Proceedings of National Seminar
on
CURRENT TRENDS IN BIOLOGY 2023

10th November 2023

Marian College of Arts and Science, Kazhakuttam

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CONTENTS

Focal Theme: Global Warming, Biodiversity, Climate change &Environmental sustainability

A PRELIMINARY OBSERVATION ON THE ISOPTERANS OF SHENDURNEY WILDLIFE SANCTUARY, WESTERN GHATS, KERALA, INDIA.

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ABSTRACT

Termites are a complex group of polymorphic eusocial insects living in large or small colonies composed of extraordinary morphological forms or castes. They play an important role in the ecosystem as decomposers in humid to semiarid regions of the earth. The present study is a preliminary attempt to assess the Termite fauna of selected habitats of Shendurney WLS, a biodiversity hotspot in the southern Western Ghats. The study was conducted from January 2023 to August 2023. During the study period, 19 species of termites belonging to 8 genera from4 subfamilies of the family Termitidae were collected and identified. The study also reports three major feeding groups of termites, humus feeders (42.11%), wood feeders (21.05%), and fungus-growing wood/litter feeders (36.84%).

Keywords: Isoptera, Western Ghats, Shendurney Wildlife Sanctuary, Termitidae, Feeding Groups.

INTRODUCTION

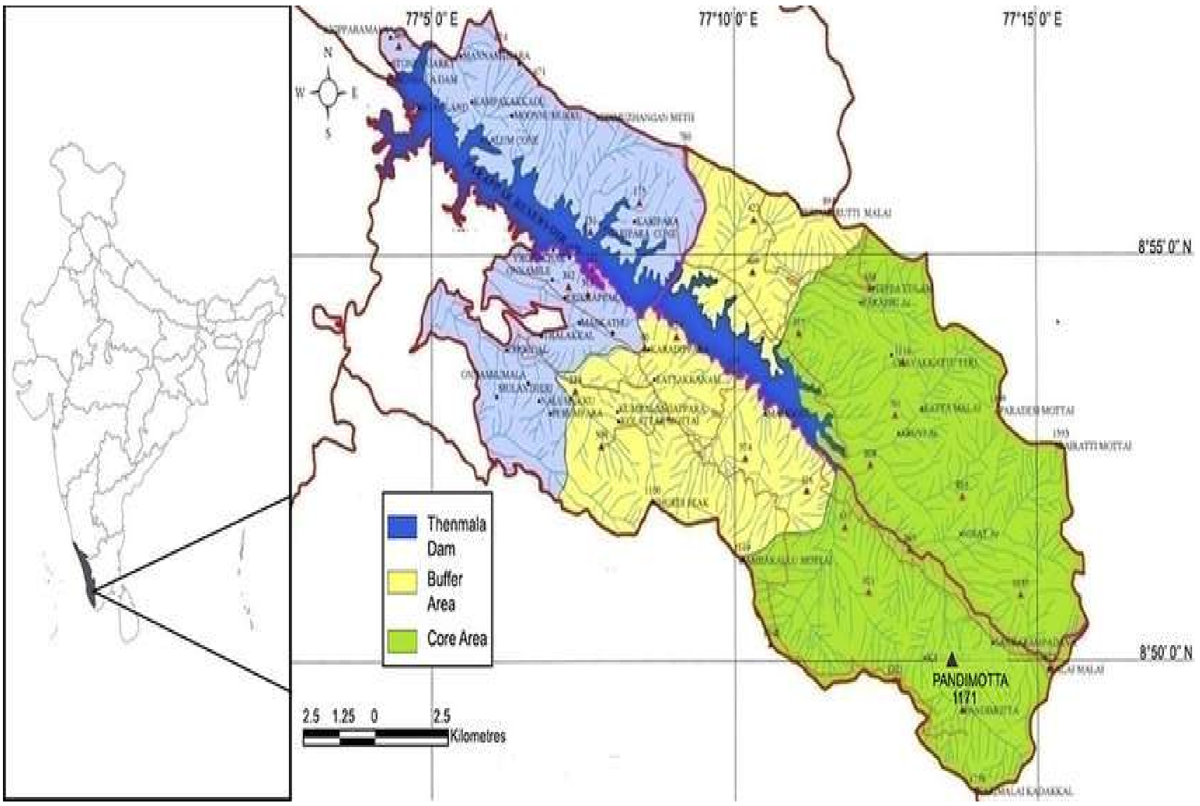
Termites (order Isoptera) are dominant soil macro arthropods in tropical ecosystems (Govorushko, 2019) and play an essential role in ecosystem functioning as decomposers and maintain the forest ecosystem dynamics in the tropics. Among the soil invertebrates, termites act as ecosystem engineers and contribute to spatial heterogeneity, which in turn has significant consequences for ecosystem structure and function in terms of soil turnover, litter decomposition, nutrient cycling, and productivity (Acanakwo*et al.,* 2019; Chakraborty & Singh, 2020) as well as variation of microhabitats, associated species assemblages, and vegetation characteristics (Beaudrot *et al.,* 2011; Muvengwi*et al.,* 2017). India has a high diversity of termites, but the Indian termite fauna shares a tiny portion of the global fauna, i.e., approximately 295 species, 52 genera, and six families (Krishna *et al.,* 2013; Rajmohana*et al., ., .,*2019). According to recent studies by Amina *et al.,* (2020), there are 60 species under 28 genera of termites in Kerala. Termite fauna of Western Ghats comprises 44 species belonging to 13 genera and six sub-families under two families (Amina *et al.,* 2020).Two-thirds of described termite species belong to the family Termitidae. They are the most dominant and widely distributed group and comprise eight subfamilies, 238 living genera, and 2072 living species (Krishna *et al.,* 2013). In India, there are 208 species under 35 genera belonging to four subfamilies of Termitidae (71%) (Amina *et al.,* 2013). Although the economic importance of termites has become evident, intensive studies during the last two decades have precisely suggested the roles played by diverse termite populations in different habitats. As Shendurney Wildlife Sanctuary is relatively unexplored regarding termites, this study is a preliminary attempt to document the termite diversity from selected habitats of the sanctuary.

MATERIALS AND METHODS

Study Site: The study was conducted in Shendurney Wildlife Sanctuary (8.80–8.95 N, 77.07–77.27 E), with an area of 171 km^2, is located in the northern aspect of the Agasthyamalai hills of the southern Western Ghats and lies in the catchment of Parappar dam, constructed across the west-flowing Kallada River. Much of the region's terrain is undulating, with valleys and high hills. The altitude ranges from 100m at the base of the hill to 1550m on top of Alwarkurichi, the highest peak. The weather is hot and humid, with 2,500–5,000 mm of rainfall received during both the monsoons (Nair, 1991). The temperature varies from 16 °C to 35 °C (Mathew *et al.,* 2004). Most of the region is accessible from strategically located base camps for biodiversity assessments. The biotic richness and distinct biographic features of this forest area make it an ideal gene pool reserve. Shendurney Wildlife Sanctuary has substantial natural vegetation ranging from southern secondary moist mixed deciduous forest to southern subtropical hill forest. The significance of the sanctuary lies in its ecological, faunal, floral, and geo-morphological importance. Various factors contributing to the significance of the area are the rich abundance of *Gluta travancorica.*

Sampling: Four significant habitats in the Shendurney Wildlife Sanctuary viz Semi-evergreen forests (S_1), Moist deciduous forest (S_2), Riparian Vegetation (S_3), and Southern Hilltop evergreen forest (S_4) were selected for the collection of termites. Sampling was conducted on a monthly basis from January 2023 to August 2023. Five random Quadrants (2m X 2m each) were used for sampling termites at the selected sites, and all the probable microhabitats of termite (mounds, logs, fallen trees, and living trees up to a height of 2 m, sticks, leaf litter, and vegetation) were examined and searched for termites. Soldiers and workers were collected and labelled, and transported to the laboratory, where they were counted, labelled, and placed in 70% (v/v) ethyl alcohol. Specimens were identified to the lowest possible taxonomic ranks by using the keys of Roonwal and Chottani (1989), Chottani (1997), and Kalleshwaraswamy *et al.,* (2013). Voucher specimens were placed as permanent collections in the Conservation Biology Laboratory, Department of Zoology, University of Kerala, Thiruvananthapuram.

Fig 1. Map of Shendurney Wildlife Sanctuary



Data Analysis: The number of species encountered in the quadrant was used as an indicator of relative abundance of species within each habitat. Percent occurrence of each species was calculated in the four habitats, and temporal changes in species diversity were calculated. Termite species diversity and richness were calculated using Shannon's diversity index (H'), Simpson's diversity index (D) and Margalef's diversity index (K).

RESULTS AND DISCUSSION

A total of 1738 individuals of termites from 61 colonies belonging to 19 species under 8 genera from 4 subfamilies of the family Termitidae were identified from the Shendurney Wildlife Sanctuary (Table 1).

Table 1. Preliminary Checklist of Termites from Shendurney Wildlife Sanctuary.

	Subfamily/Species	Feeding Group
	AMITERMITINAE	
1.	*Microcerotermes cameroni* Snyder, 1917	Wood Feeder
2.	*Microcerotermes fletcheri* Holmgren, 1917	Wood Feeder
3.	*Speculitermes emersoni* Bose, 1984	Humus Feeder
	MACROTERMITINAE	
4.	*Odontotermes anamallensis* Holmgren & Holmgren	Fungus growing Wood/Litter Feeder
5.	*Odontotermes ceylonicus* Wasmann, 1902	Fungus growing Wood/Litter Feeder
6.	*Odontotermes feae* Wasmann, 1896	Fungus growing Wood/Litter Feeder
7.	*Odontotermes graveyli* Silvestri	Fungus growing Wood/Litter Feeder
8.	*Odontotermes horni* Wasmann	Fungus growing Wood/Litter Feeder
9.	*Odontotermes obesus* Rambur, 1842	Fungus growing Wood/Litter Feeder
10.	*Odontotermes vaishno* Bose, 1961	Fungus growing Wood/Litter Feeder
	NASUTITERMITINAE	
11.	*Ampoulitermes wynaadensis* Mathur & Thapa	Wood Feeder
12.	*Nasutitermes brunneus* Snyder, 1934	Wood Feeder

	TERMITINAE	
13.	*Dicuspiditermes gravelyi* Silverstri, 1922	Humus Feeder
14.	*Dicuspiditermes incola* Wasmann, 1893	Humus Feeder
15.	*Dicuspiditermes sisiri* Chhotani, 1997	Humus Feeder
16.	*Krishnacapritermes dineshan* Amina &Rajmohana, 2020	Humus Feeder
17.	*Krishnacapritermes maitii* Chhotani, 1997	Humus Feeder
18.	*Krishnacapritermes thakuri* Chhotani, 1997	Humus Feeder
19.	*Pseudocapritermes fletcheri* Holmgren, 1917	Humus Feeder

Table 2. Measures of species diversity and richness of Termites in selected habitats of Shendurney Wildlife Sanctuary.

Diversity Indices	**S_1**	**S_2**	**S_3**	**S_4**
Shannon-Weiner Index (H')	2.654	2.727	2.202	2.421
Simpson Index (D)	0.926	0.932	0.875	0.907

Figure 1. Percentage Composition of Termite Subfamilies of Shendurney Wildlife Sanctuary.

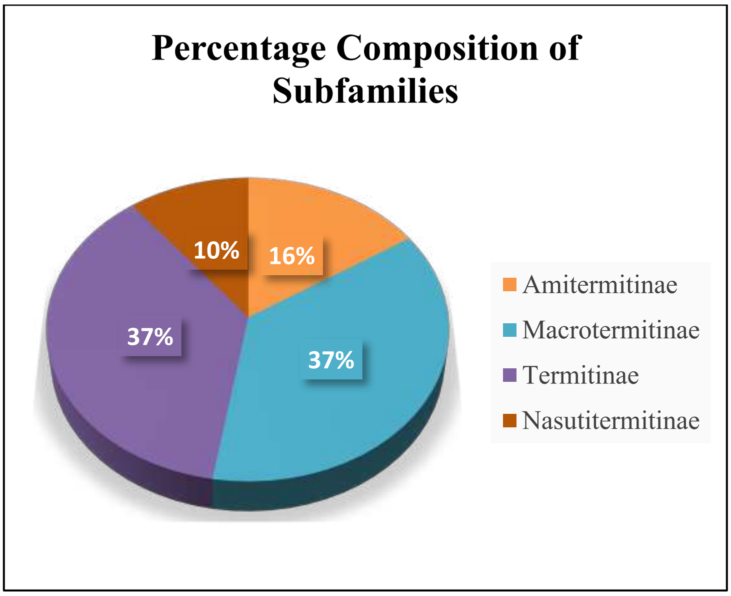
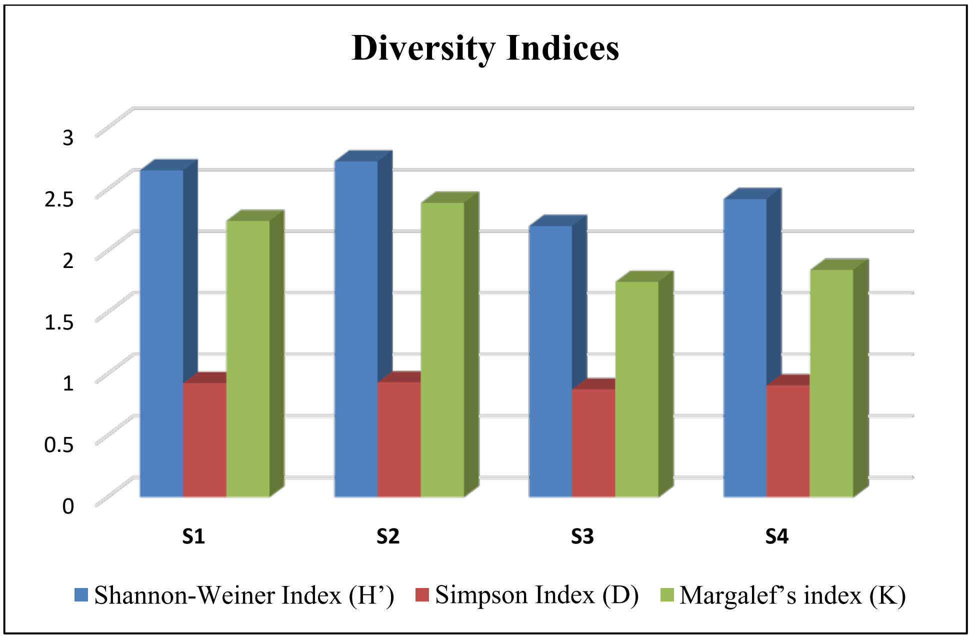


Figure 2. Site-wise variations in Diversity indices of 0Termites in Shendurney Wildlife Sanctuary.



Termites belonging to subfamilies Amitermitinae, Macrotermitinae, Nasutitermitinae, and Termitinae were found. The most species-rich subfamilieswere Macrotermitinae (36.84%) and Termitinae (36.84%), with 7 species each, followed by Amitermitinae (15.79%) with 3 species. The least number of species was reported from the subfamily Nasutitermitinae (10.53%), with 2 species. The four subfamilies represented in these collectionscome under three major feeding groups, namely humus feeders (42.11%), wood feeders (21.05%), and fungus-growing wood/litter feeders (36.84). Species diversity and richness varied across the four habitats. Shannon's diversity index (H') clearly showed that the moist deciduous habitat (2.727) was more diverse than the semi-evergreen (2.654), the hilltop evergreen (2.421) or the riparian (2.202) habitats. Margalef's index demonstrated that species richness was higher in the semi-evergreen forest (2.243), followed by the moist deciduous forest (2.39) and southern hilltop evergreen forest (1.845).

CONCLUSION

From the collected isopterans, *Odontotermes* was the most abundant genus with 7 species, and *Krishnacapritermes* is one of the endemic genera from the Western Ghats of India with four species. Among them, *Krishnacapritermes dineshan* was recently reported by Amina *et al.,*. (2020) from the present study site. Though faunal assessment of other invertebrates has been carried out in Shendurney Wildlife Sanctuary, there has been no previous systematic assessment of isopteran fauna. It is expected that the present study would form a baseline for augmenting efforts for the conservation of these social insects. As this study is a preliminary attempt, much more collecting, field studies, and taxonomic studies will be necessary for precise recognition of patterns of species diversity, habitat preferences, and community structure of the termite fauna of Shendurney Wildlife Sanctuary.

This is an attempt to document the isopteran fauna of selected habitats of Shendurney Wildlife Sanctuary, one of the rich diverse regions of Southern Western Ghats. A preliminary checklist of termite species from Shendurney Wildlife Sanctuary is given in this article. However, this by no means is comprehensive and only suggests the great diversity of isopteran fauna of Shendurney Wildlife Sanctuary and this warrants more detailed and systematic exploration of termites of this region.

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TIGERS IN CAPTIVITY: BEHAVIOURAL STUDY ON ATHE ACTIVITY PATTERNS AND INCIDENCE OF STEREOTYPIC BEHAVIOUR IN CONFINED ENVIRONMENT (*Panthera tigris tigris*)

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ABSTRACT

This study depicts behavioural patterns of tigers in captivity, with a specific focus on Bengal tigers (*Panthera tigris tigris),* inhabited in zoological garden Thiruvananthapuram. The research presents a comprehensive evaluation of the impact of enclosure size, environmental factors, enrichment facilities, visitors present, keepers present on the behaviour of tigers. The study indicates that the housing facilities are not optimal for the normal well-being of animals as the tigers are exhibiting pacing, as large proportion of their daily activity pattern. This indicates the inadequate space, limited enrichment Furthermore, the presence of keepers and visitors affects the tigers' behaviour, underscoring the need for optimal management practices. Climate and temperature plays a vital role in captivity. Enrichment facilities, larger area like enclosure complexity, pool availability, and cohabitation strategies, prove pivotal in reducing stress and stereotypic behaviours. This study indicates the importance of zoological gardens in improving the housing facilities and calls for continuous research and adaptive measures for the welfare of these big cats.

INTRODUCTION

The tiger, largest feline species have long been part of zoo animal Collections. Which have long attracted people and maintained in captivity for the purpose of education, research and recreation. The Felidae, species hold a special privilege in this list, especially the larger species like the lion (*Panthera leo*) and tiger (*Panthera tigris*) (Breton 2014). As a result, we can experience these ferocious big cats in every zoo in the globe.

It has been clearly shown that captivity alters physiological parameters, generates abnormal repetitive behaviour and can have important negative consequences on growth and reproduction during the entire life of animals (Garner, 2015; Mason,2010). Abnormal behaviour may develop in animals where the captive human made environment is not suitable for them to carry out their Natural/ Instinctive behaviour (Carlstead 1996). The captive environment of most zoological park do not & cannot provide for their behaviours due to spatial constraints (Mellan *et al.*, 1998). Stereotypic behaviour are repetitive, unvarying and apparently functionless behaviour pattern which captive animals may develop as a response to physical restraints, lack of stimulation, or inescapable fear / frustration due to the poor welfare conditions in captivity (Mohapatra, 2014).

Behavioural studies are useful method for knowing the welfare of zoo animals. Focusing the abnormal stereotypic behaviours & comparison with the behaviour conspecifics in the wild (Robinson, 1998). The use of behaviour in stress and welfare assessment must be based on the knowledge of normal species-specific behaviour & on the nature of deviations in response to different stimuli & emotions (Keeling *et al.*,2002) Behaviours is thought to be the reflect of an animals first attempt to cope with a stressor & thus may indicate a situation where welfare is at risk earlier than any known measure of physiology/ pathology (Dawkins,1998).In the light of the foregoing studies, it was thought worthwhile to study activity pattern and incidence of stereotypic behaviour of Bengal tigers in captive conditions.

MATERIALS AND METHODS

Study Area

The study was undertaken in zoological garden in Thiruvananthapuram. The subject of the present study were 6 captive tigers (*Panthera tigris tigris*) of the total of 7 tigers. There were 5 males, 2 females, and one sub adult female. The tigers are housed in old open carnivore enclosure and four old fashioned cages, including a squeeze cage. In Trivandrum Zoo there are five tigers who are captive born and two of them are wild born. Two Bengal tigers from Delhi zoo.

Other details regarding the study are collected from curator, veterinary surgeon, zoo keepers and from zoo records.

The study was carried out from January to March 2021.The behavioural patterns were observed for a very short period three months from 10:00to 3:30 PM. Each tiger was observed with 30 minutes intervals. The observation is done on the basis of behavioral patterns shown by the animals. First we studied the normal behavior of the animals and later identified the stereotypic behaviors showing repeatedly without achieving any goal. Observation was made when animals were out of sight were not included. The behaviours are divided into 3 categories active, passive and stereotypic. Frequencies of behaviours were summed on daily basis for each behaviour and behavioural category. Finally, they are categorized into Active, passive and stereotypic behaviours.

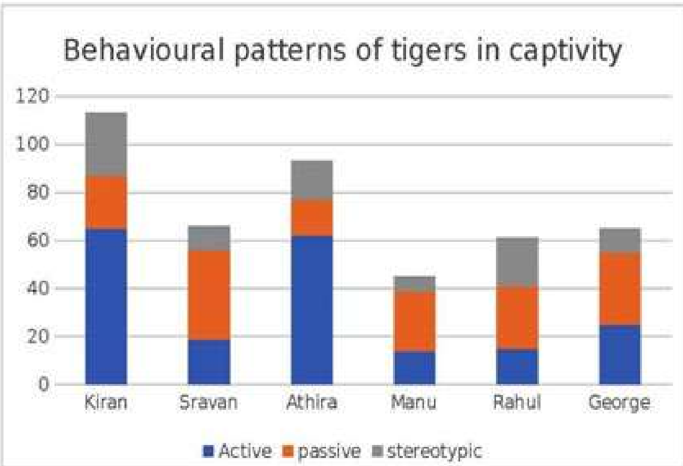
Table 1: Showing the details of animals under study

Sl.No	Name of tiger	Sex	Age
1	Kiran	Male	17
2	Manu	Male	14
3	George	Male	20
4	Rahul	Male	18
5	Sravan	Male	Not known
6	Athira	Female	4

OBSERVATION

We observed the behavioral patterns of 6 captive tigers, observed behaviors are active behaviours such as alert, aggressive, clawing, cooling, drinking, feeding, digging, eyes squinting, climbing, licking, playing, swimming, jumping, roaring, running, scent marking, stalking, tail quivering, sniffing, grooming, standing.

Fig:1

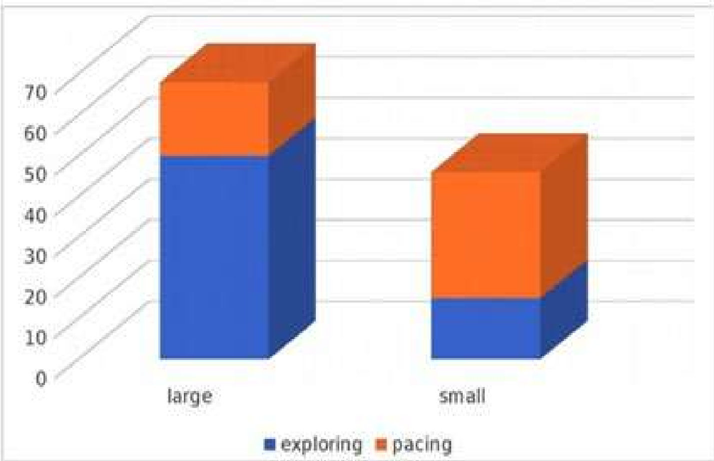


Passive behaviours such as panting, yawning, laying on the back, roll over, sleeping, resting awake, sitting. And stereotypic behaviour observed is pacing which is the repeated walking movements in same path without achieving any goal. We can see evident change in behavioural patterns during morning, afternoon and evening. Visitors Prescence, climate changes, mental stress affects the intensity of stereotypic behavior.

RESULTS

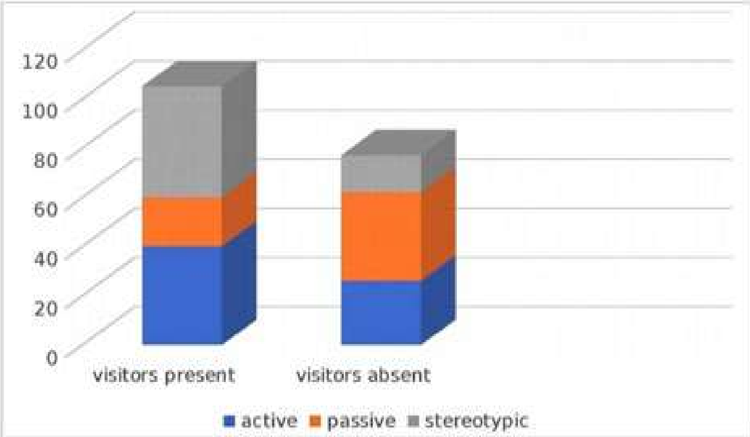
The analysis shows that each individual tigers are showing different behavioural patterns. Enclosure, cage size, visitors presence, climatic conditions, etc influence the behaviour of tigers in captive environment. Significant variation is also seen among different age groups, sex and coat colour. Total 28 behaviours observed 20 active behaviors,7 passive behaviours and one stereotypic behaviour. Kiran spent most of the times in active behaviours like walking, aggressive, growling, stalking, digging, standing, climbing, cooling, alert etc. Whereas Sravan, Manu, Rahul, George spent most of the time in passive behaviours, by resting awake, sleeping, roll over on back ,panting etc. While stress is typically less in case of Rahul, Manu as they are provided by a larger enclosures. Athira sub adult female showing high alert and escaping tendency, frustrated stressful behaviour she is inhabited in a small closed cage. Pacing is severely observed in 6 tigers, higher in case of Kiran, and Athira (Fig: 1). Pacing is the stereotypic behaviour that shows when the animal is stressed, it is the repeated walking movement in the same path without achieving any goal. They spent 41 % time on active behaviours, 44% of time on passive behaviours ,15% on stereotypic behaviours

Fig: 2 Effect of enclosure size on exploratory and pacing behavior.



The first peak in active behaviours are observed between 10:00am-12:00am and for stereotypic behaviours observed from 11:00 am to 12:00am due to the predictable feeding schedule and presence of visitors is high during these times (Fig:2).The resting behaviour occurred during mornings ,mid days, and evening hours. A drop in time spent in resting behavior are noted between 9:00 am to 12:00am, at these time we can see a rush in visitors. The presence of keepers and visitors can rapidly influence their behaviours. Tiger who are provided with pool facility is well utilizing it to cool down their bodies.

Fig: 3 Effect of behaviors in presence and absence of visitors



DISCUSSION

Behavioural observations plays a vital role in analyzing the welfare of animals. The findings of the present study show the changes in the behavioural patterns of tigers in captivity, with respect to some environmental variables like enclosure size, substrate, pool availability and enrichment facilities etc. The factors are very important in animal husbandry (Carlstead 1996; Bush *et al.,* 2002, Hediger, 1969, Law *et al.,* 1997). The study indicates that the housing facilities are not optimal for the normal wellbeing of animals as the tigers are exhibiting pacing, as large proportion of their daily activity pattern. It has been suggested that stereotypical behaviour beyond the level of 10% of the total activity is generally un acceptable for any captive animals (Broom, 1983). According to Mason more than 5% of studied population performs stereotypic behaviours (Mason 1991). Similar observation are reported by Mohapatra (2014). In our study 15%of stereotypic behaviour was noted. Stereotypic behaviour pacing is observed in the edges of the enclosure were also reported by other studies involving various fields (Lyon *et al.,* 1997; Mallapur *et al.,* 2002; Sajjad *et al.,* 2011). Similar findings are noticed in the present observations. The stereotypic behaviours showed rise from morning to evening with slight fall during the mid-days. Similar observations are reported in the study of Mohapatra in 2014. Kiran, Rahul allocate major times budgets to pacing. Passive behaviours like resting and sleeping are higher than that of active behaviours. A predictable feeding schedule resulted in increased levels of stereotypical behaviour (Qurike *et al.,*2012). In the present observation also, it was noticed that Tigers are showing periodic pacing near the holding area and also insight of keeper at the time of feeding. In presence of keeper tigers are showing aggressive behaviour at every time.

They are also showing restless behaviour in presence of keeper and visitors, similar result is noticed in the study of (Mohapatra *et al.,* 2010 and Palita 1997). Keeper presence is animal can influence the behaviour and location of the animals (Baldwin 1991; Thompson 1989) It was noticed that the major problem faced by tigers in captivity is the limitation of space as they generally create a large territory of their own when in wild. It was observed that tigers housed in larger enclosure had a less stress compared to those housed in very small cages irrespective of whether they are wild born or captive born.

Tigers who were providing more natural and complex enclosure performed less stereotypic pacing and more exploratory than that housed in natural enclosure. This result supports the findings of several other studies addressing the issue (Barclay and Lewis 1998; Law 1991;Wooster 1997: Pitsko 2003). The presence of a pool, stream, tub, pond or other water bodies can increase exploratory behaviour and strongly reduces stereotypic pacing. Effort should be made to reduce stress in captive animals, not only for general well-being of animals, but also to increase the success of captive breeding.

CONCLUSION

This study emphasized on how the captive environment affect the normal behavioural patterns of animals in captivity. The results shows that some more welfare measures should be adopted in captivity for the well-being of animals. Incidence of stereotypic behaviour is high in the case of carnivorous species like tiger in confined environment it was evidently noticed in our study. The authorities should not only focus for their physical needs but also meet their mental wellbeing. Stereotypic pacing was an important behaviour to evaluate, as captive carnivores often display this behaviour when stressed. The enclosure size and stress level are inversely proportional, keeper presence, visitors' presence affects the normal behaviours. Climate and temperature play a vital role in captivity. Enrichment facilities, pool availability, and co -habituation of the cage of same sex also plays important roles in behaviour of tigers. Further research will help us to understand the cause of stereotypic behaviours and identify any effect of behavioural enrichment on it.

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SPACE DEBRIS: A TECHNICAL EXAMINATION OF ITS ENVIRONMENTAL FOOTPRINT

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INTRODUCTION

Space exploration has enabled us to gain a deeper understanding of our planet and its place in the cosmos. Satellites orbiting Earth provide invaluable data on climate change, deforestation, and other environmental challenges. Additionally, space-based technologies have been instrumental in developing solutions to environmental problems, such as solar energy and remote sensing.

Space-based technologies have revolutionized our ability to monitor and study the Earth, providing invaluable insights into climate change, deforestation, and other pressing environmental concerns. Furthermore, the development of sustainable space technologies holds the potential to mitigate our impact on the environment, paving the way for a more harmonious relationship between humanity and our planet.

While space exploration has yielded countless benefits for humanity, it has also introduced a pressing environmental concern-space debris. The accumulation of space debris poses a significant threat to the environment. Orbital debris can collide with satellites, causing them to malfunction or even be destroyed. Additionally, re-entering debris can burn up in the atmosphere, releasing harmful pollutants. This technical review embarks on a journey into the uncharted depths of the environmental consequences associated with space debris.

By carefully examining the challenges and opportunities presented by space debris, we can strive to minimize its negative impact while harnessing the immense potential of space exploration to address pressing environmental concerns.

DEFINITION AND ORIGIN OF SPACE DEBRIS

Space debris also known as Space Junk is any human-made object in orbit around Earth that no longer serves a useful purpose. It can include defunct satellites, spent rocket stages, microscopic particles of rocket propellants and fragments from collisions. Space debris poses a growing threat to spacecraft, with larger pieces posing an even greater risk of re-entry and impact.

Most of the space junk orbiting Earth is the result of violent collisions and explosions, known as breakup events. These events can be caused by a variety of factors, including:

- Collisions between satellites or other space objects: Even a small collision can create a cascade of debris, as each fragment collides with other objects.
- Explosions of rockets or satellites: This can happen due to malfunctions, accidents, or even intentional destruction.
- Fragmentation of old, decaying satellites: Over time, the materials in satellites can degrade and become brittle, making them more susceptible to fragmentation.

IMPACT OF SPACE DEBRIS ON ENVIRONMENT

The risk of re-entering debris reaching the ground is extremely low. Due to their high orbital energy, most re-entering spacecraft, upper stages, and fragments are destroyed by atmospheric heating. Only in exceptional cases can solid pieces of large or compact objects survive re-entry and reach the Earth's surface.

The space debris can lead to multiple environmental consequences. These include:

i. **Aerospheric Influence:**
   - Every year, space debris, make their way back to Earth's atmosphere. While most of this debris incinerates upon re-entry or lands unnoticed on Earth, it doesn't simply vanish. The extreme heat from atmospheric friction can disintegrate and melt these fragments, yet the chemicals they are composed of are still discharged into the atmosphere. Certain composite materials and polymers, when they re-enter and combust in the atmosphere, undergo chemical reactions that generate nitric oxide, a substance known to deplete ozone.
   - In light of the considerable scale of our planet and the boundless expanse of space, the numerous fragments of debris re-entering Earth's atmosphere annually has a relatively insignificant environmental impact. However, it's important to note that human activities on Earth have a significantly more detrimental effect on ozone depletion and climate change compared to the minor impacts caused by the re-entry of numerous small pieces of space debris.

ii. **Risk to Forthcoming Space Missions:**
   - The escalating issue of space debris poses a significant risk to upcoming space missions. As we continue to launch satellites and conduct space explorations, the amount of space debris orbiting Earth has been steadily increasing. This accumulation

of debris has created a congested environment in space, making it increasingly challenging to navigate satellites and spacecraft without the risk of collision.

- The risk associated with space debris is twofold. Firstly, there's the immediate physical threat to spacecraft. Even small pieces of debris, when traveling at high speeds, can cause significant damage upon impact. This could lead to mission failure, loss of expensive equipment, and even potential harm to astronauts aboard manned missions. The International Space Station (ISS), for instance, has had to perform numerous debris avoidance manoeuvres over the years to evade approaching space junk.
- Secondly, there's the long-term sustainability of space activities. The more debris there is in space, the higher the likelihood of collisions. Each collision generates more debris, leading to a domino effect known as the Kessler Syndrome. If left unchecked, this could result in certain regions of space becoming too hazardous for future missions.

iii. **Terrestrial Impact:**

- The physical damage caused by space debris can vary widely, depending on factors such as the size, composition, and velocity of the debris. Small pieces of debris are likely to burn up completely upon re-entry and pose little threat. However, larger objects, particularly those made of dense materials like metal, can survive re-entry and reach the Earth's surface. When these larger pieces of debris impact the Earth, they can cause damage similar to a meteor impact. This can range from creating a small crater to causing an explosion if the debris is large enough. In addition to the immediate physical damage, debris impacts can also have environmental consequences. For example, if the debris contains hazardous materials, these could be released into the environment upon impact.
- Despite the potential for physical damage, it's important to note that the risk of being struck by falling space debris is extremely low. Space is vast, and the Earth's surface is mostly uninhabited. Most pieces of space debris that survive re-entry are likely to land in the ocean or in unpopulated areas. However, as the amount of space debris continues to increase, the risk of debris impacts could also rise.

MITIGATION MEASURES FOR SPACE DEBRIS

Space debris poses a global risk, threatening the crucial services satellites provide, such as weather prediction, communication, navigation, and scientific research. As the volume of space debris escalates, so does the collision risk, potentially causing mission failures, equipment loss, and astronaut endangerment. Therefore, the development and implementation of effective mitigation measures for space debris is of paramount importance.

A fundamental approach to mitigating space debris is to curb the creation of new debris. This involves designing spacecraft and missions in such a way as to minimize the creation of new debris. For instance, satellites can be designed to de-orbit and disintegrate in Earth's atmosphere after their operational lifespan, preventing them from becoming space debris. Similarly, rocket stages can be designed to either fall back to Earth or be propelled into 'graveyard orbits' where they are unlikely to pose a threat to operational satellites

Another crucial tactic is enhancing the tracking of space debris. By precisely monitoring the numerous fragments of space debris presently in orbit, we can forecast possible collisions and initiate preventive measures if required. This necessitates the employment of cutting-edge radar systems and other tracking technologies, along with the creation of complex algorithms for forecasting the trajectory of space debris.

Apart from prevention and monitoring, there's a growing interest in the active removal of space debris. This is a more formidable task as it necessitates the actual seizure and de-orbiting of space debris pieces. Numerous techniques for active debris removal have been put forward, encompassing the utilization of nets, harpoons, lasers, and even robotic arms. Although these techniques are primarily in the developmental stage, they offer an optimistic path for upcoming studies.

International collaboration is also a vital element in mitigating space debris. As space debris is a worldwide issue, it necessitates a global resolution. This implies that space-faring nations need to work together to develop and implement effective mitigation strategies. This cooperation could encompass data sharing for tracking, synchronization on spacecraft and mission designs to reduce debris, and joint research efforts into the active removal of space debris.

CONCLUSION

In conclusion, although the present impact of space debris on the environment is relatively small compared to the effects of human activities on Earth, it's an issue that requires attention. As we continue our exploration and use of space, we must do so responsibly, ensuring that our activities in space don't negatively affect our planet's environment.

The risk to future space missions due to space debris is an immediate concern that needs urgent attention. As we stand on the threshold of a new era of space exploration, ensuring the long-term sustainability of space activities is paramount. It's a multifaceted problem, but one that we must confront directly to ensure our continued presence in space.

Therefore, it's imperative that we approach space exploration with responsibility and foresight, implementing effective strategies to manage existing debris and prevent the creation of new debris. Only through such measures can we ensure the long-term sustainability of space activities and safeguard our planet for future generations.

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A STUDY OF THE BEHAVIOURAL PATTERN OF LION-TAILED MACAQUE (*Macaca silenus*) UNDER CAPTIVE CONDITIONS

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ABSTRACT

The present study was conducted to observe the behavioural pattern of lion-tailed macaque under captive condition (in TVM Zoo). The behavioural type observed are normal self-directed, normal social interaction, abnormal self-directed, and abnormal social interaction. The four lion tailed macaques under study are Kuttan (male, wild caught), Lekshman (male, wild caught), Ramu (male, born on TVM Zoo), and Ammu (female, wild caught). Kuttan and Lekshman were in off exhibit which means visitors are unable to see them & Ramu and Ammu were in open exhibit the visitors are allowed to see. Wild caught animals are not suitable for their living under captive condition and thus prevent them from natural species interaction behaviour. High degree of abnormal behaviours such as stereotypic behaviour, masturbation, growl etc. are due to the insufficient environmental enrichment in the zoo. Visitor's presence and absence also influenced the behaviour of those lion-tailed macaques. Lion-tailed macaquesare endangered species and Thiruvananthapuram Zoo is also remarked as one of the breeding centre of lion-tailed macaques.

INTRODUCTION

To thrive in captivity, a species must adapt to the Zoo environment, its ability to respond to captive conditions with behavior forms its normal repertoire depending on the degree to which the particular captive conditions resembles it's natural environment (Carlshed and Shepherdson 1994:Mallapur and Choudhary 2003). To house a species living in such ecologically rich environment, the captive environment must also be equally enriched. Captive environment enforces an artificial environment on the animal which alters greatly from their natural habitat.

The amount of behavioral changes seen in them depends upon the enrichment provided in the enclosure. For a species such as LTM, which rarely interact with human in its natural environment, so zoo visitors probably serve as a source of stress as compared with other non human primates in captivity, Stress and boredom are two important phenomenon inducing behavioral pathogens in captive animals (Mallapur and Choudhury, 2003). Abnormal self-directed behaviors stereotypic activities, abnormal social interaction behaviors have been seen in these animals when they are under captivity. Highest degrees of frequency of abnormal behavior have been seen in captivity. A distinguishing behavioral difference among free ranging and captive individuals is that free ranging animals spend most of their time foraging and gathering food travelling a long distance within their territory, but the zoo primates are devoid of such opportunities as they are provided food at definite durations and thus they do not require any kind of such opportunities as they are provided food at definite durations and thus they do not require any kind of foraging on gathering activity (Mallapur, Waren et al 2005). In the view of the information available in the present study an attempt has been made to study the behavioral pattern of Lion tailed macaques under captivity.

METHOD

During this pilot survey, the study was among 4 lion tailed macaques and individuals were observed. The behavioral observation was done for a short period of 2 months from February to March (2021) and the between 10:30am to 3:30pm. Among the four LTMs, two were kept in an open space for visitors to see and others are in off exhibit were visitors are not allowed.

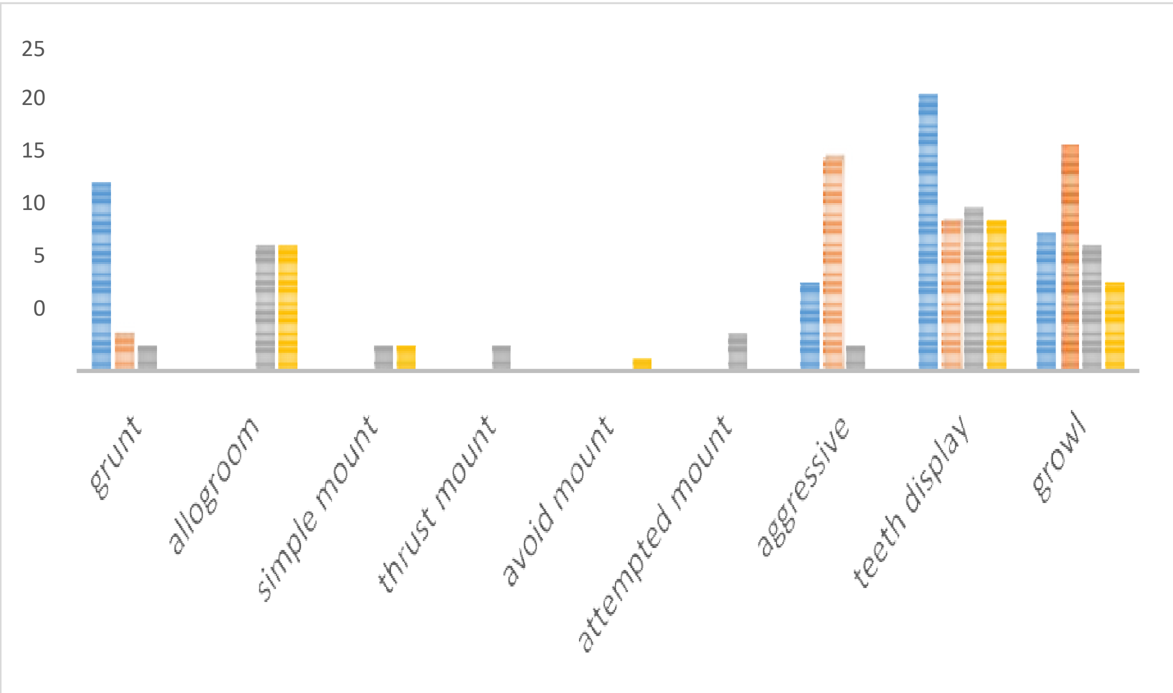
One adult male and one adult female named Ramu and Ammu were in open space, Kuttan & Lekshman were in off exhibit. The feeding time and the time at which the animal keepers cleaned the enclosures at same time. Other details regarding the study are collected from curator, veterinary surgeon, and from zoo records.

