



Publishers :

Thanuj International Publishers,
8/173-B, Vengayapalayam, Rasipuram,
Namakkal, Tamil Nadu, India – 637406.
E-mail: thanujinternationalpublishers@gmail.com

Printers :

Dhazh Computers (Graphic Designer)
No : 442- A, 10th East Cross Street,
Munthirithoppu, Annanagar,
Madurai – 20, Tamil Nadu, India.
E-mail: narennarayanamy@gmail.com

ISBN: 978-93-94638-73-0



9 789394 638730

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Exploring Boundless Frontiers : Interdisciplinary Perspective in Research

First Edition

Exploring Boundless Frontiers: Interdisciplinary Perspective in Research



Editors

Dr. P. Madhiyazhagan
Dr. Praseeja Cheruparambath
Mrs. Deepa K

Thanuj International Publishers, Tamil Nadu, India

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First published in India in February, 2024

This First Edition published by Thanuj International Publishers

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ISBN: 978-93-94638-73-0

Price: Rs: 850.00



Published by:

Thanuj International Publishers,
8/173-B, Vengayapalayam, Kakkaveri, Rasipuram,
Namakkal, Tamil Nadu,
India – 637406.
www.darshanpublishers.com
E-mail: thanujinternationalpublishers@gmail.com

Printed by:

Dhazh Computers (Graphic Designer)
No: 442- A, 10th East Cross Street,
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Foreword



Dr. R. Nishi
Former Professor and Head,
Department of Zoology,
Sree Narayana College, Alathur, Palakkad, Kerala.

I wish to congratulate the authors for this initiative. I am glad steps have been taken to bridge the gap between different subjects. The gap is indeed reducing and the fact that integration of the different branches that lead to solving universal scientific problems is the need of the hour. When many minds work in unison solutions will work out. The authors have to attract people of different fields to bring out their thought of action. Slowly but definitely such initiatives will bear fruit. Here's wishing good luck to the authors and all those who have put in their ideas to bring forth this journal.

Preface

Welcome to the exploration of boundless frontiers through an interdisciplinary lens. In today's rapidly evolving world, the pursuit of knowledge knows no bounds, transcending traditional disciplinary boundaries. This book embarks on a journey to navigate these frontiers, offering a holistic view of research through interdisciplinary perspectives.

As we delve into the realms of various disciplines, we uncover connections, synergies, and novel insights that emerge at the intersection of diverse fields. By embracing this interdisciplinary approach, we transcend the limitations of singular viewpoints, fostering innovation and pushing the boundaries of human understanding.

Through the collaboration of scholars from diverse backgrounds, this book embodies the spirit of interdisciplinary research, bridging gaps and fostering dialogue across disciplines. From the sciences to the humanities, from technology to the arts, each chapter offers a unique vantage point, enriching our collective understanding of the world.

As we embark on this intellectual journey together, let us embrace curiosity, open-mindedness, and a willingness to challenge conventional wisdom. By exploring boundless frontiers through an interdisciplinary perspective, we embark on a quest for deeper insights, greater innovation, and a more interconnected world.

Join us as we embark on this exhilarating voyage of discovery, where the possibilities are limitless, and the frontiers are boundless.

Editors

Dr. P. Madhiyazhagan
Dr. Praseeja Cheruparambath
Mrs. Deepa K

About Editors



Dr. P. Madhiyazhagan is currently serving as an Assistant Professor in the Department of Zoology at J. K. K. Nataraja College of Arts and Science. With 8 years of combined teaching and research experience, he has established himself as an expert in the field of entomology, particularly focusing on green Nano-based mosquito and agricultural pest control. He has an impressive publication record, having authored 62 research articles and 9 book chapters in highly reputable journals. His contributions have garnered a total impact factor of 84.5, with 3389 citations, h-index of 30, and i-index of 42. In addition to his research accomplishments, he has actively participated in the academic community. He has served as a reviewer and editorial board member for prestigious publications, including Springer and Elsevier. He is also a lifetime member of various scientific organizations. Furthermore, he has shared his expertise as a resource person in seminars and short-term courses. His commitment to both research and education underscores his significant contributions to the field of Entomology.



Dr. Praseeja Cheruparambath is currently working as an Assistant Professor in the Department of Zoology Sree Narayana College, Alathur, Affiliated to University of Calicut Kerala. She has 6 years of combined teaching and research experience, She is now recognised as research Guide under the university of Calicut with 3 Ph.D. research scholars with CSIR JRF fellows. She has established herself as an expert in the field of Microplastics, Conservation Biology, Dietary Supplementation, entomology-particularly focusing on green synthesised Nano-based mosquito and agricultural pest control. She has an impressive publication record, having authored more than 18 research articles and 5 book chapters in highly reputed journals. Her contributions have garnered high impact factor, with high citations, h-index, and i-index . In addition to her research accomplishments, she has actively participated in the academic community. She served as a reviewer and editorial board member for various publications. She is

also a lifetime member of various scientific organizations. Furthermore, she has shared her expertise as a resource person in seminars and short-term courses. Her commitment to both research and education is highly appreciable.



Ms. Deepa K is currently serving as an Assistant Professor in the Department of Botany at Sree Narayana College Erattakulam, Alathur, Kerala with 8 years of combined teaching and research experience, she has established herself as an expert in the field of Mushroom Research, Seed biology, Medicinal plant studies, particularly focusing on extension activities at the local level for the better agricultural productivity and biodiversity conservation. She has an impressive publication record, having authored research articles and book chapters in highly reputable journals. In addition to her research accomplishments, she has actively participated in the academic community. She is also a lifetime member of various scientific organizations. Furthermore, she has shared his expertise as a resource person in seminars and webinars. Her commitment to both research and education underscores her significant contributions to the field of Interdisciplinary biology.

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ISBN: 978-93-94638-73-0

First Edition, April -2024

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Physico-chemical and bacteriological analysis of water samples collected from open wells of Pudunagaram and Kozhinjampara panchayat, Palakkad.

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Abstract

Water is one of the vital needs of all living beings. Humans need water in many daily activities like drinking, washing, bathing, cooking etc. If the quality of water is not good then it becomes unfit for drinking and other activities. The quality of water usually described according to its physical, chemical and biological characteristics. Hence it becomes necessary to find the suitability of water for drinking, irrigation and Industry purpose. It is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know details about different Physico-chemical parameters such as colour, temperature, turbidity, acidity, hardness, pH, sulphate, chloride, alkalinity used for testing of water quality. Bacteriological analysis of water is also important for analysing water to estimate the numbers of bacteria present & its type. It represents one aspect of water quality. It is then possible to draw inferences about the suitability of the water for use. In this study two well water samples were collected from 2 different places and were compared. The parameters such as pH, turbidity, conductivity, TDS, alkalinity, acidity, hardness, calcium, magnesium, chloride, fluoride, iron, sulphate and bacteria like coliforms and *E.coli* were analysed. The result indicates that both the samples were safe for drinking purpose and is suitable for human health.

Keywords: Physio-chemical parameters, Bacteriological analysis, Water quality, *Escherichia coli*

Introduction

Water is the integrated system of biological metabolic reactions in aqueous medium that is a must for maintaining life on earth. All organisms including human beings continuously make use of the benefits of water since the first cell formed inside the womb of the mother. Water form a vital part of every organism that essentially involved in their survival. So, as component of both organic and inorganic substances as well as in its function as solvent, reaction and transport medium, water is essential for all abiotic and biotic processes on earth (Gordella. B. Miller and F. H Frimmel 2007). Water is extraordinarily abundant on the planet as a whole, but fresh potable water is not always available at the right time or the right place for human or ecosystem use. 71% of earth's crust is blessed of water and 97% of this resides purely in the oceans.3% of freshwater sources are detected on which more than 2% exists as ice caps, glaciers, etc.

This calls out the significance of water conservation. Conservation of water and judicious management of water resources are the most important challenges faced not by a country or state but by the whole humanity. Restricted and uneven distribution of water resources on the earth is the natural cause of water scarcity faced by people. In addition to this, increasing urbanization, industrialization and various anthropogenic activities increases the surface and ground water pollution (Sushil Kumar *et. al.* 2017). Due to this, various organisms including plants are badly affected and their existence becomes highly complicated.

The World Health Organization (WHO) estimated in 1996 that every eight seconds a child dies from a water-related disease and that each year more than five million people died from illnesses linked to unsafe drinking water or inadequate sanitation. Of all the water quality issues facing lakes everywhere, eutrophication is of great concern. Eutrophication is a term used to describe the aging of a lake, resulting due to the accumulation of nutrients, sediments, silt and organic matter in the lake from the surrounding watershed. The main cause is excessively adding of phosphorus and nitrogen resulting in high algal biomass, dominance by cyanobacteria and loss of macrophytes (S. P. Gorde1, M. V. Jadhav -2013).

Physical properties of water like pH, color, odour, smell, turbidity, conductivity, TDS etc are dynamic in nature. It may vary from time to time and place to place. The permissible limits and standard composition of water is determined by various agencies like BIS, APHA, AWWA, WPCF etc. Since the physical parameters mentioned above and chemical parameters like amount of chloride, sulphate, iron, total hardness etc alters the properties of water, it is important to analyse water physically, chemically and bacteriologically in regular time periods. Common water borne illness is caused by pathogenic microbes present in the water. Coliforms are the major microbial indicators for monitoring water quality. These are rod shaped, non-sporing, motile or non-motile, gram negative, aerobic and facultative or anaerobic bacteria. Faecal contaminate drinking water can spread diseases like hepatitis, cholera, dysentery, typhoid and diarrhea.

The deleterious health and socio- economic effects of Physico-chemical and bacteriological factor in drinking water sources are generating a serious concern in urban and rural communities. Private drinking water wells should be tested annually to monitor these changes. It is therefore imperative to develop a base line data of these parameters. As such in the present investigation an attempt has been made to study the Physico-chemical and bacteriological parameters of well water from two different places of two different panchayats.

Methodology

Study area

Pudunagaram and Kozhinjampara are two panchayaths of Palakkad district. Pudunagaram is about 10 km south of Palakkad and 8 Km from Kollengode(Fig.1). The sample was collected from Padikkalpadam, which is a part of this panchayat and is about 3 km away from the Pudunagaram town. Kozhinjampara is a town in the Palakkad district, state of Kerala, India alongside the borderline of Tamilnadu. It forms a part of the area administered by the Kozhinjampara gram panchayat. The sample was collected from Athicode, which is 4km away from Kozhinjampara town.

The area selected for the study was Padikkalpadam of Pudunagaram panchayat and Athicode of Kozhinjampara panchayat. One sample was collected from each of these places.

Sample 1: Open Well Water from Padikkalpadam of Pudunagaram panchayat

Sample 2: Open Well Water from Athicode of Kozhinjampara panchayat

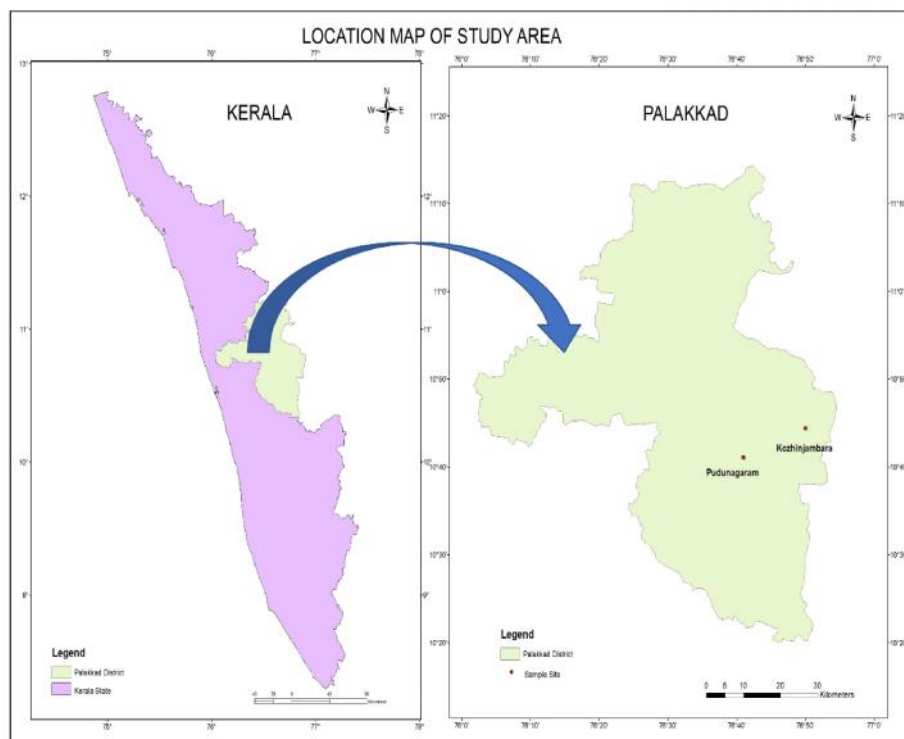


Fig.1 Location map of sample sites in the study area

Collection of water samples

The two samples were collected from two different open wells from two different places in a well cleaned, dried and sterilized 1 litre plastic bottles. The samples collected were carried to Ahalya Central Laboratory in the Ahalya Campus, Kozhippara, Palakkad district within a day. The samples were further tested for analysing physical, chemical and bacteriological parameters and the results were obtained.

Physico-chemical parameters

Physico-chemical parameters such as pH, turbidity, conductivity, TDS, hardness, presence of sulphides, chlorides, iron were analyzed in the laboratory by standard methods (APHA (2017) Standard methods for the examination of waste and wastewater). The recorded results were compared with the standard values (IS10500, B. I. S. (2012). Indian Standard Drinking Water–Specification).

Bacteriological parameters

Bacteriological parameters influencing the water quality like faecal coliforms and total coliforms count were carried out using Membrane Filter Technique. MF technique is advantageous over Most Probable Number (MPN) procedure for microbial analysis of water samples since it aids in the isolation of disjunct colonies of bacteria whereas MPN procedures only detects the presence or absence of imprecise number of organisms.

The procedure is completed in three steps:

1. Preparation of M-ENDO Agar medium for the culturing of total coliforms.
2. Preparation of M-FC Agar medium for culturing fecal coliforms
3. This is followed by Membrane Filtration.

Observation and Result

The results of Physico- chemical and bacteriological analysis of sample 1 and sample 2 is presented below:

Table 1: results of physical parameters of sample 1 and sample 2:

SL. No	Characteristics	Test method	Sample 1 Result	Sample 2 Result	Acceptable Limits IS 10500:2012	Permissible Limits IS 10500:2012
1	pH at 25 C	APHA,2017	6.34	7.14	6.5 to 8.5	No Relaxation
2	Turbidity, NTU	APHA,2017	7.8	7.4	1	5
3	Conductivity, $\mu\text{m/ppm}$	APHA,2017	655.5	1458		
4	Total Dissolved Solids, Mg/L	APHA,2017	343.6	778.4	500	2000

NTU – Nephelometric turbidity units, $\mu\text{m/ppm}$ – Micro Siemens/ parts per million, APHA – American Public Health Association.

Impression: All the physical parameters are under acceptable limit, except turbidity of both samples and TDS of sample 2. The water is safe for drinking purpose.

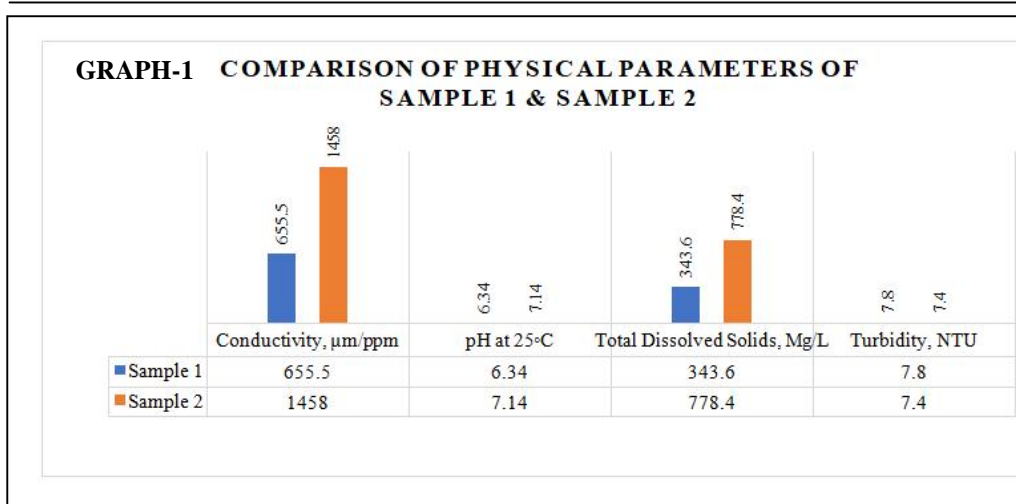


Table 2 showing results of chemical parameters of sample 1 and sample 2

SL. No	Characteristics	Test method	Sample 1 Result	Sample 2 Result	Acceptable Limits IS 10500:2012	Permissible Limits IS 10500:2012
1	Total Alkalinity as CaCO ₃ , mg/L	APHA, 2017	146	360	200	600
2	Acidity, mg/L	APHA, 2017	22	16		
3	Total Hardness as CaCO ₃ , mg/L	APHA, 2017	120	202	200	600
4	Calcium as Ca, mg/L	APHA, 2017	24.03	36.04	75	200
5	Magnesium as Mg, mg/L	APHA, 2017	14.58	21.87	30	100
6	Chloride as Cl, mg/L	APHA, 2017	100	160	250	1000
7	Fluoride as F, mg/L	APHA, 2017	0.38	0.63	1	1.5
8	Iron as Fe, mg/L	APHA, 2017	0.27	0.37	0.3	1
9	Sulphate as SO ₄ , mg/L	APHA, 2017	32	56	200	400

mg/L- microgram / Liter

Exploring Boundless Frontiers: Interdisciplinary Perspective in Research

Impression: All the chemical parameters are under the acceptable limits except total alkalinity, total hardness and iron of sample 2. The water is safe for drinking purpose.

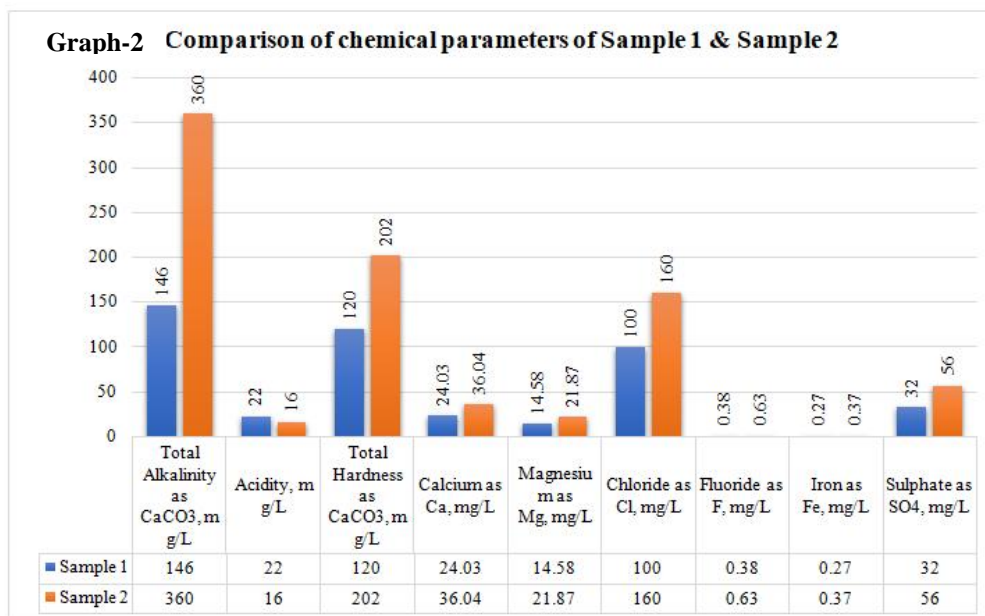


Table 3 showing results of Bacteriological analysis of sample 1 and sample 2

SL. No	Characteristics	Test method	Sample 1 result	Sample 2 result	Acceptable Limits IS 10500:2012	Permissible Limits IS 10500:2012
1	Coliforms, MPN/100ml	APHA,2017	Absent	Absent	Shall not be detectable in 100ml sample	
2	Escherichia coli, MPN/100ml	APHA,2017	Absent	Absent	Shall not be detectable in 100ml sample	

MPN – Most Probable Number

Impression: The water is safe for drinking purpose and is suitable for human health

Discussion

Water is the most important and mostly manipulated natural resource than any other. It is very much associated to all living organisms, ecosystems, human health, food production, economic development. Two samples from two different places were selected. The places were Padikkalpadam and Athicode. The open well of Padikkalpadam is newly constructed and that of Athicode is constructed years ago. The people living nearby depend upon these well waters for basic household works like washing, bathing, drinking, etc. So in order to analyse the quality of water both the samples were collected and checked for 15 physical, chemical, and bacteriological parameters.

pH

pH is the most relevant physical part that reflects how acidic or alkaline a water sample is. pH of water sample was recorded using a digital pH meter. The normal range for pH in ground water lies in between 6.5-8.5 as per the WHO standards. The pH of water samples collected is tolerable for living system.

Turbidity

Turbidity in water is caused by suspending organic or inorganic material. Solid particles suspended in water absorb or reflect light and cause the water to appear "cloudy" (L. R Gutierrez. Lucas *et. al.* 2017) Turbidity is measured using nephalo turbidometer. The samples under study were found to be more turbid and exceed the permissible limit. High turbidity indicates the higher levels of disease-causing microorganisms like bacteria and some other parasites. The turbidity of sample 1 is 7.8 and that of sample 2 is 7.4. This may be due to the recent rainfalls. The high turbidity may be an indication of the presence of fewer or more disease-causing microorganisms.

Conductivity

Conductivity or Electrical Conductance is a measurement of the ability of an aqueous solution to carry an electrical current. Conductivity is closely related to total dissolved solids (TDS) present in the water sample. Elevated TDS cause an increase in its EC and gives a mineral taste to drinking water. EC of the samples collected varies from 655.5 – 1448 $\mu\text{s/ppm}$. According to Indian Standard Specification, the permissible limit of EC is 1000 $\mu\text{s/cm}$. Both the samples has an EC that lies within the permissible limit.

Total Dissolved Solids(TDS)

Total Dissolved Solids are mainly composed of carbonates, bicarbonates, phosphates, chlorides and nitrates of calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium, sodium (Na^{+}) and organic matter and other particles (Mahananda *et. al.* 2010). TDS concentration are used to evaluate quality of fresh water system. The amount of TDS was measured in both the samples and ranged from 343.6-778.4mg/l. Since both conductivity and TDS present is relatable, they follow a linear relation. Thus sample 1 has the minimum TDS and sample 2 has the maximum TDS amount.

Alkalinity

Alkalinity refers to the capability of water to neutralize acid. Living organisms, especially aquatic life function best in a pH range of 6.0-9.0. Sample 1 does not have any alkaline presence. Sample 2 is highly alkaline and exceeds the acceptable limit but is within the permissible limit. Alkalinity in water comes from high concentration of carbon-based mineral molecules suspended in the water. Also, alkalinity is often related to hardness because the main source of alkalinity is CaCO_3 , which comes from rocks seen as limestone or can be sometimes leached from dolomite and calcite in the soil.

Acidity

Acidic water refers to water with a pH of less than 7. It can also have many undesirable and potentially dangerous side effects. It's not recommended to drink acidic water, as its high acidity and concentration of heavy metals can have several negative health consequences. Both the samples taken have the acidity within the permissible limit.

Total hardness

Hardness is a very important chemical parameter that determines the quality of water and it depends upon the quantity of magnesium or calcium salts (APHA 1998; Adejuwon and Adelakun, 2012). The permissible limits of total hardness in potable water ranged within 500 mg/L (Shivaraju H. P, 2011). In the present study, the obtained T. H ranged between 120 mg/L – 202 mg/L. Sample 2 has the maximum value for hardness. But the samples possess hardness within the desirable limits. A maximum hardness may be due to the high amount of TDS present in it.

Calcium

The desirable permissible extends of calcium ranges from 75-200 mg/L and the amount of calcium present in the samples under study were found to be

very much lower from the desirable limit and it varies from 24.03-36.04 mg/L. Sample 1 has the minimum amount of calcium while sample 2 possess the maximum. Though excess Ca^{2+} can lead to formation of kidney or gall bladder stones, it ensures the regular uptake of Ca^{2+} which is essential in supplying strength to bone and teeth in various classes of organisms. Here both the samples show desirable amount of calcium.

Magnesium

Magnesium is another important class of metal ions that contribute for the water hardness. The suggested permissible limit of magnesium ions ranges from 30-100 mg/L and amount of magnesium in all the study samples were v much lower than the desirable limit. It varies from a lower 14.58 mg/L in sample 1 to higher 21.87 mg/L in sample 2. Magnesium intake of organisms is essential to an extent since it is needed for various biochemical reactions. The samples under study have an appreciable amount of magnesium ions and are safe for drinking and all other domestic purposes.

Chloride

Chlorides are the salt resulting from the combination of gas chlorine with a metal. Chlorine alone as Cl_2 is highly toxic and it is often used as a disinfectant. Chlorides may get into surface of water from several sources like rock containing chloride, agricultural runoff, wastewater from industries and effluent waste water from waste water treatment plants. The samples contain the chlorine value that varies from 100 mg/L – 160 mg/L. Chloride can corrode metals and effect taste of food products. Here, both the samples have a chlorine level that is below the acceptable limit.

Iron

The amount of iron in both water samples were under the required desirable limit with the IS Standard of 0.3 mg/L which denotes there are no serious issues concerned with iron content.

Fluoride

Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals etc.in nature. Among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock minerals assemblage through which the ground water is circulating. As per IS: 10500-2012 Desirable limit for fluoride is 1 and 1.5 mg/l in Permissible limit. Both the samples have the fluorine within the limit.

Sulphate

Two forms of sulphur are commonly found in drinking water: sulphate and hydrogen sulphide. Both forms are nuisance and usually do not pose a health risk at concentrations found in domestic wells. Desirable limit of sulphate in surface water is 200mg/L and permissible limit in the absence of an alternative source is 400mg/L. Both the samples contain medium level of sulphur and is not harmful, beyond the permissible level it may cause gastrointestinal irritation in human, a bitter taste to water.

Bacteriological analysis

Several species of bacteria like salmonella sps, vibrio cholera, coliform sps etc. Cause serious health issues in human beings. Coliform bacteria are one among them which constitutes aerobic, facultative anaerobic, gram negative and spore forming bacilli. Checking for coliform, especially *E.coli* reveals that whether the water is exposed to faecal contamination or not. Large amount of faecal coliform bacteria in water indicates a high risk of pathogens in the water. Membrane filtration technique was implemented for the microbial analysis of water samples.

The acceptable limit of MPN/ml prescribed for drinking purpose by Indian standard limit should be less than 10 total numbers of coliform bacteria and zero for faecal coliform bacteria per 100 ml (Adegboyega A.M *et. al.* 2015). According to recommendations by the United States Environmental Protection Agency, as well as the Department of Housing and Urban Development, a septic tank should be at least 50 feet away from a well that is used for drinking water. Coliform bacteria exceeding acceptable limits are indicative of pollution from domestic wastes causing severe water borne disease risking the public health (Adegboyega A.M *et. al.* 2015). The study therefore found absence of coliform counts in both the water samples thus making it safe for drinking. If the water is unsafe, this problem can be solved by proper chemical treatment and avoid the practice of contaminating water resources with manmade waste since "prevention is always better than cure".

Conclusion

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physic-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different

types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Groundwater is the most important source of water supply for drinking, irrigation and industrial purposes. Increasing population and its necessities have led to the deterioration of surface and sub-surface water. The modern civilization and urbanization frequently discharging industrial effluent, domestic sewage and solid waste dump. The cause of ground water gets pollute and create health problems. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source it therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it. So before using of water we should investigate qualitative analysis of some physicochemical parameters of groundwater. This may be considered as reference for the society to get cautious about the impending deterioration of their environment and health.

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Environmental
Sciences

Quick Response Code

DOI: [10.22192/ebfipr.2024](https://doi.org/10.22192/ebfipr.2024)

How to cite this Chapter:

S. Sabira Beegam, Bindu K B and Praseeja Cheruparambath. (2024). Physico-chemical and bacteriological analysis of water samples collected from open wells of Pudunagaram and Kozhinjampara panchayat, Palakkad. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), *Exploring Boundless Frontiers: Interdisciplinary Perspective in Research*. India: Thanuj International Publishers. pp: 1-14.

Medicinal plants studies from Erattakulam, Alathur taluk of Palakkad district, Kerala.

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Abstract

Medicinal plants have been used since ancient times to treat various diseases or active ingredients for serious illnesses. The present study aims to identify and document the medicinal plants in Erattakulam village from September 2023 to March 2024. Erattakulam is a small village located in Alathur taluk of Palakkad, Kerala. The Locality is a hilly area surrounded by green forests with a rich diversity of flora; there is a huge variety of medicinal plants that help the natives from various diseases; they have been using plants as medicinal sources for years. In this area, most of the plants with medicinal properties belong to the family Fabaceae. Fabaceae members include *Mimosa pudica*, *Adenanthera pavonina*, *Abrus precatorius*, *Clitoria ternatea*, etc.,. Families such as Solanaceae, Malvaceae and Liliaceae marked their presence here with several species. Members of the family Myrtaceae, Bignoniaceae, and Convolvulaceae are found rare in this region. The observation of various medicinal plants in Erattakulam village executes the study. It is found that these medicinal resources have tremendous features. Hence, it is the local people's responsibility to conserve these plants and their sustainable use in the area.

Key words: medicinal plants, natives, diversity, conserve, sustainable

Introduction

India is one of the richest floristic regions of the world and has been a diverse source of plant products and many of these plant species are used for medicinal purposes. Medicinal plants occupy an important position in the social-cultural, and therapeutic arena of India (Kurup *et al.*, 1979, Sasidharan, N., 2003). Medicinal plants, also called medicinal herbs, have been discovered

and used in traditional medicine practices since prehistoric times and can be a good alternative for more diseases and conditions. Plants have been used in the Indian subcontinent for the treatment of disease and health maintenance for thousands of years, and remain important staples of health and folk medicine for millions. Plants have been provided with many of their essential needs, including lifesaving pharmaceutical agents. Recently World Health Organization estimated that 80% of people worldwide widely use herbal medicines. Many developing countries intensified their efforts in documenting the data and scientific research on medicinal plants. Plants play a significant role in curing and preventing a variety of diseases occurring in humans and animals and continue to provide new bioactive leads for researchers in drug discovery.

India has a rich diversity of plants and their uses to meet their day-to-day needs and health care. The knowledge of floristic composition is essential to understanding the ecosystem of an area; it also reflects the variety of vegetation of a specific geographical area, which provides an occasion for proper identification and sustainable utilization of plants. The data on the flora of an area is necessary for the study of biodiversity and understanding of the present environment. Thus, common medicinal plants are always useful for village people to use easily with the help of local healers or traditional knowledge. In this study, we focused on scientific documentation of knowledge on common medicinal plants used by local people. Hence, this information could be more beneficial to the local village people of Erattakulam village of Palakkad. Therefore we surveyed medicinal plants to document traditional knowledge in the Erattakulam village. Moreover, transferring the knowledge from one generation to the next generation sustains the medicinal plant diversity and knowledge which can be useful for human health society. This wisdom is now fast vanishing due to modernization, habitat destruction and the tendency of the younger generation to discard their traditional lifestyle.

The value of medicinal plants and herbs is being lost due to a lack of awareness and deforestation (J M Aswathy and K Murugan, 2017). The important vegetation occurring in Kerala consists of flowering plants, which have been estimated as 4465 taxa which include 812 trees (Sasidharan., 2003). Among the flowering plants of Kerala, 20 per cent are trees and 30 per cent of them are Western Ghats endemics (Sasidharan, 2006). Malabar region is an area of southern India lying between the Western Ghats and the Arabian Sea. Scientists working on infectious diseases are always been of great interest in Biologically active compounds from natural sources. The practices of plant-based traditional medicine are based on hundreds of years of belief and

observations, which predate the development and spread of modern medicine and this knowledge has been passed on orally from generation to generation without any written document (Kurup PNV., 2003). During the last few decades, the study of medicinal plants and their indigenous use in the world has been increasing and is an interesting issue for the researcher and natural resource manager traditional medical practices are an important part of the primary health care system in the developing world (Gamble. 1936).

Plants synthesize hundreds of chemical compounds for various functions, including defence and protection against insects, fungi, diseases, and herbivorous mammals. The major use of herbal medicine is for health promotion and therapy for chronic, as opposed to life-threatening, conditions. However, usage of traditional remedies increases when conventional medicine is ineffective in the treatment of disease, such as in advanced cancer and the face of new infectious diseases. This study was conducted to identify and document local healers' practices of treating human diseases and quantitatively document indigenous knowledge of medicinal plants, as well as to highlight the species of public interest for bioprospecting potential. Traditional knowledge of medicinal plants and their use by indigenous cultures are not only useful for the conservation of cultural traditions and biodiversity but also for community healthcare and drug development in the present and future.

Medicinal plants in the treatment of diseases

Herbal medicine has a long history in the treatment of several kinds of diseases. India is one of the 12 mega-diversity countries in the world so it has a vital stake in the conservation and sustainable utilization of its biodiversity resources. Plant secondary metabolites have been of interest to man for a long time due to their pharmacological relevance. With this in view, the bark powder of *Acacia auriculiformis*, *A. nilotica*, *Juglans regia*, and the fruit powder of *Terminalia bellerica*, *T. chebula*, *Emblica officinalis*, and a combination drug "Triphala," which are known to be rich in polyphenols, has been practised by man for many years and is still being widely practised even today.

Morvin Yabesh (2014) medicinal plants used by traditional healers in the Silent Valley of Kerala and reported medicinal plants are treating and preventing a variety diseases and there is urgency in recording such data. Anand et al (2021) compiled and emphasized the most important part of ethnodermatology, namely, traditional knowledge of medicinal plants and their applications for several skin diseases in India he also reviewed and explained dermatology in Ayurvedic and Unani medicine. Ethnodermatological use of

medicinal plants in India is still a subject to conduct more studies to see if there is chemical, microbiological, and/or clinical evidence, from a scientific perspective, of their effectiveness for those skin disorders.

Medicinal plants, a source of different phytochemical compounds, are now subjected to a variety of environmental stresses during their growth and development. Different ecologically limiting factors including temperature, carbon dioxide, lighting, ozone, soil water, soil salinity and soil fertility have a significant impact on medicinal plants' physiological and biochemical responses, as well as the secondary metabolic process. Secondary metabolites (SMs) are useful for assessing the quality of therapeutic ingredients and nowadays, these are used as important natural-derived drugs such as immune suppressants, antibiotics, anti-diabetic, and anti-cancer. Plants can synthesize a variety of secondary metabolites to cope with the negative effects of stress. Many medicinal plants have been used for the treatment of diabetes mellitus in the Indian system of medicine and in other ancient systems of the world. Medicinal plants are a significant source of biological compounds and many of the currently available biological compounds have been derived directly or indirectly from them. It is globally recognised that medicinal plants play a significant role in providing health benefits to human beings. The World Health Organization (2000) has estimated that 80 % of the inhabitants of the world rely mainly on traditional medicines for their primary healthcare needs, and it may be presumed that a major part of traditional healing involves the use of plant extracts or their active principles. Plants are rich in a wide variety of secondary metabolites, such as tannins, terpenoids, alkaloids, and flavonoids, which have been found in vitro to have antimicrobial properties. These studies reveal that *Ocimum sanctum* has a unique combination that includes; antimicrobial, Antibacterial, Antiviral, and Antifungal properties. *Phyllanthus emblica* fruit extract has proven anticancer properties. *Phyllanthus emblica* is rich in polyphenols and hydrolysable tannin-derived compounds that act as antioxidants. Ethnodermatological use of medicinal plants in India is still a subject to conduct more studies to see if there is chemical, microbiological, and/or clinical evidence, from a scientific perspective, of their effectiveness for those skin disorders

Indian medicinal plants traditionally used in medicines were subjected to preliminary antibacterial screening against several pathogenic and opportunistic microorganisms that exhibited antibacterial activity against one or more test pathogens (Ahmad 1998). A maximum number of plants, either alone or in combination were used for eye diseases followed by diarrhoea and dysentery, loss of hair and snake bite. Plants used as animal and insect

repellents and for cattle diseases were also documented. Information was also obtained on diagnostic and prophylactic plants. During the last few decades there has been an increasing interest in the study of medicinal plants with their traditional use and related pharmacological research all over the World (Silambarasan., 2015)

Among selected medicinal plants *Alpinia galanga*, *Allium Sativum*, *Andrographis paniculata*, *Curcuma longa*, *Phyllanthus emblica*, show profound effects on inflammatory cytokines, lymphopenia, decreases NLR (Neutrophil Lymphocyte Ratio) marker of systemic inflammation in COVID19. Hence, these medicinal plants can alleviate the symptoms, improve the immune response, and might lower the mortality rate of COVID19. Dietary use of wild fruits, nuts, seeds, and leaves appears in numerous historical records. Today, most human plant foods are based on a rather limited number of crops. However, it is clear that in many parts of the world, the use of wild plants is not negligible. In India, the indigenous fruits collected from the wild play a significant role in the food and nutrient security of rural poor and tribals. Some wild fruits have been identified to have better nutritional value than cultivated fruits (Ajesh., 2012)

India has a rich tradition of plant-based knowledge on healthcare. A large number of plants/plant extracts/decoctions or pastes are equally used by tribals and folklore traditions in India for the treatment of cuts, wounds, and burns they use the species/its parts or their suitable crude preparations for treating various ailments. The information reveals the potentiality of the plant in terms of curing wounds, skin diseases, hair loss, muscle pain, diabetes, rheumatism, stomach ulcers and fever. Interestingly, the aqueous extract was used for most of the treatments. The crude extract was biochemically analyzed qualitatively and quantified and confirmed as anthocyanin pigments. The traditional indigenous knowledge-based system particularly associated with the extraction and processing of natural dyes from plants is an ancient process. They have traditionally been engaged in the extraction, processing and preparation of dyes using barks, leaves, fruits and roots of plants (Aswathy and Murugan., 2017)

Medicinal plant studies in India

Traditional herbal medicine is still an important component of human healthcare worldwide. Vast knowledge of medicinal plants has existed in India since ancient times. In the last two centuries, Ayurveda has received little official support and hence less attention from good medicinal practitioners and research must now be done on the botany, pharmacognosy, chemistry,

pharmacology and biotechnology of herbal drugs. There has been a continuous growth of demand for herbal medicines globally. The demand has been increasing as a result of the growth of the human population, habitat loss, alteration, exploitation, overgrazing and deforestation. During the last two decades, some notable progress has been made in the field of medicinal plants and their traditional use in different parts of India.

