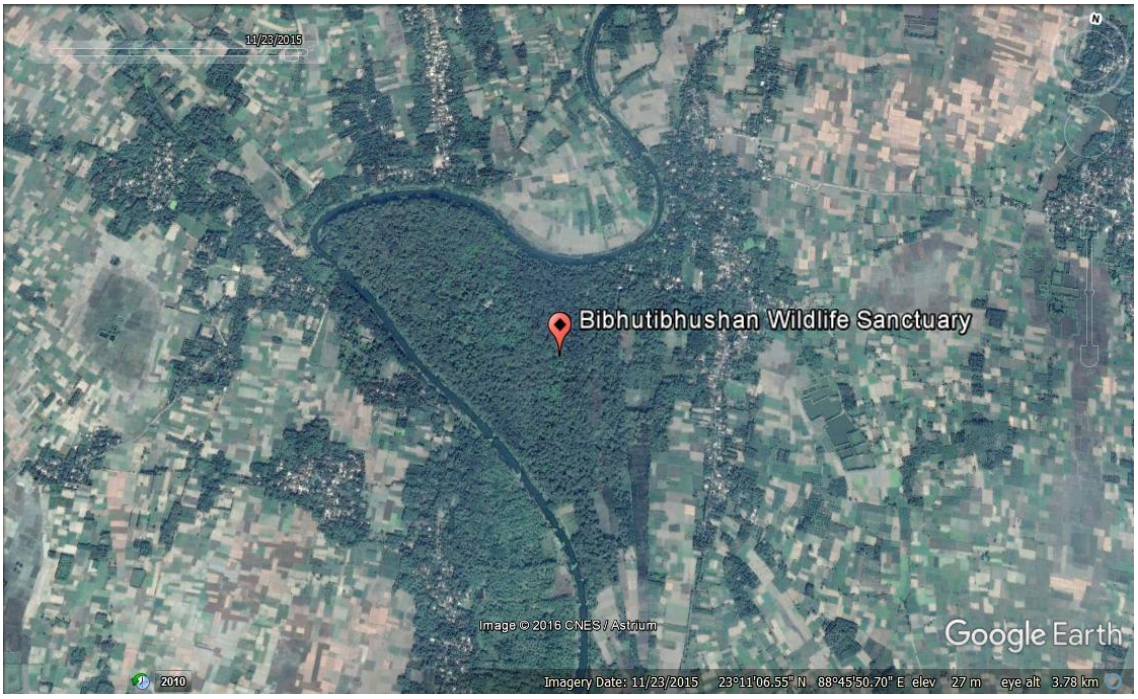


Fig. 1. The map of the study area, BBWLS, West Bengal, India

Methods

Fortnightly avifaunal surveys were carried out for three years (June 2013 -May 2016) in the study area. Field surveys were carried out during 0730-1030 hrs and 1500–1700 or 1800 hrs depending on the day length and morning and evening counts was altered between sites. During each visit, fixed-radius (25 m) point count method was carried out to record the species richness of avifauna at each count station (Bibby *et al*., 2000; Sutherland, 2006). Observation points were randomly placed throughout the study area. We recorded bird species (seen or heard) in 25 m radius around each of those point count stations in 360° arc for 10 minutes. Besides, opportunistic observation of birds during other times and other places were also included to prepare a comprehensive checklist of avifauna of the study area. Field visits were carried out on foot only on days with ambient weather conditions (i.e., in the absence of rain or strong wind).

Birds were observed using a binocular (Olympus 7 x 35 DPS I) and were identified following Grimmett *et al.,* (1998). Photographs were taken with a digital camera (Nikon P600 / Canon EOS 7D Mark II) for documentation.

Birds were classified based on their seasonal dispersal pattern and were classified as resident (R), summer visitor (SV), winter visitor (WV) and passage migrants (P) following Grimmett *et al*. (1998). We also assigned a local status for each species following Khan & Naher (2009) where very common (Vc) are bird species which were recorded on 80–100 % of field visits, common (Co) are noted on 50–79 % of field visits, fairly common (Fc) are seen on 20–49 % of field visits and rare (Ra) are avian species which were recorded on less than 20 % of field visits. The study of avian feeding guilds is also important for understanding the complexity of ecosystem structure (Azman *et al*., 2011). So, we classified the avian species into seven guilds, *viz.* carnivore (Ca), omnivore (O), frugivore (F), herbivores (H),

nectarivore (N), granivore (G) and insectivore (I). Systemic position (Order and Family), common name and scientific name of each species was accorded following Praveen *et al*., (2016).

RESULTS

A total of 102 species of birds belonging to 13 orders and 46 families were recorded during the study period (Table 1), out of which order Passeriformes (49 species) dominated the avifauna in this area, followed by the orders Pelecaniformes (8 species), Piciformes (7 species), Accipitriformes, Coraciiformes, Cuculiformes (6 species each), Columbiformes (5 species), Strigiformes (4 species), Caprimulgiformes, Psittaciformes (3 species each), Charadriiformes, Gruiformes (2 species each) and Anseriformes (1 species).

Cuculidae, Accipitridae and Muscicapidae were three richest families each of which were represented by 6 species, followed by Columbidae (4 species), Sturnidae (4 species), Picidae (4 species), Alcedinidae (3 species), Campephagidae (3 species), Corvidae (3 species), Dicruridae (3 species), Turdidae (3 species), Rhamphastidae (3 species), Psittaculidae (3 species), Strigidae (3 species), Caprimulgidae (2 species), Meropidae (2 species), Rallidae (2 species), Cisticolidae (2 species), Estrildidae (2 species), Laniidae (2 species), Monarchidae (2 species), Motacillidae (2 species), Nectarinadae (2 species), Oriolidae (2 species), Phalacrocoracidae (2 species) and one species belonged to each of the Anatidae, Apodidae, Charadriidae, Scolopacidae, Coraciidae, Aegithiniidae, Artamidae, Hirundinidae, Irenidae, Leiothrichidae, Paridae, Passeridae, Pellorneidae, Phylloscopidae, Pittidae, Pycnonotidae, Vangidae, Zosteropidae, Ciconiidae and Tytonidae families (Table 1).

Analysis of their local abundance indicated that 24 species were Vc (very common), 41 species were Co (common), 22 species were Fc (fairly common), and 15 species were Ra (rare). Analysis of feeding guild data revealed that 46.08% were insectivore, 22.55% were carnivore, 15.69% were omnivore, 6.86% were granivore, 5.88% were frugivore, 1.96% were nectarivore and 0.98% were herbivore (Fig. 2). Seasonal dispersal pattern of the avian assemblage in the study area revealed that 81.37% birds were resident (83 species), 14.71% (15 species) were winter visitor, 2.94% (3 species) were summer visitor and 0.98% (1 species) was passage migrant (Fig. 3). We noted 38 species of birds (including 36 residents and 2 summer visitors) to breed within the sanctuary. Of all avian species, two species *viz.* Grey-headed Fish Eagle (*Icthyophaga ichthyaetus*) and Red-breasted Parakeet (*Psittacula alexandri*) fall under Near Threatened (NT) category of IUCN (Fig. 4). All the remaining species (n= 100) are placed in the Least Concern (LC) category.

DISCUSSION

Ecologically, birds are of tremendous importance to the human society. They act as a good medium for dispersing seeds, pollinating plants, biological control and they are important to continue the ecological cycle. (3-2-2). Despite small in size, this protected area supports diverse bird community and 10.89% of total avian species of this state (N = 937) are recorded here. Although we did not record the relative abundance of each species, still the avian diversity is comparable with many other protected areas of this state. For instance, Roy *et al*., (2011) studied avifaunal diversity in three different national parks and reserve forest in North Bengal and recorded 117 bird species belonging to 42 families; Dubey *et al*., (2015) noted 99

species belonging to 43 families, Pramanik *et al*., (2010) reported 29 bird species of 20 families from Kulik Bird Santuary Raigang, and Patra & Chakrabarti (2014) observed 86 bird species belonging 10 orders and 35 families in Digha coast of West Bengal. Species composition of birds in an area is related to the type of vegetation, height above the sea level, availability of microhabitats and various other factors (Pramanik *et al*., 2010). Perhaps heterogeneity of habitat in the study area augments availability of diverse resource, which in turn sustains different bird species with characteristic species richness.

Availability of food and suitable habitat attract resident and migrant birds to visit the sanctuary throughout the year. However, the species richness varies seasonally. This small protected area harbours 19 migratory species which include 15 winter visitors, 3 summer visitors and 1 passage migrant. Migratory birds displayed a definite species specific pattern for arrival at and departure from the study site. The basic requirements of migratory birds at their wintering ground are adequate food supply and safety (Lakshmi, 2006), which are fulfilled by BBWLS, nearby agricultural fields and also by river *Ichhamati*. This sanctuary also serve as important breeding habitat for 38 species (36 resident and 2 summer visitors) who construct nest within this wildlife sanctuary. This protected area serves as a regular breeding site for 'Near Threatened' (IUCN) Grey-headed Fish Eagle (*Icthyophaga ichthyaetus*). Hooded Pitta (*Pitta sordida*), a summer visitor to the region, recorded after 80 years from southern West Bengal (Law, 1938; Chakraborty *et al*., 2016), also found to breed here.

Species assemblage within BBWLS also reflects possible variation in their functional roles, feeding habits and resource utilization pattern. The diverse feeding habit of the avifauna suggests that the study area provides a rich source of a variety of food resources. Insectivore species were highest in the study area, indicating rich abundance and easy availability of insects in this forested habitat. These insectivorous birds also play very important role in the biocontrol of insect pest thriving in the agriculture, horticulture, and forests (Mahabal *et al*., 2005; Thakur *et al*., 2010) of adjoining areas. But indiscriminate use of pesticides in surrounding paddy fields might lead to drastic decline in the insect abundance of these areas, leading to the lack of food for the insectivorous birds. If these birds forage on the insects exposed to such chemicals, then being in the higher trophic level they are at potential risk of decline suffering from toxic effects of bioaccumulation of chemical pesticides. So, monitoring insectivorous species of BBWLS might reflect the impact of pesticide use this avian guild.

Birds in different habitats are under threat due to increased anthropogenic activities resulting in habitat destruction and fragmentation (Baral & Inskipp, 2005, Datta, 2011, Gautam & Kafle, 2007). Moreover, changes in climatic conditions in recent decades have been unanimously reported to influence bird diversity most negatively (Sekercioglu *et al*., 2012). Inspite of the fact that conservation of global biodiversity has become the issue of prime importance in recent decades (Turner *et al*., 1990; Ehrlich & Wilson, 1991), still most of the protected areas are presently inflicted with some major anthropogenic disturbances like urbanization, tourist pressure, livelihood dependence (mainly in the form of cattle grazing and fuel wood collection) and pollution (Islam & Rahmani, 2004; Mallick, 2010; Karmakar, 2011) and BBWLS is no exception. Presence of several villages around the sanctuary poses potentially high risk of encroachment, as well as, overexploitation of resources from this protected area. It has been observed during the course of this study that (legal or illegal) influx of large number of people within the sanctuary disturbed many shy and secretive bird species. Condition get even worse during mid winter (particularly during

December and January), while large number of people enter BBWLS for picnic, play loudspeakers and litter the area with leftover food, plastic and other materials. All these activities within any protected area are violation of the provisions of Wildlife (Protection) Act. These activities need to be urgently called off to protect the avifauna and other wildlife of BBWLS from sheer stress of habitat disturbance. Legislations should be more strictly implemented to prevent random human entry inside the sanctuary. Notifying a buffer area around the existing PA, if possible through community involvement, will ultimately decrease human pressure on the natural resources of the sanctuary.

This is the first scientific documentation of avian species richness in BBWLS, which supports a good number of birds. From the present study, the basic information of bird diversity and abundance patterns can be used for further ecological assessment & comparative research. Regular monitoring of avifauna is an excellent means of monitoring forest health, and it will also help to foster a sustainable improvement of the habitat. Monitoring avian community of this protected area might also provide an early indication if this ecosystem suffer from any detrimental change. This area constitutes a promising region for ecological and behavioural research of avifauna. In depth studies on population abundance, habitat use, nesting breeding and foraging behaviour and assessment of threats and conservation issues might be useful to bridge the gap of existing knowledge on avifauna of this study area.

ACKNOWLEDGMENTS

We are grateful to the officials of the Bibhutibhusan Wildlife Sanctuary for kind permission to carry out the avian surveys. We are indebted to Dr. Sanjay Poddar of Barasat Government College for his constant encouragement. Permission and infrastructural facilities provided by Principal, Barasat Government College and Principal, Shibpur Dinobundhoo Institution (College) are gratefully acknowledged. Special thank is due to Mr. Sourav Mondal for providing the photographs and help during the survey.

LITERATURE CITED

[1] Ali, S. 2002. *The book of Indian birds*, Oxford University press. New Delhi., 326 pp.

[2] Allen, D., Anderton, J. & Kazmierczak, K. 1997. Report on an ornithological visit to Buxa Tiger Reserve, West Bengal, India, 17 February to 6 March, 1992. *Forktail*, 12 : 31-48.

[3] Anonymous. 1993. Important fauna of tiger reserves. New Delhi: Project Tiger, Ministry of Environment and Forests, Government of India : 1087-1111.

[4] Azman, N. M., Latip, N. S. A., Sah, S. A. M., Akil, M. A. M. M., Shafie, N. J., & Khairuddin, N. L. 2011. Avian diversity and feeding guilds in a secondary forest, an oil palm plantation and a paddy field in riparian areas of the Kerian River Basin, Perak, Malaysia. *Tropical Life Sciences Research*, 22 (2): 45-64.

[5] Baral, H. S., & Inskipp, C. 2005. *Important Bird Areas in Nepal: key sites for conservation*. Bird Conservation Nepal, 5(2) : 153-157.

[6] Bilgrami, K. S. 1995. *Concept and conservation of biodiversity*. CBS Publishers and Distributors, Delhi.

[7] Chakraborty, M., Mukhopadhyay, S., & Mondal, S. 2016. A report of the Hooded Pitta *Pitta sordida* from southern West Bengal, India. *Indian Birds*, 11 (3): 78–79.

[8] Chen, I. C., Hill, J. K., Ohlemüller, R., Roy, D. B., & Thomas, C. D. 2011. Rapid range shifts of species associated with high levels of climate warming. *Science*, 333 (6045): 1024-1026.
[9] Datta, T. 2011. Human interference and avifaunal diversity of two wetlands of Jalpaiguri, West Bengal, India. *Journal of Threatened Taxa*, 3 (12): 2253-2262.
[10] DeFries, R., Hansen, A., Turner, B. L., Reid, R., & Liu, J. 2007. Land use change around protected areas: management to balance human needs and ecological function. *Ecological Applications*, 17 (4): 1031-1038.
[11] Delany, S., & Scott, S. 2002. *Waterbird Population Estimates–Third Edition. Wetlands International Global Series No. 12*. Wetlands International, Wageningen, The Netherlands.
[12] Dubey, S. K., Chakraborty, D. C., Gupta, S., Mitra, M., Bhattacharya, R., & Neogy, A. B. 2015. Avian Diversity in the Jaldapara National Park, West Bengal, India with a Notes on their Habitat Association and Feeding Guild. *Indian Forester*, 141 (10): 1092-1101.
[13] Ehrlich, P. R., & Wilson, E. O. 1991. Biodiversity studies: science and policy. *Science*, 253 (5021): 758-762.
[14] Gautam, R., & Kafle, G. 2007. A Preliminary Survey of Waterbirds in Phewa Lake, Kaski. *Danphe*, 16 (3/4): 6-8.
[15] Grimmett, R. C. Inskipp & T. Inskipp 1998. *Birds of the Indian Subcontinent*. Oxford University Press, New Delhi, 888 pp.
[16] Heal, G. 2000. Valuing ecosystem services. *Ecosystems*, 3 (1): 24-30.
[17] Hughes, J. B., Daily, G. C., & Ehrlich, P. R. (1997). Population diversity: its extent and extinction. *Science*, 278 (5338): 689-692.
[18] Inglis, C. M., Travers, W. L., O'Donel, H. V., & Shebbeare, E. O. 1919. A tentative list of the vertebrates of the Jalpaiguri district, Bengal. *Journal of Bombay Natural History Society*, 26 (3): 819-825.
[19] Islam, M. Z, & Rahmani, A. R. 2004. *Important Bird Areas in India: priority sites for conservation*. Bombay Natural History Society, India, xviii+1133.
[20] IUCN 2016. *The IUCN Red List of Threatened Species*. Version 2016-3. http://www.iucnredlist.org. [Accessed on 25 January 2017].
[21] Karmakar, M. 2011. Ecotourism and its impact on the regional economy-a study of North Bengal (India). *Tourismos*, 6 (1): 251-270.
[22] Kattan, G. H., & Franco, P. 2004. Bird diversity along elevational gradients in the Andes of Colombia: area and mass effects. *Global Ecology and Biogeography*, 13(5): 451-458.
[23] Khan, S. I., & Naher, H. 2009. Birds in Kurigram district of Bangladesh. *Journal of Threatened Taxa*, 1(4): 245-250.
[24] Kumar, S. A. 1998. Birds of Jaldapara Wildlife Sanctuary. *Newsletter for Birdwatchers*, 38: 7-8.
[25] Lakshmi, B. B. 2006. Avifauna of Gosthani estuary near Visakhapatnam, Andhra Pradesh. *Journal for Nature Conservation*, 18 (2): 291-304.
[26] Law, S. C. 1938. Haunts and habitat of *Pitta cuculatta* in Bengal. *Journal of Bombay Natural History Society*, 40: 759-762
[27] Lobo, P. 2003. *Checklist of birds of Mahananda Wildlife Sanctuary*, West Bengal. Unpublished, pp. 17.
[28] Mahabal, A., Subramanian, K. A., & Jadhav, S. S. 2005. Aves, pp. 275-339. *Fauna of Western Himalaya*, Zoological Survey of India, Kolkata.
[29] Mallick, J. K. 2010. Past and present status of the Indian Tiger in northern West Bengal, India: an overview. *Journal of Threatened Taxa*, 2 (3): 739-752.