OBERVATION AND RESULTS

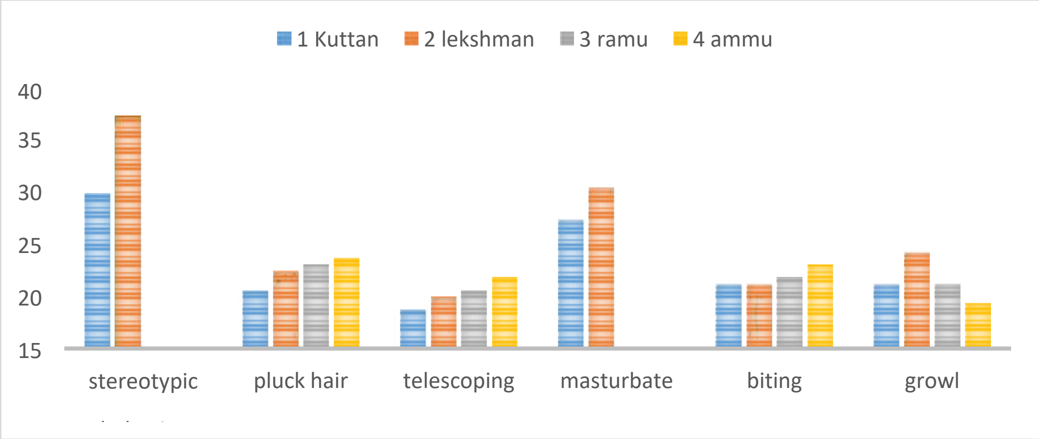
The captive animals displayed most of the normal behavioural traits which are very commonly seen among the wild animals. When compared out of these behavioural traits, Most of the behavioural patterns are displayed by Kuttan, 21 types of behaviour are observed. In Kuttan normal self-directed behaviour teeth display (11%), inspect penis (7%), sit & stand (7%) are in high degree, and abnormal self-directed behaviour such as stereotypic behaviour (18%), growl (17%), masturbate (10%) are in high degree.19 types of behaviour were noticed in Lekshman of which standing (12%) and bipedal stand (11%) are most shown normal behaviour & stereotypic behaviour(25%), masturbating(18%) are most shown abnormal behaviour. In Ramu and Ammu were in open exhibit shows many social interacting behaviour between them & 17 types of behaviours are to be observed. In Ramu high degree of normal behaviours such as sitting (13%) and walking (11%), swiping insect (9%). In Ammu high degree of behaviours observed siting (14%) & standing (13%), swiping insect (8%). Mating, allogrooming, lip smacking etc. are the behaviours observed in open exhibit animals. The off exhibit Kuttan and Lekshman show high degree of abnormal behaviour is due to the insufficient environmental enrichment provided by the zoo.

According to behavioural types, Normal self-directed behavours are mostly displayed by Ammu and Ramu in high degree then Kutttan then Lekhman. Normal social interaction behaviours between them are mostly displayed by Ramu and Ammu. Allogrooming, mating behaviors such as simple mount, attempted mount, avoid mount, etc also found in Ramu and Ammu. If we approach before Kuttan he raised his hand, grunt and display teeth. More aggressive behavior is displayed by Lekshman. Teeth display and growl are expressed by them in almost equal proportions. Abnormal self-directed behaviors such as stereotypic pacing and masturbation are mostly displayed by Lekshman followed by Kuttan. Circle repeatedly around the cage are the stereotypy shown by Lekshman. In one stereotypic pacing maximum seven times he circles around the cage. Like that, Kuttan shows to and fro walk inside the cage approximately five to six times in one stereotypic pacing. Pluck hair, growl, telescoping and biting almost in equal proportions. Abnormal social interaction behaviours such a peeping and begging ect. are shown by Ramu and Ammu while seeing the visitors.

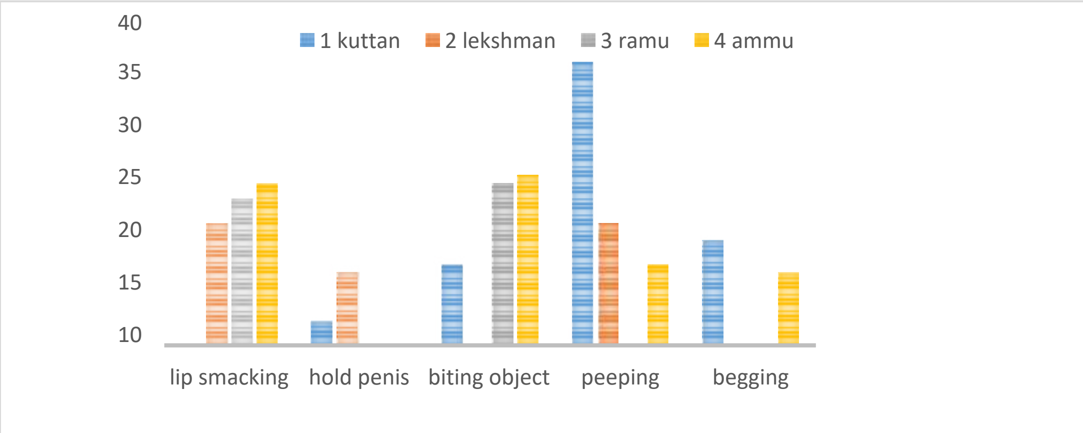
NORMAL SOCIAL INTERACTION BEHAVIORS



ABNORMAL SELF DIRECTED BEHAVIOUR



ABNORMAL SOCIAL INTERACTION BEHAVIOURS



DISCUSSION

Behavioural studies are the most common form of non-intrusive research used to assess the welfare ofanimals in captivity (Mench and Mason, 2000). Lion-tailed macaques have been observed to exhibit several types of abnormal behaviours in captivity (Marriner and Drickamer, 1994, Mallapur and Choudhury, 2003, Mallapur, in press)

In the present study there are many behaviours are observed among the individuals under captivity. Stereotypic behaviours, masturbation, peeping, begging etc., are the abnormal behaviours observed in high degree. This may be due to the insufficient enrichment and lack of social interaction among them.

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MORPHOLOGY AND CHEMICAL CHARACTERISTICS OF WING SCALES OF COMMON MORMON *Papilio polytes* Linnaeus, 1758 (Papilionidae: Lepidoptera)

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ABSTRACT

The Common Mormon, *Papilio polytes*, is a sexually dimorphic butterfly that belongs to the order Lepidoptera and the family Papilionidae. The male form is characterized by having black wings with numerous white specks that get smaller towards the apex in the forewing and appears as elongated white bands in the hindwing. In this study *P. polytes* were collected from the Kerala University Campus, Kariavattom and dried and preserved. The surface morphology and chemical spectra of *P. polytes* male hind wing scales are studied, which is responsible for the coloration, using Scanning Electron Microscope (SEM), Fourier Transform Infrared Spectroscopy (FTIR) and Energy Dispersive Xray Spectroscopy (EDAX). The Scanning Electron Microscopic images shows several long dendated scales with upper lamina, lower lamina and stalk. Nanostructure reveals the presence of grooves and transverse lines. The functional groups from four different regions of hind wing namely, dorsal black and white spots and ventral black and white spots reveal the presence of hydroxyl groups, amides, alkanes, alkenes, organic nitrates and nitro compounds, carboxylates, ethers, aromatic phosphates, ester, phosphorous-oxy compounds, sulfonates, fluoro compounds, alkyl halides, phosphate and silicate ions. The EDAX shows elements, carbon, oxygen, and gold as the major constituents, and magnesium appears to be minor. The present study provides the first report on the ultrastructure and chemical make of the wings of this butterfly.

Keywords: Butterfly, *Papilio polytes,* Morphology, Chemical spectra, Nanostructure, Spectroscopy.

INTRODUCTION

The colorful and intricate wing patterns of *P. polytes* butterflies make them a relevant subject for investigating the composition and structure of their wing scales. While previous research has primarily focused on mimicry and morphometrics in this species, there has been a notable absence of studies concerning the chemical composition of their wing scales. Recent research has explored the phenotypic plasticity of *P. polytes*, particularly in non-mimetic females, suggesting a potential basis for natural selection favoring mimetic color patterns during the course of evolution (Shimajiri and Otaki, 2022). Another study reported the biology and morphometrics of *P. polytes* on citrus leaves under controlled laboratory conditions (Islam, 2019). The present study aims to comprehensively analyze the morphology of wing scales, determine their elemental composition, and identify functional groups present within the scales of *P. polytes* male butterflies.

MATERIALS AND METHODS

Male *P. polytes* butterfly was collected from Kerala University Campus, Thiruvananthapuram using insect net and the specimen is dried and preserved. The hind wing of *P. polytes* was dissected carefully using clean forceps and the black and white band are subjected to analysis using Scanning Electron Microscope (SEM), Fourier Transform Infrared Spectroscopy (FTIR) and Energy Dispersive Xray Analysis (EDAX).The nanostructure of scales was analyzed using Scanning Electron Microscope (Carl Zeiss Evo 18).Functional group of *P. Polytes* hind wing was studied using FTIR spectroscopy (Smart Orbit™Thermoscientific Nicolet iS50).The acquired spectra from the wing sample were analyzed to identify the chemical constituents present in the wing scales and were compared using FTIR frequency chart. EDAX analysis was conducted using AMETEK coupled with Carl Zeiss Evo 18. The X-ray analysis was carried out to ascertain the elemental composition. Quantitative analysis provided insights into the abundance of different elements in the scales.

RESULTS

Scanning Electron Microscopy

The hindwing of male *P. polytes* butterflies displays considerable diversity in scale characteristics, encompassing variations in both shape and size. The fundamental structure of these scales consists of three key components: an upper lamina, a lower lamina, and a stalk. The stalk is firmly attached within a socket, as shown in Figure 1(f). The dendations, or projecting elements, exhibit variations in their number, with some scales featuring six dendations, others four, and still others three toothed dendations, as illustrated in Figure 1(b). When examined at the nanostructural level, distinct transverse lines and grooves become evident, as depicted in Figure 1(e).

Fourier Transform Infrared Spectroscopy

The FTIR spectra of *P. polytes* male hind wing scales unveiled distinct peaks, corresponding to specific chemical components. Dorsal black region shows peaks at 3273.94, 2918.51,1628.60,1540.75, 1449.67, 1376.57, 1235.80, 1159.34, 1073.73, 525.66wavenumber

cm^{-1}. This shows the presence of functional groups such as hydroxyl group (H- bonded O-H stretch), Amide (Ammonium ion, N-H stretch), alkane (Methylene asymmetric), C=C stretch, open chain imino group, open chain azo, and organic nitrates, nitrogen oxy compounds such as aliphatic and aromatic nitro compounds, methyl C-H asymmetric stretch, methylene C-H bend and carbonate ion, methyl C-H symmetric bend, O-H bend, phenol or tertiary alcohol, carboxylate, aliphatic nitro compounds, nitrate ion, alkane C-H bending and nitro N-O stretch, methyne, skeletal C-C vibrations, aromatic ethers, aromatic phosphates and presence of phosphorous oxy compounds, secondary amine C-N stretch, sulphur-oxy compounds- sulfonates, C-N stretch, aliphatic flouro compounds, alkyl substituted ether, C-O stretch, phosphate ion, silicate ion, alcohol CO stretch, alkyl halide C-F stretch, ether C-O stretch and ester C-O stretch, C-I aliphatic iodo compounds and alkyl halide C-Br stretch.

Dorsal white region shows weak peaks at 3277.62 cm^{-1}, 2921.82 cm^{-1}, 1653.82 cm^{-1}, 1629.55 cm^{-1}, 1546.01 cm^{-1}, 1512.48 cm^{-1}, 1437.98 cm^{-1}, 1377.69 cm^{-1}, 1235.13 cm^{-1}, 1159.03 cm^{-1}, 1069.12 cm^{-1}, 578.63 cm^{-1}, 525.40 cm^{-1}, 508.93 cm^{-1} and 458.29 cm^{-1}.

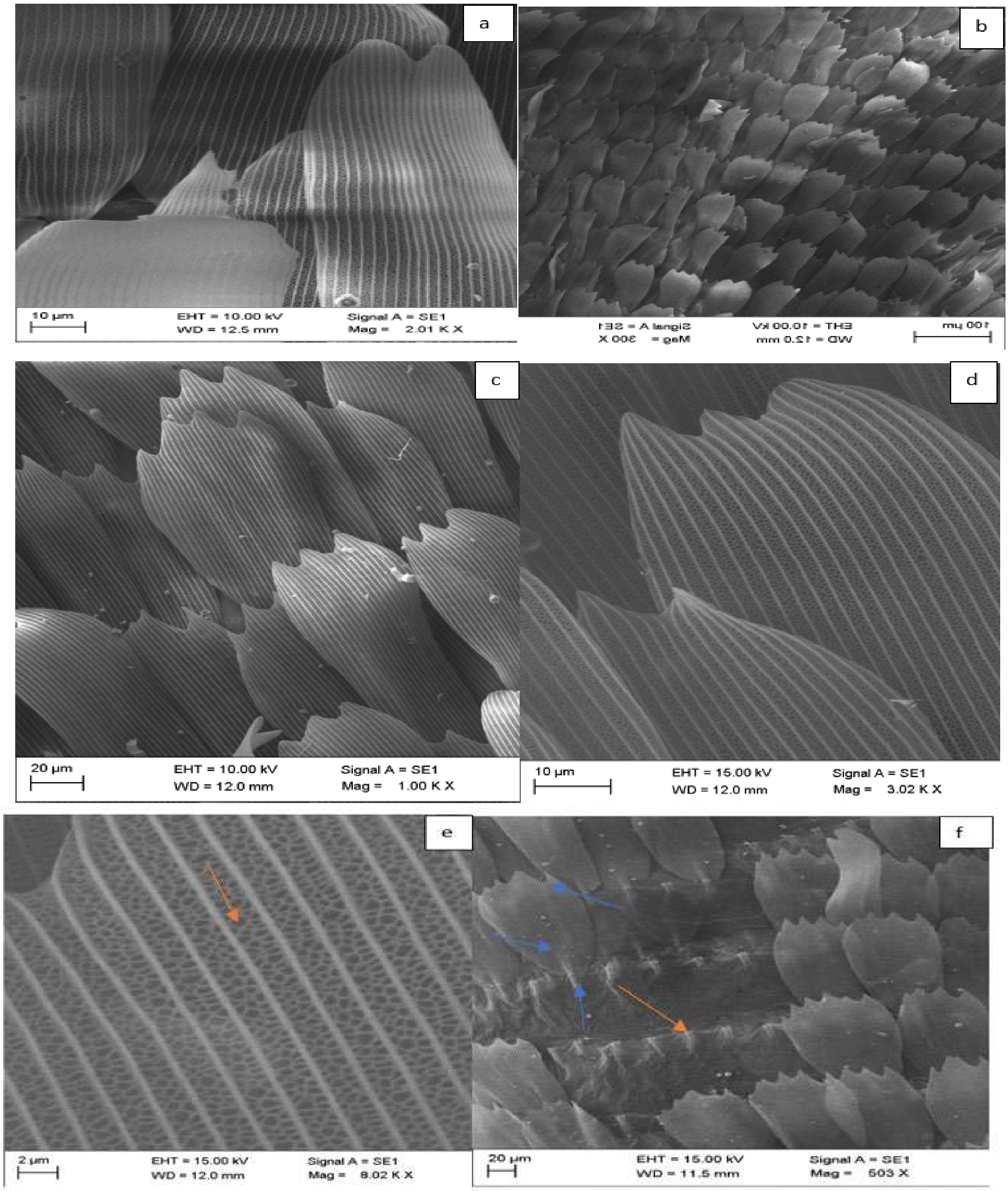
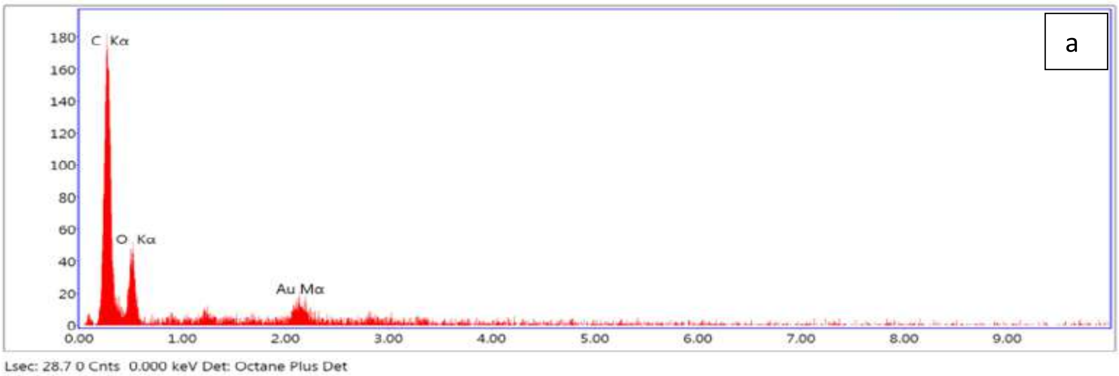
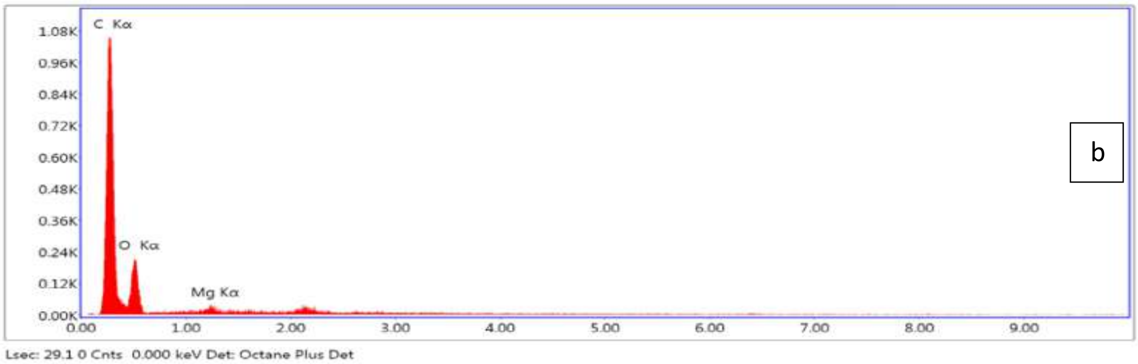


Fig 1a-f. Nanostructure of *P. Polytes* male hind wing scales. a-dScale cluster and nanostructure. e -Transverse lines and grooves. f -Scales and the socket..



eZAF Smart Quant Results

Element	Weight %	Atomic %
C K	64.98	73.40
O K	31.04	26.33
AuM	3.98	0.27



eZAF Smart Quant Results

Element	Weight %	Atomic %
C K	69.81	75.60
O K	29.69	24.14
MgK	0.49	0.26

Fig 2. Elemental composition of *P. polytes* in EDAX analysis. a-Elements in white bands and their percentage weight and atomic composition. b-Elements in black area and their percentage weight and atomic composition.

The functional groups present in this area are normal "polymeric" OH stretch (O-H), ammonium ion (inorganic ions), alcohol (O-H) stretch – H bonded, amide (N-H stretch), C-H methylene asymmetric, alkene (C-H stretch), and acid (OH) stretch, alkenyl C-C stretch, amide C=O stretch, open chain imino, C=C stretch alkenyl, N-H stretch primary amine, N-H secondary amine,nitrogen oxy compounds, aliphatic nitro compounds, aromatic nitro compounds, aromatic C=C stretch, methyl C-H asymmetric stretch, carbonate ion, alkane (C-

H) bending, methyl symmetric bend, carbonyl compound, nitrogen oxy compounds, organic sulfates, nitrate ion, alkane (C-H) bending, nitro (N-O) stretch, aromatic ethers, C-O stretch - ester, C-N stretch secondary amine, C-N stretch tertiary amine and cyanate stretch, sulfonates, alkyl halide (C-F) stretch, ester (C-O) stretch, alkyl substituted ether, aliphatic iodo compounds (C-I) stretch, disulfides (C-S stretch), C-Br alkyl halide stretch and aryl disulfides (S-S stretch).

Energy Dispersive X-ray analysis

EDAX analysis provided valuable insights into the elemental composition of the wing scales (Fig 2). Primary elements detected included carbon, oxygen, aurum and magnesium suggesting their presence in the scales. Quantitative analysis indicated that carbon was the predominant element in all region studied, followed by oxygen, aurum and magnesium. Carbon, oxygen and aurum are observed in the white bands while carbon, oxygen and magnesium are observed black region of *P. polytes* wing (Fig2-a,b). These elemental composition data offer crucial information regarding the materials involved in the formation of wing scales

DISCUSSION

The study on morphology explores the presence of scales arranged in organized overlapping rows. The wings of butterflies possess a distinctive structure characterized by an arrangement of minute scales organized in overlapping rows and a standard scale comprised of the upper lamina and lower lamina, featuring transverse ribs, which possess a smooth surface (Giraldo, 2008). Scales can be readily dislodged from the wing without causing harm to the butterfly (Chapman, 1988; Scoble, 1995 and Heppner, 2008). This distinctive scale arrangement plays a pivotal role in the visual appearance and coloration of butterflies, as well as their ecological interactions.

Functional groups play a crucial role in various biological and ecological processes. These chemical groups, which consist of specific atoms or atom arrangements within organic molecules, contribute to the diversity and adaptability. It has been reported in earlier studies that hydrocarbons present in insects exhibit inherent variability, rendering them a valuable tool for taxonomic purposes (Archana *et al.,* 2022). Even among species that share indistinguishable morphological characteristics, these hydrocarbon profiles enable discrimination (Schlick-Steiner *et al.,* 2006). Within the context of insect cuticle composition, it has been observed that alkanes are integrated with alkenes on the external layer of the cuticle (Archana *et al.,* 2022).

Alkanes, alkenes, and alkynes, hold considerable significance for various facets of insect biology, encompassing nest recognition, mate selection, and egg identification (Martin and Drijifhout, 2009). An additional category of compounds frequently detected in insects comprises alkyl halides, alcohols, and phenols, which play essential roles in insect communication and gender identification (Schlick-Steiner *et al.,* 2006). Alkyl halides, characterized by the attachment of halogen atoms to carbon groups, also function as agents that inhibit aphrodisiac effects (Gibbs and Pomonis, 1995; Chung and Carroll, 2015). The presence of O-H stretch signals indicates the presence of alcohols and phenols. Hydrocarbons present in the cuticle play a pivotal role in regulating trans-cuticular water flux, thereby affording protection against desiccation (Martin *et al.,* 2004). Carboxylic acids function as anti-desiccation agents and waterproofing agents, thereby contributing significantly to the insect's capacity to withstand environmental challenges (Chung and Carroll, 2015). The presence of carbon, oxygen, magnecium and aurum plays important role in insect biology suchas magnecium has role in intermediary metabolic pathways of insects, carbon has ability to form large molecules, role of oxygen in flight of insects,aurum nanoparticles exhibit insecticidal and antiparasitic efficacy (Clark, 1958; Albert, 2002; Fountain *et al.,* 2016; Benelli, 2018).

CONCLUSION

The study of *P. polytes* male wing scales is important for several reasons, particularly in the field of evolutionary biology and ecology. The SEM, FTIR and EDAX analyses of *P.polytes* male butterfly wing scales have unveiled the morphology, chemical and elemental composition of these intricate nanostructures. The presence of specific chemical components and elements elucidates the optical properties and gives vivid colours to the butterfly wings. Future research in this domain holds potential for the development of bio-inspired materials and technologies.

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AROCLOR 1254 INDUCED ALTERATIONS IN THE LIVER AND GONADS OF A FRESHWATER FISH, *Anabas testudineus*- A PROBABLE SIGN OF ENDOCRINE DISRUPTION

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ABSTRACT

The present study was undertaken to evaluate the effect of a polychlorinated byphenyl (Aroclor 1254), a potent xenobiotic, on the gonads and liver of a freshwater fish, *Anabas testudineus* through histological study. The edible nature of fish increases the significance of the study. Experimental doses (15µg, 30µg and 45µg/bodyweight) of aroclor-1254 were prepared in cornoil as vehicle. Laborotary acclimatized fish were divided into ten groups consisting eight in each group. Nine groups were administered intraperitoneally (ip) with 15, 30 and 45µg/g bodyweight of aroclor-1254 for 10, 20 and 30 days. The tenth group was injected with cornoil only and maintained as control. After stipulated periods of injection, liver and gonads were excised from decapitated fish and fixed for histological study. Haematoxyline and eosine staining method was employed for tissue processing.. Tissues were observed and photographs were taken by using image analyser (Leica, Germany). Hepatic tissue of control fish exhibited parenchymatous cells with intact nucleus, reduced number of melanomacrophage centre (MMC) etc. But the liver of experimental fish showed the loss of normal cell structure presence of more MMC, disrupted hepatic duct etc. Testis of control fish showed normal seminiferous tubules, enormous spermatids etc. But in treated fish the testis showed interstitial fibrosis, disrupted testicular wall, reduced quantity of spermatids, disrupted seminiferous tubules etc. Ovary of control fish showed normal oocytes with all stages of development. But in the ovary of experimental fish, reduced numbers of viable oocytes, many ateritic oocytes, etc. were found. Here it is evident that the influence of aroclor-1254 adversely affected the normal functioning of liver and gonads.

INTRODUCTION

Endocrine disrupting chemicals (EDCs) are environmental pollutants that alter major metabolic pathways and physiological processes by disrupting the normal functioning of the endocrine system. Polychlorinated biphenyls (PCBs) are one of the important ECDs, which have been identified as contaminants in almost every component of the ecosystem including fish, wildlife and human adipose tissue, breast milk and serum (Anne *et al.,* 2007). PCBs cause a variety of serious reproductive problems in several types of wildlife like mammal, bird, fish, reptile, crustacean and insect, which shows that PCBs are affecting reproductive traits shared by the wide range of creatures. Human beings share a similar reproductive biochemistry; therefore, these wildlife health risks should serve as a warning of potential human effects. Aroclor-1254, one important PCB widely used as coolants in electric plants, production of plastics, pesticides, adhesives, wood and floor finishes, newsprint, paints and varnishes etc. poses serious threat to both humans and wild life. They bioaccumulate in lipid-rich tissues, in the organs of animals, and in sediments of water bodies. Therefore, animals at the top of an aquatic food chain (e.g., fish-eating birds) can accumulate more PCBs than organisms at the bottom of the food chain (e.g., zooplanktons). In the fish, *Micropterus salmoides,* methoxyclor altered reproductive signaling in the liver and decreased reproductive success (Jason *et al.,* 2008). Aroclor 1254 are persistent organic global pollutant of major concern to human and animal reproduction. They hold an important position in the environment as endocrine disrupters. They disrupted the steroidogenic pathway in rat by disrupting the endocrine system (Murugesan *et al.,* 2005). They can act directly or indirectly on the reproductive system of animals. Sometimes they directly affect the steroidogenic pathway, disrupting the synthesis of steroidogenic enzymes, affecting the synthesis of testosterone etc. Aroclor 1254 caused all these endocrine disrupting activities in rat leidig cells (Murugesan *et al.,* 2008). Another cause of gonadal atrophy in fish is the generation of free radicals by xenobiotics, mainly endocrine disrupting chemicals like polychlorinated byphenyles (Aroclor 1254). They can create oxidative stress in gonads by altering major metabolic pathways. Thereby they can disrupt the entire gonadal architechture. Aroclor 1254 induced oxidative stress in testicular mitochondria, affected sperm quality and organ weight in *Boleophthalmus pectinirostris (*Shanying *et al.,*2011)

Exposure of lead and aroclor-1254 in a fish, Atlantic croaker altered reproductive neuroendocrine function. In this fish they impair hypothalamic serotonin metabolism, leading to the impairment of gonadal growth (Khan and Thomas, 2000). Studies have examined the relation between PCB exposure and human health effects using indirect or surrogate measures of exposure such as fish consumption. Some studies reported neurobehavioral effects and development in children (Jacobson and Jacobson, 1996; Korrick, 2001) endocrine mediated effects including shortened menstrual cycle (Mendola *et al.,* 1997). In the European eel, *Anguilla anguilla* exposure of Benzo[a]pyrene, aroclor 1254 and dioxin resulted in DNA strand breaks and apoptosis in erythrocytes.(Nigro *et al*., 2002; Regoli *et al.,* 2003).

MATERIALS AND METHODS

Experimental animal

The experimental model used for the present study was a freshwater fish, *Anabas testudineus*. Fish were collected from local places and acclimatized in large cement tanks with dechlorinated tap water ($26\pm2^{o)}$ under natural photoperiod. They were fed with standard commercial feed on alternate days.

Experimental design

Laboratory acclimatized fish were divided into ten groups consisting eight in each group. Experimental doses of aroclor-1254 were selected after determining the LC_{50} in corn oil as vehicle. Nine groups were separately administered intraperitoneally (ip) 15, 30 and 45µg/gm bodyweight aroclor-1254 for 10, 20 and 30 days and maintained as experimental group. The tenth group of fish was injected with vehicle alone and considered as control. After stipulated periods of injection, fish were sacrificed by spinal concussion, liver and gonads were excised and fixed in aqueous Bouin's fluid for histology.

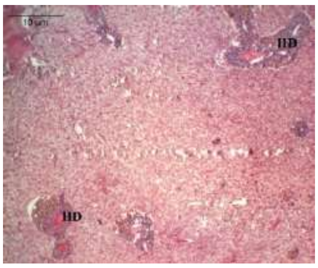
Fixed tissues were dehydrated through ethanol series, cleared and embedded in paraffin with melting point $55\text{-}60^{0}C$. Paraffin sections were cut at 4µm, mounted on slides and stained in haematoxylin and eosin. Slides were observed under binocular research microscope and photographs were taken by image analyzer (Leica, Germany).

RESULTS AND DISCUSSION

Administration of all three sub lethal doses of aroclor-1254 resulted in hepatic and gonadal atrophy. Liver tissue of control fish showed parenchymatous cells with intact nucleus, blood vessels, hepatic duct, reduced number of melanomacrophage centers, absence of vacuolation etc. (Fig1). But aroclor-1254 (15 and 30µg) administered liver tissue showed loss of normal cell architecture, more melanomacrophage centre, hepatic haemorrhage, etc. (Fig2 and 3). Hypertrophy, pyknotic nucleus, vacant blood vessel, intense vacuolation, disrupted and vacant hepatic duct etc. could be noticed in liver tissue administered with 45µg aroclor-1254 (Fig 4). Normal ovary exhibited previtellogenic, vitellogenic and post vitellogenic oocytes (Fig 5). But ovary of experimental fish (15 and 30µg) showed reduced number of oocytes, presence of ateritic oocytes etc. (Fig6 and 7). But injection of 45 µg aroclor-1254 lead to the formation of vacuoles, under development and disruption of post vitellogenic oocytes etc. (Fig 8). Testis of control fish showed seminiferous tubules with spermatids, spermatocytes etc. (Fig 9). But under the influence of aroclor-1254 testis exhibited interstitial fibrosis, more melanomacrophage centre, reduced quantity of spermatids, disrupted testicular wall, disrupted and vacant seminiferous tubules etc (Fig.10, 11 and 12).

The present study revealed that influence of aroclor-1254 lead to hepatic and gonadal alterations. Liver is the primary organ for metabolism, detoxification of xenobiotics, excretion of harmful substances etc. The administration of sublethal doses of aroclor-1254 caused serious leisions in the liver and may affect the normal metabolic processes. This is highly corroborated with the work of Mandal and Kulashresta (1980). They reported that the catfish, *Clarius batrachus* exposure to DDT caused rapid regeneration and vacuolation, empty blood vessels, hypertrophy etc. in liver tissue. John *et al.,* (1993) reported that endosulfan resulted extensive vacuolation, loss of polygonal cell shape, necrosis etc. in the hepatic tissue of *C. carpio.* This work also supports our present study. Alterations in the liver tissue clearly indicated the toxic nature of the compound. This was also evident in the study of (Sivarajah *et al.,* 2006). Alterations in the gonads were another major consequence of aroclor-1254 administration. Both ovary and testis was found to be disrupted, indicating the ability of this compound to affect adversely the steroidogenic pathway. EDCs can activate or inhibit estrogen, androgen and thyroid receptor signaling and effects on steroidogenesis (EATS-pathways) Amir *et al.,* (2021). Same results were obtained in the study of Peter Thomas *et al.,* (2003). They found out that aroclor-1254 caused retardation in ovarian growth, alteration in the synthesis of vitellogenin and lead to reproductive anomalies in fish, *Gadus morhua*. It also produces testicular abnormalities in Cod, *Gadus morhua* (Sangalang *et al.,* 1981).

Fig.1: Control liver with normal hepatic duct (HD), parenchymatous cell (PC) etc.



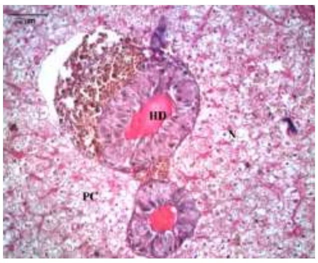


Fig.2: Experimental liver (15µg/g bodyweight) with MMC, disrupted blood vessel (BV) etc.

Fig.3: Experimental liver (30µg/g bodyweight) with haemorrhage

Fig.4: Experimental liver (45µg/g bodyweight) with vacant blood vessel (BV) and vacuolation (VC)

Liver (45µg/g bodyweight) with vacuolation (VC) in the hepatic duct, pyknotic nucleus etc.

Fig.5: Control ovary showing vitellogenic (VT), previtellogenic (PRV), post vitellogenic (PSVT) oocytes

Fig. 6: Ovary (15µg/g body weight) with ateritic oocytes (ATO), reduced number of oocytes, etc.

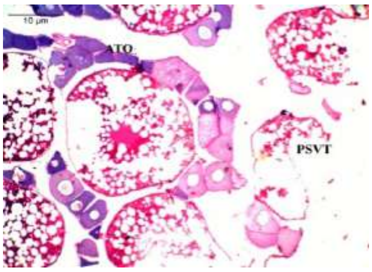
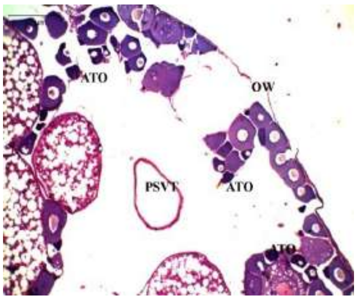


Fig. 7: Ovary (30µg/g bodyweight) with vacant PSVT, ateritic oocytes and distructed ovarian wall (OW).



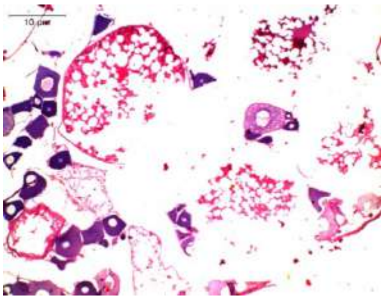
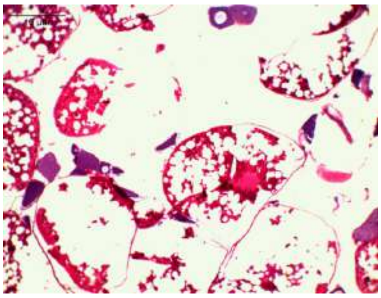
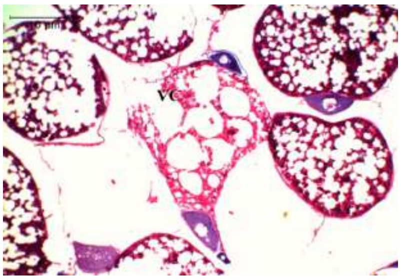


Fig.8: Ovary (45µg/g bodyweight) with damaged PSVT, vacuoles in the oocytes (VC) and vacant oocytes



Ovary with vacant oocytes



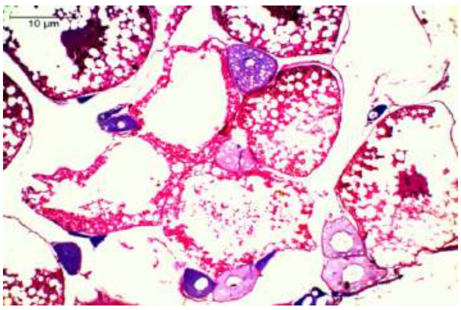


Fig.9: Control testis with seminiferous tubules (ST), spermatids (SP)

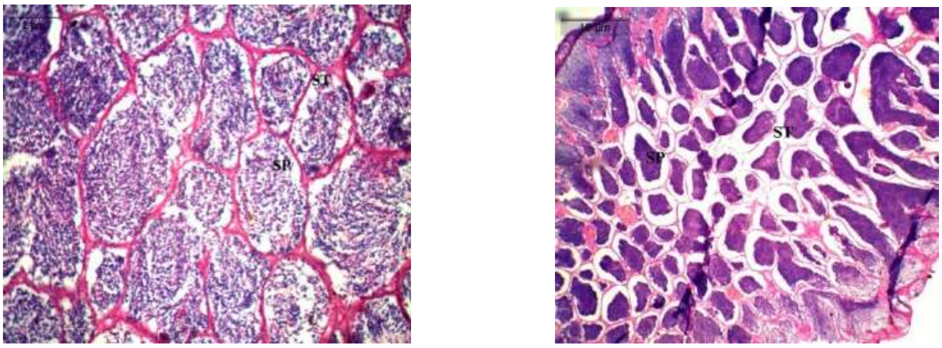


Fig.10: Testis (15µg/bodyweight) with melanomacrophage centre (MMC), vacant seminiferous tubules

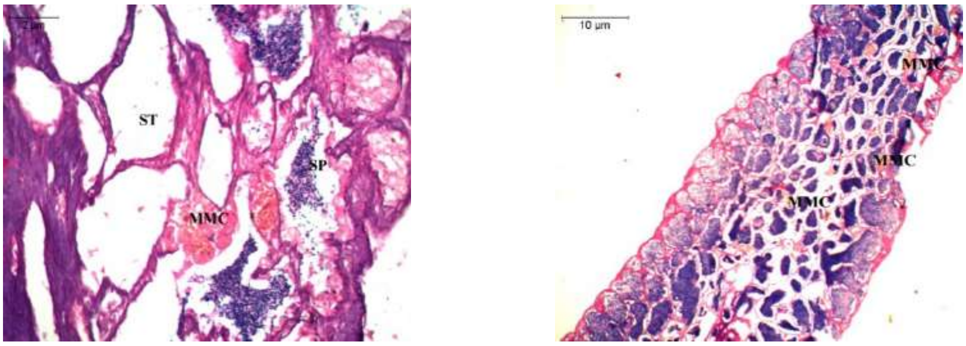


Fig.11: Testis (30µg/bodyweight) with disrupted and vacant seminiferous tubules (ST)

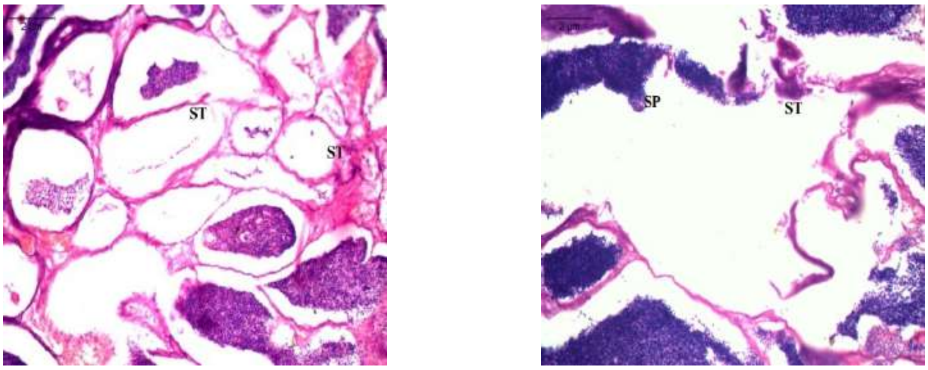
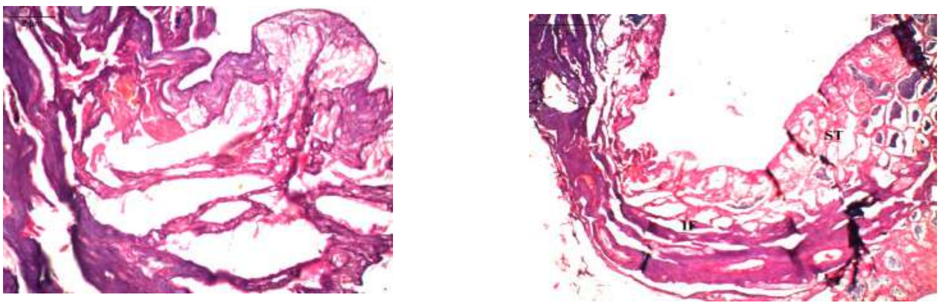
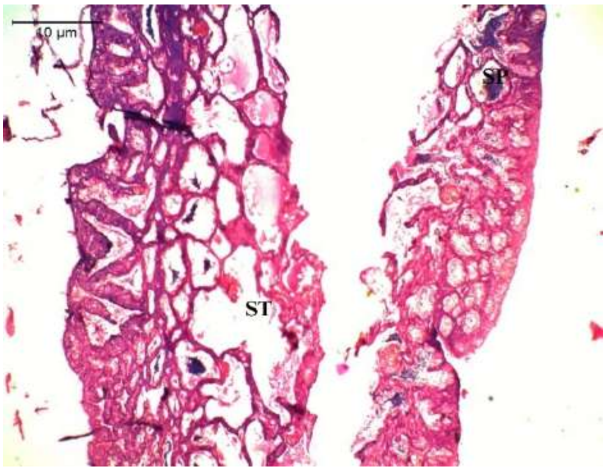


Fig.12: Testis (45µg/bodyweight) with interstitial fibrosis



Disrupted appearance of entire testicular tissue



CONCLUSION

All the changes induced by aroclor-1254 may be due to the imbalance in the endocrine physiology caused by the compound aroclor-1254. If so this compound can be included in the category of endocrine disrupting chemicals or xenobiotics. Due to its adverse effect on hepatic tissue, it can also damage major metabolic pathways and other physiological activities in the body. Since the ECDs act on the steroidogenesis pathway, it is very easy to affect the reproductive system. Here the gonadal architecture was highly disrupted, indicating the endocrine disrupting capacity of aroclor-1254. Being an edible fish these consequences may happen in higher trophic levels including man through the process of biomagnification. Here histopathology stands as a valuable tool for assessing the toxicity of Aroclor 1254.

ACKNOWLEDGEMENT

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A PRELIMINARY STUDY ON SPIDER DIVERSITY IN THE ENIGMATIC MYRISTICA SWAMPS OF AMBANAR FOREST, PATHANAPURAM, KERALA.