Human beings have been utilizing plants for preventive and curative health care since time immemorial. The properties of medicinal plants have been described in *Vedic* literature, particularly in *Rig Veda* and *Adharva Veda*, perhaps constituting the first ever written document available in the history of Indian medicine. Ayurveda accomplished its goal by treating the diseases as well as coordinating the body, mind and soul nexus with the help of a vegetarian diet, herbs, exercise and meditation.

Medicinal Plants constitute an important component of the plant resource spectrum of Kerala. Recent analysis shows that out of an estimated 4600 flowering plants in Kerala, about 900 possess medicinal values. Of these, 540 species are reported to occur in forest ecosystems. Over 150 species of plants that are either indigenous or naturalized in Kerala are used in the Indian system of Medicine like Ayurveda and Siddha. The rural folk and tribal communities make use of about 2,000 species of lesser-known wild plants for various medicinal uses. About 60 to 65% of plants are required for Ayurvedic medicine and almost 80% of plants used in Siddha medicine are found in the forests of Kerala. The major medicinal plants obtained from the forests of Kerala are *Asparagus racemosus*, *Piper longum*, *Cassia fistula*, *Azadirachta indica*, *Phyllanthus niruri*, *Aegle marmelos* etc., Only the indigenous people, the Kani tribe, knew of the anti-fatigue properties of the Arogyapacha plant (*Trichopus zeylanicus* ssp. *travancoricus*), which they ate during long treks in the hilly Western Ghats region.

Medicinal plants also called medicinal herbs have been discovered and used in traditional medicinal practices since pre-historic times. Despite tremendous advances made in allopathic medical practices, medicinal plants have played an important role throughout the world in treating and preventing a variety of diseases. Palakkad is a district situated in the Northeast side of Kerala with various species of huge variety of medicinal plants including *Ocimum sanctum*, *Piper nigrum*, *Catharanthus roseus*, *Ixora coccinea*, *Zingiber officinale*, *Capsicum annum* L., *Curcuma longa*, etc., Most common among them is *Murraya koenigii*, *Adathoda vasica* L., *Azadirachta indica*, *Aloe barbadensis* Mill, *Carica papaya*, *Phyllanthus niruri* L., *P. emblica*,

Anacardium occidentale L., *Moringa oleifera*, *Solanum nigrum*. *Chlorophytum palghatanese* is a rare species that was recently found in the grassland ecosystem of Dhoni and Muthikulam forest in the Western Ghats.

Medicinal plants are widely used as folk medicines in Palakkad, mainly because they are readily available and cheaper than modern medicine. Villagers of Palakkad have depended on medicinal plants over modern medicines since ancient times. They have been growing and using medicinal plants for generations. Medicinal plants are a part of the life of the tribal community of Palakkad. It plays a major role in leading their life. Medicinal plants are inseparable from local livelihoods because they have been collected, consumed, and managed through local customs and knowledge.

Area of study

Palakkad, the second largest administrative district in Kerala state, has an area of about 4480 sq. km with a population of 26, 17,482 individuals and is famous for paddy fields and Palmyras. The district lies between 10°15' to 11°15' latitude in the north and 76° and 77° longitude in the east. It is surrounded by the Coimbatore district of Tamil Nadu on the east; Malappuram and Thrissur districts on the west; on the north by Malappuram and Nilgiri (state of Tamil Nadu) districts and on the south by Thrissur district. Palakkad forms a natural gap in the Western Ghats and thus connects the west coast with the Deccan Plateau. The district has two major tribal zones, namely Attappady and Parambikkulam among the seven zones, identified for Kerala.

We conducted this study surrounding the Sree Narayana College Erattakulam campus and associated areas, we collected and identified the plants (Gamble 1969). The medicinal plants are arranged in alphabetic sequence of Binomial name, local name, Family Name, Habitat, Part of uses, method of use, and the disease cured are enumerated.

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Tabular column of medicinal plant

Sl. no	Scientific name	Family	Common name	Habit	Parts used	Uses
1	<i>Abelmoschus moschatus</i> L.	Malvaceae	Kasturi venda	shrub	Leaves, fruit, seeds	Tea made using the leaves are used to cure urinary infection .seeds are made into paste and mix with honey Taking this daily will cure mouth ulcers and sexual disorders
2	<i>Aegle marmelos</i> .L	Rutaceae	Koovalam	tree	Root,leaves, fruits	Having juice of leaves control diabeties root is made into juice and used against ear disease and also having healing properties .leaves are made into paste and apply on the breast of feeding mother will prevent the child from disease.
3	<i>Capsicum annum</i> L.	Solanaceae	Kantharimulakku	shrub	Fruits	Including fruits in the diet regularly will control chloestrol,heartdisease and diabetes.a drink is made using fruits,curry leaves and curd used for digestion
4	<i>Cassia fistula</i> L.	Caesalpiniaceae	Kanikkonna	tree	Leaves,bark	Paste of leaf is used for scorpionbite.apaste made using leaf and rice water is applied on the skin to treat skin disease .decoction of bark is used for stomach pain.oil made using flowers are used for skin diseases.
5	<i>Coccinia grandis</i>	Cucurbitaceae	Koval	Climber	Fruit and tuber	Used against diabetes, jaundice and skin diseases
6	<i>Azadirachta indica</i>	Meliaceae	Veppu	Tree	Leaves ,Flower,Seed	It is Anti-inflammatory, antiarthritic, antipyretic, antigastric ulcer, antifungal and antibacterial.
7	<i>Artocarpus heterophyllus</i>	Moraceae	Plavu	Tree	Leaf, seed and root	To treat rheumatic disorders, ulcer and skin diseases.
8	<i>Biophytum sensitivum</i>	Oxalidaceae	Mukkutti	Herbs	leaves	To treat stomach ache, asthma, insomnia, cramps and chest complaints.

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9	<i>Mimosa pudica</i> L.	Fabaceae	Thottavadi	Herbs	Whole plant	Used to treat eczema, cracks on foot, constipation, insomnia, tumour, blood disorders and urogenital infections.
10	<i>Osimum sanctum</i> L.	Lamiaceae	Thulasi	Shrubs	Whole plant	Cough, fever, gastric distension, and skin diseases.
11	<i>Aloe barbadensis</i> Mill.	Liliaceae	Kattar vazha	Herbs	leaves	For blood purification. Used against skin problems, blood sugar.
12	<i>Ensete superba</i> Roxb.	Musaceae	Kalluvazha	Tree	Seed	Used against diabetes, kidney stone and improving general health.
13	<i>Eclipta alba</i> L.Hassk.	Asteraceae	Kayyonni	Herbs	Whole plant	Rejuvenates hair, kidney and liver.
14	<i>Solanum torvum</i> Sw	Solanaceae	Chunda	Shrubs	Leaves	To treat diabetes, hyper tension, tooth decay and reproductive problems.
15	<i>Adenanthera pavonina</i> L.	Fabaceae	Manjadi	Tree	Leaves and bark	Treat diarrhea and inflammation, migraine, bacterial infections, dysentery.
16	<i>Adathoda vasica</i> L.	Acanthaceae	Adalodakam	Herbs	Leaves	Against cough, cold, head ache, asthma, diarrhea, chronic bronchitis, fever.
17	<i>Abrus precatorius</i> L.	Fabaceae	Kunnikuru	Climber	Leaves and seed	Treat tetanus, prevent rabies and leucoderma.
18	<i>Cassia fistula</i> L.	Caesalpiniaceae	Kanikkonna	Tree	Leaves and bark	Healing of wound and gastrointestinal illness.
19	<i>Capsicum annum</i> L.	Solanaceae	Kantharimulaku	Shrubs	Fruit	Treatment of cough, tooth ache, sore throat, parasitic infection and wound healing.
20	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	Communist pacha	Shrubs	Leaves and root	Healing wounds, anti-inflammatory, analgesics, anti-pyretic, anti-microbial and diuretic.
21	<i>Clitoria ternatea</i> L.	Fabaceae	Shanku pushpam	Climber	Whole plant	Memory enhancer, anti-stress, anti-depressant and sedative agent.
22	<i>Eclipta prostrata</i> L.	Asteraceae	Kanjunni	Herb	Whole plant	Treatment of skin problem, hepatic problems, jaundice, gastrointestinal problems.
23	<i>Clerodendrum</i>	Verbenaceae	Vishnu kireedam	Tree	Leaves	Treatment of diabetes, digestive problem,

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	<i>paniculatum</i> L.					control of yeast infection, vermifuge.
24	<i>Gliricidia sepium</i> (Jacq.) Steud.	Fabaceae	Seema konna	Herbs	Whole plant	Used as a stomach tonic, allergies, asthma, fever and liver problems.
25	<i>Saraka asoca</i> (Roxb) wild	Fabaceae	Ashokam	Tree	Whole plant	Treatment of uterine, genital and other reproductive disorder in women.
26	<i>Psidium guajava</i> L.	Myrtaceae	Pera	Tree	Leaves and fruit	Diarrhea, dysentery, stomach ache and indigestion.
27	<i>Pongamia pinnata</i> L.	Fabaceae	Ungu	Tree	Flowers	Treatment of tumors, piles, skin diseases and ulcer.
28	<i>Phyllanthus niruri</i> L.	Phyllanthaceae	Keezhzrnelli	Herbs	Whole plant	Anti-bacterial, anti-viral, hepato protector and immunomodulator.
29	<i>Phyllanthus emblica</i> L.	Phyllanthaceae	Nellikka	Tree	Fruit	Treatment of diarrhea, jaundice and inflammation.
30	<i>Peperonia pellucida</i> Kunth	Piperaceae	Mashithand	Herb	Roots	Used against fevers, cold, kidney-prostate problems and high blood pressure.
31	<i>Ipomoea obscura</i> L. Kergawl	Convovulaceae	Thiruthali	Climber	Whole plant	Source of anti-oxidant and anti-inflammatory. Used against constipation, burning sensation.
32	<i>Leucas aspera</i> (wild)	Lamiaceae	Thumba	Herbs	Whole plant	Anti-bacterial agent, chronic skin eruption and chronic rheumatism.
33	<i>Hibiscus sabdariffa</i> L.	Malvaceae	Pulivenda	Shrub	Flower	Reduce level of sugar, fats in the blood, reduce swelling, anti-biotic.
34	<i>Cynodon dactylon</i> L.	Poaceae	Karukka	Herbs	Whole plant	Used as a laxative, expectorant, analgesic and treatment of dropsy and syphilis.
35	<i>Centrosema pubescens</i> L.	Fabaceae	Butterfly pea	Climber	Whole plant	To be a good antidote and particularly for insect bite.
36	<i>Asystasia gangetica</i> L.	Acanthaceae	Chinese violet	Herb	Leaves	Used as an anthelmintic and cure for intestinal worm.
37	<i>Anacardium occidentale</i> L.	Anacardiaceae	Kashu mavu	Tree	Fruits and leaves	Anti-inflammatory, anti-asthmatic, diarrhea, warts and boost the immune system.

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38	<i>Ageratum conyzoides</i> L.	Asteraceae	Communist pacha	Herb	Leaves	Against dysentery, diarrhea and it is an insecticide, nematicide.
39	<i>Albizia lebbbeck</i> L.	Fabaceae	Kattuvaka	Tree	Bark	Treating insomnia, tuberculosis and irritability.
40	<i>Jasminum sambac</i> L.	Oleaceae	Mulla	Shrub	Leaves, flowers and root	To treat dysmenorrhea, ringworm and as antidepressant, anti-inflammatory.
41	<i>Myristica fragrans</i> Houtt.	Myristicaceae	Jathika	Tree	Fruit, Seed	Helpful in abdominal pain due to its anti-inflammatory properties.
42	<i>Cenchrus ciliaris</i> L.	Poaceae	Buffel grass	Herbs	Leaves	Reduces body pain, menstrual and urinary infections.
43	<i>Crotalaria pallia</i> Aiton	Fabaceae	Kilukka chedi	shrub	Seeds and leaves	Used to treat urinary problems, gout, pain and swellings, wounds and cuts.
44	<i>Moringa oleifera</i> Lam.	Anacardiaceae	Muringa	Tree	Leaves and bark	Constipation, head ache, immune booster, typhoid and hyper tension.
45	<i>Mangifera indica</i> L.	Anacardaceae	Manga	Tree	Fruit	Used against fever, malaria, cough and typhoid.
46	<i>Tectona grandis</i> L.f.	Lamiaceae	Teak	Tree	Leaves	Sedative, in treatment of piles, leukoderma, hair promoter.
47	<i>Luffa aegyptiaca</i> Mill.	Cucurbitaceae	Potha	Climber	Dried fruit	To remove dead cells and stimulate the skin.
48	<i>Zingiber officinal</i> Roscoe	Zingiberaceae	Inji	Herb	Rhizome	Cold, sore throat, cough, stomach ache and anal ulcer.
49	<i>Carica papaya</i> L.	Caricaceae	Pappaya	Tree	Fruit , flower and leaves.	Intestinal worm infestation, epilepsy and malaria.
50	<i>Lawsoniainermis</i> L.	Lythraceae	Mylanchi (Henna)	Tree	Leaves	Scabies, fungal infection, eczema and hair dry.
51	<i>Amaranthus viridis</i> L.	Amaranthaceae	Cheera	Herb	Leaves and stem	Against Artherosclerosis, stomach ulcers, tuberculosis.
52	<i>Solanum nigrum</i> L.	Solanaceae	Manthakkali	shrub	Leaves and fruit	Medicine for liver and pancreas infection

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53	<i>Gloriosa superba</i> L.	Colchicaceae	Karthika poovu	climber	leaf	To cure asthma, leprosy, skin diseases, bleeding piles.
54	<i>Asparagus racemosus</i> Wild.	Liliaceae	Shatavari	Herb	Roots	To treat dysentery, tumour, blood and eye disorder.
55	<i>Ocimum basilicum</i> L.	Lamiaceae	Rama thulasi	Herb	Leaves	To treat stomach spasms, loss of appetite, intestinal gas and kidney contions.
56	<i>Mentha longifolia</i> L.	Lamiaceae	Puthina	Herbs	Leaves	To treat indigestion, oral care, improve brain power and boost immunity.
57	<i>Bacopa monnieri</i> L. Pennell	Plantaginaceae	Brahmi	Herb	Leaves and stems	Treat snake bites; improve memory power, anti-anxiety medication.
58	<i>Loranthus - Dendrophthoe falcata</i> (L.f.) Ettingsh	Loranthaceae	Ithilkanni	Climber	Leaf, bark	Used for urinary disorders and menstrual disorders.
59	<i>Datura stramonium</i> L.	Solanaceae	Umman	shrub	Leaf, fruit	Used against skin diseases, dandruff, intestinal pain, tooth ache.
60	<i>Thespesia populnea</i> L. Sol. ex Correa	Malvaceae	Poovarashu	Tree	Leaf, bark	Treating for liver disorder, skin disease and urinary disease.
61	<i>Senna occidentalis</i> L. Link	Fabaceae	Ponthakara	Shrub	Leaf, seed	To treat urinary tract disease, diathoea and dysentery.
62	<i>Nymphaea nouchali</i> Burm.f.	Nymphaeaceae	Ambal	Herb	Whole plant	Used to treat liver disorders, heart diseases, diabetes, and dysentery.
63	<i>Hemidesmus indicus</i> L. R. Br.	Apocynaceae	Nannari	Shrub	Root	Treating rheumatism, leprocy, urinary tract and skin infections.
64	<i>Alstonia scholaris</i> L. R. Br	Apocynaceae	Ezhilampala	Tree	Bark	To treat fever, skin disease, rheumatism.
65	<i>Averrhoa bilimbi</i> L.	Oxalidaceae	Irumbanpuli	Tree	Leaves,	Folk medicine used to treat diabetes mellitus

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					flowers and fruit	and hypertension and as an antimicrobial agent.
66	<i>Passiflora foetida</i> L.	Passifloraceae	Pooda pazham	Herb	Leaf and fruit	To treat cough, diarrhea, dysentery and skin disease
67	<i>Jasminum grandiflorum</i> L.	Oleaceae	Pichi	Shrub	Leaf, flower	To treat wounds, gingivitis and skin diseases
68	<i>Bauhinia variegata</i> L.	Fabaceae	Mandharam	Tree	Bark and root	To treat abscess, thyroid and tumours
69	<i>Ficus religiosa</i> L.	Moraceae	Arayal	Tree	Leaf and bark	Used against poisonous stings and bites, skin diseases.
70	<i>Sida retusa</i> L.	Malvaceae	Kurunthotti	Shrub	Leaf and root	To treat rheumatic diseases and diarrhea.

Results and Discussions

This study has highlighted the importance of primary health care, Medicinal plants are inseparable from local livelihoods because they have long been collected, consumed, and managed through local customs and knowledge. Management of traditional therapies is urgent because the therapies are empirically and knowledge-based, often culturally inherited and important to pharmacology and local livelihoods. In addition under favourable circumstances, medicinal plants could be useful components of a development strategy that enhances sustainable rural livelihoods. For medicinal plants with limited abundance and slow growth, destructive harvesting generally results in resource exhaustion and even species extinction.

The traditional knowledge about medicinal plants could be a useful activity for mankind's health and well-being. The local people have incredible knowledge of the medicinal properties and uses maintained in perpetuity through verbal transmission only. Through this effort, the present study has attempted to document and explore the traditional medicinal knowledge of the people inhabiting the Alathur taluk. It was observed that almost all the plant parts are used for medicinal values including roots, leaves, stems, flowers, fruits and seeds. The study also recorded the plants that are used to cure basic remedy properties such as fever, cough, diabetes, stomach ache, and jaundice. Consequently, medicinal plants used in communities are not only vital as an essential part of the traditional medical system of local folks but might also play a significant role as sources of therapeutic drugs in the future. This study showed that the traditional uses of medicinal plants which might be used as positive indicators for the effectiveness of the reported medicinal plants in treating many human ailments and diseases.

Conclusion

This study showed that the traditional uses of medicinal plants which might be used as positive indicators for the effectiveness of the reported medicinal plants in treating many human ailments and diseases therefore the sustainable use of medicinal plants should be considered, and good harvesting practices must be formulated. However, the species that have been used for many decades as traditional medicinal and knowledge accumulated in their utilization over generations will aid in the identification of medicinal purposes. Medicinal plants are inseparable from local livelihoods because they have long been collected, consumed, and managed through local customs and knowledge. Management of traditional therapies is urged, because the therapies are empirically and knowledge-based, often culturally inherited and important to

pharmacology and local livelihoods. Medicinal plants are rich in biological phytochemicals, which have an immense potential to enhance human health also aid in improving diseases. Gathering the present study we can recommend the plants *Capsicum annum L.*, *Azadirachta indica*, *Biophytumsensitivum*, *Aloe barbadensis* Mill (highly wound resistance), *Solanum torvum*, *Adathodavasica L.*, *Phyllanthus niruri L.* with high use value. Medicinal plants can be a good alternative for many diseases and conditions.


The study conducted on the topic of medicinal plants from Erattakulam taluk of Palakkad district, Kerala' at Sree Narayana College and associated areas collected about 70 plants with high medicinal values. Among them, the family Fabaceae shows its domination with 10 members. Families Solanaceae and Lamiaceae are followed by Fabaceae with 5 members each. Malvaceae, Asteraceae, and Lamiaceae are present with 4 members. 3 plants belong to the family Anacardaceae. Rutaceae, Caesalpinaceae, Cucurbitaceae, Oxalidaceae, liliaceae, Acanthaceae, Pyllanthaceae, Poaceae, Oleaceae, and Apocynaceae families are found with 2 members each. The rest of the families including Meliaceae, Moraceae, Musaceae, Bignonaceae, Verbanaceae, Myrtaceae, Piperaceae, Convolvulaceae, Mimosaceae, Zingerberaceae, Caricaceae, Lythraceae, Amaranthaceae, Colchicaceae, Plantaginaceae, Loranthaceae, Nymphaeaceae, Passifloraceae, Moraceae have only single member each.

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Access this Chapter in Online	
	Subject: Medicinal plants
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter: Deepa Kesavan, Arya. C, Ashamol. S, Drishya. D, Jyothimani. C and Sreya. S. (2024). Medicinal plants studies from Erattakulam, Alathur taluk of Palakkad district, Kerala. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 15-30.

Present Status, challenges, Scope and Nutritional requirements of Fresh water and Marine Ornamental fishes in India

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Introduction

Aquaculture is the commercial farming, husbanding and harvesting of economically important aquatic animals and plants under controlled conditions. Aquaculture is playing an increasingly important role in world fishery production. Increase in product and profit is the main goal of aquaculture. Ornamental fish keeping at home is emerging as one of the most popular hobbies in the world. Aquarium keeping is said to be the second largest hobby next to photography in the world. Aquarium fish and accessories industry is fast gaining importance due to its tremendous economic opportunities and prospects. Minimum requirement of space and/or attention compared to other pet animals is the reason for growing interest in keeping aquaria all over the world. Further setting up of an aquarium is relatively inexpensive and can be installed in any location at home, here there is a diffused light (Nimisha *et al.*, 2011). Ornamental fish keeping and their propagation have been an attractive activity for many people in the world, which provide not only aesthetic beauty and pleasure but also financial benefits. Aquarium keeping has become increasingly popular in developed countries. In developing countries including India, keeping aquarium at home is gaining its momentum. The brilliant, flamboyant colour and attractive appearance of certain fishes' appeal to everyone. About ten per cent peoples in the world keep aquarium in their homes. People keep fish in their homes for variety of reasons: for decoration, children's education, enjoyment, good fortune and to collect rare species or even to propagate them. Indian waters possess a rich diversity of ornamental fish, with over 250 indigenous varieties with rich biodiversity hotspots like north-eastern states, Western Ghats, Andaman & Nicobar Islands and Lakshadweep. In addition to the above, many exotic species that are bred in captivity are also being exported from India (James *et al.*, 2003).

About 600 ornamental fish species have been reported world over from various aquatic habitats. Most of them are of small size, having attractive colours. Their movements are gentle and quiet without causing any sound. They have adaptability to live within a confined space in captivity. Naupliar stage of crustacean artemia are widely used in aquaculture as feed for the larval rearing of many fish species and crustaceans. Ornamental fishes are peaceful, generally tiny and available in attractive colours and capable of living in confined spaces like aquarium condition or garden pool. They are often called as 'living jewel' due to their colour, shape, behavior and origin. Ornamental fish production is a multibillion-dollar industry in the world. Initially, developed countries were the major ornamental fish keepers as attractive hobbies but recently it has been gaining momentum in developing countries too as they now contribute about two third of the total export value. Overall it is the growing interest in aquarium fishes that has resulted in steady increase in aquarium fish trade globally. Around 2000 species and 1.0 billion ornamental fish are traded annually, involving more than 100 countries, in the ornamental fish trade but only some 30-35 species of freshwater fish dominate the market. The developing countries continue to be the major source of ornamental fish. The UK is the largest importer of ornamental fish followed by USA, whereas, Singapore is the major exporter. In India, aquarium hobby is about 70 years old. In spite of having immense potential, India's contribution to the international ornamental fish trade is negligible. If the resources are managed properly, India can be one of the leaders of the world ornamental trade in coming years (Keshavanath and Patil, 2006).

This has been well established that aquarium fish can fetch about 100 times more price than the food fish and marine ornamentals are about ten times costlier compared to freshwater fishes. Profitability of an ornamental fish-exporting unit works out to be highly lucrative, provided the activity is taken up on scientific lines with appropriate marketing strategies. The ornamental fish culture and breeding activity is possible not only on large scale but on a small-scale basis as well. It provides good opportunity even to small entrepreneurs. Institutional funding for research and development activities is, however, essential. Commercial banks can formulate schemes for extending financial assistance to prospective entrepreneurs for short-term training programs on production of ornamental fishes. Two of the major areas which require urgent attention are (a) in-house breeding of selected species of marine ornamental fishes which are in great demand to release the pressure on wild capture and (b) scheme for educating/training of fisher folk in more skilled and

specialized techniques of collecting, handling, sorting and transport of ornamental fish which could revolutionize the fishery industry to greater extent.

Present status of ornamental fish farming and trade in India

India is endowed with vast sea coasts, rivers, brackish waters and a variety of freshwater resources. In the aspect of freshwater fishery development, the country has witnessed during the past few decades a tremendous growth. India is blessed with a rich diversity of freshwater fishes both in the North-Eastern hills and Western Ghats. Among the 300 species of freshwater fishes in the Western Ghats, 155 are considered ornamental; of which 117 are endemic to the Western Ghats. At present, only a small fraction of the endemic fish diversity is utilized in ornamental fish trade in the domestic market and major share of ornamental fishes marketed in India are exotic varieties. Even though there are quite a lot of indigenous fishes, having high potential as ornamental fishes, they have not been properly exploited. The fish fauna of the Western Ghats includes variety of barbs, rasboras, killifishes, glass fishes, catfishes, hill trouts, and danios, which are suitable candidates for ornamental fish trade. More than 100 varieties of indigenous freshwater ornamental fish species are known in Indian waters. Some of the species fetch high price in the world market and support trade outside the country. This ornamental fish due to the nature of breeding are broadly classified as live bearers and egg layers. Molly, platy, guppy and swordtail are typical examples of live bearers. Gold fish, barbs, koi carp, gouramies, fighters, oscars, discus, chichlids, gouramies, etc are egg layers (Sargent *et al.*, 2002).

The potential of streams and rivers of the Western Ghats as a rich source of the ornamental fish is yet to be recognized. About 80% of ornamental fishes are from freshwaters and the rest from brackish and marine waters. Most of the ornamental species are warm water tropical except some eurythermal carps like gold fish, koi, which are cold temperate in origin and now having a worldwide distribution. Ninety per cent of the freshwater ornamental species are farmed and wild species through capture are only 10%. In case of marine and brackish water species reverse is the case. The north-eastern states contribute around 85% of the total market and the rest comes from the southern states of India. There are about 58 indigenous ornamental fishes occurring in the North Eastern states are currently being exported. Demand for different indigenous ornamental fishes changes from year to year. Most potential species

from north-eastern states for aquarium fish are *Botiadarario*, *Dania dangila*, *Puntius shalynius* and *Schistura reticulofasciatus*. (Panday and Mandel, 2017).

The ornamental fish exports from India showed an increasing trend and an exponential growth over the years. The share of India in world ornamental fish exports fluctuated and remained less than one per cent for most of the years. India's share in world market ranged from 0.12% to 1.16% during 1991-2009. India gained highest market share of 1.16% during the year 2007. In 2008 it had a share of 0.64% which again declined to 0.33% in 2015 (Van Deer Meeren, 2001).

In contrast to the freshwater ornamental fishes, marine ornamental fishes are the most popular attractions in worldwide due to their adaptability to live in confinement. The variety of shapes, sizes, colours, behavior and ecology exhibited by reef fishes is amazing. In Gulf of Mannar, a total of 113 marine ornamental finfish species have been recorded under 24 families of which the family Acanthuridae, Balistidae, Chaetodontidae, Haemulidae, Labridae, Pomacanthidae, Pomacentridae, Scaridae and Syngnathidae have a very rich biodiversity perspective in Gulf of Mannar.

Conclusion

Aquaculture is an important source of income and employment generation in many developing countries like India. Some of the growth enhancers and immunostimulants increased productivity. Immunostimulants and some of the growth enhancers are increased the productivity and most of them are disease resistant. It is considered to be a priority area of research. For effective use of these medicines' factors such as timing, dosage, method of administration and physiological conditions of fish are important. The trade opportunities of ornamental fishes from India have been recognized by the producers, collectors and traders both nationally and internally. Business opportunities in ornamental fish farming can be realized by production, marketing and wild catch of ornamental fishes. Even though, India is one of the global hotspots of ornamental fish biodiversity but its ornamental fish trade is based mostly on wild collection. To conserve these species and to get economic benefit on sustainable manner, development and due attention is required. There is ample scope to develop entrepreneurship on the indigenous fish and plant species having ornamental value. Apart from the ornamental fish, there is a scope for the development of industry on live food and artificial feed and aquarium accessories required for ornamental fish keeping. More


intensified research and development in both fresh and marine water fishes can lead to development of culture technologies for many species of demand in the aquarium trade in the globe.

There is no proper policy for the development of ornamental fish industry in India, especially in the export trade at present. More initiatives by the government like providing incentive to establish ornamental fish production units, considerable private investment can be attracted to this industry, which would generate additional employment opportunities and improvement of livelihood of the community. With the intensive efforts of all stakeholders, the ornamental fish farming can be developed substantially in the region and thereby will gain a larger share in the global market. Public private partnership can be encouraged through establishment of ornamental fish production units in different parts of the region to make this sector more vibrant and remunerative for employment generation and livelihood improvement.

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Access this Chapter in Online	
	Subject: Aquaculture
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

P. Nimisha and Shameema Kodasseri. (2024). Present Status, challenges, Scope and Nutritional requirements of Fresh water and Marine Ornamental fishes in India. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 31-36.

**Gender Mapping in the World of Disney:
A Comparative Study of *Snow White and
the Seven Dwarfs* & *Beauty and the Beast***

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Abstract

Fairy tales have never failed to amuse us. In our childhood these stories have taken us to an imaginary world where we met many heroines and heroes who have amused and inspired us. These stories are to entertain and also to pass on ideas, thoughts and beliefs from one generation to another. With the popularity of movies in America, we can see that the responsibility of moulding young people was taken up by movies. Disney Movies are actually adaptations of famous fairy tales and folk tales that are passed down to generations. When the stories told by our grandparents led us to the world of imagination, Disney Productions reinforces those ideas and visualizes our imagination there by performing the dual function of entertaining and educating at the same time. The purpose of this study is to analyze two popular Disney movies according to the major organizing principles of society: gender and sexual orientation. This study also focuses on finding an answer to the question why gender stereotype is popular as a topic of discussion and why Disney Company purposely makes movies that highlight gender stereotypes. Disney movies are accused for functioning as a tool for gender appropriation, and also for reinforcing the idea of gender stereotypes. By interpreting the two popular Disney movies *Snow White and the Seven Dwarfs* and *Beauty and the Beast* in the light of the theory of Gender studies, this chapter focuses on analyzing how far this accusation against Disney Movie Studios is true, and it also researches about why Disney movies commonly exhibit such kind of a pattern. The scope of this study is limited to these two movies as both stand as replica of two different time periods.

Keywords: Gender, Stereotypes, Patriarchy, Disney Movies, Fairy Tales

Introduction

Fairy tales not only guide us to be the best version of ourselves but also connects us to the nature, and also to the world that is beyond our imagination. It also portrays the importance of relationships, friendship with animals and many other related topics. The darker elements in some tales often reveal the elements feared within to be precise these tales work upon the fear of the unknown that all of us instinctively possess. Hollywood was the birthplace of movie studios, which were of great importance to America's public image in the movie industry. The earliest and most affluent film companies were Warner Brothers Pictures, Paramount, RKO, and 20th Century Fox, each of whom owned their own film production sets and studios. From its origins in the 1920's as a cartoon network, the Walt Disney Company has become one of the five biggest media groups of the world, with products ranging from movies, television shows, and other media programming to a global network of theme parks and a variety of consumer products.

With this paradigm shift from tales to movies, 'Disney' became a major topic of discussion among people in the society. A lot of discussions and debates aroused and people began to think about how these Disney Movies influence their children in moulding their beliefs and attitudes. The first film was a massive success and to Bollywood's shock *Snow White and the Seven Dwarfs* received glowing reviews, and to the shock of the Disney staff, the film received a standing ovation at its premiere at the Carthay Circle Theatre in December, 1937.

The role of Disney in propagating patriarchal values is often questioned. Almost all Disney Movies are said to be made in a way that reinforces the idea of gender stereotypes. The word 'stereotype' is defined by Merriam and Webster's online dictionary as, "to believe unfairly that all people or things with a particular characteristic are the same." The messages conveyed by fairy tales are given an animation or live-action representation in these movies. Themes like true love, sacrifice, family, relationships etc. can be identified commonly in both movies and tales. As an addition to these characteristics Disney Movies has also been a guide for women that teaches them how an ideal woman should behave in all walks of life.

We all live in a society that embraces patriarchal values directly or indirectly. This system has been in practice from the very olden days. Gender stereotype is actually a social construction that is prevalent even in this twenty first century. The male dominated society imposed some random rules and regulations on women in the society by considering them as less capable than

male gender in all aspects. Even if this twenty first century seems like a modern world in which we all have acquired gender equality, but still in some corners of the world women are considered as inferior to men, and in many real life situations we can witness the shadow of patriarchal domination on women.

The study of gender focuses on these societal constructions and how these rules and regulations put forward by the male dominated society impact women. M H Abrams and Harpham in their work, “A Glossary of Literary Terms” defines gender studies as:

Gender studies is based on the premise that, while sex (a person’s identification as male or female is determined by anatomy, gender(masculinity or femininity in personality traits and behavior) can be largely independent of anatomy and is a social construction that is diverse, variable, and dependent on historical circumstances. Gender criticism analyzes differing conceptions of gender and their role in the writing, reception, subject matter, and evaluation of their literary works.(147)

Media is used as a medium to propagate age old beliefs and ideas. Disney movies particularly target young generation as they will be amazed by the grand presentation and also these rules and norms will stick on to their minds. Disney movies influence children to a great extent. It shapes their attitude and behavior, and teaches them how to face certain situations in life.

Snow White and the Seven Dwarfs: Reinforcing Gender Stereotypes

Snow White and the Seven Dwarfs, the world’s first animated full-length feature film, released in 1937, that established Walt Disney as one of the world’s most innovative and creative moviemaker, the plot of this movie is loosely connected with Brothers Grimm’s fairy tales. Apart from the factor of entertainment this movie has a lot of underlying meanings that reinforce the patriarchal norms and values that were prevalent in the society. The movie featured a heroine who fits the domestic expectations of pre-World War Second women. It was also an escape route from the Great Depression of that time.

As the plot of the film unfolds we can see the princess Snow White eagerly waiting for her prince charming to find her. The beautiful and kind hearted princess Snow White charms every creature in the kingdom except one- her jealous stepmother, the Queen. When the magic mirror proclaims Snow White as the fairest one of all, she must flee into the forest, where she befriends the lovable seven dwarfs- Doc, Grumpy, Happy, Bashful, Sleepy and

Dopey. But when the Queen tricks Snow White with an enchanted apple, only the magic of true love's kiss can save her.

It is necessary to understand the societal conditions during the time period so as to analyze how far this movie is capable of reflecting the society and its values and as well as its true colors. The World Wars were fundamental in reshaping America's expectations for its women. During World War First it had become clear that women and men could work together to achieve war time victory but as soon the War ended women had to return to their places in the home and men returned to reclaim their jobs.