[30] Mukherjee, A. K. 1959. Pakhirala, Sajnakhali-an introduction to a bird sanctuary in the Sundarbans. *Journal of the Bengal Natural History Society,* 30 (3&4): 161-165.
[31] Mukherjee, A. K. 1975. The Sundarban of India and its biota. *J. Bombay Nat. Hist. Soc*, 72 (1): 1-20.
[32] Newton, I. 1995. The contribution of some recent research on birds to ecological understanding. *Journal of Animal Ecology*, 64 (6): 675-695.
[33] Olechnowski, B. F., Debinski, D. M., Drobney, P., Viste-Sparkman, K., & Reed, W. T. 2009. Changes in vegetation structure through time in a restored tallgrass prairie ecosystem and implications for avian diversity and community composition. *Ecological Restoration,* 27 (4): 449-457.
[34] Padoa-Schioppa, E., Baietto, M., Massa, R., & Bottoni, L. 2006. Bird communities as bioindicators: The focal species concept in agricultural landscapes. *Ecological indicators*, 6 (1): 83-93.
[35] Patra, G., & Chakrabarti, S. 2014. Avian Diversity in and around Digha, District—East Midnapore (West Bengal, India). *Advances in Bioscience and Biotechnology*, 5(07): 596.
[36] Prakash, V., Sivakumar, S., & Varghese, J. 2001. Avifauna as indicator of habitat quality in Buxa Tiger Reserve (Final report). Bombay Natural History Society, Mumbai.
[37] Pramanik, A. K., Santra, K. B., & Manna, C. K. 2010. Abundance and Diversity of Plants and Animals in the Kulik Bird Sanctuary, Raiganj, West Bengal, India. *J Biodiversity*, 1(1): 13-17.
[38] Praveen, J., Jayapal, R., & Pittie, A. 2016. A checklist of the birds of India. *Indian Birds*, 11 (5&6): 113-172.
[39] Rahmani, A. R., Narayan, G., Rosalind, L. & Sankaran, R. 1990. Status of the Bengal Florican in India. Pp. 55-78. *In*: Status and Ecology of the Lesser and Bengal Floricans, with reports on Jerdon's Courser and Mountain Quail. Final Report. Bombay Natural History Society.
[40] Rapoport, E. H. 1993. The process of plant colonization in small settlements and large cities. In *Humans as components of ecosystems,* Springer New York, Pp. 190-207.
[41] Roy, U. S., Pal, A., Banerjee, P., & Mukhopadhyay, S. K. 2011. Comparison of avifaunal diversity in and around Neora Valley National Park, West Bengal, India. *Journal of Threatened Taxa,* 3 (10): 2136-2142.
[42] Sanyal, P. 2002. Sunderbans Biosphere Reserve. In *Traditional Ecological Knowledge for Managing Biosphere Reserves in South and Central Asia*. Eds. Ramakrishan, P., Rai, R. K., Oxford & IBH Pub., New Delhi, pp. 536.
[43] Şekercioğlu, Ç. H., Primack, R. B., & Wormworth, J. 2012. The effects of climate change on tropical birds. *Biological Conservation*, 148 (1): 1-18.
[44] Shahi, S. P. 1983. A little known Bird Sanctuary. *Hornbill*, 1983 (2): 30-32.
[45] Spillett, J. J. 1967. A report on wild life surveys in north India and southern Nepal: The Jaldapara Wild Life Sanctuary, West Bengal. *J. Bombay Nat. Hist. Soc*, 63: 534-556.
[46] Subramanya, S. 1996. Distribution, status and conservation of Indian heronries. *Journal of the Bombay Natural History Society,* 93 (3): 459-486.
[47] Sutherland, W. J. (Ed.). 2006. *Ecological Census Techniques: a handbook.* Cambridge University Press, New York, pp 432.
[48] Talukdar, S. & Sanyal, A. K. 2013. First record of the genus *Nesticodes* Simon, 1894 from India with taxonomic studies on a red cob-web-spider *Nesticodes*

rufipes (lucas, 1846) (Araneae : Theridiidae) from West Bengal, India. *Rec. zool. Surv. India*: 113 (Part-3): 41-47

[49] Taper, M. L., Böhning-Gaese, K., & Brown, J. H. 1995. Individualistic responses of bird species to environmental change. *Oecologia*, 101 (4): 478-486.

[50] Thakur, M. L., Mattu, V. K., Lal, H., Sharma, V. N., Raj, H., & Thakur, V. 2010. Avifauna of Arki Hills, Solan (Himachal Pradesh), India. *Indian Birds*, 5(6): 162-166.

[51] Turner, B.L., Clark, W.C., Kates, R.W., Richards, J.F., Mathews, J.T. & Meyer, W.B. 1990. *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*. Cambridge University Press and Clark University, Cambridge, 713 pp.

[52] Whelan, C. J., Wenny, D. G., & Marquis, R. J. 2008. Ecosystem services provided by birds. *Annals of the New York Academy of Sciences*, 1134 (1): 25-60.

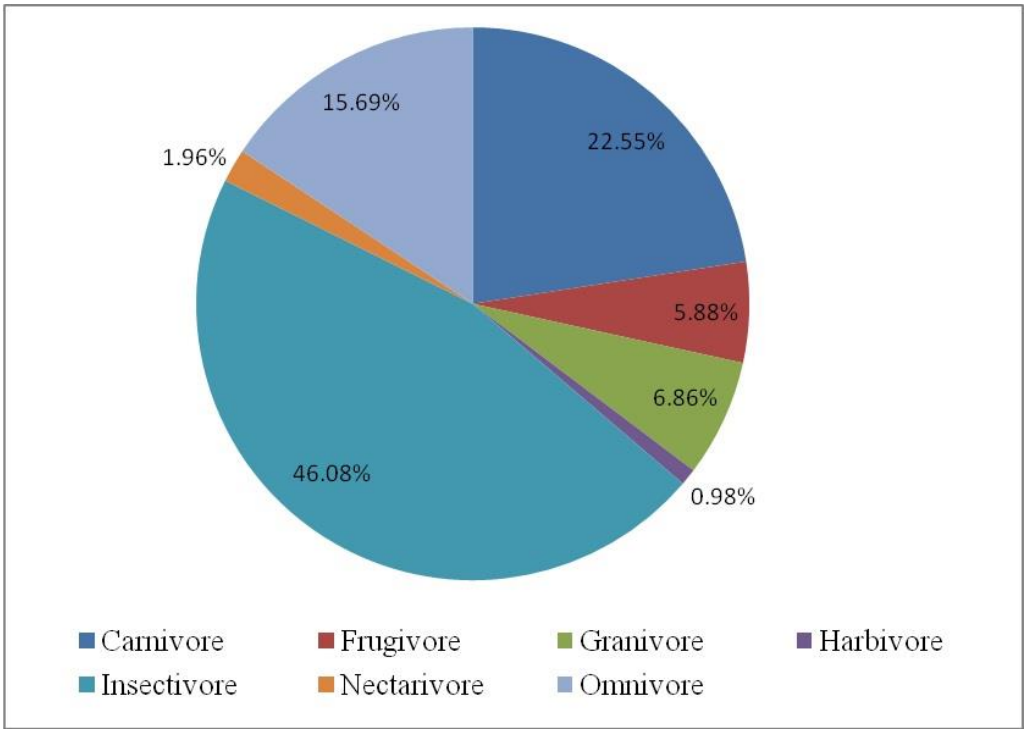


Fig. 2. Percentage of Feeding guilds

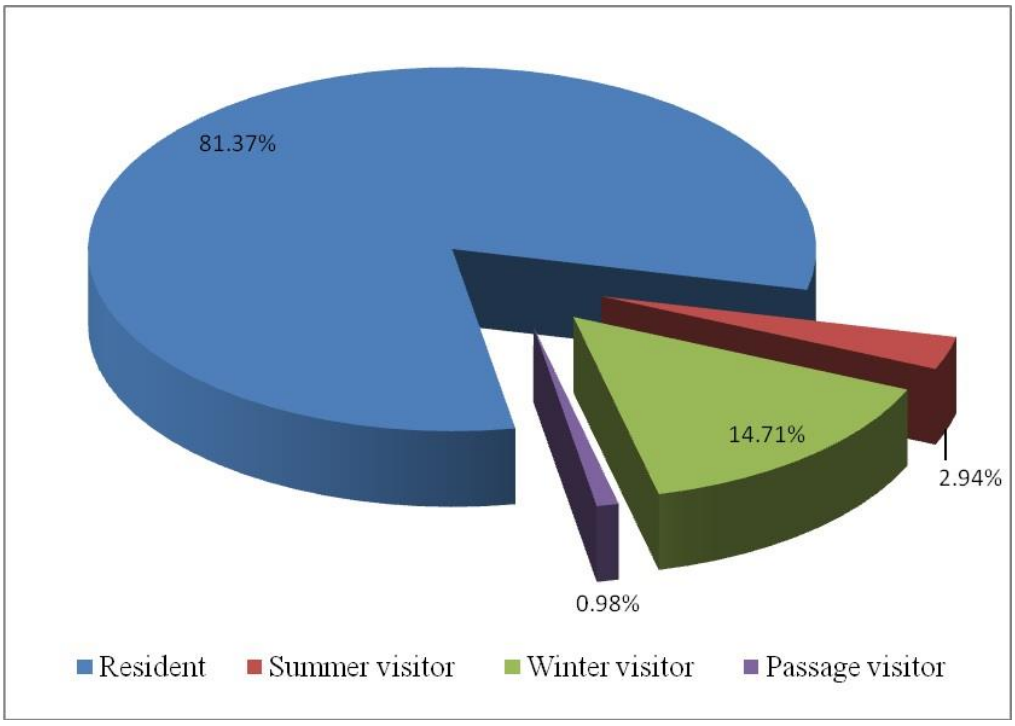


Fig. 3. Percentage of Seasonality

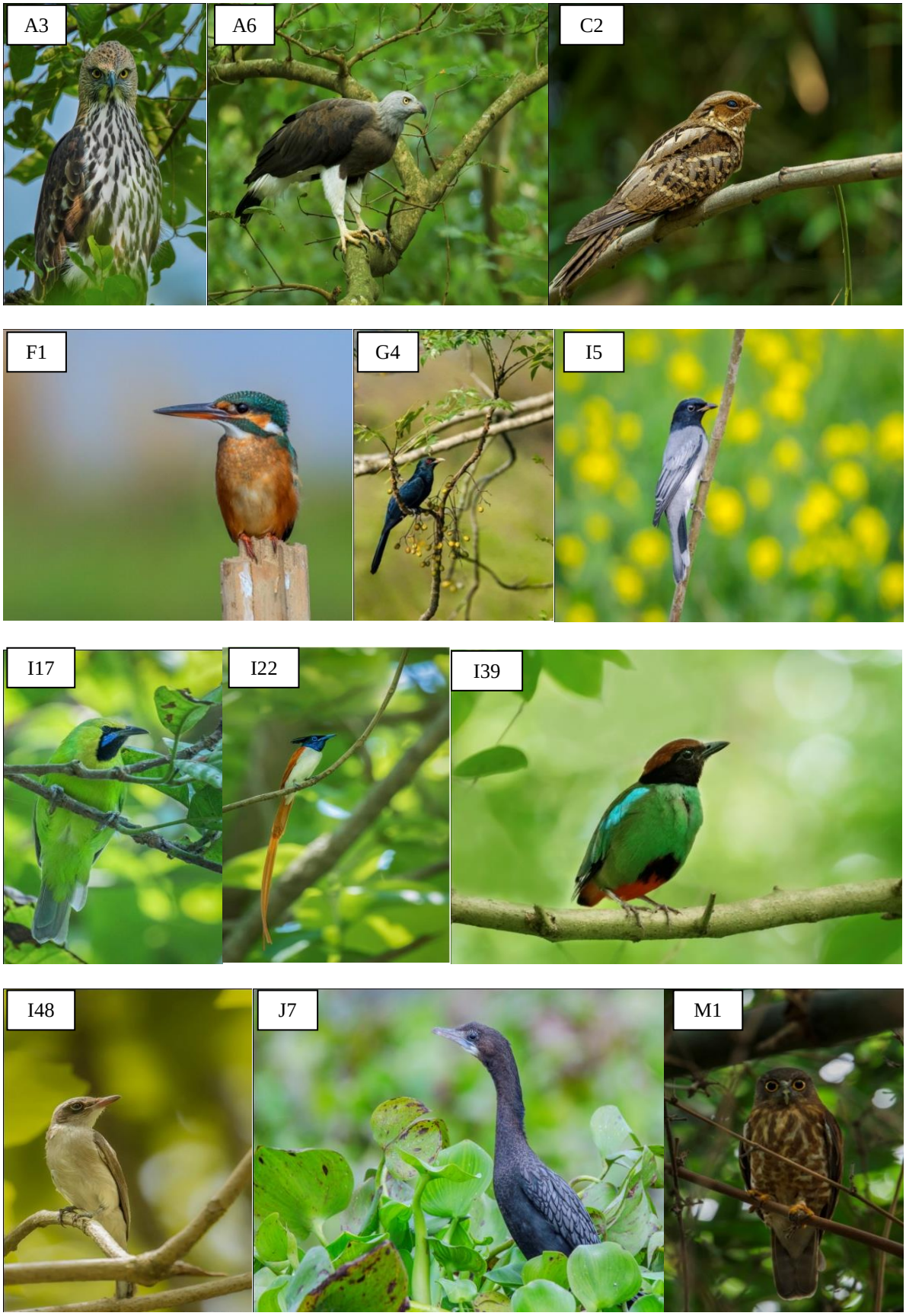


Fig. 4. Photographs of representative bird species
(see Table 1 for symbols and corresponding names)

Table 1. The bird species observed in Bibhutibhushan Wildlife Sanctuary, North 24 Parganas, West Bengal, India, along with respective feeding guild, seasonality and local status

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
Order: Accipitriformes					
A1	**Accipitridae**	Oriental Honey Buzzard (*Pernis ptilorhynchus*)	Ca	R	Co
A2		Crested Serpent Eagle (*Spilornis cheela*)	Ca	R	Fc
A3		Changeable Hawk Eagle (*Nisaetus cirrhatus*)	Ca	R	Co
A4		Booted Eagle (*Hieraaetus pennatus*)	Ca	WV	Ra
A5		Shikra (*Accipiter badiusi*)	Ca	R	Fc
A6		Grey headed Fish Eagle (*Icthyophaga ichthyaetus*)	Ca	R	Co
Order: Anseriformes					
B1	**Anatidae**	Lesser Whistling-Duck (*Dendrocygna javanica*)	O	R	Vc
Order: Caprimulgiformes					
C1	**Apodidae**	Asian Palm Swift (*Cypsiurus balasiensis*)	I	R	Co
C2	**Caprimulgidae**	Large-tailed Nightjar (*Caprimulgus macrurus*)	I	R	Fc
C3		Indian Nightjar (*Caprimulgus asiaticus*)	I	R	Fc
Order: Charadriiformes					
D1	**Charadriidae**	Red-wattled Lapwing (*Vanellus indicus*)	Ca	R	Fc
D2	**Scolopacidae**	Green Sandpiper (*Tringa ochropus*)	I	WV	Fc
Order: Columbiformes					
E1	**Columbidae**	Rock Pigeon (*Columba livia*)	G	R	Vc
E2		Red Collared Dove (*Streptopelia tranquebarica*)	G	R	Co
E3		Spotted Dove (*Streptopelia chinensis*)	G	R	Vc

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
E4		Yellow-legged Green Pigeon (*Treron phoenicopterus*)	G	R	Co
E5		Emerald Dove (*Chalcophaps indica*)	G	R	Fc
Order: Coraciiformes					
F1	**Alcedinidae**	Common Kingfisher (*Alcedo atthis*)	Ca	R	Vc
F2		Stork-billed Kingfisher (*Pelargopsis capensis*)	Ca	R	Co
F3		White-throated Kingfisher (*Halcyon smyrnensis*)	Ca	R	Vc
F4	**Coraciidae**	Indian Roller (*Coracias benghalensis*)	I	R	Co
F5	**Meropidae**	Green Bee-eater (*Merops orientalis*)	I	R	Co
F6.		Chestnut-headed Bee-eater (*Merops leschenaultia*)	I	R	Ra
Order: Cuculiformes					
G1	**Cuculidae**	Greater Coucal (*Centropus sinensis*)	O	R	Vc
G2		Pied Cuckoo (*Clamator jacobinus*)	I	SV	Fc
G3		Chestnut-winged Cuckoo (*Clamator coromandus*)	I	P	Ra
G4		Asian Koel (*Eudynamys scolopaceus*)	O	R	Vc
G5		Common Hawk Cuckoo (*Hierococcyx varius*)	I	R	Co
G6		Indian Cuckoo (*Cuculus micropterus*)	I	R	Ra
Order: Gruiformes					
H1	**Rallidae**	White-breasted Waterhen (*Amaurornis phoenicurus*)	O	R	Co
H2		Watercock (*Gallicrex cinerea*)	H	R	Ra
Order: Passeriformes					
I1	**Aegithinidae**	Common Iora (*Aegithina tiphia*)	I	R	Co
I2.	**Artamidae**	Ashy Woodswallow (*Artamus fuscus*)	Ca	R	Co

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
I3	**Campephagidae**	Small Minivet (*Pericrocotus cinnamomeus*)	I	R	Co
I4		Rosy Minivet (*Pericrocotus roseus*)	I	WV	Ra
I5		Black-headed Cuckoo-Shrike (*Lalage melanoptera*)	O	R	Fc
I6	**Cisticolidae**	Plain Prinia (*Prinia inornata*)	I	R	Co
I7		Common Tailorbird (*Orthotomus sutorius*)	I	WV	Vc
I8	**Corvidae**	Rufous Treepie (*Dendrocitta vagabunda*)	I	R	Vc
I9		House Crow (*Corvus splendens*)	O	R	Vc
I10		Large-billed Crow (*Corvus macrorhynchos*)	O	R	Co
I11	**Dicruridae**	Black Drongo (*Dicrurus macrocercus*)	I	R	Vc
I12		Bronzed Drongo (*Dicrurus aeneus*)	I	R	Fc
I13		Hair-crested Drongo (*Dicrurus hottentottus*)	I	R	Ra
I14	**Estrildidae**	White-rumped Munia (*Lonchura striata*)	G	R	Co
I15		Scaly-breasted Munia (*Lonchura punctulata*)	G	R	Fc
I16	**Hirundinidae**	Barn Swallow (*Hirundo rustica*)	I	WV	Co
I17	**Irenidae**	Jerdon's Leafbird (*Chloropsis jerdoni*)	O	R	Co
I18	**Laniidae**	Brown Shrike (*Lanius cristatus*)	I	WV	Co
I19		Long-tailed Shrike (*Lanius schach*)	I	R	Co
I20	**Leiothrichidae**	Jungle Babbler (*Turdoides striata*)	O	R	Vc
I21	**Monarchidae**	Black-naped Monarch (*Hypothymis azurea*)	I	R	Fc
I22		Indian Paradise Flycatcher (*Terpsiphone paradise*)	I	SV	Co
I23	**Motacillidae**	Paddyfield Pipit (*Anthus rufulus*)	I	R	Co
I24		White Wagtail (*Motacilla alba*)	I	WV	Co