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ABSTRACT

Myristica swamps are one of the rarest wetland ecosystems within the sub-tropical evergreen forests of the Western Ghats, India. These swamps are considered as living museums of ancient life and could promote better understanding of the influence of climate change on the evolution of plants. Diversity study of spider fauna was conducted in the Myristica swamp of Ambanar, Pathanapuram forest division, Kollam District, Kerala from January 2023 to June 2023. Spiders are terrestrial predators with eight-legs and hollow fangs for injecting venom. They are known for their ability to produce silk webs. From the study fourteen species of spiders belonging to nine families were identified. The dominant family is Araneidae with four species. Swamps are extremely beneficial plant communities and provide a variety of benefits to wildlife including food, nesting areas, shelter, and water. They also serve mankind as flood control and purifiers of water.

keywords: Myristica swamp, Spider, Ambanar, Wetland, Western Ghat

INRODUCTION

The Western Ghats has three distinctive freshwater swamp types cradled within its fertile lap – Myristica swamps, Elaeocarpus swamps, and Hadlus. Among these, the Myristica swamps are one of the rarest ecosystems present in the tropical world (Thacker and Karthik, 2022). Myristica swamps in India were first reported by Krishnamoorthy (1960) from the Travancore region of the Southern part of the Western Ghats. Western Ghats of India is home to patches of fresh water swamp forests which support some unique endemic species of Myristicaceae R. Br. and therefore are commonly known as Myristica swamps (Talbot,1911). Myristica swamps are freshwater ecosystems occupied by members of the family Myristicaceae (Chandran & Mesta, 2008; Bhat et al. 2009). Chandran et al. (1999a, b) suggested that Indian Myristica swamps are the remnant of primeval forests of the Western Ghats and evolved about 140 million years ago. Loss of Myristica swamps directly threatens species adapted to live in these swamps with extinction while losing out on important ecosystem services provided by these swamps. However, due to human interventions, the swamps today are highly threatened and are highly fragmented.

A high local diversity of spiders may be found in wetlands, mainly by the availability of prey and by the predatory behaviour of spiders, with various strategies of foraging (Buchholz, 2010). Spiders are classified in the order Araneae, one of several orders within the larger class of arachnids, a group which also contains scorpions, mites, ticks and Opiliones (harvestmen). While most arachnid species are terrestrial, some are wetland dependent, or even inhabit marine and freshwater environments. From the earliest studies, it has been clear that the physiognomy or physical structure of environments has an important influence on the habitat preferences of spider species, and ultimately on the composition of spider communities (Uetz,1991). Spiders have an amazing array of prey catching strategies ranging from simple ambushing to the use of complex silk snares. Insects provide the vast majority of spiders' food and many web-based prey catching strategies. They donot live in bodies of water or in the air, but can adapt to almost any type of environment: hot or cool, wet or dry, in the garden. Spiders exhibit a complex functional response to increased prey densities. Spiders thus maintain stable population densities despite local fluctuations in prey numbers. They are the dominant predators and stabilizers of the invertebrate community in natural habitats (Susan, 1974). Spiders have recently gained attention as a result of a number of significant studies. In addition, because of their small size, short lifespan, and the strong influence of genetic control on their behaviour, spiders are regarded with keen interest as model organisms in behavioural ecology (Uetz, 1992). According to previous studies forty-seven different spiders have been recorded from the Myristica swamps of southern Kerala. Of these one could only be identified to family level and 27 to genus level. Nineteen spiders were identified to species level. Fifteen families and 34 genera of spiders were identified from the swamps. A world without spiders would have serious problems affecting the whole food chain and cause an imbalance in the ecosystem.

MATERIALS AND METHODS

The study was carried out in Pathanapuram forest range (N 9 °5 ' 7.2528 '', E 76° 51 ' 18.36'') area under Punalur division in Kollam district, Kerala, India (Figure1). The observed Myristica swamps from Pathanapuram forest range are seen inside Ambanar model forest station. In the Ambanar region, Myristica swamps are specifically observed in the Manthadam area. The current investigation was carried out from January 2023 to June 2023. Spiders were collected using the visual searching method, with all surveys taking place in the morning hours between 7:30 am and 12:00 pm. Ground searches mainly, focused on leaf litter, fallen debris, and dry wood. To collect spiders dwelling

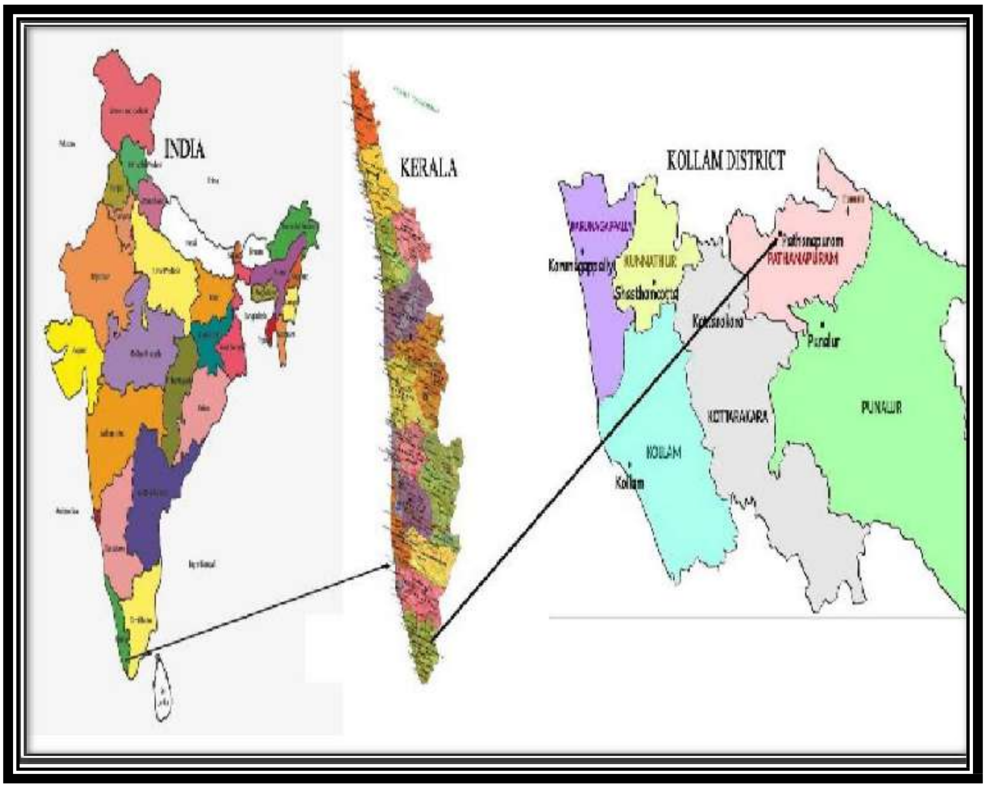

Fig 1: Map of the study area.

in the foliage of herbs and shrubs, the sweep netting method was employed. Beating was done with a wooden stick and an inverted umbrella was placed under the trees to catch the spiders. After collection, the spiders were carefully placed into separate vials containing 70% ethyl alcohol for preservation and further analysis. The collection date, collection time were recorded on each vial. Spiders were photographed using Sony SLTA58 camera and identified up to the species level following the identification keys by Jose et al., (2007); Joyce and Roby (2007); Fathima (2021) et al., and by seeking expert opinion. Permission for entering protected areas and reserve forests and collection of specimens was obtained from the Divisional Forest Office, Forest Head Quarters, Thiruvananthapuram.

RESULT AND DISCUSSION

During the study period a total of 14 species of spiders belonging to 9 families were identified from the sampling site. A list of species of each family are provided in Table 1. A total of 14 spider species belonging to 9 families were recorded in the study area. Among these, Araneidae was the most abundant family, represented by four species. Members of this family are orb-weaving spiders known for their three-clawed builders of flat webs with sticky spiral capture silk. Araneidae is one of the largest endemic families. The exclusive presence of multiple spider species from the Araneidae family may be attributed to the existence of a favourable microclimate and/or suitable web support for these species. The richness of spider species was significantly influenced by the habitat and vegetation structure.

Previous studies have also demonstrated a clear correlation between the structural complexity of the habitat and spider species diversity (Uetz 1979; Rosenzweig 1995; Rendon et al. 2006; Rodriguez et al. 2015; Malvido et al. 2020). Prey density also plays a role in spider richness, as an increase in spider population depends on the availability of prey. The Tetragnathidae and Lycosidae families were the second most dominant, with two species each. The remaining families, including Sparassidae, Oxyopidae, Pisauridae, Salticidae, Dictynidae, and Cheiracanthiidae, were represented by one species each. The lower species richness and abundance in these families could be attributed to factors such as habitat homogeneity, destruction of microhabitats, or changes in microclimatic conditions within the habitat. The impact of deforestation has been particularly detrimental to certain spider species, such as those belonging to the Argiope and Oxyopes genera. The web-building sites of these spiders are highly susceptible to environmental factors, and competition may arise when their web spaces overlap. Web-building species are particularly vulnerable to environmental factors, and competition may arise when their web spaces overlap. Studies have shown that spiders are highly sensitive to even small changes in habitat structure, including complexity, litter depth, and microclimate characteristics. Environmental changes can modify species coexistence patterns, leading to direct or indirect effects on local and regional spider diversity (Boixetal, 2004). Factors such as erosion, land subsidence, droughts, and other disturbances can cause fluctuations in spider populations and reduce species diversity. Habitats with low heterogeneity tend to have lower spider diversity, as noted in previous studies (Greenstone 1984; Cabra- Gracia et al.,2010). The structure of habitats plays a crucial role in determining the c composition of spider communities (Cunhaetal.,2012). Spiders have specific preferences for humidity and temperature, which limit their distribution to areas within their physiological tolerances. Therefore, they serve as valuable indicators for land conservation studies. Spiders play a crucial role in ecosystems as dominant generalist predators. They exhibit a wide diet range, engage in intraguild predation, and help control herbivore populations in terrestrial habitats (Hooks et al., 2006). Their abundance, diversity, and biological functionality enable them to inhabit diverse ecosystems and adapt to various living environments. Additionally, spiders contribute to nutrient cycling and serve as an essential component in ecological interactions within these ecosystems (Hodkinson et al., 2001). Wetlands including Myristica swamps, support diverse spider communities due to the availability of resources and their unique ecological characteristics. However, these valuable ecosystems face threats that endanger the survival of spiders and their important ecological roles. Conservation efforts are necessary to protect these habitats and preserve the rich biodiversity they sustain. Their degradation would lead to irreparable losses. Although some swamps fall within reserve forests, they do not receive the same level of protection as national parks or wildlife sanctuaries. However, spiders in these habitats are currently threatened by multiple factors, including habitat loss, fragmentation, climate change, and disturbances caused by human activities.

In recent times, research on spider distribution and diversity has been conducted in various parts of the world. However, there is a lack of comprehensive documentation on spiders in southern India. This study serves as a pioneering effort to uncover the spider diversity in and around the Myristica swamps of the Ambanar forest area in Pathanapuram, Kerala, India. Prior to this study, no research had been carried out in this specific study site, making it the first of its kind. The findings of this study reveal a rich species diversity in the limited area surveyed. However, it is important to note that this diversity may decline in the future due to a lack of awareness regarding the conservation of this unique and degrading ecosystem. The results of this study emphasize the need for conservation efforts focused on preserving spider species inhabiting the Myristica swamps. As mentioned in previous studies, Myristica swamps have been fragmented and reduced to patches, posing a significant threat to their overall health and biodiversity. This study adds to the existing body of knowledge by shedding light on the spider fauna in this specific ecosystem. It underscores the urgency of conservation measures to protect these fragile habitats from further degradation.

In conclusion, this study represents the first documentation of spider diversity in the Myristica swamps of the Ambanar forest area. It highlights the importance of raising awareness and implementing conservation strategies to safeguard the unique spider species found in this ecosystem, which is currently facing degradation and fragmentation.

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IMPACT OF QUINALPHOS, AN ORGANOPHOSPHATE INSECTICIDE, ON SELECTED GUT ENZYMES AND DNA PROFILE IN THE EPIGEIC EARTHWORM, *Eudrilus eugeniae.*

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ABSTRACT

Pesticides are widely used in agricultural production to increase the crop yield and to prevent or control pest. Despite their popularity and extensive use, pesticide arises serious concerns about human health. They not only contaminate the environment but also cause damage to flora and fauna. Earthworms, are the key organisms for monitoring the fertility of the soil, so they are called the `farmers friend'. From this perspective, earthworm, *Eudrilus eugeniae* was exposed to different sub-lethal concentrations of organophosphate insecticide, quinalphos. The LC50 of quinalphos were determined as 60µl/kg. *E. eugeniae* were exposed to two sub lethal doses, 30 µl/kg and 40 µl/kg, also gut enzyme activities were analyzed. Changes in morphology and behavior were observed such as decreased burrowing activity and morphological changes were seen during the experiment. Different biochemical estimation like amylase, protease, xylanase, acidphosphatase, and alkaline phosphatase were performed in the gut of the earthworm. The result showed significant changes in the activity of these enzymes. In agarose gel electrogram, no fragmentation was observed in any of the test group exposed to quinalphos.

INTRODUCTION

Currently, modern agriculture should deal with some important global issues, such as population growth, food security, agrochemicals risks, pesticide resistance, natural environment degradation, and climate change (Nicolopoulou *et al.,* 2016). These pesticides protect crops and crop commodities from pests including weeds, insects and diseases. They increase the effectiveness of agricultural production, and so they are called plant protection products. Pesticides are an essential compartment of agricultural management; they take an important part in increasing the yield and quality of crops (Qian *et al.,* 2018). These chemicals control pests, diseases, and weeds more easily, cheaply, and effectively; therefore, they are used extensively in the world. However, the usage of pesticides has increased crop productions, but the extensive, unselective, excessive, and wrong use of these chemicals caused heavy damage to the ecosystem, extending toxicity and pollution in the environment (Stanley *et al.,* 2016)**.**

The global concerns and worries are raised due to soil biodiversity declination and food safety, as these are contaminated by pesticide usage (Silva *et al.,* 2019). The residues of pesticides are accumulated in plants and their products, causing environmental pollution (Stanley *et al.,* 2016). Developmental exposure to various types of environmental chemicals and pesticides has the potential to induce adverse neurological effects in humans or animals (Wu *et al.,* 2018). These toxicants cause some health problems, such as central nervous system diseases, endocrine (hormones) system disorders, birth defects, and cancer (Khan and Rahman, 2017). It was realized that the enormous usage of pesticides has ecotoxicological effects in birds as well as carcinogenic effects in humans (Solecki and Ritz, 2019). The group of substances known as pesticides pertains to substances used as insecticides, fungicides, herbicides, rodenticides, molluscicides, and nematicides (Bernardes *et al.,* 2015). It is generally accepted that pesticides play an important role in agricultural development because they can reduce the losses of agricultural products and improve the affordable yield and quality of food s (Aktar *et al.,* 2008; Strassemeyer *et al.,* 2017). In the present study, the impact of quinalphos on the enzyme systems such as amylase, cellulase, xylanase, protease, acid phosphatase and alkaline phosphatase. Cellulase enzyme is related with the decomposition of cellulose and of some related polysaccharides. Cellulases breakdown cellulose into β glucose. Cellulase enzymes belong to a large family of glycosyl hydrolases which occur generally in two enzyme systems. The first enzyme system is composed of independent extracellular cellulases while the second type is constituted by an enzyme complex known as the “cellulosome”. Amylase is an enzyme that catalyses the hydrolysis of starch into sugars. Amylase constitute a class of industrial enzymes having approximately 25% of the enzyme market (Sidhu *et al.,* 1997; Rao *et al.,*1998). Protease is an enzyme that catalysis proteolysis, breaking down proteins into single aminoacids. Proteases are important industrial catalysts that are used in a variety of industrial applications Endo-xylanase(p- 1,4-D-xylan-xylanodydrolase, EC 3.2.18) is the key enzyme for xylan depolymerization. Xylanases have been widely detected in bacteria and fungi and many microorganisms produce multiple forms of the enzyme. Acid phosphatase (ACP), a lysosomal enzyme, is related to intracellular digestive (Kuzir *et al.,* 2012 and Gajger *et al.,* 2013). Alkaline phosphatase (ALP), on the other hand, is involved in important physiological functions of fish tissues, including absorption, transportation, excretion, calcification and nucleic acid metabolism.

MATERIALS AND METHODS

Animal and maintenance

Earthworms, *Eudrilus eugeniae* used in the experiment were procured from Integrated Farming Systems Research Station (IFSRS), Nedumcaud, Karamana, Thiruvananthapuram, Kerala. They were carefully brought to laboratory along with mother culture and moist soil. Before experimentation, the earthworms were acclimatized for 15 days in rearing tank (95×55×75cm3), containing 10 cm layer of uncontaminated cow dung with moist soil (1:1). A thin layer of leaves and dried moist grass were used for shade and moisture. The moisture level of the containers was maintained at about60–70%throughout the study period by sprinkling an adequate quantity of water. To prevent moisture loss, the containers was covered with gunny bags and placed in a humid and dark room at a temperature of 27°C.

Dissection of test animal

The earthworm was starved 24hr prior to sacrifice for getting optimum and stable physiological state. After the starvation the earthworm will be washed in distilled water and anesthetized by using chloroform or 30% alcohol and pinned down horizontally in the dissection tray with dorsal part down ward. The ventral part was cut open longitudinally along the earthworm using sterilized dissecting kit. The gut was removed for sample preparation. The total work carried out under sterilized condition by using 90% ethanol.

Assay of gut enzyme

Assay of cellulase activity

Carboxymethyl cellulose (CMC)– substrate preparation**:** CMC stock was prepared by adding 0.5gm of cellulose powder (CMC) in 0.2M 100 ml of phosphate buffer. 0.5 ml CMC was added to the test tube and incubated in 50^0C water bath for 10min. To this 0.25ml of enzyme was added and again incubated at 50^0C for 10min.Reactionwasterminatedbyadding 1.5ml dinitro salicylic acid (DNSA) and kept in boiling water bath for 10 minutes. After incubation, it was then kept in cold water to cool down the contents. Absorbance was read at 540nm. The enzymeblankwaskeptbyadding0.5mlof CMC and 1.5 ml of DNSA and 0.25 ml of enzyme. The reagent blank was also kept by adding 0.5 ml of CMC and 0.25 ml of phosphatebufferand1.5ml of DNSA. The amount of reducing sugar released was determined by dinitro salicylic acid (DNSA) method (Miller 1959).

Assay of xylanase activity

Xylanase activity was determined by determination of reducing sugars liberated from xylan by3,5-dinitrosalicylic acid (DNSA) method given by Miller *et al.*, (1959).

The sample was first centrifuged at 10,000rpm for 10 min at 10°C. 1% w/v beechwood xylan (Himedia MB141-10G) prepared in 0.05M sodium citrate buffer was used as a substrate. 1ml of substrate was incubated with 500µl of enzyme (supernatant obtained from centrifuged culture broth) at 50°C for 15min. The reaction was terminated by the addition of 3ml of DNSA reagent and the mixture was boiled for 10 min in a water bath. The absorbance was measured at 540nm after cooling the mixture. Xylanase was used as standard. One unit of xylanase activity (U) is defined as the amount of enzyme that liberates 1µmol of reducing sugar- xylose per min under the standard assay conditions.

Assay of alkaline phosphatase activity

Alkaline phosphatase (ALP) at an alkaline pH hydrolyses p-nitrophenyl phosphate to form p-nitrophenol and phosphate. The rate of formation of p- nitrophenol is measured as an increase in absorbance which is proportional to the ALP activity in the sample.

Alkaline phosphatase estimation done using ALP kit (Coral, Clinical systems, India, Catalogue No- 1102270075). 0.02ml of homogenised samples were taken to this 1ml of working reagent (dissolve 5ml of substrate reagent to 20ml of buffer reagent) was added, mix well and read the initial absorbance and after 5min reading at 405nm by using the spectrophotometer.

Assay of acid phosphatase activity

Acid phosphatase (ACP) at an acidic pH hydrolyses α naphthyl phosphate to form α-naphthol and inorganic phosphate. The α- naphthol formed is coupled with Fast Red TR salt to form a diazon dye complex. The rate of formation of this complex is measured as an increase in absorbance which is proportional to the ACP activity in the sample. Tartrate inhibits prostatic ACP and the testing in its presence is done to find the non-prostatic ACP. The difference between the activities of the total and non-prostatic ACP gives the activity of the prostatic ACP.

ACP activity was calculated using ACP kit (coral, Cat No- 1102010102) 0.1 ml of sample was taken in a test tube. 1ml of working reagent was added to this tube and mix well and read the initial absorbance A0 and after 5. Calculated the mean absorbance changes per min (ΔA/Min).

Assay of amylase

α-Amylases (EC 3.2.1.1) is an enzyme of glycoside hydrolases that plays a well-known role in hydrolysing a-1,4- glycosidic bond between glucose in starch. α-Amylase activity was quantitatively assayed by a slightly modified version of the 3,5-dinitrosalicylic acid method of Miller (1959).

In numbered tubes, prepared 15 glucose dilutions ranging from 1 to 100µl from 1mg and 10mg/ml stock. Included a blank tube with reagent grade water only. Into a series of corresponding numbered tubes, pipetted 1ml of each dilution of glucose. Added 3ml of dinitrosalicylic acid colour reagent. Incubated in boiling water bath for 5min and cool to room temperature. Add 10ml distilled water to each tube and mix well. Absorbance was measured at 540nm versus micromoles glucose.

Pipetted 0.25ml of respective enzyme dilutions into a series of numbered test tubes. Included a blank with 0.25ml reagent grade water. Incubated tubes at 50°C for 3- 4min to achieved temperature equilibration. At timed intervals, add 0.75ml starch solution. Incubated exactly 3min and at timed intervals add 3ml dinitro salicylic acid colour reagent to each tube. Incubated all tubes in a boiling water bath for 5min. Cool to room temperature and added 10ml reagent grade water. Mix well andreadA540nm versus blank. Determine micromoles glucose released from standard curve. This catalytic activity is expressed in IU/mL. One international unit is expressed as the total amount of enzyme capable of acting as a catalyst to convert 1µM of substrate/minutes under standard conditions.

Assay of protease

A modified Folin and Ciocalteu method (1927) was used to determine protease activity. 200µl of the protease broth was added to the reaction mixture, containing 0.65% (w/v) casein in 800µl of 50mMin phosphate buffer (pH 9). The mixture was incubated at 75ºC for 10min. The reaction was stopped by the addition of 1 ml of 5% (wv-1) Trichloroacetic acid (TCA), followed by centrifugation at 10,000rpm for 15min.The supernatant was analysed by the Folin-Ciocalteu reagent. The method combines the reactions of copper ions with the peptide bonds under alkaline conditions (the Biuret test) with the oxidation of aromatic protein residues. The concentration of the reduced Folin reagent (heteropolymolybdenum blue) is measured by absorbance at 660nm. One unit of protease activity was defined as the amount of enzyme that liberated 1μg tyrosine per min per ml of protease broth. The enzyme assay was quantitatively determined by Lowry's method where the Folin's reagent gets reduced and thus, develops blue colour when measured at 660nm. The intensity of colour obtained indicated the concentration of protein present.

Statistics

Data analysis was done by (ANOVA). The difference in means were analysed by using Duncan multiple range test (Duncan, 1995). Significant level was $p<0.05$. The statistical analysis was carried out using the software SPSS 22.0 package for windows.

Agarose gel electrophorectic detection of DNA damage.

Isolation of DNA from whole earthworm and electrophoresis was carried out according to the method of Iwasa et al. (1996) with some modifications. Briefly, the homogenised whole earthworm was lysed with buffer containing 100mM Tris- HCl,25m MEDTA,0.5%SDS and1mg/ml proteinase K and kept in a water bath for 12hrs at 370C. DNA was extracted twice with equal volume of phenol: chloroform: isoamyl alcohol (25:24:1). To the aqueous phase, sodium acetate was added and the DNA was precipitated with chilled isopropanol. Following a 70% ethanol wash, the precipitated DNA was resuspended in Tris-EDTA buffer. 5μg of DNA per sample were electrophoretic ally separated on 1% agarose gel containing 0.5μg/ml ethidium bromide in submarine gel electrophoresis system. The stained gels were captured using gel-doc (Gelstan, Medicare, Germany). The migration distance of the DNA molecules from the top of the gel was used as a measure of DNA damage. It is recognized that the highly fragmented, low molecular weight DNA strands will migrate farther than non- damaged high molecular weight DNA strands.

RESULT AND DISCUSSION

The current study investigated the behavioural and morphological changes on *E. eugeniae* after exposure to sub-lethal doses of quinalphos. The changes included, decreased burrowing activity and coiling. The intensity of these changes increased with increase in the concentration of quinalphos. The study of Reddy and Rao, (2008) showed, acute toxicity, morphological alterations and histological effects of an organophosphorus insecticide, profenofos (PFF) in earthworm, *Eisenia foetida.* Morphological and histological observations showed body ruptures, bloody lesions, and internal excessive formation of glandular cell mass and disintegration of circular and longitudinal muscles, which failed to regulate the internal coelomic pressure, leading to fragmentation in earthworms. The current study analysed gut enzyme activities of quinalphos on *E. eugeniae.* In this study, the activities of amylase, protease and xylanase showed significant changes upon exposure to quinalphos. However, quinalphos exposure on *E. eugeniae* resulted in significant changes in the activities of acid phosphatase, cellulase and alkaline phosphatase. Golovanova *et al.* (2006) noticed significant decrease in the activity of amylase to the short-term exposure of fertilised fish eggs of juvenile roach to chlorophos. Golovanova *et al.* (2008) who have evidenced decline in the activity of amylase on exposure of fish during embryogenesis to N-methyl-N-nitro-N-nitrosoguanidine Senapati *et al*. (2013) noticed significant decrease in the protease activity on the stomach and intestine of *Anabustes tudineus* exposed toalmix 20wp herbicide. Senapati *et al.* (2009) also reported alteration of protease activity in the alimentary canal of *C.punctatus* due to chronic exposure of glyphosate herbicide. Vyjayanti *et al*. (2002) evaluated that fenvalerate treatment decreased the activity of midgut protease activities of *Bombyx mori* larvae. Teng *et al*. (2021) noticed significant increase in the cellulase activity in earthworm, *Eisenia foetida* on exposure to chlorpyrifos, abamectin, imidacloprid and acetamiprid. Elevation of acid phosphatase activity in brain was reported earlier in stress-exposed *Channa punctatus*(Sastry and Sharma, 1980) and in *Labeo rohita* (Das, 1998). Kumar *et al.* (2012), studied the changes in the levels of different biochemical stress markers such as, acid and alkaline phosphatases in different organs such as brain, liver, kidney, gills and muscle of a freshwater muddy fish, *Channa punctatus* in effect to pyrethroid insecticides, cypermethrin and λ- cyhalothrin treated for 96 hours. The results showed significant increase in the levels of acid and alkaline phosphatases in a dose dependent manner.

CONCLUSION

The present study provides a clear idea about the potential impact of quinalphoss insecticide in the gut and whole body of *E. eugeniae.* This study deals with behavioral and morphological changes in *E. eugeniae* and also focused on the changes in the gut enzymes and DNA profile. Earthworm shows avoidance, a behavioural resistance to insecticide and also their body have a stress response system to cope up with the insecticide or chemicals in the soil.

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ETHNOBOTANICAL SURVEY OF SELECTED *IMPATIENS* SPECIES (BALSAMINACEAE) AS WONDER HERBALS FROM BONACAUD REGIONS OF AGASTHYAMALA HILLS

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INTRODUCTION

Balsaminaceae includes annual and perennial herbs that show prominent and complex floral morphology. *Hydrocera* Wight & Arn., (monotypic genus) and *Impatiens* L.,(high number of species) represent the two genera of the family. *Hydrocera* is identified by its pentamerous, polypetalous nature with capsular berry while *Impatiens* were tetramerous with fused petals into two wing like structure and a 5-valved capsule. *Hydrocera triflora* is a semi-aquatic herb reported from the Indomalesian region. *Impatiens* accounts approximately 1000 species (Janssens *et al.,* 2009) and distributed along the tropical and subtropical parts of the Old World as well as along the North temperate zones (Mabberly, 2008). The genus is recorded along the hotspots such as tropical Africa, Madagascar, South India, Sri Lanka, Eastern Himalaya and Southeast Asia (Yuan *et al.,* 2004).

According to the studies of Kerala Forest and Wildlife Department, some species of *Impatiens* are enlisted in the red data book as endangered species in Kerala like *Impatiens aliciae, I. anaimudica, I. cochinica, I. coelotropis, I. concinna, I. johnii, I. leptura, I. macrocarpa, I. munnarensis, I. pandata, I. platyadena, I. pallidiflora, I. rivulicola, I. verecunda* etc. They are notonly rare butalso endemic to this region.In this juncture, the present study aims to document the medicinal balsam used by the locals as magic herbs deserves scientific validation for conservation and sustainable utilization of these resources.

MATERIALS AND METHODS

Study area

Bonacaud (Thiruvananthapuram, Kerala) is the base station of Agasthyarkoodam in the Agasthya hills. The Agasthya hill range is luxurious for rare herbs and medicinal species. There is a tea estate for the locals of Bonacaud established by the British people. The hill resort Ponmudi is near to Bonacaud. It is located at 8°45′25″N 77°11′20″E.

Regular field visits were conducted at Bonacaud hills during 2017 January to 2018 March and collected the information from the ethnic people through oral interview after obtaining PIC and questionnaire were prepared according to the methodology suggested by Jain (1991).

Informers details:

Name...

Gender...

Age...

Occupation...

Location/Residence..

Data about medicinal plant and its use:

Plant (Local name)...

Habit (Tree/ Herb/ Shrub/Climber)…………………………………..

Plant part used...

Cultivated/ Wild...

If cultivated, cultivated for……………………………….....................

If wild, availability in natural resources (easy/ difficult/ very difficult). Conservation needs…………………………………………………….

Conservation efforts made by Government and local residents…………

Method of collection and storage……………………..........................

Name of the disease(s) treated……………………………......................

Other uses (if any)………………………....……..............................

Mode of preparation……………………………………………………..

Remarks:

Plant identified as ………………………………………… (Botanical name and family).

RESULTS AND DISCUSSION

Nine *Impatiens* species were documented and identified them by its morphological and floral characters. They are described here with details. Ethno medicine play a major role in rural areas and various locally produced drugs as remedies for curing different diseases or ailments. Although the knowledge of medicinal herbal species were under threat because, the traditional healers do not practice any conservation measures to ensure the sustainability of such plant resources. A recent study by Upasani *et al.,* (2017) has documented the ethno-medicinal knowledge gathered from the community members revealed the great advantage of balsam species to future generations. The major reasons for the vulnerability of the *Impatiens* flora were habitat degradation, habitat alteration and unsustainable collection of NWFP species and also for other purposes. The alteration of habitats such as grasslands (low, medium and high altitude), monoculture plantations, riparian ecosystems as reservoirs, low lying evergreen forests as agricultural land and homesteads has resulted in to the loss of many species. They are described here with details;

Table1. List of Balsam species documented from Bonacaud

Sl No	Plant Name	Local name& voucher	Common name in literature	Availability	Parts used	Uses
1	*Impatiens uncinata*Wight.		Hook-tail balsam	Common	Leaves and flower	Repellent to insect pests, virus and
2	*Impatiens chinensis* Linn.	Paily,Mechingam,Oonapoovu	Chinese Balsam	Common	Whole plant	Fever and pain reliever, antidote, blood circulation inducer, diarrhoea, urinary infections and healing carbuncles
3	*Impatiens floribunda* Wight.		Free-flowering balsam	Common	Leaf and flower	Microbicidal
4	*Impatiens balsamina*L.	Thilam Oonappuu	Garden balsam, garden jewel	Common	Leaves and young shoots.	Tender parts are edible if cooked.

			weed, rose balsam, spotted snapweed, touch-me-not		Leaf	cathartic, diuretic and emetic, cures joint pain, warts, wounds and skin inflammation
					flower	Snakebites, colouring instead of henna for dyeing finger and toenails.
					flower with alcoholic extract	antibiotic power against some pathogenic fungi and bacteria.
					seed	antitumour, powdered seeds are given to women for strength during labour .
					root	To treat irregular menses, wound healer, inflammations of the skin and torn nails.
5	*Impatiens auriculata* Heyne.		Green-lip balsam	Rare	Leaf and root	Taken as abortifacient.

					Leaves Whole plant	used on swollen parts to relieve pain. applied twice daily in red eye (conjunctivitis).
6	*Impatiens henslowiana* Ar*n.*		Henslow's balsam	Common	Leaves and sometimes roots. flower	Used in poultices for wounds, skin diseases, pustules, torn nails. Antimicrobial prop erties and effective in cases of lumbago, intercostal neuralgia and as haemostatic.
7	*Impatiens cordata* Wight.	Thottachin ungi	Heart-leaf balsam,	Rare	Whole plant	Pesticidal
8	*Impatiens tomentosa* Heyne ex W&A		Marsh balsam, tomentose balsam	Common	leaves	Pesticidal
9	*Impatiens modesta* Wight		Modest balsam	Rare	leaves	Microbicidal

Table 2. Ingredients added for the preparation of herbal medicines by the tribals of Bonacaud.

Sl. No.	Botanical name	Other plant parts added	Illness cure
1	*Impatiens uncinata* Wight.	*Cynodondactylon*	microbicidal
2	*Impatiens chinensis* Linn.	*Piper nigrum*	Fever,bodypain,healing, antidote
3	*Impatiens floribunda* Wight.	*Cleome viscosa*	Microbicidal
4	*Impatiens balsamina* L.	Nil	Diuretic,pain, antidote, fever
5	*Impatiens auriculata* Heyne.	*Streblus asper*	Abortifacient pain
6	*Impatiens henslowiana* Ar*n.*	*Justicia adhatoda*	Conjunctivitis
7	*Impatiens cordata* Wight.	*Terminalia arjuna*	Wound healing
8	*Impatiens tomentosa* Heyne ex W&A.	*Allium sativum* (Bulb)	Pesticide
9	*Impatiens modesta* Wight.	*Piper betle*	Pesticide

The interesting observation noticed in the present study is that all the recorded balsam species are ethnomedically important. Similarly, the preparation mode and illness cure was also analysed among the balsam species (Table 2). In most of the cases, other proved medicinal species are mixed with the balsam species for getting the required impact *I. balsamina* was found to cure skin issues which suggest that this species was relatively more effective. Interestingly, paste of the fresh leaves of *I. balsamina* was used to cure boils. Plant genetic resources and knowledge of traditional medicine studies in Tamil Nadu substantiates the importance of *I. balsamina* and referred it as as “Poddhapachai by palliyan tribes ,they used its leafy twig as a paste along with grounded onion and applied to boils (Rajendran *et al.,* 2000).

The different parts of the plants such as leaves, stem and flower possess diverse pharmacological activities like bactericidal, fungicidal, analgesic, anti-inflammatory, antioxidant, antipruritic features. Leaf juice was used to treat warts and snakebite, and the flower to burns. This knowledge was substantiated by the studies of Basha *et al.,* (2013). The extracts of *I. balsamina* was also employed as long lasting skin moisturizer and it prevent dryness, rough skin, dandruff and splitting hair ends, hence used to prepare lotions, creams, hair tonics, cosmetics, bath preparations and detergents.

CONCLUSION

The anthocyanin content in the flower of balsam species make them unique medicinal herb. The habitat and climatic conditions influence the anthocyanin contents of flowers of different cultivars i.e., an increasing trend of colour of the flower was noticed among temperate grown cultivars. The study presented here provided valuable data with regard to medicinal values of balsam species and flowers as good source of anthocyanin for preparation of natural food colourants. Many *Impatiens* species are used as colouring agent and herbal remedies for the various treatments by tribals/locals in different parts of the world. This work also gives scope for appropriate scientific studies on the phytochemical and pharmacological activities of *Impatiens balsamina* for its commercial utilization.

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DIVERSITY OF COMMON EXOTIC FRESHWATER ORNAMENTAL FISH OBSERVED IN AQUARIA IN THIRUVANANTHAPURAM DISTRICT, KERALA

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ABSTRACT

The introduction of exotic fishes in the Indian waters can be traced as having more than a century old history.by introduction of several exotic fish species from various parts of the world to different regions of India for augmenting fish production through aquaculture, for sport fishery, for mosquito / weed control, for ornamental purpose etc. More than 168 species of fishes, representing 37 families have been introduced outside their natural distribution range world over with 67 species establishing breeding populations in different water bodies and 27 species turning out to be pests. The high availability of exotic ornamental species in India have led to the unintentional introduction was mainly from the hobbyists or aquaculturists during climatic events like floods when the farm and houses are inundated with water and the exotic fish are carried off to the nearest water bodies. This is a reason that exotics are being seen as a threat to the indigenous fish species diversity. This paper tries to work out the availability of exotic freshwater species that are commonly used as ornamental fish in aquaria around Thiruvananthapuram district, Kerala.

Keywords- Introduction, unintentional, alien, exotic

INTRODUCTION

Aquarium keeping also known as ornamental fish keeping is considered to be the second most common hobby in the world after photography with about 100 million hobbyists worldwide. The aquarium, accessories and ornamental fish industry is gaining prominence due to its high economic prospects. Aquarium pets require less space and lesser attention when compared to other pet species as well as the lower cost of setting up an aquarium along with the ease in installing anywhere in the house are factors helping the fats growth of the ornamental fish industry.

There are a variety of reasons for keeping one: aesthetics, education, enjoyment, collection, and propagation of rare and exotic species as well as part of ways to attract wealth (feng shui); and due to these about 10% of the world's population have aquarium in their home.

WORLD SCENARIO

World ornamental fish trade in retail is more than 2500 species (60% freshwater) and involves more than US $ 18 – 20 billion (MPEDA, 2010). In the ornamental fish keeping race, developed countries are the forerunners but now the developing countries are also gaining momentum; with these countries contributing up to two-thirds of the total export value. Some 30 – 35 species dominate the market with US and EU. Japan is the largest importer and Singapore is the largest exporter of ornamental fishes (Rana, 2007).

INDIAN SCENARIO

From the Indian standpoint, the contribution of exotic fish is very large when it comes to the ornamental fish trade; with over 90% of the trade conducted in exotic species

EXOTIC FRESHWATER ORNAMENTAL FISH

The introduction of exotic fishes in the Indian waters can be traced as having more than a century old history. While the country was under the British rule, such fisheries were possibly introduced as a means for recreational fisheries. Sir, Francis Day, the author of the classical work on the Fish fauna of Indian region, was probably the first person who tried to introduce the brown trout, *Salmo trutta fario* in the Nilgiri waters in the year 1863, but his attempt was unsuccessful. This was followed by introduction of several exotic fish species from various parts of the world to different regions of India for augmenting fish production through aquaculture, for sport fishery, for mosquito / weed control, for ornamental purpose etc with successes and failures. The larvicidal fishes, such as, *Poecilia retiuculta* and *Gambusia affinis* were introduced in the year 1908 and 1928 respectively, to contain mosquito larvae in confined waters. here are hundreds of ornamental fish species being imported to our country since the aquarium trade is in progressive growth stage/ insecticidal value of these species is not well established. Exotic species of fishes were introduced in many parts of the world for improving local fishery potential and for broadening speciesdiversity in aquaculture programmes, sport fishing,for aquarium keeping, andcontrolling of unwanted organisms (mosquitoes).

As per Welcomme (1988) about 168 species of fishes, representing 37 families have been introduced outside their natural distribution range world over with 67 species establishing breeding populations in different water bodies and 27 species turning out to be pests. Kottelet and Whitten, 1996 suggested that the transfer of fishes to different habitats even within the country should be done with as much precaution as those crossing the borders of the country.

In India, a recent study at Madurai Kamaraj University of Tamil Nadu, revealed that More than 3000 terrestrial ornamental plants, including herbs, shrubsand trees and 65 genera of freshwater fishes and 66 genera of marine fishes are available in 19 states and Union Territories that support on-line shops and other small pet animal. Most of the traders are exclusively trading selected group of species. Separate shops are there for marine and freshwater exotic plants and animals (Soundararajan *et al.,* 2015). Further the study pointed out that Andhra Pradesh, Chandigarh, Gujarat, Karnataka, Kerala, Maharashtra, New Delhi, Tamil Nadu and West Bengal are pioneer in this trade (Soundararajan *et al.,* 2015). 65 species available on online shopping sites. The high availability of exotic ornamental species in India have led to the unintentional introduction was mainly from the hobbyists or aquaculturists during climatic events like floods when the farm and houses are inundated with water and the exotic fish are carried off to the nearest water bodies. This is a reason that exotics are being seen as a threat to the indigenous fish species diversity.

MATERIAL AND METHODS

Aquarium and pet shops selling various freshwater fishes located in different parts of Thiruvananthpuram district were identified, visited and survey conducted. Data on the freshwater ornamental species was also collected from the "Nagara Vasatham" show at Kannakakunnu, and "Matsyolsavam" at Puthirikandam Maidanam, Thiruvananthapuram.

The invasive fish species available in these shops were photographed and the characters of each species were obtained. This data was then compared for identification (Fishbase, Simplyfish, MPEDA) and the IUCN website provided the conservation status.

RESULTS

Xiphophorus helleri **(Swordtail)**

Classification

Class - Actinopterygii

Order – Cypriniodontiformes

Family – Poeciliidae

Genus - *Xiphophorus*

Species – *X. helleri*

Characters

Range – North and Central Americas

Size – upto 12.5 cm

Life span – 3 – 5 years

Temperature – 23 to 28°C

pH – 7 to 8.4

Feeding habit – Omnivorous; eats plants as well as small crustaceans, annelids, and insects.

Behaviour – Peaceful but can be aggressive towards other males.

Sexual dimorphism – Female larger than male, lack the sword in the tail. Modifies anal fin (gonopodium) in males.

Reproduction – Live bearers

***Apteronotusalbifrons* (Ghost knife fish)**

Classification

Class - Actinopterygii

Order - Gymnotiformes

Family - Apteronotidae

Genus - Apteronotus

Species – *A. albifrons*

Characters

Range – South America; from Venezuela to Paraguay.

Size - 50 cm

Life span – 7 years

Temperature – 23 - 27°C

pH – 6.5 - 8

Feeding habit – Carnivores, live prefers bloodworms, prawns, tubifex, artemia.

Behaviour – Nocturnal, active and aggressive. Tank mates should not be small.

Sexual dimorphism – males have eyes on top of head and females on the front of head.

Reproduction – Not known much. Pond breeding easier than tank breeding.

***Pterophyllumscalare* (Angel fish)**

Classification

Class - Actinopterygii

Order - Cchliformes

Family - Cichlidae

Genus - *Pterophyllum*

Species – *P. scalare*

Characters

Range – South America

Size – 15 cm

Life span – 12 years (captivity); 15 years (wild)

Temperature -27 - 30°C

pH -6.5 – 7.5

Feeding habit - Omnivore

Behaviour – Generally peaceful when not mating; semi-aggressive.

Sexual dimorphism – Difficult to identify till ready to breed.

Reproduction – egg layer; places 100 to 1200 eggs on hard surface; external fertilization and parental care.

***Betta splendens* (Siamese fighter fish)**

Classification

Class - Actinopterygii

Order – Anabantiformes

Family - Osphronemidae

Genus - Betta

Species – *B. splendens*

Characters

Range – Southeast Asia (Malay peninsula, Thailand, Cambodia, Vietnam)

Size – 7.5 cm

Life span – 2-5 years

Temperature – 24 -28°C

pH - 6.9 to 8.2

Feeding habit – Omnivore, diest includes insect, insect larvae and plant materials.

Behaviour – mostly aggressive to other *Betta* males but can live with females and other smaller species.

Sexual dimorphism – Males have bigger fan like fins and tail.