This idea of women's world limited within four walls is visualized in this movie. Women must do the household chores and men must engage themselves in hard labor to earn money, these are the well-known gender roles assigned to both genders. Gender roles are a perceived set of behavioral norms usually associated with males and females in a given social group or system. They allow individuals to refer to certain attitudes or behaviors that class a person's stereotypical identity. This concrete behavior of individuals is a socially enforced rule and value as well as being individual's disposition, genetic, unconscious, or conscious. Gender roles are often conditioned by household structure, access to resources, specific impacts of the economy and other local relevant factors. V. Geetha in her book "Gender" discusses about this in the chapter 'Role Play':

The third set of arguments accepts that men and women may be innately different, but does not grant this fact is particularly pertinent. Masculine and feminine modes of behavior are relevant in as far as they reflect social expectations. Men and women enact different roles, because society expects them to act in these ways and reward them if they do, punishes them if they do not. (47)

In the movie one can see that two genders are portrayed differently in terms of their roles. Male characters are more prominent and have a recognizable job, more independent, assertive, brave, responsible, and stronger than the female characters whereas the central character, Snow White, is portrayed as weaker and easily controllable by others. She is emotional, gentle, naïve, romantic, affectionate, sensitive and passive than male characters.

Snow White, the central character, sings and happily does all the household works as if she likes doing it and not as something that she is compelled to do. The evil Queen, her stepmother, has denied Snow White all pleasures of a princess but still Snow White is happy and content with her life.

Instead of searching for a way to get out of this slavery she dreams of a charming prince who will come in search of her and her ultimate aim is to be loved by her male counterpart, not freedom or identity of her own.

Snow White is assigned a passive role throughout the movie. In the beginning she sings her dreams to the wishing well that a charming prince should come to her as she is not capable of going in search of him. When the Queen orders the huntsman to kill Snow White, the huntsman commands her to run into the woods to save her life and to come back never. Snow White never takes a single decision of her own. She always expects someone else to protect her.

As per the assumption of patriarchal society women are unable to protect themselves and men, the so called 'saviors' protect women from dangers and women have to depend on men throughout their entire life in order to lead a content and happy life. This general idea that was prevalent in the society is implied through the passive role assigned to Snow White. This idea is reinforced in the movie in the scene in which Snow White gets trapped in the middle of the forest. She becomes scared of everything around her simply because she is all alone. She has to face a lot of difficulties in the forest. Everything that is strange scares her because she is merely a woman who is not capable of exploring the forest bravely.

Here the idea behind the portrayal of Snow White as uncomfortable and scared is to convey the idea that a woman is not safe in a world outside the four walls of her home. The prince in the end of the movie also plays the role of savior as the sleeping dead Snow White can be brought back to life only by a true love's first kiss. So throughout the movie without the help of male characters things would have become much worse in the life of Snow White. Even if the fault is not hers she has to face the difficulties which depict women as victims of everything bad that could happen in the society. Her helplessness further elaborates the concept that a woman cannot exist without a man.

The roles played by men are in contrast to that of the women characters. They are brave, hardworking, saviors and superior to women. In this movie the first male voice that appears is that of the magic mirror. The evil Queen asks "Magic mirror on the wall, who is the fairest one of all?" (2:53). The evil Queen is a witch who can perform magic tricks and can even change her disguise as she did to give the poison apple to Snow White. But still she seeks the opinion of a male voice in order to confirm that she is the most beautiful woman. This is the first instance where we can see the dominant role played by men. Even if

the Queen thinks of herself as powerful, she subconsciously depends on the male mentality of beauty in order to convince herself.

To the question asked by the Queen the mirror answers, “Famed is thy beauty, majesty. But hold, a lovely maid I see. Rags cannot hide her gentle grace. Alas, she is fairer than thee” (3:00) – this is the root of all problems faced by Snow White in the movie. It is true that the Queen is evil, but it is the opinion of the mirror that makes her to decide to kill Snow White.

Secondly, the prince is portrayed as manly, brave, attractive and dominant. When he listens to Snow White’s song he directly approaches her whereas Snow White runs away as she is too shy to speak to him. She thinks that as she is in rags, she may appear ugly and so she becomes afraid of not being loved by the prince and hides herself behind the door. Here bravery is attributed to the prince whereas coyness to Snow White because this is how things should happen or this is how both genders are supposed to behave according to the rules and norms of patriarchal society. Next is the case of the huntsman, the Queen orders him to take Snow White into the woods and to kill her. Huntsman appears as a savior of Snow White. He becomes unable to kill Snow White because of her innocence and so he commands her to run away for her life and to never come back.

Another important portrayal of the dominant male attitude in the society is through the characters of seven dwarfs named Doc, Sneezy, Grumpy, Happy, Bashful, Sleepy and Dopey. These seven dwarfs are the exact representation of patriarchal voice. They engage in mining diamonds which requires hard labor. Even if these dwarfs are presented in a comical angle still traces of male virtues can be seen in them. They bravely go upstairs to see if it is a monster that has trespassed into their house. Even after knowing that Snow White is the princess they allow her to stay only when she says, “And if you let me stay, I will keep house for you, I will wash and sew and sweep and cook” (38:49). On the next day when the dwarfs go to work they warn Snow White to stay alert and to beware of strangers. And Grumpy says, “Now I’m warning ya. Don’t let nobody or nothing in the house” (1:07:34). The point is that Snow White interprets these commands from the dwarfs as the care that they have for her and not as overpowering dialogues of the dominant male. This is how the society has taught her, to interpret everything men say as for her own good as they are the ‘saviors’ of women.

The image of female characters is divided into two: ideal and evil. Snow White is presented as the ideal woman because not even once she questions the authority that others impose upon her. She without being hesitant

adheres to every single command given to her. She dutifully does the household works at her own home and also in the house of dwarfs. She immediately runs away when the huntsman orders her to run away for her life without even thinking about what to do next. As a contrast to Snow White we have the evil Queen. She treats Snow White like a maid and takes the power in her own hands despite of asking for permission from the King. This ambitious and cunning nature of the Queen is the very reason for her doom.

Curiosity is presented as a vice for women and virtue for men. According to the norms of the patriarchal society, if a woman does not accept her patriarchal gender role, then the only role left for her is that of a monster. And as a consequence for misbehavior the Queen falls off from a cliff and dies; the perfect reward for her curiosity and cunningness.

An interesting fact about the movie is that Disney has presented no men as villain. The evil Queen is the only villain character. Jealousy is presented as the root of all evil in women. The society wants women to be patient, sacrificial, content and happy with what they have so that those women who complain to male about what they lack are also presented as bad manners. The Queen orders to kill Snow White because she is jealous of Snow White, who is more beautiful than her. It is this jealousy that tempts the Queen to cross her limits and as a result she achieved nothing but downfall. And so without directly saying that being ambitious, cunning, smart are not meant for women, the movie portrays it through an angle of presenting Snow White as ‘good’ female character and Queen as ‘evil’ and destined to doom whereas Snow White lives happily ever after with the prince.

Female rivalry is presented as a characteristic feature of evil female character. It is always believed and heard in almost all fairy tales like “Cinderella” that a woman who comes to the position of second wife is always evil and develops a rivalry towards other female in the family. It is presented in movies as it is something that is inherent in the character of a woman.

Disney is creating visual representation of ideal beauty. Movies capture our attention by visualizing our imagination. Our concept of princess that took shape from fairy tales is visualized in Disney movies. Princesses are narrated as fair and beautiful in fairy tales. The way they dress, the way they speak, their naïve expressions and a lot more characteristics that are assumed to be the qualities of ‘beautiful’ women are depicted in this movie. Even though Snow White is said to be in rags as she is reduced to the position of a maid by her stepmother, when she goes out of the palace with the huntsman we can see her in beautiful dress and in ornaments as well. Her slim figure with prominent

chest, thin hips, red lips and fair skin is the ideal beauty code set by the male dominated society.

The concept of marriage and 'happily ever after' are the only dreams that the society allows a woman to have. And so like Snow White all women in the patriarchal society are not even aware of the world that exists beyond the four walls of their home. Throughout the movie Snow White remains as a flat character, the one who never attains any maturity or gain any enlightenment from the experiences she had.

This movie not only talks about how patriarchal society sees women, it also presents the condition of the society and how women were treated in a male dominant world. The society sends the message that to achieve greatest happiness, women must be physically attractive, obedient and submissive. In all these aspects it can be understood that *Snow White and the Seven Dwarfs* is a movie that reflects the society along with reinforcing the gender stereotypes that were prevalent during that time.

Beauty and the Beast: Breaking the Stereotypes

An American musical romantic fantasy film directed by Bill Condon, *Beauty and the Beast* is a live-action retelling of the studio's animated classic, released in 2017 and screenplay written by Stephen Chobosky and Evan Spiliotopoulos and co-produced by Walt Disney Pictures and Mandeville Films. The movie is an adaptation of Jeanne Marie Leprince de Beaumont's eighteenth century fairytale.

The movie revolves around Belle, who lives in a small town with her father, but does not fit in with her community. Belle dreams of venturing out into the world and getting more out of life. One day, her father gets lost in the woods and is captured by a beast in a castle. Belle sets out to rescue him and ends up sacrificing herself for her father's freedom. Over the course of her imprisonment, Belle starts to develop feelings towards the Beast. When she is allowed to return home to help her father, the villagers organize a hunt for the beast after hearing of him. Upon that, Belle returns to the castle to help protect the beast. She ends up expressing her love to him and a curse that was cast upon him is broken, turning him back into the human prince that he used to be and, again, they 'live happily ever after'.

As a latest addition to the Walt Disney collections, that are actually adaptations of famous fairy tales, this movie shows some deviation from the traditional movies by Disney productions. In order to analyze how this

particular movie stands apart from other Disney productions it is essential to carry out an in depth analysis of the movie.

As a movie that is released recently and indeed as a one that gained wider acceptance and appreciation from audience, this movie is actually a reflection of gender stereotypes and its progression over time. In this movie we can find that gender images have evolved to match the changes that have occurred in the society. Reviews about the movie highlights the character of Belle (Emma Watson) and how she represents a woman of the modern world. The character 'Belle' is treated as a revolutionary character, someone who is totally new to the world of Disney.

The best way to know the difference between Belle and other Disney heroines is by focusing on the way how women are portrayed. Almost all heroines in Disney movies are princesses who are gentle, naïve and obedient to the rules and norms of the society. These princesses never dare to or to be precise they never even think of questioning society and the rules that have chained them. In the history of Disney movies indeed Belle is a revolutionary change brought by the company. Other infamous pathetic heroines like Cinderella, Snow White etc. are the so called ideal women characters presented by Disney.

The character of Belle is a sensible, confident and outspoken girl from a quiet village. Her personality breaks away from previous stereotypes of Disney characters. She is venturesome and dreamy intellectual of the village. A song in the movie depicts the attitude of the people in village towards Belle. They are of the opinion about Belle that she is, "Never part of any crowd because her head is up on some cloud" (6:10).

Belle is introduced in the movie as an interesting female character that inhabits certain 'unfeminine' traits and subsequently is being marginalized by the rest of her community as a strange 'other'. She is the one who stands apart from the category of the so called ideal women. Belle exhibits a kind of dissatisfaction with her life and she expects a lot more than the normal village life.

Throughout the movie Belle is disobedient to men around her. This trait is actually new for a heroine to have. Belle breaks the stereotypical portrayal of women and represents woman as who she really is and as something that the society wants her to be. Many instances can be pointed out from the movie to substantiate this argument. Even though Belle is being criticized by everyone around her she still chooses to be herself than changing for the sake of

acceptance from the society. For instance Gaston tries to convince Belle to marry him, not that he loves her but simply because she is the most beautiful girl in the village. Here Belle stands against the idea of seeing her as an object of beauty and rejects the proposal of Gaston thereby turning down the age old belief of woman as an object that is to be adored. She even refers to Gaston as brainless. When the elders in the society try to stop Belle from teaching little girl to read Belle never listens to them. Towards the end of the movie when the whole society calls Belle and her father insane, she proves them wrong and stands against the whole society by showing the Beast on the magic mirror.

Allegations from the society never lessen Belle from what she really is. The attitude of society towards Belle is actually a reflection of how the conventional society looks up on a modern woman. As exactly as it happens in reality in the movie as well the whole society comments Belle in all the negative aspects as possible. People in the village calls her strange and distracted. Belle is actually a puzzle to the rest of the people in the village. All of them admires that she is a beauty but at the same time calls her 'odd'. It is only to Gaston she seems 'strange but special' an object of beauty that he wants to possess the song in which people speak about Belle exemplifies nothing but the collective reaction of the society to a woman who wishes to live a life of her choice. When she rejects Gaston, he tries to scare Belle by explaining to her life after the death of her father. Gaston's dialogue reveals how society tends to scare women by pointing out the insecurities she would feel without a man in her life. Belle never gives priority to what others say about her. This attitude of Belle towards society in general reflects that the only way for a woman to be herself is by ignoring the rest of the world.

To answer the question, 'What makes Belle the different one?' one has to analyze the characteristics attributed to her character. Unlike other women in the society Belle dared to dream and that made all the difference. Belle never let the opinion of others intrude her freedom of being herself. According to her, freedom and choice are the basic needs of an individual and thus she never does anything against her will in the movie. When the beast asks her is she happy in the castle, she replies him in a question, "Can anybody be happy if they are not free?" (1:28:16). This signifies the importance that she gives to individual freedom and personal choice in the pursuit of happiness, rather than simply needing love. She is a lover of adventures and the books she read suits her interest. Education to an extent has helped her to become what she really wants. In the movie Belle visits the library and says to the librarian Pere Robert, "Thank you, Pere Robert. Your library almost makes our small corner

of the world feel big.”(6:52) It is through the books she read that she understood that there is a world outside.

Her confidence and courage makes her totally different from other women in the society. Even when the whole society considers her as ‘odd’ she believes in herself and never tries to change. Her braveness is revealed in the scene in which she encounters the beast. She dares to stand in front of the beast that is a nightmare to the whole in the village, she even asks him to show his face to her. Without any fear she locks herself in the prison to save her father’s life. None of the other Disney princesses has ever dared to do such a thing as all of them were passive and totally obedient to and dependent on male.

Belle’s nature is revealed more when the beast enters her life. Even though it is the beast that makes Belle a prisoner, she never behaves as a slave and is always ready to fight with the beast to regain her freedom. Throughout the movie Belle not even pleads or cries. In spite of accepting what has happened to her, Belle plays the role of an active heroine in the movie. She tries different ways to escape from the castle unlike other Disney heroines who simply accept what has happened as their fate. Beast in the beginning behaves rudely to Belle but without being afraid of his anger she yells back at him and even rejects his offer to dine together.

The way in which Belle reacts to the beast even after realizing that she is a captive clearly makes us understand of her courage. Unlike traditional heroines Belle undergoes a lot of challenges and what is to be highlighted is that she bravely faces any hardships that come through her way. For instance in the movie she fights with the beast and escapes from the castle and in the forest she has to face some dangerous wolves as well.

Another important deviation in the character of heroine is that she is the one who is destined to save the life of the Prince by breaking the spell casted by the enchantress with her kiss. She plays the role of a savior, in fact the first woman character by Disney without whom ‘the happily ever after fantasy’ would not have become possible. All these instances from the movie prove that Belle is truly a character that is quite different from the other heroines. This also proves that the character of Belle to an extent breaks stereotypes of gender and she also is a representation of those women who dared to see beyond the four walls of patriarchy.

The relationship between Belle and her father, Maurice, is another important deviation in the movie. Maurice stands out from the patriarchal mindset and as a loving father he encourages Belle to be herself. As an

inventor of clocks and also as an artist Maurice is presented as an intelligent man in the village. Belle is presented as equally intelligent as her father. She even invents a machine to do laundry but was ruined by the men in village. Maurice is a character who is tormented by the past because of the death of his wife. He raised Belle all by himself in a society which says that only women can raise children. As a successful father he knowingly or unknowingly breaks the stereotypes and encourages Belle to do the same.

Conversations between father and daughter signify how deep and valuable is their relationship. May be without a father like Maurice, Belle actually couldn't have become the real Belle. Belle asks her father whether she is really 'odd' as people say for that he replies that, this is a small village and hence small minds. He tells Belle the story of her mother who was different and mocked at by villagers till one day when all of them started imitating her. Unlike a conventional father who wants his daughter to fit in the society, Maurice actually does not instruct Belle how to be a dutiful and ideal woman. Instead he comes up with the concept that people will always criticize no matter whether you do good or bad.

The image of male characters is presented in a way that is different from other conventional movies. In this movie we can see reversal of roles. Instead of presenting woman as a villain here Gaston is the one with evil thoughts and motives. Beast is another central character in the movie. In the beginning of the movie the story of a prince who was turned into a beast by an enchantress is narrated. An old lady came to his castle seeking shelter from the storm and as a gift she offered him a single red rose. He laughed and mocked at her by seeing her physical appearance. For this the old lady warned him not to be deceived by appearances, for beauty is found within. The prince was not ready to listen to her words and when she turned into a beautiful enchantress he asked for forgiveness but there was no love in his heart. As a punishment she turned him into a hideous beast and cursed everyone in the castle with a spell.

The prince is presented as an evil character who was selfish and unkind. The beast behaves rudely to Belle in the beginning. Even if the beast is a giant and powerful male figure, he can free himself from the curse only if he receives true love. Here the beast is male but vulnerable and dependent on a woman to get back his normal appearance. Gaston is the villain and he is the representative of the ideology and mindset of the male dominated patriarchal society. Even though everyone respects Gaston he is presented in a funny manner and Belle calls him brainless and rejects his offer to marry her. So here the male villain is powerless and doesn't play a major role in the movie. Other

male characters are the talking Candelabra and the Clock in the castle. They behave nicely to Belle because they think that she is the one who could save them and get back them their human form.

Almost all male characters revolve around Belle and without her the male characters have no existence in the movie. Female characters in the castle express a positive attitude towards Belle and her decisions. Mrs.Pott, the enchanted teapot, is an efficient maid and a maternal figure who feels affection for Belle. They never criticize her and find positive aspects in what she is doing. For instance the talking teapot appreciates Belle by saying that it was a very brave thing that Belle did for her father. Throughout the movie we can see Belle playing the role of savior. She saves the beast from the curse and even loves him and becomes his 'forever'. In the movie when the wolves attack Belle, it is the beast that saves her. This 'saving each other' scenes indirectly reveals the concept that men and women are interdependent on each other.

Although the movie in many ways breaks the stereotypes of gender through the character and plot still we can see a lot of underlying conventional ideas in the movie. Belle reads books that are appropriate for her gender. Her favorite book, the one she couldn't put down is a story of far off place, having daring sword fights, magic spells and a prince in disguise. Although she does not like the life that she is currently living she is, like every other woman, more inclined towards topics that are light and romantic. She cannot be considered as a character who disrupt the gender roles or question the stereotypes but still the village calls her 'odd' and 'different from the rest of us' because she has got some traits that are absent in women those who are defined as ideal in the male dominated society.

We can also see that Belle's stubborn nature did not last that long. The independence and intelligence Belle had before meeting the prince seems to have evaporated when she finds that something in him that she didn't see. Without any second thoughts she lets go of her anger, her strong and rational mind only to become an overly nurturing and self-sacrificing bride for the prince in disguise of a beast simply because he saved her life from the wolves by sacrificing his life. Here Belle turns out to be an example for the patriarchal society to teach girls to forgive the unforgivable.

To an extent Belle is resistant to the beast's abuse by yelling back at him but still knowingly or unknowingly she happens to develop a soft corner towards the beast. She ultimately changes the beast and forgives his abusive behavior, without him ever apologizing. Certain critics point out that Belle is

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having Stockholm syndrome, intense bonding with one's captors in order to develop identification with the aggressor.

The movie indirectly focuses on the expectations of every woman from a man and instructs men to behave so in order to conquer her heart. For instance in the movie Mrs. Pott advises the beast in order to impress Belle. She asks him to be gentle, calm and kind also to give her a dashing smile as these are the ways to attract a girl, things that she will definitely fall for.

We can also see hidden elements that reinforce the idea of social norms and that keep binary gender system in place. Example is the distribution of roles and signification of gender among the living objects within the beast's castle. The clock and candelabra are the male characters whereas teapot, wardrobe and a cleaning duster are presented as female characters. When Belle complains about the beast's behavior to the talking teapot, it replies that master is not as bad as he seems. Indirectly this conveys that men are allowed to be angry and it is a part of their character. This in a more broad sense reveals the idea that 'boys will be boys'.

In the beginning of the movie there is a dialogue, "For who could ever learn to love a beast?" for which we get an answer in the climax, that of course only a woman can learn to love a beast because she is the one who is taught from her very childhood that being kind and adjusting yourself to the situation will make you the ideal one.

The idea presented here is not against gender stereotypes. It simply reveals that women should be given the opportunity of taking on a variety of roles. However, a woman should not be looked down even if she chooses to be a traditional woman like Belle. The essential idea that is revealed here is that her position should be based on personal freedom and choice, rather than being motivated by ideological and oppressive social systems. These explorations and alterations can be seen as reflecting the changes in the ongoing social debate on gender and a changing social climate.

Conclusion

Snow White and the Seven Dwarfs and *Beauty and the Beast*, are movies in which we can see multiple dimensions of gender stereotypes. Nevertheless these two movies are released in two entirely different time periods; still we can see a lot of similarities between them. The concept how a woman should behave has been in practice from the very olden times. A woman was considered as a care taker of the family and in course of time even if the attitude towards this concept began to fade a little still the society hasn't

changed as a whole. The sad truth is that even women in the patriarchal society believe that this is how things should happen in the society. And so they train their daughters to follow the rules and regulations put forward by the male dominated world. Girls, knowingly or unknowingly, develop an understanding in their minds about what are the dos and don'ts that makes one an ideal woman in the society.

By analyzing the heroines of these two movies we can see clearly their similarities and differences as women of two different worlds but still these female characters show similarities in certain aspects. Both heroines dream of a prince charming, and the prince they have in their imagination is a male stereotypical character who is brave, with a muscular body, loving and caring etc. All they need is someone to protect and love them forever. Belle and Snow White are in search of their better half till the end of the movies and they consider this search as the purpose of their life.

Disney movies are accused of being sexist and it is also said to be as a medium for reinforcing gender stereotypes through characters. Starting with Snow White, Disney productions has introduced a lot of heroines like Cinderella, Sleeping beauty etc. All those princesses are the reflections of how a woman is being treated in the society. The recent character by Disney is Belle, the one who subverts the portrayal of women in movies. Even though before Belle we have characters like Jasmine in Aladdin, Belle is the first woman who stood as a central active character from the beginning to the end of the movie.

So far we saw how similar are heroines of two different periods because of the similarities that they live in the patriarchal society and because they belong to the category women. One can find a lot instances in the movie where Belle stands out from the patriarchal mindset and becomes an active woman who fights for freedom and identity. These differences between Snow White and Belle, and also many visible differences in the plot of the movies makes it clear that Disney was not actually being sexist but was only reflecting what was happening in the world.

Comparing the characters of these two movies, Snow White and Belle, we saw a lot of similarities between them but with that we cannot arrive at a conclusion that Snow White and Belle are the same. Snow White is a passive, dependent, vulnerable woman who fits in perfectly in the male dominated world. Snow White neither takes decisions of her own nor fights for freedom and identity.

The roles assigned to these two characters are also different. Snow White throughout the movie is treated as an object of beauty by everyone. It is her beauty alone that is being praised but not her identity. All she has to do is obey the male characters those who protect her. Being an obedient girl Snow White receives everything that she ever dreamed of: a happy life surrounded by people who love her and the Prince of her dreams. In contrast to Snow White, Belle is assigned an active role. She even appears twice as a savior. She fights for freedom, stands strong in her opinion, never sacrifices her identity for anyone and till the end she believes in herself. So Belle is the image of a modern woman who struggles to break the barriers and chains imposed upon her by the male dominated society. Even though Belle shows some conventional feminine characteristics one can find more of a modern woman in her than of a conventional one. Accusation against Disney movies as sexist does not stand a chance in the portrayal of Belle as she is presented as a brave woman who achieves freedom and true love in the end.

Comparing *Snow White and the Seven Dwarfs* and *Beauty and the Beast*, we can see the emergence of a new kind of Disney movie in which female characters are portrayed as equally important and talented as male characters. By challenging the old stereotypical roles assigned to women *Beauty and the Beast* has brought about a revolutionary woman character who struggles against all odds to stand on her own. Certain overlapping aspects can also be seen in these movies because of the fact that we cannot retrieve ourselves from the age old traditions and conventions, as all of us are mentally programmed to follow them from our very childhood.

From a detailed analysis of these two movies it can be understood that both movies show significant changes while also maintaining similarities when it comes to the representation of gender. The topic 'gender stereotypes' to this date hold priority in the list of the most discussed and debated topics. This concept of gender has been practiced and propagated from time immemorial. Patriarchal system and its impact upon women is another topic that holds equal priority as the former one. No one has been successful in finding the roots of this discrimination on the basis of sex that is prevalent in the society. Who created gender and who decided that men is superior to women continues to exist as a million dollar question. The discrimination based on the concept of gender has indeed created a lot of problems like inequality, powerlessness attributed to the female gender etc.

Society has constructed a web of such ideas about gender. As it is gender that shapes ideas, morals, values and opinions of an individual, knowingly or unknowingly we all have this inherent inclination towards gender and its practices. As per the definitions of gender and sex, it can be understood that sex is biological orientation whereas gender is a social construction. From this we can understand the fact that we are born as male or female and it is the male dominated society that chained human beings by inventing a new word called 'gender' and role that are corresponding to it. These social constructions are certain beliefs that are blindly instructed and propagated by the male dominated society in order to prioritize male gender over female.

Gender plays a massive role in the working of a society. Power relations between men and women are artificially woven in order to balance the gender order, which is a patriarchal system of ideological and material practices that are propagated by certain individuals in the society. It is this order which is maintained by the society, is represented in Disney movies though we can witness some changes in the representation over time.

In *Snow White and the Seven Dwarfs* this gender order is strictly followed whereas in *Beauty and the Beast* we can see deviations from this stable order that has been in practice since early centuries. An exact representation of what is going on in the society is what we observed in the two selected movies. *Snow White and the Seven Dwarfs* gives us a picture of the 1930's whereas *Beauty and the Beast* gives a picture of twenty first century. By choosing two movies that can be clearly located at two different points of time, one can clearly point out the changes that happened in the society in course of time. These movies are indeed an exact reflection of what is happening around or what is going on in the minds of people who live at that particular point of time.

Changes take time, this is the fact that we arrive at by comparing and contrasting the selected movies. This is indeed a tactic of Disney productions to release movies that match exactly with the attitude of the society. A detailed analysis of the plot made us realize that time has brought some serious changes in the way people think. Even though it has not altogether changed the mentality of the society as a whole, one can still find that in course of time the role played by gender stereotypes began to change its track at least to a little extent. Belle is indeed an example that can be given to substantiate this argument. She has got some conventional traits but indeed she is a new version of female heroine, someone who is very different from characters like Snow White, Cinderella.

This analysis not only reveals slight variation that has happened to gender roles but also portrays how people of two different centuries perceive life. Lives of characters in *Snow White and the Seven Dwarfs* such as Snow White, Prince, and Queen etc. revolve around the normal mundane activities of life whereas the characters in *Beauty and the Beast* diverge from their routine and focus on invention, exploring, adventures etc.

Another argument that this chapter puts forward is that Disney movie productions is not sexist. But one cannot deny the fact that they do propagate gender stereotypes indirectly. Accusing Disney movies as sexist is something that can be read in every single review written by film critics whenever Disney productions release a movie. Other movies of Disney productions also had to face similar questions like why are characters so obsessed with the looks of heroines, why does not Cinderella have any talents or hobbies, and why does not Sleeping Beauty do anything besides get drugged and await rescue etc.

Basically movie companies release movies that will attract the interest of audiences. And the best way of gaining recognition is by producing movies that match the ideas and opinions of people. When a movie portrays something that is unacceptable in the society its reputation will be ruined and no matter how good the content is no one is going to watch or appreciate a movie that is 'odd' in their view. So, one can clearly see that Disney Productions is clever enough, as they played smart in order to gain popularity. If *Beauty and the Beast* was released in the 1930's, may be no one would have even cared to watch it, but in this twenty first century where women struggle to break the chains people will be able to connect this idea to what is happening around.

After recognizing this fact we can comprehend that Disney productions is not trying to make some revolutionary changes but is simply representing or reflecting the society and its true colours as it is. It is more like a marketing technique put forward by Disney productions because all they want to do is make money by matching popular interests. The main intention of movie makers is to entertain the audience and they also try to convey a message that is relevant in that particular society. Through the movie *Snow White and the Seven Dwarfs* the necessity of a woman to remain passive in order to look beautiful is conveyed whereas in *Beauty and the Beast* the message is about the struggles a woman undergo to free herself from the clutches of the society. The pattern in which Disney Company makes movies has not changed but the world has.

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By analyzing the two selected movies through this lens, it can be understood that, what Disney Productions is trying to do is to reflect the common mentality of people. People are partially unaware of the fact that knowingly or unknowingly we adhere to these age old beliefs and gender stereotypes that are ingrained in our minds. Before accusing Disney for presenting movies that propagate some sexist ideas indirectly, we all must think about whether we all are sexists in some way or the other.

As a part of this society we all, at least in certain aspects, unknowingly share its mindset, values and norms. We all are byproducts of a society that strictly believes and propagates gender stereotypes, even though it is true that changes are happening in the society in a slower pace. Disney movies are not creating anything new that is not seen in the society in general, they are simply reflecting to us the mirror image of our ideas, beliefs and a mindset that we all unintentionally possess.

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Access this Chapter in Online	
	Subject: Gender Mapping
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Divya M K . (2024). Gender Mapping in the World of Disney: A Comparative Study of *Snow White and the Seven Dwarfs & Beauty and the Beast*. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 37-56.

An overview of seed biological research with special emphasis on physiological and biochemical aspects

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Abstract

Seeds are the natural propagule of plant species and these mysterious genetic capsules contain many secrets that have yet to be revealed. These structures have many more mechanisms to cope with their surroundings to establish a viable population of respective species, hence the research on seed biology become essential nowadays to address various viability-related issues of conservation needed species. This chapter addresses various aspects of seed biological research like phenology, seed development, seed desiccation, seed germination, seedling characterisation and seed storage, which gives an in-depth idea of this topic.

Introduction

Seeds are the fundamental component of the plant's existence, and they store and transmit genetic information from one generation to the next, thus successfully maintaining the species. Being a double-fertilised product, it has a lot of potential according to its surroundings, thus exhibiting a form of synchrony with nature. Seeds are the natural propagule of all plant species, hence effective seed biological research is inevitable to understand the responses of these structures, which are highly relevant in the line of conservation of species. Many of plant species are facing a lot of constraints regarding plant regeneration through seeds due to various issues including physiological, biochemical, molecular and cytological levels. This chapter addresses various parts of seed biological research with special emphasis on physiological and biochemical aspects, which provides insight into the different scientific approaches of this less-explored area of research. The various aspects of seed biological research including phenology, seed

development, seed desiccation, seed germination, seedling characterisation and seed storage are discussed here.

Phenological aspects

Phenology is the study of the annual cycling of biological events regarding the functional rhythm of plant and plant communities. The timing of various phenological activities such as leaf drop, bud break, flowering, fruit dehiscence and germination are important for the survival and reproductive success of many plant species. Abiotic environmental conditions such as rainfall, change in temperature, presence/ absence of pollinators, competitors and herbivores have been shown to play a significant role in the timing of phenological events. Quantitative phenological studies and research that elucidates the levels of asynchrony among individuals and between species will help to understand the impact of climate change on tropical trees, as well as the potential consequences of these changes on the ecological community as a whole. The synchronization of leaf flushing and flowering in a number of species will be related to moisture, temperature and day length. The flowering and fruiting activity of *Ceiba pentandra* are limited to the dry season in Neotropical forests and their reproductive intensity was varied at both temporary and spatial scale. Grittoet *al* (2015) recorded the phenological data regarding periods of leaf fall, flowering and fruiting of selected 50 medicinal species at the Pachamalai hills of Tiruchirappalli district, Tamilnadu. The direct effect of climate change will be less serious than the effect of changed phenology on pollinators and seed dispersal agents.

Seed development aspects

In the life cycle of higher plants, seed development is the key process connecting two distinct sporophytic generations. There was enough literature available regarding the development of desiccation-tolerant seeds but little has been published on desiccation-sensitive seeds. Seed development is a process that consists of a set of morphological, cellular and biochemical changes that commences from ovule fertilization to seed maturation. The process is highly regulated, with distinct transcript, protein and metabolite switches occurring in a concerted manner throughout its progression. During seed development, three broad stages were generally recognized. The first stage is characterized by fertilization, cell division and histo differentiation of all major tissues. During the second stage, a massive accumulation of storage proteins, lipids and starch occurs, mirrored by an increase in the seed's dry weight. Seed dehydration is characteristic of the third phase, together with biological mechanisms leading to embryo desiccation resistance and, at last, germination viability. During seed

maturation, embryo growth ceases, mitosis is less intense, tegument tissue differentiates, storage compounds start to accumulate and the seed acquires tolerance against desiccation in a clear developmental switch from cell proliferation and differentiation to cell adaptation. The end process of seed formation shows major differences between orthodox and recalcitrant seeds. The orthodox seeds undergo a nearly essential process of desiccation at the end of maturation and thus allow the seeds to change their metabolism from development to germination. However, these changes are not observed in recalcitrant seeds due to several factors including hormonal balance, proteins, sugars, and water physical properties among others. Globally, 20 - 25 % of angiosperms and gymnosperms species produce non-orthodox seeds.

According to Shaw and Loomis (1950), physiological maturity denotes the development stage when a seed reaches maximum dry weight to recapture the reproducing capacity of the younger generation and marks the end of the seed-filling period, where the flow of nutrients is frozen to the seed from the mother plant. According to Patrick and Offler (2001), the maximal germination capacity and vigour are merged with the physiological maturity stage. The harvesting maturity stage has been determined based on physiological markers, including dry weight and water content, germination percentage and emergence rate index, accelerated ageing and electrical conductivity, and fruit and seed colour. Biochemical techniques were also employed for assessing seed quality throughout late maturation which includes the activity of enzymes involved in cell respiration and mobilization of reserves. The physiological maturity stage of various species was determined based on maximal dry weight and considerably reduced water content which includes *Capsicum baccatum*, *Crotalaria pallida*, chickpea and cowpea. In both *Inga uruguensis* and *Hopea hainanensis*, the seedlings raised from mature embryos show maximum dry weight and vigour compared to immature ones, demonstrating the higher physiological potential linked with maturation.

All reserve compounds found in the mature seeds are derived from simple molecules like sucrose, amino acids and mineral ions and follow this transportation mechanism by a concentration gradient of metabolites that favours the differentiation events. The electrical conductivity of seeds has been adequately employed as an indirect marker of seed vigor which indicates membrane damage and consequent cell death. The accumulation of proteins during the last phase of development is fundamental, as these proteins will be degraded and used during embryo germination, thereby supplying free amino acids for the beginning of seedling development. Starch played a part as a temporary carbon storage during early seed development in *Arabidopsis*

thaliana, *Medicago truncatula*, *Glycine max* and *Capsicum baccatum* which probably contributed to embryo formation and reserve biosynthesis. Baud *et al* (2002) observed that only about 10 % of the transient starch accumulating during seed development of *Arabidopsis* localizes to the embryo while the remaining higher amounts are associated with the integuments. Sugar and nitrogen are signals regulating seed development and metabolic exchanges, as well as signalling crosstalk between seed and mother plant, which are intermediated by the seed coat. Hormones play a fundamental role in various processes during seed development such as from the beginning of embryo formation, tissue development, reserve accumulation and mobilization during germination. Absciscic acid (ABA) impairs early germination in the pod (viviparity) and is associated with Late embryogenesis abundant proteins (LEA) protein synthesis and desiccation resistance. ABA promotes embryo maturation, and mid and late developmental stages reach peak concentrations.

Seed desiccation aspects

Orthodox seeds are desiccation tolerant to low (generally < 7 %) moisture contents with little effect on viability while recalcitrant seeds are killed by drying the seed/ embryo to water contents as high as 20 - 30 %. Many recalcitrant seeds quickly lose viability as a common behaviour, when their moisture contents fall below a high critical level. Seed-critical moisture content precedes a significant reduction in germination percentage coinciding with the lethal moisture content. The lowest safe moisture content or critical moisture content of the seed is dependent on various factors such as drying methods, seed size, seed development stages, and the chemical nature of the principal food reserves.

Desiccation tolerance has been defined as the ability of seeds to germinate following drying and drying methods may affect the viability of desiccated seeds over a period of time. The rapid decrease of germination percentage in accordance with moisture loss is an established fact in the viability loss of recalcitrant seeds. Moisture content and water potential are not directly related to each other in recalcitrant seeds because the water potential range varies with seed sample composition. The temperature to which the seeds are subjected at the time of desiccation is also an important factor affecting the viability of recalcitrant seeds. Fast drying has been reported to allow the tissues of several recalcitrant seeds to achieve greater desiccation tolerance. It was hypothesized that uneven distribution of water in the seed tissues could improve the desiccation tolerance in the fast-dried seed axes. Liang and Sun (2000) concluded that desiccation damage under rapid drying appeared to be mainly

resulting from ‘mechanical or physical stress’, while damage under slow drying is likely to be a consequence of physio-chemical damage induced by ‘metabolic alterations and damages’.