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
I25	**Muscicapidae**	Oriental Magpie-Robin (*Copsychus saularis*)	I	R	Vc
I26		Brown-breasted Flycatcher (*Muscicapa muttui*)	I	WV	Ra
I27		Blue-throated Flycatcher (*Cyornis rubeculoides*)	I	WV	Co
I28		Verditer Flycatcher (*Eumyias thalassinus*)	I	WV	Ra
I29		Taiga Flycatcher (*Ficedula albicilla*)	I	WV	Co
I30		Siberian Stonechat (*Saxicola maurus*)	I	WV	Fc
I31	**Nectariniidae**	Purple Sunbird (*Cinnyris asiaticus*)	N	R	Vc
I32		Purple-rumped Sunbird (*Leptocoma zeylonica*)	N	R	Co
I33	**Oriolidae**	Black-hooded Oriole (*Oriolus xanthornus*)	O	R	Co
I34		Indian Golden Oriole (*Oriolus kundoo**)*	I	R	Fc
I35	**Paridae**	Cinereous Tit (*Parus cinereus*)	I	R	Fc
I36	**Passeridae**	House Sparrow (*Passer domesticus*)	O	R	Vc
I37	**Pellorneidae**	Abbott's Babbler *Malacocincla abbotti*	I	R	Co
I38	**Phylloscopidae**	Greenish Leaf Warbler (*Seicercus trochiloides*)	I	WV	Co
I39	**Pittidae**	Hooded Pitta (*Pitta sordid*)	I	SV	Co
I40	**Pycnonotidae**	Red-vented Bulbul (*Pycnonotus cafer*)	O	R	Vc
I41	**Sturnidae**	Asian Pied Starling (*Gracupica contra*)	O	R	Vc
I42		Chestnut-tailed Starling (*Sturnia malabarica*)	I	R	Co
I43		Common Myna (*Acridotheres tristis*)	O	R	Vc
I44		Jungle Myna (*Acridotheres fuscus*)	O	R	Vc
I45	**Turdidae**	Scaly Thrush (*Zoothera dauma*)	I	WV	Ra
I46		Orange-headed Thrush (*Geokichla citrina*)	I	R	Co

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
I47		Tickell's Thrush (*Turdus unicolor*)	I	WV	Ra
I48	**Vangidae**	Common Woodshrike (*Tephrodornis pondicerianus*)	O	R	Co
I49	**Zosteropidae**	Oriental White-eye (*Zosterops palpebrosus*)	I	R	Fc
Order: Pelecaniformes					
J1	**Ardeidae**	Yellow Bittern (*Ixobrychus sinensis*)	Ca	R	Fc
J2		Indian Pond-Heron (*Ardeola grayii*)	Ca	R	Vc
J3		Cattle Egret (*Bubulcus ibis*)	Ca	R	Vc
J4		Intermediate Egret (*Ardea intermedia*)	Ca	R	Co
J5		Little Egret (*Egretta garzetta*)	Ca	R	Vc
J6	**Ciconiidae**	Asian Openbill (*Anastomus oscitans*)	Ca	R	Co
J7	**Phalacrocoracidae**	Little Cormorant (*Microcarbo niger*)	Ca	R	Vc
J8		Indian Cormorant (*Phalacrocorax fuscicollis*)	Ca	R	Fc
Order: Piciformes					
K1	**Picidae**	Lesser Golden-backed Woodpecker (*Dinopium benghalense*)	I	R	Co
K2		Streak-throated Woodpecker (*Picus xanthopygaeus*)	I	R	Fc
K3		Greater Golden-backed Woodpecker (*Chrysocolaptes lucidus*)	I	R	Ra
K4		Fulvous-breasted Pied Woodpecker (*Dendrocopos macei*)	I	R	Co
K5	**Ramphastidae**	Lineated Barbet (*Psilopogon lineatus*)	F	R	Fc
K6		Blue-throated Barbet (*Psilopogon asiaticus*)	F	R	Vc
K7		Coppersmith Barbet (*Psilopogon haemacephalus*)	F	R	Fc
Order: Psittaciformes					
L1	**Psittaculidae**	Red-breasted Parakeet	F	R	Ra

Sl. No.	Family	Common Name (Scientific Name)	Feeding Guild	Seasonality	Local Status
		(*Psittacula alexandri*)			
L2		Alexandrine Parakeet (*Psittacula eupatria*)	F	R	Co
L3		Rose-ringed Parakeet (*Psittacula krameri*)	F	R	Co
Order: Strigiformes					
M1	**Strigidae**	Brown Hawk Owl (*Ninox scutulata*)	Ca	R	Ra
M2		Spotted Owlet (*Athene brama*)	Ca	R	Co
M3		Collared Scops Owl (*Otus bakkamoena*)	Ca	R	Ra
M4	**Tytonidae**	Brown Fish Owl (*Ketupa zeylonensis*)	Ca	R	Fc

Diversity of Avifauna And Their Heterogeneous Habitat Preference In A Sub-Urban Area In West Bengal, India

Anirban Chakraborty

Post Graduate Department of Zoology, Barasat Government College,
Barasat (North 24 Parganas), Kolkata, India
E-mail: anirban.16oct@gmail.com

ABSTRACT

Avifauna are important for the ecosystem as they play various roles as scavengers, pollinators, seed dispersal agents and predators of insect pest and an important indicator to evaluate different habitats both qualitatively and quantitatively. A study was conducted during February 2012 to February 2015 in Chinsurah, the district town of Hooghly, West Bengal, India. This study was done in six different habitats present in the core region of the town. These are agricultural land, river bank, small woody area, small water body, grassland and human habitat. A total of 67 avian species were recorded during this study. These species show preferences to various habitats, where some are specialist to one of the habitats and some are generalist to different habitats. Abundance of birds in different habitats is different, most probably due to the variation in amounts of resources in these habitats. Due to loss of natural habitats habitat specialists are gradually replaced by habitat generalists.

Keywords : Avifauna, Chinsurah, Species richness, Habitat generalist, Habitat Specialist

INTRODUCTION

Study of biodiversity has been of prime focus towards the latter half of the last century. What started as a fashionable hobby in the Victorian era was gradually picked up with much seriousness, owing to the understanding of complex inter-relationships of different component of environment. More and more reports started to flow in and a panoramic overview of the global status of different organism began to emerge, of which the diversities of Indian bird populations have always been a topic of interest to ecologists. With the increase in number of natural and man made threats to the survival of different bird species, the diversity is subject to continuous changes. Bird-watching has gained much popularity, not just because of vibrant colours or the soothing notes of birds, but also because they are important members of any ecosystem and are serious markers of environmental fluctuations. A sharp decline in a specific bird's population can well mark the onset of catastrophe in an ecosystem. Hence to observe and analyse the changes, proper documentation of avifauna is necessary over different time span, in different ecosystems and geographical locations (Chaudhuri *et al*., 2013).

Biodiversity conservation in urban areas has become significant not only because of increasing anthropogenic activities in urban centres but also because it is one of the innovative ways to conserve biodiversity as suggested by various global environmental conventions (Chaudhuri *et al*., 2013). Progressive urbanization often leads to biotic homogenization whereby a few widespread and successful species replace a diverse avifauna

(Mc Kinney and Lockwood, 2001 & Crooks *et al*., 2004). Study of avifaunal diversity in different urban habitats gives us proper knowledge about city planning and conservation.

Objective of this study is the quantification of avifaunal diversity from diverse habitat patches of Chinsurah, a sub-urban area in West Bengal, India. The changes in the population trends of bird species due to habitat alteration were also taken into account.

Study site

Present study is carried out in Chinsurah, the district town of Hooghly, West Bengal, India. It lies about 35 km. north of Kolkata. Chinsurah is at 22.90°N 88.39°E. The town is on the flood plain on the right bank of river Ganges (Bhagirathi-Hooghly). It is a town consisting of a large area of human habitation surrounded by small villages, farmlands and thin forest. Concretes as well as temporary colony like habitations cover most of the study area.

Fig. 1. Map of study site (Chinsurah)

This study was done in six different habitats (marked by various colours) present in different regions in the ore region of Chinsurah. These habitats are agricultural land (YELLOW), river bank (BLUE), small woody area (GREEN), human habitat (RED), small water body and grassland. The last two are scattered all around the town.

Fig. 2. Habitat distribution in Chinsurah

MATERIALS & METHODS

Observations were made in the morning and afternoon from February 2012 to February 2015. Surveys were conducted at different locations like human habitats, large gardens, agriculture fields, wetlands, river banks, road side trees, rice research centre campus, mango orchards, and municipal damping area. At each sighting birds were counted using a binocular and identified. In case of doubtful identification, photographs were taken and the species is identified later by consulting experts. Area search method and opportunistic observations were used for sampling. Birds were observed using a binocular (Olympus 7 x 35 DPS I) and were identified following Grimmett *et al*. (1998) and Ali (2012). Photographs were taken with a digital camera (Nikon Coolpix S6200) for documentation.

The birds are divided into habitat specialist and habitat generalist. The species that use only one habitat is called Habitat Specialist and the species that use more than one habitat is called Habitat Generalist.

The abundance of bird species in different habitats is compared in graphical representation. Chi-square test is done to verify the significance of the observed data.

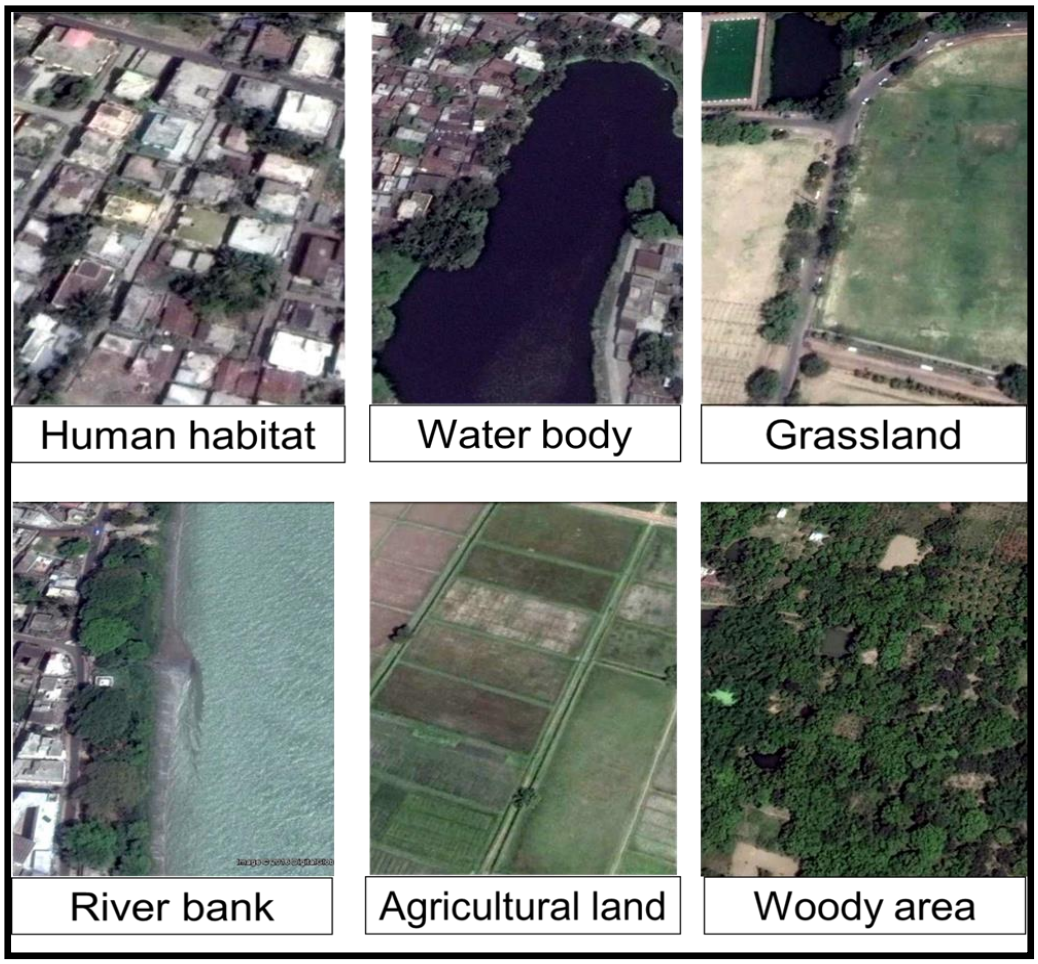


Fig. 3. Different types of habitats in Chinsurah

RESULTS

During the present study 67 bird species were observed and identified (Table 1; Plates 1 & 2). When the bird community of six different habitats were compared it was found that 23 species are found in 2 types of habitats; 6 species are found in 3 types of habitats; 3 species (Asian Pied Starling, Cattle Egret, Black Drongo) are found in the most no. (4) of habitats (Tables 2 & 3).

Table 1. The bird species observed in Chinsurah, West Bengal, India, along with respective habitats
(Abbreviation: HH- Human Habitat, AL- Agricultural Land, RB- River Bank, SWA- Small Woody Area, GL- Grassland, SWB- Small Water Body)

Sl. No.	Family	Common Name (Scientific Name)	Habitat
Order: Accipitriformes			
1	**Accipitridae**	Shikra (*Accipiter badiusi*)	SWA

Sl. No.	Family	Common Name (Scientific Name)	Habitat
2		Black Kite *(Milvus migrans)*	HH
Order: Caprimulgiformes			
3	**Apodidae**	Asian Palm Swift (*Cypsiurus balasiensis*)	HH, RB
4		House Swift *(Apus affinis)*	HH, RB
Order: Charadriiformes			
5	**Scolopacidae**	Common Sandpiper *(Actitis hypoleucos)*	RB
Order: Columbiformes			
6	**Columbidae**	Rock Pigeon (*Columba livia*)	HH
7		Eurasian Collared Dove *(Streptopelia decaocto)*	AL
8		Spotted Dove (*Streptopelia chinensis*)	HH, AL, SWB
9		Yellow-legged Green Pigeon (*Treron phoenicopterus*)	HH, SWA

Order: Coraciiformes			
10	**Alcedinidae**	Pied Kingfisher *(Ceryle rudis)*	SWB
11		Stork-billed Kingfisher (*Pelargopsis capensis*)	SWB
12		White-throated Kingfisher (*Halcyon smyrnensis*)	RB, SWB
13	**Meropidae**	Green Bee-eater (*Merops orientalis*)	HH, AL, SWA
14	**Upupidae**	Common Hoopoe *(Upupa epops)*	GL
Order: Cuculiformes			
15	**Cuculidae**	Greater Coucal (*Centropus sinensis*)	SWA
16		Pied Cuckoo (*Clamator jacobinus*)	HH
17		Asian Koel (*Clamator jacobinus)*	HH, SWA

Order: Passeriformes			
18	**Alaudidae**	Bengal Bush Lark *(Mirafra assamica)*	GL
19	**Cisticolidae**	Plain Prinia (*Prinia inornata*)	AL, SWA
20		Common Tailorbird (*Orthotomus sutorius*)	HH
21	**Corvidae**	Rufous Treepie (*Dendrocitta vagabunda*)	HH, SWA
22		House Crow (*Corvus splendens*)	HH, RB, GL
23		Large-billed Crow (*Corvus macrorhynchos*)	SWA
24	**Dicruridae**	Black Drongo (*Dicrurus macrocercus*)	HH, AL, SWA, GL
25	**Estrildidae**	Scaly-breasted Munia (*Lonchura punctulata*)	HH
26	**Laniidae**	Brown Shrike (*Lanius cristatus*)	HH, AL, SWA
27		Long-tailed Shrike (*Lanius schach*)	AL
28	**Leiothrichidae**	Jungle Babbler (*Turdoides striata*)	HH, SWA
29	**Motacillidae**	Paddy field Pipit (*Anthus rufulus*)	AL
30		Olive-backed Pipit *(Anthus hodgsoni)*	GL
31		White Wagtail (*Motacilla alba*)	GL
32		Western Yellow Wagtail *(Motacilla flava)*	GL
33	**Muscicapidae**	Oriental Magpie-Robin (*Copsychus saularis*)	HH, SWA
34		Taiga Flycatcher (*Ficedula albicilla*)	HH, SWA
35		Black Redstart *(Phoenicurus ochruros)*	HH, GL
36	**Nectariniidae**	Purple Sunbird (*Cinnyris asiaticus*)	HH
37		Purple-rumped Sunbird (*Leptocoma zeylonica*)	HH
38	**Oriolidae**	Black-hooded Oriole (*Oriolus xanthornus*)	HH, SWA
39		Indian Golden Oriole (*Oriolus kundoo**)*	SWA

40		Black-naped Oriole *(Oriolus chinensis)*	SWA
41	**Paridae**	Cinereous Tit (*Parus cinereus*)	SWA
42	**Passeridae**	House Sparrow (*Passer domesticus*)	HH
43	**Pycnonotidae**	Red-vented Bulbul (*Pycnonotus cafer*)	HH, SWA
44		Red-whiskered Bulbul *(Pycnonotus jocosus)*	HH, SWA
45	**Rhipiduridae**	White-throated Fantail *(Rhipidura albicollis)*	HH, SWA
46	**Sturnidae**	Asian Pied Starling (*Gracupica contra*)	HH, AL, RB, GL
47		Chestnut-tailed Starling (*Sturnia malabarica*)	HH, SWA
48		Brahminy Starling *(Sturnia pagodarum)*	HH, SWA
49		Common Myna (*Acridotheres tristis*)	HH, AL, GL
50		Jungle Myna (*Acridotheres fuscus*)	HH, SWA
51		Bank Myna *(Acridotheres ginginianus)*	RB
Order: Pelecaniformes			
52	**Ardeidae**	Indian Pond-Heron (*Ardeola grayii*)	RB, SWB
53		Cattle Egret (*Bubulcus ibis*)	AL, RB, GL, SWB
54		Black-crowned Night Heron *(Nycticorax nycticorax)*	RB
55	**Ciconiidae**	Asian Openbill (*Anastomus oscitans*)	SWB
56	**Phalacrocoracidae**	Little Cormorant (*Microcarbo niger*)	RB, SWB
57		Indian Cormorant (*Phalacrocorax fuscicollis*)	SWB
Order: Piciformes			
58	**Picidae**	Lesser Golden-backedWoodpecker (*Dinopium benghalense*)	HH, SWA
59		Yellow-crowned Woodpecker *(Leiopicus mahrattensis)*	SWA
60		Lesser Yellow nape *(Picus chlorolophus)*	SWA

61		Fulvous-breasted Woodpecker (*Dendrocopos macei*)	SWA
62	**Ramphastidae**	Blue-throated Barbet (*Psilopogon asiaticus*)	SWA
63		Coppersmith Barbet (*Psilopogon haem acephalus*)	HH, SWA
Order: Psittaciformes			
64	**Psittaculidae**	Alexandrine Parakeet (*Psittacula eupatria*)	SWA
65		Rose-ringed Parakeet (*Psittacula krameri*)	HH, SWA
Order: Strigiformes			
66	**Strigidae**	Spotted Owlet (*Athene brama*)	HH
67	**Tytonidae**	Barn Owl *(Tyto alba)*	HH, SWA

Table 2. Distribution of bird species among habitats
(Abbreviation: HH- Human Habitat, AL- Agricultural Land, RB- River Bank, SWA- Small Woody Area, GL- Grassland, SWB- Small Water Body)

	HH	AL	RB	SWA	GL	SWB
HH	9	0	2	16	1	0
AL	0	3	0	1	0	0
RB	2	0	3	0	0	3
SWA	16	1	0	11	0	0
GL	1	0	0	0	5	0
SWB	0	0	3	0	0	4

*6 species are found in 3 types of habitats; 3 species (Asian Pied Starling, Cattle Egret, Black Drongo) are found in 4 types of habitats.