Reproduction – Males prepare bubble nests, courtship dance and male shows parental care towards eggs and the larvae till they are old.

***Paracheirodoninnesi* (Neon tetras)**

Classification

Class - Actinopterygii

Order - Characiformes

Family - Characidae

Genus - *Paracheirodon*

Species – *P. innesi*

Characters

Range – South America (southeastern Colombia, eastern Peru, western Brazil)

Size – 4 cm

Lifespan – 5-10 yrs

Temperature – 20 to 26°C

pH - 7

Feeding habit – Omnivore, fine flake food, small granules, live brine shrimp, daphnia

Behaviour – Social, peaceful, schooling of atleast 6, need densely planted tanks.

Sexual dimorphism – female rounder with bent blue line and males slender with straight blue line

Reproduction – Egg scatterer

***Astronotus ocellatus* (Oscar)**

Classification

Class - Actinopterygii

Order - Cichiliformes

Family - Cichilidae

Genus - *Astronotus*

Species – *A. ocellatus* (Agassiz, 1831)

Characters

Range – Tropical South America

Size – 30-36 cm

Lifespan - 10-20 years

Temperature – 22-27°C

pH – 6 to 7.5

Feeding habit - Omnivorous diet (pellet food, freeze-dried shrimp, live worms, peas, etc.)

Behaviour – Territorial and can be aggressive.

Sexual dimorphism - Male and female almost indistinguishable

Reproduction – Lay eggs on flat rock or clearing; external fertilization; aggressive guarding by both parents.

***Symphysodon discus* (Discus)**

Classification

Class - Actinopterygii

Order - Cichliformes

Family - Cichlidae

Genus - *Symphysodon*

Species – *S. discus*

Characters

Range – Amazon River basin

Size- 12.3 to 15.2 cm; up to 23 cm (captivity)

Life span – 10 years

Temperature – 26 to 30°C

pH – 6.8 to 7.6

Feeding habit – Omnivores; algae, plant and detritus, small invertebrates.

Behaviour - Highly social; live in groups of dozens.

Sexual dimorphism - no clear dimorphism, males larger than females

Reproduction – Parental care high; adults produce secretions to feed larvae.

***Cyprinus rubrofuscus* (Koi carp)**

Classification

Class - Actinopterygii

Order -Cypriniformes

Family -Cyprinidae

Genus -*Cyprinus*

Species – *C. rubrofuscus* var. koi

Characters

Range – Originated in Japan but now worldwide.

Size – 2 to 3 feet

Temperature -15 to 25°C

pH – 6.5 to 9

Feeding - Natural bottom feeders; omnivores include wide variety of food from algae to snails.

Behaviour – Peaceful

Sexual dimorphism – indistinguishable till sexual maturity; subtle differences

Reproduction – spawning during spring and summer; courtship. Lay sticky, sinking eggs and multiple males fertilize single batch of eggs, cannibalism seen

DICUSSION

Aquarium fish keeping is a popular hobby among the people in Kerala and the demand for exotic species is met by commercial breeders and farmers within and outside the state. There are around 168 registered aquarium shops in the state (Ghosh, 2001) and hundreds of unregistered ones. About 500 units are involved in breeding and this makes Kerala the third largest ornamental fish producing state in India.Most of the fish that are present in the aquarium trade in India belong to the exotic group and are brought in from various parts of the world especially South America and Southeast Asia. The introduction of exotic species has led to the change and rapid decline in the aquatic biodiversity along with other factors like habitat loss, pollution, over exploitation, etc (Moyle and Moyle, 1994). As per Nelson (1994), the loss of aquatic biodiversity is high in freshwater as they are the cradle for 40% of species but contain only 0.1% of the water and a staggering 20% of freshwater fish fauna is either extinct or on the verge of extinction (Moyle and Leidy, 1992).

The ornamental fish are divided based on reproduction into live bearers and egg layers. Table 1 provides few of the commercially important exotic egg laying and live bearing ornamental species in Indian aquarium trade.

Table. 1. List of commercial exotic ornamental fish in India.

Live Bearers	Egg Layers

Poecilia reticulata	*Astronotus ocellatus*
Poecilia sphenops	*Balantiocheilus melanopterus*
Poecilia velifera	*Betta splendens*
Xiphophorus helleri	*Carassius auratus*
Xiphophorus maculates	*Cyprinus carpio* var. koi
	Paracheirodon innesi
	Pterophyllum scalare
	Symphysodon discus
	Trichogaster trichopterus

Out of the above list, eight species were commonly seen in almost all the shops visited. Out of the eight, three were live bearers and rest were egg layers. The live bearers are commonly considered to be the best species when it comes to beginner aquarists and hence, have a very big demand. The exotic species are very common in the shops because most of these species have known biology and their breeding cycles are comparatively simpler and the breeding techniques have been standardised in their native countries. Due to these reasons, they are commercially bred in many areas of India. The reason for the increased demand for exotic species; other than ease to acquire and breed; is that they are of highly vibrant colours and there are lots of hybrids and genetically modified strains that provide numerous colours and intricate designs providing a wide range of options for aquarists as well as increased income for the breeders.

Even though exotic species are the major contributor in the ornamental fish trade it does have various adverse effects on the ecosystem, endemic flora and fauna as well as the economy which is dependent on the freshwater aquatic biodiversity. This necessitates the introduction of laws and regulations that would check and control these exotic species along with their future in the hands of the breeders, aquarists, and hobbyists.

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COMPARITIVE STUDY OF COLLEMBOLAN DIVERSITY IN DIFFERENT ORGANIC AND CONVENTIONAL AGRO-ECOSYSTEMS OF THIRUVANANTHAPURAM, KERALA

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ABSTRACT

Collembolans are good representatives of the diversity of soil fauna playing a major role in nutrient recycling and decomposition of organic matter. Seasonal sampling of soil and collection of collembolans was done from November 2020 to October 2021 at four different sites of Punchakari, Thiruvananthapuram. Extraction of collembolans was done and specimens were identified using standard taxonomic keys. Relative abundance, seasonal fluctuations, and Diversity indices of collembolan population were calculated. Correlation analysis was carried out to determine the impact of various soil physico-chemical parameters on the population of collembolans. Collembolan population showed irregular trends of fluctuations depending on temperature and monthly rainfall. A positive correlation can be stated between collembolan distribution and organic carbon content. According to the findings of this study, collembolans are good indicators of various farming practices, and hence their diversity can be analysed to better understand the gradient of soil disturbances. Knowing this, alternative land use techniques for sustainable soil health management might be developed to protect soil biological communities and ecosystem resilience.

Keywords: Collembola, Relative Abundance, population dynamics, edaphic factor, seasonal variation

INTRODUCTION

Soil is a highly dynamic, complex, and diverse system that supports the growth of a huge range of ecological niches. (Gardi and Jeffery, 2009) for a wide range of organisms. Agricultural practices influence diversity, distribution and population dynamics of micro arthropods. Without arthropods most terrestrial ecosystems would rapidly collapse (Iloba and Ekrakene, 2008, Lavelle *et al.,* 2006). Anthropogenic soil change, mainly due to land use activities, has led to a decline of biodiversity among soil dwellers. Land use activities repeatedly modify soil structure and chemo-edaphic variables, resulting in harmful effects on soil fauna. (Bhagawati *et al.,* 2021).

Collembolans are soil and litter dwelling arthropods. They are major representatives of soil faunal diversity (Cassagne *et al.,* 2003) and play a significant role in nutrient recycling, organic matter decomposition, and soil decomposition. Because of their fast responses to numerous environmental changes, including human-induced disruptions, collembolans can be regarded as sensitive indicators among soil fauna. There are around 8143 collembolan species worldwide, classified into 764 genera and 19 families, while the Indian Collembola fauna is represented by 301 species subdivided into 109 genera and 19 families. (Bhagawati *et al.*, 2021). In India only a small fraction of Collembola population is documented. Studies on diversity and the distribution patterns of Collembola could serve as a potential bioindicator of land use changes. Previous studies have noted that environmental factors influences the distribution and diversity of soil arthropods. The effect of environmental factors on collembolan populations are quantified in terms of species diversity and abundance.

In the present study, we evaluate the role of different edaphic factors and diversity of collembolan population in different agro-ecosystems. The inference gathered from this study may be helpful in the development of conformational strategies in agricultural practices and monitoring of natural and human impacted area.

Materials and methods

Site description

The study was conducted on “Punchakari”, (8.449077^0 N, 76.977309^0E) which is a vast area of Paddy fields, wetlands and other cultivations situated in Thiruvananthapuram, Kerala. The study site is situated very close to Vellayani Lake. The area has highly suitable temperature with a minimum of 24°C during night and a maximum of 35°C during day, and with a relative humidity of 76%. Four different sites from Punchakari was selected for the study, which includes two paddy fields and two plantain field. In each ecosystem one follow organic cultivation (chemicals are not used) and the other follows conventional cultivation (synthetic chemicals such as fertilizer and pesticides are applied).

Collection of soil samples

From November 2020 to October 2021, soil samples were taken from each of the ecosystems during three seasons (pre monsoon, monsoon, and post monsoon). Soil was collected at a depth of 0–10 cm using a soil sampler. After collecting the soil from the sampler, the samples were appropriately sealed, labelled, and transferred to the laboratory for Collembola extraction. Large arthropods were hand sorted and collected with the help of aspirator. Extraction of micro-arthropods was done by modified Berlese Tullgren funnel kept for 48-72 hrs. They were collected in collecting tubes that contained 70% ethyl alcohol. Collembolans was then observed under a stereo-zoom microscope and identified using taxonomic key published by (Babenco *et al.*, 1994; Christiansen and Bellinger, 1980, Prabhoo, 1971). In each ecosystem, the relative abundance and density of collembolans, as well as the seasonal variation of the overall collembolan population, were calculated.

Analysis of Soil Physico-chemical Properties

For the analysis of soil parameters, soil samples were collected from each of the ecosystems during different seasons using Standard V-Method. Physico-chemical factors like soil pH, soil temperature, soil moisture by Oven-dry method (Dowdeswell, 1959), and organic carbon content by Walkley-Black procedure (Walkley & Black, 1934), was estimated during the period of study.

Statistical Analysis

The Shannon-Wiener's diversity index (Krebs, 1999), was used to calculate the diversity of collembolans. To study the effect of different soil physico-chemical parameters on collembolan population. Simple correlation was done to understand the effect of different edaphic parameters on the collembolan population using SPSS 20.

Result and discussion

A total of 748 collembolans were collected from all the sites and was identified upto the level of genus. 15.6% collembolans belonged to Site A (Conventional paddy field) where, Entomobrya showed highest and Cyphoderus showed lowest frequency of occurrence. 28.87% were collected from Site B (Organic paddy field); Lepidocyrtoides showed highest frequency of occurrence followed by Isotomurus (Figure 1). 18.44% of the population was constituted by the collembolans collected from Site C (Conventional Plaintain farm). Here Isotomurus sps showed highest and Pararrhophalites showed least frequency of occurrence. 37.03% of the total specimen were collected from Site D (Organic Plantain Farm). In these Proisotoma showed highest showed and Seira showed least frequency of occurrence (Figure 2). Collembolan population was lower in Site A & C, where Conventional farming using chemical fertilizers and pesticides were done, compared to Site B and Site D.

A total of 16 genus of collembolans were recorded from all the study sites. The species composition was found to be different in all the four agro-ecosystems. Willowsia, Cyphoderus, and Campylothorax *sps* were collected from all of the four ecosystems. Hypogastrura, Trogolopedetes, Sminthurus, and Lepidocyrtoides sps were only collected from Organic Paddy field. Seira, Pararrhophalites, Bilobella and Lepidocyrtus are the four genus which was only observed in Plantain ecosystem, of which Bilobella and Lepidocyrtus were collected only from Organic Plantain farm. Entomobrya sps was recorded in both Conventional Paddy field and Plantain farm, which may indicate its high tolerance to the chemicals and pesticides (Table 1).

Figure 1: Pie Chart showing Relative Abundance of Collembolans in Conventional and Organic Paddy field

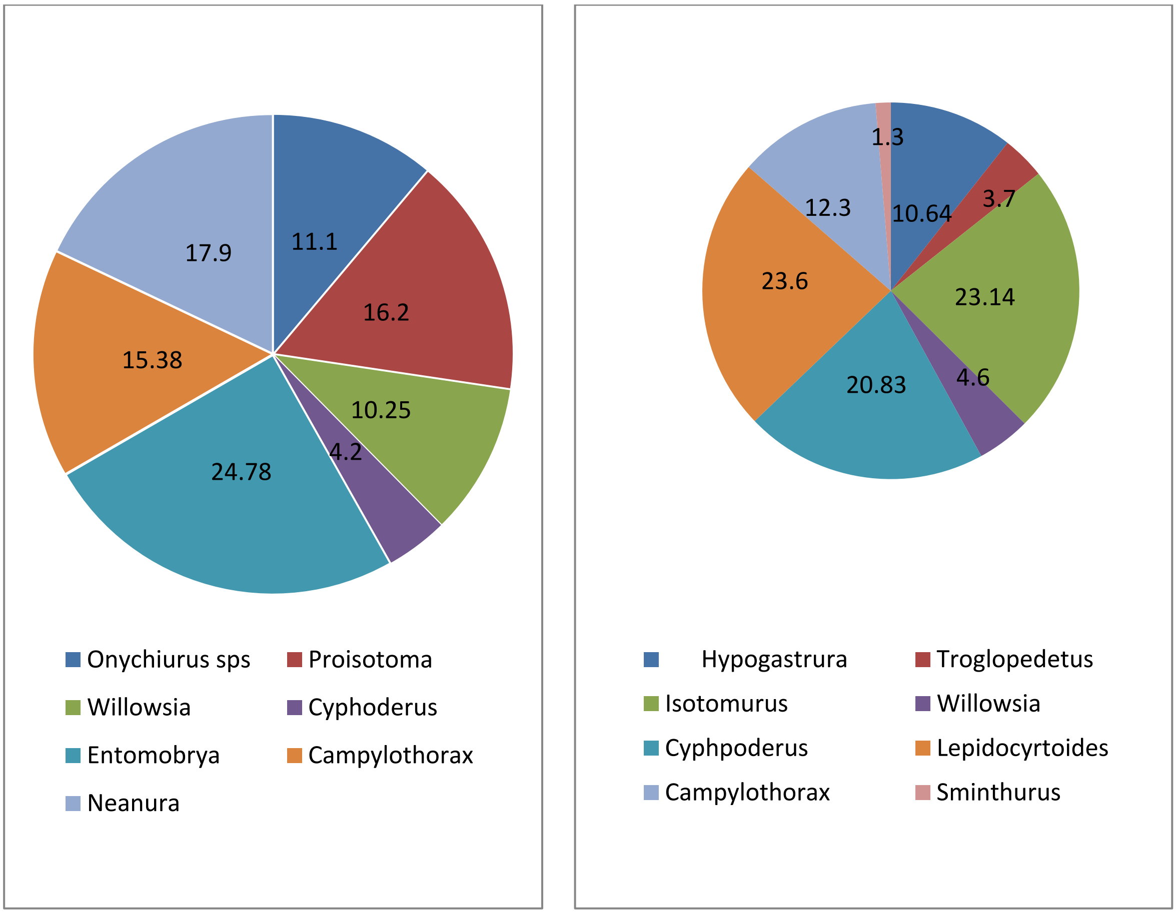
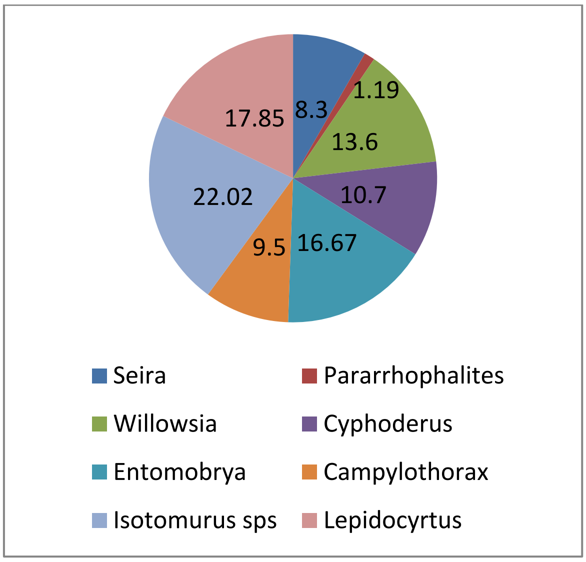


Figure 2: Pie chart showing Relative Abundance of Collembolans in Conventional and Organic Plantain farm



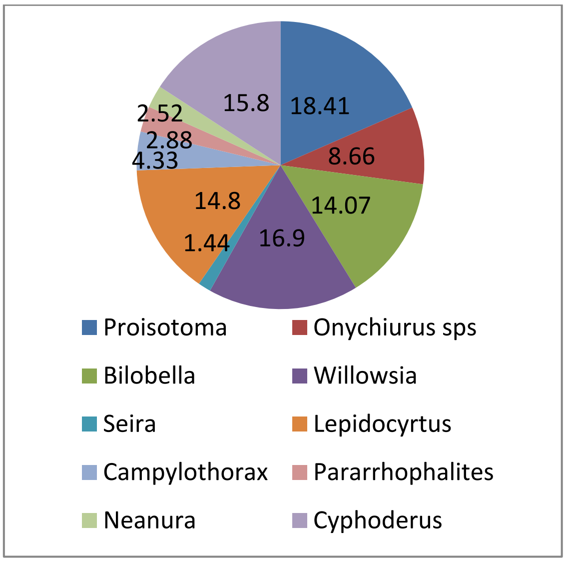


Table (1) showing species composition of Collembolans in Different Ecosystems

Species	Conventional Paddy field	Organic Paddy field	Conventional Plantain farm	Organic Plantain farm
Seira sps	-	-	+	+
Pararrhophalites sps	-	-	+	+
Willowsia sps	+	+	+	+
Cyphoderus sps	+	+	+	+
Entomobrya sps	+	-	+	-
Campylothorax sps	+	+	+	+
Isotomurus sps	-	+	+	-
Prosisotoma sps	+	-	-	+
Onychiurus sps	+	-	+	+
Bilobella sps	-	-	-	+
Lepidocyrtus sps	-	-	-	+
Neanura sps	+	-	-	+
Hypogastrura sps	-	+	-	-
Troglopedetes sps	-	+	-	-
Sminthurus sps	-	+	-	-
Lepidocyrtoides sps	-	+	-	-

Figure 3: Graph showing Shannon-Weiner Index of Collembolan populations during different seasons

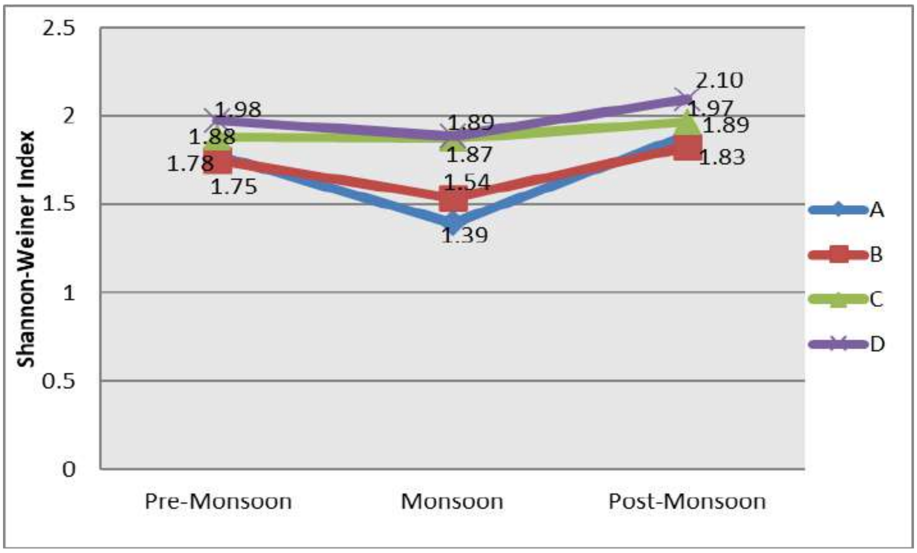


Figure 4: Graph showing Mean Total Density of Collembola in different Agro-Ecosystems

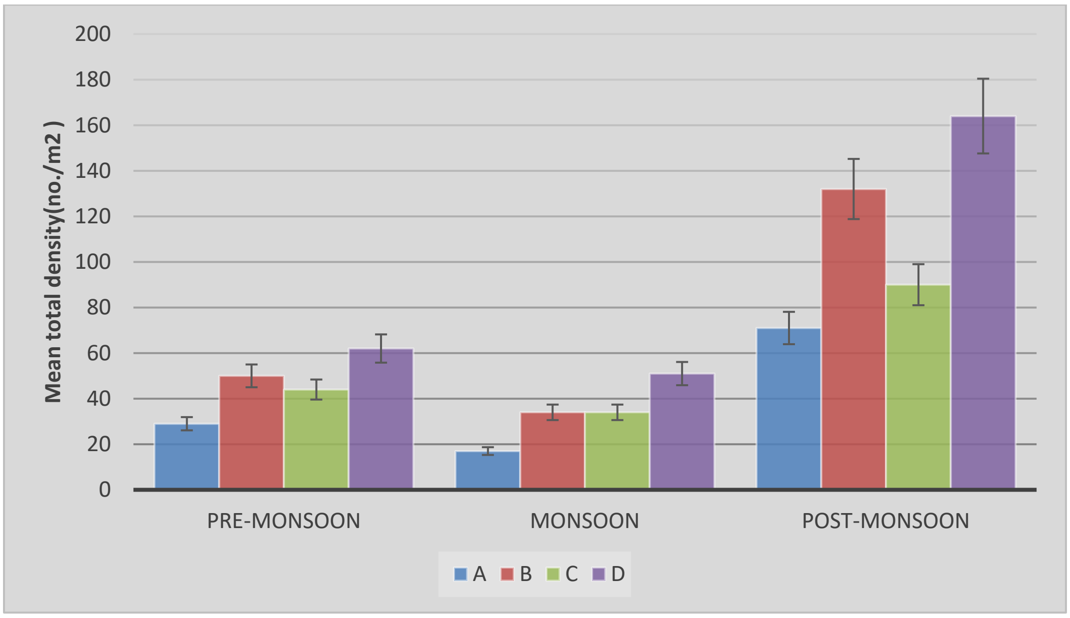


Table (3). Correlation between Collembolan Density and Soil properties in four different Ecosystem

Soil Property	Conventional Paddy Field			Organic Paddy Field			Conventional Plantain farm			Organic Plantain farm		
	Pre-Monsoon	Monsoon	Post-Monsoon	Pre-Monsoon	Monsoon	Post-Monsoon	Pre-Monsoon	Monsoon	Post-Monsoon	Pre-Monsoon	Monsoon	Post-Monsoon
Temperature (^{0}C)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
pH	NS	NS	NS	NS	NS	0.831*	NS	NS	0.863*	NS	NS	0.830*
Soil Moisture	0.891*	0.37*	0.856*	0.843*	0.925*	0.935*	0.933*	0.856*	0.897*	0.968**	0.823*	0.917*

(%)												
Organic Carbon (g/kg)	**0.813***	**0.838***	**0.974****	**0.892***	**0.905 ***	**0.812***	**0.862***	**0.941 ***	**0.968****	**0.987****	**0.912***	**0.993****
*** indicates 0.05 Level of Significance ; ** indicates 0.01 Level of Significance**												

Diversity of collembolans in all the agro-ecosystems exhibits a seasonal trend. The value decreased from pre-monsoon period to monsoon and then shows an increase from monsoon to post-monsoon period. Shannon-Weiner Index showed a sharp decline from pre-monsoon to monsoon in Paddy ecosystem (Value decreased from 1.78 to 1.39 in Site A and 1.75 to 1.54 in Site B) than Plantain farms. The Value showed a sharp increase (1.39 to 1.89 in Site A and 1.54 to 1.83 in Site B) from monsoon to post-monsoon (Figure 3). Compared to Paddy ecosystems, Plantain fields exhibited only a slight variation in index value. Evenness values were closer to one, indicating that collembolans were distributed evenly throughout all the ecosystems at all seasons (E = 0.85–0.96). The highest density and diversity were recorded in the post-monsoon period, followed by the pre-monsoon period, while the lowest density was recorded during the monsoon period (figure 4).

Role of Physicochemical Properties of Soil on Density of Collembola

The density of collembolans in each ecosystem was correlated with important soil chemo-edaphic factors. In all ecosystems as well as during all seasons, the density of collembolans indicated a significant positive correlation (p0.05 and p0.01) with soil moisture and organic carbon (Table 3). Except for soil ph (r = 0.905,0.878) of organic paddy field and organic plantain farm, during post monsoon, which showed a remarkable positive relation (p0.05) with collembolan density, the rest of the soil physicochemical properties did not show any distinct significant relationship with density of collembolans in the selected ecosystems during all four seasons.

DISCUSSION

An important result obtained in the study is that the site B and site D (organic cultivation sites) soil harboured a rich composition of collembolan species as compared to conventional cultivation sites (Site A and C). In addition, density and diversity analysis also confirmed the higher density and diversity of collembolan population in plantain farms than paddy fields. Agricultural soil is often exposed to stressful disturbances such as tillage operations and thrashing, which lead the uppermost layers to dry up and the litter to be removed from the soil surfaces, making the ecological niche unfit for soil fauna (Singh,2018;

Fiera, *et.al* 2020). Adoption of chemo-centric agriculture, as well as indiscriminate use of synthetic pesticides, affects soil chemical characteristics and has a deadly effect on collembolan populations (Tsiafouli *et.al* 2015; Harta *et.al* 2020). The Organic cultivation sites managed to overcome this issue by increasing the soil fertility using organic fertilizers.

During the post-monsoon, soil moisture along with temperature accelerated the rate of litter and organic matter decomposition, promoting the release of carbon in the soil establishing a favourable environment for collembolan assemblages. The abundance of soil dwelling collembolans was considerably affected by a short-term increase in soil temperature during the post-monsoon period (Holmstrup et. al, 2018). Hazra and Bhattacharyya reported in 2003 that an elevation in Collembola population is associated with an increase in soil organic matter. Since the seasonal soil samples gathered from the four study sites were mainly acidic, they may not have had a direct effect on the collembolan population .Another significant finding in this study is that the collembolan density, had a significant positive correlation with soil moisture and organic carbon content in all four ecosystems over all three seasons. The role of collembolans in the decomposition of dead organic materials may explain the link between the collembolan community and soil moisture and organic carbon concentration (Ghiglieno *et.al* 2020).

The present study supports the fact that Collembolans have a significant ecological association with both biotic and abiotic factors, and they often respond strongly to environmental and geographical conditions. The study shows that collembolans are good indicators of various land use practices, and hence their species richness can be explored to better understand the gradation in soil disturbances. Knowing this, alternative land use techniques for sustainable soil health management could be developed to protect soil biological communities and ecosystem stability.

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Conflict of Interest

The authors declare that they have no conflict of interest

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EXPLORING AMPHIBIAN DIVERSITY IN MYRISTICA SWAMP FORESTS: A PRELIMINARY SURVEY OF AMBANAR, SOUTH WESTERN GHAT

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ABSTRACT

Myristica swamps was described as a special type of habitat from the Travancore region of South Indian Western ghats four decades ago. This study reveals the amphibian diversity of Myristica swamps in Ambanar forest region of Kollam district, Kerala. In the animal kingdom, class Amphibia refers to all amphibians- which are animals capable of surviving both on land and in water. The study period is six months up to 2023 January to 2023 June. During the study 13 species of amphibians from six families are recorded from the site. The study is done by collecting samples in plastic jars. Further identifications are done by taking photographs. According to the study Dicroglossidae are the family which identified more in number and also Microhylidae and Ranidae are the family identified least in number. The delicate and fragmented Myristica swamp ecosystem is facing multiple threats due to the expansion of human settlements and activities. Massive tracts of swamps have disappeared in recent decades only to be replaced by human settlements and farmlands. Due to the destruction of swampy forests the amphibian lost their natural habitat and also some other human interferences. As a result, the amphibians are at the brink of extinction. So, from this study it can be concluded that conservation measures are quickly adapted to keep the diversity as such by conserving the myristica swamps.

Key words: Myristica swamp, Amphibian, Ambanar, Wetland, Fresh water ecosystem

INTRODUCTION

Freshwater swamps in the Western Ghats are among the least explored ecosystems, yet they hold significant hydrological and ecological importance. These swamps create a distinct ecosystem, harbouring a plethora of rare and relic plant and animal species, many of which are endemic and threatened. The Western Ghats has three distinctive freshwater swamp types – Myristica swamps, Elaeocarpus swamps, and Hadlus (Ganesan *et al.,* 2002). Among these, the Myristica swamps stand out as a precious ecosystem within the Western Ghats, which is globally renowned as a mega diversity hotspot (Chandran *et al.,* 2001). These marshy areas are characterized by an abundance of tree species from the Myristicaceae family, alongside numerous other unique and endangered plant, and animal species. Myristica swamps in India are distributed across various districts in Kerala, Karnataka, Uttar Pradesh, and have recently been reported in Maharashtra and Goa as well. The discovery of this forest type was first reported by Krishnamoorthy in 1960, who observed that it is exclusively confined to the southernmost part of the Western Ghats. These unique ecosystems hold significant value, and monitoring them is of utmost importance because they were once widespread along the Konkan coast. These precious ecosystems are now confined to small isolated patches due to various factors (Priya *et al.,* 2022). Preserving and safeguarding these swamps is essential to protect the rich biodiversity and ecological significance they hold within the Western Ghats. One major issue that threatens certain Myristica swamps is the diversion of water for plantations and the construction of check-dams for potable water. These activities are detrimental to the swamp- dwelling trees, which have evolved to rely on perennially-flowing water. Such alterations to the natural water flow disrupt the delicate balance of the ecosystem. By addressing the issues of water diversion and habitat fragmentation, as well as implementing measures to protect the unique flora and fauna, we can help preserve the Myristica swamps and the valuable biodiversity they harbor within the Western Ghats.

The current study is centered on investigating the amphibian diversity within the Myristica swamps of Ambanar forest division in Thiruvananthapuram District. Amphibians, being semi-aquatic, have a unique life cycle that involves migration between isolated wetlands and the surrounding terrestrial system. Due to their primitive body plan, they were among the first vertebrate organisms to be affected by water pollution. Thus, the presence of healthy amphibian populations serves as an indicator of a healthy ecosystem (Abraham *et al.,* 2013). Previous studies conducted in Myristica swamps have documented the presence of 56 species of amphibians, which belong to 15 genera and five families (Jose *et al.,* 2014). Among the various locations surveyed, the highest number of amphibian species was recorded in the Kulathupuzha Forest Range, followed by the Shendurney Wildlife Sanctuary.

The study's results emphasize the vital role of Myristica swamps as essential habitats for diverse amphibian communities, underscoring the need to preserve these ecosystems for overall ecological health (Abraham *et al.,* 2018). Notably, the location in Anchal showed the lowest number of amphibian species. Among the species recorded, twenty were unique to the Western Ghats, and one each was exclusive to Kerala and India, highlighting the importance of these swamps in harbouring regionally endemic amphibians. The potential loss of these forests poses a serious threat to the amphibian population and ecological balance in the region. Amphibians exhibit an array of morphological characteristics, each adapted to their specific ways of life. Protecting the Myristica swamps becomes essential in safeguarding these specialized amphibians and maintaining the ecological harmony within the Western Ghats (Gururaja *et al.,* 2014).

The majority of amphibians, especially frogs, are smaller in size compared to typical land-dwelling frogs. They possess distinct body patterns, such as colours and stripes, that closely resemble the marsh's natural hues found in swamps. This camouflage makes them indistinguishable within the swamp environment and also helps them blend in with dead and decaying leaves (Gururaja *et al.,* 2010). These exceptional adaptations offer them protection from predators. Any alterations to the habitat and environmental conditions can result in adverse effects on the amphibian population. In Myristica Swamps, the variety of amphibians exceeds that of typical forest ecosystems. Amphibians living in swamps, exhibiting green, brown, and black colours, benefit from camouflage among bryophytes (Duellman and Trueb., 1994). The 2006 IUCN red list assessment revealed that 30 percent of Western Ghats amphibians are at risk, with 4 percent being near threatened, 29 percent having insufficient data, and 22 percent classified as least concern. The main reasons for this status are their specific habitat requirements and limited distribution. The primary threats to Indian amphibians are habitat disturbance, loss, and fragmentation. Due to their vulnerable porous eggs and semi- permeable skin, they are highly susceptible to environmental dangers. From climate change and pollution to disease, amphibians face significant risks from various sources (Biju *et al.,* 2014).

MATERIALS AND METHODS

The research was conducted within the geographical coordinates of N 9°5'7.2528" and E 76°51'18.36", specifically in the Pathanapuram forest range, which falls under the authority of the Punalur division in Kollam district, Kerala, India, as illustrated in Figure 1. The study focused on Myristica swamps situated within the Ambanar model forest station. Notably, these Myristica swamps are primarily concentrated in the Manthadam area. The investigation was carried out over the period from January 2023 to June 2023." To quantify the diversity, we employed Visual Encounter Surveys, scanning tree trunks up to a height of 2 meters. In addition to the systematic surveys, we also made note of opportunistic sightings. To study the amphibians, we carefully collected them by hand using transparent plastic jars, allowing for safe observation. Each captured amphibian was then photographed and measured before being released back into their natural habitat. To ensure future reference and verification, we retained a minimum number of voucher specimens per species. Alongside the physical vouchers, we also maintained photographic vouchers, documenting the appearance of each species. For photography purposes, we utilized Sony SLT A58 camera. Identification was made using available literature named Nair *et al.,* (2014). and also, the common amphibians of Kerala by

P.S Siva Prasad (2014) and by seeking expert opinion. Permission for entering protected areas and reserve forests. and collection of specimens was obtained from the Divisional Forest Office, Forest Head Quarters, Thiruvananthapuram. Overall, our research focused on quantifying the amphibian diversity within the Myristica swamps of the Ambanar region. We used a combination of Visual Encounter Surveys, opportunistic sightings, careful collection, photography, and measurements to obtain comprehensive data for further analysis and understanding of these unique ecosystems.

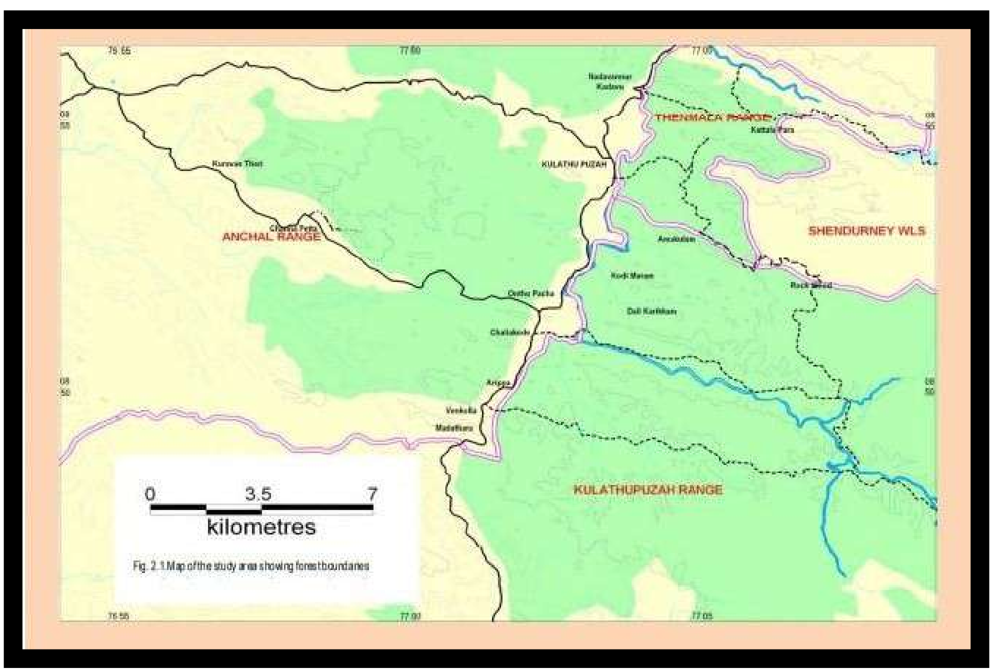

Figure 1: Map of study area

RESULT AND DISCUSSION

In our study of amphibian diversity in Myristica swamps within the Thiruvananthapuram district, located in the southern part of the Western Ghats, we made several noteworthy observations. Our research identified a total of 13 amphibian species spanning six distinct families within the sampling site figure 1, revealing a rich variety of amphibian life in this unique ecosystem also, their general details and common names are also provided in Table 1. Of particular significance was the prevalence of species from the Dicroglossidae family, which is endemic to the Western Ghats. These amphibians exhibited a range of diverse reproductive behaviours tailored to their specific swamp habitat, suggesting a strong ecological adaptation. In contrast, we found the families Ranidae and Microhylidae to have the lowest diversity, each represented by only one species. This finding raises questions about the ecological preferences and constraints affecting these families in Myristica swamps, warranting further investigation. Importantly, our study highlights the critical importance of conserving Myristica swamps as crucial habitats for a variety of amphibian species, particularly endemics. To enhance our understanding of these ecosystems, future research can delve into habitat preferences, population dynamics, and potential threats, contributing to the broader conservation efforts aimed at preserving biodiversity in the Western Ghats.

The variation in species distribution within Myristica swamps, characterized by some families having higher diversity while others exhibit lower diversity, can be attributed to a complex interplay of ecological factors. One key factor is habitat preference, as amphibian families often possess specific requirements and adaptations tailored to particular environmental conditions (Ranganathan *et al.,* 2022). Those families displaying greater diversity may be more finely attuned to the specific characteristics of Myristica swamps, including moisture levels, temperature, and vegetation structure (Chandran *et al.,* 2010). Resource availability also plays a pivotal role, with some families potentially having a wider range of resource utilization strategies, thereby reducing intra-family competition, and facilitating the coexistence of numerous species (TVR *et al.,* 2022). Distinctive reproductive behaviours within amphibian families could further contribute to this variation, with families exhibiting reproductive strategies better aligned with the swamp's environmental conditions enjoying a competitive edge (Abraham *et al.,* 2013). Historical factors, such as past climatic and geological events, biogeography, and interactions with other species, can also shape species distribution patterns. Ultimately, unravelling the intricate mechanisms governing these disparities would necessitate comprehensive ecological investigations, genetic analyses, and ongoing monitoring of amphibian populations within Myristica swamps.

The destruction of Myristica swamps poses a significant threat to the distribution of amphibians in these unique ecosystems. Human activities, such as deforestation, agriculture expansion, urban development, and pollution, have been responsible for the degradation and loss of Myristica swamps in many regions (Venkataraman *et al.,* 2018). As these wetlands vanish, amphibian habitats shrink, leading to habitat fragmentation and population decline for many species (Hedge *et al.,* 2023).

Table. 1. A list of species collected from the study area.

FAMILY	SPECIES	NATURAL HISTORY
Nyctibatrachidae	*Nyctibatrachus aliciae (Inger, Shaffer, Koshy and Bakde, 1984)*	Wrinkled frog or Alicia ‘s night frog or Alice ‘s night frog.
	Nyctibatrachus minor (Inger, Shaffer, Koshy and Bakde, 1984)	Small wrinkled frog or Kerala night frog or Miniature night frog.
Rhacophoridae	*Philautus tinniens* (Jerdon*, 1853)*	Spotted bush frog or Black bush frog or Rao’s bubble - nest frog or Nilgiri yellow fingered bush frog.
	Rhacophorus malabaricus(Jerdon, 1870)	Malabar gliding frog or Malabar flying frog.
	Polypedates leucomystax(Graven horst ,1829)	Common tree – frog or Four- lined tree frog or Golden tree frog or striped tree frog.
Ranixalidae	*Indirana beddomii (Gunther,* 1876)	Beddome’s leaping frog or beddome’s Indian frog or Beddome’s frog.

	Indirana leithii (Boulenger's, 1885)	Leith's leaping frog or leith's frog, Boulenger's brown frog or Matheran leaping frog or Matheran Indian frog.
Dicroglossidae	*Hoplobatrachus tigerinus (Daudin*, 1802)	Indian bull frog or Indus valley bull frog.
	Euphlyctics hexadactylus (Lesson, 1834)	Green pond frog or Indian green frog or Indian five – fingered frog or Indian pond frog or six fingered frog or Six - toed green frog.
	Euphlyctics cyanophylctis (Schneider, 1799)	Common skittering frog.
	Fejervarya limnocharis (Johann Ludwig and Christian Graven horst, 1829)	Asian rice frog or Asian grass frog or Common Pond frog or Field frog or Grass frog or Indian rice frog or Alphine cricket frog.
Ranidae	*Indosylvirana aurantiaca (Boulenger*, 1904)	Golden frog, Trivandrum frog, The common wood frog, or the small wood frog.
Microhylidae	*Ramanella triangularis (Gauther,* 1876)	Malabar dot frog or Malabar narrow – mouthed frog or Malabar Ramanella or Triangular- spotted Ramanella or Triangular spotted frog.

The disruption of Myristica swamps can result in altered microclimates and reduced water availability, impacting the survival of amphibians adapted to these specific conditions. Species that were once abundant may become increasingly vulnerable to extinction as their habitats diminish. Conservation efforts are crucial to mitigate the destruction of Myristica swamps and safeguard the distribution of amphibians within them. These initiatives include habitat restoration, land-use planning, and pollution control measures aimed at preserving these critical ecosystems and the diverse amphibian species that call them home.

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SEASONAL DIVERSITY OF FISHES IN KADINAMKULAM ESTUARY WITH RESPECT TO HYDROGEN SULPHIDE POISONING

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ABSTRACT

The estuaries are unique environments that play an important role in the transfer of products of continental weathering to the ocean. In Kadinamkulam estuary, the traditional and conventional method of coconut husk retting creates adverse impacts in fauna and flora. The present investigation was carried out in the Kadinamkulam estuary, the largest among the estuaries in Thiruvananthapuram district, Kerala, India. For the present, fish samples were collected with the help of fisherman using suitable sized fishing nets during pre-monsoon, monsoon and post monsoon seasons from the selected stations of Kadinamkulam such as Kotrakiri (SI), Kadinamkulam (SII), Madanvila (SIII) and non-retting station Perumathura near Pozhi (SIV). From the present study the fish diversity were reduced to a total of 28 species, and among them, only eighteen species were found in retting zones, no shell fishes were observed in the retting zones. The fish like *Sardinella* was not found in the retting zones but in monsoon season, it was seen the non retting area like Pozhi. Ten fish species are merely associated with non retting zones. Ten species rarely found in retting zones and seven species commonly found both in retting and non retting zones. Among the 28 species of fishes identified, the fish *Oreochromis mossambicus* and *Meghalops cyprinoids* are the abundant species in this estuary during all three seasons. From the present study on the diversity and abundance of fishes it can be seen that the fish diversity in Kadinamkulam estuary was under threat.