Seeds with high moisture content showed a negative relationship between moisture content and efflux of electrolytes and organic solutes. Since the membrane system is important for the regulation of cell transport, material exchanges and enzyme activities, once damaged due to dehydration results in abnormal metabolic changes and the loss of seed vigour. The viability loss during desiccation could be correlated with irreversible solute leakage. The high proportion of seed lipids in orthodox species of *Caesalpinia echinata*, *Erythrina speciosa* (ie., 7 - 12 %), *Dalbergia miscolobium* (more than 50 %) and a trace amount in recalcitrant embryos of *Inga* sp. indirectly convey the involvement of lipids in the mechanism of tolerance to desiccation. Nevertheless, works related to carbohydrate composition in recalcitrant seeds are very rare compared with orthodox seeds. The changes in carbohydrate metabolism, absence of cryoprotection sugars and changes in the microtubular cytoskeleton are the possible causes of viability loss in *Inga vera* seeds during desiccation. Under stress conditions, the metabolism of soluble sugars is a dynamic process simultaneously involving degrading and synthetic reactions. Soluble sugars not only function as metabolic resources and cell structural constituents but also act as signals regulating various processes related to plant growth and development. Sugar signalling pathways interact with stress pathways into a complex network to modulate metabolic plant responses. Accumulation of sucrose and raffinose family oligosaccharides (RFO) has been correlated with the development of desiccation tolerance in seeds of maize, wheat, soybean, lupin and bean. The interaction of raffinose restricts the crystallization of sucrose, thus enabling maximal desiccation tolerance in orthodox seeds. Studies on seed desiccation tolerance in selected tropical tree species pointed out that, freezing and artificial seed desiccation methods are not involved in the induction of protective mechanisms against dehydration with special reference to sugar metabolism.

Proline accumulation is a common physiological response to salinity and osmotic stress in many plant species. Proline, a highly water-soluble amino acid is mainly synthesized from L - Glutamic acid and the pathway was found in the cytoplasm and plastids. Under osmotic or dehydration stress conditions, proline may interact with enzymes to preserve protein structure and activities and maintain membrane integrity by preventing protein denaturation. In angiosperms, the accumulation of proline varies among plant organs, highest level found in flowers and seeds and while lowest in roots

Seed germination aspects

Seeds are the fundamental component of the plant life cycle which carry the genetic information essential for the next generation. Seed germination can be considered as a response with a simple output of embryo emergence requiring the input of multiple factors such as developmental programs or environmental factors. As an important stage of plant development, the germination phase comprises distinct physiological and biochemical events such as resumption of respiratory activity, activation of repair mechanisms, protein synthesis from stored and newly synthesized mRNA and reserve mobilization. The first process, which occurs during germination, is the uptake of water by the seed due to imbibition. The extent to which imbibition occurs is determined by three factors; the composition of seed, the permeability of seed coat to water and the availability of water in the liquid or gaseous form in the environment. Seed germination is a critical phase of the plant life cycle, influencing the distribution and abundance of species in plant communities. In natural conditions, biotic and abiotic factors interact synergistically directly affecting time to germination and the percentage of successful seed germinations. The abiotic factors like temperature, light and substrate affect seed germination in a species-dependent manner and may, in many cases, inhibit the germination process. The knowledge of seed germination and seedling growth is necessary for the success of efforts on augmentation, introduction and reintroduction of tree populations.

During germination, seeds mainly exhibit a tri-phasic pattern of water uptake. Phase I is rapid due to the large water potential gradient between the dry seed and the environment, Phase II is a period of varying duration, when little or no change occurs in seed water content. In Phase III, a further increase in water uptake occurs only after germination is completed, as the embryonic axis elongates. The duration of each phase depends on certain inherent properties of the seeds such as hydratable substrate levels, seed size, permeability of seed coat, oxygen uptake *etc.*, and on the prevailing conditions during hydration (*eg*: temperature, moisture levels, composition of substrate). The visible sign of germination is usually the penetration of structures surrounding the embryo by the radicle and subsequent events including the mobilization of major storage reserves associated with the growth of the seedling. In recalcitrant seeds, development and germination are on a continuum and immediately after shedding germination-associated metabolic changes occur. According to Farrant *et al* (1993), it was difficult to differentiate the switch from reserve accumulation to the germination associated with reserve mobilization. The studies regarding the relationship between seed

germination and stage of harvest in soybeans explicated that the seed germination, vigour index, seedling fresh weight and seedling dry weight were significantly reduced with the advancement of different stages of harvest after physiological maturity.

The reduction of dry matter in germinating seeds of different species including linseed, cotton and tobacco showed a negative correlation with the period of germination, which was mainly due to the water uptake and excessive respiration process. Macromolecules accumulated in seeds are an energy source for early seedling development and seed germination. The change of accumulation of various biomolecules including total proteins, total amino acids, reducing sugars, total soluble sugars and lipids occurred during various stages of seed germination in *Sterculia urens* was thoroughly reviewed by Satyanarayana *et al* (2011). During seed germination, the storage proteins are mainly distributed in the radicle and shoot of growing seedlings, and mobilization is mainly mediated by two enzymes carboxypeptidase and aminopeptidase though total activity has not taken place at the same time in different parts of the seed. Proteomic analysis of seed germination in *Arabidopsis thaliana* indicated that during the process of seed germination, 74 proteins were altered before radicle emergence and protrusion. Storage proteins are the major source of amino acids for the growing embryo and released amino acids are used to make the necessary enzymes and components for seedling growth. The amino acids used for protein synthesis and assembly are mainly obtained from the reserves in the cotyledons. Starch, hemicellulose or Triacylglycerol in cotyledons are the alternative sugar sources for the growing axis during the germination but amino acids are not used to produce sugars. Triacylglycerol (TAGs) are hydrolysed by lipases, enzymes catalyzing the hydrolytic cleavage of the fatty acid ester bonds, to yield glycerol and free fatty acids. Free fatty acids enter the glyoxysome for conversion to oxaloacetic acid, pass into mitochondrion and ultimately into the cytosol for conversion to sucrose which is then transported as an energy source from cotyledons to the growing axis of seedlings. Monneriet *al* (1986) reported a constant rate of starch depletion throughout germination and also postulated that the growing embryonic axis acts as a sink for hydrolyses which occur predominantly *via* the amylolytic pathway. During the germination of several species, amylase activity has been increased in cotyledons thus starch content declined. Many tropical plants produce seeds containing high concentrations of secondary metabolites (phenolic compounds) and phenolic oxidases. Plant phenols are known to form a barrier to water loss, diffusion and pathogen attack and

furthermore function as antioxidants. It has been hypothesized that high phenol concentrations increase seedling vigour and greater lignifications.

Seedlings Characterization aspects

Seedling recruitment is vital for the persistence and expansion of plant populations and to ensure rapid recovery from perturbations. Seedling morphology, which is dealt with under plant morphology, is a less explored but emerging domain in plant science. The study of seedlings may clarify the nature of some morphological characters or document their changes during their development from early stages to maturity. Due to their small size and delicate nature, seedlings are greatly susceptible to resource limitations and other factors that affect their establishment and subsequent growth. Seedling morphological features have significance at the tribe level for identification and drawing interrelationships within the taxa studied. *de Vogel* (1980) classified seedlings based on their development into *Macaranga* type, *Soloanea* type with two subtypes, *Sterculia stipulate* type, *Ternstroemia* type, *Cyclamen* type, *Rhizophora* type, *Barringtonia* type, *Cynometramiflora* type, *Heliciopsis* type with two subtypes, *Heliciopsis* type/*Koordersiodendron* subtype, *Coscinium* type, *Garcinia* type, *Orobanche* type, *Endertia* type, *Endertia* type/*Streblus* subtype, *Endertia* type/*Chisocheton* subtype, *Endertia* type and subtype, *Hodgsonia* type, *Blumeodendron* type, *Horsfieldia* type with two subtypes, *Horsfieldia* type/*Psueduvaria* subtype. Cotyledons are of various types based on their functions in seedling development. According to *Garwood* (1996) cotyledons are classified cryptocotylar (C) means inside the seed coat, phanerocotylar (P) means free of seed coat; epigeal (E) means above the ground, hypogeal (H) means at or below the ground; foliaceous (F) means thin and photosynthetic and reserve (R) means storage or absorption. A study on Cassava revealed that reserve cotyledons (R) can be of two types namely storage (s) *i.e.*, thick fleshy cotyledons, which store reserves and translocate them directly to germinating seedlings and haustorial (h) *i.e.*, thin cotyledons, which absorb reserves from the abundant endosperm and translocate them to the germinating seedlings. Seedling characters are as important and reliable as that of floral ones in the delimitation of species, genera and sometimes families. The characters of seedlings are limited in number, but their diversity is large and thus their assemblage serves the purpose of identification.

Seed storage aspects

The importance of seed storage has been recognized ever since humans began to domesticate plants producing seeds ranging from a few to many years. An assured supply of good quality seeds during the lean period can be achieved

only from the seed stock held in storage and it is more cost-efficient to collect surplus seed to cover the needs of the succeeding period. Hence, efficient seed storage is an important criterion for accomplishing a continuous and cost-effective supply of healthy tree seedlings, which is a prerequisite for afforestation programmes. Standardized seed storage protocols of tree genetic resources, those ravaged by deforestation as well as by catastrophes such as forest fires, drought and floods were inevitable for conservation. The period of successful storage was mainly based on objectives and the species concerned. A successful storage regime must ensure that seeds retain unimpaired vigour and viability for a useful period *ie.*, from harvesting until required for planting. The seed storage behaviour determines the survival and longevity of the seed under various storage conditions. Seed longevity was considered as the expected outcome of storage but it varies among accessions within species because of differences in genotype and provenance. Provincial influence mainly results from the cumulative effect of the environment during seed maturation, harvesting, drying pre-storage environment *etc.*

Roberts (1973) categorized seeds into two groups such as orthodox and recalcitrant based on storage characteristics. Orthodox seeds can be dried to moisture contents of 10 % or less thus successfully stored at subfreezing temperatures while recalcitrant seeds neither can be dried below relatively high moisture levels (25 to 45 %) nor stored below freezing. Ellis *et al* (1990) have proposed a separate seed category called intermediate, which is placed in between orthodox and recalcitrant based on storage response. The optimum storage conditions for some temperate recalcitrant species like *Acer saccharinum* L., *Quercus macrocarpa* Michx., *Quercus pagoda* Raf., *Quercus robur* L. and *Quercus rubra* L. were already standardized, on which seed moisture content ranges from 35 to 50 %, storage temperature lies between 1 to -3⁰C and viability period extends from 6 months to 3 years approximately. The tropical recalcitrant species of *Araucaria hunsteinii* K. Schum. & Hullrung, *Azadirachta indica* Adr.Juss, *Dipterocarpus turbinatus* C.F.Gaertn., *Hopeahelperi* (Dyer) Brandis, *Shorea robusta* C.F.Gaertn., *Shorea roxburghii* G.Don and *Shorea talura* Roxb. were showed maximum storage performance on temperature within 13.5 to 26⁰C, seed moisture content ranges between 10 - 50 % and viability extends from 1 to 9 months. Seeds placed in defined groups of storage behaviour are often tenuous because the recalcitrant storage behaviour of *Fagus* L. was shifted to a sub-orthodox nature with extended storage life at subfreezing temperatures. Seed storage behaviour was highly influenced by plant ecology because recalcitrant species tend to originate from ecosystems in which seeds are subjected to high humidity during seed

development, maturation and after shedding. For example, *Coffea arabica*, which is native to the dry and cool region of Ethiopia showed intermediate storage behaviour, while *Coffea liberica* native to the hotter and humid region of Liberia exhibits recalcitrant seed storage behaviour.

Seed morphology, seed chemical composition, seed maturity, seed handling before storage, storage environments including moisture, temperature, atmosphere, storage facilities of cold storage, containers and moisture control play significant roles in successful storage. Seed weight is a variable character within species and it is influenced by genetic, developmental and environmental factors. Seed morphology is important to the storage life of seeds in the context of protection for the embryo. The influence of the chemical composition of seeds on storage was evidenced in *Quercus* that acorns of the black oaks, which are somewhat oily with very little carbohydrate, store longer than acorns of the white oaks, which are full of carbohydrates and less lipids. *Trichilia dregeana* seeds of poor quality declined their viability from 100 % to 20 % when stored wet over three weeks at 16⁰C, in contrast to those, uninfected seeds retained viability for 8 months under the same conditions. Recalcitrant seeds are shed at high moisture content (MC), are sensitive to dehydration and so are difficult to store. Viability decline during seed drying at comparatively high moisture contents and formation of ice crystals insubzero temperature storage are the major constraints for recalcitrant seed longevity.


Conclusion

The seed can be considered the most important plant reproductive element, as a dispersal unit for successful reproduction in all gymnosperms and flowering plants. Seed biology is a highly dynamic field of plant science and it has been greatly advanced in recent years. The critical seed research starts from the fertilization events and it passes through seed development, pre and post-harvest responses, water physiology and storage aspects. The amalgamation of conventional seed biological knowledge as well as advanced biological techniques are inevitable for the sustenance of the quality of seed viability. The integrated approaches in seed biological research are essential for addressing various enigmatic issues related to seed viability in various horticultural, agricultural as well as forest species.

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DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Prajith T M. (2024). An overview of seed biological research with special emphasis on physiological and biochemical aspects. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 57-68.

Rose Bengal and Eosin Y Mediated Multicomponent Reactions

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Abstract

This chapter provides a succinct overview of the photocatalytic multicomponent reactions facilitated by Rose Bengal and Eosin Y. The fundamental presentation herein includes schematics accompanied by brief explanatory text to illustrate the concept effectively. Chemists will find this chapter valuable for grasping the challenges inherent in the described methods, along with insights into future opportunities, encompassing substrate selection and catalyst exploration.

Introduction

Photocatalysis has gained much importance in the field of organic synthesis due to its incredible advantages including environmentally benign, cost effectiveness, recyclability of the photocatalysts, etc. It harnesses the energy supplied by light to initiate reactions that are often challenging, occasionally even unfeasible, to execute in the absence of light. Any material that make use of the light energy to drive a chemical reaction (thermodynamically uphill, in the case of photosynthesis, or thermodynamically downhill) is regarded as a Photocatalyst.¹ Photochemistry employs photons as imperceptible and renewable agents to energize substrates and reagents, thereby initiating chemical reactions and modifying the reaction speed.² An optimal photocatalytic material should exhibit specific physical attributes to facilitate efficient photocatalysis. These include broad and intense spectral absorption, a low exciton binding energy to facilitate effective electron or hole migration, enabling photogenerated carriers to travel to the catalyst's surface. Additionally, suitable band edge positions are necessary to provide the requisite oxidation-reduction potential for the targeted reaction. Moreover, long-term operational stability is crucial to sustain the continuous progression

of the catalytic reaction.³ General mechanism followed by a photocatalyst is depicted in Figure 2.¹⁷

Multicomponent reactions entail a chemical synthesis process wherein multiple reactants undergo simultaneous reaction to yield the desired products without the need for separating and purifying intermediates.⁵ Multicomponent reactions have gained prominence in synthetic organic and medicinal chemistry due to their numerous advantages, such as high atom efficiency, cost-effectiveness, and shortened reaction times.

Rose bengal, (Figure 1) also known as 4,5,6,7-tetrachloro-2',4',5',7'-tetraiodofluorescein, is indeed a stain commonly used in various laboratory applications. It belongs to the class of organic compounds called xanthenes, which are aromatic heterocycles containing a xanthene backbone. Xanthenes are characterized by a polycyclic structure consisting of two aromatic rings connected by an oxygen-containing bridge. They are often used as dyes, fluorescent indicators, and biological stains due to their colorful and fluorescent properties. Rose bengal, specifically, is known for its application in ophthalmology, microbiology, and histology for staining biological samples. Indeed, rose bengal's unique properties⁵ make it valuable beyond its traditional use as a biological stain. In synthetic chemistry, it serves as a visible light photoredox catalyst, facilitating various photochemical reactions.⁶

Photochemistry of Rose Bengal

Functioning as a type II photosensitizer, rose bengal (RB) transforms triplet oxygen molecules into singlet oxygen when exposed to blue light at a wavelength of 450 nm through a photo-catalytic mechanism. Furthermore, the energy difference between the singlet and triplet states, often denoted as E , is minimal for RB, approximately 0.35 eV.¹⁰ Singlet oxygen is a highly reactive species that can undergo diverse chemical transformations, including [2 + 2] cycloadditions with alkenes and related systems.

These [2 + 2] cycloaddition reactions are significant in organic synthesis as they allow for the efficient construction of cyclic structures, often with high selectivity and atom economy. The ability of rose bengal to generate singlet oxygen under visible light conditions expands the scope of photochemical transformations accessible to chemists, providing a valuable tool for the synthesis of complex molecules. Rose bengal derivatives have been explored for various medical applications, including cancer treatment. One notable example involves creating derivatives that are sonosensitive but photoinensitive. This property allows them to be activated by high-intensity

focused ultrasound (HIFU) rather than light, making them suitable for cancer therapy in situations where light-based therapies might not be feasible or effective.⁷

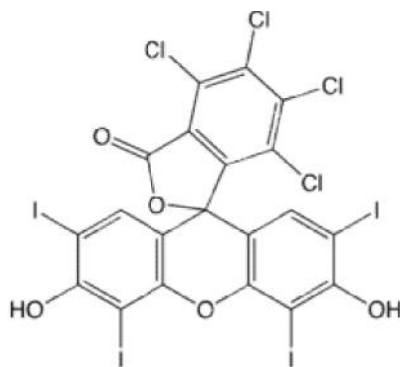


Figure 1: Rose Bengal

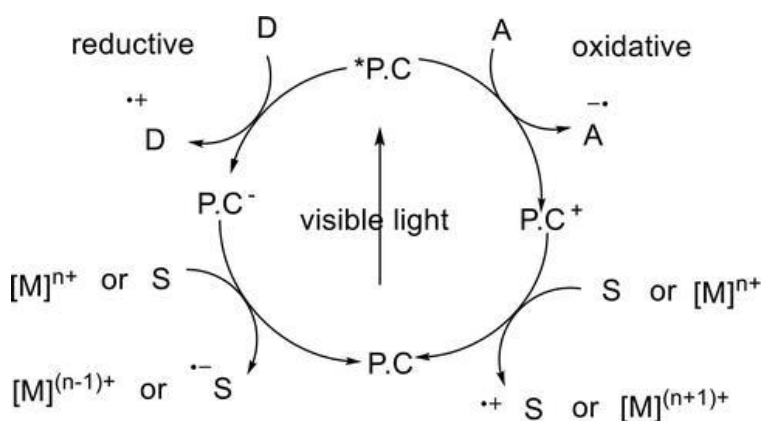


Figure 2: General mechanism followed by a redox photocatalyst.

This review focuses on exploring a range of multicomponent synthesis methods that utilize rose bengal as a photosensitizer.

Eosin Y (Figure 3)¹⁸ a member of triarylmethane dyes are produced from fluorescein by bromination. Eosin Y has been extensively utilized as an organic photocatalyst in various synthetic processes. This well-established dye has a wide range of applications including cell staining, pH indication, analytical halide determination according to Fajans, and as a dye pigment, such as in lipsticks.

Photochemistry of Eosin Y

Upon being stimulated by visible light, eosin Y swiftly transitions through intersystem crossing to its lowest energy triplet state, which persists for approximately 24 microseconds. Eosin Y primarily absorbs green light, evident from its UV-Vis spectrum displaying a distinctive peak at 539 nm with a molar extinction coefficient (ϵ) of 60,803 M⁻¹ cm⁻¹. Following excitation, eosin Y demonstrates increased reducing and oxidizing properties compared to its ground state. The redox potentials of the excited state can be approximated by correlating the standard redox potentials of the ground state, as determined through cyclic voltammetry, with the energy of the triplet excited state. (Figure 4). Furthermore, the photoexcited state of eosin Y might also engage in energy transfer.¹⁸ The photoredox catalytic cycle of eosin y is depicted in Figure 5.¹⁹

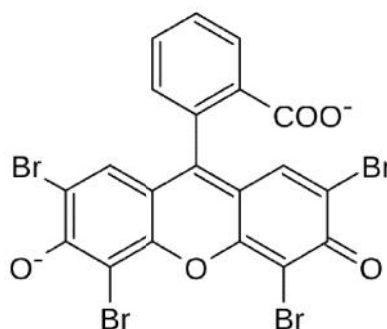
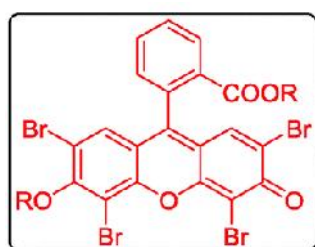


Figure 3: Eosin Y



R = H, eosin Y spirit soluble

R = Na, Na₂-eosin Y

R = (nC₄H₉)₄, TBA-eosin Y

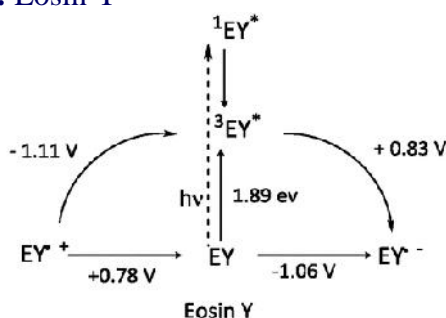


Figure 4: Different forms of eosin Y and the redox potentials of eosin Y in CH₃CN–H₂O (1:1) in ground and corresponding excited states

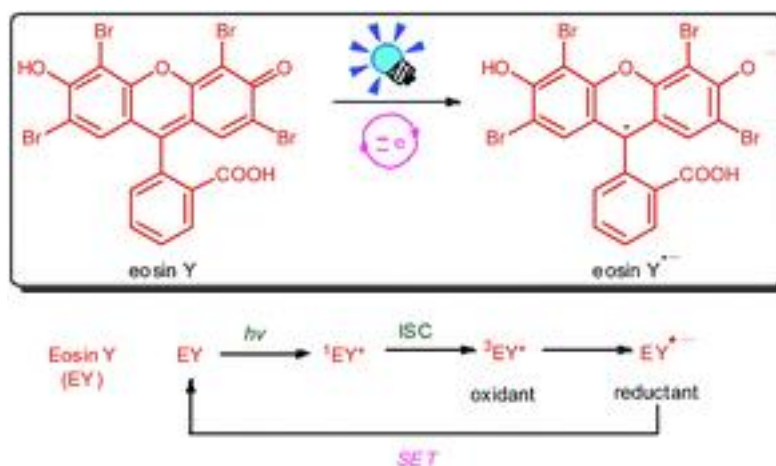
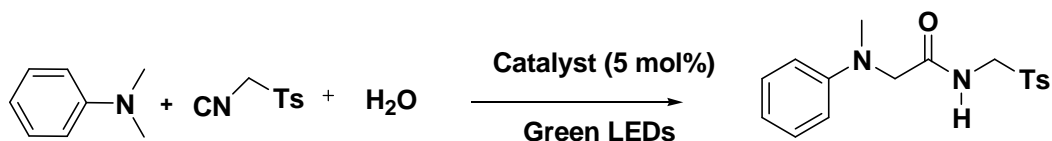


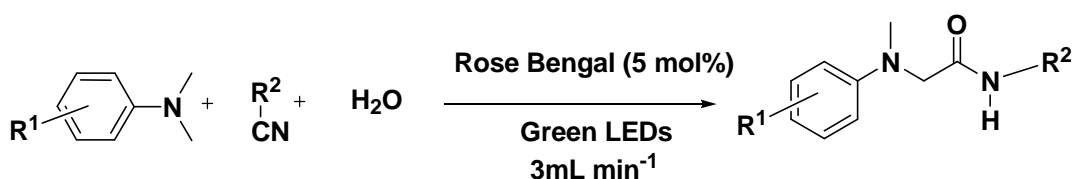
Figure 5: Photoredox catalytic cycle of Eosin Y

Rose Bengal Mediated Multicomponent Reactions

In 2013, Rueping and colleagues described a novel approach to the oxidative Ugi multicomponent reaction, employing N,N-dimethylaniline, p-toluenesulfonyl methyl isocyanide, and water. Employing a continuous flow technique, they identified rose bengal as a highly efficient organic photocatalyst for facilitating the reaction.⁸(Scheme 1a, 1b). N,N-dimethylanilines have been successfully employed in the Ugi-multicomponent reaction within a flow setup, leading to the synthesis of valuable α -amino amides in good yields. A variety of compounds were synthesized in multiple instances, with yields varying between 20% and 80%.⁸

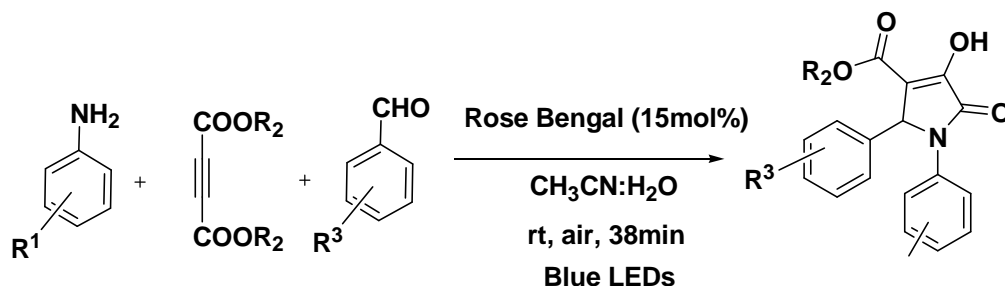


Scheme 1a: Flow Oxidative Ugi Multicomponent Reaction with Rose Bengal



Scheme 1b: Flow Oxidative Ugi Multicomponent Reaction with Rose Bengal

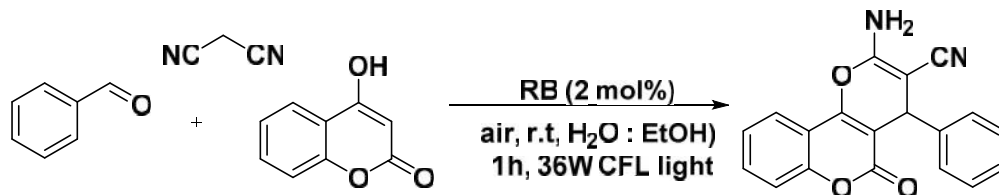
Nongkhlaw *et al.*, developed a novel approach towards the synthesis of pyrrolidinone derivatives via the visible light initiated one-pot multicomponent reaction of arylamines, aromatic aldehydes and acetylenedicarboxylate using Rose Bengal as a photoredox catalyst (Scheme 2).⁹ and a satisfactory product yield of 94% was obtained. When exposed to light, Rose Bengal (RB) becomes activated to RB*. In this excited triplet state, RB* facilitates the conversion of aniline into a radical cation through single-electron transfer (SET). This radical cation then reacts with benzaldehyde to produce an intermediate, which, after undergoing SET and dehydration, forms an imine intermediate. Additionally, DEAD undergoes a nucleophilic addition reaction with water to generate a 1,3-dipolar intermediate. This intermediate, through an SET reaction with RB*, yields a 1,3-dipolar radical. Subsequently, the reaction between the imine intermediate and the 1,3-dipolar radical, followed by cyclization, results in the formation of another intermediate. This intermediate then undergoes elimination of ethanol to yield the final target molecule.⁹ Several control experiments were carried out, and numerous derivatives were synthesized, achieving yields between 77% and 94%.



Scheme 2

Justin Thomas and colleagues have identified Rose Bengal as a highly effective photocatalyst for facilitating the synthesis of 2-amino-5-oxo-4-phenyl-4H,5H-pyrano[3,2-c] chromene-3-carbonitrile through a multicomponent reaction involving aromatic aldehyde, malononitrile, and 4-hydroxy coumarin, as illustrated in (Scheme 3). According to the suggested

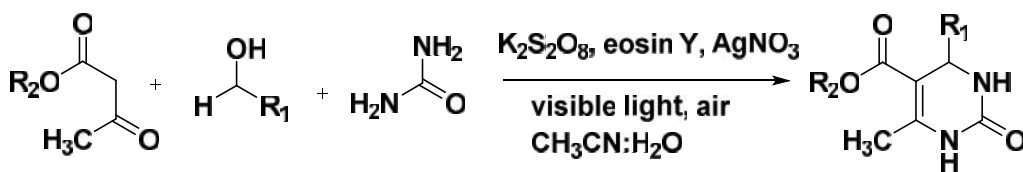
mechanism, the ultimate formation of the product, 2-amino-5-oxo-4-phenyl-4H,5H-pyrano[3,2-c]chromene-3-carbonitrile, occurs through a Knoevenagel condensation between an aldehyde and malononitrile, resulting in the production of benzylidinemalononitrile. Subsequently, this compound reacts with hydroxycoumarin to generate a radical intermediate, ultimately undergoing cyclization to yield the final product.¹²



Scheme 3

Eosin Y Mediated Multicomponent Reactions

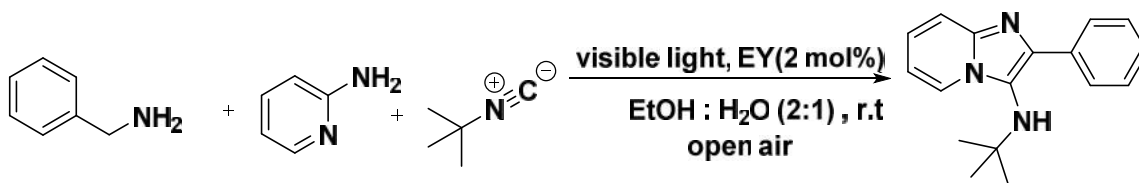
In 2022, Rupesh Kumar and co-workers introduced a method where Eosin Y is utilized as a photocatalyst in the Biginelli synthesis. This protocol involved a one-pot, three-component reaction incorporating primary alcohols, -ketoesters, and urea, resulting in the formation of pharmacologically significant 3,4-dihydropyrimidin-2(1H)-ones (Scheme 4).²⁰ Different variations of 3,4-dihydropyrimidin-2(1H)-ones (3,4- DHPM) were synthesized with high yields reaching up to 88%. The reaction proceeds through a two-step mechanism. Initially, the primary alcohol undergoes in-situ oxidation, which is then activated by Eosin Y in conjunction with -ketoester. The activated aldehyde subsequently reacts with urea to generate an imine, liberating a molecule of water. Then, the activated -ketoester attacks the imine, leading to the formation of 3,4-dihydropyrimidin-2(1H)-one by releasing another water molecule.



Scheme 4

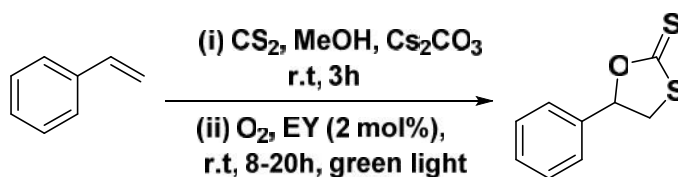
In 2020, Sundaram Singh and colleagues have successfully synthesised biologically important moiety aminoimidazopyridine through the

multicomponent reaction of benzylamine, 2-aminopyridine, and t-butyl isocyanide under visible light using eosin Y as a photocatalyst. (Scheme 5)²¹ Approximately 20 instances were synthesized with outstanding yields ranging from 92% to 97%. Initially, eosin Y (EY) is excited by visible light to form excited eosin Y (EY*). EY* then abstracts a hydrogen atom from the benzylic amine, creating an intermediate which undergoes oxidation to yield a benzylimine intermediate. The benzylimine reacts with 2-aminopyridine to form an imine intermediate, releasing ammonia. Subsequently, this imine intermediate is attacked by an isocyanide, resulting in another intermediate. Under the influence of visible-light radiation, this intermediate (referred to as D) generates free radicals, leading to cyclization. Following cyclization, a 1,3-H shift occurs, ultimately yielding the desired product.



Scheme 5

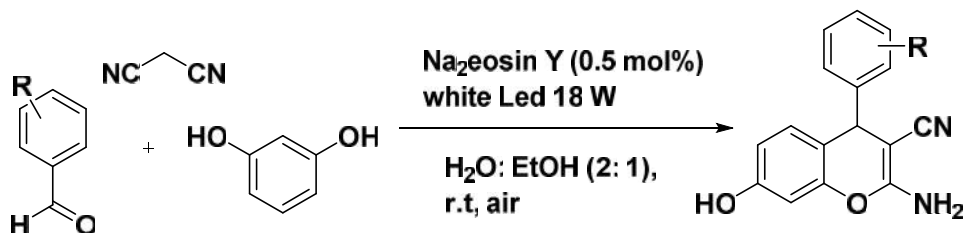
In 2016, Yadav *et al.*, developed a highly regioselective method for synthesizing 1,3-oxathiolane-2-thiones (also known as cyclic dithiocarbonates) directly from styrenes, CS₂, and air (O₂). This protocol employs Eosin Y as an organophotoredox catalyst and utilizes clean resources such as visible light and air (O₂) as sustainable reagents. The reaction occurs at room temperature in a one-pot procedure (Scheme 6).²² A compound library comprising 15 compounds was prepared, with yields ranging from 68% to 95%. The xanthate anion, generated in situ from CS₂ and alcoholates, is transformed into radicals, which are then captured by styrenes. Subsequently, under aerobic conditions, the radicals undergo cyclization to produce 1,3-oxathiolane-2-thiones.



Scheme 6

FarzanehMohamadpour, in 2022, described a method utilizing Knoevenagel–Michael cyclocondensation with malononitrile, aryl aldehydes,

and resorcinol, serving as a sustainable multicomponent strategy for synthesizing 2-amino-4H-chromene scaffolds without the need for metal catalysts. Within this approach, the photo-excited state species from Na₂ eosin Y acted as direct catalysts for hydrogen atom transfer in aqueous ethanol at ambient temperature under visible-light-induced conditions (Scheme 7).²³ Under visible light, malononitrile undergoes tautomerization, forming a species that reacts with aldehydes to generate arylidenemalononitrile. This arylidenemalononitrile is then photochemically activated, leading to the formation of a radical intermediate. Through reverse hydrogen atom transfer (RHAT) between this radical adduct and eosin Na₂ Y-H, an intermediate (A) is formed along with ground-state Na₂ eosin Y. Intermediate (A) subsequently undergoes removal of a hydrogen atom by the malononitrile radical, resulting in intermediate (B). Following this, intermediates (F) and (A) combine as a Michael acceptor to produce intermediate (C). Finally, intermediate (C) undergoes intramolecular cyclization and tautomerization to yield the product. Several compound examples were synthesized with yields ranging from 85% to 96%.



Scheme 7

Conclusion

The literature contains numerous studies demonstrating the efficacy of Rose Bengal and Eosin Y as photocatalysts in diverse organic transformations. This chapter selectively outlines the successful utilization of Rose Bengal and Eosin Y in various multicomponent syntheses.


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Access this Chapter in Online	
	Subject: Chemistry
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Divya K. Nair, Supriya E. T. and Sari Radhakrishnan O. (2024). Rose Bengal and Eosin Y Mediated Multicomponent Reactions. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 69-80.

**Neutraceuticals and Bioactive potentials of
Carica papaya Linn**

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Abstract

Carica papaya L. is commonly known as papaya well-known fruit worldwide, is one of the economical fruit crops belonging to the Caricaceae family, and grows in tropical and subtropical regions. The fruit has a unique flavour, taste, and health-promoting qualities; it is regarded as functional food or a potent nutraceutical. Traditionally papaya leaves and fruits are used in folk medicine for the treatment of various ailments like diarrhoea, flatulence, gastric pain, wounds, rheumatism, ulcers, etc. Papaya possesses antioxidant, antimicrobial, anticancer, antidiabetic, and anti-inflammatory activities, supporting a great therapeutic potential and a wide range of clinical applications. It is rich in antioxidant compounds and contains a high level of ascorbic acid content, carotenoids, and phenolic compounds. The oil extracted from the seed principally presents oleic fatty acid followed by palmitic, linoleic and stearic acids, whereas the leaves have high contents of food fibres and polyphenolic compounds, flavonoids, saponins, pro-anthocyanins, tocopherol, and benzyl isothiocyanate. It has also been reported that it aids in the treatment of diabetes mellitus and the reduction of cholesterol levels. Thus, both the pulp and the other parts of the plant (leaves and seeds) present antioxidant, anti-hypertensive, hypoglycemic, and hypolipidemic actions, which, in turn, can contribute to the prevention and treatment of obesity and associated metabolic disorders. Papaya fruit is highly perishable, so to increase its shelf life, it may be processed into various value-added products like papaya juices, squash, nectar, leather, jam, jellies, powder, etc. This chapter describes in detail the papaya plant, its ecological requirements for its growth, various methods of its propagation, current knowledge about its nutraceutical properties and its application in preparing papaya-based value-added products.