Table 3. Species diversity in different habitats

Habitat	**Human habitat**	**Agricultural land**	**River bank**	**Small woody area**	**Grassland**	**Small water body**
Species diversity	36	11	11	33	12	8

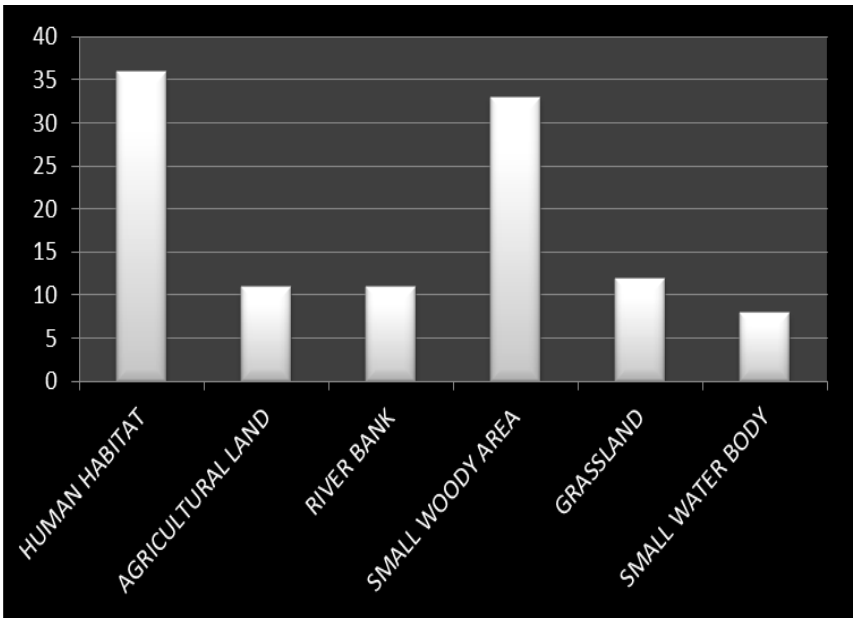


Fig. 4. Total no. of species in different habitat

A **chi-square test** was done to verify the significance of this data. The calculated value of chi-square = **42.24 > 11.07** = critical value of chi-square at 5% level of significance for degree of freedom 5. So, there is **significant variation** with the data. Now, it can be said that Human Habitat has highest species richness followed by Small Woody Area. Least amount of species richness is present in Small Water Body (Fig. 4).

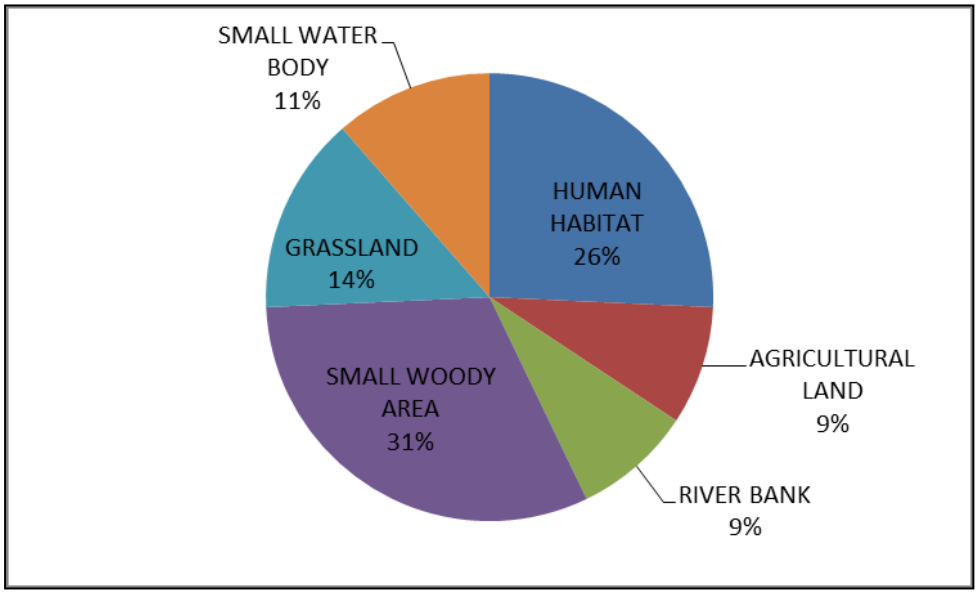


Fig. 5. Habitat preference by Specialist species

A **chi-square test** was done to verify the significance of the data of Table 4, in case of Habitat Specialist species. The calculated value of chi-square = **9.74 <11.07** = critical value of chi-square at 5% level of significance for degree of freedom 5. So, there is **no significant variation** with the data.

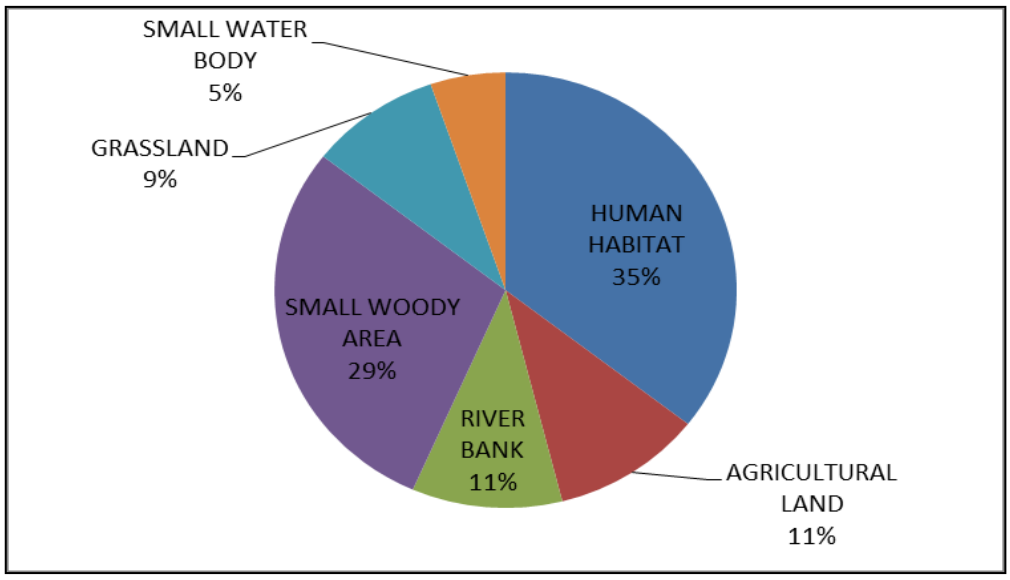


Fig. 6. Habitat preference by Generalist species

No. of Habitat specialist species (species that use only one habitat) found in this study is 35 and no. of Habitat generalist species (species that use more than one habitat) is 32.

Table 4. No. of Specialist species present in different habitats

Habitat	Human habitat	Agricultural land	River bank	Small woody area	Grassland	Small water body
No. of Habitat Specialist species	9	3	3	11	5	4

Table 5. No. of Generalist species present in different habitats.

Habitat	Human habitat	Agricultural land	River bank	Small woody area	Grassland	Small water body
No. of Habitat Generalist species	27	8	8	22	7	4

A **chi-square test** was done to verify the significance of the data of Table 5, in case of Habitat Generalist species. The calculated value of chi-square = **35 > 11.07** = critical value of chi-square at 5% level of significance for degree of freedom 5. So, there is **significant variation** with the data.

So, it can be said that there is no significant variation in the presence of Specialist species in different habitats; rather more or less all the habitats have its own species which are specialist in occupying those habitats. But in case of Generalist species, Human habitat contains most no. of species followed by small woody area.

DISCUSSION

Human habitats are enjoyed by most no. of species, probably due to presence of various resource materials in large amount that are exploited by the birds. The garbage and thrown away foods are a huge source of food materials which are only found in human habitats. Apart from these fruits from road side trees and ground insects help the human habitat to become a place with full of resource materials for birds. In Grassland, Small water body, River bank and Agricultural land, the total percentage of habitat specialist (43%) is more than the total percentage of habitat generalist (36%). This is most probably due to the availability of specialised resources in those habitats. As most habitat specialists have a special choice in their food preference, they occupy that habitat which has a plenty supply of that resource material. One severe problem, experienced during this study is that, the natural habitats for these avian species are being destroyed at an alarming rate due to anthropogenic activities. The trees are being cut for household and commercial purposes. The water bodies are being filled regularly for construction purposes. The agricultural systems are being disturbed by large scale grazing, courtesy domestic animals of the villagers. Due to loss of natural habitats, number of Habitat Specialist species are declining. Human Habitat, containing the most Habitat Generalist species, is engulfing the natural habitats. Habitat Specialists are solely dependent upon the habitats where they live. As those habitats are decreasing, the Habitat Specialists are being replaced gradually by Habitat generalists. Proper city planning and sustainable development are needed immediately. A balance in the total amount of all the habitats is required to protect the avifauna of this town. To save this urban avifaunal diversity awareness in the local people about the ecosystem and environment is needed.

ACKNOWLEDGEMENTS

I am indebted to Dr. Sumana Saha who constantly encouraged me to carry on the work. I am grateful to Dr. Kuladeep Roy for his support in this study. I would also like to thank Mr. Kunal Sarkar who helped me a lot in the field. My sincere thanks go to Google for using the satellite maps of the study areas.

LITERATURE CITED

[1] Ali S. 2012. The book of Indian birds.Oxford University Press, New Delhi, 13th Edn, 512 pp.

[2] Chaudhuri, P., Acharya, S. & Dey, C. 2013. Avifaunal diversity of Chandannagar suburban area of West Bengal. *J. Environ. and Sociobiol.* 10 (2). 137-142.

[3] Crooks, K.R., Suarez, A.V. & Bolger , D.T. 2004. Avian assemblages along a gradient of urbanization in a highly fragmented landscape. *Boil. Conserv*. 115: 451-462.

[4] Grimmett, R., Inskipp, C. & Inskipp, T. 1998. Birds of the Indian Subcontinent. Oxford University Press, New Delhi, 888 pp.

[5] Kheraa, N., Mehtaa V, Sabatab, B.C. 2009. Interrelationship of birds and habitat features in urban greenspaces in Delhi, India. *Urban Forestry & Urban Greening*, 8:187-196.

[6] Mc Kinney, M.L. & Lockwood, J.L. 2001. Biotic homogenization: a sequential and selective process. *Biotic Homogenization*. Kluwer, New York., 1-17.

PLATE 1
Photographs of representative bird species
(see Table 4 for Sl. No.and corresponding names)
[17,46 – Human Habitat] [19,13 – Agricultural Land] [53,57 – River Bank]

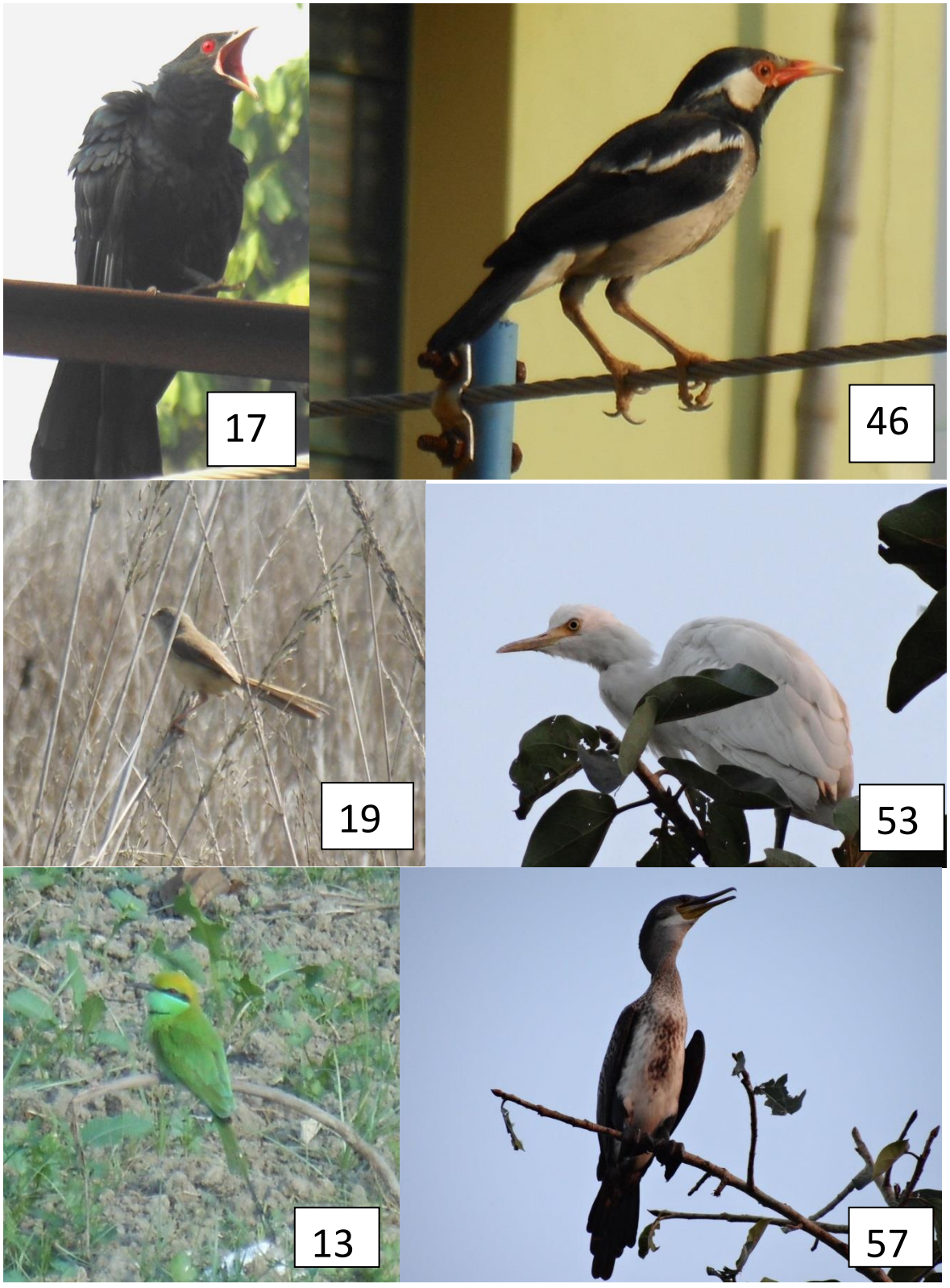
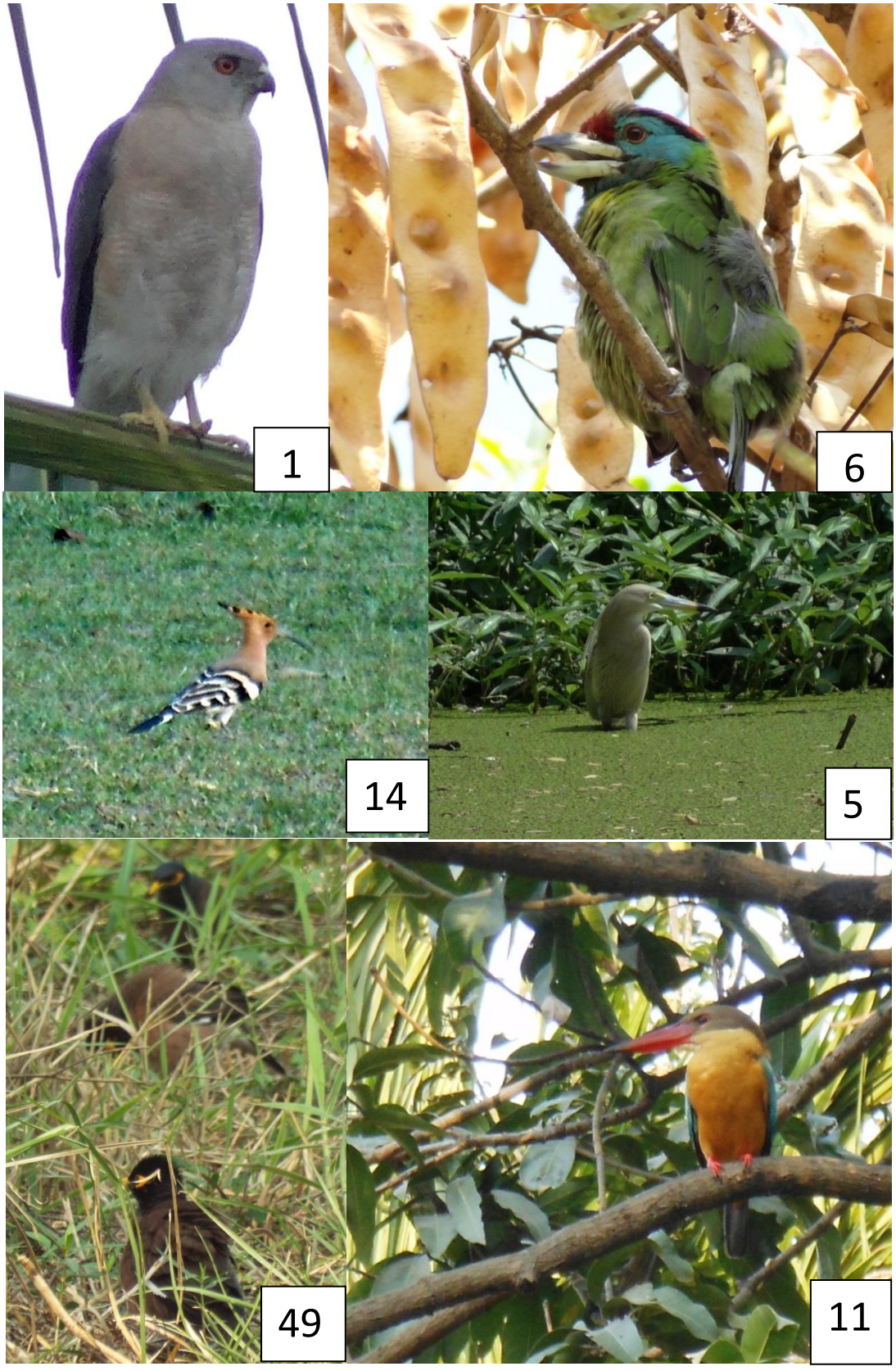