Keywords: Kadinamkulam estuary, Retting, *Oreochromis mossambicus* and *Meghalops cyprinoids*

INTRODUCTION

Fishes are the most important biological resource available from the water and they form a considerable portion of the world's natural aquatic resources. An outstanding feature of the Kerala's coastal zone is the presence of a large number of perennial or temporary estuaries popularly known as backwaters (*Kayals*). An important characteristic of backwaters is their biological diversity, which refers to the diversity of various species of living organisms, plants and animals, the presence of various ecosystem services, and genetic diversity. Such diverse combinations of living organisms and ecological services constitute the natural resource entitlements of the local communities (Subramanian, 2000). The wide variety of fish and shellfish resources, aquaculture systems, the brackish water agriculture, mangroves and innumerable forms of micro-organisms are directly useful and sustain the economy of local population. The fish fauna in the estuaries and backwaters of India are represented by fin fishes and shell fishes. The backwater environment of Kerala forms an indispensable habitat for a variety of biologically and economically important resident and migratory aquatic fauna. These interconnected backwaters spanning about 62,500 ha preferred habitats for about 200 resident migratory fish and shell fish species, and forms the crux of the inland fishery resource of the state. The fishing activities in the backwater support about 0.2 million fisher folks and provide employment to about 50,000 fishermen (Unnithan*et al.,* 2005). These backwaters are grounds of prawns, crabs and fin fishes and the breeding grounds for the freshwater prawns. Retting activity in the backwaters has not only affected the very existence ofthe planktonic and benthic organisms but also the valuable fishery resources. Mass mortality offishes due to intense pollution from anoxia coupled with sulphide and other organic pollutants could be observed from the retting zones of the backwaters particularly during the dry and stagnant premonsoon period.

MATERIALS AND METHODS

The present investigation was carried out in the Kadinamkulam estuary (latitude 8° 35' to 8°40' N and longitude 76°45' to 76°52' E), the largest among the estuaries in Thiruvananthapuram district, Kerala, India. The location map is given in Figure.1. The average depth of the Kadinamkulam estuary is 8 m. The fish samples were collected with the help of fisherman using suitable sized fishing nets during pre-monsoon, monsoon and post monsoon seasons from the selected stations of Kadinamkulam estuary representing the major fish resources of this estuary such as Kotrakiri (SI), Kadinamkulam (SII), Madanvila (SIII) and non retting station Perumathura near Pozhi (SIV). Each station has an appropriate quarter of 100 m circumference for sample collection. The captured fishes were counted and the selected samples were preserved in 5% formaldehyde solution for identification. The specimens were identified upto the lowest possible taxonomic level using the key of Day (1878), Fischer (1978) and

Jhinghran (1983). For the assessment of impact of coconut husk retting on fish diversity, comparisons of fish catch data, from all four stations studied, the retting zones, as well as of non retting zone, among and between them was done in terms of species, number of individuals present in each station in three different seasons. Abundance of individual fish species was judged in terms of their frequency of occurrence and number of individuals.

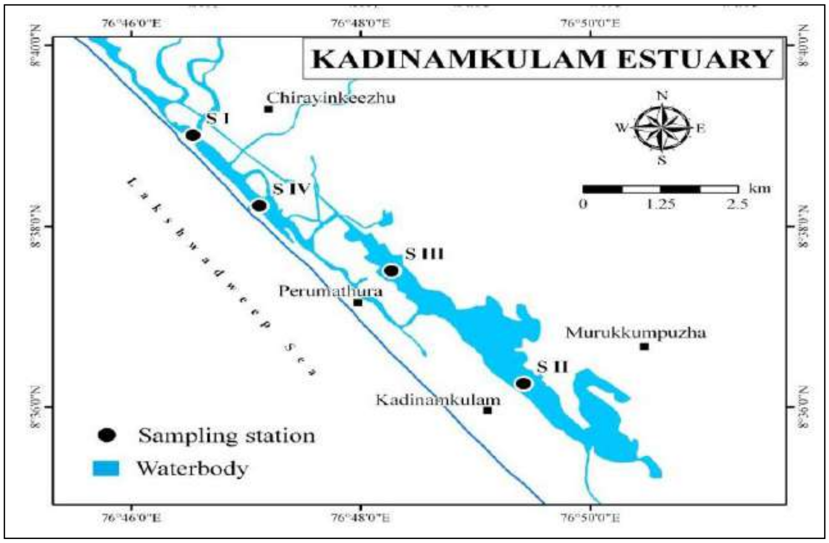

Fig. I Location map of the study area

RESULTS AND DISCUSSION

Fish diversity observed during different seasons from four different study stations in the Kadinamkulam estuary are depicted in the Tables 1 to 3. In the present study the fish diversity were reduced to a total of 28 species, and among them, only eighteen species were found in retting zones. In this study no shell fishes were observed in the retting zones. The fish like *Sardinella* was not found in the retting zones but in monsoon season, it was seen the non retting area like Pozhi. Ten fish species are merely associated with non retting zones. Ten species rarely found in retting zones and seven species commonly found both in retting and non retting zones. Among the 28 species of fishes identified, the fish *Oreochromis mossambicus* and *Meghalops cyprinoids* are the abundant species in this estuary during all three seasons. From the present study on the diversity and abundance of fishes it can be seen that the fish diversity in Kadinamkulam estuary was under threat. Previous studies by Nandan (1997) reported 37 fin fish species, five species of prawns, and two species of crabs and bivalves in the Kadinamkulam estuary, and of these twenty species of fin fish species were identified in the retting zones. No shell fishes were observed in the retting zones in his study also. Unnithan *et al.,* (1990) observed thirty species of fishes from Kadinamkulam backwaters.

Studies undertaken by Nandan and Unnithan, (2004) in the retting zones of Kadinamkulam-Anchuthengu back water had reported the massive depletion in the fishery wealth of this region. Form his study he collected a total of 37 species of fishes, 5 species of prawns and two species of crabs and bivalves from the non retting zones of Kadinamkulam - Anchuthengu backwater, whereas only 20 species were present in retting zones, that too collected dead. No shellfishes were observed in the retting zones of this backwater during the study. The retting zones ofKayamkulam backwater also showed low incidence of fishery resources, 17 species of fisheswere reported from the retting zones and 30 numbers were present in the non retting zones in monsoon season (Nandan and Unnithan, 1998). Earlier studies conducted by Mary John (1958) reported 125species of fishes from the same back water. This has further authenticated the fact that retting activity has not only led to low diversity of fauna in the retting zones, but also in the non retting zones.

Table 1. Fin fish and shell fish diversity in the retting and non retting zones of Kadinamkulam estuary during pre-monsoon season

Sl. No.	Fish Species*	SI	SII	SII	SIV
1	*Glossogobius giuris*	+	+	+	+ +
2	*Mugil cephalus*	+ +	+ +	+ +	+ +
3	*Liza parica*	+	+	+	+ +
4	*Therapon jarbua*	+	+	+	+ +
5	*Etroplus suratensis*	+ +	+ +	+ +	+ + +
6	*Etroplus maculatus*	+	+	+	+ + +
7	*Oreochromis mossambicus*	+ ++	+ + +	+ + +	+ + +
8	*Cynoglossus lida*	+	+	+	+ +
9	*Stolophorus indicus*	+ +	+ +	+ +	+ +
10	*Chanos chanos*	+	+	+	+ +
11	*Liza macrolepis*	+ +	+ +	+ +	+ +

12	*Sphyraena jello*	+ +	+ +	+ +	+ +
13	*Gerreomorpha setifer*	+	+	+	+ +
14	*Brachirus orientalis*	-	-	-	+ +
15	*Thysanophrys indicus*	-	-	-	+ +
16	*Pseidogobiu sjavanicus*	-	-	-	+
17	*Eleotris fusca*	-	-	-	+ +
18	*Leiognathus equulus*	-	-	-	+
19	*Gerres oyena*	+ +	+	+ +	+
20	*Hyporhampus limbatus*	-	-	-	+ +
21	*Hemiramphus cantori*	-	-	-	+ +
22	*Rhynhorapus georgi*	-	-	-	+ +
23	*Tachysurus maculates*	+	+	+	+ +
24	*Megalops cyprinoids*	+ + +	+ +	+ +	+ +
25	*Pranesusduo decimalis*	-	-	-	+ +
26	*Valamugil seheli*	-	-	-	+
27	*Chanda commercinalis*	-	-	-	+
Shell fishes					
1	*Penaeus indicus*	-	-	-	+ + +
2	*Matapenaeus monoceros*	-	-	-	+ +
3	*Macrobrachium monoceros*	-	-	-	+ +
4	*Macrobrachium idila*	-	-	-	+ + +
5	*Scylla serrata*	-	-	-	+ + +
6	*Neptunus paeagicus*	-	-	-	+ +
7	*Vilorita cyprinoides*	-	-	-	+ + +
8	*Crassostrea madrasensis*	-	-	-	+ +
*Showing number of abundant (+ + +), common (+ +) and rare (+) species					

Table 2. Fin fish and shell fish diversity in the retting and non retting zones of Kadinamkulam estuary during monsoon season					
Sl. No.	**Fish Species**	**SI**	**SII**	**SII**	**SIV**
1	*Glossogobius giuris*	+	+	+	+ +
2	*Mugil cephalus*	+ +	+ +	+ +	++ +
3	*Liza parsia*	+	+	+	+ +
4	*Therapon jarbua*	+	+	+	+ +
5	*Etroplus suratensis*	+ +	+ +	+ +	+ + +
6	*Etroplus maculatus*	+	+	+	+ + +
7	*Oreochromis mossambicus*	+ + +	+ + +	+ + +	+ + +
8	*Cynoglossus lida*	+	+	+	+ +
9	*Stolophorus indicus*	+ +	+ +	+ +	+ +
10	*Chanos chanos*	+	+	+	+ +
11	*Liza macrolepis*	+ +	+ +	+ +	+ +
12	*Sphyraeno jello*	+ +	+ +	+ +	+ +
13	*Gerreomorpha setifer*	+	+	+	+
14	*Brachirus orientalis*	-	-	-	+ +
15	*Thysanophrys indicus*	-	-	-	+ +
16	*Pseidogobius javanicus*	-	-	-	+
17	*Eleotris fusca*	-	-	-	+ +
18	*Leiognathus equulus*	-	-	-	+
19	*Gerres oyena*	+ +	+	+ +	+
20	*Hyporthampus limbatus*	-	-	-	+ +
21	*Hemiramphus cantori*	-	-	-	+ +
22	*Rhynhorapus georgi*	+	+	+	+ +
23	*Tachysurus maculates*	+	+	+	+ +

24	*Megalops cyprinoids*	+ + +	+ +	+ +	+ +
25	*Pranesus duodecimalis*	-	-	-	+ +
26	*Valmugil scheli*	-	-	-	+
27	*Chanda commercinalis*	-	-	-	+
28	*Sardinella*	-	-	-	+ +
Shell fishes					
1	*Penaeus indicus*	-	-	-	+ + +
2	*Matapenaeus monoceros*	-	-	-	+ +
3	*Macrobrachium monoceros*	-	-	-	+ +
4	*Macrobrachium idila*	-	-	-	+ + +
5	*Scylla scrrata*	-	-	-	+ + +
6	*Neptumus pelagicus*	-	-	-	+ +
7	*Vilorita cyprinoides*	-	-	-	+ + +
8	*Crassostrea madrasensis*	-	-	-	+ +
*Showing number of abundant (+ + +), common (+ +) and rare (+) species					

Table 3. Fin fish and shell fish diversity in the retting and non retting zones of Kadinamkulam estuary during post monsoon season

Sl. No.	Fish Species	SI	SII	SII	SIV
1	*Glossogobius giuris*	+	+	+	+ +
2	*Mugilc ephalus*	+	+	+ +	+ +
3	*Liza parica*	+	+	+	+ +
4	*Therapon jarbua*	+	+	+	+ +
5	*Etroplus suratensis*	+ +	+ +	+ +	+ +
6	*Etroplus maculatus*	+	+	+	+ +
7	*Oreochromis mossambicus*	+ + +	+ ++	+ +	+ + +
8	*Cynoglossus lida*	+	+	+	+ +

9	*Stolophorus indicus*	+ +	+	+ +	+ +
10	*Chanos chanos*	+	+	+	+ +
11	*Liza macrolepis*	+ +	+ +	+ +	+ +
12	*Sphyraena jello*	+ +	+	+ +	+ +
13	*Gerreomorpha setifer*	+	+	+	+
14	*Brachirus orientalis*	-	-	-	+ +
15	*Thysanophrys indicus*	-	-	-	+
16	*Pseidogobius javanicus*	-	-	-	+
17	*Eleotris fusca*	-	-	-	+ +
18	*Leiognathus equulus*	-	-	-	+
19	*Gerreso yena*	+ +	+	+	+
20	*Hyporhampus limbatus*	-	-	-	+ +
21	*Hemiramphus cantori*	-	-	-	+ +
22	*Rhynhorapus georgi*	+	-	+	+ +
23	*Tachysurus maculates*	+	+	+	+ +
24	*Megalops cyprinoids*	+ +	+ +	+ +	+ +
25	*Pranesus duodecimalis*	-	-	-	+ +
26	*Valamugil seheli*	-	-	-	+
27	*Chanda commercinalis*	-	-	-	+
Shell fishes					
1	*Penaeus indicus*	-	-	-	+ + +
2	*Matapenaeus monoceros*	-	-	-	+ +
3	*Macrobrachium monoceros*	-	-	-	+ +
4	*Macrobrachium idila*	-	-	-	+ + +
5	*Scylla serrata*	-	-	-	+ + +
6	*Neptunus pelagicus*	-	-	-	+ +

7	*Vilorita cyprinoides*	-	-	-	+ + +
8	*Crassostrea madrasensis*	-	-	-	+ +
*Showing number of abundant (+ + +), common (+ +) and rare (+) species					

CONCLUSION

The backwaters of Kerala are known for the rich resources of fish and shellfishes. Retting activity in the backwaters has not only affected the very existence of the planktonic and benthic organisms but also the valuable fishery resources. Mass mortality of fishes due to intense pollution from anoxia coupled with sulphide and other organic pollutants could be observed from the retting zones of the backwaters particularly during the dry and stagnant premonsoon period. The study shows that the crustaceans were totally absent from the retting zones whereas they were present in unpolluted areas of Kadinamkulam estuary. Seventeen species of fishes were recorded from the non retting zones, whereas only seven species (*Channa stariatus*, *Oligolepis acutipennis, Pertica filamentosa, Etroplus suratensis, Etroplus maculatus, Tachysurus ocelatus* and *Oreochromis mossambicus* were present in the retting zone capable of surviving in the anoxic-sulphide rich conditions.

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ALIEN EXOTIC SPECIES DIVERSITY USED AS FRESHWATER ORNAMENTAL FISH IN THIRUVANANTHAPURAM DISTRICT, KERALA

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ABSTRACT

An Invasive Alien Species (IAS) is defined by Convention on Biological Diversity (sixth Conference of Parties; Decision VI / 23) as "a species, sub-species or lower taxon, introduced outside its natural past or present distribution, which includes any part, gametes, seeds, eggs or propagules of such species that might survive and subsequently reproduce". Invasive alien species have emerged as the second biggest threat to global biodiversity after habitat destruction. Introduction of alien fish species, both intentional and non-intentional cause bioinvasions and expansion in the natural range of the concerned species. More than 300 alien fish species - 291 ornamental species, 31 aquaculture species and three larvicidal fishes have been recorded in India. The exotic species such as goldfish, angel, guppy, swordtail, oscar, platy, cichlids, tetras, gouramis, sucker mouths, pacu etc. are common and well-stablished. Out of these exotic species a few have been able to acclimatize to the new environment and produce breeding populations along with impacting the indigenous fish species thus, they have become the Invasive Alien Species. One of the major reasons for the decimation or loss of native fish biodiversity in freshwater ecosystems in India and other hotspots is the introduction of the such alien species that can establish themselves in a new environment. This study deals with the freshwater species that are major alien species but are rampantly sold in aquaria around Thiruvananthapuram district, Kerala.

Keywords – Exotic, invasion, indigenous, establish

INTRODUCTION

The aquarium keeping hobby is comparatively new to India. This hobby is just 70 years old. The contribution of India to the international ornamental fish trade is very less but if it can be properly managed, India can be one of the leaders of the world trade in aquarium fish. The freshwater ornamental fish species can be grouped into indigenous (native), exotic (imported) and invasive species depending on their original habitat range.

An Invasive Alien Species (IAS) is defined by Convention on Biological Diversity (sixth Conference of Parties; Decision VI / 23) as "an alien species is a species, sub-species or lower taxon, introduced outside its natural past or present distribution, which includes any part, gametes, seeds, eggs or propagules of such species that might survive and subsequently reproduce" (CBD, 2002). Invasive alien species have been emerging as the second biggest threat factor to global biodiversity after habitat destruction, and it is expected to soon surpass the damage caused by habit destruction and fragmentation factor (Zhang and Chen, 2011; Surendra *et. al.,*2013). some of the invasive alien species can indirectly and directly affects the human health and also damage the livelihood of the native / regional community and ultimately destabilize the regional economy (Surendra *et al.,*2013; Sandilyan, 2016).

One of the human activities that effects the aquatic ecosystem is the introduction of alien fish species, both intentional and non-intentional (Garcia-Berthou, 2007) and both cause bioinvasions or expansion in the natural range of the concerned species. More than 300 alien fish species - 291 ornamental species, 31 aquaculture species and three larvicidal fishes have been recorded in India. The ornamental fish trade in India is dominated mainly by the presence of over 500 alien fish varieties exported or introduced from various countries all over the world. The exotic species such as goldfish, angel, guppy, swordtail, oscar, platy, cichlids, tetras, gouramis, sucker mouths, pacu etc. are common and well-stablished. Out of these exotic species a few have been able to acclimatize to the new environment and produce breeding populations along with impacting the indigenous fish species thus, they have become the Invasive Alien Species. One of the major reasons for the decimation or loss of native fish biodiversity in freshwater ecosystems in India and other hotspots is the introduction of the such alien species that can establish themselves in a new environment (Garcia-Berthou *et al.,*2005, Garcia-Berthou, 2007; Singh and Lakra, 2011).

In the past, the risks of such introductions were not thoroughly understood as the negative impacts became apparent many years after the alien species were introduced and established in the ecosystem (Singh, 2014).

According to Padilla and Williams, (2004) and Liang *et al., (*2006), one-third of the world's worst aquatic invasive species are exotic ornamental fishes and are a major source of ecological destruction in the introduced area. The impacts of the invasive alien species are that ornamental alien fishes frequently alter the aquatic ecology by changing water chemistry; damage the aquatic vegetation and exploit the food resources; cause the extinction of native fishes by predation destroying the eggs, larvae, sub adult and adult (Pimentel, 2001; Biju Kumar *et al.,*2015) and the carnivorous species are capable of wiping out the native species.Hybrids between the alien and native species like that of African catfish, tilapia, trout and pacu are known to lower the wild genetic stock leading to blotched gene pools (Pimentel, 2001); the alien species can also be carriers of new diseases that can affect the non-resistant native fish species destroying their populations (Poulos *et al.,*2012).

MATERIAL AND METHODS

Aquarium and pet shops in various localities of Thiruvananthpuram district, that sell freshwater fishes, were identified and survey conducted. These shops were visited. The "Nagara Vasatham" show at Kannakakunnu, and "Matsyolsavam" at Puthirikandam Maidanam, Thiruvananthapuram were also visited for collecting data on the freshwater ornamental species.

The invasive fish species commonly found in these aquariums and pet shops were photographed; the various characters and features of each fish were obtained through discussion with the shop owners. This data was then compared to websites for identification (Fishbase, Simplyfish, MPEDA) and the conservation status was assessed from IUCN website.

RESULTS

Osphronemus goramy **(Giant gaurami)**

Classification

Class - Actinopterygii

Order - Anabantiformes

Family - Osphronemidae

Genus - *Osphronemus*

Species – *O. goramy*

Characters

Range – Southeast Asia

Size- 45 cm (70 cm max.)

Life span – 20 years

Temperature – 20 to 30°C

pH – 6.8 to 7.8

Feeding habit – Herbivores; can be fed tubifex, blood worms and brine shrimp.

Behaviour – Loners but not aggressive. They are aggressive when they are young and taking care of eggs.

Sexual dimorphism – Males have pointed anal and dorsal fins; females have larger lips and rounder fins.

Reproduction – Egg layers and nest builders; males show maximum parental care.

***Poecilia reticulata* (Guppy)**

Classification

Class - Actinopterygii

Order - Cyprinidontiformes

Family - Poeciliidae

Genus - *Poecilia*

Species – *P. reticulata* (Peters, 1859)

Characters

Range – Originally from northeast South America; introduced worldwide.

Size – males – 1.5 to 3.5 cm; females – 3 to 6 cm

Life span – 2 to 3 years

Temperature – 20 to 26°C

pH – 6.5 to 8

Feeding habit - Omnivore

Behaviour – Peaceful, social fish; can be grouped with non-aggressive species.

Sexual dimorphism – Males brightly coloured with ornate tails have modified anal fin (gonopodium), females larger, rounder and drab in colour.

Reproduction – Livebearers.

***Xiphophorus maculatus* (Platy)**

Classification

Class - Actinopterygii

Order - Cyprinidontiformes

Family - Poeciliidae

Genus - *Xiphophorus*

Species – *X. maculatus*

Characters

Range – North and Central America

Size - 6 cm

Life span – 3 – 5 years

Temperature – 18 - 25°C

pH – 7 - 8

Feeding habit – Ominovores; plants to small crustaceans, inscets and worms.

Behaviour – Peaceful, social, and active

Sexual dimorphism – Caudal fin pointed and gonopodium present in male; female have fan shaped anal fin.

Reproduction – Livebearers.

***Pterygoplichthys multiradiatus* (Armoured sailfin catfish)**

Classification

Class – Actinopterygii

Order - Siluriformes

Family - Loricariidae

Genus - *Pterygoplichthys*

Species – *P. multiradiatus*

Characters

Range – Orinoco River basin, South America

Size – Max. size 50 cm

Life span – 10-12 years

Temperature – 23 – 27 °C

pH – 6.5 – 7.8

Feeding habit – Bottom feeders also eat worms, larvae, and bottom dwelling invertebrates.

Behaviour -Peaceful and solitary, needs lots of places to hide. Territorial with own kind.

Sexual dimorphism – Difficult to distinguish. Males' genital papillae small but thick stump protrudes out females its less obvious and flat with body.

Reproduction – males dig 1 m long burrows in mud: females deposit eggs and males guard eggs. Captive breeding not known.

***Pygocentrus natterei* (Red-bellied piranha)**

Classification

Class - Actinopterygii

Order - Characiformes

Family - Serrasalmidae

Genus - *Pygocentrus*

Species – *P. natterei*

Characters

Range – Amazon Basin, South America

Size – 15-20 cm

Life span – 10 years

Temperature – 15 - 35 °C

pH – 6 – 7.8

Feeding habit – Predatory, carnivorous.

Behaviour – Aggressive, shoaling, active hunters.

Sexual dimorphism – Females have redder colour on bellies.

Reproduction – Egg layers; males make nests near plants, parental care by males.

***Carassius auratus* (Goldfish)**

Classification

Class - Actinopterygii

Order - Cypriniformes

Family - Cyprinidae

Genus – *Carassius*

Species – *C. auratus*

Characters

Range - China

Size – 2.5 to 5 cm

Life span – 10 years

Temperature – 20 - 25°C

pH -7 - 8.4

Feeding habit - Omnivores

Behaviour – Gregarious, shows schooling behaviour.

Sexual dimorphism – Males are slightly smaller and skinnier with flowing fins and tails. Females have softer rounder abdomen.

Reproduction – Egg layers, adhesive eggs, external fertilization

***Gambusia affinis* (Mosquito fish)**

Classification

Class - Actinopterygii

Order - Cyprinidontiformes

Family - Poecilliidae

Genus - *Gambusia*

Species – *Gambusia affinis*

Characters

Range – Southeastern United States and Mexico

Size - Males- 4cm; females – 7 cm

Life span – 6 months to 1.5 years

Temperature – 10 -29 °C

pH – 6 to 8

Feeding – Larvivores; diet includes zooplankton, insect, insect larvae and detritus.

Behaviour – Aggressive, cannot be kept with fish with ornate and large fins or ones that are slower.

Sexual dimorphism – Males are shorter and slender with modified anal fin (gonopodium). Females can be identified by the gravid spot on the abdomen.

Reproduction – Livebearers

***Atractosteus spatula* (Alligator gar)**

Classification

Class - Actinopterygii

Order - Lepisosteiformes

Family - Lepisosteidae

Genus - *Atractosteus*

Species – *A. spatula*

Characters

Range – North America

Size – up to 3 ft

Life span – 20 years

Temperature – 20 – 25 °C

pH – 6.5 – 7.5

Feeding habit - Piscivorous

Behaviour – Peaceful, hostile to same species

Sexual dimorphism – Females are smaller than males.

Reproduction – Internal fertilization; lays eggs in nest.

DISCUSSION

The growth and development of ornamental market worldwide is mainly due to globalization and increased international trade in live flora and fauna (Mack and Lonsdale, 2001). India's share to global ornamental fish trade is less than 1% but still India is projected as a "sleeping giant" because of yet untapped potential resources (Rani *et al.,* 2013). At present, all the ornamental fishes marketed in India are exotic.

Most of the time the invasive species manage to escape to the wild from the hobbyist and traders and evolve as an invasive species and damage to Indian aquatic diversity (Sandilyan, 2016). So far, more than 10 ornamental fish species established a good breeding population in Indian inland aquatic systems (Sandilyan, 2016). Five exoticornamental fishes viz*., Gambusia affinis, Oreochromis mossambicus, Osphronemus goramy, Poecilia reticulata, Xiphophorus maculatus* were reported from Chalakudy River in the Western Ghats, a biodiversity hotspot which harbours 16 endangered and 4 critically endangered species.Four out of 11 species, of exotic species have been found in waterways of Kerala, are popular aquarium pets; *Pterygoplichthys multiradiatus*, *Poecilia reticulata* (Raghavan *et. al.,*2008), *Trichogaster trichopterus* (three-spot gourami) (Krishnakumar *et. al.,*2009) and *Xiphophorus maculatus* (platy) (Raghavan *et. al.,*2008) *P.multiradiatus*, armoured catfish from South America has been recorded from three natural freshwater ponds in Thrissur district (Raghavan *et. al.,*2008) and the Chackai canal in Thiruvananthapuram district (Baiju, 2009). They are large, omnivores and territorial species that can tolerate pollution as they are air breathers (Gibbs et. al., 2021). They are known to cause impacts on the periphyton feeders and bottom spawners like *Etroplus suratensis.* Grazing on benthic algae and detritus reduces food and covers (shade and protection) for aquatic insects altering the food web (Liang *et. al.,*2005). In the case of Chackai canal, the large population has replaced many herbivorous fishes (Baiju, 2009) and are known to cause economic loss for the fisherman by damaging fishing gears mainly the nets (Raj*et. al.,*2021).

The popular aquarium fish, guppy *Poecilia reticulata* species have established a breeding population in this in the small streams of Chalakuddy River (Raghavan *et al.,* 2008), main branches of Meenachil River in Kottayam (Narayanan *et. al.,*2005), drainage canals of Ernakulam city connected to natural water bodies including Vembanad Lake. The main reason for this is the comparatively early maturation (males at 2 months and females at 3 months) that make them capable of proliferating and becoming a pest. Similarly, the platy, Xiphophorus maculatus is an early maturing, insectivorous fish that has become a competitor for the indigenous barbs like *Puntius fasicatus, P. ticto, P. vittatus* and killifish like *Apolocheilus lineatus, A. panchax* and *A. dayi.* (Raghavan *et al.,* 2008). Platy is now coexisting with *A. lineatus* in Chalakudy river and found to be sympatric with P. fasciatus in first order streams of Chalakudy river (Raghavan et al., 2008). The next popular aquarium fish, three spot gourami has been collected from the canals flowing into Vembanad lake and is the first report from Kerala. They are spotted in local catches (Krishnakumar *et. al.,* 2000). They are opportunistic carnivores with territorial and aggressive behaviour and they are harmful for native ornamental species like *Pseudosphronemus cupanus* and *A. lineatus.*

Most of aquarium fish species that are released accidently or intentionally will survive or be able to reproduce and ultimately become pests abut if sufficient numbers of individuals survive, they may be able to reproduce (Calado and Chapman, 2006) and establish feral populations that will turn invasive endangering the native fish populations in the future.

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STUDIES ON STORED GRAIN PESTS FOUND IN HOME STORED PRODUCTS

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ABSTRACT

Stored product pests gain access to the grain storage from the standing crop in the field to various stages of grain processing and storage. Although, about one thousand species of insects have been associated with stored products in different parts of the world, a few pests are considered as pests causing severe damage to the stored grains. Preventative methods and sanitation are the keys to avoiding an infestation or contamination of foodstuffs.

INTRODUCTION

The stored grain insect pests can be categorized on the basis of their feeding behaviour as internal and external feeder or as major and minor pests based on the severity of damage, they cause. Stored grains are ravaged by a number of insect pests. The stored grain pests infest grains to fulfill their food and shelter requirements resulting in qualitative as well as quantitative losses. The tropical climate of India is highly favourable for continuous occurrence of storage insect pests throughout the year. A number of insect pests gain access to the grain storage at various stages of processing of food grains/ seeds viz., during the process of development and maturation of seeds/grains, processing in threshing yards, during transit or while in storage. Some insect pests initiate damage at the ripening stage of crops and continue during storage. Major sources of infestations are old bags, storage structure, old containers, and cross over infestation (Pruthi and Singh, 1950) The stored grain insect pests can be categorized as major or minor pests based on the severity of damage. Based on their feeding behaviour, these can be grouped as external and internal feeders (Cotton, 1960).

To prevent the infestation of foodstuffs by pests of stored products, or "pantry pests", a thorough inspection must be conducted of the food item intended for purchase the place of purchase. The expiration date of grains and flour must also be noted, as products that sit undisturbed on the shelf for an extended period of time are more likely to become infested. This does not, however, exclude even the freshest of products from being contaminated. Packaging should be inspected for tiny holes that indicate that there might be an infestation. Foodstuffs susceptible to infestation include dried grains, flour, cereals, and whole-grain products. If there is evidence of an insect infestation, the product should not be purchased. Using the oldest products first and buying grains and cereals in smaller quantities which can be used up quickly, depending on the size or intake of the family, decreases the chances of infestation. Preventative methods and sanitation are the keys to avoiding an infestation or contamination of foodstuffs.

MATERIALS AND METHOD

The analysis of major pests that most commonly infest stored products, beginning with the type of foods infested, signs indicative of a particular insect infestation, and a description of the larvae, pupae, and adults, including behavior as well as appearance is the objective of present study.

The survey and surveillance was carried out during 2020 -2021 at houses at monthly intervals for three months, (December to February). During the study identification of insects, prevention and traditional eradication methods were done.

RESULT AND DISCUSSION

Tribolium castaneum **(Red Flour Beetle)**

It is a serious pest also in flour mills and wherever cereal products and other dried products. They are flat and oval in shape and usually range around 1/8- inch long. Their exoskeleton is reddish brown with a shiny and smooth texture. The eggs usually tend to be a white color, or at times even colorless. They are very small in size and have a sticky outer covering that causes certain food particles to stick to it. The flour beetles mainly infest grains. Once they are present in areas with potential food sources, resulting in a sharp odor or moldy flavor.

Damaged caused by Red Flour Beetles

Generally, the beetle is attracted to grain with high moisture content, and usually causes the grain to acquire a grayish tint. The beetle may also impart a bad odor, which then affects the taste of the infested products, as well as encouraging the growth of mold in the grain. This foul odor and taste in the various food products are caused by pheromones and toxic quinone compounds.

Oryzaephilus surinamensis **(Sawtoothed Grain Beetle)**

The sawtoothed grain beetle is commonly found in kitchen cabinets. They are the most common grain and stored product pest. They are very active and tend to crawl rapidly while searching for food. They are small insects. The body shape of the beetle is flat, slender, and brown in color.

***Plodia interpunctella* (Indian meal Moth)**

Indianmeal moths can infest a variety of foods found in the home. Coarsely ground grains, cereals, dried fruits, and herbs are common items the moths have been known to infest. They have also been found in animal food such as dry dog food, fish food and even bird seed. The adult moth is small. As adults, the moths are easily identified by an overall grayish complexion. However, the wing tips have a bronze co lor that helps differentiate this particular moth from other household moths.

Sl.no	Storage Practice
1	Storage of pulses with common salt
2	Turmeric application method
3	Sun drying of grains
4	Use of garlic cloves
5	Mixing of leaves
6	Use of salt and chilli powder
7	Use of Neem leaves
8	Use of Neem leaves and dry chillies
9	Use of camphor
10	Use of Tulsi seeds

Indian meal moths infest both cereal and stored grain products, packaged goods, grain in storage, and surface layers of shelled corn. The most telltale sign of the Indian meal moth is the silk webbing that the larvae (caterpillars) produce when feeding on the surface of foods. This silk webbing may appear to be or resemble cobwebs inside the products container. Often, a few larvae may be found in the packaging of the product, along with the 'cobwebs', cast skins. Larvae are white worms with black heads, which, when ready to pupate, crawl up the walls of the home in most cases, and are suspended from the ceiling attached by a single silken thread.. An important aspect of the Indianmeal moth is that the larvae are the only stage of the insect's life cycle to feed on stored products, the adults do not.

These observations are imperative, as there are not always larvae, pupa, or adults readily available for examination and identification. In the absence of physical specimens, conclusions were drawn about the probable insect that is infesting the product just by noting the damage done to the particular food. Although identifying the food is mostly used as a guideline, as some insects are more likely than others to be found in certain types of grain, flour, etc. Using the infested item as a guideline, noting the type of damage done to the product is the next step. Some insects, leave telltale tiny holes in the damaged product, while Indianmeal moths are notorious for the spider web-like threads left behind in the food they infest. These observations can generally lead to a mostly accurate conclusion about the type of insects that are causing the damage, but obviously the most accurate conclusion relies on any specimen found either directly in the stored product or in the vicinity. The larvae, pupae, and adults can be found directly in the product while usually only the pupae and adults are found in the vicinity of the product. This collection of traditional agricultural knowledge/practices is of great significance in conserving and maintaining sustainability of the environment. It also requires integration with modern scientific knowledge to generate a wide range of new ideas and practices for the betterment of the mankind. There is need to motivate the use of these practices and conserve these indigenous knowledge

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THE CONSTITUTION AND THE JUDICIARY: A DYNAMIC PARTNERSHIP FOR ENVIRONMENTAL PROTECTION IN INDIA

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INTRODUCTION

The term 'Environment'[1] is defined under section 2(a) of The Environment (Protection) Act, 1986. It encompasses water, air, and land, and the interrelationships that exist among and between them, humans, other living organisms, plants, microorganisms, and property. Therefore, the environment includes all elements that have a direct or indirect impact on humans.

In this current epoch, the safeguarding and conservation of the environment is paramount for human survival. Mankind, being the primary utilizer of natural resources, bears the brunt of the blame for the ongoing resource exhaustion and environmental degradation. With the possession of rights comes the burden of responsibilities, hence making environmental protection an immediate necessity for both the present and future generations to lead a harmonious and balanced life.

The Constitution of India, which forms the basis for all lawmaking, enshrines the mandate to protect and enhance the environment. It underscores the importance of environmental protection through its various provisions. These constitutional provisions aid in fostering coordination for environmental protection.

The Constitutional (42nd Amendment) Act of 1976 incorporated Articles 48-A and 51-A(g) into the constitution, highlighting the significance of environmental protection. Article 48-A, which is included in the Directive Principles of State Policy under Part IV of the constitution, obligates the state to endeavour to safeguard and enhance the environment and conserve the country's forests and wildlife. According to Article 37, these principles, while not legally enforceable, are essential to the governance of the country, and it is incumbent upon the state to consider these principles when legislating new laws.

Article 51-A(g), which forms part of the fundamental duties under Part IVA of the constitution, serves as a reminder to citizens that they have a responsibility to protect and improve the natural environment, including forests, lakes, rivers, and wildlife, and to exhibit compassion for living creatures. This article underscores that citizens, in addition to their rights, have certain obligations to fulfil for the betterment of society and the nation as a whole.

In the case of T.N. Godavarman Thirumalpad v. Union of India & Ors,[2]a three-Judge Bench of the Court interpreted Articles 48-A and 51-A collectively, laying the groundwork for a jurisprudence of environmental protection. The Court ruled that both the State and its citizens have a fundamental duty to protect and enhance the environment, including forests, lakes, rivers, wildlife, and to exhibit compassion for living creatures.

Liberalisation of locus standi: The Supreme Court's Green Crusade.

The term 'Locus Standi' refers to the right to bring a case to court. Traditionally, only a person whose legal rights have been infringed upon could initiate a lawsuit. However, this concept has evolved over time, with Public Interest Litigation (PIL) serving as a notable exception to this rule. Pioneered by Justice V.R. Krishna Iyer and Justice P.N Bhagwati, PIL allows any public-spirited citizen or social organization to approach the court to enforce the rights of individuals or groups who, due to poverty, lack of knowledge, or socio-economic disadvantages, are unable to seek justice themselves. This liberalization of locus standi plays a significant role in the Supreme Court's efforts towards environmental protection.

Public Interest Litigation: Case Laws that Shaped Justice.

1. **M.C.Mehta v. Union of India (Ganga Pollution [Tanneries] case)**:[3]The Supreme Court mandated the shutdown of tanneries in Jajmau, Kanpur, which were polluting the Ganga River, unless they implemented treatment plants. The court noted that while the closure of tanneries could lead to unemployment and revenue loss, the importance of life, health, and ecology outweighs these concerns. This lawsuit was initiated as a public interest litigation by the petitioner.
2. **M.C.Mehta v. Union of India (Taj Trapezium case)**:[4] A PIL was lodged to protect the Taj Mahal from the yellowing effects of emissions from nearby industries. The court ordered these industries to switch to natural gas as fuel and to relocate, in order to prevent air pollution and preserve the monument.
3. **Vellore Citizen's Welfare forum v. Union of India**:[5]The Supreme Court ruled that while industries are crucial for the country's development, they must not be allowed to harm the

ecology, degrade the environment, or pose a health hazard. Industries are not permitted to operate unless they install pollution control devices.

Article 21 states: “No person shall be deprived of his right to life and personal liberty except according to procedure established by law.” This article holds a unique place in our constitution due to its broad interpretation by the Indian judiciary. The right to a healthy environment has been encompassed within the scope of Article 21 through various Supreme Court judgments.

In the case of Subhash Kumar v. State of Bihar, the court ruled that the right to life is a fundamental right under Article 21 of the Constitution. This right includes the enjoyment of pollution-free water and air for the full enjoyment of life. If any action endangers or impairs this quality of life in violation of laws, a citizen has the right to resort to Article 32 of the Constitution to eliminate the pollution of water or air that may be harmful to the quality of life.

In the case of ‘Vellore Citizen’s Welfare Forum v. Union of India,’ The petition highlighted the environmental pollution caused by the significant discharge of untreated effluent from tanneries and other industries in Tamil Nadu. The Supreme Court ruled that while such industries are crucial for the country’s development, they cannot be permitted to destroy the ecology, degrade the environment, or pose a health hazard. They were not allowed to continue their operations unless they installed pollution control devices. The court, in its wisdom, emphasized the adoption of the “Sustainable Development” principle as the golden mean between ecology and economy. It declared that the “Precautionary Principle” and the “Polluter Pays” principle are the twin pillars of sustainable development. The process of sustainable development includes the restoration of the harmed environment. The polluter is responsible for compensating the individual victims and also bearing the expenses of restoring the damaged ecology.

Thus, Article 21 has served as a pivotal element in the development of environmental law in India, affirming the right to a clean environment as a basic right. It has opened avenues for citizens to seek legal recourse for the enforcement of this right, thus playing a vital role in the preservation of the environment in India.

The balance of our ecosystem is being threatened by the excessive, inappropriate, and extreme utilization of environmental resources. This imbalance endangers the continuity of human existence. Any interference with nature, and thus the ecological equilibrium, has profound impacts on human life.

The Constitution provides the legal framework for environmental laws, regulations, and policies. It empowers the government to enact laws for environmental protection and conservation. Fundamental duties also foster a sense of responsibility towards the environment among citizens. Through judicial activism, the right to a healthy environment has been recognized as a fundamental right. This allows citizens to seek legal remedies against activities that cause environmental harm.

The Constitutional provisions and the Judiciary acts as a shield against environmental harm. It sets the stage for laws and policies that protect the environment, ensuring that nature's voice is heard in the corridors of power. It can be seen as a bridge between humanity and nature. It underlines our duty to the environment and asserts that it is not merely a resource for consumption, but a heritage that we must conserve for future generations.

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Phytochemical Analysis of Solvent Extract of *Thuidium tamariscellum* (C.Muell.)Bosch. & Sande-Lac. a moss.

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ABSTRACT

Bryophytes are the simplest primitive, poikilohydric land plants. They are cosmopolitan in distribution and are found growing both in the temperate and tropical regions of the world. They were known to be used in ethno-botany and were applied to cure many diseases. But the phytochemistry of these miniature plants is poorly documented and the results were scattered. The present study reveals the phytochemical profiling of *Thuidium tamariscellum,* a small creeping epiphytic moss growing on trunks and branches of trees as well as on moist shady rocky surface at high altitudes areas. As an initial part of the study, a qualitative analysis was attempted using various solvent extracts. It revealed the presence of flavonoids, alkaloids, glycosides, terpenoids, coumarins, tannins, saponins, and phlobatannins. Further the major phytochemicals were quantified. The overall result of the present study showed that the moss is rich in terpenoids when compared with other secondary metabolites.

Key words: Moss, terpenoids, *Thuidium tamariscellum*, bryophytes, solvent extracts, medicinal.

INTRODUCTION

Bryophytes are a group of plant species that reproduce via spores rather than flowers or seeds. Most bryophytes are found in damp environments and consist of three types of non-vascular land plants: the mosses, hornworts, and liverworts (Huang et al., 2010; Asakawa, 2007; Mossang et al., 2021). Despite being common almost everywhere, bryophytes often are ignored because of their small stature, lack of familiar features. Bryophytes are not damaged by fungi, bacteria, larvae because of the presence of phenylquinone, aromatic and phenolic compounds which provide defense (Asakawa, 2001). More than 700 terpenoids and 220 aromatic compounds isolated from bryophytes have been evaluated for their biological activities. Various compounds isolated display high potential as chemotherapeutic agents. It has been reported that marchantin

A, isoriccardin C, riccardin B, plagiochin E, and marchantin C isolated from Reboulia hemisphaerica were found to show cytotoxicity against EYFP-tubulin HeLa cells (Gao et al., 2009). This study was carried out to determine the phytochemical constituents in the moss *Thuidium tamariscellum*.

MATERIALS AND METHODS

Plant material *Thuidium tamariscellum* is a moss belonging to Thuidiaceae. Plant body is yellowish-green forming mats, filamentous in appearance, main stem creeping, distributed in wide range of habitats. The identity is confirmed by floras and authenticated by comparing with the herbarium of University of Calicut.

Hot continuous soxhlet extraction

Fresh plants were chopped, air dried and sequentially extracted with 250 ml of chloroform, petroleum ether, ethyl acetate, ethanol and water for 8 h continuous hot extraction by soxhlet method.