Keywords: nutraceutical, antioxidant, carotenoids, phenolic compounds, value-added products

Introduction

Carica papaya. Linn (Caricaceae) is a type of tropical plant that is the only species in the genus *Carica*. Papaya is of great economic and food interest and is cultivated in the tropical and subtropical regions of the world. Its propagation can occur both asexually and sexually. The papaya fruit is slightly sweet with an agreeable musky tang which is more pronounced in some varieties and in some climates than in others. The fruit has a unique flavour, taste, and health-promoting qualities, it is regarded as a functional food or potent nutraceutical (Kesarvani R K et al.,2020). The term nutraceutical was coined by Stephen DeFelice in 1989 from nutrition and pharmaceuticals. It is defined as a food that provides health benefits, including prevention and cure of a disease. The term nutraceuticals as commonly used in marketing has no regulatory definition (Gupta S et al., 2010). The concepts of nutraceuticals, functional food, designer food, phytochemicals, bioactive compounds, etc. are misnomers and quite confusing and are often used interchangeably. The supplementary diets or dietary supplements however differ from nutraceuticals in many ways. Nutraceuticals are not only supplementary food included in diets but also conventional food which is part of the daily diet having health benefitting potentials. Nutraceuticals are also referred to as natural functional food or bioactive phytochemicals that have health-promoting, disease-/disorder-preventing, or medicinal properties. These nutraceuticals contain the macro- and micronutrients like carbohydrates, proteins, fats, lipids, vitamins, minerals, antioxidants, etc.; however, bioactive compounds are minor components of food and are defined as having the following characteristics: they are present in low concentrations; they are not considered to be nutrients; and they have a proven health effect. Interaction between functional food components such as prebiotics, probiotics, phytochemicals, and intestinal microflora affects human health (Yahia E M 2017).

Morphological features of papaya

Papaya is an herb in nature but its structure is not similar to herb and looks somewhat like a tree but not woody. *Carica papaya*. L is commonly called Papaya. The papaya is a polygamous species. (have male, female or hermaphrodite flowers on the same plant). It is diploid, with 9 pairs of chromosomes and a genome of 372Mbp. The male plant produces only pollen and no fruit. The female plant produces small, inedible fruits unless pollinated.

The hermaphrodite plant can self-pollinate. Almost all papaya orchards grow only hermaphrodites.

The plants may be classified into three primary sex types such as (i) Male (staminate), (ii) Hermaphroditic (bisexual), and (iii) Female (pistillate). In addition, some plants can produce, at the same time, more than one kind of flower. Also, some produce flowers that are not of these basic forms but exhibit different degrees of maleness and femaleness. This tendency to change in sexual expression seems to be triggered by climatic factors, such as drought and variable temperatures. The tendency to produce male flowers seems to increase at high temperatures.

Leaves

Leaves are of compound type. Leaves are very large and the morphology of leaves shows palm shape and the average size of the leaf is 50–70 cm in diameter. The leaves are spirally arranged in a terminal cluster. The margins of the lobes are very variable, and range from entire to undulate to deeply lobed. The bundle of leaves is dark green to yellow-green, bright, visibly marked by the off-white nerves embedded and reticulated veins; the underneath surface is pale green-yellow and opaque with visibly prominent vascular structures; the petioles are round and yellow-green, with sporadic purple or violet stains, fistulous form, fragile, 25-100 cm length and 0.5-1.5 cm thick. The lifespan of each leaf is 4 to 6 months.

Flowers

Papaya flowers are generally dioecious. The biological function of a flower is to facilitate reproduction. Six types of flowers are known in papaya plants.

Typical female flower

It is a rather large flower of conical shape when closed, when open, its five petals spread from the base. The ovary is large, circular and smooth or slightly undulated. Fruits produced by this flower are spherical or ovoid.

Typical male flower

This type of flower has a long and thin corolla containing anthers in two series of five; one series longer than the other. They have a rudimentary pistil with no stigma and are non-functional. Male flowers are morphologically distinct from female flowers. Male inflorescences are borne in many-flowered panicles of cymes on horizontal or pendant stalks up to 1 m long. The flowers are yellowish, 2-4 cm long. The petals are fused into a long tube, have 10

fertile stamens, and a rudimentary, non-functional ovary. Female inflorescences are much shorter only 3-4 cm long and have fewer flowers. Environmental factors may also influence sexual expression, and the sexuality of a plant may change seasonally or for its lifetime. Thus the sexuality of any one plant in cultivation depends on a complex mix of genetic, developmental, and environmental factors.

Female flowers have a calyx formed by a crown or five-pointed star easy to differentiate. On top of the calyx, the ovary is located by five yellowish sepals when young, they show a purple colouration. There are five round-shaped yellow stigmas. Fruits from this flower are usually large and balloon-like. Hermaphroditic flowers have both sexes and the tree bearing these has three different types of flowers. One is called pentandria, resembling a female flower, but when petals are taken apart 5 anthers are seen and the ovary is lobed.

Fruits

The fruit that develops varies in shape depending on the flower type. The fruit is 5–30 cm long and yellowish orange in colour. The fruit contains several black seeds and pulp is sweet. Fruits are balloon-shaped and lobed. An ovoid-oblong berry pyriform or almost cylindrical, large, fleshy, juicy, grooved along the upper longer side, green-yellow to yellow or yellow-orange colour when ripen, a single cell of orange or reddish internal colour with many parietal seeds and a length of 10-25 cm or longer and 7-15 cm or more of diameter. Generally, the fruit is melon-like, oval to nearly round, somewhat pyriform, or elongated club-shaped, 15-50 cm long and 10-20 cm thick; weighing up to 9 kg. Semi-wild (naturalized) plants bear miniature fruits 2.5-15 cm long. The skin is waxy and thin but fairly tough. When the fruit is green and hard it is rich in white latex. As it ripens, it becomes light or deep-yellow externally and the thick wall of succulent flesh becomes aromatic, yellow, orange or various shades of salmon or red. It is then juicy, sweetish and somewhat like a cantaloupe in flavour; in some types quite musky. Flower lightly to the wall by soft, white, fibrous tissue, are usually numerous small, black, ovoid, corrugated, peppery seeds about 3/16 in (5 mm) long, each coated with a transparent, gelatinous Seeds

Seeds

The seeds account for about 16 % of the fresh fruit weight and each seed is made up of sarcotesta and endosperm. Papaya seed extracts have been shown to have several medicinal as well as nutritional properties several

species of Caricaceae have been used as a medication against a variety of diseases it had been argued by scientists that all parts of a papaya plant, including the seeds, roots, rinds, and fruits have positive effects on general health preventing diseases.

Nutritional Values

The fruit papaya is considered one of the most common fruits in human consumption and provides a favourable cost-benefit in consideration of its nutritional value, with a low caloric content and rich concentration of vitamins and minerals. Papaya plants possess valuable phytochemicals such as tocopherols, phytosterols, flavonoids, carotenoids and alkaloids. These compounds with interesting nutraceutical properties play key roles in ameliorating and treating some medical conditions such as inflammation, hyperglycemia, fertility-related complications, and hypertension and possess anticarcinogenic activities. Papaya fruits, seeds, peels, and leaves have nutraceutical values, which make them important in human diets. These papaya parts are rich in macro- and micronutrients with varying degrees.

For example, the seeds and leaves contain 16–32% protein, regardless of the cultivars. The seeds contain a good amount of lipids (21–30%) and carbohydrates (8–58%) in seeds and leaves making them good alternative energy sources that may complement the undernourished populations. Contrary to the fresh papaya seed with a strong spicy flavour, its oil has a unique aroma composition. The papaya seed oil (20.97–30.10%) is enriched with lipophilic phytochemicals and essential fatty acids such as oleic acid (70.84–79.10%). Oleic acid is widely identified as an anti-inflammatory agent and may even have positive effects on genes associated with tumours. Palmitic, arachidic, linolenic, and stearic acids are other reported fatty acids in the seeds. The high levels of lipids in papaya seeds offer economic attraction for industrial consumption relative to other oilseeds. Papaya seeds and peels contain a notable amount of dietary fiber. Dietary fibres are widely known for several health benefits; they remove toxins from the digestive system and lower the levels of cholesterol.

Papaya peels contain 68–87% moisture, 7.00–20.00% protein, 0.20–2.00% fat, and 3.00–12.00% ash. These peels could also be considered as a source of macro-minerals and trace minerals. Papaya seeds are a good source of phytochemicals. They contain valuable phytochemicals such as phenolics, tocopherols, phytosterols, and carotenoids. Phytochemicals generally offer an array of beneficial properties from the anti-proliferation of cancer cells to shielding against cellular oxidative injury; they also reduce the risk of non-

communicable diseases' incidence. Phenolics, isothiocyanates, terpenes, phytosterols, flavonoids, and anthraquinones can scavenge reactive molecules thus protecting the cellular environment against the damaging impacts of oxidative and inflammatory activities of carcinogens

Important phytochemicals Papaya, especially when green or unripe, contains *papain*, an enzyme that aids digestion. It is one of the most important phytochemicals that we can get from these fruits. It is also known as vegetable pepsin (digestive enzyme) and can be found in fruit latex and leaves (white latex). This white latex comes from the extraction of tree enzyme of papaya, pepsin. Commercially, the papain has varied industrial uses such as the food making industry, production of chewing gum, chill-proofing beer and meat tenderizers to break down the protein. Besides, papain is also used in drug and anti-bacterial preparations for various digestive ailments and the treatment of gangrenous wounds and in the cosmetic industry such as in shampoo and soap making. It also has been used in the textile industry, for degumming silk and softening of wool. Furthermore, it is also used like *bromelain*, a similar enzyme form in pineapple that can be used to treat sports injuries, other causes of trauma and allergies

Biochemical constituents of papaya leaf

Leaves contain large amounts of alkaloids, carpaine and pseudo carpaine which create positive effects on the heart as well as on respiration. Leaf extract of *C. papaya* is well known as an anti-tumour agent. Aside from its value as a remedy for dyspepsia and kindred ailments, it has been utilized for the clarification of beer. The active components of leaves can increase the total antioxidant power in blood and reduce lipid peroxidation levels, such as papain, chymopapain, cystatin, tocopherol, ascorbic acid, flavonoids, cyanogenic glycosides and glucosinolates (Noriko Otsuki et. al., 2010)

Main phytochemical compounds present in *C. papaya* L. (papaya): ripe fruit pulp, seeds and leaves (X Wang et al., 2020).

Phytochemical Composition

Pulp	Seeds	Leaves
Glutathione peroxidase	Benzyl isothiocyanate glucosinolates	
Polyphenols		
Glutathione transferase	Fatty acids- oleic, palmitic,	Flavonoids
Glutathione reductase	linoleic and stearic	Saponins
Catalase	cryptoxanthine	Proanthocyanin
Glucose-6-phosphate	Carotenoids	Lycopene
Total phenols	Tocopherols(and)	Tocopherol
Alkaloids	carotene	Benzyl isothiocyanate
Terpenols	Phenolic compounds	

1. Bioactive potential of papaya**Antibacterial activity**

Research investigation was carried out to check the antimicrobial activity of fresh and dried leaf extracts (acetone, aqueous, and ethanol) of papaya by disc diffusion method. Papaya leaf extract showed antimicrobial activity against *Pseudomonas aeruginosa*. The leaf extract showed superior effects against all Gram positive bacteria as compared to Gram negative bacteria also reported the antibacterial activity of papaya leaf aqueous and methanolic extracts against *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*.

Anti-diarrheal responses

Chloroform extract (25 mg/mL) of raw *C. papaya* and acetone extract (25–0.39 mg/mL) of ripe *C. papaya* had essential antidiarrheal activity against gut pathogens. The antidiarrheal activity of ripe *C. papaya* extract was extensively seen against *Plesiomonas shigelloides* with ranges from 50 mg/mL to 0.39 mg/mL. DAS 77 (herbal mixture prepared dried root of *C. papaya* with young bark of *Mangifera indica*) effective in the treatment of diarrhoea. DAS 77 was tested on mice and the result showed that DAS 77 possesses antidiarrhoeal activity. In another study antidiarrheal activity of leaf aqueous extract of *C. papaya* was tested in rats' model and found that extract has good antidiarrheal activity (Sani M A et.,al.,)

Wound-healing activity

Various skin disorders as well as wounds can be cured by papaya. The ethanolic papaya seed extract was tested in Sprague Dawley rats, results showed that the seed extract assists wound healing in rats. It also exhibited strong antibacterial activity against both *S. aureus* (Gram positive) and *E. coli* (Gram negative). In a research investigation, the effect of aqueous extract of the root of *C. papaya* shows remarkable wound healing activity like standard FSC (Framycetinsulpha cream) (Sing et al., 2020).

Anticancer activity

In vitro investigation of *C. papaya* suggested that it has anti cancer properties. The enzyme, *papain* is very helpful in cancer treatment. Fibrin breaks down by papain which coats the tumor cells into amino acid. The pigment lycopene is found inside the papain which is highly reactive towards free radical and oxygen. Papaya also contains isothiocyanate which protects the breast, prostate, pancreas, lung, leukemia, and colon cancer. In a research study, it was revealed that the leaf extract of *C. papaya* can prevent the progression of cancerous cells. It has been reported that the black seed extract is effective against prostate cancer cells whereas the white seed shows a stimulating effect on pre existing prostate cancer cells (Pandey et al, 2016).

Anti-malarial activity

There were several reports available that support the anti malarial activity of *C. papaya*. Papaya along with other plants was used by people in the treatment of malaria and related symptoms

Anti-dengue activity

Larvicidal efficiency of chloroform, methanol and aqueous extracts of *C. papaya* latex against larvae of *C. quinquefasciatus* and *A. aegypti* which were effective in a dose dependent manner. *C. papaya* leaf juice was prepared by the traditional method, and two tablespoons of juice were given to 5 dengue patients three times/day after 6 h. It was found that leaf juice causes a significant intensification in the platelet counts within 24 hours of treatment. An increase in platelet count was observed when a patient was given *C. papaya* leaf extract tablet three times daily for five days and it was suggested that this effect may be due to the expression of the gene responsible for platelet construction named as platelet activating factor receptor gene. Another investigation has also shown that the leaves of *C. papaya* have a promising effect on to increase in the platelet counts of a dengue patient.

Anti-inflammatory and immunomodulatory responses

Papaya contains an extensive range of secondary metabolites such as alkaloids, tannins, flavonoids, and saponins, which have been shown to marked effect on reducing chronic inflammatory reactions. Proteolytic enzymes that are present in papaya such as papain and chymopapain also showed an anti inflammatory effect as well as an effect on immunomodulation (Renganathan S et al., 2009). Papain in combination with another proteolytic enzymes such as trypsin and chymotrypsin reduces TGF β 1 levels in osteo-myelo-fibrosis, rheumatoid arthritis and herpes zoster. Alkaloids of papaya such as choline and nicotine showed anti inflammatory potential.

Nutraceutical attributes

Carica papaya. L is a plant that is easily accessed and widely available. The fruit of *C. papaya* is considered one of the most common fruits concerning human consumption and provides a favourable cost-benefit in consideration of its nutritional value, with low caloric content and rich concentration of vitamins and minerals. Papaya fruits, seeds, peel, and leaves have nutraceutical values, which make them important in human diets. These papaya parts are rich in macro- and micronutrients with varying degrees. In addition, it has high carotene content when compared with other fruits. The valuable phytochemicals present in papaya such as phytosterols, tocopherols, flavonoids, alkaloids, and carotenoids have interesting nutraceutical properties and play key roles in ameliorating and treating some medical conditions such as inflammation, hyperglycemia, fertility-related complications, and hypertension and possess anticarcinogenic activities. However, further studies are warranted to validate the dosage, mode of action, and safety profile of papaya seeds, peels, and leaves when used as medicine.

The studies have pointed out that this fruit is an excellent source of beta-carotene (888 IU/100 g), preventing harms caused by free radicals, besides exerting a role in the prevention of cardiovascular illnesses, diabetes mellitus (types 1 and 2) and in the reduction of cholesterol levels through its high content of fibres, which diminish fat absorption. The bioactive compounds and a lipidic composition reduce inflammatory markers and anti-platelet aggregation, protect against thrombogenesis and oxidative stress, and prevent hypercholesterolemia factors that can be triggered by obesity. Considering the nutrients present in its composition, beneficial effects have been observed, with a significant improvement in the cardiovascular system, protecting against cardiovascular illnesses, heart attack and strokes.

Value added products

Fruits are directly consumed by health-conscious people but the changing era, lifestyle, and urbanization have drastically modified the food habits of people like frequent use of ready-to-eat food, ready-to-serve fruit juices, jams, jelly, leather, powder, etc. Papaya is a powerhouse of nutrients and is available throughout the year. Despite the large acreage of land devoted to papaya the fruit loss is reported to be between 40-100 per cent of total annual produce (*Source: Database of National Horticulture Board, Ministry of Agriculture, Govt. of India*). Papaya softens quickly during ripening, being a climacteric fruit and therefore has a relatively short shelf life that limits the distribution of fresh papaya fruit in the market. Thus, to increase the self life of papaya fruit, they can be used for the development of processed foods such as juice, puree, jam, jelly, syrup, nectar, fruit paste, or canned as halves associated products.

Use of papaya waste

A large number of wastes and by products are generated by the huge quantities of papaya produced every year and are utilized for different purposes. The cosmetic world is a major industry in today's time. Cosmetics are used throughout the world to improve the general appearance of the human body. Various types of cosmetic products are available in the market for the use of different parts of the body. Herbal cosmetics are in great demand in the current situation to avoid damage caused by chemical cosmetics. Bioactive components of botanicals are used in different herbal cosmetic products such as face creams, face packs, lotions, and hair products such as oil and conditioner. They are preferred for their safe use with no side effects. Papaya also has a great effect on skin and hair according to many investigations. Sadek (2012) has reported that the unripened fruit of papaya can be used as an ingredient for facial products such as face creams.

By introducing latex extraction from Papaya, we can convert the utility of this crop into a different magnitude, like Rubber in Kerala and Assam, thus a sustainable income can be generated regularly from latex extraction. The development of entrepreneurial skills for optimum utilization of local resources can be established by the formation of small-scale industrial units. Thus, there is further scope for new entrepreneurs to establish value-added products from Papaya.

Conclusion

Today, a major concern of any individual is achieving better health and quality of life either through the use of synthetic chemical drugs like multivitamins or through supplementary diets or dietary supplements. However, the pharmaceutical industry is more focused on the development of new indigenous plant-based drugs through the investigation of leads from traditional systems of medicine and traditional uses of natural compounds. Thorough screening of literature available on *Carica Papaya*. L depicted various importances of papaya leaf, fruit, and seed in treating a large number of diseases and their use in making many value-added products. These products have immense potential to enhance the monthly income of farmers. But these products are yet to be introduced in the market as no branded products are available in the market. The major drawback is the peculiar smell at the ripening stage which needs biotechnological intervention to make this crop a superfood. Although papaya possesses enormous health benefits, it can be an efficient nutraceutical in combating malnutrition and food security. Many research studies done on these lines regarding the different verities suitable for Asian countries and quality and quantitative production.

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Code

DOI: [10.22192/ebfipr.2024](https://doi.org/10.22192/ebfipr.2024)

How to cite this Chapter: Deepa Kesavan, Soumya M, Praveena V, Hitha V, and Thoyiba V M. (2024). Neutraceuticals and Bioactive potentials of *Carica papaya* Linn. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 81-82.

Composting of house hold organic wastes using microbial inoculum

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Abstract

In less-developed countries, composting has emerged as a vital technology to recycle biodegradable waste while generating a useful product. Wastes classified as organic can biodegrade quite quickly. These wastes are generated from a variety of sources, including municipal solid trash, agricultural waste, market waste, kitchen waste, and urban solid food waste. Waste materials can cause various environmental issues if not properly managed. Composting is therefore the finest low-cost method to solve this issue. All organic wastes, including fruits, vegetables, plants, yard wastes, and others, can be broken down using composting. The organic waste that can be utilized as a soil amendment, crop nutrient, and environmental control material. This work concentrates on household waste management by bin composting. The inoculum used was obtained from IRTC Mundur and used for composting Kitchen waste generated from houses. The observations were made on three vegetable crops and degradation was studied. The compost obtained was used as fertilizer and growth parameters were measured. It was found a significant increase in all the parameters studied. Since the system as a whole is closed, the fly problem is likewise resolved automatically.

Key words: biodegradable, composting, organic wastes, inoculums, degradation, fertilizer

Introduction

Composting is a controlled, aerobic (oxygen-required) process that converts organic materials into a nutrient-rich, biologically stable soil amendment or mulch through natural decomposition. The end product is

compost. The interaction between the garbage and its microbes during the composting process is intricate. The process of composting is how nature recycles. It is among the most effective things we can do to combat climate change, lessen our rubbish, and create healthy soil. We convert our waste streams into a valuable, additional soil amendment and utilize it to preserve the environment and build resilient communities by turning our food scraps and yard trimmings into compost. Before composting, biodegradable wastes need to be separated: To produce high-quality compost, only pure food waste, garden waste, wood chips, and occasionally paper trash are appropriate. The three main components of the composting process are vermicomposting aerobic composting, and anaerobic composting.

Earthworms are used in vermicomposting as naturally occurring, adaptable bioreactors for the conversion process. Vermicomposting is a precision-based method that needs to be managed by a professional. The process of turning organic wastes into compost or manure in the presence of air is known as aerobic composting, and it can involve a variety of techniques. One of the most important factors in regulating composting waste activities is aeration, which affects the microorganisms' access to oxygen, moisture, and temperature (Wu *et al.*, 2019). Without air, organic matter breaks down during anaerobic composting. It is possible to gather organic materials in trenches, cover them with a thick layer of dirt, and then leave them undisturbed for six to eight months. The resulting compost might not be entirely transformed and might contain aggregated materials. Composting anaerobically can be done at any size. Anaerobic digestion is the term commonly used in the business context. While the procedure is essentially the same as what you would do on a small scale, large-scale anaerobic composting can be more difficult than large-scale commercial aerobic composting. Anaerobic digestion is much more controlled and fine-tuned by the methods and technology applied to produce products like biogas. This is where an understanding of biochemistry comes in. This can be as easy as burying organic material in a pit, placing it in a sealed container, or letting it decay in a plastic bag. Adding completed compost to the ground, the addition of organic matter, which enhances the structure and health of your soil, Aids in keeping nutrients and moisture in the soil, Decreases the use of fertilizers and pesticides by drawing beneficial organisms to the soil, Lessens the possibility of soil erosion, Absorbs carbon from the soil, Increases resistance to climate change's effects.

It is also a more costly choice. Kitchen garbage composting is a very sustainable practice. The creation of a compost pit is accessible to anyone to make compost out of kitchen garbage. It's a common misperception that making compost only involves mixing everything. This is not accurate since the right procedure must be followed. It's not enough to just throw a banana peel into a mound of dirt and hope for the best for the soil.

Inoculum used in composting

Inoculum is a material used for inoculation in compost. In microbiology, a field of biology that studies microorganisms such as bacteria, viruses, and unicellular organisms, the phrase “inoculation” is frequently used. The population of microbes or cells injected into the fermentation medium, or any other suitable media, is referred to as an inoculum. Large populations of advantageous microbes are present in the high-quality compost produced by the microbial inoculants, and these bacteria continue to function after the compost is applied. This enhances crop growth and yields as well as the condition and quality of the soil. The use of microbial inoculants provides for a more rapid and effective conversion of raw organic material into compost. The majority of compost's breakdown and heat production is caused by bacteria. Compost can be applied as mulch or as a soil amendment. Add two to four inches of compost to the top six to nine inches of your soil as a soil amendment. To use as mulch, remove the top two to three inches of soil and cover the surface with a three-inch layer of compost, keeping it a few inches away from tree trunks and plant stems.

Advantages of composting kitchen garbage

Rapid urbanization has led to the wide spread of residential buildings in cities with the compression of living space. This development trend also drives the shift of home composting commonly in the garden to indoors, for example, on the balcony with a much smaller scale. Indoor composting is typically anoxic as the composter needs to be sealed to avoid odour release. Thus, both solid compost and leachate can be produced and used as soil conditioners and/or fertilizers for flower and vegetable plots on the balcony and in the local community. Since kitchen waste makes up a large portion of domestic rubbish and has the biggest influence on municipal waste management, it is the exercise's primary goal. Unmanaged kitchen trash is a highly putrescible material that can grow diseases, attract insects, flies, and rats to urban areas, and create filthy leachate and polluted odour. Additionally, kitchen trash is a significant source of biofertilizer for community gardens and urban landscaping. (Ma *et al.*, 2020)

Composting kitchen waste reduces the amount of garbage that is dumped and you can practice food waste management in the kitchen without going over budget. Recycling food waste is an issue, so when any food or ingredient may go bad, composting can fix this problem. Kitchen waste composting can help to lower the carbon footprint. Kitchen waste composting can lead to a farm-to-table movement. Composting kitchen garbage can make us more environmentally friendly, compost can be applied as a mulch or as a soil amendment and crops can be planted and harvested.

All the prerequisites needed for natural processes, like interactions with matter, microbial action, and a way of bio char composting with several organic substances, are provided by co-composting with different organic substrates. Compost is made up of various nutrients that work together to enhance soil nutrition. Decomposing plants, food scraps, and other organic materials are used to prepare it. The resulting mixture is full of worms and fungal mycelium, which are helpful creatures and plant nutrients. In addition to giving plants nutrition, compost also enhances the texture and fertility of garden soil.

Food waste composting

Food waste composting should take place both at the composting plants and housing level. However, there are some drawbacks to home composting. For example, the final compost may not be uniform at the end of the process, and smells from the biological degradation process may deter homeowners from participating in the process because they release gaseous pollutants. The addition of additives has benefits as well as drawbacks. An important step before starting the composting process is to establish an appropriate recipe. This study aims to develop a composting recipe starting from the investigation of food waste like peel and pomace of fruits and vegetables which are very common in waste generated at the housing level.

The responsibility of municipal authorities is to manage storage facilities in a way that prevents unclean and unhealthy circumstances. It is necessary to conduct a fresh survey on municipal solid waste generation and classification in India. (Gupta *et al.*, 2015). Throughout the composting process, several physicochemical and biological characteristics were observed, such as temperature, pH, odour, C: N ratio, amylase activity, cellulose activity, lipase activity, protease activity, and variations in the amounts of fat and humic acid.

Composting food waste and other organic waste allows organic waste to decompose aerobically, imitating nature's process of disintegration. Composting significantly lowers the amount of garbage that is dumped in landfills and lowers greenhouse gas emissions. By adding organic matter, compost enhances the texture and structure of the soil, making it more favourable for plant growth. Higher proportions of organic matter in the soil help it hold on to more water, nutrients, and air, which benefits the ecosystem as a whole by improving plant conditions and lowering runoff and erosion. Because it is composed of so many various kinds of materials, compost also has a wider variety of nutrients than fertilizers. Compost lowers the demand for fertilizers because it improves soil structure and adds nutrients, which helps the soil retain nutrients longer. One of composting desired goals is to break down organic material into stable humus, which enhances soil quality, composting reduces the need for pesticides and synthetic fertilizers.

Approximately two-thirds of household waste may be kept out of landfills by using decentralized waste sorting and composting. The usage of these composts has some environmental dangers, one of which is the high electrical conductivity that results from the presence of salt chloride in food. The ecotoxicity of the composts is influenced by electrical conductivity. Another significant environmental issue is the presence of pesticides in composted food. Composting time was lowered and organic matter breakdown was accelerated with the addition of compost. The addition of mature compost accelerated the growth of maturity-related bacteria during the first stage. The addition of mature compost also enhanced the number of organic matter-related microorganisms.(Yumei *et al.*, 2022). Composting conditions can be adjusted to effectively reduce greenhouse gas emissions. Physically porous additives can be used to reduce anaerobic gaseous products. Chemical additions cut gaseous emissions considerably, but they have negative effects on the application of compost that need to be avoided.

A part of the biodegradable trash generated by households could be diverted from landfills via home composting. To increase the Compost waste diversion rate, a sizable percentage of local households must actively and consistently participate in home composting, which is a voluntary activity. About 75% of local government has encouraged the use of home composting by providing homeowners with subsidized compost bins: yet, the efficiency of home composting for trash diversion remains questionable because of the significant practical challenges associated with process monitoring.

Exploring Boundless Frontiers: Interdisciplinary Perspective in Research

Studying the efficiency of compost production Utilizing this compost as manure for growth Compost is a collective term for organic material that has broken down which can be utilized as a crop fertilizer and for land repair. It is free, assists with recycling your kitchen waste, and is safe for the environment because it lessens the quantity of waste that is dumped in landfills, which contaminates the air. It is employed in landscaping and gardening. Compost has various applications such as fillings, managing soil erosion, acting as a soil pesticide, and as a land correction agent.

Steps in household organic waste composting by an experimental set of bio bins

Materials used for composting

Bucket

Soil

Dry leaves

Inoculum

Vegetable waste

Garden Pot

Compost

Organic waste materials and debris was gathered in a bucket, including dry leaves, egg shells, and kitchen scraps and food wastes. Collection was done periodically. They were sorted as per the size to ensure the maximum availability of surface area.

The experimental set was maintained by labelling Control and experimental buckets. In a three-tier bucket system, the experimental composting was done. The microbial inoculum was purchased from IRTC Mundur, Palakkad. Then one layer of soil at a thickness of 5 inches was spread in the bucket followed by a layer of dried leaves. and then by the inoculum in 5 inches thickness in the first bucket. Fully drained waste materials were used for filling the buckets. All other waste materials were made into small pieces to increase the surface area. Four holes were made in the bottom of the bucket. Then vegetable waste is layered in the bucket. The inoculum is covered by vegetable waste. Everyday bucket is spread with waste and the inoculum is covered by the way to complete the whole bucket. The bucket is tightly packed

by using wires. Weekly, the mixture was mixed properly. The whole system was kept in a cool area away from direct Sunlight and rain.

The process of decomposition was evaluated every 7 days by direct observation. Physical indicators for monitoring fermentation such as smell, colour, temperature, and pH were tested. Physical parameters like Odour and colour change of the decomposition process were observed directly, two categories such as non-offensive smell (esters, alcohol etc) and offensive smell (ammonia, H_2S etc) were detected using olfactory judgement. Colour change and Appearance were detected through visual observation.

The sorted waste materials included vegetable waste like onion peel, vegetable waste, food waste like rice, curry waste, leafy waste from the garden, dried wastes of leaves and paper waste. An average of 0.5 to 1 Kg wastes were sorted every day. In every home triplicates of systems were maintained in pots. Pots were maintained in the garden near the kitchen. The system is kept away from rain and direct sunlight. A layer of garden soil is first layered in pots. Every day refilling of waste was done the waste was drained fully before putting in the buckets. Every week remixing up and down was done. This was to ensure air circulation in the bucket system.

Discussion

The present study provides a cost-effective method of solid waste management and an economical method of biofertilizer production. At a time when the globe is facing two problems at a time: fulfilling the food requirements of the expanding population and managing biodegradable solid waste, the consolidated bioprocessing approach by transforming solid waste into biofertilizers will be a major milestone in sustainable agriculture. The current study is technically possible and, if carried out on a commercial scale, can lead to sustainable management of municipal solid waste with low-cost manufacture of biofertilizers, which is currently in demand in the agricultural market.

Evaluation of physical properties

After 45 days every 4 buckets were observed and recorded for decomposition the different properties were evaluated in the bucket system of household waste management. In the control bucket without inoculum, there was a strong offensive smell of Ammonia and Hydrogen sulphide. This may be

due to a reduction in the number of *Lactobacillus* as well as other microorganisms which enhance the degradation process. It was consistently detected throughout the decomposition process even at the 40 day itself. In the microbial inoculum added waste composting bucket observed a strong offensive smell from the 14th day onwards and reduced after 21 days onwards. This may be due to the conversion of waste into reduced form. This appeared to result from a reduced number of Lactic acid bacteria in the sample leading to putrefaction producing hydrogen sulphide.

After 45 days of observation, the compost is finally formed. when, we opened the bucket. the waste was changed into compost. The fast formation of compost was done by the use of inoculum. The mixture that results is full of beneficial creatures like nematodes, fungi, bacteria, and protozoa as well as plant nutrients. In organic farming, urban agriculture, horticulture, gardens, and landscaping, compost increases soil fertility and lessens reliance on synthetic fertilizers. Compost serves as a soil conditioner, increases the amount of humus or humic acid in the soil, and introduces helpful bacteria that help to inhibit pathogens in the soil and lessen soil-borne diseases, among other uses for compost.

Change in pH and appearance during the composting

A white cottony mass of colonies was observed over the decomposing bucket from the 7th day onwards. This is due to the presence of Actinomycetes colonies. The earthy odour produced by Actinomycetes was also detected. The odour persisted upto 35 days of observation when the whole waste were converted to powdery form. Black mold were also observed which was identified as *Aspergillus* sp which are fungi helping in composting. There was a change in colour of the waste materials from green to brown and thereafter to dark black color which confirmed the conversion to compost.

The pH changed from 12 to 4 in the observations from 7th to 35th day. This shows the pH a shift from initial condition towards more acidic condition by producing organic acids and which enhances the fertility of the soil by bringing the pH down. Also, lactic acid produced by *Lactobacillus* contributed to the acidic pH. The initial drop in pH reflects the synthesis of organic acids, which serve as substrates for succeeding microbial populations. The subsequent rise reflects the utilization of organic acids by microorganisms.

Role of Microbial inoculants

From the present study, it is shown that microbial inoculants decreased the degradation time of waste. This indicates microbial culture was an effective tool to facilitate the shortening of the composting period. The addition of inoculation increased the waste decomposition rate within a shorter span. It also enhanced enzymatic activity and minimized initial lag time of the biological process, accounted for the accelerated composting by the effective microbes present in the inoculum. A positive effect on emission of odorous compounds and ammonia was detected during kitchen waste composting. Our results show there is a decrease in odour from the 7th day onwards due to the addition of microbial inoculum. Microbiota and physicochemical characterization of food waste in a new method of food composting.

Conclusion

Composting is one of the most sustainable ways to manage organic waste, and using renewable resources is crucial to reducing environmental concerns. Aerobic microorganisms predominate in the composting process, they require oxygen to live and keep their metabolism going (Zeng *et al.*, 2018). Higher temperatures are not necessary because the oxygen in composting also eliminates extra moisture from the composting pile (Zhang *et al.*, 2021). When all of the components have been mineralized and the microbiological decomposition is finished, the compost is considered mature. This improves the physical, chemical, and biological qualities of the soil and makes the components available to plants (Gou *et al.*, 2017). Temperature and moisture conditions depend on the degradation of the food waste. inoculum added for the rapid degradation of food waste, the microorganisms present in it. It has the efficiency to speed up the degradation and change into compost. This study showed that adding mature compost accelerated organic matter decomposition and reduced the amount of time needed for composting.


Household waste has the potential to be converted into Organic Fertilizer because the organic waste contains nutrients that can be used as fertilizer and are useful for application to plants. Fertilizer is a substance that is added to increase the nutrient content in the soil. Organic fertilizers have several benefits, including encouraging and increasing the formation of leaf chlorophyll and improving soil properties. This organic fertilizer has many advantages, including quickly overcoming nutrient deficiencies, not causing problems in nutrient leaching, and providing nutrients quickly.

Management of household waste treatment aims to improve the understanding and skills of women toward the problem that occurs in their surroundings. This is done to improve the quality of life of housewives and provide a positive and active role in society. The activities of housewives as producers of organic waste from food scraps, vegetables, and fruits must be given an understanding of the negative impact of the waste generated on the environment and given education on how to handle waste so that it can be used as a by-product and sustainably. Household waste can be processed into organic fertilizer, which can be used to fertilize plants around the house or other yards. Therefore, by knowing the knowledge of waste management, housewives will desire to produce safer and healthier organic vegetable commodities.

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DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Renju Krishna V, Vandana Sivadas, Varsha Narayanan and Sneha Sathyanarayanan. (2024). Composting of house hold organic wastes using microbial inoculum. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), *Exploring Boundless Frontiers: Interdisciplinary Perspective in Research*. India: Thanuj International Publishers. pp: 93-103.

Amelioration of psychological stress by odour evoked memory

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Introduction

The relationship between odour memory and psychological stress is a growing area of interest within psychological and neuroscientific research. The premise is that certain smells can trigger memories that have a profound effect on an individual's emotional state, which in turn can influence physiological stress markers such as cortisol levels, heart rate, and blood pressure. This interconnection highlights the potential of utilizing scent as a tool for managing stress and emotional wellbeing. There is a strong connection between olfactory cues and emotional regulation, including stress response. Odour can evoke potent emotional and memory responses that can modulate psychological and physiological states, including stress (Herz, 2009).