PLATE 2
Photographs of representative bird species
(see Table 4 for Sl. No. and corresponding names)
[1,6 – Small Woody Area] [14,49 - Grassland] [5,11 – Small Water Body]



Comparing Avifaunal Diversity In And Around Pench Tiger Reserve, Maharashtra And Madhya Pradesh

Sonia Mondal[1] and **Suman Bhattacharyya**[2]

Post Graduate Department of Zoology, Ecology Unit, Bangabasi College, Kolkata - 700009
[1]Email: soniamondal680@gmail.com
[2]Email: suman_y26@yahoo.co.in/ durermita@gmail.com

ABSTRACT

Large tracts of natural habitat are being readily replaced by urban sprawl worldwide. We have limited knowledge about the anthropogenic activities on native species in these ecological regions. Human intervention has led to conversion of much of the global diversity by means of habitat alterations. Our conservation methods are also suffering from those superficial strategies. The present study was carried out to investigate the importance of habitat heterogeneity for the diversity, distribution and abundance of avifauna in and around Pench Tiger Reserve. In February 2014, a total of 79 bird species were recorded during the study period, applying the modified point count method. We compared species abundance and richness in Pench Tiger Reserve, considering four zones as metacommunity. Avifaunal community was distributed among Kolitmara (Western Pench, Maharashtra), Sillari (Maharashtra), Mansinghdeo (Maharashtra) and Seoni, Pench (Madhya Pradesh). Site specific biodiversity indices reflect the occurrence pattern of avifauna. Shannon –Wiener and Species diversity Index scored highest (9.56 and 1.78 respectively) in Mansinghdeo Wildlife Sanctuary. But species dominance was found high (0.62) in and around Sillari. Study areas with dense canopy closure were found to have more habitat specialist bird species, while areas having human settlements showed more opportunistic ones. An overall negative impact of human settlements on avian diversity, distribution and abundance was evidenced from the present study but more intensive study is needed to infer on the dynamics. Moreover, intensive studies may enrich us about avian diversity and distribution pattern of the study zone.

Keywords: Habitat alterations, Habitat heterogeneity, Avifauna, Species abundance, Biodiversity indices

INTRODUCTION

Pench Tiger Reserve (PTR) (77 °55'W to 79°35'E and 21 08' S to 22 00'N), lies in the south west region of the state of Madhya Pradesh. The Tiger reserve comprises of the sanctuary and the National park of the same name Covering an area of 757.85 sq.km. zoo-geographically PTR is a part of Oriental region and floristically it belongs to the Indo-Malayan region. Among its huge fauna, avifauna includes 162 resident, 77 winter visitor, 5 summer visitor, 17 local migratory and 5 vagrant /straggler species of birds.

Diversity study was mainly confined to four areas, which are as follows : Site 1 – Kolitmara (Western Pench, Maharashtra), Site 2 – Sillari (Maharashtra), Site 3- Mansingdeo Wildlife Sanctuary (Maharashtra) and Site 4 – Seoni Pench (Madhya Pradesh).

In 1977 an area of 449.39 sq. km. was notified as the Pench Game Sanctuary (vide Madhya Pradesh State Forest Department Memo No. F/15/77-10(3) Bhopal, dated 30.09.1977). In March 1983, the Government of Madhya Pradesh notified its intention to constitute an area of 292.85 sq. km. as Pench National Park, to be carved out of the pre-existing Pench Sanctuary area [vide notification No. 15/5/82-10(2) Bhopal dated 01.03.1983 (3)]. The present Pench Tiger Reserve was included into the stream of the Tiger Reserves in 1992. This was then the 19th Tiger Reserve of India. The Pench River, from which the reserve derives the name, flows through the center of the park dividing it into the west Chindwara and the east Seoni block. The total area of the National Park is 292.85-sq. km. out of which 145.24 sq. km. lies in Seoni District and the rest in Chindwara District (Basu, 2012).

MATERIALS & METHODS

Point Count for Bird Census

We collected data on the relative abundance of individual bird species at multiple point-count locations. Point locations (with an inter station distance of 150 m) were sampled between 22- 25 February, 2015. Birds flying over the station were not recorded because they were unlikely to be breeding in the area. All bird surveys were conducted by the primary author on clear days during the first 4 hrs following sunrise, to coincide with peak singing activity. According to Sutherland (2006) point count method is the most effective for estimating avifaunal diversity from varied habitat types. In the present study a fixed radius circular plot method was used. At each point count observations were made for 10 minutes for all the birds seen and photographed if not identified immediately.

Birds seen or heard within the fixed radius plot were counted separately from those detected outside the plot. Grimmett *et al*. (1999), Ali (2002) were followed for identification. Replication in space rather than performing multiple point counts at fewer locations can be an advantage, because such replication leads to more certainty about the species–habitat

associations at the expense of certainty about a particular species' presence at any individual point (Bolger *et al*., 1997, Goodinson, 2000).

Diversity indices

Structural associations (% abundance) were also analyzed from pooled data and finally enumerating avifaunal diversity by applying biodiversity indices (Brower *et.al*.,1997). These include- Shannon-Wiener index, Evenness index, Species diversity index and Species richness.

RESULTS AND DISCUSSION

Table 1. Recorded Avian Species.

Sl. No.	Name	Scientific Name	Family	Site 1	Site 2	Site 3	Site 4
1.	Lesser whistling-Duck	*Dendrocygna javanica*	Anatidae	✓			
2.	Ruddy Shelduck	*Tadorna ferruginea*	Anatidae	✓			
3.	Spot-biiled duck	*Anas poecilorhyncha*	Anatidae	✓			
4.	Lesser yellownape	*Picus chlorolophus*	Pividae			✓	✓
5.	Malabar Pied Hornbill	*Anthracoceros coronatus*	Bucerotidae		✓	✓	
6.	Common Hoopoe	*Upupa epops*	Upuidae	✓	✓	✓	✓
7.	Indian Roller	*Coracias benghalensis*	Coraciidae	✓		✓	✓
8.	Common kingfisher	*Alcedo atthis*	Alcedinidae	✓		✓	✓
9.	Stork-billed Kingfisher	*Halcyon capensis*	Alcedinidae	✓		✓	
10.	White Throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	✓		✓	
11.	Pied Kingfisher	*Ceryle rudis*	Alcedinidae	✓	✓		
12.	Green Bee Eater	*Merops orientalis*	Meropidae	✓	✓		
13.	Indian Cuckoo	*Cuculus microptrus*	Cuculidae	✓		✓	✓
14.	Asian Koel	*Eudynamys scolopacea*	Cuculidae	✓		✓	
15.	Greater Coucal	*Centropus sinensis*	Cuculidae			✓	
16.	Alexandrine Parakeet	*Psittacula eupatria*	Psittaculidae	✓	✓	✓	✓
17.	Rose Ringed Parakeet	*Psittacula krameri*	Psittaculidae	✓	✓	✓	✓
18.	Plum Headed Parakeet	*Psittacula cyanocephala*	Psittaculidae	✓	✓	✓	
19.	Asian Palm Swift	*Cypsiurus balasiensis*	Apodidae	✓	✓	✓	
20.	House Swift	*Apus affinis*	Apodidae	✓		✓	
21.	Spotted Dove	*Streptopelia chinensis*	Columbidae	✓	✓	✓	✓
22.	Eurasian Collared Dove	*Streptopelia decaocto*	Columbidae		✓	✓	
23.	Emerald Dove	*Chalcophaps indica*	Columbidae		✓	✓	
24.	Yellow-footed Green Pigeon	*Treron phoenicoptera*	Columbidae		✓	✓	
25.	White Breasted Waterhen	*Amaurornis phoenicurus*	Rallidae	✓	✓		
26.	Common Coot	*Fulica atra*	Rallidae		✓	✓	

27.	Eurasian Thick-knee	*Burhinus oedicnemus*	Burhinidae		✓	✓	✓
28.	Black Winged Stilt	*Himantopus himantopus*	Recurvirostridae		✓	✓	
29.	Little Ringed Plover	*Chararadious dubius*	Charadriidae	✓		✓	
30.	Yellow- wattled Lapwing	*Venellus malabaricus*	Charadriidae	✓		✓	
31.	Red –wattled Lapwing	*Venellus indicus*	Charadriidae	✓		✓	
32.	River Tern	*Sterna aurantia*	Sternidae		✓	✓	
33.	Orient Honey-buzzard	*Pernis ptilorhyncus*	Accipitridae	✓			✓
34.	Black –shouldered Kite	*Elanus caeruleus*	Accipitridae	✓			
35.	Brahminy Kite	*Haliastur Indus*	Accipitridae	✓			
36.	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Accipitridae	✓			
37.	Egyptian Vulture	*Neophron percnopterus*	Accipitridae		✓		
38.	Crested Serpent Eagle	*Spilornis cheela*	Accipitridae		✓	✓	
39.	Shikra	*Accipiter badius*	Accipitridae		✓	✓	
40.	Little Grebe	*Tachybaptus ruficollis*	Podicipedidae	✓			
41.	Darter	*Anhinga melanogaster*	Anhingidae	✓			
42.	Little Cormorant	*Phalacrocorax niger*	Phalacrocoracidae	✓			
43.	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	✓			
44.	Little Egret	*Egretta garzetta*	Ardeidae	✓	✓	✓	
45.	Grey Heron	*Ardea cinerea*	Ardeidae	✓	✓	✓	
46.	Purple Heron	*Ardea purpurea*	Ardeidae		✓	✓	
47.	Great Egret	*Casmerodius albus*	Ardeidae		✓	✓	
48.	Black Crowned Night Heron	*Nycticorax nycticorax*	Ardeidae		✓	✓	
49.	Black –headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae		✓	✓	
50.	Painted Stork	*Mycteria leucocephala*	Ciconiidae		✓	✓	
51.	Asian Open Bill	*Anas tomusoscitans*	Ciconiidae			✓	
52.	Black Stork	*Ciconia nigra*	Ciconiidae		✓	✓	
53.	Woolly-necked Stork	*Ciconia episcopus*	Ciconiidae		✓		
54.	Brown Shrike	*Lanius cristatus*	Laniidae			✓	✓
55.	Long –tailed Shike	*Lanius schach*	Laniidae			✓	✓
56.	RufousTreePie	*Dendrocitta vagabunda*	Corvidae	✓	✓		✓
57.	Black-hooded Oriole	*Oriolus xanthornus*	Oriolidae	✓	✓	✓	✓
58.	Large Cuckooshrike	*Coraci namacei*	Campephagidae		✓		
59.	Small Minivet	*Pericrocotus cinnamomeus*	Campephagidae	✓		✓	
60.	Long-tailed Minivet	*Pericrocotus ethologus*	Campephagidae			✓	
61.	Scarlet Minivet	*Pericrocotus flammeus*	Campephagidae			✓	
62.	Black Drongo	*Dicrurus macrocercus*	Dicruridae	✓	✓	✓	

63.	Orange-headed Thrush	*Zoothera citrina*	Turdidae		✓	✓	
64.	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae		✓	✓	
65.	Indian Robin	*Saxicoloides fulicata*	Muscicapidae		✓	✓	
66.	Black Redstart	*Phoenicurus ochruros*	Muscicapidae	✓			
67.	Common starling	*Sturnus vulgaris*	Sturnidae	✓			
68.	Asian Pied Sterling	*Sturnus contra*	Sturnidae		✓	✓	
69.	Common Myna	*Acridotheres tristis*	Sturnidae	✓	✓	✓	✓
70.	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	✓	✓	✓	✓
71.	Common tailor Bird	*Orthotomus sutorius*	Cisticolidae	✓	✓	✓	✓
72.	Common Babbler	*Turdoides caudatus*	Leiothrichidae	✓	✓		
73.	Jungle Babbler	*Turdoides striatus*	Leiothrichidae		✓	✓	
74.	Forest Wagtail	*Dendronanthus indicus*	Motacillidae		✓	✓	
75.	White Wagtail	*Motacilla alba*	Motacillidae		✓	✓	
76.	Yellow Wagtail	*Motacila flava*	Motacillidae		✓	✓	
77.	Peacock	*Pavo cristasus*	Phasianidae				
78.	Grey Horn bill	*Ocyceros birostris*	Bucerotidae	✓		✓	
79.	Black sholdered Kite	*Elanus caeruleus*	Accipitridae			✓	✓

Table 2. Site specific biodiversity indices of recorded avian species

Diversity Indices	SITE 1		SITE 2	SITE 3	SITE 4
MARGALEF'S INDEX	4.61		1.107	4.29	3.32
PIELOU'S EVENNESS INDEX	0.79		4.29	6.89	0.99
SHANNON WIENER INDEX	1.553		1.293	9.563	0.692
SPECIES DIVERSITY INDEX	1.56		0.707	1.78	1.41
DOMINANCE DIVERSITY INDEX	0.4		0.625	0.4	-

The major objective of the study was to compare the avifaunal diversity (Table 1) in four different zones (sites) of Pench Tiger Reserve. These zones have little difference in respect to their topological characteristics or in ecological characters. The sites are different in terms of compactness of vegetation, canopy cover and most importantly the degree of human intervention and exploitation. The results show that Shannon- Wiener Index and Species Diversity Index (Fig. 1, 2) are higher in case of Mansinghdeo Wildlife Sanctuary i.e., 9.56 and 1.78 respectively, as compared to other zones. It is to note that as compared to other sites, Mansinghdeo has less exploitation and less human activities with highest vegetation compactness causing more bird species to assemble; whereas Dominance diversity index (Fig.3) of Sillari is 0.625 that appears much higher than other places. In Sillari, vegetation is less compact with more human activities, causing more of opportunistic species to take refuge. Though a little difference can be made in these zones, yet, more human activities has

been observed in case of Kolitmara and Sillari. Such a situation might have led to more of opportunistic birds who mostly stay in close proximity to humans, resulting in decrease of heterogeneity and higher dominance index (Fig 3). For example, Jungle Babbler, a completely opportunistic population, is much high in Sillari, as they basically depend on human leftovers (Table 1). Find of more of opportunistic species in Kolitmara may be related with the maximum human activity. High diversity recorded at Mansinghdeo speaks of habitat heterogeneity. Study areas with dense canopy cover were found to favour more habitat specialist bird species. An overall negative impact of human settlements on avian diversity, distribution and abundance was evidenced from the present study. However, more intensive study is needed to elaborate the explanation of diversity, distribution and abundance of avifauna in Pench Tiger Reserve.

Fig. 1

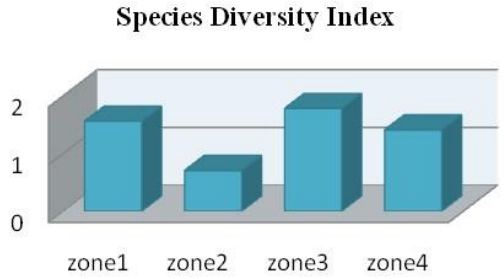


Fig. 2

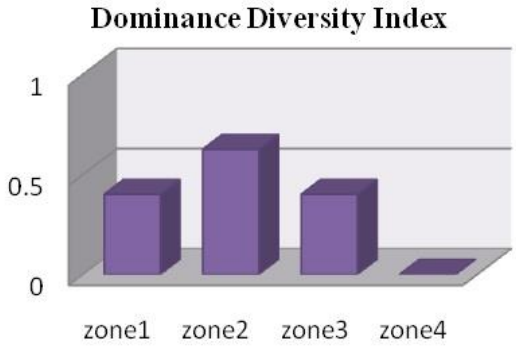


Fig. 3

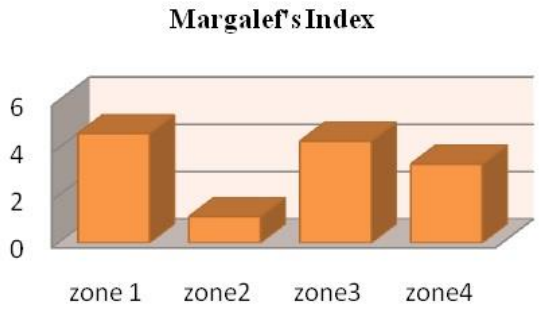


Fig. 4

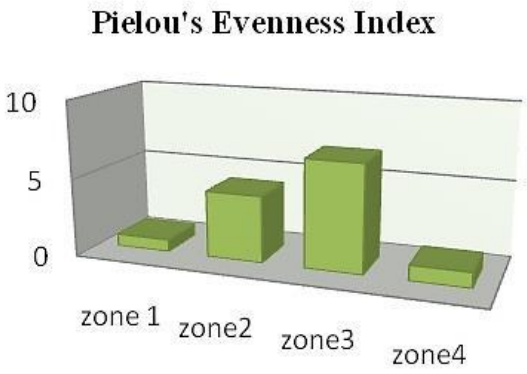


Fig. 5

CONCLUSION

Unprecedented rates of species extinctions have prompted extensive research into the consequences of biodiversity losses on ecosystem functioning especially in our country. The consequences of species loss for the functioning of ecosystems have been addressed through several major research programmes in recent years, mostly in terrestrial environments (Kinzig *et al*., 2001; Loreau *et al*., 2002). Biodiversity loss in ecosystems is an increasing phenomenon, mainly due to human activity (Abell, 2002). The main causes are habitat destruction and defragmentation, exotic species introduction and global climate change impacts (Saunders *et al*., 2002).