Preliminary qualitative phytochemical analysis

The different solvent extracts from soxhlet hot continuation method were evaluated for the presence of secondary metabolites according to the protocol of Khandelwal, (2007).

Estimation of terpenoids

Total terpenoids was determined by the method of Ferguson, (1956).

RESULT AND DISCUSSION

Phytochemical analysis revealed the presence of pool of secondary metabolites such as alkaloids, flavonoids, glycosides, saponins, triterpenoids, coumarins, tannins and phlobatannins which are considered as active medicinal phytochemical constituents (Table1). Chloroform extract contain flavonoids, triterpenoids, reducing sugar and tannins. Meanwhile, petroleum ether extract showed alkaloids and glycosides only. Aqueous extract contain saponins, coumarins and Phlobatannins. Further quantitative analysis showed that the moss *Thuidium tamariscellum* possess remarkable level of terpenoid (25.95 mg/g). *Plagiochila rutilans* showed the presence of R-pulegone and several other monoterpenoids (Mossang et al., 2021).

Table-1: Phytochemical screening of *T. tamariscellum* using various solvent extracts.

Secondary metabolites	Chloroform	Petroleum ether	Ethyl acetate	Ethanol (90%)	Water
Alkaloids	_	+++	_	+	_
Flavonoids	+++	_	_	_	+
Glycosides	_	+++	_	_	_
Saponins	_	_	_	_	+++
Triterpenoids	+++	_	++	+	_
Reducing sugar	+++	_	_	_	+
Coumarins	_	_	_	_	++
Phlobatannins	_	_	_	_	+++
Tannins	++	_	+	_	_
Anthraquinones	_	_	_	_	_

Nebojsa et al., (2007) reported the presence of flavonoids (aglycones and glycosides), phenolic acids and triterpenes in three bryophyte species: *Polytrichum formosum*, *Eurhynchium hians* (mosses) and *Pellia endiviifolia* (liverwort). Adedeji et al., (2012) analyzed the two moss species *Thuidium gratum* and *Barbula indica* in terms of flavonoids, saponin and alkaloids and the saponins and compared with the medicinal plants of Nigeria and suggested that these two mosses are potential source of useful drugs and can be used for the treatment of many ailments. The most anticancer activity was found in Brachytheciaceae, Dicranaceae, Grimmiaceae, Hypnaceae, Mniaceae, Neckeraceae, Polytrichaceae, and Thuidiaceae (Spjut et al., 1986; Mossang et al., 2021). Bryophytes were used as medicines for the treatment of various kinds of diseases in India, China and some parts of native America. *Rhodobryum roseum* (Hedw.) Limpr., *Marchantia polymorpha* L. *Rhodobryum giganteum* (Schwägr.) Paris, *Rhodobryum ontariense* (Kindb.) Paris, and *Cratoneuron filicinum* (Hedw.) Spruce displayed potential in treating various cardiovascular diseases (Mossang et al., 2021).

CONCLUSION

Thuidium tamariscellum is a moss belonging to the family thuidaceae used in traditional medicine. The crude extract in various solvents showed a pool of phytochemicals and therefore continues to play an essential role in local health care. Further, there is a continuous and urgent need to discover lead molecule with chemical structures and novel mechanisms of action.

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TOXICOLOGY AND IMMUNOMODULATION OF CADMIUM, THE ENVIRONMENT POLLUTANT

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ABSTRACT

Environmental pollution poses significant risks to human health due to its complex and multifaceted nature. Air pollution is a major concern for human health, since it is known to trigger several pathologies and subsequently increase morbidity and mortality rates. Many studies have found connections between particulates in the air and rates of chronic diseases. Among these pollutants, heavy metals stand out as particularly toxic due to their high bioaccumulation rates and classification as potential carcinogens.Cadmium (Cd), a biologically non-essential heavy metal, is widespread in the environment, including the air, water, and soil, and is widely present in foods. Cd enters the body primarily via inhalation and ingestion and it accumulates in immune cells, modulates the function of the immune system, triggers immunological responses, and leads to diverse health problems. This review summarizes the immunological toxicityof Cd, as a major environment pollutant.

INTRODUCTION

Heavy metals occurs naturally in the environment but it is also released from anthropogenic sources such as from industrial combustion, mining and from other sources.Cadmium (Cd), an important heavy metal, originates from both natural andanthropogenic sources (Wang et al., 2021).It can enter into the body through such contaminated water or food or respiration fromoccupational contact or recreationalsmoke. Once entered, it cannot be metabolized by the human body and is difficult to excrete; as a result, it has a biological half-life of 10–35 years in humans (Kubier et al., 2019).In many countries, Cd levels in humans have been found to exceed the tolerance of various organs and are associated with increased risk of chronic disease conditions, such as cancer,diabetes, and osteoporosis (Satarug et al., 2017). Cd accumulation occurs in several organs and tissues. Cd causes acute or chronic toxicity in the lungs, kidneys, liver, and bones and can be absorbed into the blood from the lungs and gastrointestinal tract, where it binds to blood cells, thus affecting the blood system (Hossein et al., 2020).

The mechanisms underlying cadmium-induced toxicity may be multifactorial. Cadmium affects biomolecules required for signal transduction (receptors, enzymes, transcription factors etc.), ion transport (ion pumps, channels or carriers) and metalloproteins such as Zn-, Ca-, and Fe-binding proteins. These activities interact with DNA repair mechanism, the generation of reaction oxygen species (ROS) and the induction of apoptosis. Besides, Cadmium affects cell proliferation, differentiation, and apoptosis and thus alters the immune response.

THE IMMUNE SYSTEM

The immune system is a complex network of immune organs (bone marrow, spleen, lymph nodes, tonsils, and thymus, etc), immune cells (lymphocytes, macrophages, neutrophils, eosinophils, and basophilic cells, etc), and immune-active substances (antibodies, lysozymes, complement factors, immunoglobulins, interferons, and other cytokines, etc), in which immune cells communicate with each other through direct interaction or through soluble cytokines (Farmer et al., 1986). An effective immune system must be able to discriminate by distinguishing self from non-self and harmless non-self from dangerous non-self. Therefore, the immune system is responsible for immunologic surveillance and defense, and immunoregulation (Kumar et al., 2014).

The immune system is divided into innate immunity and adaptive immunity (Moraes-Pinto et al., 2021). Innate immunity refers to the normal physiological defense mechanism of the body. As the firstline of host defense, it is fast and non-specific response. Innate immune activation can promote tissue inflammation or immune resolution directly through phagocytosis and the secretion of biologically active molecules or indirectly through activating the adaptive immune response mediated by antigen-presenting cells (Sun et al., 2020). The adaptive immune response is antigen-specific and forms the second line of host defense. Adaptive immunity includes cell-mediated T lymphocytes (T-cells) and B lymphocytes (B-cells) immunity, which plays vital roles in driving tissue inflammation (Sun et al., 2020). The B-cell response is characterized by the production of antibodies, which play prime role in both innate and adaptive immunity. There are two types of B-cell immunity: T-cell-dependent and independent (Watanabe et al., 2017). The innate and adaptive immune systems work in concert to achieve the removal of senescent cells and defense against invading pathogens (Viana et al., 2021). Cd, as an immunotoxic inhibitor, interacts directly with immune cells and alters their functionality, thus damaging the immune system in time- and dose-dependent manners (Mirkov et al., 2021).

CD AND IMMUNE RESPONSE

Cd induces the differentiation of immune cells and alters the composition and proportion of lymphocyte subsets. Desforges et al. found that Cd exposure affects the development of immune organs, differentiation of immune cells, and specific and non-specific immune responses in marine mammals (Desforges et al., 2016). In mice, Cd exposure affects the composition and proportion of lymphocytes, including CD4+,CD8+, CD25+, CD44+, and CD223+ cells (Hanson et al., 2012; Pathak et al., 2010). In addition, Cd treatment reportedly encourages DNA synthesis, the adherence capacity of macrophages and lymphocytes, and cell proliferation. This further suggests that Cd can interfere with normal immune system growth and development.

Cd also alters the cell signalling pathways in different ways. Micromolar concentrations of Cd activate cascades of multiple signaling pathways, especially, the nuclear factor kappa B (NF-kB) and mitogen-activated protein kinase (MAPK) pathways, in immune cells and induce the upregulation of inflammatory markers and mediators (Pathak et al., 2008, Holásková et al., 2012). Besides, Cd can induce ROS production, cause mitochondrial injury, reduce antioxidant enzyme activity, induce the oxidative stress response, and activate endoplasmic reticulum stress (ERS) pathways, thereby playing a proinflammatory role in immune cells (Chen et al., 2017, Jin et al., 2016). Thus, Cd severly affects various cell functions, including the regulation of immune-cell activity and the secretion of cytokines in innate and adaptive immunity.

IMMUNOMODULATORY EFFECTS OF CD ON INNATE IMMUNITY

Long-term exposure to low doses of Cd results in accumulation in innate immune cells. Once Cd has entered the cell, it tends to occupy metal-binding protein domains, replacing essential co-factors in enzymes and thus inhibiting their ability to maintain normal function of cell (Marth et al., 2001). However, apoptosis is an important feature of Cd toxicity. Many innate immune cells and mechanisms facilitate self- and non-self-recognition (Dzik et al., 2001). Innate immune cells include monocytes, macrophages, neutrophils, natural killer (NK) cells, and dendritic cells (DCs) (Marth et al., 2001). Cd exposure affects multiple aspects of innate immunity by regulating innate immune responses, including chemokine expression and release (Razzuoli et al., 2018).

Macrophages play crucial roles in innate immunity and inflammation processes. Wu et al. reported that macrophages exposed to Cd in vitro have abnormal surface levels of Fc-RIIB, resulting in severe cell damage. Macrophages are classified as classically activated (M1) or alternatively activated (M2) based on their pro- or anti-inflammatory phenotype, respectively. The proportion of these two subtypes plays a crucial role in tissue inflammation, injury, and repair (Charles et al., 2012). In response to lipopolysaccharide (LPS) and Toll-like receptor signaling, M1 macrophages polarize and secrete a range of proinflammatory cytokines, such as interleukin (IL)-1b, IL-23, IL-12, and tumor necrosis factor (TNF)-α (Hu et al., 2020). A recent study showed that LPS activates immunity-related processes in macrophages, whereas Cd inhibits these processes (Cox et al., 2016).

Mast cells are distributed throughout the body, generally participate in humoral and antibody-mediated immune responses, and play an important role in the first line of immunity (Akiko et al., 2015). Garcıa-Mendoza et al.´ reported that under Cd exposure in vitro, mouse mast cells showed full dose-response depletion of glutathione (GSH) to below cytotoxic levels. In contrast, LPS-induced TNF- α and immunoglobulin (Ig)E-mediated histamine release in mast cells were attenuated by Cd (Garcıa-Mendoza et al., 2019).

Neutrophils are important participants in the early response to pathogens and acute inflammation. Acute Cd (5 ppm and 50 ppm) treatment elicited an inflammatory effect in rats and increased the number of neutrophils in their spleens (Demenesku et al., 2014). Jiaxin et al. reported that Cd (10 μM) triggered the cytochrome P450s (CYPs) pathway and impaired antioxidant activity, leading to apoptosis and immunosuppression of neutrophils, in the common carp (Jiaxin et al., 2020).

IMMUNOMODULATORY EFFECTS OF CD ON ADAPTIVE IMMUNITY

T-cells are immune system cells that play a vital role in the cell-mediated adaptive immune response (Akiko et al., 2015). Considering that Cd exerts DNA damage and that DNA repair by non-homologous end-joining is required for T-lymphocyte differentiation, it could be expected that Cd affects T-lymphocyte differentiation through this mechanism. However, Viau et al. showed that Cd does not affect non-homologous end-joining or base and nucleotide repair, but that Cd toxicity in T-cells is linked to cell-cycle perturbations (Viau et al., 2007). Cd intake by thymocytes altered the expression of thymocyte surface markers in mice, leading to phenotypic changes, and the lowest Cd concentration used in the study (10 mM) induced changes in different T-cell subsets. In mice, Cd treatment resulted in dose- and time-dependent accumulations of Cd in CD4+ cells and dose- and timedependent decreases in the CD4+ /CD8+ ratio, which is a bioindicator of immunotoxicity. This immunosuppression is result from reduced expression of IL-2 and interferon (IFN)-γ in T-helper (Th)1 cells and reduced expression of IL-4 in Th2 cells (Pathak et al., 2008).

In addition, Cd treatment shows abnormal immune phenotypes in the mouse uterus. Prenatal Cd exposure affected the transcriptomes of T-cells and CD4+ cells and disrupted cAMP-responsive element-binding protein 1 (CREB1) signaling, which is involved in T-cell stability (McCall et al., 2018). When Cd stimulates T-cell subsets, T lymphocytes secrete cytokines, which inturn regulate the cellular immune response. Additionally, IFN-γ, TNF-α, and IL-2 secreted by Th1 lymphocytes inhibit the proliferation of Th2 lymphocytes, while IL-4, IL-5, IL-6, and IL-10 are secreted by Th2 lymphocytes inhibit the proliferation of Th1 lymphocytes. Cd exposure decreased cytokine production in Th1 (e.g., IFN-γand IL-2) and Th2 (e.g., IL-4) lymphocytes (Hanson et al., 2012. Cd affected multiple T-lymphocyte subsets and promoted the expression of inflammatory mediators, thereby enhancing the inflammatory response (Turley et al., 2019). Altogether, Cd significantly alters the adaptive immune response by increasing the inflammatory T cell mediators.

SUMMARY

Cd enters the body via inhalation and ingestion. It accumulates in different various organs, tissues, and cells, and acts on immune organs and immune cells. Thus, most studies investigating the effects of Cd exposure on immunomodulation have been committed to exploring the effects focused on Cd toxicity ion the different organs. When in immune cells, Cd dose-dependently affects cell vitality and functions and can induce apoptosis. Cd exposure impacts innate immunity in terms of phagocytic capacity, proliferation, and status transformation of macrophages, and the increase of neutrophils, thus resulting in an inflammatory response. Cd exposure affects adaptive immunity mainly by resulting in apoptosis of T-cells and B-cells. In B-cells, Cd exposure affects surface antigen expression and selectively inhibits the synthesis of antibodies. Thus, Cd exposure can directly affect the growth of immune cells and their function. Thus, for both occupational and non-occupational exposure to Cd, it is important to focus research to improve public health immunization and awareness to reduce the toxic effects of Cd on the immune system.

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POPULATION GENETICS OF VECTOR MOSQUITOES DETERMINES ENDEMIC ZONES OF DENGUE FEVER & TRANS OVARIAN TRANSMISSION- A CASE STUDY ON *Aedes aegypti* & *Aedes albopictus* IN ECOLOGICALLY DISTINCT ECO ZONES OF THIRUVANANTHAPURAM DISTRICT.

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ABSTRACT

The proportionate distribution of *Aedes aegypti* and *Aedes albopictus* was found to be significantly different in three environmentally diverse eco zones of the Thiruvananthapuram district, Kerala. *A. aegypti* was the most abundant vector in a coastal zone of Thiruvananthapuram city, while *A. albopictus* was the most abundant vector in a hilly, arid suburbanzone. In the city, both mosquito species were found in approximately similar numbers. The high frequency of dengue fever in Thiruvananthapuram city may be due to the abundance of microhabitats that sustain *Aedes aegypti.* Fourth instar larvae were recognized using larval keys and later validated their identities after emergence during breeding habitat surveys. Lower instar larvae were raised in the lab and identified using adult keys after emergence. According to a study on Molecular Analysis, Type 1 was the most prevalent of the four dengue serotypes. The high frequency of dengue fever in the urban zone may be due to the abundance of microhabitats in Thiruvananthapuram that sustain *Aedes aegypti*.

Key words: *Aedes aegypti, A. albopictus*, dengue hyper endemic zones, microhabitat specificity, Container Index, House index, Breteau index

INTRODUCTION

Dengue fever (DF) is one of the world's most widespread infectious diseases, with transmission occurring in 128 countries (Mahalingam *et al.,* 2013). Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS), which affect over half of the world's population, can spread epidemically and endemically in any location where Aedes mosquitoes (*Aedes aegypti, Aedes albopictus*) reproduce (Farrar *et al*., 2007).

DF is most common in the tropics during wet seasons. The mosquito becomes infective after biting an infected human after an incubation period of 8 to 22 days, with an average of 11 days. Dengue fever was first reported in India in 1780 by 224S. Sunil Kumar *et al.,* Of Chennai, and the authentic report was available Kolkata in 1963 (Gupta *et al*., 2012).

DF infections were documented in India during the 1970s from states such as Karnataka (George and Soman, 1975),Uttar Pradesh (Chadurvedi *etal*.,1974) and Maharashtra (Prasada Rao *etal*.,1981), with *Aedes aegypti* as the predominant vector. Following an epidemic in Kerala in 2003, multiple instances of DF were recorded from a number of districts, including those in the WesternGhats' sylvian surrounds, such as Idukki and Kottayam (Tyagi *etal.,*2006). During the year 2006, a sparse distribution of DF was recorded from various parts of Kerala, with Thiruvananthapuram district accounting for 65 percent of all human viremiacases. DF infection with several DSS and deaths was recorded from various regions of Kerala in 2017, with the Thiruvananthapuram district being the worst impacted in the state (Kumar *et al*., 2013).

Kerala, with an average population density of 819 people persquare kilometre, provides adequate opportunities for vector mosquitoes to survive. DENV1-4 is four closely related viral strains that cause dengue fever. The flaviviruses transmitted by mosquitoes are single-stranded RNA viruses that are antigenically different yet have 60-80% similarity. Infections provide long-term protection against one serotype but no resistance to other serotypes (Gupta *et al.,* 2014). Serological examinations of patients during a dengue fever out break in Delhi in 2003 revealed that DENV1, DENV2, and DENV3 were similarly dispersed, but DENV4 could not be found (Lalith Dhar *et al.,* 2006).

The present study was undertaken to know the dynamics of dengue transmission in relation to microhabitat analysis of different sites of Thiruvananthapuram city on the basis of the vector density of related species of mosquitoes.

OBJECTIVES

1. To analyze the mosquito index of different eco zones of Thiruvananthapuram District.
2. To study the role of environmental factors in the distribution and abundance patterns of *A. aegypti* & *A. albopictus* along analtitudinal gradient.

3. Direct Multiplex RT-PCR for the detection of viral antigen

METHODOLOGY

1. **Study site:**

The Indian state Kerala has a total area of 38863 km2 and a population of 36.6 million, with 31.16% lives in urban areas. Thiruvananthapuram district of Kerala is fairly humid and warm throughout the year with relative humidity ranging from70-90% and temperature ranging between 22-35.50 C respectively. The annual precipitation is high, reaching up to 300cm / year (Meteorological Department, Meteorological Centre, and Thiruvananthapuram). The larval surveys were undertaken in 3 months. March, April and May (summer). Since Thiruvananthapuram forms the epicenter of this disease, sites such as Kannammoola, Pattom (Urbansite), Sreekaryam, Pangappara (Sub-urban) and Poonthura,Vizhinjam (Coastal site) were selected for entomological and clinical study. 50 houses were selected from each site for the study. Urban sites are within the heart of the city and population density is highest among the three study sites. The study site in Sub-urban is moderately an elevated and arid zone.

Entomological survey: In each of these representative sites, 50 houses were thoroughly checked for the breeding of Aedes mosquitoes. The survey was carried out on outdoors, indoors and also at premises of houses. The breeding sites such as cisterns, cement tanks, metal containers, plastic drums, grinding stones, mud pots, plastic bottles, flowerpots, flower vases, polythene sheets and natural breeding sites such as coconut shells, tree holes, fallen spates or bracts were observed from these localities. Among the above breeding sites mudpots were found to be possessing highest number of larval and pupal density.

Small containers (< 20 litter) were drained through strainer in to white larval sampler (25x20x4 cm) to collect the immature stages of mosquitoes. Large breeding places like ground level cement tanks; fountains etc were sampled using a 250ml larval dipper. Five dips were taken from the surface water of each breeding place.The duration of study was 3 months.

Collection of *Aedes* egg and larvae from 3 different eco zones-urban, sub urban and coastal areas of Trivandrum district.

SI.No.	Divisions	Study Site	No. of houses studied
1	Urban	Kannammoola, pattom	50
2	Sub-urban	Sreekaryam, Pangappara	50
3	Coastal	Poonthura,Vizhinjam	50

2. **Identification and maintenance of Experimental organism**: The eggs were collected using ovi traps and the larvae were reared in bug dorm and fed with yeast or cat food. Larval identification was done using standard taxonomickeys (Barraud, 1934; Harbach, 2014).

3. **Viral Nucleic Acid (RNA) Isolation**: the samples were subjected for cryo pulverization using liquid nitrogen. The technique was done using a mortar and pestle, the samples were frozen in liquid nitrogen and grinded into a fine powder. The powder was then dissolved incelllysis buffer and centrifuged at12000 rpm for10 minutes;the supernatant was collected and preceded to then extstep.Viral nucleic acid isolation from the supernatant was carried out using QIAGEN's QIAamp Viral RNA Extraction Kit®(QIAGEN,Germany),following the manufacturers protocol.

One-step one-tube Multiplex PCR amplification with serotype-specific primers:A direct one-step, onetube multiplex PCR amplification reaction was performed for differentiation of dengue virus serotypes. This method involves the usage of the isolated viral RNA directly with D1 consensus primer and serotype specific primers in a single tube reaction. The isolated viral RNA is directly used as the template. The PCR products were then electrophoresed on 1.5% Agarose gel in 1X TAE buffer. 0.5 µL each of the serotype specific primers TS1, TS2, TS3, TS4 as reverse primers, were added along with 0.5 µL D1 forward primer in one single tube along with TaKaRa's Prime Script One Step RT-PCR Master Mix (TaKaRa, Japan) consisting of 12.5 µL of 2X One Step RT buffer, 0.5 µL of Taq Polymerase (5 units/µL), 0.5 µL of 5X Reverse Transcriptase Enzyme and 3.0µL of RNase Freed H_2O. A total reaction volume of 25µL wassubjected to PCR for 40 cycles, with an initial cDNA synthesis step at 420 C for 5 min, initial denaturation at 940 C for 10 sec, denaturation at 940C for 30 sec, annealing at 550 C for 60sec, and extension at 720 C for 60 sec, and a final extension at 720C for 60 sec. The products were analyzed as bands on a 1.5% Agarose gel in 1XTAE buffer.

Table1: Oligonucleotide primers and their sequences used in RT-PCR

Name	**Nucleotide sequence (5'to3')**	**Product size(bp)**
D1	TCA ATA TGC TGA AAC GCGCGAGAA ACCG	511
TS1	CGTCTCAGTGAT CCGGGGG	482
TS2	CGCCACAAGGGC CATGAACAG	119
TS3	TAACATCATCAT GAGACAGAG C	290
TS4	TGTTGTCTTAAA CAAGAGAGGTC	392

1. **Data analysis:** From the entomological data the following indices were calculated as described in standard methods, House Index (HI), Container Index (CI) and Breteau Index (BI) (WHO, 2009).

2. House Index (HI) =number of houses positive for Aedes breeding/ houses checked X 100 Container Index (CI) = number of positive containers/ total containers checked X 100 Breteau Index (BI) =number of positive containers/total number of houses searched X 100

RESULTS

The study is on the distribution of different species of mosquitoes in the selected sites such as urban, semiurban and coastal zones of Thiruvananthapuram City proved that *A. aegypti* and *A. albopictus* are the dominant mosquito species. Sporadic occurrence of *Culex quinque fasciatus, Anophelis stephensi* and *Armingerus subalbatus* were also located in the study sites. Occurrence of *Culex quinque fascitus* was observed in foul smelling water collection such as leakages of drainage vessels and septic tanks possessing rich sources of putrefied animal wastes. Larvae of *A. aegypti* and *A. albopictus* were observed in comparatively less polluted water with no foul smell. Even indoor collection of water for drinking purposes, stored in closed containers possessing very little space between the lid and rim of containers were the breeding sites of both species of Aedes. More than 8 types of habitat diversity is noted from the study including barrels/drums, plastic tanks, cement tanks, coconut shell, discarded tyres, flower pots, minor plastic containers, flower vases/pots for keeping money plants or lucky bamboos, drip trays of refrigerators or coolers, leaf axils etc. (Plate1, Fig1 and Table1).

Table 2. Habitat Diversity indoor and outdoor

Breeding Habitats Outdoor	**Breeding Habit at Indoor**
Barrels/drums	Flower vases
Plastic tanks	Pots
Cement tanks	Driptrays inrefrigerators
Coconutshells	Driptrays incoolers
DiscardedTyres	Leaf axils
Flowerpots	
Minorplastic containers	

Fig1. Habitat diversity outdoor and indoor:a-plastic container,b-drum,c-tyre,d-plastic covered cement tank, f-drip tray in refrigerator, g-flower pot, h-leafaxil.

The three eco zones of Thiruvananthapuram city showed marked variations on the occurrence of *A. aegypti* and *A. albopictus.* The semi urban zone of Thiruvananthapuram city is a dry and elevated site from sea level, where almost 90% of the mosquito larvae observed was *A. albopictus* and the remaining was shared by *A. aegypti* and no other species of mosquito was observed (Table 2). In coastal zone, almost 90% of the mosquito larvae were that of *A. aegypti* and remaining of the larvae were *A. albopictus* (Table2). Coastal zone possessed a scanty distribution of *Anopheles stephenci* larvae, which were observed in water collection with less pollution or less stench. In the city core area both *A. aegypti* and *A. albopictus* were observed almost equal proportion. The vector density of the three eco zones was different. The larval indices of each study site have a stable density of mosquitoes. The median (HI)of coastal zone and sub urban area is almost same 30 and 31 and in case of BI its same ,that is 32.The urban zone the all the vector indices are lower than the suburban and coastal (Table2).The CI of coastal zone is higher from all the other areas.

The dominant vector mosquitoes observed in three study sites exhibited sharp variation in terms of species and number. The sub urban zone is dry and elevated site from the sea level almost 90 % of the mosquito larvae were *A. albopictus* and the remaining were shared by *A.aegypti.* In coastal zone, almost 90 % of the larve were that of *A.aegypti* and 10% of the larvae were *A.albopictus*. (Table 2). Coastal zone possess a scanty distribution of *Anopheles stephenci* larvae. In the urban area 80% of larvae were *A.albopictus* and the remaining is *A. aegypti*. Presence of culex, anopheles and *Aedes vittatus* were observed as part of study.The vector density of the 3 eco zones was different. The larval indices such as HI, CI and BI were high in suburban and coastal zones.

Table 3. Larval indices of three eco-zones of Thiruvananthapuram city and the distribution of *A. aegypti* and *A.albopictus*

Study Site	URBAN			SUB-URBAN			COASTAL		
Month Index	HI	CI	BI	HI	CI	BI	HI	CI	BI
March	10	25	10.5	30	49	29	35	50	32
APRIL	15	20	19	40	35	32	31	47	43
MAY	7	11	13	28	40	33.6	36	54	30

MEDIAN	10	20	10.5	30	35	32	31	47	32
Proportion of& *A. Aegypt* *A. albopictus*	1:2			1:9			9:1		

Table 4. Incidence of dengue fever in Kerala and respect of Thiruvananthapuram district (Directorate of Health Services, Kerala)

MONTH	Thiruvananthapuram District		Kerala State	
	Dengue Fever	Death	Dengue Fever	Death
March	27	1	136	1
April	37	-	164	-
May	25	-	113	1

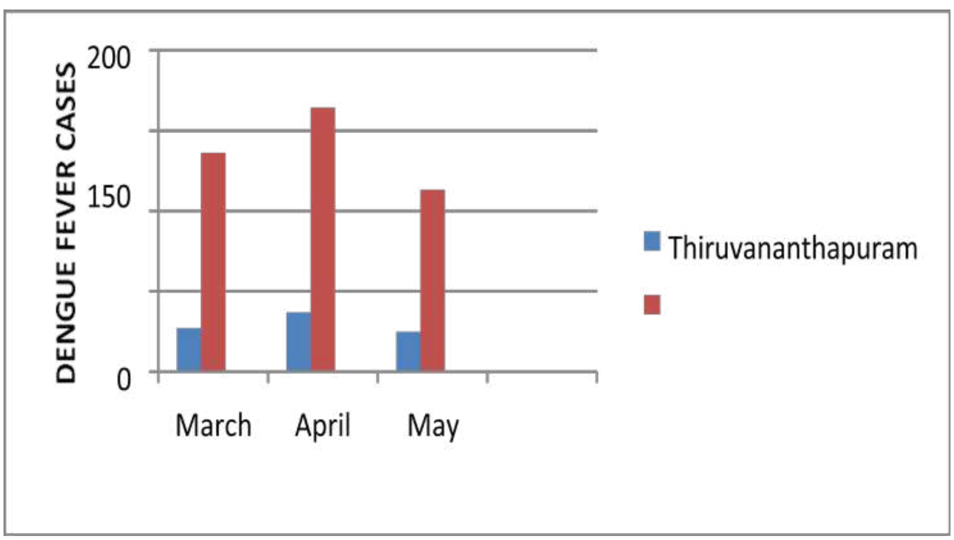

Figure 2. Dengue fever cases in Kerala and Thiruvananthapuram

The 511 basepair fragment obtained from the amplification of the Dengue viral nucleic acid was used as a cDNA template for a second round of amplification using a single tube multiplex PCR reaction. The same serotype specific primers (TS1,TS2,TS3, and TS4) were used as reverse primers along with D1consensus primer as the forward primer in a single tube. The amplification gave serotype specific fragments, which were observed on the gel. The fragment size of each serotype corresponded to the expected size. Fig 2 From the molecular analysis it is clearly understood that that from all the 3 zones dengue cases were reported.

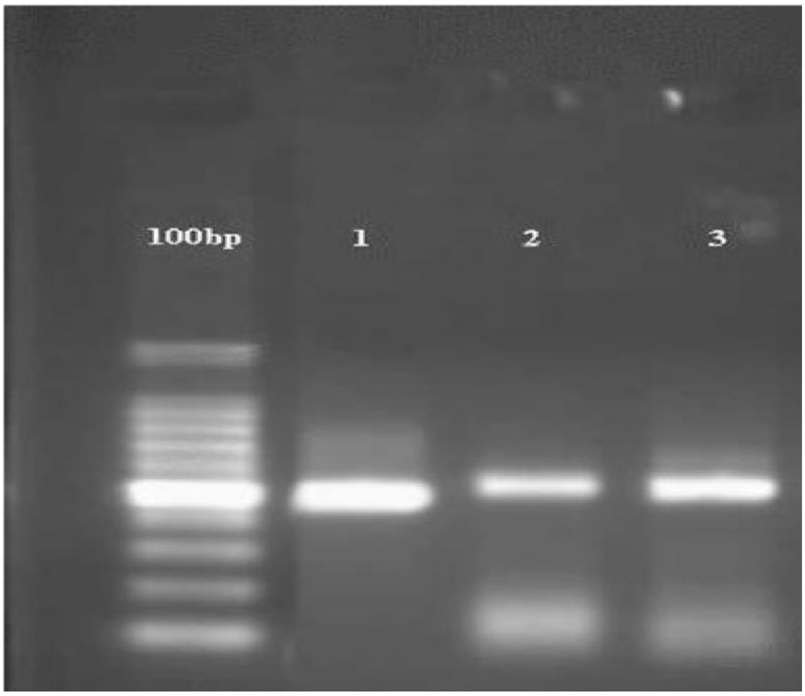

Fig 3. Agarose gel electrophoresis showing dengue viremia from 3 ecozones (1. urban 2. Sub urban 3. Coastal zone)

DISCUSSION

The present study clearly showed that the species diversity of mosquitoes in three eco-zones of Thiruvananthapuram city exhibited contrasting difference especially on the distribution of *A.aegypti* and *A. albopictus*. In the coastal zone *A.aegypti* was the dominant species and in the hilly suburban zone *A.albopictus* was the dominant species. In the city core area (urban) almost equal distribution of both species of Aedes mosquitoes were observed. Similar observations were reported from Rajastan in which different eco zones such as desert area, forest and river area and semi arid area exhibited sharp difference on the distribution of *A.aegypti* and different strains of DENV (Bennet and Joshi, 2009). Both species of mosquitoes are highly precise on their preference in niche selection. Previous reports also supports the present investigation that, in Trissur district of Kerala,the rubber plantations possessing coconutshells used for collecting rubber latex showed the larvae of *A. albopictus* only during rainy season and no *A. aegypti* larvae in the whole plantation area (Sumodan, 2003). A very remarkable observation made in the present study is the relationship between dengue viremia in the study sites and the distribution of mosquito population. Insuburban site, *A.albopictus* was the dominant mosquito, in which Dengue infection were moderate but in the other study site, the coastal zone, there was high prevalence of Dengue infection, in which the dominant mosquito vector was *A.aegypti* (WHO, 2003). This clearly indicates that *A. aegypti* is one of the true vectors of DF and the role of *A.albopictus* role is significant.

House index (HI) describes of vector mosquitoes in a region. According to WHO estimates, an area with high HI (higher than 10%) is considered as high risk zone for the dengue fever ,and a zone with lowHI (less than 1%) is safer and low risk zone. The present study demonstrated that all three areas exhibited HI>10%which indicated that all 3 zones are high risks for dengue transmission.

Container index (CI) illustrated the number of positive water reservoirs which contains larvae.The higher value of CI in a place indicates the high risk of occurrence and spread of mosquito-borne disease.The standard value set by WHO for CI are less than 5% (WH0,2003). The CI was high is all 3 sites indicates the higher riskof occurrence and spread of disease.

The Breteau Index (BI) establishes a relationship between several positive containers and houses. BI indicates prevalence rather than abundance. Among the 3 inidices, BI is considered as the best which is more qualitative, and it has more epidemiological significance. As per the WHO criteria, a region with BI lower than 5 is considered as safe zone and BI 5to 20 and 35 to 50 are considered as regions with low risk and higher risk, respectively. The fact is that if it refers to the WHO criteria, there will be no area that is safe from dengue infection. In our study site the urban and sub urban sites falls under the category of low risk area whilecoastal zone shows high risk status.

Clinical data from the Department of Health, Govt. of Kerala, clearly showed that, Thiruvananthapuram district of Kerala carry the major share of DF. This clearly indicated either ecological factors or genetic factors of vector mosquitoes is favoring Thiruvananthapuram district to be the most favorable zone in Kerala for maintaining dengue virus. Similar type of observations is reported from Australia in which socio demographic and ecological features play a significant role on the distribution of *A.aegypti.* People of high economic group possessing rain water harvest tank above the houses provide ample chances to this mosquito to breed in this tanks, but the people living in small houses, where the disease is uncommon because the abundant vector in such places is *A.albopictus* (Rokeya *et al.*, 2017). Compared to Thiruvananthapuram species level difference on the distribution of DENV, it is not a rare phenomenon preference in relation to egg laying behavior of *A. aegypti* changed in accordance with season. During summer, the preferred egg laying sites for Aedes mosquitoes were indoor collections of water, but after summer rains and during rainy seasons the preferred sites were outdoor collection of water in discarded containers. Dengue infection in three study sites showed a co-relation with species level distribution of *A.aegypti* and *A.albopictus*. Dengue infection in areas with abundance of *A. aegypti* was higher than that of the areas with abundance of *A. albopictus.* The present study proved that *A. aegypti* and *A.albopictus* exhibits microhabitat specificity on their distribution and this has major influence on the transmission of DENV on each microhabitat.

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ASSESSMENT OF TOXIC EFFECTS OF GLYPHOSATE ON EPIGEIC EARTHWORM, *Eudrilus eugeniae*.

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ABSTRACT

For the last few decades, an excessive use of chemical pesticides in agriculture has polluted soil to an alarming level. It leads to change in aeration of soil and its fertility which further leads to an imbalance between flora and fauna residing the soil. Earthworms are the excellent bioindicator for evaluating the health status of soil ecosystem. Earthworms digest organic matter and increase nutrient content in the top layer of soil. They protect humanhealth by ingesting decomposing litter and serving as bioindicators of soil activity. Application of chemical fertilizers and pesticides in the field increased the crop yield but also disturbed the biodiversity of earthworms and other soil microbes in the soil. Pesticides have had harmful effects on growth and reproduction on earthworms. From this perspective, earthworm, *Eudrilus eugeniae* were exposed to different concentrations of herbicide glyphosate for 96h by soil toxicity method. The LC50 of glyphosate were determined by probit analysis. To assess the sub-lethal effect of this herbicide, *E.eugeniae* were exposed to 3 sub-lethal doses (1800µl/kg, 1700µl/kg and 1600µl/kg) of glyphosate for 3, 6, 9 days. Variations in morpho-behavioural changes were observed after treatment. Other than these, the present study showed significant changes in antioxidant enzymes. Such changes indicate potential health risk to *E. eugeniae* if exposed to the high concentrations of this herbicide in soil.

Keywords: *Eudrilus eugeniae*, Glyphosate, Antioxidant enzymes

INTRODUCTION

Glyphosate-based herbicides (GBHs) are the globally most widely used pesticides applied in many sectors of agriculture, forestry, landscape planning, municipalities, and in private gardens (Zaller, 2020). Several hundred GBHs are in use and it is estimated that about 825 million kilo-grams of the active ingredient (AI) glyphosate (N-phos-phonomethyl- glycine) is globally used per year (Benbrook, 2016). It is rarely acknowledged that the AI glyphosate is not a single chemical but rather used in various salt forms with different chemical, physical and toxicological properties. Glyphosate has been shown to cause acute and chronic toxicological effects on a variety of animals. Glyphosate and its metabolite amino methylphosphonic acid (AMPA) are among the most commonly found pesticide residues in soils (Silva *et al.,* 2017) and water bodies around the world (Borggaard and Gimsing, 2008). In aquatic systems glyphosate residues can affect the growth of algae and development of amphibians (Baier *et al.,* 2016).

Earthworms constitute the majority of soil faunal biomass in many temperate agroecosystems with up to1000 individuals and 300g of biomass in each square metre of land (Relyea, 2005). They modulate Agro ecosystem function by affecting nutrient cycling and decomposing organic material (Creamer *et al.,* 2015), recovering soil carbon pools after disturbance (Relyea, 2005), maintaining soil microbial diversity (Schimel and Schaefer, 2012), controlling plant pathogens (Angst, 2019), influencing water infiltration, and interacting with above ground organisms (Liu *et al.,* 2019). Thus, any herbicide-induced effect on earthworm activity will impact these ecosystem functions and influence water infiltration, and the binding and leaching of glyphosate.

MATERIALS AND METHODS

Experimental design

Glyphosate was used as the test chemical. Based on the acute toxicity studies, 96hr LC50 value of the chemical was found according to Organization for Economic Co-operation and Development (OECD, test number: 207) Guidelines by using probit analysis. Based on this, sub-lethal doses of glyphosate such as 1600µl/kg, 1700µl/kg, and 1800µl/kg were selected for exposure.

Animals and maintenance

Earthworms, *Eudrilus eugeniae* used in the experiment were procured from Integrated Farming Systems Research Station (IFSRS), Nedumcaud, Karamana, Thiruvananthapuram, Kerala. They were carefully brought to laboratory along with mother culture and moist soil. Before experimentation, the earthworms were acclimatized for 15 days into rearing tank (95×55×75cm3), containing 10cm layer of uncontaminated cow dung with moist soil (1:1).A thin layer of leaves and dried moist grass were used for shade and moisture. The moisture level of the containers was Maintain about 60–70% through out the study period by sprinkling an adequate quantity of water. To prevent moisture loss, the containers was covered with gunnybags and placed in a humid and dark room at a temperature of 27°C.

Sampling and sample preparation for enzyme assay and protein measurement

The earthworm was starved 24hr prior to sacrifice for getting optimum and stable physiological state. 100mg muscle was homogenized in1ml of Tris HCL buffer (pH 7.2). Homogenates were centrifuged at 10,000 rpm for 10min at 4^0C (Eppendorf, Germany). After centrifugation, the supernatant was collected and kept in a deep freezer (Rotek) maintained at -20^0C until biochemical analysis.

Determination of protein

The total protein content was determined separately using the same tissue extract according to the protocol of Bradford (1976), and bovine serum albumin was used as a standard. The absorbance was measured at 595 nm.

Assay of antioxidant enzymes

Superoxide dismutase (SOD)

The activity of SOD was estimated as per the protocol of Kakkar *et al.,* 1984. The assay mixture was composed of 1.2ml sodium pyrophosphate buffer(0.052M,pH 8.3), 0.1 ml of 186 mM phenazine methosulphate, 0.3ml of 300mM nitroblue tetrazolium, 0.2ml of 780mM nicotinamide adenine dinucleotide (NADH), appropriately diluted enzyme preparation, and water in a volume of 3ml.The reaction was started by the addition of NADH and was stopped by the addition of 1 ml of glacial acetic acid after the incubation at 30°C for 90s. The assay mixture was agitated vigorously and shaken with 4 ml n- butanol and was allowed to stand for 10 min, centrifuged at 2500 rpm for 10 min, and the butanol layer was carefully pipetted out. The color intensity of the chromogenin butanol was measured at 560 nm against a blank (butanol) using ultraviolet–visible spectrophotometer (Perkin Elmer). One unit of enzyme activity was defined as the concentration of SOD required to inhibit the optical density at 560nm of chromogen production by 50% in 1min under the assay conditions. The specific activity was expressed as IU/mg protein.

Catalase (CAT)

The activity of CAT was measured as stated by Maehly and Chance (1954). The activity was spectrophotometrically estimated after the decrease in absorbance at 230 nm. The assay mixture consisted of 3 ml phosphate buffer (0.01 M, pH 7), 0.2 ml of 2 mM hydrogen peroxide (H_2O_2), and 1 ml of approximately diluted extract prepared by homogenizing the tissue in 10 mM buffer. A system lacking the extract constituted blank. The specific activity was expressed in terms of n moles of H2O2 decomposed/minute/mg protein.

Glutathione S transferace

The activity was assessed according to Habig *et al.,* 1974. The admixture comprised 1 ml phosphate buffer (0.5 M, pH 6.5), 100µl 1-chloro,- 2,4- dinitrobenzene (CDNB) (30 mM), 0.1 ml reduced GSH (30 mM), and 100µl tissue extract. The increase in optical densitywas measured against the blank at 340 nm for 2 min.The activity was expressed as n moles of CDNB–GSH conjugate formed/minute/mg protein for tissue samples.

Glutathione content (GSH)

GSH content was estimated according to the protocol of Benke and Cheevar (1974). The assay mixture contained 2ml of 0.3 M phosphate buffer (pH 7.4), 500µl 5,5′-dithio-bis-2-nitrobenzoicacid(0.04%), and 200µl tissue extract. A system without extract was taken as blank. Change in absorbance was measured at 412nm within 10min.The specific activity was expressed as nmol/ 100 g tissue.

Statistics

Data evaluation was done by the analysis of variance. The differences in means were tested by using Duncan's analysis. The significance level used was 0.05. The association of variables was studied by the Pearson correlation test. All the statistical analyses were carried out using the software SPSS 20.0 for Windows.