The exposure to stress-related odours can activate stress responses in the brain, suggesting that not only can pleasant odours reduce stress by evoking positive memories, but unpleasant odours can also induce stress by recalling negative memories. de Groot *et al.*, (2012) provide insight into how olfactory cues can be potent modulators of emotional and physiological states. The direct pathway from the olfactory system to the limbic structures of the brain makes scent a unique medium through which psychological and physiological stress can be influenced. However, the specificity and variability of these effects can depend on individual differences in past experiences, genetic factors, and the context in which the odours are perceived.

Intentional odour delivery can indeed impact cognitive operations, influencing various aspects such as memory, attention, and decision-making. The exposure to pleasant odours improved performance on cognitive tasks, while unpleasant odours had a detrimental effect. Moreover, event-related potentials (ERPs) recorded during the tasks showed that pleasant odours reduced the amplitude of ERP components associated with distraction,

suggesting enhanced attentional focus. Conversely, unpleasant odours increased ERP amplitudes, indicating greater distraction and reduced cognitive performance (Seo & Hummel, 2010).

A pleasant ambient odour led to improved decision-making performance compared to an unpleasant odour or no odour condition. The intentional odour delivery can influence cognitive operations by modulating attention, memory, decision-making, and mood. The findings of Johnson *et al.* (2012) suggest that the olfactory system plays a significant role in shaping cognitive processes and highlight the potential applications of scent in various contexts, including enhancing cognitive performance and creating more conducive environments for learning and productivity. Ambient odours, including unpleasant ones, can impair cognitive performance in complex tasks (Baron, 1997).

Odour evoked memory and psychological responses

One of the main components of olfactory cognition is odour memory, which is separated into two different cognitive-perceptual processes. One is the capacity to identify and recall if one has previously smelled a particular odour. This type of olfactory memory bears similarities to other sensory-semantic cue recognition, such as remembering that a specific sound indicates your dog is barking. A crucial aspect of human health is the ability to recognize and identify odours, and more specifically, when this ability fails. The second type of odour memory is odour-evoked memory-autobiographical memories and associations that are triggered by odours (Engen, 1982; Herz & Engen, 1996; Pinto *et al.*, 2014).

Odour-induced memories have been demonstrated to be more positive than memories triggered by other cues, and happy moods and feelings are known to be advantageous for psychological health. When Willander and Larsson (2007) examined memories elicited by verbal labels, odours, and odours + labels in healthy older persons. The study explained that odour-evoked memories were noticeably more enjoyable than label-evoked recollections. Autobiographical memories evoked by scents were found to be more emotionally vivid and positive in male and female adults than memories prompted by verbal labels for the same odours. Odour-induced memories were linked to greater activity in the temporal gyrus and temporal pole than verbally elicited memories. Since the temporal poles are involved in the processing of happy memories, it is hypothesized that the superior positive aspects of odour-

evoked memories may be due to higher temporal pole activity (Arshamian *et al.*, 2013; Piefke *et al.*, 2003).

Invoking pleasant autobiographical memories has been employed as a therapeutic strategy to repair emotional discomfort in a variety of clinical circumstances (Josephson *et al.*, 1996; Panagioti *et al.*, 2012). Pleasant autobiographical memories can promote happy mood. Odours have the ability to generate more positive emotional memories than other stimuli, and as a result, they may be particularly useful for elevating mood states. Matsunaga *et al.*, (2011) explained that when men and women between the ages of 21 and 38 were exposed to the aroma of a perfume that held personal significance for them, they reported feeling happier, more positive, and less anxious than when they were exposed to a pleasant scent that did not bring back memories.

According to Matsunaga *et al.*, (2013) scents that brought back memories of a particular experience caused young adults to feel nostalgic about 6.5 times more strongly than scents that did not. Moreover, fragrances induced more than twice as many nostalgic reveries as did music, according to a comparison of music- and odour-driven nostalgia (Reid *et al.*, 2015; Barrett *et al.*, 2010). This is a significant discovery because music is known to induce strong emotions and is frequently associated with memorable experiences (Royet *et al.*, 2000). Miles *et al.*, (2011) provided more evidence for the nostalgic appeal of scents when they compared different qualitative aspects of 12 common stimuli in verbal, visual, and olfactory formats for a sizable sample of female college students. They found that memories evoked by odours were judged as more relevant to one's life story than memories elicited by verbal or visual cues.

Reid *et al.*, (2015) conducted analysis of odour-evoked nostalgia using 12 common scents on college students. They found that high levels of odour-evoked nostalgia were linked to high levels of positive affect, self-esteem, self and social connectedness, optimism, and life meaning. The pleasant feelings were felt during odour-induced nostalgia twice as much as during music-evoked nostalgia, and that nostalgic odours evoked three times as many happy emotions as negative emotions (Barrett *et al.*, 2010). Thus, nostalgia caused by scents is more pleasurable than nostalgia evoked by other sensory stimuli, as is the case with the significant positivity of odour-evoked memories.

It should be mentioned that memories associated with smells can also provoke negative feelings. In fact, they have the potential to be incredibly strong triggers for PTSD (post-traumatic stress disorder). Studies on PTSD cases have shown that scents associates with a person's traumatic experience can cause severe flashbacks that last for decades and don't go away (Vermetten *et al.*, 2003). In a lab study on aversive memories that when healthy college students were asked to recollect episodes from a traumatic documentary that had been associated with either an auditory, visual, or olfactory cue a week prior, the olfactory cue elicited more vivid, intense, and unpleasant memories of the documentary than the auditory cue (Toffolo, 2012). These results advise caution that depending upon an individual's past experience with an odour, the emotional states and responses that it elicits can be very negative.

Conclusion

This review concluded that the positive emotional states elicited by odour-evoked memories can ameliorate psychological response and lower stress (Masaoka *et al.*, 2012) (Matsunaga *et al.*, 2011; Pressman & Cohen, 2005). Moreover, the positively charged memories associated with smells seem to have the ability to lower inflammation through psycho-neuroimmune interactions (Matsunaga *et al.*, 2011; Matsunaga *et al.*, 2013). Therefore, using the power of pleasant smells to trigger memories has significant health benefits.

An odour has the power to affect psychological and physiological wellbeing in a variety of ways. For example, it can trigger happy autobiographical memories in a person, reduce stress, increase positive emotions, interfere with cravings, and reduce inflammatory immune responses. The exact feelings that a particular odour-evoked memory generates can also boost other emotions, such as self-confidence, motivation, and energy, which in turn might energize behaviour. All these states could be inspired and have beneficial physiological effects, for instance, by an odour that evokes the memory of winning a significant race. Furthermore, an individual scent can be associated with a significant prior personal event due to the unique resistance to retroactive interference that is inherent in olfactory cognition. Furthermore, a particular smell associated with a significant previous personal event can be a very dependable therapeutic agent due to the unique resistance to retroactive interference that is essential to olfactory cognition.

More so than any other kind of memory experience, odour-evoked memories are emotionally charged and transport us back to the past. The tragic situation where someone unexpectedly loses their sense of smell due to an accident, along with their mental stability, sense of self and others, and overall quality of life, is the most striking example of this remarkable aspect of scent (Herz, 2007; Croy *et al.*, 2012; Smeets *et al.*, 2009). The autobiographical memories and emotional associations evoked by scents are clearly vital to our psychological and physical well-being, as evidenced by a multitude of viewpoints.


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	Subject: Psychological science
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

K Shameema and Naseef P. (2024). Amelioration of psychological stress by odour evoked memory. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 104-111.

Butterfly (Lepidoptera) diversity in NSS college Manjeri campus, Kerala, India

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Abstract

The campus of NSS College Manjeri, which is tucked away within the Manjeri Municipality, provides a dramatic contrast to the region's mostly concrete surroundings. The campus is home to many nectar sources, plants that lay eggs well, sunny open areas, little pesticide use, and other favourable factors that have all contributed to the development of a vibrant and varied butterfly population. There were 41 species of butterflies found in all, the most common being the Nymphalidae family, which has 20 species. The number of butterflies varied from month to month, peaking in October and falling off in January. Comparing the monsoon season (September to November) with the post-monsoon period (December to February), seasonal patterns showed that variety was higher during the former. The importance of campus habitats is highlighted by the existence of this diverse group of butterflies. Carefully designed gardens and landscaping can increase the diversity of butterflies even more, which makes the campus a perfect location for studies and conservation related to butterflies, particularly those that study their complex relationships with flowers. With the goal of expanding and improving our knowledge of these vital elements of the ecosystem, this study acts as a starting investigation of the butterfly wealth on the NSS College campus.

Key words -Butterfly, diversity, campus, conservation, seasonal pattern

Introduction

According to Robbins and Opler (1997), butterflies are among the insect groups that have been studied the most in taxonomy. There are more than 28,000 species of butterflies in the world, and most of them live in tropical areas. According to Tiple's 2011 assessment, India's varied topography, temperature, and vegetation are home to about 1,504 species of butterflies. Tiple et al. (2007) noted that Lepidoptera is one of the largest orders of insects among the others. This order includes both moths and butterflies, totaling

17,425 species that have been identified to far. According to Tiple et al. (2007), of these, 17,950 are butterflies, and the remaining species are moths. Butterflies are thought to be important environmental indicators and are of significant taxonomic significance. Their vast range, preference for specific vegetation types, rapid responsiveness to disturbances, ease of taxonomic recognition, statistically significant population numbers, and convenience of sampling have all led to their standing as excellent organisms for monitoring environmental changes. Butterflies are prized for their beauty, elegant flight, and vivid colors in addition to their scientific value. In addition to being important pollinators, they also act as markers of environmental change. Furthermore, butterflies are valuable both aesthetically and commercially. Tiple (2012) noted that butterflies are excellent markers of environmental changes because of their sensitivity to habitat degradation and climatic variability. By aiding in pollination and acting as crucial linkages in the food web, they are integral parts of food chains and provide ecosystem services. Given the loss of green spaces brought about by urban expansion and the rising levels of industrial and vehicular pollution in Indian cities, it is imperative to acknowledge the significance of butterflies in protecting and detecting vulnerable habitats. Butterflies and other species are dying at an accelerated rate as pollution levels rise and greenery disappears. The survival of many species as well as the balance of the ecosystem are seriously threatened by this. Indian cities, though rapidly urbanizing, nonetheless provide a variety of habitats, including parks, traffic island gardens, and urban forests with different kinds of trees. These kinds of habitats are perfect for a wide range of insect species, especially butterflies. We chose this research topic because of the important role butterflies play in our ecosystem. They are trustworthy markers of a robust ecology, a fact Evans acknowledged in 1932. The campuses act as a haven of safety, offering an appropriate habitat for this group of insects.

Materials and Methods

Study area

Situated in the Manjeri Municipality, the NSS College Manjeri campus is located at coordinates 11° 07'10'' N and 76° 07' 71'' E. Among a landscape dominated by concrete buildings, the college stands out for its wooded surrounds (IMAGE 1). The five-acre college campus is covered in rich vegetation, with long grasses, dense shrubs, and huge trees that provide home for butterflies. Many nectar supplies, plants that lay eggs well, open sunlight areas, and low levels of pesticide use have contributed to the region's diversity

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of butterfly species. Hot summers from March to early June, a humid southwest monsoon season from mid-June to August, a northeast monsoon from September to November, and a post-monsoon period from December to February characterize the climate in the research area (IMAGE 2).

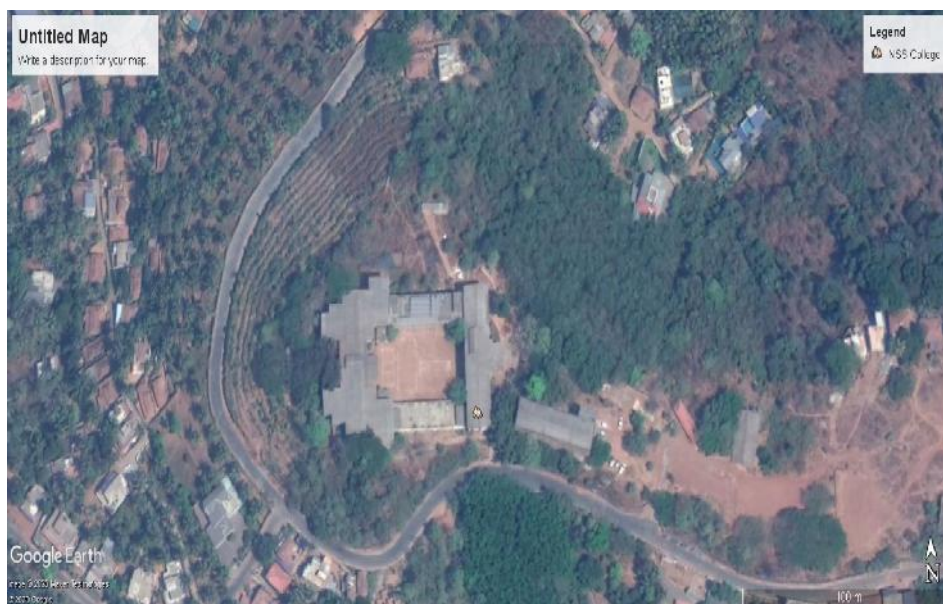


Image 1. Satellite overview map of study locality

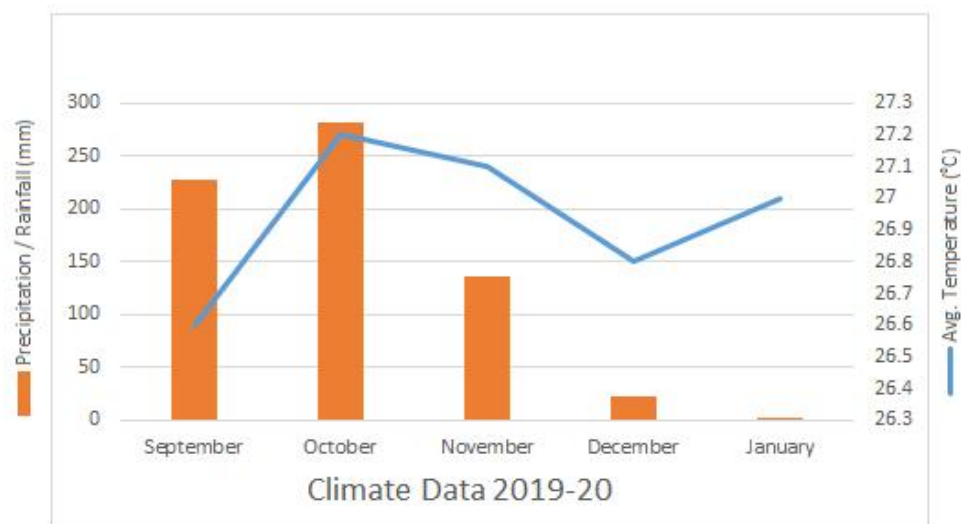


Image 2. Climatic data of Manjeri NSS College

Study design

On fixed transects measuring three by one hundred meters, butterflies were sampled using the Pollard walk method. Each of the three 100-meter-long transects was set up at a different location to cover a variety of vegetation types. Between September 2019 and March 2020, random polls were used to get the data that is shown here. With the use of Bushnell binoculars (8x40), the entire college campus was inspected between 9 a.m. and 5 p.m. To aid in the identification of species, photographs of butterflies were shot from a variety of perspectives. Photography was done with digital cameras, such as the Nikon 3600 and mobile cameras. Field guides were mostly used for on-site identification of butterflies, with photography serving as a crucial tool. Using the aid of a field guide, specimens that were unable to be identified on the spot were gathered using handheld aerial sweep nets, sealed in envelopes, and sent to the laboratory for additional identification. Based on how frequently they were seen on the NSS College campus, the observed butterflies were divided into five categories: C (common, 50-100 sightings), NR (not rare, 15-50 sightings), R (rare, 2-15 sightings), and VR (very rare, 1-2 sightings). VC stands for very common. N.S.S College Manjeri conducted a five-month study on butterfly species, from September to February. Observations were split into two categories: one for the North East monsoon season (September–November) and another for the post-monsoon season (December–February) in order to capture seasonal diversity and abundance. On Tuesdays, observations were made every 30 minutes in the morning (9–9:30 a.m.), afternoon (1–1:30 p.m.), and evening (3:30–4 p.m.). On the east, west, south, and north faces of the college campus, five transects, each measuring 100 meters, were set up, and butterflies were found inside these boundaries.

Result

A total of 41 butterfly species were identified on the college campus, including three species protected by the Indian Wildlife (Protection) Act of 1972. The majority of butterflies belonged to five families (Table 1), with Nymphalidae being the most prevalent (20 species), followed by Papilionidae (8 species), Pieridae (7 species), Lycaenidae (5 species), and Hesperidae (1 species).

Table 1. List of sighted butterflies with their occurrence status

Month	Total individuals	Nymphalidae	Papilionidae	Pieridae	Lycaenidae	Hesperiidae
September	28	16	6	5	1	0
October	30	12	8	6	4	0
November	26	10	5	5	4	2
December	24	9	5	3	6	1
January	17	3	4	7	3	0

Nymphalidae, making up 48.7% of the total species, was the dominant family, followed by Papilionidae at 19.5%, Pieridae at 17.07%, Lycaenidae at 12.19%, and Hesperiidae at 1.83%. Notable species sightings included *Ypthima huebneri* in the Nymphalidae family, *Graphium agmemnon* in the Papilionidae family, *Leptosianina* in the Pieridae family, and *Castaliusrosimon* in the Lycaenidae family. Butterfly abundance varied by month, with the highest recorded in October (30 individuals) and the lowest in January (17 individuals), as detailed in Table 2.

Table 2. Butterfly families and their relative abundance at NSS College

Family	No. of genera	Relative abundance	No. of species	Relative abundance
Papilionidae	4	14.2	8	19.5
Pieridae	4	14.2	7	17.07
Nymphalidae	14	50	20	48.7
Lycaenidae	5	17.8	5	12.19
Hesperiidae	1	3.8	1	1.83
Total	28	100	41	100

The study spanned from September to February, allowing for a distinction between the monsoon and post-monsoon seasons. September to November was considered the monsoon season, while the remainder of the period constituted the post-monsoon season. The monsoon season exhibited higher species diversity and richness compared to the post-monsoon season. During the monsoon season, out of a total of 125 recorded individuals, 84 were observed, with the highest number in October and the lowest in November (26 individuals). Among families, Nymphalidae had the most individuals (38).

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In the post-monsoon season (December-February), a total of 41 species were recorded, including 12 Nymphalidae individuals, 9 Papilionidae individuals, 10 Pieridae individuals, 9 Lycaenidae individuals, and 1 Hesperidae individuals. December had the highest number of individuals observed (24), while January had the lowest (17).



Discussion

The presence of host plants for their larvae and nectar plants for their adults is associated with a butterfly's choice for particular settings. The wide variety of floral species on campus is reflected in the diversified butterfly population, which is especially home to Nymphalids and Lycaenids. Given its tropical climate, the campus has a variety of plants, most of which are herbs and shrubs. There are comparatively less trees. Butterflies can find a variety of habitats, food supplies, and breeding locations among the plant species belonging to different families, such as the Annonaceae, Apocynaceae, Fabaceae, Malvaceae, Acanthaceae, Rubiaceae, and others. Wynter-Blyth (1957) noticed that butterfly variety varies periodically, with times of abundance and rarity throughout the year. In India, peak butterfly seasons are found in March-April and October. According to Tiple et al. (2007), Tiple (2012), and Tiple & Khurad (2009), the post-monsoon season (late August to October) had the highest numbers of butterflies during this study. In contrast, there were fewer butterflies during the monsoon season. Butterflies are vital native pollinators, depending on native plants to complete their life cycle, in addition to being significant indicators of biodiversity. Therefore, a healthy ecology is usually indicated by a thriving population of butterflies. In addition, butterflies are important pollinators of both developed and wild plants. On the other hand, their populations are seriously threatened by habitat loss, pollution, overgrazing, and urbanization. Invasive plants, road runoff, litter, trampling, and human leisure activities also have a deleterious effect on butterfly populations. The impacts of urbanization and development may not be totally avoided, but they can be lessened by planting native plants and trees that benefit the local fauna. This will lessen the likelihood that the common butterfly species will go extinct, at the very least.


Conclusion

The study's findings highlight how important college campuses are to butterflies as their preferred habitats. With careful planning and maintenance, gardens can increase the variety of butterflies on campus, which would be a great starting point for more study and butterfly conservation initiatives. Furthermore, this study will further our efforts to understand the complex mutual connections that flowering plants and butterflies have, which are essential to the continuation of ecosystem services. It's important to remember that this study is the first to examine the butterfly population on the campus of NSS College. The list of butterfly species that is currently available is not all-inclusive, and we want to keep researching and expanding this list in the future.

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	Subject: Biodiversity
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

K. Anil and M Sheeba. (2024). Butterfly Lepidoptera) diversity in NSS college Manjeri campus, Kerala, India. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), *Exploring Boundless Frontiers: Interdisciplinary Perspective in Research*. India: Thanuj International Publishers. pp: 112-120.

Establishing a baseline data: A pilot study on the Butterflies in the Butterfly Garden in Kanakakkunnu Palace ground Thruvananthapuram, Kerala

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Abstract:

In the study conducted, diversity of butterflies was documented in the Butterfly garden at Kanakakkunnu palace ground when butterfly garden was established by Kerala Forest research Institute in 2018. A total of 25 species of butterflies from 4 families were reported in the initial stage of establishment. The data reveals that the Nymphalidae was the dominant family with the maximum number of species, followed by Papilionidae, Pieridae and Lycaenidae. There were no members of Hesperidae. Endemic species like Common Evening brown and rare species like Common Baron were observed. The Common migratory species like tawny coster, Lime butterfly, Crimson rose have also been reported. This highlights the importance of such green spaces in urban areas

Keywords: Butterfly diversity, Kanakakkunnu, Butterfly garden, Nymphalidae green space

Introduction

Butterflies are important to our ecosystem, as they have intrinsic aesthetic, educational, scientific, ecological and economic values. Among insects, butterflies have proved to be invaluable flagship species for conservation (Thomas, 2005). India hosts about 1,501 butterfly species, 350 in peninsular India and 333 in the Western Ghats alone (Gaonkar H. 1996), from 5 different families, viz., Papilionidae, Pieridae, Lycaenidae, Nymphalidae, and Hesperidae. Butterflies being very sensitive towards any type of change in their habitat are considered as excellent Biological Indicators (Parmesan *et al.* 1999). Thus, the butterfly diversity portrays a good picture of the ecological status of an area. Butterfly gardens are green spaces designed for this group of

insects to feed, mate and rest. To promote awareness of insect conservation in the general public, such parks have been established in campuses, schools and other institutions. The establishment of butterfly gardens helps maximize butterfly diversity and abundance in urban and suburban areas, conserving species that might otherwise become rare or even disappear. (Mathew 2001)

Here the present investigation was chosen to assess the diversity of butterflies in Kanakakkunnu Palace in Trivandrum City which is an urban hot pocket in the buzzing city of the state Capital and to collect a baseline data of butterfly fauna from the newly constructed butterfly garden (an initiative by Kerala forest research Institute, Peechi 2018).

Methodology:

The study area chosen was the garden established in Kanakakkunnu Palace, located 800 meters north east of the Napier Museum in the heart of Trivandrum city. The type of vegetation in Kanakakkunnu Palace is tropical vegetation. The area is enriched with many types of flowering plants, shrubs, herbs and tall trees. The garden included several host plants for butterflies. The site included *Ixora* (*Ixora coccinea*), yellow allamanda (*Allamanda cathartica*), Kilikkampetti (*Crotalaria pallide*), wood apple (*Aegle marmelos*), Mussaenda (*Mussaenda alaxa*), Tragia (*Tragia involucrate*), Neermathalam (*Crataeva* sp), Blood flower (*Asclepias curassavica*) Shoe flower (*Hibiscus rosasinensis*) marigold (*Tagetes erecta*), Mexican zinnia (*Zinnia haageana*), Sida (*Sida rhombifolia*) Rajamalli (*Caesalpinia pulcherrima*).

The data was collected in the month of January 2018. The main methodology followed here was all out search sampling. Observation was taken from 8.30 am to 4.00 pm, when butterflies were more active. The butterflies were counted by visual sighting and photo documented. This method of observation was followed so as not to harm the species. The butterflies were identified with pictorial guides of George Mathew (2004) and consultation with a specialist from KFRI.

Result and discussion

The work was done to assess the species diversity of butterflies in Kanakakkunnu Palace. During observation, a total of 25 species of butterflies belonging to four families were recorded from Kanakakkunnu palace. Family Nymphalidae showed the maximum species richness comprising of 12 species, followed by Papilionidae with 7 species, family Pieridae comprising 4 species and the family Lycaenidae comprising of 2 species.

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Sl No	Common Name	Scientific Name	Family Name	Host Plant
1.	Common Hedge Blue	<i>Acytolepis puspa</i>	Lycaenidae	<i>Peltophorum pterocarpum</i>
2.	Common Emigrant	<i>Catopsilia pomona</i>	Pieridae	<i>Cassia obtusifolia</i>
3.	Common Mormon	<i>Papilio polytes</i>	Papilionidae	<i>Murraya koenigii</i>
4.	Great Egg fly	<i>Hypolimnas bolina</i>	Nymphalidae	<i>Sida rhombifolia</i>
5.	^Tawny Coster	<i>Acraea terpsicore</i>	Nymphalidae	<i>Passiflora edulis</i>
6.	Blue tiger	<i>Tirumala limniace</i>	Nymphalidae	<i>Plumbago zeylanica</i>
7.	Dark Blue tiger	<i>Tirumala septentrionis</i>	Nymphalidae	<i>Catotrophis giganteum</i>
8.	Common Indian Crow	<i>Euploea core</i>	Nymphalidae	<i>Ficus pumila</i>
9.	Common rose	<i>Pachliopta aristolochiae</i>	Papilionidae	<i>Aristolochia indica</i>
10.	Mottled Emigrant	<i>Catopsilia pyranthe</i>	Pieridae	<i>Senna alata</i>
11.	Common mime	<i>Papilio clytia</i>	Papilionidae	<i>Cinnamomum camphora</i>
12.	Red Pierrot	<i>Talicaadanyseus</i>	Lycaenidae	<i>Kalanchoe pinata</i>
13.	Common Jezebel	<i>Delias eucharis</i>	Pieridae	<i>Loranthus spp.</i>
14.	Common Baron	<i>Euthalia aconthea</i>	Nymphalidae	<i>Mangifera indica</i>
15.	Lime butterfly	<i>Papilodemoleus</i>	Papilionidae	<i>Citrus spp.</i>
16.	Brown king Crow	<i>Euploea klugii</i>	Nymphalidae	<i>Cerbera odollam</i>
17.	Red Helen	<i>Papilio helenus</i>	Papilionidae	<i>Citrus spp.</i>
18.	Plain Tiger	<i>Danaus chrysippus</i>	Nymphalidae	<i>Calotrophis gigantea</i>
19.	Common grass yellow	<i>Eurema hecabe</i>	Pieridae	<i>Citrus spp.</i>
20.	Chocolate Pansy	<i>Junonia iphita</i>	Nymphalidae	<i>Ruellia repens</i>
21.	Lemon pansy	<i>Junonia lemonias</i>	Nymphalidae	<i>Barleria spp.</i>
22.	Nigger	<i>Orsotriaena medus</i>	Nymphalidae	<i>Rice plants, grasses</i>
23.	Common Evening Brown	<i>Melanitis leda</i>	Nymphalidae	<i>Megathyrus maximum</i>
24.	Crimson Rose	<i>Pachliopta hector</i>	Papilionidae	<i>Aristolochia indica</i>
25.	Common Jay	<i>Graphium doson</i>	Papilionidae	<i>Polyathia longifolia</i>

The diversity of butterflies was found to be high at site with the Nymphalidae family being the most specious. The diversity and abundance of species is highly correlated with the availability of food plants in the surroundings (Kunte, 2000). The number of butterflies coming under the family Papilionidae, Lycaenidae, Pieridae was seen to be less. In the study there were no representatives from Hesperidae, It may be partially due to sampling bias, Some Hesperids are crepuscular habits, that is, they are active early in the morning and, to a lesser extent, in the evening, they are also active in the shade (Kunte 2000). However, in most diversity studies, Hesperids are found in less numbers. There are 3 species recorded from sites which are enlisted in the Indian Forest Act 1972 under schedule I and II.

Conclusion

The present study reveals that the Nymphalidae was the family with maximum number of species, followed by Papilionidae, Pieridae and Lycaenidae. There were no members of Hesperidae. The study area provides favourable ecological conditions and habitat for butterflies. Since the study area harbors some of the endemic and protected species, the habitat needs to be conserved to protect the butterfly fauna of this region. So for the conservation of species in human dominated landscape, any area maintaining butterfly gardens and high plant diversity is a good option. Being good indicators of climate as well as seasonal and ecological changes, they can serve in formulating strategies for conservation. Hence a long-term study is recommended to conserve these fluttering jewels.

Acknowledgement

The authors sincerely thank Dr.TV.Sajeev, Scientist, Forest Entomology Lab, KFRI and other Staff for granting permission to conduct the survey at butterfly park. A special thanks to Soumya Anil for identification of the species. They also thank the principal of MG College, Trivandrum for allowing permission for students to conduct the studies and also they are grateful to Dr. Balamurali R.S, Head of the department of Zoology and other staff for their invaluable support and encouragement.

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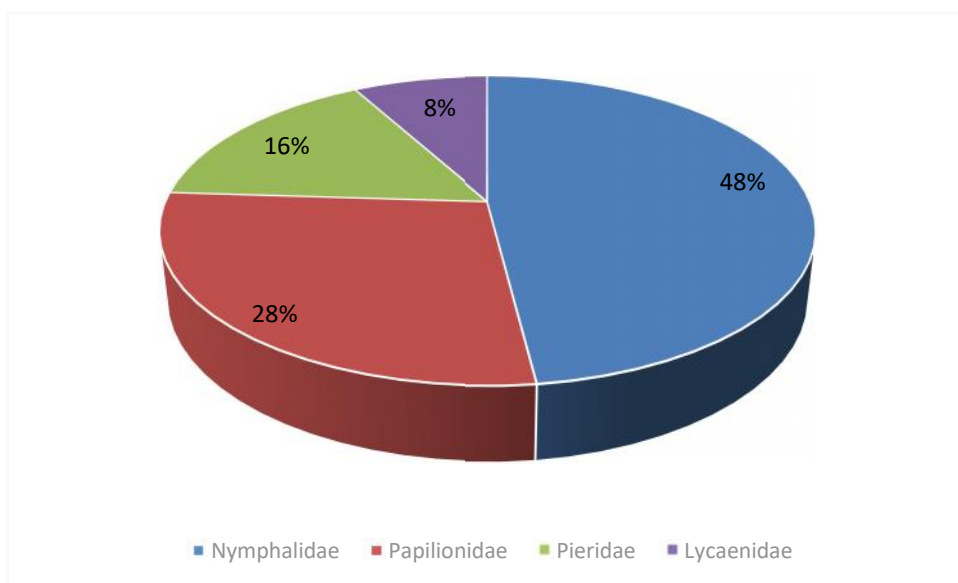
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PLATES







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Code

DOI: [10.22192/ebfipr.2024](https://doi.org/10.22192/ebfipr.2024)

How to cite this Chapter:

P.Lakshmi Devi Menon, Athira S.A, Swathy Suresh, Anagha P.Nair, Greeshma M.R, and Midhya Mohan MG. (2024). Establishing a baseline data: A pilot study on the Butterflies in the Butterfly Garden in Kanakakkunnu Palace ground, Thruvananthapuram, Kerala. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 121-128.

Study of the diversity of aquatic birds and their distribution in the banks of Kallayi river, Kozhikode

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Abstract

The present study has been undertaken to assess the diversity of aquatic birds and their distribution in the banks of the Kallayi River, involving the examination and analysis of the different species of birds that inhabit the areas surrounding the river. Kallayi River is located in the state of Kerala in India and is known for its rich biodiversity. The river flows through various habitats, including tropical forests, agricultural land, and urban areas, providing a diverse range of bird habitats. The study of bird diversity on the banks of the Kallayi River typically involves conducting surveys to identify and document the different species of birds in the area. Researchers will typically use a combination of visual and auditory surveys to identify birds and record their behaviour and habitat use. These surveys can provide important information about the abundance and distribution of bird species in the area and their ecological role in the ecosystem. One of the key goals of studying bird diversity on the banks of the Kallayi River is to gain a better understanding of the factors that influence bird populations in the area.

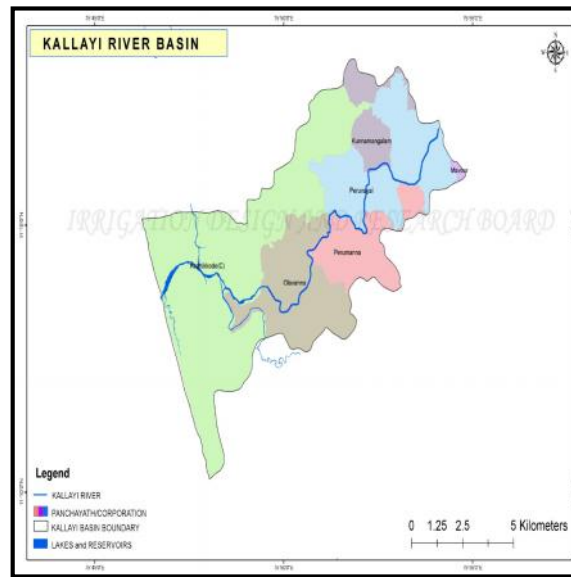
Key words: Aquatic birds, Kallayi River, Bird diversity, Shannon index

Introduction

Kallayi River is a river flowing in the southern state of India, Kerala. The river rises in the Western Ghats of Cherikkulathur village. It is linked to the Chaliyar River by an artificial canal on the south side of the small timber village of Kallayi, which is situated on the bank of the river. The river flows through Cherikkulathur, Kovur, Olavanna, Mankavu, Kallayi, Pallikkandi and Kothi and ultimately evacuates in the Arabian Sea at Kozhikode. The river basin is located in the Kozhikode district. The river is 22km in length and is spread over an area of 96 sqkm. The river is commercially very significant. The basin

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is considered as the ancient place of international trade and was used for inland water transport.



The Canoli Canal in the north and Beypore-Kallayi Canal in the south are linked to the Kallayi River. The Canoli canal which has a length of 11.5 km connects Kallayi River and Elathur River. This canal as earlier used for bringing timber from Beypore and Nilambur and for inland navigation. Kallayi River was one of the most important place in the world for Timber Business, during the 19th century, famous for its Teak and Rosewoods, sourced from the famous Nilambur Forests.

Vast stretches of mangroves flank the banks of the river. Mangroves grow in harsh environmental conditions such as high saline conditions and are therefore also called halophytes. Mangroves are a diverse group of salt-tolerant trees and shrubs that grow in intertidal zones in the tropics and subtropics, and play a critical role in coastal ecosystem function and resilience (Dr. Catherine Lovelock, 2002). Water birds are those bird species that rely on aquatic habitats for their survival, including feeding, nesting, and raising young. (Dr. Karen Hodges, 2006). Water birds are a diverse group of bird species that inhabit aquatic habitats and have physical adaptations such as webbed feet and waterproof feathers (Dr. David Winkler, 2016). Some water birds (e.g. wading birds) are more terrestrial while others (e.g. waterfowls) are more aquatic, and their adaptations will vary depending on their environment.

Biodiversity indices

Several biodiversity indices have been developed that mathematically combine the effects of richness and evenness. 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.). The most widely used is the Shannon index.

Materials and Methods

The study aimed at the occurrence and species diversity of bird communities along the Kallayi river banks (Mankavu, Kallai, Mooriyad, Kaduppini, Kothi) of Kozhikode district. The transect was preplanned. The observer walks on a predetermined transect and records the birds which he/she sees. In each recording of species encountered, activities like feeding, flying, resting etc were also noted. The recording was done during the morning between 6:30 am and 9:30 am. The survey was conducted every weekend during the year 2022-2023 from December to March. Camera (Nikon d3500), a Carl Zeiss binocular of power 8×30, and recording books are the materials used. Area mapping and nest searching are the standard methods used in the survey. For the identification of bird species the methods used are,

Observing the shape, size, and colour of the bird.

Observing unique field marks (wing bars, white outer tail feathers, eye lines).

Watching the flight pattern – (how they flap wings and manoeuvre of flight).

Behaviour and habitat of birds.

Watching the flight Silhouette -the overall shape in flight.

All the birds sighted were captured in the camera.

Study Area

Kallayi is one of the rivers in Kerala. It originates in Cherikkulathur in Western Ghats, at an elevation of 45 meters and 22 km long. It is linked to Chaliyar by a man made canal on the South Side of the small timber village of kallayi lying on its banks. Kallayi flows through Kovur, Olavanna, Mankavu, Kallayi, Pallikkandi and kothi. Vast stretches of mangrove flank the banks of the river which add its visual splendour. Flocks of birds, both migratory and

indigenous, resting in the mangroves and on the floating timber are a common sight in Kallayi.