Above study conducted leads to a conclusion that the entire park encompassing the area partly in Madhya Pradesh and Maharashtra have different canopy cover type. As in Kolitmara, the canopy is moderately dense where as in Seoni, Pench (Madhya Pradesh) have low canopy cover, in contrast zones of Mangsingdeo Wildlife Sanctuary and Silliary have much denser canopy cover .The most highlighted part of the study is that due to high human movements these areas are losing their heterogeneity and birds of more opportunistic type are inhabiting these areas who also have negative influences on the rest of the avifauna that are not accustomed with humans. Our short-term study involved only a few selected patches of forests; a more intensive study might unfold many more spectrum. Detailed study might improve the list of avian species and their characteristic distribution in different forest patches from the present location. The impact of anthropogenic alteration of the habitats in and around Pench National Park also needs further intensive study.

LITERATURE CITED

[1] Abell, R.A., Olson, D.M., Dinerstein, E., Hurley, P.T., Diggs, J.T., Eichbaum, W., Watters, S., Wettengel, W., Allnutt, T., Loucks, C.J., & Hedao, P. 2000. *Freshwater Ecoregions of North America, A conservation Assessment*. Island Press, Washington D.C., 164 pp.

[2] Ali, S. 2002. *The Book of Indian Birds* (13th edition), Bombay Natural History, Society, Oxford University Press. 354 pp.

[3] Basu, S. 2012. *Evaluation of Impact of Landscape changes on Large mammal Habitat in Pench Tiger Reserve, M.P, India*. Ph. D.Thesis, Saurastra University, Rajkot, Gujarat, 39-43 pp.

[4] Brower, J.E., Zar, J.H. and Ende, C.N.V. 1998. *Field and laboratory methods for general Ecology*. (4th Ed.), WCB Mc. Graw- Hill, 178-186 pp.

[5] Goodinson, C. 2000. *Limitations of the point count method for inferring stand-level species resource relationships: a sampling simulation approach.* Ph.D. Thesis. University of British Columbia, Vancouver, British Columbia, Canada, 67 pp.

[6] Grimmett, R., Inskipp C., & Inskipp, T. 1996. *Pocket guide to the Birds of the Indian Subcontinent.* Oxford University Press, 888 pp.

[7] Kinzig, A. P., Pacala, S.W. & Tilman, D. (eds). 2001. *The functional consequences of biodiversity*. Princeton Univ. Press, 136 pp.

[8] Loreau M., Naeem, S. & Inchausti, P. (eds). 2002. Biodiversity and ecosystem functioning: synthesis and perspectives. Oxford Univ. Press, 294 pp.

[9] Sutherland, W.J. 2006. *Ecological Census Technique a Handbook.* Cambridge University Press, NY, 342 pp.

Winter Avian Aggregation at Santragachi Jheel: An Urban Wetland in West Bengal, India

Utpal Singha Roy[1,*] and **S. K. Mukhopadhyay**[2]
[1]Department of Zoology, Durgapur Government College, JN Avenue,
Durgapur – 713214, West Bengal, India
[2]Ecotoxicology Laboratory, Government College of Engineering and Leather Technology,
LB-III, Salt Lake, Kolkata - 700 098, India
*E-mail: srutpal@gmail.com

ABSTRACT

India has an estimated 58.2 million hectares of wetlands that are important repositories of aquatic biodiversity. The variety of wetlands in India perfectly matches the diverse eco-climatic regimes of the country. This includes wetland systems ranging from high altitude cold desert wetlands to hot and humid wetlands in coastal zones with its characteristically diverse flora and fauna. Around 15 km away from the center of Kolkata city, West Bengal, lies a 12.77 ha (mean depth 1.5 m) freshwater lake, known as the Santragachi Jheel, in the district of Howrah of West Bengal, India (Lat. 22^{o} 34' 60N Long. 88° 17' 60E; Altitude 8m msl) which has recently attracted the attention of avian migrant watchers India-wide. The Jheel plays an important role as the host of thousands (4000-5000) of migratory water birds as well as many resident species during the colder months of the year (October – March). More than twenty-five bird species colonize this lake during the winter months including the most abundant Lesser Whistling Duck and comparably infrequent Northern Pintail, Northern Shoveller, Gargany, Gadwall, Cotton Pigmy Goose, Common Teal and Baikal Teal. But this urban wetland most recently has been subjected to a wide variety of turbulences that includes incessant anthropogenic activities, improper development and management structures and lack of awareness about the vital role played by this ecosystem. So it was felt important to identify the status of Santragachi Jheel with reference to urbanization and various anthropogenic interventions to formulate suitable conservation, restoration and management strategies for this unique wetland with its magnificent avian repository.

Keywords: Conservation, Habitat alteration, Santragachi Jheel, Waterbirds, Winter migrants

INTRODUCTION

Wetlands being the transitional zone between land and water are perhaps the most attractive landscapes that have earned explicit global importance during the last few decades. These are the areas where, water being the primary factor controls the ecological functioning and associated wildlife and plant life. They provide important habitats for a wide variety of waterbirds. The Government of India has listed almost all of the 655 Prioritized Indian Wetlands for their importance as waterbirds habitat. However Rapid urbanization has led to the conversion of natural wetlands by means of addition of pollutants, nutrients, sedimentation and introduction of alien species. Ever increasing anthropogenic activities have resulted in the alteration of wetlands and as a consequence many of them around the globe are on the verge of decline and loss, leading to decrease in both wetland fauna and flora.

Despite of marked decline in the number of migratory waterbirds from the wetlands of West Bengal, a small lake (Santragachi Jheel) near the crowded and noisy Santragachi railway station, 20 km from the East Calcutta Wetlands (a Ramsar site), regularly supports 4000-5000 migratory waterbirds between the colder months of October to March. Lesser Whistling Ducks (*Dendrocygna javanica*) mostly dominate this lake, but several other species have also been reported from this lake (Mazumder *et al*., 2005; Roy *et al*., 2011). Unfortunately in recent years many of them have stopped migrating to this lake and most recent studies have reported that both the number and abundance of different waterbirds have reduced remarkably. Most probable cause of this waterbird loss is the immense pressure of different anthropogenic activities and increasing vegetation cover (mainly water hyacinth) over the lake.

Local people around Santragachi Jheel along with several dynamic Non-Government organizations and the State Government holistically have taken a number of notable measures to protect this lake. We carried out the present study with an objective to evaluate the effectiveness of the steps taken so far for saving the avian population of this lake and to spot light on the future perspective for management, restoration and conservation of Santragachi Jheel.

MATERIALS AND METHODS

Study Area

Figure 1. Satellite image of the Santragachi Jheel showing the infestation of water hyacinth and its intimate location to the Santragachi railway station.

The present study was undertaken during the colder months (October – March) of 2004 – 2014. Santragachi Jheel is an urban wetland situated adjacent to the Santragachi railway station, in the district of Howrah of West Bengal, around 8 km away from the center of Kolkata (Fig. 1). It is surrounded by dense human habitations, small scale industries and

railway yards. The lake lies in an area of around 12.77 hectare with an average depth of 1.5 m. The lake is generally dominated by *Eichhornia crassipes* which covers whole water surface of lake by its rapid propagation in the months of migratory bird non-colonization (*i.e.* during April – September). There are twelve small islands at the center of the lake that plays an important role as the shelter of many migratory waterbirds like lesser whistling duck, fulvous whistling duck, northern pintail, northern shoveller and gargany. A large number of local non-migratory bird species that include bronzed winged jacana, pond heron and cattle egret also inhabit this lake. The Jheel has large trees along its bank which provides shelter and food for many wetland dependent avian species like kingfishers and drongos. More than 25 species of waterbirds use this wetland as their roosting ground during the winter months of the year (October – March).

METHODOLOGY

Avian population estimation

For the estimation of the avian population of the lake mainly line transect method (Hutto *et al*.,1986; Bibby *et al*., 1992; Buckland *et al*.,1993) was applied. Sampling was done randomly; however, each of the four sides of the lake was traversed at each sampling time; each side was traversed by walking along a transect line and all birds seen were counted within 50 m of the transect, all parts of which were at least 50 m from the edge of the shoreline. Birds were counted as seen more than 50 m in front or behind as long as they were within 50 m perpendicular to the transect (Fig. 2). The time and weather was recorded at the beginning of each sampling. Birds flying over the habitat were recorded separately from those using the habitat.

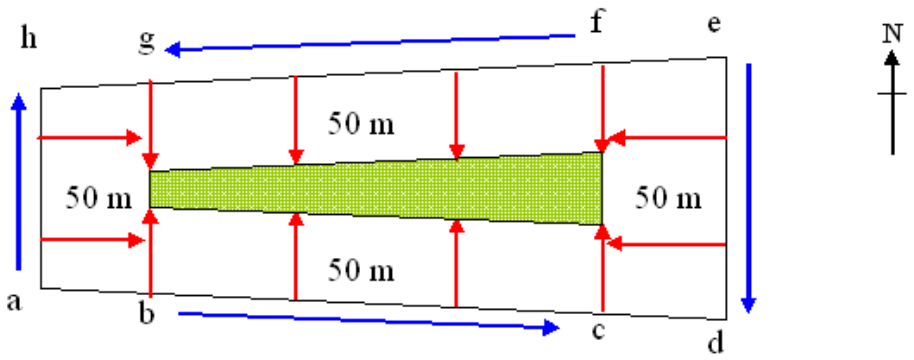


Figure 2. As Santragachi Jheel is almost rectangular in shape (average length X width = 1300 X 100 m) the line transect was laid at 50 m distance from shoreline (shown by red arrows in the figure). For north and south section of the lake, sampling was done from point f-g and from b-c respectively. The terminal 50 m left on both north and south sections were taken into account while sampling the east and west side of the lake i.e., from point e-d and a-h respectively. Area falling beyond 50 m was sampled by hand frame method and binocular frame method, which ultimately were calculated and averaged together to supplement the transect counts.

But for more precise estimation random hand-frame method and binocular-frame counts (Gopal, 1995) of the birds were also applied in three selected distance-ranges, viz., 50m, 100m and 150m. Areas of both hand-frame and binocular-frame were standardized by the average of three measurements, working out the ground cover on land at the pre-set distances. Such frame-counts encompass all the avian species, either resting on the bank or

islands, or wandering on the water surface. Three individual counts at three time intervals were averaged to get the representative data of a particular month.

Observations were made by the help of Olympus 8x40 DPS I binocular while Digital cameras were used for identification and supporting pictures. Ali (1996), Grimmett *et al.* (1998) and Kazmierczak & Perlo (2000) were followed for avifaunal identification work and common and scientific names.

Measurement of anthropogenic pressure over the Jheel

Anthropogenic pressure in and around the lake was measured by direct count method of all solid and liquid pollutant sources that included domestic and wastewater inlets, garbage dumps and dustbins.

RESULTS AND DISCUSSION

Santragachi wetland plays host to more than 5,000 migratory and resident birds while, more than twenty-five species of water birds use this wetland during the colder months of the year (October – March). Lesser Whistling Duck is most common in this lake and they occupy the lake invariably in the winter months. Northern Pintail, Northern Shoveller, Gargany, Gadwall, Cotton Pigmy Goose also visits this lake during the winter season. Table 1 shows the monthly density (Mean ± SD Nos. ha^{-1}) and diversity of waterfowl during the study period. The abundance of different bird species was found to be highest in the month of December and January. But the matter of concern is that the number of birds has been found to decrease consistently during the study period. Though the population of most abundant bird species migrating to the lake i.e. the Lesser Whistling Duck was found to maintain regularity in their assemblage number, most other migratory bird species including Ferruginous Pochard, Common Teal and Fulvous Whistling-Duck was found to be disappearing from the lake in more recent years.

Table 1. Seasonal changes in the migratory waterfowl densities (Nos. ha^{-1}) and diversity at Santragachi Jheel during the study period (2004 - 2014). (0=Not Recorded; values given as Mean±SD)

Common Name	Scientific Name	October	November	December	January	February	March
Northern Pintail	*Anas acuta*	0.05±0.03	0.28±0.13	9.45±5.22	12.99±4.52	5.58±2.46	0.31±0.10
Mallard	*Anas platyrhynchos*	0.00±0.00	0.00±0.00	0.00±0.00	0.06±0.03	0.00±0.00	0.00±0.00
Lesser Whistling Duck	*Dendrocygna javanica*	11.56±7.87	142.25±26.78	245.23±22.45	198.54±16.14	158.18±11.63	46.16±18.67
Fulvous Whistling Duck	*Dendrocygna bicolour*	0.00±0.00	0.00±0.00	0.00±0.00	0.06±0.03	0.00±0.00	0.00±0.00
Gadwall	*Anas strepera*	0.26±0.15	0.85±0.33	6.90±2.40	5.29±2.47	2.56±1.15	0.61±0.24
Gargany	*Anas querquedula*	0.06±0.03	0.12±0.04	0.18±0.06	0.29±0.06	0.16±0.04	0.06±0.03

Northern Shoveller	*Anas clypeata*	0.00±0.00	0.06±0.03	0.39±0.12	1.46±0.63	1.27±0.58	0.09±0.03
Cotton Pigmy-Goose	*Nettapus coromandelianus*	0.25±0.09	0.57±0.18	7.36±5.21	6.09±3.87	0.89±0.53	1.67±0.87
Ferruginous Pochard	*Aythya nyroca*	0.06±0.03	0.06±0.03	0.12±0.06	0.00±0.00	0.00±0.00	0.00±0.00
White Breasted Waterhen	*Amaurornis phoenicurus*	0.45±0.11	0.67±0.23	0.58±0.32	0.57±0.49	1.47±0.88	0.89±0.42
Common Moorhen	*Gallinula chloropus*	0.06±0.03	0.29±0.07	0.85±0.32	1.74±0.41	1.24±0.48	1.39±0.61
Bronze Winged Jacana	*Metopidius indicus*	0.29±0.06	1.45±0.38	1.78±0.47	1.58±0.52	2.68±0.67	0.95±0.24
Common Coot	*Fulica atra*	0.00±0.00	0.36±0.12	0.58±0.29	0.68±0.31	0.47±0.23	0.00±0.00
Little Cormorant	*Phalacrocorax niger*	1.48±0.37	1.52±0.47	3.73±1.03	1.87±0.29	2.41±0.72	4.25±1.39
Asian Openbill	*Anastomus osciatans*	0.00±0.00	0.06±0.03	0.06±0.03	0.06±0.03	0.00±0.00	0.00±0.00
Pond Heron	*Ardeola grayii*	0.48±0.22	0.76±0.27	1.69±0.86	0.57±0.14	1.99±0.78	1.70±1.01
Grey Heron	*Ardea cinerea*	0.00±0.00	0.12±0.03	0.12±0.03	0.17±0.06	0.12±0.06	0.00±0.00
Purple Heron	*Ardea purpurea*	0.00±0.00	0.00±0.00	0.12±0.06	0.12±0.05	0.00±0.00	0.00±0.00
Common Sandpiper	*Actitis hypoleucos*	0.00±0.00	0.00±0.00	0.36±0.12	0.47±0.25	0.37±0.13	0.18±0.07
White Wagtail	*Motacilla alba ocularis*	0.38±0.16	0.35±0.15	0.46±0.16	0.34±0.14	0.28±0.11	0.10±0.04
Citrine Wagtail	*Motacilla citreola citreola*	0.00±0.00	0.00±0.00	0.00±0.00	0.26±0.07	0.12±0.06	0.00±0.00
Grey Wagtail	*Motacilla cinerea*	0.06±0.03	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

Both the solid and liquid wastes were found to contaminate the Jheel and its water. Solid wastes especially domestic garbage was found to be dumped throughout the entire bank of the Jheel. Wastewater from train washing, industries, hotels and households come directly to the Jheel, untreated through inlets of different sizes. Though there are dustbins encircling the entire bank of Jheel, due to irregular cleaning and less aware inhabitants they were mostly found to be of no use. Solid and liquid wastes coming to the Jheel that contaminated the water of the Jheel found to deteriorate the habitat conditions affecting the bird population. The major causes of Santragachi Jheel contamination and degradation were generalized as follows:

- Dumps of domestic solid wastes throughout the bank of the Jheel, containing both biodegradable and non-biodegradable waste materials.

- Trains are regularly washed in the Santragachi Railway Station, the wastewater containing petroleum and other pollutants flows into the adjacent water bodies and through connectives the polluted water contaminates the Santragachi Jheel.
- There are many hotels adjacently located to the wetland and they have been found to use water of the wetland for various purposes like washing utensils. Leftovers of the hotels along with their other waste materials are directly released into the Santragachi Jheel. Further, there are about 40 shops around the lake that were found to use and pollute the Jheel's water in different ways.
- Unfortunately there is a slum located at the bank of the wetland. The inhabitants were found to use the Jheel's water for their daily uses such as bathing, washing clothes and cooking utensils. They also have open toilets, the wastewater was found to flow directly into the Jheel.
- Dustbins that were placed by Santragachi municipality encircling the bank of Jheel have been found rendered to be mostly of no use due to irregular cleaning and less aware inhabitants.
- The vegetation of the Jheel was found to be dominated by water hyacinth which covered almost the whole water surface of lake by its rapid propagation. As these plants cover the whole water body the dissolved oxygen and light penetration were found to decrease which altogether hampered the optimum physical condition of the Jheel. More than 50% of the Jheel (57.92±13.15%) was found to remain covered by water hyacinth, during the early winter, when the water birds starts migrating to the lake the weed coverage remained to be the highest. Whimsical clearing of weeds by the Forest Department found to be of little help to winter migrants.