RESULTS AND DISCUSSION

Morpho-Behavioural study in the wholebody of *E. eugeniae* after exposure to glyphosate.

The earthworms, which were treated with glyphosate showed a number of behavioural changes. Decreased burrowing activity, coiling of their body and sluggish movement were observed during the experimentation on earthworm. The rate of changes increased with increasing concentration of glyphosate.The control group of earthworms were free from behavioural changes. There were certain morphological changes observed in the earthworms during treatment with glyphosate. The major morphological changes were body fragmentation, discolouration, haemorrhage, bloody lesion, mucus release, rupturing of clitellum, clitellar swelling, blisters in body, body swelling and tissue inflammation. According to Rao *et al., ., .* (2003), chlorpyrifos exposure caused morphological alterations on earthworm, *Eiesnia foetida.*

In the present study, SOD activity decreased significantly in glyphosate exposed test groups, with respect to the control. Owagboriaye *et al.,* (2020), reported significant increase in SOD activity in three earthworm species including *Alma millsoni*, *Eiesnia foetida* and *Libyodrilus violaceus*, exposed to glyphosate. Influence of the test chemicals may significantly alter the SOD activity. SOD catalytically scavenges superoxide radical, which appears to be an important agent of toxicity of oxygen, and this provides a defense against oxygen toxicity. The activities of CAT, and GPx showed a significant increase after exposure to glyphosate. This indicates that the whole body of earthworm experienced oxidative stress due to the increased H2O2level (Neuhauseretal.,1995). CAT breaksdown hydrogen peroxide, forming water and oxygen. It is primarily found in peroxisomes; however, it is present in mitochondria and cytosol as well. CAT activity is considered as a sensitive biomarker of oxidative stress in fish (Gul*et al.,* 2004). In this investigation,it is obvious that activity of CAT increased significantly at all exposures to sublethal doses of glyphosate.

CONCLUSION

The current investigation offers an insight into the potential impact of widely used herbicide, glyphosate in the whole body of *E. eugeniae.* This study demonstrated the behavioural and morphological changes in *E.eugeniae,* also the alteration in antioxidant enzyme system. From present study, it is understood that this test chemical have altered the activity of antioxidant enzymes along with behavioural and morphological changes. This study showed that earthworm is an excellent model organism for the study of various effects of toxic chemical present in soil, since they can metabolize and concentrate pollutants present in the soil. Monitoring of the biomarkers in living organisms including earthworm is a good approach and serve as early warning of adverse changes and damage resulting from insecticides and other chemicals present in the soil.

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A PRELIMINARY INVESTIGATION INTO THE ABUNDANCE OF SOIL ARTHROPODS IN SELECTED LANDSCAPES OF THIRUVANANTHAPURAM DISTRICT

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ABSTRACT

Soil is a complex ecosystem harbouring an enormous diversity of organisms. Soil biota promotes soil health and fertility. Arthropods are litter transformers or ecosystem engineers which physically modify their habitat, directly or indirectly. Present study is a preliminary investigation into the presence of diverse groups of soil arthropods in different habitats. The relative abundance of isopods was high in all the sites, the highest being recorded in site I (35.7) and lowest (19.01) in site II. Chilopoda showed lowest abundance among the orders in all the sites, the lowest being recorded in Site I (1.12). Collembolans were found in moderate abundance in all the sites. Acarines showed highest abundance in Site II. Of the eight orders identified in this study, Chilopoda and Diplopoda showed least relative abundance in all the sites. Diversity indices provide important information about rarity and commonness of species in a community.

Key words: Soil arthropods, relative abundance, diversity index

INTRODUCTION

Biodiversity represents the sum total of various life forms such as unicellular micro-organisms and multicellular organisms at various biological levels of ecosystems. In terrestrial systems, the soil is considered a major reservoir of biodiversity. It is a dynamic three-dimensional natural body of landscape developed from weathering of rocks through various pedogenic processes, possessing distinct physico-chemical and biological characteristics (Pal, 2016). Soil is one of the species-rich habitats of terrestrial ecosystems, especially if the definition is extended to related habitats like vertebrate faeces, decaying wood, and humus of hollow trees,the soil biota in turn promoting soil health and fertility. The soil, including the deepest horizons and the rhizosphere, might constitute a huge reservoir for biodiversity (Andre *et al.,* 1994).

Each member of the diverse soil biota has a specific role in the complex web of life in the soil. Most of them are soil or litter dwellers whichact as ecosystem engineers transforming plant litter physically and chemically into substances amenable to further degradation by microflora and vice versa. Studies on the role of soil fauna in ecosystem functioning require accurate characterization of the soil community food web, identification of the potentially important species and groups as well as the interactions among them (Menta C, 2012). Soil ecosystem supports a complex of animal communities of which soil arthropods were of prime importance since they constitute the major component of soil mesofauna in all types of soils. The soil arthropods include a variety of mites, collembolans, pseudoscorpions, centipedes, millipedes, symphylans, diplurans, proturans, hymenopterans, coleopterans etc. Arthropods are litter transformers or ecosystem engineers which physically modify their habitat, directly or indirectly (Jones *et al.,* 1994). Of the hemiedaphon and euedaphon, five major groups represented are Isopoda, Myriapoda, Insecta, Acari, and Collembola, the latter two being by far the most abundant and diverse (Eisenbiech and Wichard, 1987). Saprophagous arthropods affect decomposition directly as they feed on litter and adhering microflora, thus converting the energy contained therein into production of biomass and respiration, and indirectly, through conversion of litter into feces and re-ingestion of fecal material, mixing of litter with soil, and regulation of the microflora through feeding and the dissemination of microbial inoculum (Lavelle, 1997).

The microarthropods comprise the important middle links of soil food webs, serving, in their role as both predator and prey, to channel energy from the soil microflora and microfauna to the macrofauna on higher trophic levels (Colemann *et al.,* 2004). Soil microarthropods play significant role in ecological dynamics in soil and therefore have drawn attention of workers around the globe including India (Crossley and Coleman, 1999; Colman *et al.,* 2004; Devi and Singh, 2006; Chitrapati and Singh, 2006). Soil practices in agricultural ecosystems significantly alter arthropod community which in turn has significant effect on soil productivity. Hence, understanding soil arthropod communities will prove useful in developing management plans for both wild and cultivated ecosystems. Heneghan *et al.,* (1999) reported that there was a positive relationship between species richness and the contribution of the fauna to litter mass loss within each site.

Ecosystem-based, baseline arthropod fauna are integral to evaluating existing cropping practices and aid in the redesign of farming systems to make them economically viable and environmentally sustainable (Olfert, 2002). Vasileios *et al.,* (2014) compared management systems and agroecological zones in terms of total abundance, diversity, and functional subgroup. Ecological investigation, such as their distribution and abundance helps in understanding, describing and studying the distributional pattern of these animals and also major role in soil formation, nutrient cycling etc. The objective of the present study is to identify the presence of major groups of soil arthropods inhabiting three habitats and the abundance of the different groups.

MATERIALS AND METHODS

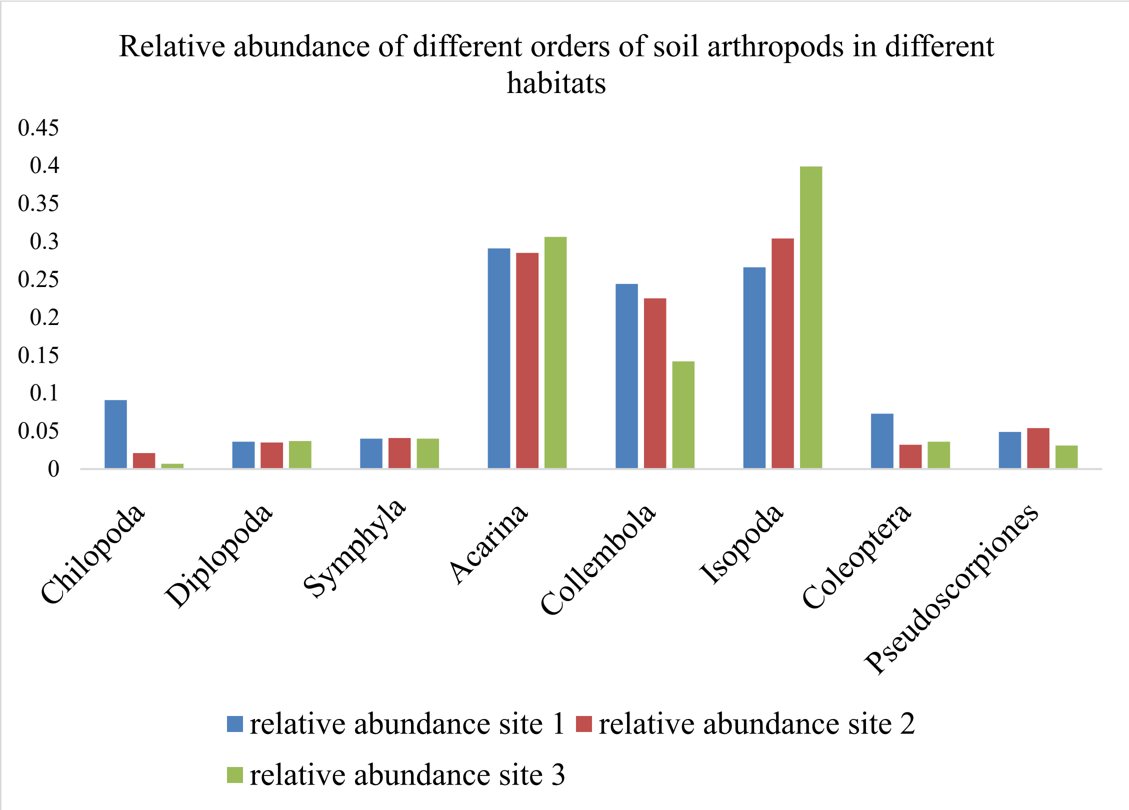
Soil samples were collected from three sites in Neyyatinkara Taluk of Thiruvananthapuram district.Site I was a mixed agro ecosystem , site II was a natural system with varied vegetation and site III, a monoculture plantation (rubber plantation). Fifteen core (5cm diameter) samples were collected from each of the five sub-plots of $1m^2$ area from each site. Extraction was done using Tullgren funnel apparatus. Macroarthropods were counted manually. Microarthropod groups were sorted from the extract and preserved in 80% alcohol. As a trial, wood board traps were also set in the field which provide a natural hiding place for the cryptic species. The microarthropods were identified using a dissection microscope up to the level of orders. Abundance and relative abundance were calculated. Diversity indices were also found out.

RESULTS AND DISCUSSION

The number of individuals from each sample was counted and analyses were done. Of the eight orders identified collected from the site 1,the relative abundance was high for Order Acarina (0.299) while lowest value was for Order Chilopoda (0.017).The relative abundance was high for Order Isopoda (0.304) while lowest value was for Order Chilopoda (0.021) at site 2.Order Isopoda (0.399) showed highest relative abundance in site 3 while lowest value was for Order Chilopoda (0.007).In all the study areas relative abundance of Chilopoda was found to be least while Isopods showed highest abundance in site 2 and site 3. Acarines showed highest relative abundance in in site 1 and comparatively high abundance in other two sites, while isopods were found in abundance in site 2 and site 3. Acarines, Collembolans and Isopods are known for their litter decomposition activity. The soil in site 2 and site 3 was found to be rich in humus in physical examination of soil. Symphyla, Diplopoda and Psudoscorpiones showed almost even abundance in these habitats.

The high relative abundance of acarinaat all the sites can be due to the presence of decayed wood material in the habitat. Chitrapati (2002) reported that Acarina comprised 66% of total soil microarthropods.Ojeda and Gasca (2019) in their study regarding diversity of microarthropods reported that acari was the most abundant and diverse group and is dominated by Prostigmata and Oribatida; Hexapoda represented by Collembola, Coleoptera, Hemiptera, Hymenoptera,

Figure 1: Graph showing the relative abundance of different orders of soil arthropods.



and Psocoptera, attributing the differences in mite assemblages to the type of vegetation at different sites. Collembola showed high abundance at site 1 and 2. Coleoptera showed highest value at mixed agroecosystem. Fahri*et al.,* (2016) noted that a polyculture area with fairly low intensity of disturbance and availability of branches, decayed wood and dense canopy cover supports high cerambycid diversity which can be attributed to availability of twigs and bark as a major habitat of beetle larvae. Felin (1980) observed that larvae of longhorn beetles play an important role in wood decay, by eating dying plants or dead wood. The food preference of Cerambycid beetles points to their role as biological indicators of forest areas (Yanega, 1996). Greater abundance of Acari compared to Collembola indicates good soil quality and habitat stability. Soil fauna affects the distribution of organic matter in the soil profile which in turn is the result of the nature of litter present and the faunal effects tend to be greatest in ecosystems under transition, like those under successional stages. (Frouz, 2018).

Chilopods showed much difference in relative abundance in different habitats. Changes in centipede communities depend on changes in habitat and therefore in prey abundance. Klarnel *et al.,* (2017) observed that Chilopoda communities are affected by increasing pH in the litter layer. Isopod species were found to have relatively high abundance in all the sites. Isopod distribution and abundance is found to depend on food availability, especially dead and decaying organic matter as well as air humidity (Solomeau, 2019). Their richness tends to increase with woody plant richness and soil organic matter. Simoni *et al.,* (2014) reported a higher presence of this group in the less impacted natural cover soil than in the conservational tillage soil, highlighting the high sensitivity of Isopoda to habitat stress.

Shannon-Weiner index at site I was2.424, at site II was 2.38 and at site III was 2.19. Simpson indexat site I was 0.227, at site II was 0.23 and at site III was 0.27. Dominance indexat site I was 0.77, at site II was 0.76 and at site III was 0.72. Roy *et al.,* (2020) in their study on soil arthropod diversity in agroecosystems reported that the Shannon diversity index (H) was found to be appreciably high in organic gardens than in planned agrosystems. All the study sites were similar in evenness. The species composition and abundance of the soil fauna are influenced by the geographical location climate, physical and chemical properties of the soil, type of vegetation cover, nature and depth of the litter and humus and a variety of other environmental factors. The type of vegetation cover in the habitats studied here differs. Lakshmi and Joseph (2017) in their study regarding microarthropods in home gardens suggested the scope of implying their indicator value related to soil quality, management and conservation of tropical home garden ecosystems, which are facing threats of removal of canopy and unscientific land management practices.

The present study as a preliminary effort to study the presence of various soil arthropods in different habitats, had recorded varying presence of these organisms in different habitats. These organisms being key regulators of soil food web require much attention with regard to anthropological intervention especially agricultural practices. Negative impacts on soil faunal activities might have long term impact in crop production, global carbon and nitrogen cycles and in the removal of a range of environmental pollutants.

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COMMON INDIGENOUS FRESHWATER ORNAMENTAL FISH OBSERVED IN AQUARIA IN THIRUVANANTHAPURAM DISTRICT, KERALA

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ABSTRACT

India is blessed with a rich diversity of freshwater fishes both in the Western Ghats and Northeastern hills. Indian inland waters possess a rich diversity of ornamental fish, with over 195 indigenous varieties studiedin the North-East Region and Western Ghats. The regions exhibit high degree of biodiversity and endemism in case of freshwater ornamental fishes. The fish fauna of the Western Ghats includes variety of barbs, rasboras, killifishes, glass fishes, catfishes, catopra, hill trouts, and danios, Most potential species from north-eastern states for aquarium fish are *Botia dario, Dania dangila, Puntius shalynius* and *Schistura reticulofasciatus*. Demand for different indigenous ornamental fishes changes from year to year.Indian ornamental fish trade mostly deals with freshwater fish of which 98% are cultured and 2% are captured from wild. Even though there is such a high diversity in the case of freshwater ornamental fish, majority of the Ornamental Fish Breeders in India breed in exotic fishes. This paper gives a view of the indigenous freshwater fish diversity as seen in the aquaria of Thiruvananthapuram district, Kerala.

Keywords – Endemic, biodiversity, hotspots, aquarium

INTRODUCTION

Ornamental fish keeping is also known as aquarium keeping and isconsidered to be the second most common hobby in the world after photography with about 100 million hobbyists worldwide. The ornamental fish industry is gaining prominence due to its high economic prospects with increase in aquarium and accessories sales. Aquarium pets require less space and lesser attention when compared to other pet species as well as the lower cost of setting up an aquarium along with the ease in installing anywhere in the house are factors helping the fats growth of the ornamental fish industry.Ornamental fishes are normally tiny, calm and have a flamboyant array of vibrant colours with the ability to survive and flourish in confines spaces. They are often called “living jewels”.

About 10% of the world’s population have aquarium in their home. The people keep aquaria for a variety of reasons for keeping one: aesthetics, education, enjoyment, collection, and propagation of rare and exotic species as well as part of ways to attract wealth (feng shui). There are many benefits of keeping aquaria.

- It gives pleasure to young and old people.
- It enables relaxation of the mind and can be part of a healthy lifestyle.
- Children learn about nature and can use their time constructively.
- It can be an avenue for self-employment

Developed countries are the forerunners in the ornamental fish keeping race but now the developing countries are also gaining momentum; with contribution of up to two-thirds of the total export value. World ornamental fish trade in retail is more than US $ 18 – 20 billion involving more than 2500 species (60% freshwater) (MPEDA, 2010). Some 30 – 35 species dominate the market with US, EU (Czech Republic is the prominent in the EU), Japan are the largest importers with Singapore is the largest exporter of ornamental fishes (Rana, 2007).

In the case of India, the waters are abundant with large varieties of ornamental fish, about250 indigenous fishes are found in the biodiversity hotspots of India – the Western Ghats, North-eastern states, Andaman aand Nicobar and Lakshdweep islands. In spite of the abundance in biodiversity, the aquarium keeping hobby is comparatively new to India. This hobby is just 70 years old. The contribution of India to the international ornamental fish trade is very less but if it can be properly managed, India can be one of the leaders of the world trade in aquarium fish.

INDIGENOUS FRESHWATER ORNAMENTAL FISH

India is blessed with a rich diversity of freshwater fishes both in the Western Ghats and Northeastern hills. Indian inland waters possess a rich diversity of ornamental fish, with over 195 indigenous varieties studiedin the North-East Region and Western Ghats. Out of the total exports, 85% of all the ornamental fishes are the wild varieties collected directly from the rivers of the North-East and Southern States. Out of 195 fish species155 species from the North-East Region, are of ornamental value. The region exhibits high degree of biodiversity and endemism in case of freshwater ornamental fishes. Prominent among them are Loaches, Eels, Barbs, Catfish, and Goby (NFDB, 2023).

The Western Ghats of India is one of the 34-Biodiversity ‘hotspot’ areas of the World (Anna Mercy,2007). Among the 300 species of freshwater fishes in the Western Ghats, 155 are considered ornamental fishes of which 117 are endemic to the Western Ghats (Ponniah and

Gopalakrishnan, 2000). At present, only a small fraction of the endemic fish diversity is utilized in ornamental fish trade. All the ornamental fishes marketed in India are exotic. 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 include variety of barbs, rasboras, killifishes, glass fishes, catfishes, catopra, hill trouts, and danios, which are ideal candidates for ornamental fish industry (Anna Mercy, 2007). Some of the species fetch high price in the world market and support trade outside the country.

The list of popular ornamental fishes distributed in freshwater are given in annexure-1. (NFDB, 2023).There are about 58 indigenous ornamental fishes occurring in the Northeastern 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 *Botia dario, Dania dangila, Puntius shalynius* and *Schistura reticulofasciatus.*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(Raja et. al., 2019). Indian ornamental fish trade mostly deals with freshwater fish (90%) of which 98% are cultured and 2% are captured from wild. The remaining 10% are marine fishes of which 98% are captured and 2% culture. Majority of the Ornamental Fish Breeders in India breed exotic fishes (Pabhu, 2021).

MATERIAL AND METHODS

Aquarium and pet shops selling various freshwater fishes were identified and survey conducted. The shops located in various areas of Thiruvananthpuram district were visited. The "Nagara Vasatham" show at Kannakakunnu, and "Matsyolsavam" at Puthirikandam Maidanam, Thiruvananthapuram were also visited for collecting data on the freshwater ornamental species.

The indigenous fish species seen in these aquariums and pet shops were photographed; the attributes like feeding habits, temperature requirements and breeding routine of each fish were discussed with the shop owners. Thisdata was compared to Fishbase, Simplyfish and MPEDAwebsites for identification and the conservation status was assessed from IUCN website.

RESULTS

***Botia striata* (Zebra loach)**

Classification

Class - Actinopterygii

Order - Cypriniformes

Family - Botiidae

Genus - *Botia*

Species – *B. striata* (Narayan Rao, 1920)

Characters

Range – endemic to Western Ghats in India

Size - 9 cm (max)

Temperature - 21-26°C

pH -7

Feeding habit – Carnivorous but also eat vegetable matter prefer live feed snails, small shrimps.

Behaviour – Peaceful, gregarious, need hiding spots. Show complex social hierarchy. Stressed if in group of less than 5.

Sexual dimorphism – Mature females' plumper than males.

Reproduction – Not naturally bred in aquarium. Commercially using hormones

Conservation status – Endangered (IUCN)

***Puntius denisonii* (Miss Kerala)**

Classification

Class - Actinopterygii

Order - Cypriniformes

Family - Cyprinidae

Genus - *Puntius*

Species – *P. denisonii* (Day, 1865)

Characters

Range – Endemic to Achenkovil, Pamba and Chaliyar rivers of Kerala

Size - 15 cm

Temperature – 15 -25°C

pH – 6.8 – 7.8

Feeding habit – Omnivores

Behaviour – Social shows schooling behaviour

Sexual dimorphism – Females bigger, heavier bodied and less bright than males.

Reproduction- Egg layers, scatter eggs among vegetation

Conservation status – Endangered

***Devario malabaricus* (Giant danio)**

Classification

Class - Actinopterygii

Order - Cypriniformes

Family - Cyrinidae

Genus - *Devario*

Species – *D. malabaricus*

Characters

Range – West coast of India and Sri Lanka

Size- 8 – 10 cm

Lifespan – 3 – 5 years

Temperature- 18 – 25 °C

pH -6 - 8

Feeding habit – Feeds on insects and detritus

Behaviour -Peaceful, social, active and hardy fish. Shows schooling.

Sexual dimorphism – Mature females larger, rounder in abdomen and dull than males.

Reproduction – Egg layers; scatters among vegetation. Light orange, sticky eggs. Shows cannibalism on eggs.

***Danio rerio* (Zebrafish)**

Classification

Class – Actinopterygii

Order - Cypriniformes

Family – Cyprinidae

Genus - *Danio*

Species – *D. rerio*

Characters

Range – Eastern India

Size - 5 cm

Temperature – 18 – 24 °C

pH - 6.5 - 7

Feeding habit - Omnivores

Behaviour – Peaceful

Sexual dimorphism – Males bit smaller, slender and torpedo-shaped than females.

Reproduction – Egg layers and exhibit cannibalism on eggs.

Trichogaster fasciata **(Banded gaurami)**

Classification

Class - Actinopterygii

Order - Anabantiformes

Family - Osphronemidae

Genus - *Trichogaster*

Species – *T. fasciata*

Characters

Range - Bangladesh, India,Nepal, Myanmar, nepal

Size - 10 cm

Lifespan – 4 years

Temperature - 21 – 28 °C

pH – 6 – 7.5

Feeding habit - Omnivorous

Behaviour – Social but can be territorial during spawning.

Sexual dimorphism– Males brightly coloured and pointed dorsal fins.

Reproduction – Egg layers. Males build bubble nests and protect the eggs aggressively.

Parambassis ranga **(Indian glass fish)**

Classification

Class - Actinopterygii

Family - Ambassidae

Genus - *Parambasiss*

Species – *P. ranga*

Characters

Range – South Asia; Pakistan, India, Malaysia and Bangladesh

Size – 8 cm

Life span – 3-5 years

Temperature – 20-30 °C

pH – 6.5 – 7.5

Feeding habit - Omnivore

Behaviour – Peaceful; group of more than 6

Sexual dimorphism – Males have deeper yellow hue and dark blue border on anal and dorsal fins.

Reproduction – Egg layers

***Etroplus maculatus* (Orange chromide)**

Classification

Class - Actinopterygii

Order - Cichliformes

Family -Cichlidae

Genus - *Pseudetroplus*

Species – *P. maculatus*

Characters

Range – South India and Sri Lanka

Size – 8 cm

Lifespan – 5 years

Temperature – 20- 28 °C

pH – 7 - 8

Feeding habit – Plankton feeder.

Behaviour – peaceful unless breeding.

Sexual dimorphism – Lot of confusion exists. Both sexes identical.

Reproduction – Egg layers, both sexes exhibit parental care.

***Dawkinsia filamentosa* (Spotted barb)**

Classification

Class - Actinopterygii

Order - Cypriniformes

Family - Cyprinidae

Genus - *Dawkinsia*

Species -*D. filamentosa*

Characters

Range – Southern Indian states Kerala, Tamil Nadu, and Karnataka

Size – 10 cm

Life span – 2-8 years

Temperature – 20-26 °C

pH – 6 - 7

Feeding habit - Omnivores

Behaviour – Active schoolers, aggressive towards weaker individuals of same species.

Sexual dimorphism – Females slightly larger, heavier-bodied, and less colourful. Males intensely coloured and have tubercules on head during spawning condition.

Reproduction – Egg scatters, no parental care

DISCUSSION

The growth and development of ornamental market worldwide is mainly due to globalization and increased international trade in live flora and fauna (Mack and Lonsdale, 2001). India's share to global ornamental fish trade is less than 1% but still India is projected as a "sleeping giant" because of yet untapped potential resources (Rani *et al.,* 2013). According to Mittermeier *et al.,* (1998), India is a mega-diverse region for ichthyo-faunal diversity. Northeastern states have 33%; southern has 24%, eastern with 23%, 6% in western region, 2% in northern states, central and western states have 2% of species and about 10% of indigenous species are found throughout the country (Swain, 2000). Out of 806 species inhabiting India, 196 are ornamental. As per the previous studies, India has very high potential for the freshwater aquarium trade as there are biological hotspots in India like the Western Ghats and the Northeast. The Western ghats region is considered to be one of the biodiversity hotspots in India with about 155 indigenous ornamental fish species identified out of which 117 are endemic (Ponniah and Gopalakrishnan, 2000). As per Anna Mercy et. al. (2007) 47 species are recommended for ornamental fish industry The fish fauna of the Western Ghats include variety of barbs, rasboras, killifishes, glassfishes, catfishes, catopra, hill trout, and danios, which are ideal candidates for ornamental fish industry. They are exceptionally beautiful with a wide variety of bands, blotches, spots, and colourful fins on their body. About 85% of the native species are from North-eastern states and rest from the southern states. West Bengal, Kerala and Tamil Nadu are blessed with high potential of indigenous ornamental fishes. The wild captured freshwater indigenous fish species contribute to about 90% of the ornamental fish export from India (Silas *et al.,* 2011). Presently 100 species are considered as aquarium fish (IASRI, 2023). Some of the indigenous fish found in the aquarium trade are *Puntius denisonii, Puntius conchonius, Colisa chune, Brachydanio rerio, Chandra nama, Botia lohachata, Notopterus notopterus, Labeo calbasu, Labeo nandina, Oreichthys cosuatis*. From the Noertheastern states, 58 indigenous species are mostly imported to countries like Singapore, Hong Kong, Malaysia, USA, China and Japan (Rani *et al.,* 2014) and the ones with most export potential are *Botia Dario, Danio dangilo, Puntius shalynius* and *Schistura reticulofasciatus.*

As seen from the results obtained in the project it was seen that there are very few indigenous freshwater fish that are used in the aquarium business sector in India. There are about eight indigenous commercial fish that have been observed to be available in the shops that we visited.Even though there are quite a lot of indigenous species, having high potential as ornamental fishes, they have not been properly exploited. At present, only a small fraction of the endemic fish diversity is utilized in ornamental fish trade. All the ornamental fishes marketed in India are exotic.

In spite of the fact that the Western Ghats of India is a gold mine of endemic freshwater fishes suitable for the ornamental fish trade, no concerted efforts have so far been undertaken for the development of sustainable market for these resources. The dependency on the captured wild population due to absence of captive breeding programs on the commercial scale; inadequacy of data on the freshwater resources and the absence of benchmark data on the availability and abundance of such species along with the lack of organised trade, improved technologies, awareness, appropriate infrastructure and trading have led to the poor development of the ornamental fish sector in India (Sekharan, 2006). Lack of scientific information on these native aquatic faunae and lack of fishing regulations to control unscrupulous activities are the reasons for the poor performance of the indigenous sector (Salim *et al.,* 2013).

CONCLUSION

The trade opportunities of ornamental fishes from India have been recognized by the producers, collectors and traders both nationally and internationally 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 its ornamental fish trade is based mostly on wild collection and on exotic species. To conserve the indigenous 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 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 freshwater 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 for increasing the indigenous fish species utilization along with lowering of dependency on exotics like providing incentive to research and establish native ornamental fish production units, considerable private investment can be attracted to this industry generating 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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GLOBAL WARMING - A MAN MADE AND A NATURAL DISASTER ON OUR MOTHER PLANET

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Global warming, which is mostly man-made and some part as a natural disaster causing a great impact on the Earth. This disaster can be considered as an impact of greenhouse effect. Global warming specifically refers to an increase in the Earth's average surface temperatures caused by human activities, primarily the burning of fossil fuels. This article dealing with green house effect, impacts of this disaster to Earth and ways to reduce global warming.

Overwhelming scientific evidence supports the reality of both global warming and climate change. In 2021 the Intergovernmental Panel on Climate Change (IPCC) released its Sixth Assessment Report (AR6) revealing how human activity has induced rapid climate change. AR6 covers how specific regions experienced the effects of climate change, projecting how these changes will likely play out in the future and identifying what interventions could limit increased global temperatures. AR6 estimates a rise in the global surface temperature by 1.07°C (1.93°F) from the latter half the nineteenth century through the first two decades of the twenty-first century, primarily as a result of increasing greenhouse gas and particulate emissions that trap heat in the earth's atmosphere.

The potential future consequences of global warming remain an issue of great debate and uncertainty. However, most experts predict dramatic and serious problems for future generations. Warmer oceans could result in stronger and more frequent hurricanes. As temperatures climb, some regions could experience frequent heat waves along with devastating droughts and wildfires. A heat wave in 2021 led to record-breaking temperatures. During the US heat wave, temperatures in the Pacific Northwest reached triple digits and led to the deaths of more than two hundred people in the region.

Climate change has been linked to the severe, exceptional drought that has occurred over the last twenty years in parts or all of several western states including Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington. Some observers have labelled this phenomenon a "megadrought," and it has led to massive wildfires and water shortages. From 2018 to 2021, California and Oregon endured massive wildfires that burned millions of acres and led to the displacement of thousands of residents, widespread destruction of property, and the deaths of dozens of people. California had a record-breaking wildfire season in 2020, including the state's first gigafire - a blaze that burned more than one million acres of land. By the end of the year, wildfires burned more than four million acres throughout the state. Scientists have attributed the fires to high levels of extremely dry vegetation, desiccated by rising temperatures and low soil moisture, that created conditions enabling the fires to spread rapidly and burn with fierce intensity.

The concentration of carbon dioxide and other greenhouse gases made a number of adverse effects on the Earth and may cause many environmental problems like melting of glaciers in the mountains, thermal expansion of sea water and melting of ice sheet. Global warming could also have a major impact on ecosystems and wildlife habitats. Some areas might become too dry or too wet to support agriculture. Long periods of drought could turn fertile lands into deserts with little vegetation. Plants and animals might not be able to survive the rapid changes caused by global warming and could become extinct. Over the long term, such changes would negatively impact Earth's biodiversity. Some ecosystems such as coral reefs and coastal mangrove swamps appear likely to disappear completely.

Human populations would also face serious problems. Loss of farmland, for example, would cause major disruptions in the food supply, bringing about famine in many areas. More frequent and intense heat waves could result in more heat-related deaths, and changes in air quality could also affect human health. Other experts warn of potential impacts on migration and geopolitical conflict as populations flee areas most impacted by climate change and rival countries go to war over dwindling resources.

The causes of global warming are highly contested and it is more of politics and economics agenda than any other factor. The responses of global warming among policy makers and climate scientist’s result in more dilemmas and challenges from their economic and political interests. At this end, the causes of global warming can be seen from two viewpoints. On one hand, the warming of the globe in recent years has suggested that anthropogenic influence is the cause for global warming because of increasing human activity. Contrarily, land-use change, solar variability and the sun’s brightness appear to be the causes and more significant forces warming the globe. Nevertheless, there is no debate about whether global warming is a fact. It is now more certain than ever, based on many lines of evidence that humans are changing the Earth’s climate. This is manifested by sea-level rise, a strong decline in Arctic sea ice, and other climate-related changes. In general, further global warming is inevitable if emissions of greenhouse gases continue unabated or future changes substantially exceed those that have occurred so far. Global warming focuses narrowly on the reduction of greenhouse gas emissions, but is it really about the political positions for and against regulations of greenhouse gases proposed under the Kyoto Protocol.

Global warming and climate changes have adverse impacts on sea levels, food production, loss in biodiversity , fresh water balance, threat to human health and result in many other unforeseen calamities. Therefore, the ways to reduce global warming are to reduce the emission of carbon dioxide by cutting down on the use of fossil fuels, find alternatives to chlorofluorocarbons(CFC), Plant more trees and enhance the vegetation cover which help in the increased utilization of carbon dioxide and find ways to dispose the produced greenhouse gases elsewhere than in the atmosphere.

As a result of greenhouse effect, Earth's surface is heated up causing the infrared radiations to get trapped in the atmosphere. The effects by which the radiations absorbed by the greenhouse gases, heat up the entire atmosphere is called greenhouse effect. However this changes the ozone layer to thin and lead to ozone depletion directly affecting the Earth. Deforestation, industrial emission and burning fossil fuels contribute greatly to this natural disaster. Major impacts include sea level change and rising temperature with multiple consequences on environmental and human health. To reduce global warming, we ought to reduce carbon dioxide emissions and find alternatives to effective management to greenhouse gases.The scientific community, politicians and governments have to prioritize political debates on how to reduce global warming. In this complex and never-ending debates, climate scientists and politicians have to advice policymakers and/or governments to reduce greenhouse gas emissions instead of battling the already existing realities. Hence, effective policies are indispensable if reduction of global warming is to be brought under control. Unless defensive measures are taken, global warming will undermine the efforts to combat poverty and reduce chronic food insecurity. For that reason, developed countries have to finance some developing countries that are working on the green economy packages in reducing the concentration of greenhouse emissions in the atmosphere.

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WATER BIRD ASSEMBLAGES AND THEIR CURRENT THREATS IN POKKALI FARMING

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ABSTRACT

Pokkali wetland was identified with high waterbird density. In this study, we analysed the diversity and assemblages of water birds and their current threats in Pokkali farming during January2021-January2023. Bird survey was carried out using the Direct Observation Method, Point Count Method and LineTransect Method. A total of 31species of waterbirds belonging to 8 orders and 14 families were recorded. All bird species are included in Least Concern of the IUCN Category except four species. Four waterbird species are Globally Threatened ones. They are: Oriental Darter (*Anhinga melanogaster*), Spot-billed Pelican (*Pelecanus philippensis*), Black headed Ibis (*Threskiornis melanocephalus*) and Painted stork (*Mycteria leucocephala*). Of these, three were recorded in 2021-22 and painted stork was observed in 2022-23 from Pokali wetland. Most threats affecting the waterbirds are the cause of human actions. The leading threats observed in our sampling site was habitat destruction, electriclines, fishing nets inside the water affects mainly cormorants, feral dogs and other predators, communication tower, flood, climate change, hunting of waterbirds, loss of employees, solid waste, plastics, water hyacinth, water pollution, soil and sound pollution.

Keywords: Pokkali wetland, Waterbirds, Current threat

INTRODUCTION

Pokkali farming is a unique system of rice cultivation found only in coastal regions of Central Kerala (Ranjith *et al.,* 2019). It is a traditional and organic method of rice farming practices in three districts such as Alappuzha, Ernakulam and Thrissur bordering the Arabian Sea (Shamna *et al.,* 2017). Pokkali system utilizes the relationship between Rice farming and Shrimp or fish farming (Vijayan 2016). Rice cultivation is not profitable but the Pokkali farming includes both rice and prawn cultivation and it is highly profitable (Jayan *et al.,* 2010). The economic importance of pokkali was high. Pokkali requires no pesticides or fertilizers through their farming time. Pokkali is an organic salt resistant rice variety (Tomy *et al.,* 1984). The pokkali area was prepared for rice farming at the month of last week of april or first week of may.The rice farming time of pokkali area was end of may or first week of june and cultivation ends in September. After rice farming, the field area was prepared for fish farming. Fish farming starts in last week of October or first week of November and ends in march or april.

Water birds are one of the indicators for concentrating ecological issues (Ali *et al.,* 2022). Pokkali farming support different activities of water birds like foraging and feeding, moving, resting, calling, preening, chasing etc. (Akhtar *et al.,* 2009). The present study was aimed to document the waterbird diversity, globally threatened waterbird species, assemblages of water birds and their current threats in pokkali farming during January 2021 to January 2023.

MATERIALS AND METHODS

STUDY AREA

The Pokali field (Kochuvavakkad padashekharam) was located near Pallithode Bridge (9°46'35.99"N,76°17” 9.71"E), Thuravoor. Pallithode is a village in the Alappuz district of the state of Kerala, India, on the shores of the Arabian Sea. Pallithode is within the Gram Panchayat of Kuthiathode, Pattanakkad Block of Cherthala Taluk. It is a green, palm-fringed, scenic village in the coastal region of Kerala, on a narrow strip of land, with white, sandy beaches bordering the Arabian Sea to the west, and a lake (kayal), the Pallithode Pozhi, a part of the Cochin estuary to the east, as well as extensive, interconnected paddyfields and backwaters to the east of the Pozhi. Chappakadavu beach, in South Pallithode, provides local fishing boats access to the sea. Chellanam is to the north; Valiathode, Parayakad, Chavadi, and Thuravoor are to the east; Andhakaranazhy (4 kilometres (2.5 mi) west of National Highway 66 at Pattanakad), Manokkam Harbor, Azheekal, and Ottamassery are to the south.

METHODOLOGY

The Pokkali site was observed once in a week during 6:00h–12:00h. The study was conducted during January 2021 to January 2023.Waterbirds were studied based on the Direct Observation method (Hoves and Bakewell 1989), Point Count (Ralph *et al.,* 1995, Hamel *etal* 1996) and LineTransect Method (Burnham *et al.,* 1980). Water bird species was identified with the help of Field Guide (Grimmet *et al* 2000, Ali *et al.,* 2002). Observations was done by using binoculars (10×50Nikon) and 4k series DSLR Video Camera (Nikon Coolpix p1000). Using the Point countmethod, the observer reaches at the centre of the point count plots and records all water birds seen or heard for a period of 10-15minutes (Mogaka *et al.,* 2019). Point count was avoid in days with heavy rain and stronger wind (Volpato *et al.,* 2009). Line Transect method walk through a transact will be used to record the total number of water birds from one scanning point to adjoin one (approximately 500m) along a designated transact line (Burnham *et al.,* 1980).When standing at each transact point for a ten-minute period,birds seen or heard were recorded (Buckland *et al.,* 1993). Each count was recorded for a duration of fifteen minutes during the early morning when water bird activity was high.

RESULT

Waterbird diversity of Pokkali wetland

Analysis of water bird diversity in Pokkali wetland was carried out during Jan 2021- Jan 2023. A total of 33 species of waterbirds were recorded (Table 1). Waterbirds belonging to 8 orders and 14 families. The different water birds are Cotton Pygmy Goose (*Nettapus coromandelianus*), Lesser Whistling Duck (*Dendrocygna javanica*), Garganey (*Spatula querquedula*), White – throated kingfisher (*Halcyon smyrnensis*), Stork – billed kingfisher (*Pelargopsis capensis*),Common kingfisher (*Alcedo atthis*), White breasted waterhen (*Amaurornis phoenicurus*), Purple swamphen (*Porphyrio porphyrio*),Oriental darter (*Anhinga melanogaster*), Little cormorant (*Microcarbo niger*) Great cormorant (*Phalacrocorax carbo*), Indian cormorant (*Phalacrocorax fuscicollis*), Little egret (*Egretta garzetta*), Great egret (*Ardea alba*), Median egret (*Ardea intermedia*), Indian pond heron (*Ardeola grayii*),Greyheron (*Ardeacinerea*), Purple heron (*Ardea purpurea*), Western reef heron (*Egretta gularis*), Cattle Egret (*Bubul cusibis*),Black-crowned night heron (*Nycticorax nycticorax),* Spot – Billed Pelican (*Pelecanus philippensis*), Black- headedibis (*Threskiornis melanocephalus*), Glossy ibis (*Plegadis falcinellus),* Painted stork(*Mycteria leucocephala*),Little grebe (*Tachybaptus ruficollis*), Green sandpiper (*Tringa ochropus*), Wood sandpiper (*Tringa glareola*), Whiskered tern (*Chlidonias hybrid*), Little ringed plover (*Charadrius dubius*), Red wattled lapwing (*Vanellus indicus*),Yellow wattled lapwing (*Vanellus malabaricus*),Black-winged stilt (*Himantopus himantopus*).

The most abundant resident water bird species observed in the study area was egrets, herons, little cormorants, darter and kingfishers. Other water birds such as ibis, terns, grebe, sandpipers were observed only in the winter season (Table 1). The highest water bird congregations were recorded in the winter season especially in Nov & the lowest in the

Monsoon season in July. Among 33 species of water birds observed during January 2021-2023. Of these, 39.39% of waterbird species were observed in summer, winter and monsoon season and 60.61% species of water birds were observed in the winter season (Fig. 1). The winter visitors are Cotton Pygmy Goose, Garganey, Great cormorant, Indian cormorant, Great egret,Western reef heron, Cattle egret, Black-crowned night heron, Spot-billed pelican, Black-headed ibis, Glossy ibis, Painted Stork, Little grebe, green sandpiper, Wood sandpiper, Whiskered tern, Little ringed plover, Red wattled lapwing, Yellow wattled lapwing, Black-wingedstilt. Lesser Whistling Duck, White – throated kingfisher, Stork – billed kingfisher, Common kingfisher, White breasted waterhen, purple swamphen, Oriental darter, Little cormorant, Little egret, Median egret, Indian pond heron, Greyheron, Purple heron were observed in every month.

Globally threatened waterbird species

Most of the water bird species are included in Least Concern of the IUCN Category except four. Four water birds were observed as globally threatened (Table 2) species. They are: Oriental Darter (*Anhinga melanogaster*), Spot- billed Pelican (*Pelecanus philippensis*), Painted stork (*Mycteria leucocephala*) and Black headed Ibis (*Threskiornis melanocephalus*). Black-headed ibis, Pelican and darter were observed during Jan 2021-22 and Painted stork was observed in Jan 2022-23.