Latitude and Longitude of areas under study

Mankavu - 11.2404°N, 75.8156°E

Kallayi - 11.2352°N, 75.7938°E

Mooriyad - 11.2396°N, 75.7961°E

Kaduppini - 11.2305°N, 75.80965°E

Kothi - 11.2310°N, 75.7778°E

Biodiversity was estimated using well known biodiversity index, Shannon index

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). I.e. it is a measuring of the order /disorder in a particular system. This order is characterized by the number of individuals found for each species/category in the sample. High species diversity may indicate a healthy environment.

Result

In the present study, the diversity of aquatic birds and their distribution in the banks of Kallayi River was monitored for a period of 4 months from December 2022 to March 2023. Observations were carried out on every weekend in this 4 months. 15 species of birds belonging to 6 families were recorded from the study area during this period. The list of birds recorded, their families and numbers during different months of observations is given in table 1 and 2. All the 15 species were recorded in each month. However, the number of individuals in each species decreases every month from December to March.

The bird population showed a maximum number of 155 individuals in December 2022 and a minimum number of 65 individuals in March 2023. Percentage-wise representation of different bird families observed is shown in Fig. 2 Species diversity, which can be measured directly as the number of species, is better expressed as an index that incorporates both species richness

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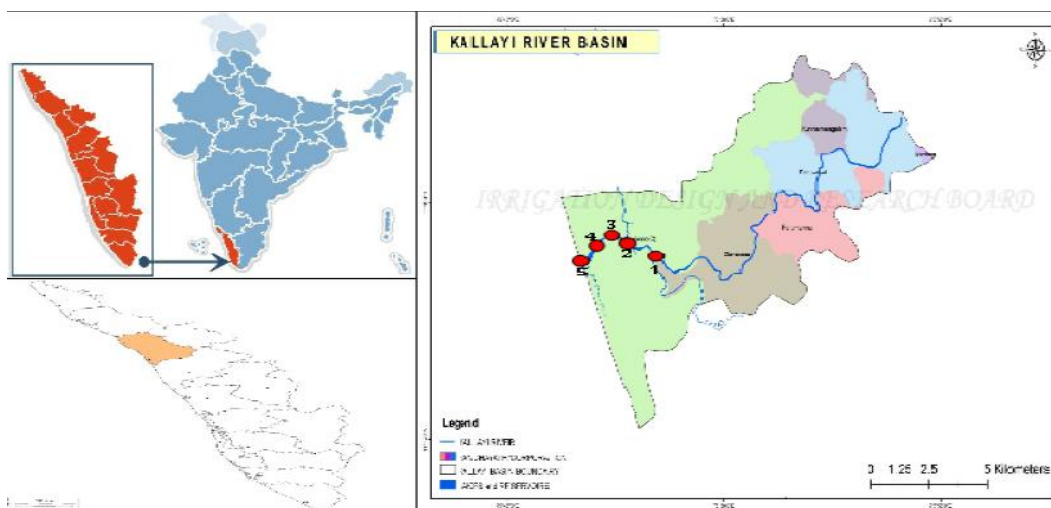
and relative abundance of species in the form of a single value. The species diversity was calculated using the Shannon index shown in Table 3.

$$\text{Shannon index } (H') = - (\sum P_i \ln P_i)$$

Where P_i is the proportional abundance of its species. The Shannon index of species diversity of the study area gave a value of 2.6559, which is an indication of the high species number and relative abundance of individuals in each species. It also reflects a better quality of the environment.

Sl.No.	Study area	Latitude	Longitude
1.	Kaduppini	N 11. 2305°	E 75.80965°
2.	Mankavu	N 11.2404°	E 75.8156°
3.	Mooriyad	N 11.2396°	E 75.7961°
4.	Kallayi	N 11.2352°	E 75.7938°
5.	Kothi	N 11.2310°	E 75.7778°

Figure- 1. Map of the study area of Kallayi River Basin, Kozhikode



We could observe 15 bird species belonging to 6 families.

1. Stork-billed kingfisher (Plate-)

Stork-billed Kingfisher (*Pelargopsis capensis*) is a resident bird in Kerala. This bird can be found in wetland habitats such as mangrove forests, rivers, lakes, and estuaries. The bird has a bright and colourful appearance with a blue head, neck, and upperparts, a chestnut-colored belly. Its bill is long, thick, and bright red in colour with a yellow tip. The bird is known for its distinctive and loud calls, and its large size, reaching up to 45 cm in length. The Stork-billed Kingfisher is listed as a species of Least Concern on the IUCN Red List.

2. White breasted kingfisher (Plate-)

The white-breasted kingfisher (*Halcyon smyrnensis*) is a resident bird in Kerala. It has a bright blue back, wings, and tail, with a rust-coloured head and a white throat. The bird is not considered endangered and is widely distributed throughout its range, including Kerala.

3. Black crowned night heron (Plate-)

Black-crowned Night Heron (*Nycticorax nycticorax*), is a migratory bird that can be found in Kerala during winter months. These birds typically arrive in Kerala in October and stay until March or April, before migrating back to their breeding grounds. During the non-breeding season, some populations of these birds migrate to warmer regions. The black-crowned night heron has a distinctive appearance, with a black cap on its head and a grey body. It has red eyes and a white patch on its cheeks. During breeding season, the adults develop long, wispy feathers on the back of their heads, which form a distinctive white plume.

The juvenile black-crowned night heron looks quite different from the adult bird. It have a brown and white speckled appearance with a heavily streaked chest and belly. Pale greyish-brown head with a darker streak extending down the crown of the head. The eyes of the juvenile are also paler in colour than those of the adult.

PLATE-



Pelargopsis capensis



Halcyon smyrnensis



Nycticorax nycticorax (adult)



Nycticorax nycticorax (juvenile)

4. Indian pond heron (Plate-)

Indian pond heron (*Ardeola grayii*) is a resident bird in Kerala. Commonly found near water bodies such as lakes, ponds, and paddy fields. It has a distinctive appearance, with a dark crown, a white forehead, and a chestnut neck. The back and wings are a dull greyish-brown, and the belly is white. During the breeding season, the bird's plumage becomes darker and it develops long feathers on its back, forming a crest.

5. Grey heron (Plate-)

Grey heron (*Ardea cinerea*) is a large wading bird, resident in Kerala. Commonly found near water bodies such as lakes, ponds and rivers. The grey heron has a distinctive appearance, with a pale grey body, a white head and a long pointed yellow bill. During the breeding season, the bird's plumage becomes darker and it develops long flowing feathers on its back and neck forming a crest.

6. Purple heron (Plate-)

Purple Heron (*Ardea purpurea*), is a migratory bird that can be found in Kerala during the winter months. These birds typically arrive in Kerala in October and stay until March or April, before migrating back to their breeding grounds. During their time in Kerala, they can be found in wetlands, paddy fields, and other freshwater habitats. During the non-breeding season, some populations of these birds migrate to warmer regions. It has a chestnut head and neck, a long and thin black bill, and a greyish-blue body. With a long neck and long legs, which are usually extended in flight, making the bird appear larger than it is. The wings are broad and rounded, and the tail is relatively short.

7. Black-headed Ibis (Plate-)

Black-headed Ibis or Oriental White Ibis (*Threskiornis melanocephalus*), is a migratory bird that can be found in Kerala during the winter months. These birds typically arrive in Kerala in November and stay until March or April, before migrating back to their breeding grounds. During their time in Kerala, they can be found in wetlands, paddy fields, and other freshwater habitats. The bird has a distinctive appearance with black feathers on its head, neck, and upper chest, while the rest of the body is white. The bill of the Black-headed Ibis is long and curved downward and it has a red patch on its lower mandible.

PLATE-



Ardeola grayii



Ardea cinerea



Ardea purpurea



Threskiornis melanocephalus

8. Little egret (Plate-)

The little egret (*Egretta garzetta*) is a species of small heron resident in Kerala. They are commonly found in wetlands, marshes, and estuaries, where they feed on fish, crustaceans and other small aquatic creatures. It has a white plumage, long black legs with yellow feet, and a pointed, thin black bill. During the breeding season, the adults grow long, wispy feathers called aigrettes on their back, neck and breast. Which they use for courtship display.

9. Yellow-billed egret (Plate-)

Yellow-billed egret (*Ardea intermedia*) is a resident bird in Kerala. It is slightly smaller than the great egret and larger than the little egret. Intermediate egrets have a white plumage, long black legs with yellow feet and a yellow bill. During breeding season, they grow long, wispy feathers on their back, neck, and breast, similar to the little egret.

10. Little cormorant (Plate-)

The little cormorant (*Microcarbo niger*) is a resident bird in Kerala that can be found in wetland habitats. It have a blackish-brown plumage with a greenish or bronze sheen, a small white patch on their cheeks, and a thin, pointed black bill. Little cormorants feed on small fish, which they catch by diving into the water and swimming after their prey. After catching a fish, they will often come to the surface to swallow it whole. They are skilled swimmers and can often be seen perched on rocks or branches with their wings spread out to dry.

11. White-breasted water hen (Plate-)

White-breasted water hen (*Amaurornis phoenicurus*) is a resident bird in Kerala, found in wetland habitats such as mangroves. It have black plumage with a distinctive white patch on their breast and a red bill and forehead. They are about the size of a domestic chicken and have long, strong legs that are adapted for walking on aquatic vegetation and mud. White-breasted water hens feed on a variety of foods, including insects, small fish, frogs, and even small snakes. They are known for their loud and distinctive calls, which can often be heard in wetland habitats.

PLATE-



Egretta garzetta



Ardea intermedia



Microcarbo niger



Amauornis phoenicurus

12. Great egret (Plate-)

Great egret (*Ardea alba*) is a resident bird in Kerala. It has a white plumage, long black legs with yellow feet, and a long, thin yellow bill. They are larger than the little egret and intermediate egret and can be easily distinguished by their size and their all-white plumage. Great egrets feed on fish, frogs, and other small aquatic animals, which they catch with their sharp bill. They are known for their graceful and elegant movements when hunting, often standing motionless in shallow water before quickly striking at their prey.

13. Western reef heron (Plate-)

The western reef heron (*Egretta gularis*) is a migratory bird that can be found in Kerala. These birds typically breed in the Red Sea, East Africa and the Persian Gulf region, and migrate to South Asia during the winter months. In Kerala, they can be spotted near the coastal areas and wetlands. The Western reef heron is a medium-sized heron that is primarily grey, with a white belly and a black bill.

14. River kingfisher (Plate-)

River kingfisher (*Alcedo atthis*) is a resident bird in Kerala that Can be found near water bodies such as rivers, lakes and canals, as they require clear water with good visibility to hunt for fish, which is their main food source. It has a bright blue and orange plumage, a long, sharp bill and short legs. They are small in size, about the size of a sparrow, but have a distinctive and unmistakable appearance.

15. Common sandpiper (Plate-)

The common sandpiper (*Actitis hypoleucos*) is a migratory bird that can be found in Kerala. These birds breed in temperate and subarctic regions of Europe and Asia and migrate to Africa, South Asia and Australia during the winter months. In Kerala, they can be found near water bodies like rivers, lakes and ponds. The common sandpiper is a small bird with a distinctive bobbing tail and a white belly. It has a brown upper body with spots on the wings and back.

PLATE-



Ardea alba



Egretta gularis



Alcedo atthis



Actitis hypoleucos

Table 1. List of Aquatic Birds observed in the banks of Kallayi River, Kozhikode

Sl.No	FAMILY	COMMON NAME	SCIENTIFIC NAME
1	Ardeidae	Grey heron	<i>Ardea cinerea</i>
2	Ardeidae	Purple heron	<i>Ardea purpurea</i>
3	Ardeidae	Yellow -billed egret	<i>Ardea intermedia</i>
4	Ardeidae	Great egret	<i>Ardea alba</i>
5	Ardeidae	Little egret	<i>Egretta garzetta</i>
6	Ardeidae	Western reef heron	<i>Egretta gularis</i>
7	Ardeidae	Indian pond heron	<i>Ardeola grayii</i>
8	Ardeidae	Black crowned night heron	<i>Nycticorax nycticorax</i>
9	Alcedinidae	White breasted king fisher	<i>Halcyon smyrnensis</i>
10	Alcedinidae	River kingfisher	<i>Alcedo atthis</i>
11	Alcedinidae	Stork-billed kingfisher	<i>Pelargopsis capensis</i>
12	Threskiornithidae	Black headed Ibis	<i>Threskiornis melanocephalus</i>
13	Phalacrocoracidae	Little cormorant	<i>Microcarbo niger</i>
14	Scolopacidae	Common sand piper	<i>Actitis hypoleucos</i>
15	Rallidae	White breasted water hen	<i>Amaurornis phoenicurus</i>

Table 2. No. of Aquatic Birds observed in the banks of Kallayi River, during the different months of study period, December 2022 to March 2023

SI. No	COMMON NAME	DEC	JAN	FEB	MAR	TOTAL
1	Grey heron	7	5	4	3	19
2	Purple heron	8	6	5	4	23
3	Yellow -billed egret	15	12	8	5	40
4	Great egret	15	14	10	8	47
5	Little egret	10	12	8	9	39
6	Western reef heron	4	3	2	2	11
7	Indian pond heron	12	12	8	3	35
8	Black crowned night heron	10	8	4	2	24
9	White breasted king fisher	12	10	10	4	36
10	River kingfisher	10	8	5	4	27
11	Stork-billed kingfisher	12	10	8	5	35
12	Black headed Ibis	10	6	4	1	21
13	Little cormorant	10	12	8	7	37
14	Common sand piper	8	8	6	3	25
15	White breasted water hen	12	11	8	5	36
	TOTAL	155	137	98	65	455

Table 3. Calculation of Species Diversity

Sl. No	COMMON NAME	Pi	ln Pi	(Pi ln Pi)
1	Grey heron	0.0418	-3.1749	- 0.1327
2	Purple heron	0.0505	-2.9858	-0.1508
3	Yellow -billed egret	0.0879	-2.4315	-0.2137
4	Great egret	0.1033	-2.2701	-0.2345
5	Little egret	0.0857	-2.4569	-0.2105
6	Western reef heron	0.0242	-3.7214	-0.0900
7	Indian pond heron	0.0769	-2.5652	-0.1973
8	Black crowned night heron	0.0527	-2.9431	-0.1551
9	White breasted king fisher	0.0791	-2.5370	-0.2007
10	River kingfisher	0.0593	-2.8251	-0.1675
11	Stork-billed kingfisher	0.0769	-2.5652	-0.1973
12	Black headed Ibis	0.0461	-3.0769	-0.1418
13	Little cormorant	0.0813	-2.5096	-0.2040
14	Common sand piper	0.0549	-2.9022	-0.1593
15	White breasted water hen	0.0791	-2.5370	-0.2007

- $\sum Pi \ln Pi = 2.6559$

Discussion

The study clearly shows that Kallayi river banks attract a large number of bird species. The number of birds shows decreasing trends from December to March. Some of the birds observed in December were migratory birds that visited Kerala during winter. As the winter passed and temperatures increased, these birds may have continued their migration, resulting in fewer birds being observed in March. The population size of native birds naturally fluctuated throughout the winter season. In winter the temperature is low and it may be suitable for the birds. In March the temperature is relatively high, and the availability of food and other resources may have decreased, causing some birds to relocate to other habitats or to migrate to other areas in search of better resources.

Out of the 6 families of the birds recorded from this area, the family Ardeidae got the maximum number of individuals (238). More than half of the birds observed belong to this family (52%). Followed by the family Alcedinidae. This family has 98 individuals. And other recorded families are Threskiornithidae (21 individuals), phalacrocoracidae (37 individuals), scolopacidae (25 individuals), Rallidae (36 individuals). The Shannon index is a measure of biodiversity that takes into account the number of different species present as well as their relative abundance. A higher Shannon index value indicates greater diversity of species. In the context of the study of aquatic birds and their distribution in the banks of Kallayi River, a Shannon index of 2.6559 suggests that there is relatively high diversity of bird species in the area. This is a positive finding, as higher levels of biodiversity can indicate a healthier ecosystem with a greater range of ecological niches being occupied.

Conclusion

The present study was aimed to get information on the kinds, numbers and species Diversity of the aquatic birds and their distribution in the banks of Kallayi River, Kozhikode. Although the study was of short duration of only four months (one observational visit in each weekend), we were able to identify the presence of 15 bird species belonging to 6 families, from the study area and the obtained biodiversity index value was also satisfactory regarding its aquatic bird diversity and environmental quality. Some of the migratory birds we could observe were the Black-crowned night heron, Purple herons, Black-headed ibis, Western reef heron and Common sand piper.


The population of great egret was relatively high. From an ecological perspective, a high population of great egret could indicate that the habitat in the banks of Kallayi River is suitable for this species, providing sufficient food, nesting sites, and other resources. It also suggest that the area has low disturbance or pollution levels, which are important factors for the survival of aquatic birds. It could also highlight the importance of preserving and restoring other wetland habitats to support the survival of other bird species and ecosystem functions.

The study also suggests that the Kallayi River and its surrounding wetlands are important ecosystems for a diverse range of bird species. The presence of these birds highlights the need for conservation efforts to protect the wetland habitats and ensure the survival of these important bird species.

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How to cite this Chapter:

Prabheena P, Shameera P and Roopa M. (2024). Study of the diversity of aquatic birds and their distribution in the banks of Kallayi river, Kozhikode. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 129-147.

Microplastics Impact on Terrestrial and Aquatic Ecosystems

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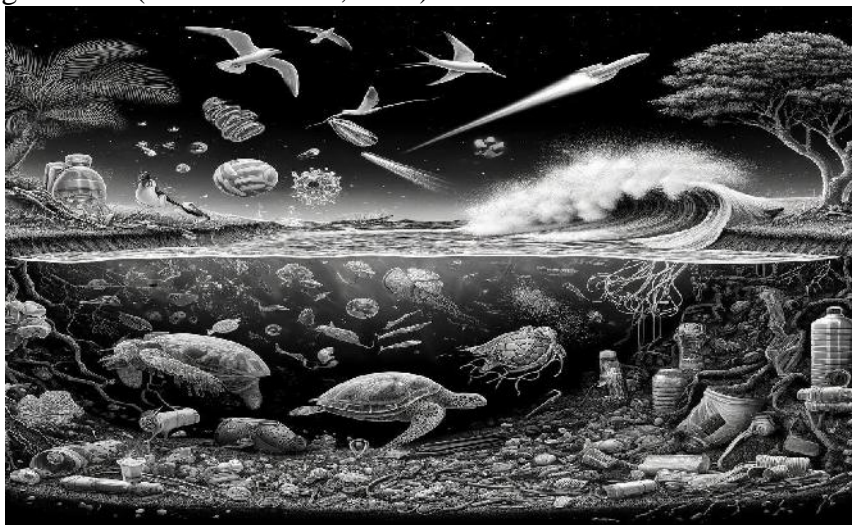
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Introduction

The presence of microplastics in the marine environment has gained increasing attention in recent years due to its potential impact on marine ecosystems and human health. Microplastics, defined as plastic particles with a size less than 5mm (Peller et al., 2022), have been detected in various marine environments, including sediments (Niu et al., 2021), water columns (Scherer et al., 2020), and biota (Bakir et al., 2020). Microplastics are becoming an emerging environmental threat due to their persistence and ubiquity in the ecosystem (Chithra et al., 2024; Singh et al., 2023). The degradation of plastics from macro- to micro- and even to nanosized particles smaller than 100 nm is a growing concern (Chandran et al., 2023).



The research focus has primarily been on the consequences of plastic waste on marine and freshwater ecosystems, leaving gaps in understanding regarding the quantities, changes, movement, and outcomes of plastics in land and underground settings (Alimi et al., 2018). Additionally, the potential impacts of microplastics in terrestrial ecosystems remain largely unexplored (De



Souza Machado et al., 2018). This literature review aims to integrate and synthesize the current research findings to shed light on the production, role in the environment, and the detrimental effects of microplastics on ecosystems, along with the current scenario to reduce microplastics and potential future research directions.

How Microplastics are Produced

Microplastics arise from either the breakdown of large plastic debris or direct release into the environment. They are commonly produced through the weathering and degradation of larger plastic materials, including bottles, bags, and other plastic products (Andrade et al., 2019). As these materials break down due to exposure to sunlight, heat (Liu et al., 2022), and mechanical forces (Kalogerakis et al., 2017), they release smaller plastic particles into the environment. Microplastics can also come from microbeads found in personal care products and microfibers from synthetic textiles (Folbert et al., 2022). These sources of microplastics can enter the environment through wastewater (Chang, 2015), runoff (Hajiouni et al., 2022), and other pathways.

For instance, microbeads, aforementioned, wash down drains and enter water bodies (Hoang et al., 2022). Plastic pellets, which serve as the primary raw material in the plastic industry; also used in textile industry (Park & Kim, 2014), contribute to microplastic pollution (Izar et al., 2022). Additionally, polyester textiles are identified as a substantial source of microplastics (Almroth et al., 2017; Graca et al., 2017), with a mechanistic study to understand microfiber release during washing (Hernández et al., 2017).

During washing, synthetic textiles shed tiny fibers that eventually reach aquatic as well as terrestrial environments (Almroth et al., 2017). Other sources include road markings (Kitahara & Nakata, 2020), tire wear (Vercauteren et al., 2023), and plastic running tracks (An et al., 2020), which also release microplastics. Urban dust contains plastic particles from various sources, contributing to soil contamination (Dehghani et al., 2017).



The majority of plastics entering the oceans were manufactured, utilized, and frequently discarded on land. Therefore, it is within terrestrial systems where microplastics may initially interact with organisms, causing ecologically significant ramifications (De Souza Machado et al., 2018). However, knowledge gaps remain in finding the specific sources of microplastics, especially in terrestrial environments (Campanale et al., 2022).

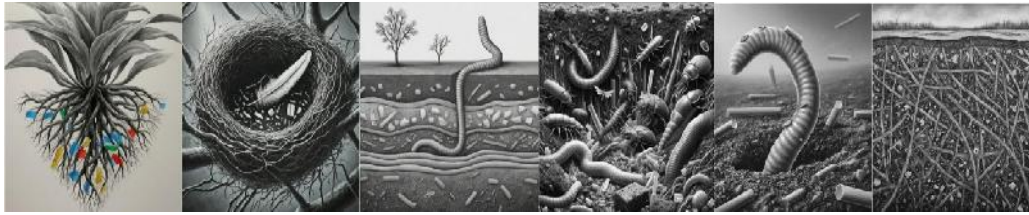


Role in the Environment (Terrestrial and Aquatic)

Microplastics, including nanoplastics, have been shown to impact terrestrial systems, with observed repercussions on the physical and chemical nature of the environment (Marinari et al., 2023). These particles could engage with terrestrial organisms facilitating crucial ecosystem services and functions (De Souza Machado et al., 2018). Microplastic particles in aquatic



ecosystems originate from the fragmentation of larger debris or enter the environment as tiny fragments. Filter-feeder organisms ingest microplastics while feeding, leading to potential impacts on the physiology of marine organisms, such as the Pacific oyster (Sussarellu et al., 2016).



Microplastics have a pervasive presence in both terrestrial and aquatic environments (De Souza Machado et al., 2018). In terrestrial systems, they negatively affect soil quality, nutrient



cycling, and water retention (Lozano et al., 2021). Microplastics can also be ingested by soil-dwelling organisms, disrupting their feeding behavior (Prakash et al., 2020), growth and reproduction (Schöpfer et al., 2020).



In aquatic ecosystems, microplastics can accumulate in the water column and sediment (Dai et al., 2018), affecting marine life such as fish (Bihanic et al., 2020), invertebrates (Chithra et al., 2024; Hurley et al., 2017), and plankton (Pan et al., 2022). Ingesting microplastics can

lead to physical harm, such as blockages and internal injuries, and chemical harm due to the absorption of toxins (Okoye et al., 2022).

The impacts of microplastics on terrestrial and aquatic ecosystems are evident, highlighting the need for further research to understand the broader toxicity and potential global change induced by microplastic contamination.

Deterioration of the Ecosystem

Detecting plastics at the nanoscale presents challenges, and they can be transported through air, soil, and water pathways. The impact of microplastics on marine and freshwater environments has been studied, revealing notable incursions in oyster reproduction, feeding modifications, and reproductive disruption, with downstream effects on offspring development (Sussarellu et al., 2016).



Moreover, microplastics affect terrestrial organisms crucial for ecosystem services and functions, including soil-dwelling invertebrates, terrestrial fungi, and plant pollinators (De Souza Machado et al., 2018).

The potential dangers associated with microplastics are considerable. They can hinder the mobility of marine organisms, potentially resulting in drowning, asphyxiation, or inflammatory (Chithra et al., 2024) responses.

In human populations, microplastics have the capacity to infiltrate the food chain and accumulate



within bodily tissues, thereby posing significant risks to health (Luo, 2023).

The persistence of microplastics in the environment can lead to long-term impacts on ecosystems (Ma et al., 2020). These particles can act as carriers for pollutants (Verdú et al., 2021), possibly introducing harmful chemicals into the food chain (Mamun et al., 2023). Microplastics can also accumulate in organisms over time, causing bioaccumulation and biomagnification of toxins (Akhbarizadeh et al., 2019). This accumulation can have detrimental effects on wildlife (Alava, 2020). Furthermore, microplastics can alter the composition (Kelly et al., 2021) and structure (Green et al., 2016) of habitats, affecting the overall health and stability of ecosystems. The long-term implications of microplastic pollution on ecosystems underscore the urgency of addressing this environmental challenge. It is crucial for safeguarding biodiversity and ecosystem integrity for future generations.

Current Scenario to Reduce the Level of Microplastics in the Environment

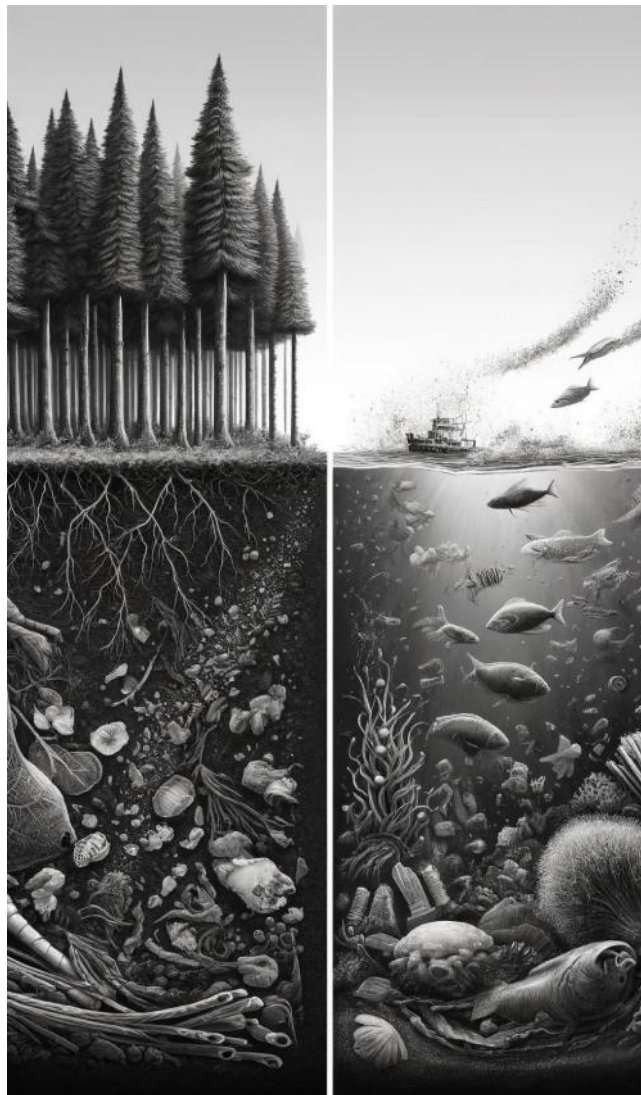
The current scenario to reduce the level of microplastics in the environment is complex, with information gaps in pointing to the sources, fate, and effects of microplastics (Burns & Boxall, 2018). Different studies have focused on exploring the sorption, desorption, and transfer of environmental contaminants by microplastics, indicating that microplastics act as vectors for environmental contaminants and highlighting the need for effective mitigation strategies (Hartmann et al., 2017). However, more research is needed to develop comprehensive management and mitigation strategies to reduce the level of microplastics in the ecosystem.

Conclusion

In conclusion, microplastics pose a remarkable threat to both terrestrial and aquatic ecosystems, with broad changes in continental environments and pivotal impacts on marine organisms. Various research has revealed the potential sources, role in the environment, and harmful manifestations of microplastics. Nevertheless, knowledge gaps exist in unveiling specific sources of microplastics in terrestrial environments, as well as the long-term ecological and environmental impacts. Overall, microplastics have emerged as a global environmental threat, and further research is essential to understand their production, role in the environment, and the detrimental effects on ecosystems. With the current scenario to reduce microplastics being complex, future research directions should prioritize addressing comprehension gaps and

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developing effective management strategies to mitigate the leverage of microplastics in both terrestrial and aquatic environments.





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Access this Chapter in Online	
	Subject: Environmental Toxicology
Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Nandakrishnan K, Sreelekha B, Yunus, Bijoy.C and Praseeja Cheruparambath. (2024). Microplastics Impact on Terrestrial and Aquatic Ecosystems. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 148-161.

Taxonomic account on Moth

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Introduction

General morphology

The Lepidoptera encompasses moths, which are characterized by their densely setose, four-winged, and mostly dull-colored. They exhibit a tripartite body structure comprising the head, thorax, and abdomen. The head of the moth features a pair of complex, multifaceted compound eyes and a pair of antennae it features sensory appendages. The adult moths are distinguished by the presence of two pairs of wings adorned with scales that exhibit overlapping arrangements. These are essential for various ecological and physiological functions, including thermoregulation, camouflage, and mate attraction. The possession of three pairs of legs, which may or may not be equipped with spurs. These features particularly the morphology of the legs serve as valuable anatomical features for species differentiation and taxonomic classification.

Thorax

The thorax is divided into three parts prothorax, mesothorax, and metathorax. These are closely fused and not readily identifiable from each other. Each part carries a pair of legs. The prothorax is small. The mesothorax is large and it bears a pair of articulated dorsal plates, and tegulae, sometimes it is scaled or hairy and vibrantly colored. The mesothorax bears a pair of forewings and the smaller metathorax bears hind wings. As well as the thorax also contains the muscles required for locomotion, nerves, and the dorsal vessel, which serves as a pulsating blood circulation chamber. Besides they also have two ears called tympanic organs, which help to detect ultrasonic sound produced by insect-eating bats to escape from them (Figure 1).

Abdomen

The abdomen is divided into ten movable segments. In many species hearing organs are located at the base of the abdomen. Moths have spiracles on

the sides of abdominal segments 1-7 in place of lungs, like other insects. Furry abdomens are common in female moths, and they are used to conceal the eggs when they are laid. Many hawk moths and prominent have hair pencils at the tip of their abdomen used for mating (Figure 1).

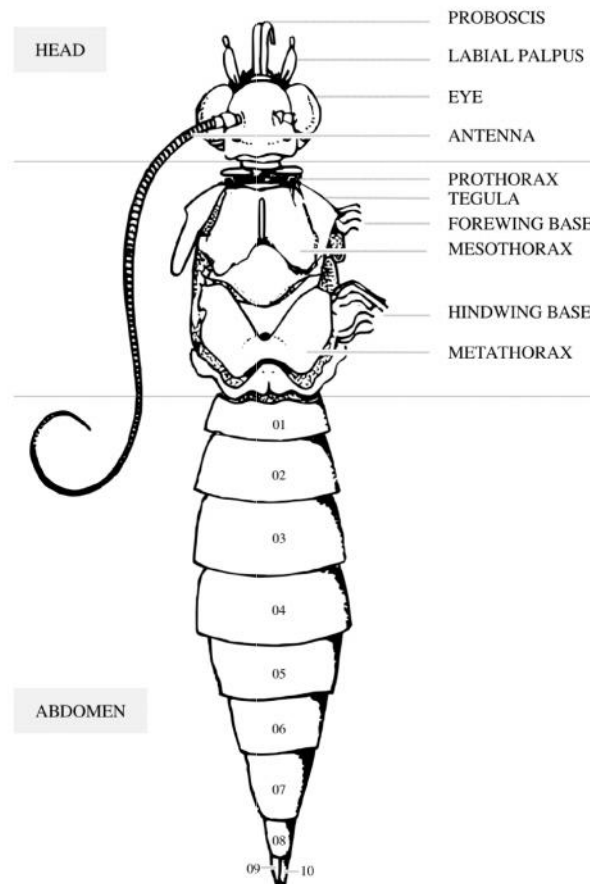


Figure 1: Dorsal view of adult

Head

The head of the moth has significant importance in their anatomy and plays a pivotal role in their ecological and physiological functions. It encompasses sensory structures where compound eyes and antennae are central to their perception of the environment. These sensory organs are intricately

involved in vital aspects of a moth's life such as navigation, reproduction, and foraging (Figure 2).

Structure of moth parts

The mouthparts of adults are proboscis a modified long coiled siphoning organ, consisting of two highly modified maxillae, composed of elongated galea that are connected by a series of hooks and spikes to form tube-like mouthparts that function as through which liquid food can be sucked and which are absent in other orders. Beneath the head, the proboscis is usually coiled up like a spring. Mandibles are reduced. Maxillary palps are generally small or absent. The labial palps are three-segmented, hairy, or scaled at the base, with forward and upward projections (Figure 2).

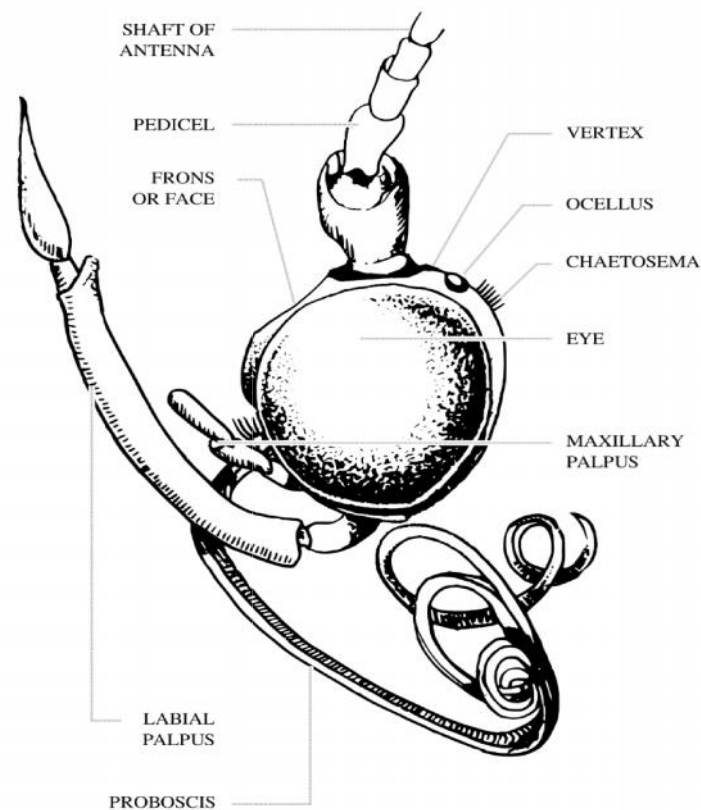


Figure 2: The head

Structure of eye

The head consists of paired compound eyes usually seen as prominent black globules at the base of the antennae, which may be smooth, hairy, or lashed (Figure 3). Most species of moths have ocelli above each eye, but due to the presence of chaetosemata, which are paired organs (hawk moth) often with hairs and lashes (Noctuidae) between the facets or small (Crambidae). The eyes are predominantly superposition type, susceptible to low light conditions that suit nocturnal species. In the case of Zygaenidae and Syntomoidae, both have apposition eyes (Figure 3).

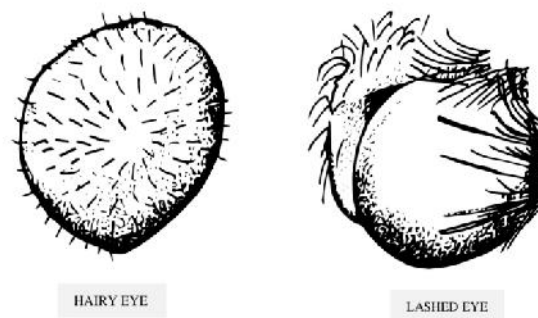


Figure 3: Structure of eye

Types of antennae

The antennae of moths are vital for their olfactory capabilities. Moths are exceptionally sensitive to pheromones, air-borne chemicals, emitted by conspecifics to communicate for mating purposes. This heightened olfactory sensitivity enables moths to locate and attract potential mates over considerable distances and locate suitable habitats for egg-laying. Different kinds of pairs of antennae are present (Figure 4), which means the shape and structure of antennae vary within families, species, and sometimes in sexes. The antennae may be filiform, unipectinate, bipectinate, doubly bipectinate, ciliate, setose-ciliate, lamellate, fasciculate, or a combination of these. The structure of many species differs significantly between sexes, making distinguishing the sexes

easy. Generally, the male antennae are more complicated than the female ones (Figure 4).