Santragachi Jheel which attracts a large population of water birds, have been observed to become degraded and polluted during the present investigation resulting in a decrease in the population of migratory water birds. To mitigate this problem and protect the migratory birds Government has already taken many steps that include:

- Fencing over the entire Jheel by iron net.
- Fishing, bathing, cloth washing and domestic use of water has been declared strictly prohibited.
- The wetland has been decaled to be protected from contamination of waste water and solid waste.
- Plenty of dustbins have been placed throughout the bank of lake /Jheel.
- The whole area has been proposed as a plastic free zone.
- Clearing of water hyacinth is performed ever year during the winter season for space allocation to waterbirds.
- Artificial roosting ground has been made for the water birds.

Though these governmental steps have an important role in conservation of the Jheel but still the sanctuary is suffering from various problems. Santragachi Jheel is unique in its characters and with thousands of migratory avifauna in the winter it becomes a perfect birders paradise. But of late it was found to face conversion, primarily from anthropogenic activities. To overcome these problems and restore the Jheel as a waterfowl habitat a proper scientific management plan is most urgently needed to be implemented.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the infrastructural support extended by the Director of Public Instruction Government of West Bengal, India. The authors are also thankful to the local people around Santragachi Jheel who cooperated in many ways, helping us complete the fieldwork.

LITERATURE CITED

[1] Ali, S. 1996. The Book of Indian Birds, BNHS, Oxford University Press, Mumbai, 310 pp.

[2] Bibby, C.J., Burgess,N.D. & Hill, D.A. 1992. Bird census techniques, Academic Press, London, 257 pp.

[3] Buckland, S. T., Anderson, D. R., Burnham, K. P. & Laake, J. L. 1993. Distance sampling: estimating the abundance of biological populations, Chapman and Hall, New York, reprinted 1999 by RUWPA, University of St. Andrews, Scotland. 446 pp.

[4] Gopal, B. 1995.WWF handbook of wetland management, World Wildlife Fund (WWF) publication, New Delhi, 395 pp.

[5] Grimmet, R., Inskipp, C.& Inskipp, T. 1998. Birds of the Indian Subcontinent. Oxford University Press, Delhi, 480 pp.

[6] Hutto, R. L., Pletschet, S. M. & Hendricks, P. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk, 103: 593-602.

[7] Kazmierczak, K. & Perlo, B.V. 2000. A field guide to the birds of the Indian Subcontinent, Yale University Press, 356 pp.

[8] Mazumdar, S., Ghosh, P. & Saha, G. K. 2005. Diversity and behaviour of waterfowl in Santragachi Jheel, West Bengal, India, during winter season. Indian Birds 1(3): 22-23.

[9] Roy, U. S., Goswami, A. R., Aich, A. & Mukhopadhayay, S. K. 2011. Changes in Densities of Waterbird Species in Santragachi Lake, India: Potential Effects on Limnochemical Variables.Zoological Studies, 50(1): 76-84.

Studies on indirect evidences of presence of wildlife from different national parks of Dooars, West Bengal, India

Somenath Dey*, Sohom Barai and **Bijon Bihari Barman**

Environmental Science Special Paper Laboratory, Post Graduate Department of Zoology,
Darjeeling Government College, 19 – Lebong Cart Road,
Darjeeling - 734101, West Bengal, India
*E-mail: somenath.prl@gmail.com

ABSTRACT

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

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

INTRODUCTION

In India as well as at global level there are a good number of forests available for eco-tourism and a handsome amount of revenue is generated from visitors or tourists. Like other parts of the world, in India also such forests are distributed in many states throughout the country. Every such forest are varied in their own characteristics, local climatic conditions, floral distribution and wildlife distribution pattern; but one thing is common for all these, i.e., after visiting one such forests maximum tourists express their opinion or rather complaints that there are no such wildlife visible in the forest. This view is also supported by the content of the Figure No. 1. And this is the inspiration that this research project is undertaken. Indirect evidences of presence of wildlife plays a vital role in the forest's studies for both academic and tourism interests.

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

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

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

Forests and protected areas of North Bengal:

The northern part of West Bengal includes three districts viz. Jalpaiguri, Darjeeling and Cooch Behar. Current status of the forest areas in these three districts is presented in Table 1.

Table 1. Current Status of forest areas in three districts of northern West Bengal

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

Table 2. Protected Areas of North Bengal

Protected areas	Area (km^2)	Bio-geographic zone	District
Wildlife sanctuaries (WLS)			
Buxa WLS	267.92	7B	Jalpaiguri
Chapramari WLS	9.60	7B	Jalpaiguri
Jorepokhri Salamander WLS	0.04	2C	Darjeeling
Mahananda WLS	158.04	7B	Darjeeling
Senchal WLS	38.88	2C	Darjeeling
National parks (NP)			
Jaldapara NP	216.51	7B	Jalpaiguri and Coochbehar
Buxa NP	117.10	7B	Jalpaiguri
Gorumara NP	79.45	7B	Jalpaiguri
Neora Valley NP	88.00	2C	Darjeeling
Singalia NP	78.60	2C	Darjeeling
Reserve Forests			
Buxa Tiger Reserve	Core area: 977.51 Buffer area: 370.29	7B	Jalpaiguri
Eastern Dooars Elephant Reserve	Core area: 484 Buffer area: 493.51	7B	Jalpaiguri

Jalpaiguri has the largest geographical area of 6,227 sq. km followed by Cooch Behar (3,387 sq. km) and Darjeeling (3,149 sq. km). Recorded forest areas, however, do not follow this trend as Cooch Behar has the least area under forest, being just 57 sq. km, which in percentage comes out to be miniscule 1.68% of the geographical area of the district. Moreover, although Jalpaiguri has more recorded forest area (1,790 sq. km) than Darjeeling (1,204 sq. km) in terms of their respective geographical areas, district Darjeeling is more forested (38.23%) as compared to Jalpaiguri (28.75%). More distinctively the data show that although Jalpaiguri is almost double the size of Darjeeling it lags behind the former by about 10 percentage points in terms of recorded forests. More disturbing scenario is observed for the Cooch Behar district, which is almost similar in size to Darjeeling but lags way behind in terms of the area under forest. The Buxa forest region is situated around 180 km from the Siliguri town and is known for tiger, leopard, elephant, clouded leopard, Himalayan black bear, gaur, pangolin and python.

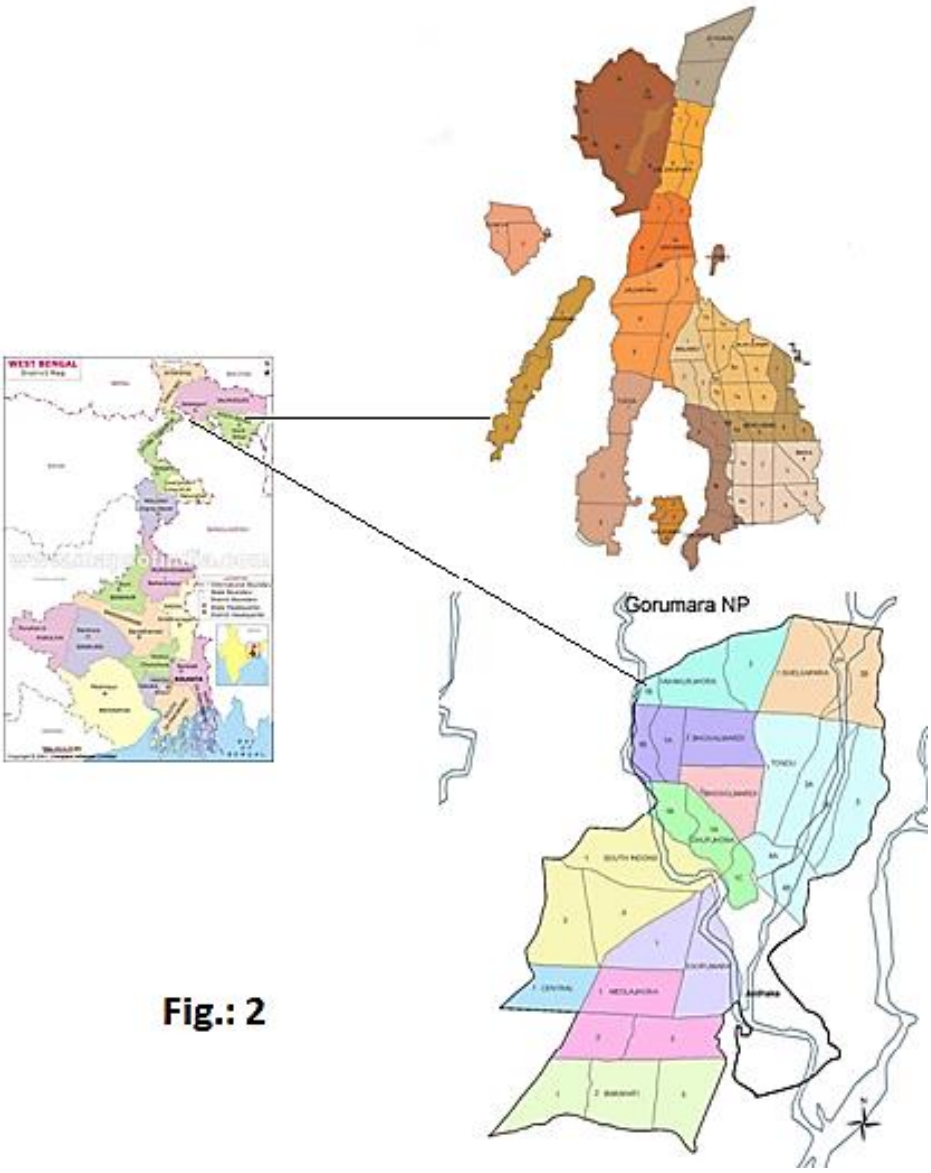
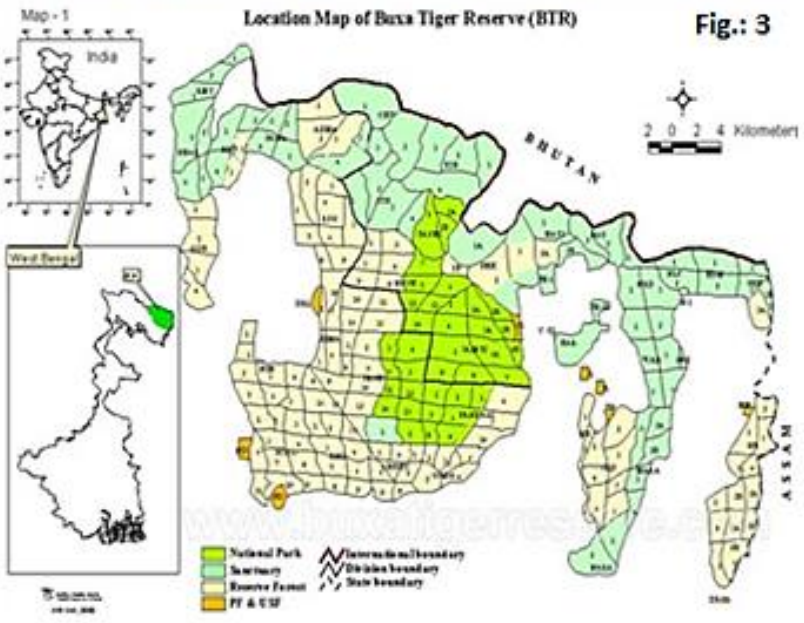


Fig.: 2

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



The forest can be further categorised into Buxa National Park, Buxa Wildlife Sanctuary and the Buxa Tiger Reserve. It shares the boundary with the Phipsu Wildlife Sanctuary of the neighbouring country Bhutan and thus serves as an international migratory tract and corridor for the elephants between Manas National Park (Assam, India) and the forests of Bhutan. Chapramari forest, in Kalimpong subdivision of the Jalpaiguri district, is located on the banks of river Murti and close to the National Highway 31, which connects the northeast region with the rest of India. Chapramari Wildlife Sanctuary is distinctively known for its elephant population. Jaldapara National Park, in Alipurdwar subdivision of Jalpaiguri district, is situated about 121 km for Siliguri and is home to a great diversity of flora and fauna. It is home to the great Indian on horned rhinos. Chilapata forest, which forms an important elephant corridor between Buxa Tiger Reserve and Jaldapara National Park, is spread near Jaldapara in the Dooars. Located about 72 km from Siliguri and further to the north of Jaldapara is Gorumara National Park.

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

MATERIAL AND METHODS

This entire study is strictly based upon observation and in possible cases collection. We studied the presence of indirect evidences of wildlife at three National Parks *viz.* Jaldapara,

Gorumara and Buxa (Also Tiger Reserve) for one year duration from September, 2014 to August, 2015 with appropriate permission of the authorities.

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

In every possible case photography has been done with Canon 60 E digital camera. During this study we also collect the pug marks by using plaster of Paris in the presence of Staff of the Forest Department (Figs. 4-7). We also collected both dry and fresh scat, also called poop absolutely in the presence of Forest Staff for future use (Figs. 8-11). At all the location of evidence collection we recorded the location points by using GPS device.

For collection of evidences we follow the path in the jungle showed by the Staff of the Forest Department (Figs. 12-13). In some cases we went beside the pond/ pool/ lake/ river etc. water resources within the forest in search of presence of evidences of wildlife with proper permission from the authorities (Figs. 14-16).

Fig. 4-7. Different steps of collection of pug mark (of Leopard).

Figs. 8-11. Collection of scat of rhino, elephant, leopard and sambar.

Figs. 12-13. Venture in the forest in search of presence of wildlife evidences.

Figs. 14-15. Visit beside water body within the forest in search of presence of wildlife evidence.

Fig. 16. Showing location of different forests at Dooars. Our study sites are marked with circles.

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

Dominance

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

Diversity Index

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

When diversity indices are used in ecology, the types of interest are usually species, but they can also be other categories, such as genera, families, functional types or haplo types. The entities of interest are usually individual plants or animals, and the measure of abundance can be, for example, number of individuals, biomass or coverage. In demography, the entities

of interest can be people, and the types of interest various demographic groups. In information science, the entities can be characters and the types the different letters of the alphabet. The most commonly used diversity indices are simple transformations of the effective number of types (also known as 'true diversity'), but each diversity index can also be interpreted in its own right as a measure corresponding to some real phenomenon (but a different one for each diversity index). [Hill, 1973; Jost, 2006; Tuomisto, 2010a and Tuomisto, 2010b].

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

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

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

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

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

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

When q = 1, the weighted geometric mean of the p_i values is used, and each species is exactly weighted by its proportional abundance (in the weighted geometric mean, the weights are the exponents). When q > 1, the weight given to abundant species is exaggerated, and when q < 1, the weight given to rare species is. At q = 0, the species weights exactly cancel out the species proportional abundances, such that the weighted mean of the p_i values equals 1 / R even when all species are not equally abundant. At q = 0, the effective number of species, ^{0}D, hence equals the actual number of species R. In the context of diversity, q is

generally limited to non-negative values. This is because negative values of q would give rare species so much more weight than abundant ones that ${}^{q}D$ would exceed R [Tuomisto, 2010a and Tuomisto, 2010b].
The general equation of diversity is often written in the form [Hill, 1973 and Jost, 2006]:

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

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

Richness

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

Shannon Index

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

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

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

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

[Shannon and Weaver, 1948].It has been shown that the Shannon index is based on the weighted geometric mean of the proportional abundances of the types, and that it equals the logarithm of true diversity as calculated with $q = 1$ [Tuomisto, 2010a]:

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

This can also be written:

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

which equals:

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

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

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

Simpson Index

The Simpson index was introduced in 1949 by Edward H. Simpson to measure the degree of concentration when individuals are classified into types [Simpson, 1949]. The same index was rediscovered by Orris C. Herfindahl in 1950 [Herfindahl, 1950]. The square root of the index had already been introduced in 1945 by the economist Albert O. Hirschman [Hirschman, 1945]. As a result, the same measure is usually known as the Simpson index in ecology, and as the Herfindahl index or the Herfindahl–Hirschman index (HHI) in economics. The measure equals the probability that two entities taken at random from the dataset of interest represent the same type [Simpson, 1949]. It equals:

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

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

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

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

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

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

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

Berger – Parker Index

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

RESULTS AND OBSERVATIONS

Data of different indirect evidences like scat, digging mark, pug mark, laying mark and scrapping mark on tree etc. of different animals were obtained from Jaldapara National Park which are showing at Table No. 3 and this table also shows different quantitative values which are generated by using "Past" programming.