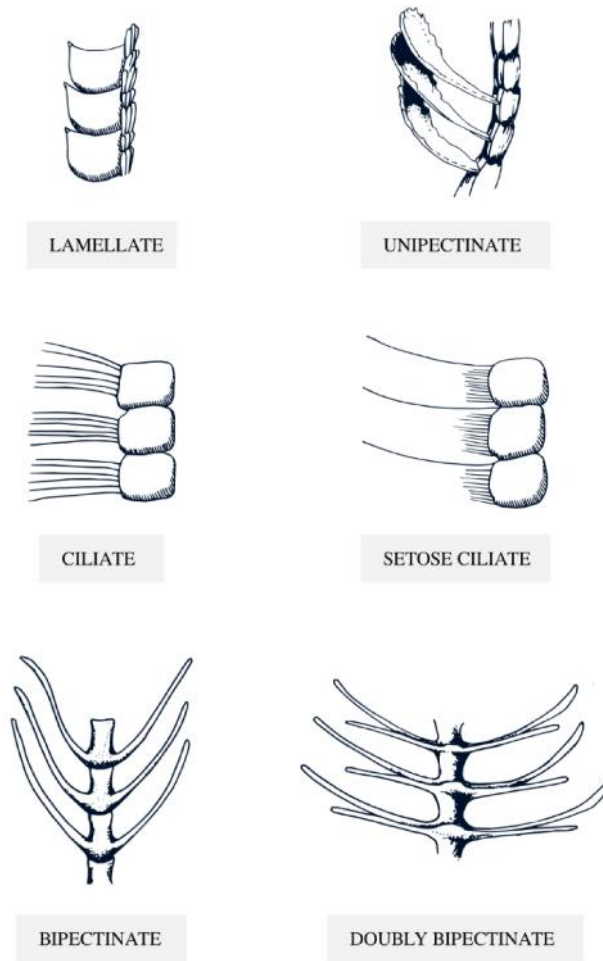


Figure 4: Different kinds of antennae

Wings

The membranous wings are often covered with powdery scales on both upper and lower sides. In some tussocks and bagworms, the wings are undeveloped. Some species of Sphingidae and male tussock scales are shed during their first flight. In some species of males, specialized scales are present called androconia. They are distinct from typical in both shape and structure and may be linked to erectile hair tuft containing pouches on the wings that release scents known as pheromones, which have a significant role in mating and courtship behavior. The wing venation is a key component in the classification of Lepidoptera.

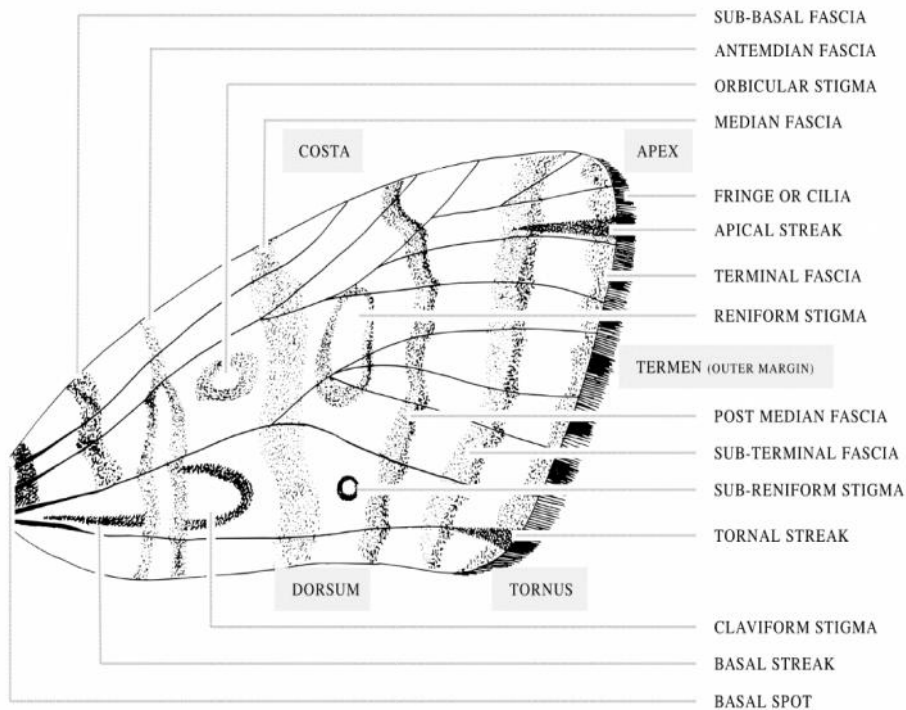


Figure 5: Forewing pattern

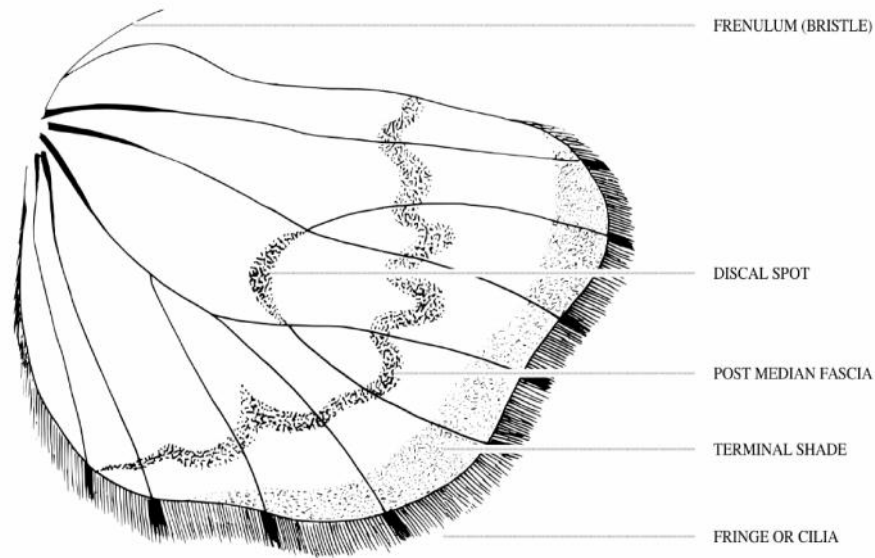


Figure 6: Hind wing pattern

Legs

Most moths have spurs on their legs, which are helpful for classification and identification. Sometimes unique hair tufts or spurs may be present, especially in males, producing a distinctive scent. Some groups have furry legs. Legs in many species are highly specialized with sensory or taste organs (Figure 7)

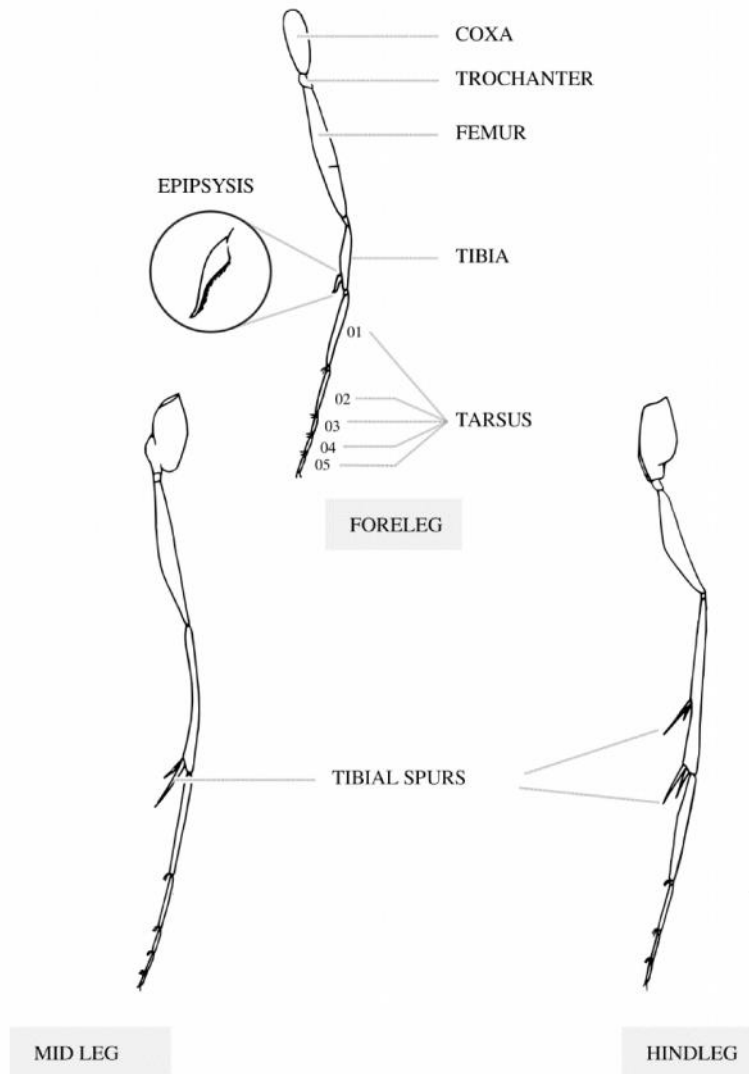


Figure 7: Structure of legs

Wing coupling mechanism

Wing coupling is a key component in the Lepidopteron classification in higher hierarchy. Four general mechanisms – a fibula, a jugum, a frenulum, and an expanded humeral angle of the hind wing allow the wings on each to function in tandem. On the posterior side of the base of the hind wing, a fibula

is a tiny roughly triangular lobe located near the base of the front wing. A jugum is a small lobe at the base of the front wing that resembles a finger and overlaps the base of the wing's anterior edge. In males, a frenulum is a large bristle or a group of bristles found at the humeral angle of the hind wing.

Resting posture

Unlike butterflies generally, three common kinds of resting positions are seen in moths. These include the planiform; in which the four wings are spread outward from the body and come in contact with the surface they are resting on horizontally, Veliform; resembling a butterfly with all forewings folded and kept closed vertically on their back, Tectiform; forewings which typically extend over and positioned in a tent-like manner above the thorax or alongside the thoracic region (Figure 8). In addition to this forward swept, foldable, 'T' shape, flat-hook, tail convex, bomber, and arrow postures are also present (Figure 9).

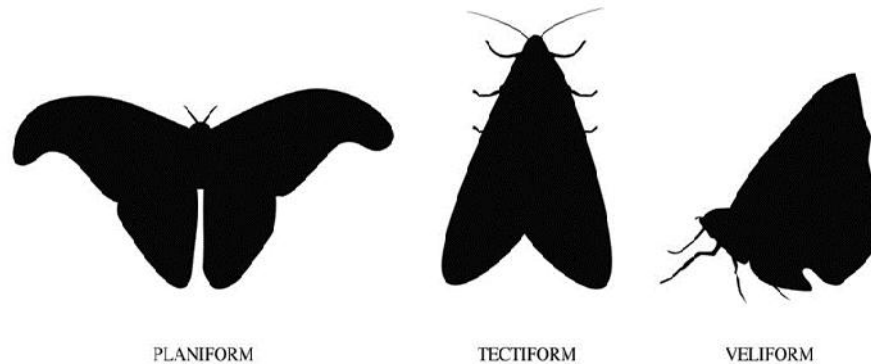


Figure 8: Three common kinds of resting positions in moths

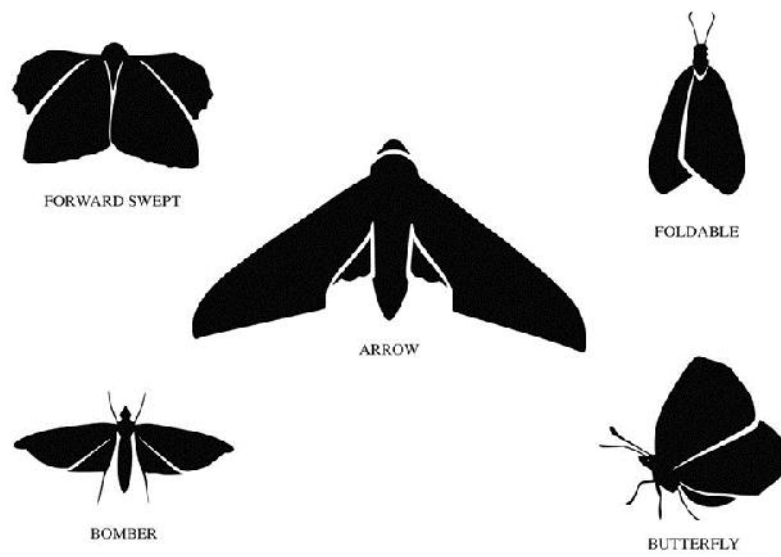
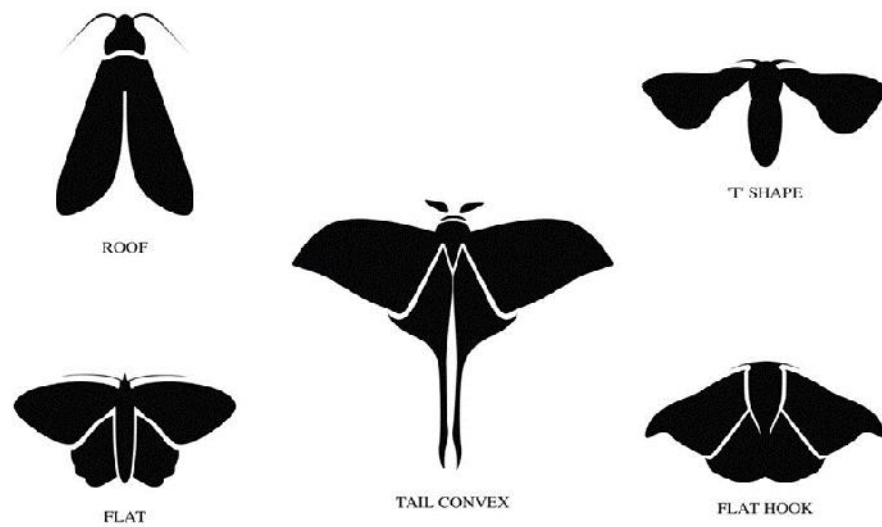



Figure 9: Inspired by Taiwan Moth Information Centre



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DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Sreelekha P C and E M Manogem. (2024). Taxonomic account on Moth. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), Exploring Boundless Frontiers: Interdisciplinary Perspective in Research. India: Thanuj International Publishers. pp: 162-172.

Wildlife forensics – A key to wildlife crimes

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Abstract

Wildlife is the term for untamed animal species. Wildlife includes any and all living creatures that are not domesticated or human. Animals, plants, and marine organisms play an enormous role in balancing our ecosystem. South East Asia is one of the mega- biodiversity hotspot regions, but it is also considered to be the major node of illegal trade of wildlife species. Wildlife species are hunted and poached for variety of reasons, including for food, pleasure, medicines, leather, tusk, fur, eggs, organs, skin, tooth, bones and more. Many of the rare and endemic species are illegally traded to other parts of the world. Moreover, species undergo several cruelties. This illegal poaching has made a lot of species extinct and many more at the verge of extinction. This causes an ecological imbalance in the biodiversity. Thus, there is a great need to protect or conserve these species and stop these illegal activities. In this review article we mainly focus on the wildlife crimes and their analysis with the help of Forensic Tools. We have outlined the techniques used in wildlife forensics for addressing the problems of species and individual identification. The forensic tools help a lot in solving wildlife crimes. The techniques include morphological analysis, microscopy, DNA analysis, mitochondrial DNA sequencing, phylogenetics, bioinformatics and evolutionary genetics, DNA barcoding, infra-red techniques, inductively coupled plasma atomic emission spectroscopy. Data gathered through forensic investigation can help the officials in linking the seized wildlife specimens to crime scenes and suspects facilitating their identification, arrest and successful prosecution. In short wildlife forensics as a field is critical for the successful

management of conservation and protection of these species and the law enforcement related to it.

Introduction

Wildlife term includes both plants 'flora' and animals 'fauna'. One of the greatest gifts received from mother nature is wildlife. The word "wildlife" encompasses every kind of organism, from the largest animal to the tiniest microscopic creatures. Animals, plants and marine creatures are just as vital to the earth's natural balance as people are. They are important for our biodiversity and ecological balance. Every living thing on Earth has a specific position in the food chain and a function that it plays in enhancing the environment. However, a large number of animals and birds are becoming endangered these days. Particularly due to human activity, natural habitats of plants and animals are being destroyed (Alok Kumar Chandrakar 2018) ^[2]. There is a great need for protecting the wildlife for a better tomorrow. The constant depletion in the number of wild species is due to uncontrolled approach of humans towards nature. This can cause a great threat to the ecological balance. The poaching and trafficking of wild species in the lure of money as well as fashion has wiped out a range of wildlife species that call for critical attention to tackle this menace (Ajay Kumar Rana *et. al.*, 2023) ^[1]. Poaching is one of the major issues caused by human that erases biodiversity and disturb the balance of food chain. Poachers act like a threat to biodiversity, wildlife and nature. Wildlife crimes mainly arise due to selfish nature of humans and their greed towards the products made out of it.

Wildlife crime is not just something affecting our country, it is a threat spreading across the whole globe. Furthermore, the wildlife crime and trade have also been linked with other organized forms like funding of terrorist activities, according to the United States Senate Foreign Relations Committee 2009 (V. Sahajpal 2021) ^[9]. Several species are being affected by this. Currently the most urgent threat to wildlife in the world is to a handful of highly vulnerable animal species: elephants (African: *Loxodonta africana*, Asian: *Elephas maximus*), rhinos (Indian: *Rhinoceros unicornis*, Javan: *Rhinoceros sondaicus*), tigers (*Panthera tigris*) and pangolins (Patel et al. 2015; Gaubert et al. 2017) ^[3,4]. These animals are poached for their ivory, horn, scales, skin, claws, bones or any other products which has great demand in world market. As per the record of the United Nations Office on Drugs and Crime (UNODC), it is considered the fourth most illegal trade after arms, drugs and human trafficking (Doody *et. al.*, 2021) ^[5]. If we look into the number of these species in detail, the Rhinoceros population have decreased remarkably

in the past 25 years, and their numbers remain critically low, which is less than 30,000. Indian forests have nearly 3600 rhinos. (Nabeshima *et. al.*, 2022)^[6]. Regarding the elephant population in the world, there has been a sharp decline. out of ~ 500,000, ~ 30,000 are residing in India (~ 50% in the forests of Karnataka, Assam, and Kerala) (Goswami *et. al.*, 2019)^[7]. India has the largest number of tigers and the rest of the world has just around 1500 or even less tigers. However, there are frequent cases of tiger poaching, with very high incidence in the states of Maharashtra, Karnataka, Tamil Nadu, and Assam, as well as in the border regions of north-east and Mumbai (Nittu *et. al.*, 2022)^[8].

Wildlife Protection Act 1972 of India, prohibits the illegal hunting, poaching and trade of wildlife and endangered species. The wild animals and their parts that are smuggled out of India are turtles and tortoises (family Testudinidae), pangolins (*Manis crassicaudata*), sea horses (*Hippocampus* spp.), tokay gecko (*Gekko gecko*), sea cucumber (class Holothuroidea), parakeets (order Psittaciformes), mynas (*Acridotheres tristis*) and munias (*Lonchura punctulata*) skins, wild boar (*Sus scrofa*), bones of tiger (*P. tigris*) and leopard (*P. pardus*), ivory, bear (*Melursus ursinus*) bile, horns of deer (family Cervidae) and one-horned rhinoceros (*R. unicornis*), mongoose (family Herpestidae) hair, snake venom and skins, musk (*Moschus leucogaster*) pods, red sander (*Pterocarpus satalinus*) timber and medicinal plants (Ajay Kumar Rana *et. al.*, 2023)^[1]. They are used in several industrial fields such as: fashion, traditional medicines, spiritual purpose, arts and crafts, cosmetics etc (Juanita Gomez *et. al.*, 2022)^[10]. In India to protect wild animals project have been launched for many species including Sea turtle, Crocodile, Hangul (Red Deer), Tiger, Elephant and one horned rhino. Recently, Indian (One Horn) Rhino Vision 2020 was established by ministry of environment and forests (2016) (Nishant K. *et. al.*, 2017)^[11]. Thus, in this contemporary world it becomes the need of the hour to use forensic tools in protecting wildlife species.

Wildlife Crimes in India

Wildlife crimes includes poaching, killing, trading, hunting of wild species. All wildlife trade is not illegal. The Wildlife (Protection) Act, 1972 prohibits the trade of over 1800 species of wild animals, plants, and their derivatives (Ms Segal Rushi *et. al.*, 2022)^[12]. According to data available from the WCCB and attached police authorities, over 9253 poachers were arrested in different poaching cases during 2012–2018 in India, but the rate of conviction was just 2% (Ajay Kumar Rana *et. al.*, 2023)^[1]. Mostly exotic species are trafficked. The exotic species list includes red-eared slider turtle (*Trachemys*

scripta elegans), iguana (*Iguana iguana*), marmoset (*Callithrix jacchus*), squirrel-sized Tamarin Monkey (*Saguinus* spp.), Tricolour Squirrel (*Callosciurus prevostii*), and several exotic birds. Similarly, many plant species, including Agarwood (*Aquilaria malaccensis*), Red Sanders (*Pterocarpus santalinus*) Sandalwood (*Santalum album*), and medicinal and aromatic plants parts such as Kuth (*Saussurea costus*) roots (Ajay Kumar Rana *et. al.*, 2023) ^[11]. In North India, Uttar Pradesh is the main region or hub of poachers, in Western India Rajasthan act as the hub for wildlife crimes and North Eastern region is the route for most of the illegal traffic. There are several unlicensed and open markets in India where animals, birds and plants are sold as food, pets, ornamental plants and medicines. Since such trade is openly available in India, while some are licensed and legalized, sellers can furtively sell (offline/online) some endangered species according to customer demand, with spurious names (Sharma *et. al.*) ^[13]. Other than hunting and trading local people living near jungles keep wild and rare speices in the belief of prosperity, good luck. But the possession of these species is also prohibited by forest officials.

Wildlife Forensics and Analysis of Wildlife Crimes

Wildlife Forensics is an emerging field of science, it is concerned with the application of forensic science to support wildlife law enforcement and solve legal matters related to wildlife crimes. It is not only useful in identification of species and prosecution of wildlife crimes but also in monitoring the health and impact of environmental factors on the wellbeing of wildlife populations (Sushanto Gouda *et. al.*, 2020) ^[14]. Some of the important techniques that have made a strong impact in the field of wildlife forensics are morphological analysis, microscopy, DNA analysis, mitochondrial DNA sequencing, phylogenetics, bioinformatics and evolutionary genetics, DNA barcoding, infra-red techniques, inductively coupled plasma atomic emission spectroscopy. Once the sample or specimen (for example; Tissue sample, Bone, Teeth, Claws, feathers, Hairs, Furs, Tusk, Poisons, Pesticides, organs, weapons, pesticides) is collected from the crime scene, they are properly labelled and sent to forensic laboratories maintaining the chain of custody. Further analysis is carried out by the experts.

Morphological Analysis: Morphological Analysis known as Physical analysis is one of the simplest and most common forensic analysis method. They provide the first line of evidence about the species. Here the physical characteristics of the specimen is taken into consideration. it is the least expensive forensic method known. Different species generally possess distinct

physical appearance like skin coat colour, pattern of coloration, eyes, pinna, tails, ivory etc (Nishant K. *et. al.*, 2017) ^[11]. Rina Rani Singh *et. al.*, in their paper characterize ivory of Asian and African elephants using Schreger angle measurements. Schreger angle pattern is one of the important morphometric characters for differentiation. The Schreger angle pattern is a characteristic structural feature of the dentine portion of elephant tusk (Rina Rani Singh *et.al.*, 2006) ^[22]. Morphological analysis is combined with anatomical analysis and microscopic analysis for better results. When the samples collected from crime scene are whole skin, body or skeleton it is easy to identify by comparing it with the reference sample or known sample. Further detailed analysis is done with the help of microscopic analysis. The major problems with morphological identifications are the non-availability of the whole animal or its intact parts preserved as such and the morphological analysis is again limited to the level of genus or its higher taxonomic level (Nishant K. *et. al.*, 2017) ^[11].

Microscopic Examination: Microscopic analysis or examination is one of the most useful tools in Forensic analysis. Microscopes are instruments that are helpful in observing microscopic samples and hair is considered as the most important physical evidence found in wildlife crime scenes. Mammals form one of the largest groups of poached species and a large number of wildlife crime cases require identification of species from hair (V. Sahajpal 2021) ^[9]. The microscopic structures in the hairs of mammal offer certain definite and unchanging characteristics which have been found useful for the purposes of identification (Hausman LA 1920) ^[15]. Thus, hair play a vital role in identification of species. Hair comes out through the epidermis and undergo keratinization. Underneath the epidermis lies dermis which accommodate the root of the hair. The hair consists of four structural units: medulla, cortex, pigment granules and cuticle. These are further classified into different categories. Several keys or guides were produced by researchers in identification of hair characteristics of different species. Sahajpal *et.al.*, characterised four species of bear found in India by studying the features including colour, hair thickness, cuticle pattern, medulla pattern, medullary index, cross-section and scale count index. They were able to categorise bear species on the basis of hair characteristics (V. Sahajpal *et.al.*, 2007) ^[16]. Sahajpal *et. al.*, further categorised four species of mongoose in India with the help of microscopic analysis of hair characters and discriminant function analysis (V. Sahajpal *et.al.*, 2009) ^[17]. If a hair sample is collected from the crime scene only the cortex and medulla are visible under the light microscope (whole mount of hair) but not fine details. To view the cuticular structure a cast

is needed to be prepared. Scanning electron microscopy (SEM) is also a recommended method to study the cuticle of hair as it offers resolution much higher than light microscopy (V. Sahajpal 2021) ^[9]. Examination of hair samples helps to narrow down to genus and species level.

DNA Analysis: DNA molecular technique is a method of utilising DNA for the identification of species. DNA act as an important and powerful tool for species identification and categorisation. Wildlife DNA forensics has been proven to be powerful especially in remote wild areas and the marine environment where poaching of protected or threatened species is tough to detect (JC Avise 1998) ^[18]. Molecular genetics provides a powerful tool for resolving the origin of wildlife products and detecting commerce in protected species (Joseph Roman 2000) ^[28]. Mostly species identification is done with the help of genetic markers. A genetic marker is a gene or a DNA sequence within a known location or position on a chromosome that is useful in individual or species identification. Mitochondrial DNA (mt DNA) is mostly used for species identification because of its easiness to extract as multiple copies of mtDNA is present in the mitochondria of a cell. In animals, mitochondrial cytochrome b (Cyt b) and cytochrome c oxidase 1 (CO1) genes are commonly used as universal mtDNA markers for species identification (V. Sahajpal 2021) ^[9]. Paul D N Hebert *et. al.*, research result indicates that sequence divergence at CO1 enable the discrimination of closely allied species in all animal phyla except the Cnidaria (Paul D N Hebert 2003) ^[19]. W Parson *et. al.*, identified diverse species from 5 major vertebrate groups (i.e. mammals, birds, reptiles, amphibians and fishes) with the help of analysing cytochrome b (cytb) gene (W Parson *et. al.*, 2000) ^[20]. In Junghwa An *et. al.*, research paper mentioned about the results that provided forensic evidences of illegal wild animal hunting. Here DNA-based analysis was performed using partial mitochondrial cytochrome b genes of five mammalian specimens and Chromo-Helicase-DNA-binding (CHD) genes of five pheasants to determine whether specimens were from illegally hunted animal (Junghwa An *et. al.*, 2005) ^[21]. And the results revealed that the species were illegally hunted ones.

DNA Sequencing: DNA Sequencing is the method of determining the order or the sequence of the bases in a DNA molecule. Sequencing is a highly effective, inexpensive and a fast method to characterise and identify species. Sequencing the CO1 gene fragment is highly informative (V. Sahajpal 2021) ^[9]. Megan L. Coghlan *et. al.*, in their paper evaluated the use of mitochondrial DNA (mtDNA) to accurately identify eggs to family, genus or species level by DNA Sequencing (Megan L. Coghlan 2012) ^[24]. The DNA is extracted from the egg shell membranes, blood, tissues and amplified. Further the

mitochondrial DNA (mtDNA) genes cytochrome oxidase I (COI), cytochrome b (Cytb), or 12S ribosomal RNA all are sequenced. Then they are checked with publicly assessable databases like GenBank and close matches are found. The aim of the study was to gain an insight into the target species being illegally smuggled into, or traded within, Australia (Megan L. Coghlan 2012) ^[24]. But the lack of data bases related to exotic species is a challenge for species identification. The ability for DNA (mtDNA, SNP's and microsatellites) to assist in species identification and population assignment (as is currently practiced in monitoring the ivory trade) will not only help to prosecute wildlife traffickers, but may also help in the conservation of threatened and endangered species (Megan L. Coghlan 2012) ^[24]. Pyrosequencing is another DNA Sequencing method; it is based on sequencing by synthesis. It relies on light detection based on the release of phosphate from the chain. The advantages of pyrosequencing are accuracy, flexibility, parallel processing and that it can be easily automated (Andreas O. Karlsson *et. al.*, 2007) ^[26]. Cristian De Battisti *et. al.*, suggested that DNA-based identification allows a clear and unambiguous detection of polymorphisms between species, permitting differentiation and identification of both commercial fraud and introduction of species with potential toxic effects on humans (Cristian De Battisti *et. al.*, 2013) ^[25]. In their study they used pyrosequencing technology for differentiation of fish species. This identification based on short and unique sequence demonstrates that it is promising and cost effective. Pyrosequencing has provided a rapid approach to species identification in an NGS format (Mirna Ghemrawi *et. al.*, 2022) ^[27].

Phylogenetic, Bioinformatics and evolutionary genetics: phylogenetic tree construction is another method for identifying species. It helps in understanding the evolutionary relationships between the unknown sample and the reference sample. These phylogenetic trees can be constructed by different methods. The methods include Neighbour Joining, parsimony, Minimum Evolution, Maximum Likelihood, Bayesian, Bootstrapping (Mark Holder *et.al.*, 2003) ^[29]. Joseph roman *et. al.*, referred a term 'mock turtle syndrome' where in their paper they explained about the turtle species that are being exploited in the turtle trade especially for commercial use. Specimens which include cooked items were collected and the DNA sequences were generated. With the help of BLAST programme, the sequences that did not match the references were compared to the entries in the GenBank to identify similarity. A neighbour-joining analysis of cytochrome b sequences was used to infer phylogenetic affiliation and species of origin. They used bootstrapping, a method of testing phylogenetic groupings, to assess the consistency of species assignments (Joseph roman *et. al.*, 2000) ^[28].

DNA Barcoding: DNA barcoding is a standard and rapid technique for the species identification and classification in an easy way for non-taxonomists and for specialists. PCR based method of species identification were prominent during the late 19th century. It is standard molecular approach of species identification and also for the study of different eukaryotic organisms and for the pathogenic strain diagnosis. The main objective of DNA barcoding is accurate species identification and paving the fastest way for identification the emergence of new species. The advantages of DNA barcoding are less expensive and gives result in less time. Since it uses the molecular data for species identification, it makes it easier than that of the identification based on the collected morphological data. In the current era many international organisations like NCBI have established DNA Barcoding as a global standard for identification of species. In DNA Barcoding they utilises a genetic marker or barcode to categorise the species. Mitochondrial gene Cytochrome C Oxidase 1 (COI) is a universal animal barcode. With the recent advancement of Next Generation Sequencing (NGS), DNA metabarcoding technology is advancing rapidly. Still, ambiguity and error prevail with the correct identification of species due to some problems (Sheikh Sunzid Ahmed 2022)^[23]. Once a sample is collected the DNA is extracted from it and amplified with the help of PCR. Later on, it is sequenced with the help of sequencing technologies and similarities are searched using bioinformatic techniques. GenBank, EMBL, DDBJ all are primary databases that stores DNA Barcode data. They are cloud-based data storage and analysis platform.

Infra-red techniques: spectroscopies like mid-infrared (mid-IR), near-infrared (NIR) and Raman in combination with chemometric techniques are highly efficient to discriminate species. NIR is mostly used in wildlife cases. Chandra Prakash Sharma *et. al.*, discussed about ATR FT-IR Spectroscopy used in the field of wildlife forensics for the identification and discrimination of species with the help of unknown blood samples. It is a non-destructive, non-invasive, and rapid method (Chandra Prakash Sharma *et. al.*, 2023)^[30]. Their study was based on some critically endangered, and protected wild species of south Asia i.e., Asian Elephant (*Elephas maximus*), Indian Leopard (*Panthera pardus fusca*), and Royal Bengal Tiger (*Panthera tigris tigris*). With this method they were able to discriminate the species with 100% accuracy.

Inductively coupled plasma atomic emission spectroscopy: This is a technique that is used for the identification of species with the help of determination of metal ion concentration in the samples. The metal ions concentration profiles of animal samples generally correlates with that of their habitat and it becomes the basis of their place of origin determination (Nishant

K. et. al., 2017)^[11]. During criminal investigations chances of misidentification of skeletal elements are high. Thus, these types of techniques help in determining the origin of skeletal remains. Samantha Dillane *et. al.*, in their research paper collected bones samples of several species like beaver, cat, rat, deer, fisher, fur seal, coyote, raccoon. They analysed the samples to measure the concentration of aluminium, boron, calcium, iron, potassium, magnesium, lead and sodium. Significant differences were observed in the results. Discriminant analysis of the species showed that it may be possible to distinguish bone fragments by feeder type, species and domestication status (Samantha Dillane *et. al.*, 2011)^[31].

Isotopes in wildlife forensics: isotopes are actually atoms that have same atomic number but different mass number. Isotopes are mainly of two types – radioactive isotopes and stable isotopes. Radioactive isotopes are having unstable nucleus and by emitting radiation they become stable. Carbon-14 (14c), which is widely used in the dating of archaeological samples and is a good example of a radioactive isotope (V. Sahajpal 2021)^[9]. As time goes by it turns into non-radioactive nitrogen 14. Whereas stable isotopes are having stable nuclei and do not exhibit radioactivity. Based on the relative abundance of isotope, we can predict the geographical origin of the sample collected. species are distributed according to ecozones and geography, their elemental profile including the relative abundance of stable isotopes is bound to vary with the geographical origins (V. Sahajpal 2021)^[9]. Inductively Coupled Plasma Mass Spectrometry and Isotope Ratio Mass Spectrometry are two techniques that help in elemental analysis with a capability to detect metals and nonmetals and very low concentrations and detect the isotopes present in the sample. These techniques are used in wildlife forensics for determining the geographical origin of the samples. C, H, O, N, S are some of the commonly used isotopes in forensic science.

Conclusion

Wildlife forensic is a field where forensic science is applied to legal issues related to wildlife. It helps in identifying the species, their origin and their conservation. Even though wildlife species play an enormous role in balancing our ecosystem, humans exploit them unconditionally. This exploitation has crossed the limit and now it's an alarming stage to take actions. Wildlife species are hunted, poached and traded illegally. Poachers kill or capture these species for selling them in locally or in world markets. Some of the rare species are captured and sold as exotic pets. Other species are poached for their meat, tusk, skin, fur, tooth, nail, organs, scales and many

more. The techniques involved in forensic aid in solving wildlife issues and concerns. Wildlife forensic laboratory analysis generate data's which help in identifying the geographical region where the seized wildlife specimen originated. These are also helpful in increasing the efficiency of law enforcement responses by ensuring that resources are directed to areas where the most significant poaching occurs. Data generated through the forensic techniques can assist the officials in linking the seized wildlife specimen to the crime scene and to the suspect. Moreover, the usage of these forensic techniques helps in wildlife crime prevention. In this chapter we have given a brief description of some of the forensic techniques like morphological analysis, microscopy, DNA analysis, mitochondrial DNA sequencing, phylogenetics, bioinformatics and evolutionary genetics, DNA barcoding, infra-red techniques, inductively coupled plasma atomic emission spectroscopy. As mentioned earlier the spectrum of wildlife forensic is wide. But in India, wildlife forensic is still underdeveloped and the officials are not trained to use these techniques in solving crimes. So, it is necessary to understand about wildlife forensics and the techniques involved in it.


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Quick Response Code	
DOI: 10.22192/ebfipr.2024	

How to cite this Chapter:

Vishnupriya C.J , Adithya V.V , Sandra N.S. (2024). Wildlife forensics – A key to wildlife crimes. P. Madhiyazhagan, Praseeja Cheruparambath, Deepa K, (Eds), *Exploring Boundless Frontiers: Interdisciplinary Perspective in Research*. India: Thanuj International Publishers. pp: 173-185.