TABLE 3. AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT JALDAPARA NATIONAL PARK (Forest Area: 216.51 KM^2 / Survey Area: 16 KM)

Name of the Animal	Scat	Digging mark	Pug mark	Laying mark	Scrapping mark on tree
Rhino	5	1	3	1	1
Wild Boar	2	2	1	1	1

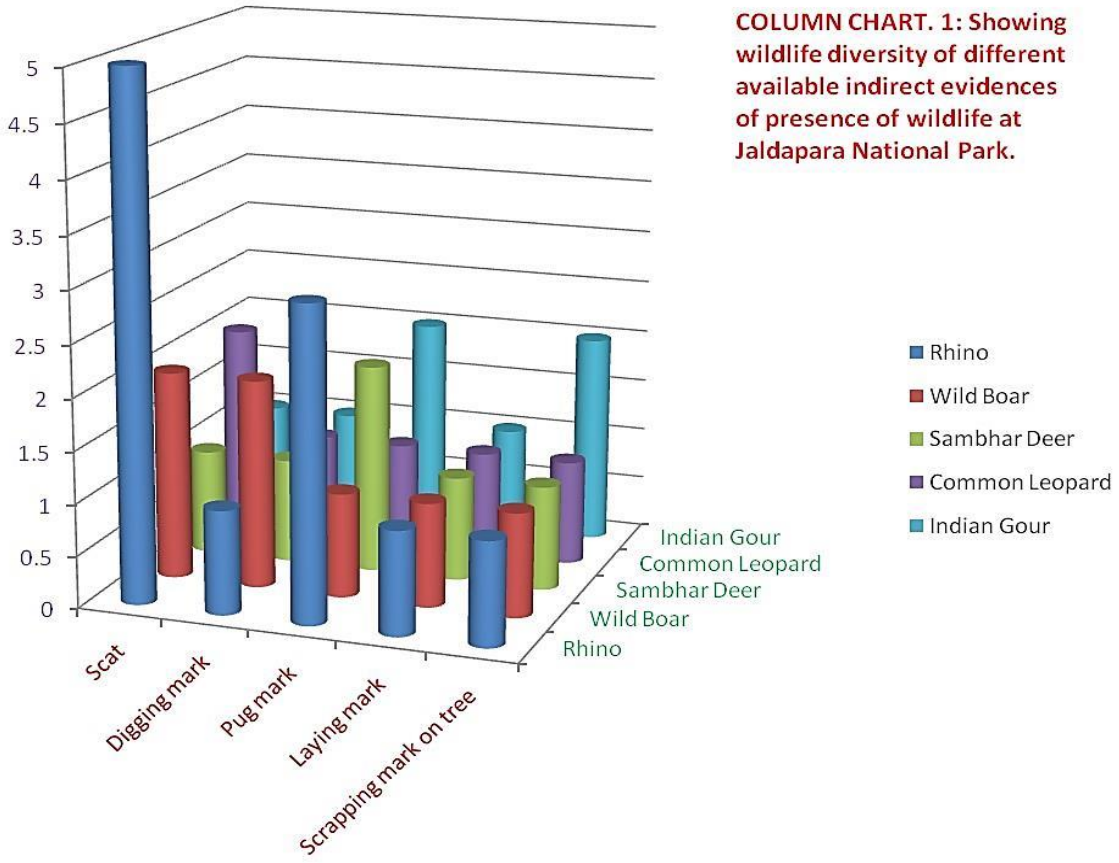
Sambhar Deer	1	1	2	1	1
Common Leopard	2	1	1	1	1
Indian Gour	1	1	2	1	2
DIFFERENT INDEXES (Generated by PAST)					
0	**A**	**B**	**C**	**D**	**E**
Taxa_S	5	5	5	5	5
Individuals	11	6	9	5	6
Dominance_D	0.2893	0.2222	0.2346	0.2	0.2222
Shannon_H	1.414	1.561	1.523	1.609	1.561
Simpson_1-D	0.7107	0.7778	0.7654	0.8	0.7778
Berger-Parker	0.4545	0.3333	0.3333	0.2	0.3333

TABLE 4. AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT GORUMARA NATIONAL PARK (Forest Area: 79.45 KM^2 / Survey Area: 16 KM)

Name of the Animal	Scat	Digging mark	Pug mark	Laying mark	Scrapping mark on tree
Indian Gour	1	1	2	2	1
Wild Boar	1	2	1	1	1
Common Monkey	3	1	1	1	1
Sambhar Deer	2	1	1	1	1
Indian Elephant	1	1	2	1	1
Leopard Cat	2	1	1	1	1
Common Leopard	2	1	2	1	1
Little Egret	2	1	1	1	1
Indian Peacock	1	1	2	1	1
DIFFERENT INDEXES (Generated by PAST)					
0	**A**	**B**	**C**	**D**	**E**
Taxa_S	9	9	9	9	9

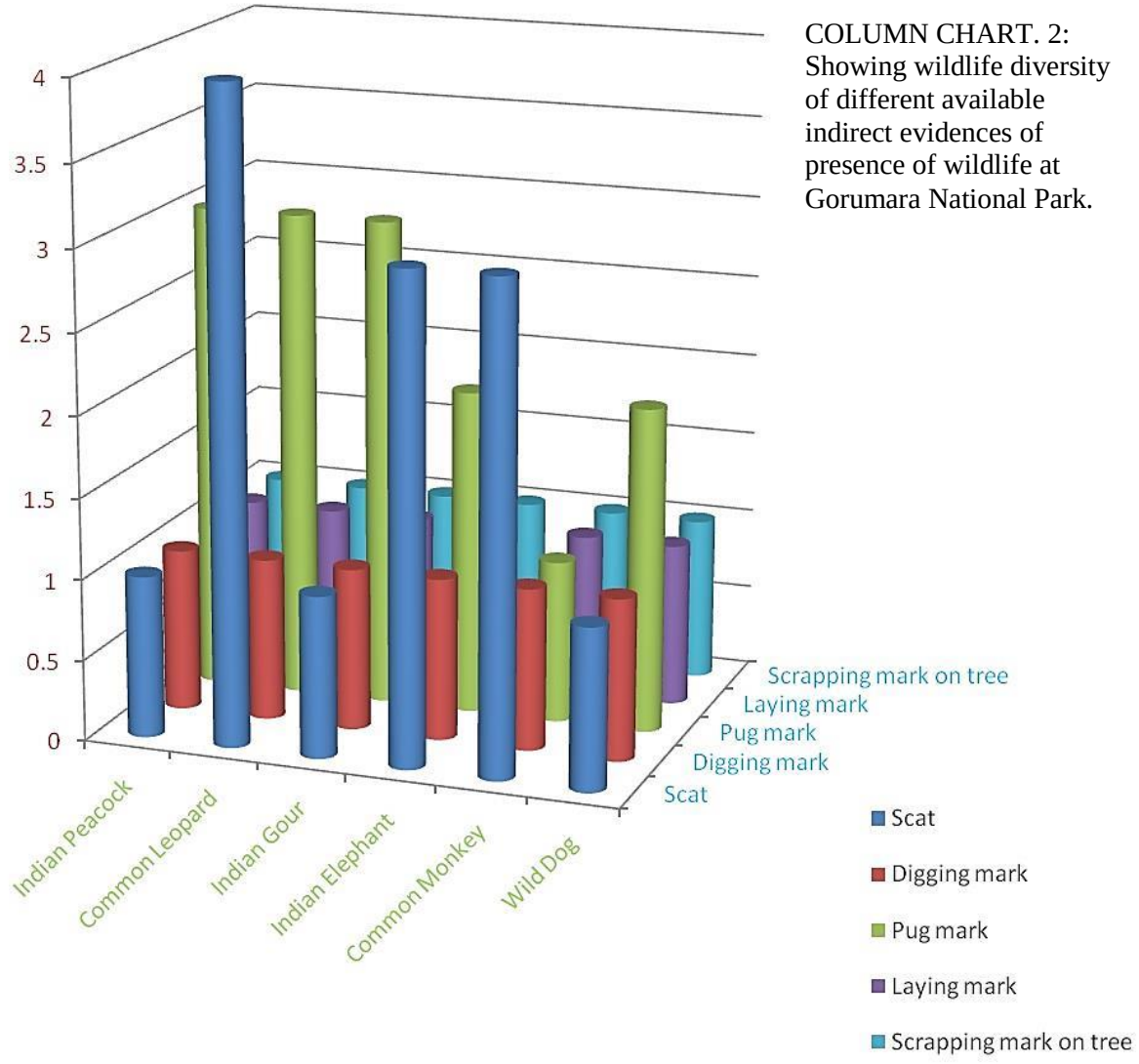
Individuals	15	10	13	10	9
Dominance_D	0.1289	0.12	0.1243	0.12	0.1111
Shannon_H	2.119	2.164	2.138	2.164	2.197
Simpson_1-D	0.8711	0.88	0.8757	0.88	0.8889
Berger-Parker	0.2	0.2	0.1538	0.2	0.1111

Cylinder Column Chart: 1 also showing the pattern of distribution of indirect evidences and richness of wildlife at the Jaldapara National Park. By comparing the obtained data from Table No.: 3 and Chart: 1 this is found that *Rhinoceros unicornis* (rhino) is the most dominant wildlife at Jaldapara National Park, whereas, least dominance is found in case of common leopard, *Panthera pardus* and Sambhar Deer (*Cervus unicolor*). During our studies we obtained scat as maximum samples as indirect evidence with dominance value of 0.2893, the Shannon index is 1.414, Simpson index is 0.7107 and the Berger-Parker index is 0.4545. Minimum samples obtained as indirect evidences were found to be laying mark. A total five number of taxa were found including *Rhinoceros unicornis* (Indian One-horned Rhino), *Sus scrofa* (Wild Boar), *Cervus unicolor* (Sambhar Deer), *Panthera pardus* (Common Leopard) and *Bison bison* (Indian Gour).



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

During our studies at the Gorumara National Park, this is found that Indian Gour or *Bison bison* and Common Leopard, *Panthera pardus* are the dominant wildlife of this forest. Maximum samples obtained as indirect evidences were found to be scat, followed by pug marks with dominance value of 0.1289 and 0.1243, the Shannon index of 2.119 and 2.138, Simpson index of 0.8711 and 0.8757 and the Berger-Parker index of 0.2 and 0.1538 respectively (See Table No. 4). The Gorumara National Park is very rich in its biodiversity and during our study we found presence of indirect evidences of nine species, *viz. Bison bison*, Indian Gour; *Sus scrofa*, Wild boar; *Macaca sp.*, Common Monkey; *Cervus unicolor*, Sambhar Deer; *Elephas maximus indicus*, Indian Elephant; *Felis bengalensis*, Leopard Cat; *Panthera pardus*, Common Leopard; *Egretta garzetta*, Little Egret; and *Pavo cristatus*, Indian Peacock. The abundance and distribution of presence of indirect evidences of different wildlife can also be observed at Cylinder Column Chart: 2.



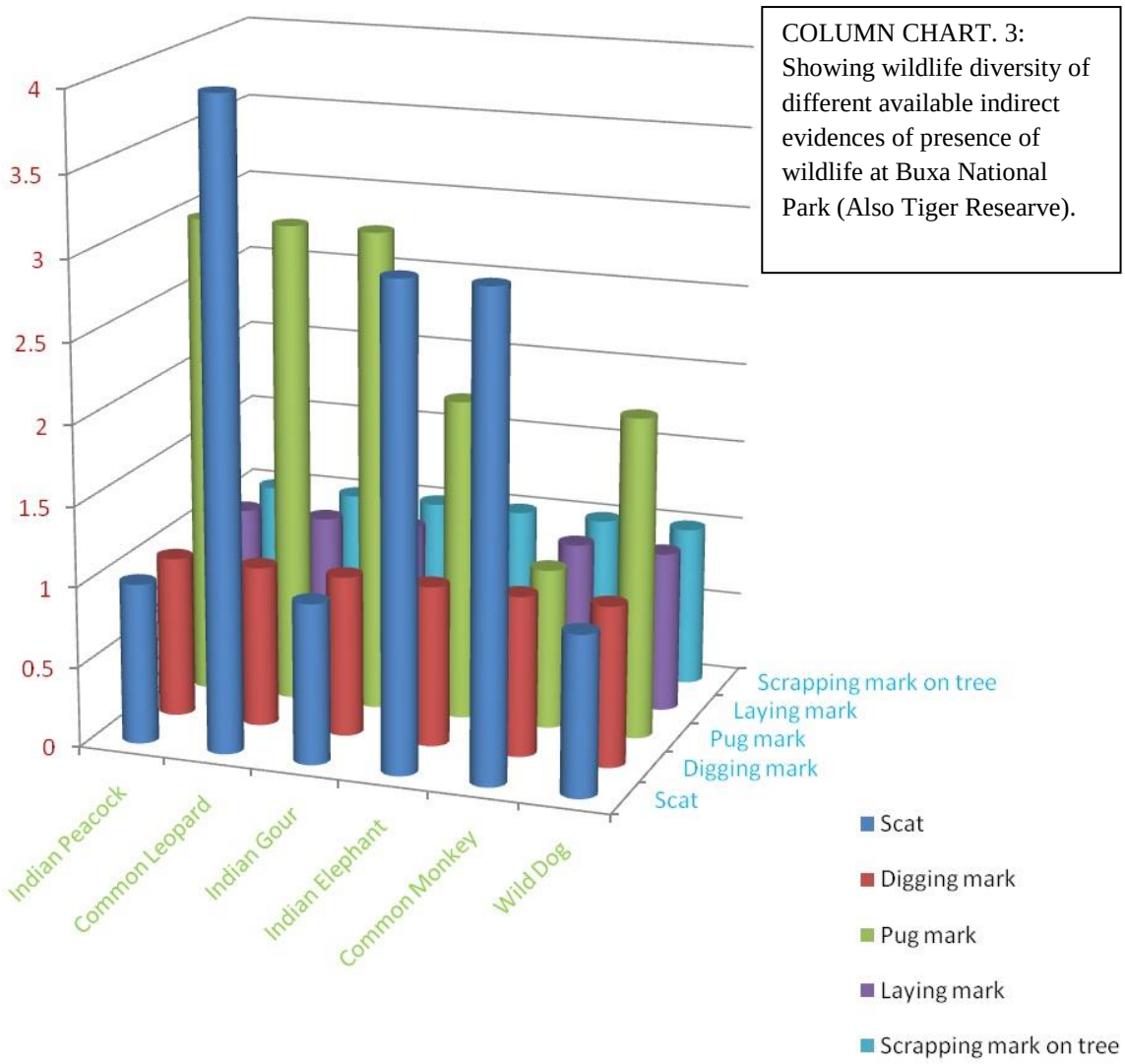
COLUMN CHART. 2: Showing wildlife diversity of different available indirect evidences of presence of wildlife at Gorumara National Park.

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

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

TABLE 5. AVERAGE ANNUAL DATA OF INDIRECT EVIDENCES OF WILDLIFE FOUND AT BUXA TIGER RESERVE / NATIONAL PARK (Forest Area: 117.10 KM^2 / Survey Area: 16 KM)

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



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

DISCUSSION AND CONCLUSION

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

During this one year studies on presence of indirect evidences of wildlife at different National Parks of Dooars this is found that beside the above mentioned anthropogenic disturbances biodiversity of these National Parks are very rich. By analyzing the indirect evidences we found presence of many types of wildlife at Jaldapara, Gorumara and Buxa National Parks. As evidences we obtained scat, pug mark, laying mark, digging mark and scratching marks on tree at different places of the different forests which suggests indirectly presence of a rich biodiversity. However, there may be some question arise regarding the

independentness of scat or pug mark or other evidences that - are those evidences belonging to different wildlife or same individual? During our studies there is no such scope to analyze each and every sample evidences at molecular level; therefore, we depended upon the forest personnel and their experiences. Moreover, there is very little literature available on studies of presence of indirect evidences of wildlife; therefore, making any concluding comment might be an exaggeration. However, whatever data we obtained during our studies, from these this is evident that till date the National Parks of Dooars supporting a very rich wildlife.

ACKNOWLEDGEMENTS

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

LITERATURE CITED

[1] Berger, Wolfgang H. & Parker, Frances L. 1970. Diversity of Planktonic Foraminifera in Deep-Sea Sediments. *Science* 168 (3937): 1345-1347. doi:10.1126/science.168.3937.1345

[2] Callaghan, J., McAlpine, C., Mitchell, D., Thompson, J., Bowen, M., Rhodes, J., Jong, Carol de, Domalewski, R. & Scott, A. 201. Ranking and mapping koala habitat quality for conservation planning on the basis of indirect evidence of tree-species use: a case study of Noosa Shire, south-eastern Queensland. *Wildlife Research.* 32 (2): 1102-1118.

[3] Datta, A., Anand, M. O. & Naniwadekar, R. 2008. Empty forests: Large carnivore and prey abundance in Namdapha National Park, north-east India. *Science Direct: Elsevier.* 141: 1429-1435.

[4] Forest Survey of India. 2009. Forest and Tree Resources in States and Union Territories, 7.29 West Bengal, Forest Survey of India, http://www.fsi.nic.in/sfr_ 2009/ westbengal. pdf (2013).

[5] Herfindahl, O. C. 1950. Concentration in the U.S. Steel Industry. Unpublished doctoral dissertation, Columbia University.

[6] Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* 54: 427-432. doi:10.2307/1934352.

[7] Hirschman, A. O. 1945. National power and the structure of foreign trade. Berkeley.

[8] Hunter, P. R. & Gaston, M. A. 1988. Numerical index of the discriminatory ability of typing systems: an application of Simpson's index of diversity. J *Clin Microbiol* 26 (11): 2465–2466. PMID 3069867.

[9] Jost, L. 2006. "Entropy and diversity". *Oikos* 113: 363–375. doi:10.1111/j.2006.0030-1299.14714.x.

[10] Little, S. J., Harcourt, R. G. & Clevenger, A. P. 2002. Do wildlife passages act as prey traps? *Biological Conservation: Elsevier.* 107: 135-145.

[11] Manoj, K., Bhattacharyya, R. & Padhy, P. K. 2013. Forest and Wildlife Scenarios of Northern West Bengal, India: A Review. *International Research Journal of Biological Sciences.* 2 (7): 70-79.

[12] Shannon, C. E. & Weaver, W. 1948. A mathematical theory of communication. *The Bell System Technical Journal*, 27, 379-423 and 623-656.

[13] Sharma, A. A., Sarkar, P. & Chaudhry, S. 2013. Status survey on carnivores and prey in Kalesar National Park and Wildlife Sanctuary in Haryana, India. *Journal of Biodiversity and Environmental Sciences.* 3 (7): 22-28.
[14] Simpson, E. H. 1949. Measurement of diversity. Nature 163: 688. doi:10.1038/163688a0
[15] State Forest Report (2010-2011). Government of West Bengal, Directorate of Forests, Office of the Principal Chief Conservator of Forests and Head of Forests Force, Aranya Bhaban, Salt Lake, Kolkata, http://westbengalforest.gov.in/ ..../SFR-2010-2011.pdf (2012).
[16] Tuomisto, H. 2010a. A diversity of beta diversities: straightening up a concept gone awry. Part 1. Defining beta diversity as a function of alpha and gamma diversity. *Ecography* 33: 2-22. doi:10.1111/j.1600-0587.2009.05880.x
[17] Tuomisto, H. 2010b. A consistent terminology for quantifying species diversity? Yes, it does exist. *Oecologia* 4: 853–860. doi:10.1007/s00442-010-1812-0


GOVERNMENT OF WEST BENGAL
BARASAT GOVT. COLLEGE
ESTD. - 1950


GO GREEN
SOLAR ENERGY