Assemblages of water birds in Pokkali wetland

The Assemblages of waterbirds was categorised into (COM) – seen on most of the visits, Uncommon (UC)–seen on a few visits and Rare (R) – seen once or twice. About 42.42% of the waterbirds are Uncommon to the area, 39.40% of birds are common and 18.18% are rare ones (Fig.2). Lesser Whistling Duck, White – throated kingfisher, Stork – billed kingfisher, Common kingfisher, White breasted waterhen, purple swamphen, Oriental darter, little cormorant,little egret, Median egret, Indian pond heron, grey heron, purple heron was observed as common waterbirds. Great egret, Western reef heron, Cattle egret, Black-crowned night heron, Black-headed ibis, Glossy ibis, Painted Stork**,** Green sandpiper, Wood sandpiper, little grebe, Whisker edtern, Red wattled lapwing, Yellow wattled lapwing, Black-winged stilt was Un common. Cotton Pygmy Goose, Garganey, Great cormorant, Indian cormorant, Spot-billed pelican, Little ringed plover was rare waterbirds.

Current threats in water birds

Many factors that are listed below threatens the Pokkali farming and it causes the decreasing level of the water bird population in these areas.

a. Electric Lines: Waterbirds use their resting and preening time on electric lines. Sometimes the electric shock may affect and can cause death. Darter, painted stork and little cormorants affects electric shock and cause death in the winter season.

Fishing nets: Farmers use two types of fishing nets having different sizes. Small-sized nets dipped inside the water cause the death of open-water species of water birds like cormorants and darters. Large- sized nets used for the top of the field area. In the fish farming season, many water birds come to the area for feeding. These type of nets affects the death of many water birds such as cormorants.

b. Solid wastes: The field area contain many coconut trees. The water birds use the trees for done their behavioural purposes. Toddy shops are common to the area. Domestic and solid wastes were found to be deposited from many the toddy shops.

c. Water contamination: Some chemicals are being used to remove the unwanted plants in the pathways. This causes the pollution of water.

d. Sound materials: At the time of fish farming, many water birds come to the field area.

Sl. No.	Order & Family	Scientific Name	Common Name	Assemblages of waterbird species	Season	IUCN
	Anseriformes Anatidae	*Nettapus coromandelianus*	CottonPygmy Goose	R	W	LC
		Dendrocygna javanica	LesserWhistling Duck	COM	W,S&M	LC
		Spatula querquedula	Garganey	R	W	LC
2.	**Coraciiformes** Alcedinidae	*Halcyon smyrnensis*	White–throated kingfisher	COM	W,S&M	LC
		Pelargopsis capensis	Stork–billed kingfisher	COM	W,S&M	LC
		Alcedo atthis	Common kingfisher	COM	W,S&M	LC

3.	**Gruiformes** Rallidae	*Amaurornis phoenicurus* *Porphyrioporphyrio*	Whitebreasted waterhen Purple swamphen	COM COM	W,S&M W,S&M	LC LC
4.	**Suliformes** Anhingidae Phalacrocoracidae	*Anhinga melanogaster* *Microcarboniger* *Phalacrocorax carbo* *Phalacrocorax fuscicollis*	Orientaldarter Littlecormorant Greatcormorant Indiancormorant	COM COM R R	W,S&M W,S&M W W	NT LC LC LC
5.	**Pelecaniformes** Ardeidae Pelecanidae Threskiornithi dae	*Egretta garzetta* *Ardea* *albaArdeainterm* *edia Ardeola* *grayii Ardea* *cinerea Ardea* *purpurea Egretta* *gularis Bubulcus* *ibis* *Nycticorax nycticorax* *Pelecanus philippensis* *Threskiornis melanocephalus* *Plegadisfalcinellus*	Little egret Great egret Medianegret Indianpondheron Grey heronPurple heron Westernreef heron Cattleegret Black-crowned night heron Spot-billed pelican Black-headedibis Glossy ibis	COM UC COM COM COM COM UC UC UC R UC UC	W,S&M W W,S&M W,S&M W,S&M W,S&M W W W W W W	LC LC LC LC LC LC LC LC LC NT NT NT
6.	**Ciconiiformes** Ciconiidae	*Mycteria leucocephala*	Painted Stork	UC	W	NT
7.	**Podicipediformes** Podicipedidae	*Tachybaptus ruficollis*	Littlegrebe	UC	W	LC

8.	**Charadriiformes**					
	Scolopacidae	*Tringaochropus*	Greensandpiper	UC	W	LC
		Tringa glareola	Woodsandpiper	UC		LC
	Laridae				W	
	Charadriidae	*Chlidonias hybrid*	Whiskeredtern	UC		LC
		Charadrius dubius	Littleringe d plover	R	W	LC
	Recurvirostrid ae					LC
		Vanellus indicus	Redwattle d lapwing	UC	W	
		Vanellus malabaricus	Yellowwattled lapwing		W	LC
		Himantopus himantopus	Black-wingedstilt	UC		
				UC	W	LC
					W	

Table1.Checklist of waterbirds recorded in the Pokkali wetland

e. To avoid the water birds, farmers use the sound producing materials which makes
f. disturbance for cormorants and darters.

High level of fishing activities: In the side of the pokkali wetland, water source was observed. The water source was helpful for entering and water to the wetland through the farming time. Farmers use these water source for fishing activities. So, fishing activities disturb the foraging behavior of water birds which leads to decreasing count of birds.

g. Flood: Due to heavy rain, high water intake affects water-edged bird species like egrets and herons and also rice farming. But it will be helpful for Cormorants and Darters under the order Suliformes.
h. White cloths: Farmers use white cloths for avoiding the waterbirds such as egrets and herons. This cause the water bird count was decreased.

During the winter season, we have observed a few nests of Spot-billed Pelicans. The nesting and parental care of Spot-billed Pelicans are very interesting. Using their large beaks, they damage the top of coconut trees and construct their nest. Interesting behaviour about that, all the time they care for their family members and young ones. In addition to water birds, we counted the shorebirds also. They are Green Sandpiper, Wood Sandpiper, Whiskered tern, Little ringed plover, Red wattled lapwing, Yellow wattled lapwing and Black- winged stilt.

DISCUSSION

Water bird diversity in Pokkali farming

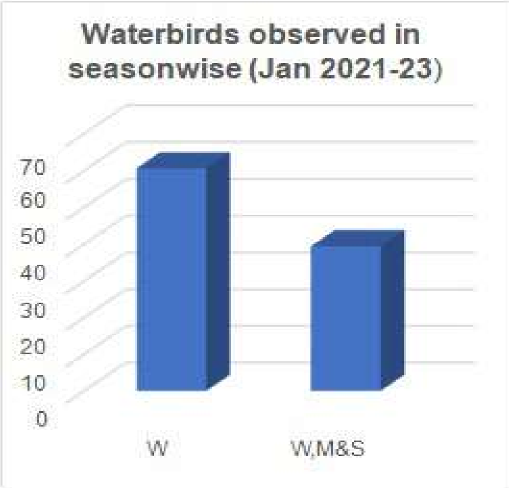
The present study was documented the diversity and assemblages of water bird species and their current threats in pokkali wetland from January 2021 – January 2023. Along with that, we had observed different types of shore birds and globally threatened ones. Sampling sites are the major feeding grounds of many Egrets, Herons, Cormorants and other waterbirds. The abundance of waterbirds is high in the Saline agroecosystem. Saline Agroecosystem consists of two farming practices (Pokkali farming) – Rice farming and Prawn farming.

Assemblagesof water birds
COM- Common
UC– Uncommon
R – Rare

Seasonwise
W- winter
S-Summer
M-Monsoon

Sl. No.	Species(CommonName)	ScientificName	Observed time
1.	Oriental Darter	*Anhinga melanogaster*	W, M,S
2.	Spot-billed Pelican	*Pelecanus philippensis*	W
3.	Blackheaded Ibis	*Threskiornis melanocephalus*	W
4.	Painted stork	*Mycteria leucocephala*	W

Table 2. Globally Threatened waterbirds from Pokkali wetland



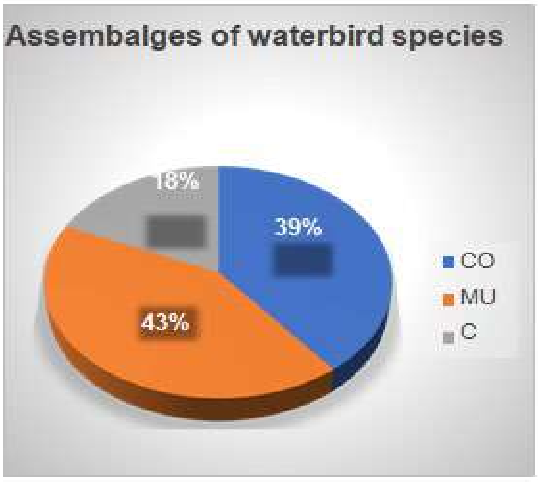


Fig 1. Water birds in season wise **Fig 2. Assemblages of waterbirds**

Most of the time the farm contains water sources. This is the reason, why the most water birds were observed in saline Agroecosystem. In India, 153 bird species are Globally Threatened (Deepa *et al* 2017). Of these, Common pochard (*Aythya farina*), Marbled duck (*Marmaronetta angustirostris*), White headed duck (*Oxyura leucocephala*) are three globally threatened waterbirds collected from Morocco at winter time (Ouassou *et al* 2021). Three species of waterbirds are Globally Threatened and these are observed from our sampling sites. They are: Oriental Darter (*Anhinga melanogaster*), Spot-billed Pelican (*Pelecanus philippensis*) and Blackheaded Ibis (*Threskiornis melanocephalus*) (Narayanan *et al.,* 2022). 13 species of globally threatened shorebirds had been observed at Nijhum Dwip National Park (Chowdhury *etal* 2021).The Bluewinged Goose (*Cyanochen cyanoptera*) observed from Lake Arekit, Southern Ethiopia. The abundance of globally threatened waterbirds has been reduced by the effect of invasive plant species, water hyacinth in Nepal (Basaula *et al.,* 2021). Globally threatened waterbirds are mainly threatened from anthropogenic factors (Ouassou *et al.,* 2021).

Conservation aspects

Many bird species are close to extinction because of habitat conversion, and disturbance of other animals (Arya *et al.,* 2019). Human beings are the main threats to these areas that were observed during the study. Protection of their habitat is one of the methods to conserve the water bird population (Karikar *et al.,* 2021). Micro plastic pollution in wetlands threatens the avifauna & other components of biodiversity in the region (Kannankai *et al.,* 2022).Heavy metals are the major pollutant threats to the wetland environment (Zhang *et al.,* 2022). Solid waste dumping affects most of the waterbirds and also pokkali farming practices. Fishermen were disturbed mainly by cormorants and darters which prevented the ongoing prawn farming. In Kerala, wetland birds are adapted to fresh urban conditions (Charutha *et al.,* 2021). Fishing nets and electric lines (Narayanan, 2022) was danger in wetland birds.

Habitat protection is important to conserve water bird communities. Major threats being faced by the wetlands are Habitat loss (Wang *et al.,* 2022), Climate change (Gutierrez *et al.,* 2022), Solid waste dumping and Reclamation (Nameer *et al.,* 2015), Pollution (Stewart *et al.,* 2021), waterfowls hunting at wetlands (Waterman *et al.,* 2022), Use of chemical pesticides (Anoop *et al.,* 2015),Flood or sea level rise (Marchesiello *et al.,* 2019), waste disposals, siltation, and intensive agricultural expansion (Tilahun *et al.,* 2022), building dams (Hasan *et al.,* 2020), Disturbance by livestock (Mahsanin *et al.,* 2014), accidental by catch shore fishing nets (Chowdhury *et al.,* 2021) results in the decline in bird population. Migrant birds were disturbed by the action of tourists, Illegal killing (deliberate hunting, poisoning and trapping) (Gallo-Cajiao *et al.,* 2020).Threats identified for the shore birds are trapping, lime shell mining, pesticide contamination (Kannan 2022) and shorebirds in fishing gear (Chowdhury *et al*., 2021).

CONCLUSION

Pokkali wetlands are the most productive salinne agro ecosystems and it provides the shelter of many waterbirds, shorebirds and globally threatened birds. Waterbirds use the pokkali wetland for feeding, roosting, preening and parental caring, etc. Pokkali farming practices was important for feeding and roostingarea of many egrets, herons, cormorants, Shorebirds and other migratory birds and also support important populations of Globally Threatened waterbirds.

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ASSESSMENT OF WATER AND SEDIMENT QUALITY PARAMETERS IN SELECTED MYRISTICA SWAMPS, WESTERN GHATS, INDIA.

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ABSTRACT

Myristica swamps, situated in the Western Ghats of India, are extraordinary wetland forest ecosystems predominantly characterized by the Myristicacea family. These swamps undergo a transformation into acidic environments due to waterlogged conditions and the accumulation of humic deposits. Key abiotic factors crucial for the persistence of Myristica swamps include the amount of rainfall and year-round water availability. Each Myristica swamp features a central stream, ensuring a consistent water supply. The hydrology of these swamps is particularly well-suited for maintaining high water quality in these streams and providing diverse aquatic habitats. Therefore, analysing the physico-chemical parameters of sedimention. Myristica swamps serves as a potent indicator of the prevailing environmental conditions in these freshwater ecosystems. A comprehensive study was conducted in the Kulathupuzha and Shendurney Wildlife Sanctuary, Kerala, India, encompassing the pre-monsoon, monsoon and post-monsoon seasons. This study involved a detailed examination of sediment samples from selected Myristica swamp forests.

INTRODUCTION

A swamp is a forested wetland (Keddy, 2010). The water of a swamp may be fresh water, brackish water, or seawater. Freshwater swamps form a long large rivers or lakes where they are critically dependent upon rainwater and seasonal flooding to maintain natural water level (Hughes, 2003). The hydrology of a swamp affects the quantity and availability of resources including oxygen, nutrients, water pH, and toxicity, which will affect the entire biogeochemical ecosystem (Mitsch, & Gosselink, 2015).Myristica swamps are the wetland forest ecosystems that inundated fully or partially a greater part of the year, characterized by the dominance of Myristicacea family members like Myristica fatua var. Magnifica and Gymnacranthera farquhariana (Bhat and Kaveriappa, 2009; Varghese and Menon ,1999). These tropical freshwater swamps are commonly found at the bottom of valleys in evergreen forests (Roby et al., 2014). Myristica swamps possess several endangered, indigenous, and important floral and faunal varieties (Ranganathan et al., 2021). Over 6 decades ago, Krishnamoorthy made a first-hand report on the endangered unique habitat of Myristica swamp from the Travancore region in Kerala State of South Western Ghats (Moorthy, 1960). According to the data so far, In Kerala these swamps were mainly spanned in the valleys of Shendurney Wildlife Sanctuary in Kollam, Kulathupuzha Reserve Forests, and adjoining regions of the Anchal forest ranges in the southern Western Ghats (Nair et al., 2007)..In addition to Kerala, Myristica swamps have also been reported from Goa, Karnataka, and Maharashtra (Sreedharan and Indulkar, 2018; Chandran et al., 1999; Govind et al., 2020). However, Myristica swamps once huge in the Western Ghats are now being reduced to remnants with increased anthropogenic activities including mining, agricultural trespass, and other types of monoculture's plantations (Chandran and Mesta, 2001). Myristica swamps are classifiedascategory4C/FSI Tropical Freshwater Swamp Forests (ChampionandSeth,1968). Characteristic traits used in the above classification were dense evergreen closed forest, presence of abundant knee roots protruding from waterlogged soil, soils with high humus and moist or inundated throughout the year (Champion and Seth, 1968). Myristica swamps are acidic, Harbor rare and endemic biotas, because of the waterlogged conditions and provide ecosystem services to humans (Thacker and Karthick, 2022).

Species inhabiting swamps have evolved physiological adaptations tailored to their unique environment. These adaptations enable them to effectively contend with the low levels of oxygen in the soil by engaging in anaerobic respiration. These plants' roots are immersed in soil rich in reduced compounds that can be detrimental to them, the roots employ oxidative processes to break down these harmful substances. Consequently, ensuring proper aeration of the roots is of utmost importance for wetland plants. Beyond facilitating the removal of toxic substances, root aeration serves as the primary gateway for oxygen to reach the root zone. Knee roots play a role in facilitating moderate levels of soil oxidation.

MATERIALS AND METHODS

Three seasons were considered for sample collection, namely Pre-Monsoon (February to May) Monsoon (June to September) and Post-Monsoon (October to January). The soil sample was collected from Eleven different sites (S1- S11) of Myristica Swamp patches of Kulathupuzha forest range and Shendurney Wild life Sanctuary, Kerala, India. Kulathupuzha include Peru.

Shendurney includes Kattila Para, Munkuthu, ManChal, Onnam Mile and Irrikappara. For the sediment quality analysis six parameters were studied, including pH, Organic Carbon, Potassium, Calcium, Magnesium, and sodium. Sediment samples was collected bimonthly using Auger from each location and transported to the laboratory. The Physico-chemical parameters were analysed using standard procedures. Metal analysis of sediment samples was done using AAS (APHA, 2005). Sediment samples were taken from the depth of 0-10 cm using Auger. All the collected soils stored in clean polythene bags.

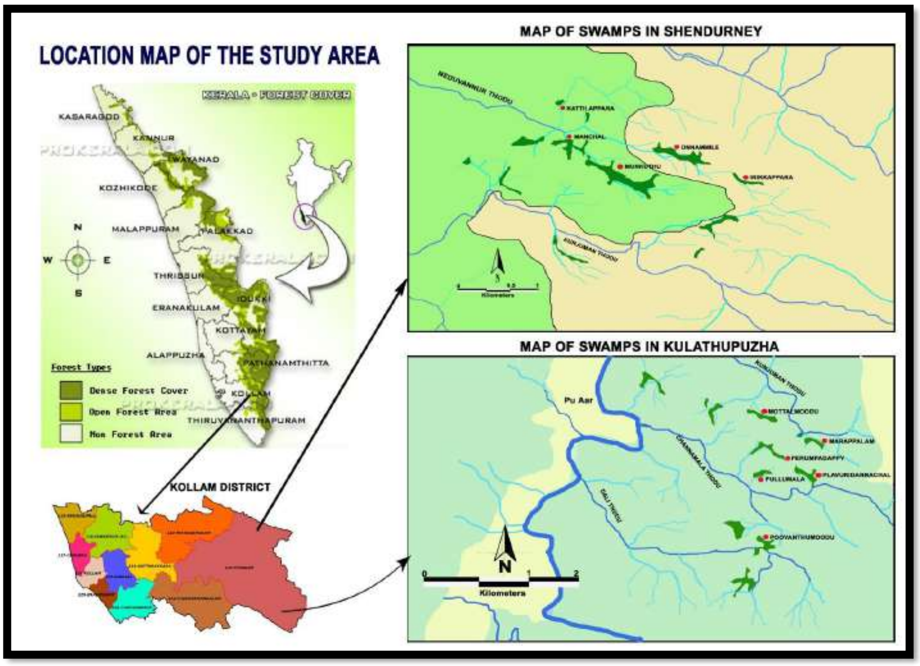

Fig1: The map showing the sampling sites in Kulathupuzha and Shendurney.

Table1: Material and Parameters were followed for the study

Sl. No	Parameters	Methods	Reference
1	Sediment pH	pH meter	APHA, 2012
2	Sediment Organic Carbon	Atomic Absorption Spectrometry	APHA, 2012
3	Sediment Sodium	Atomic Absorption Spectrometry	APHA, 2012
4	Sediment Potassium	Atomic Absorption Spectrometry	APHA, 2012
5	Sediment Calcium	Atomic Absorption Spectrometry	APHA, 2012
6	Sediment Magnesium	Atomic Absorption Spectrometry	APHA, 2012

RESULTS AND DISCUSSION

pH

The pH was found to be higher (6.52) in Post-monsoon at Manchal (Shendurney) and lowest (3.07) in Pre- monsoon Perum Padappy (Kulathupuzha). The present study revealed that the pH value ranges between 3.13 to 6.4. These soils are very acidic in nature. High amount of humus in forest soils is also responsible for low pH. High concentration of pH observed during post-monsoon season might be possibly due to greater input of effluents from different sources. The low values of pH recorded during pre-monsoon period may be due to perennial anaerobic condition in the swamp and metabolic activity of organisms, natural weathering process and anaerobic degradative activities of sediment bacteria (Hossain et al.,2016; Viju and Mohan,1994; Ponnamperuma, 1972 and Atlas, (1981). High amount of humus in forest soils is responsible for low pH (Dimtri et al., 1987).

Organic carbon (%)

Soil organic carbon (C org) describes the organic constituents in soil in various stages of decomposition such as tissues from dead plants and animals. The increasing percentage will improve soil fertility by improving the soil structure. The Organic carbon was found to be higher (3.4%) in Post-monsoon at Mottal Mood (Kulathupuzha) and lower (0.065%) in pre-Monsoon at Poovanathu Mood (Kulathupuzha), Sevgi and Tecimen,(2008) reported than higher organic carbon in the natural forest was due to production and return of higher amount of litter in natural forest. Declining trend during the Pre- monsoon season may be because organic carbon content decreases with increase in temperature (Kirschbaum, 1995; Albrecht and Rasmussen, 1995), and decomposition rates.

Table 2: Mean values of Sediment parameters in different Myristica swamps during the study period

Indicates maximum value   Indicates minimum value

	pH			0C (%)			Na (ppm)		
Stations	PRE	MON	POST	PRE	MON	POST	PRE	MON	POST
MottalMood	3.475	5.19	5.42	0.455	1.295	3.4	0.405	12.865	1.5

Marappalam	4.245	5.515	6.2	1.315	1.63	1.685	0.335	10.015	1.38
PerumPadappy	3.07	4.785	5.52	0.435	1.47	1.75	0.13	13.65	1.66
Plavu Chal	4.275	4.77	6.44	0.67	1.24	1.555	0.395	20.2	1.23
PulluMala	3.095	4.565	5.6	0.22	1.35	0.795	0.175	8.6	1.555
PoovanathuMood	3.14	5.085	5.615	0.065	0.505	1.375	0.135	9.34	1.235
KattilaPara	4.1	5.19	5.53	0.495	0.67	1.21	0.275	29.715	1.29
Munkuthu	4.355	5.41	5.475	0.605	1.245	3.325	0.39	7.8	3.3
ManChal	3.405	6.005	6.52	0.115	1.025	1.805	0.29	14.45	3.07
OnnamMile	3.385	4.615	5.57	0.45	0.91	1.34	0.11	9.735	2.705
Irrikappara	4.41	4.52	5.885	0.105	0.64	1.535	0.665	10.385	1.725

Potassium

The major reasons for salinity are the excess of ions of *sodium*, chloride, potassium, magnesium, sulfate, calcium, and bicarbonate. Natural sources of these ions include rock-water interactions, saline seeps, and minor atmospheric contributions. The potassium content was found to be higher (166.95 ppm) in Monsoon at Pullumala (Kulathupuzha) and lowest (3.01ppm) in Pre-monsoon at Perumpadappy (Kulathupuzha).The major source of potassium in freshwater is due to weathering of rocks. According to Salimetal,(2015) revealed that the amount of potassium values generally increases because of shifts in soil equilibrium; it may depend upon the type of clay minerals present, the potential seasonal variations, amount of soil humus, presence of type of vegetation etc. High rainfall, the fluctuating water table and the characteristics of swamp may be responsible for the low nutrient levels, especially K (Bhatand Kaveriappa, 2009). Chauhan (2001) found tha the increase in organic matter tends to increase the accumulation of available potassium in the soil.

Sodium

The Sodium content was found to be higher (29.715 ppm) in Monsoon at Kattilapara (Shendurney) and lowest (0.11 ppm) in Pre-monsoon at Onnam Mile (Shendurney). Highest sodium concentrations are associated with the presence of detrital sedimentary rock types, clay minerals and skeletal material (Billings and Ragland, 1968). Very low values of sodium related to the short weathering history of soil. Although sodium mobility maybe reduced by adsorption on clay minerals with high cation-exchange capacities.

Calcium and Magnesium

Calcium and Magnesium are two of the most abundant elements in wetland sediments. Calcium is an essential nutrient for plants and animals, while Magnesium is important for chlorophyll synthesis in plants. The calcium content was found to be higher (214.65 ppm) in Post-monsoon at KattilaPara (Shendurney) and lowest (14.385 ppm) in Monsoon at ManChal (Shendurney). The Magnesium was found to be higher (120.89ppm) in Post-monsoon at Munkuthu (Shendurney) and lowest (11.02 ppm) in Monsoon at Poovanathu Mood (Kulathupuzha). Magnesium and calcium are occurred naturally in waterbodies, their concentration increase as those elements are washed out from bedrock (Gałczyńska et al., 2013). The values were high in post-monsoon season may be due to the effect of the geological structures and slow flow rate of water while the reduction in calcium and magnesium concentrations in Monsoon season could be due to their retention by macrophytes and their accumulation in bottom deposits due to dilution by rainwater. A decrease in magnesium levels and a significant increase in calcium concentrations were observed in most bodies of water. The above could have been caused by the reduced absorption by plants as well as the release of calcium from partially uncovered bottom deposits.

Table 3: Mean values of Sediment parameters in different Myristica swamps during the study period

Blue: Indicates maximum value   Yellow: Indicates minimum value

	K (ppm)			**Ca (ppm)**			**Mg(ppm)**		
Stations	PRE	MON	POST	PRE	MON	POST	PRE	MON	POST
MottalMood	16.185	129	37.065	26.5	21.665	43.07	32.215	34.855	79.65
Marappalam	14.755	99.465	43.68	105.5	53.33	124	11.77	13.805	38.335
PerumPadappy	3.01	156	59.87	69.94	19.615	102.185	26.07	13.78	41.015
Plavu Chal	32.595	121.7	51.38	70.535	33.28	105.53	41.515	32.95	65.875
PulluMala	16.49	166.95	38.54	71.55	21.96	109.8	27.9	14.47	61.405
PoovanathuMood	4.82	108.83	34.4	58.255	40.05	66.865	17.55	11.02	35.8
KattilaPara	14.435	106.7	26.54	86.5	70.7	214.65	34.525	24.845	79.395
Munkuthu	14.755	63.28	29.24	81	31.1	135.7	91.16	12.165	120.89
ManChal	3.105	140.95	35.815	28.525	14.385	78.325	20.755	26.51	33.66
OnnamMile	12.795	131.4	60.06	56.895	44.535	62.745	14.4	16.68	29.28
Irrikappara	4.2775	154.25	47.86	62.55	88.645	184.75	41.945	30.07	51.545

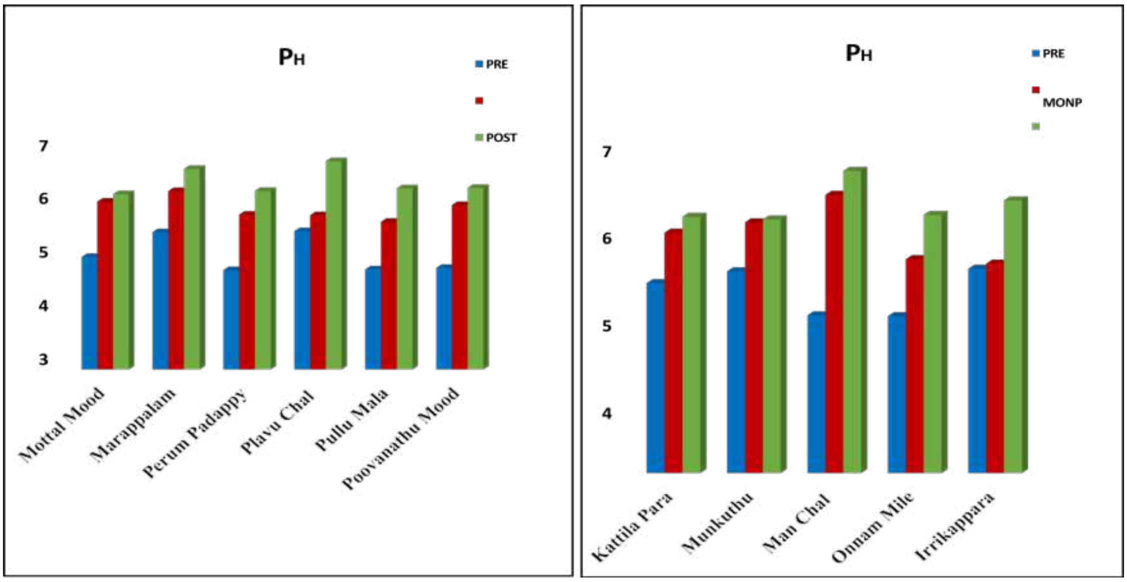

Fig 2: Variations of pH in soil samples from Kulathupuzha and Shendurney

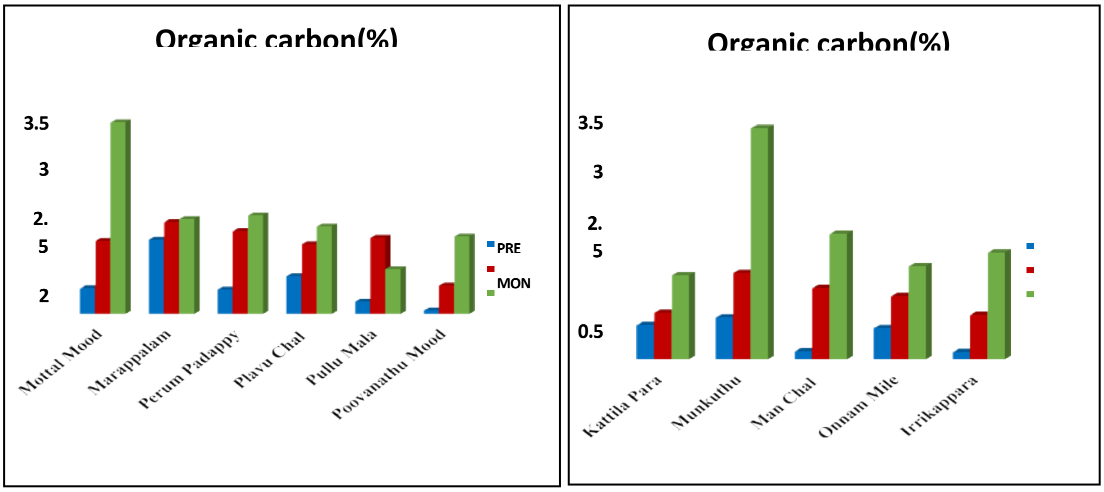

Fig 3: Variations of Organic carbon in soil samples from Kulathupuzha and Shendurney

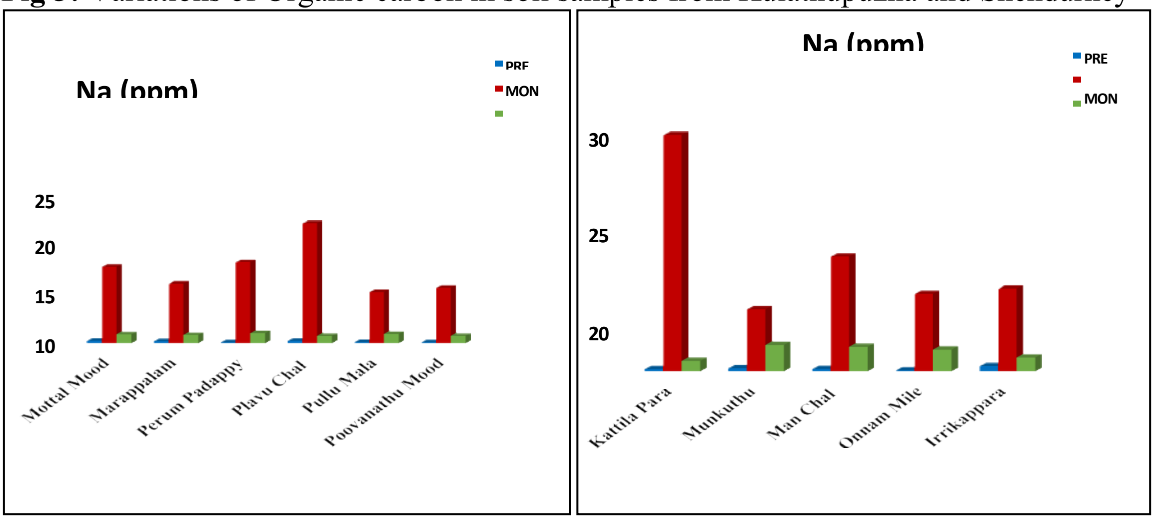

Fig 4: Variations of Potassium in soil samples from Kulathupuzha and Shendurney

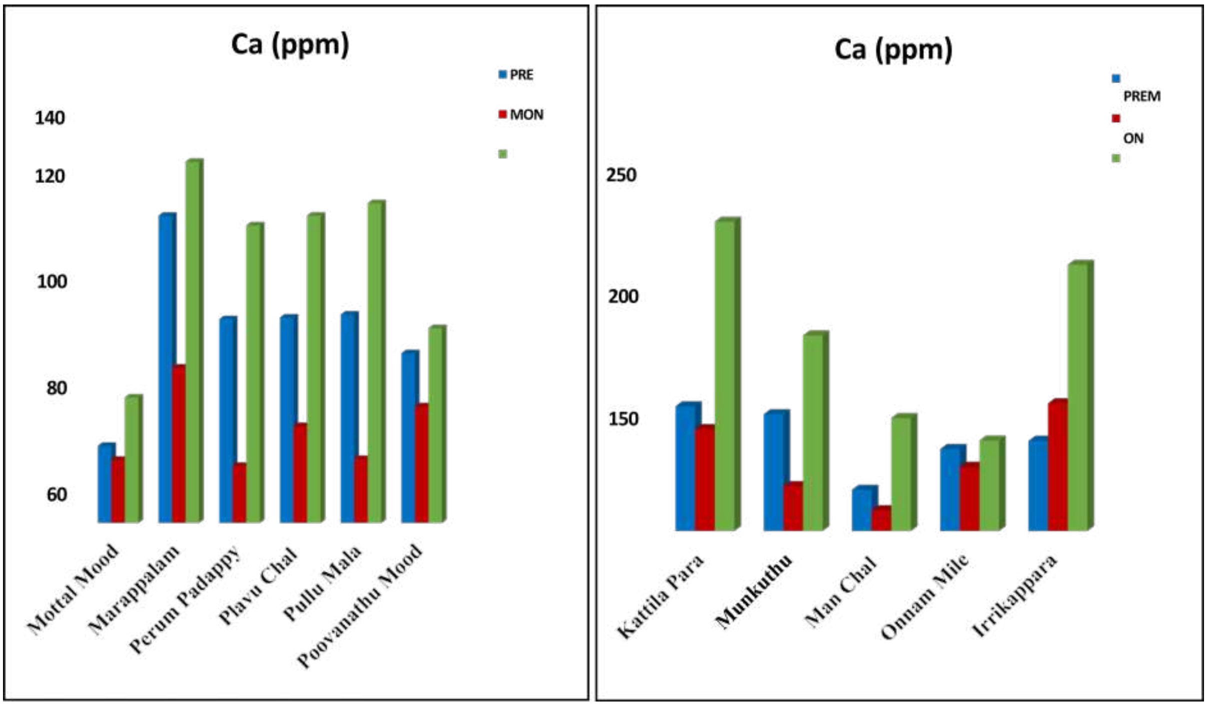

Fig 5: Variations of Calcium in soil samples from Kulathupuzha and Shendurney

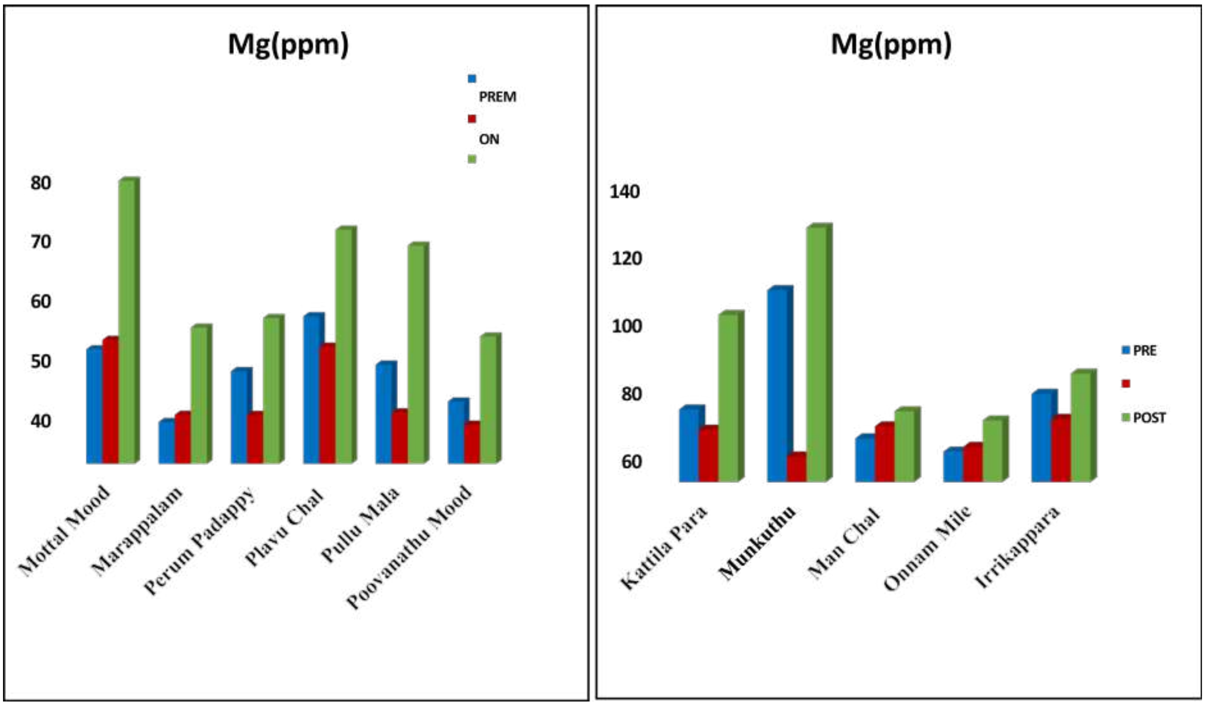

Fig 6: Variations of Magnesium in soil samples from Kulathupuzha and Shendurny

CONCLUSION

The pH of the soil was found to be very acidic in nature, ranging from 3.13 to 6.4, with the highest values observed during the post-monsoon season and the lowest values during the pre-monsoon season. Organic carbon content was found to be higher during the post-monsoon season and lower during the pre-monsoon season. The study found that the major reasons for salinity were the excess of ions of sodium, chloride, potassium, magnesium, sulfate, calcium, and bicarbonate. Sodium and potassium content were found to be higher during the monsoon season, while calcium and magnesium content were found to be higher during the post- monsoon season. The study suggests that the observed changes in soil properties are influenced by natural weathering processes, input of effluents from different sources, and metabolic activities of organisms.

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STUDIES ON THE PRESENCE OF MICROPLASTICS FROM THE SEDIMENTSAND SELECTED FISHES IN VELI LAKE AND KADINAMKULAM LAKE IN THIRUVANANTHAPURAM DISTRICT, KERALA

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ABSTRACT

Microplastics are all around us, and yet many people don't know what they are or how prevalent they are. Though studies have yet to reveal a tangible effect on humans, plastic debris can be destructive to ecological habitats. Microplastics are commonly defined as synthetic polymer particles that are smaller than 5 mm with no general agreement on their lower size. Plastics and Microplastics are a growing contaminant that is affecting the whole world. The urban and suburban area is the main source of plastic pollution which eventually end up in water bodies like rivers, lakes, seas, and oceans. Due to its size andavailability in water bodies, it is often consumed by sea organisms and indirectly consumed by human beings as food. This study was an attempt to make an estimation of average abundance of microplastic existance in common fishes and sediments. The study sites were Veli lake and Kadinamkulam lake in Trivandrum District of Kerala coast. In this study planktivores fishesfrom both the stations showed a negligible number of microplastics in both edible and inedible parts. *A. melettinus* was the herbivore fish collected from Station 1 showed 0.83 microplastics in gills and 0 microplastics in the gut and dorsal muscle + skin. Herbivore fish *S. canaliculatus* from Station 2 showed 0 microplastic abundance in gills, gut, and dorsal muscle + skin. So, it is evident that omnivore fishes presented a higher amount of microplastics than registered in herbivores/planktivores fishes.This study points out that the number of microplastics seen in fish organs of Station 1, 64% were gill microplastics, 28% were gut, and the remaining 8% belong to dorsal muscle + skin microplastics. And the number of microplastics seen in fish organs of Station 2, 74% were gill microplastics, 22% were gut, and the remaining 4%belong to dorsal muscle + skin microplastics. Here also fibers were the most abundant type of microplastics from both the stations. 38 out of 64 and 29 out of 50 were the counts of fibers reported in fishes of Station 1 and Station 2 respectively, this finding was the same in the case of

sediments.

Keywords: Microplastics, Planktivores, Abundance, Edible, Fiber

INTRODUCTION

Today, plastic is used in almost every aspect of daily life, including toys for kids, household items, construction materials, personal care products, and medical equipment. The "plastic age's" negative aspects are slowly becoming more apparent as plastic objects make social life more convenient. (Geyer et al., 2017). Researchers and scientists are very concerned about the growing pollution caused by microplastics (<5mm) as a result of the breakdown and fragmentation of plastic materials in the environment (Shen et al., 2019). Macroplastics that have disintegrated in water bodies are frequently the source of microplastics and nanoplastics. Plastic may disintegrate as a result of sun, UV, wind, waves, weathering, or other factors. According to NOAA microplastics as tiny plastic particles that are less than 0.2 inches (5 millimeters) long. They are solid, synthetic materials with a high polymer content. Chemicallythey are insoluble in water and are non-degradable in nature. Microplastics are of two types, particles that are directly discharged into the environment as a result of the manufacture or usage of consumer goods are called primary microplastics while secondary microplastics are made when bigger plastic items like fishing nets, bottles, and bags degrade. Nanoplastics, which are plastic particles with a size of less than 100 nm, are another type of plastic particulate. Fibers, Microbeads, Fragments, Nurdles, Foams, Films, Filaments, Pellets, etc are different forms of microplastics. Microplastics are everywhere from microbes to whale, from land to sky. Microplastics are of particular concern due to the adverse effects on marine and freshwater environments, aquatic life, biodiversity, and possibly to human health since their small size facilitates uptake and bioaccumulation by organisms or toxic effects from the complex mixture of chemicals these particles consist of. Main additives found in microplastics which acts as endocrine disrupters are Polychlorinated biphenyls (PCBs), Polybrominated biphenyls (PBBs) and Bisphenol A(BPA). According to the Central Pollution Control Board's 2014 report, New Delhi, India is one of the world's top consumers of plastic, generating an average of 5.6 milliontonnes of plastic each year. An average person eats 20 kg of microplastic and 2.5 kg of plastic throughout a lifetime. There be numerous microbial strains that break down plastic polymers into monomers. Microbes can be used to break down plastics in an environmentally beneficial way. Various policies and laws have been formed by various countries and organizations to curb the effect of plastic and microplastics on the environment.

MATERIALS AND METHODS

Study area

Kerala coastal area has been endowed with an expansive body of brackish waters including backwaters, lagoons, and estuaries including mangrove swamps. The backwaters of Kerala are interconnected by an extensive network of canals and they have played a significant role in thesocio-economic status and cultural history of Kerala. This study was conducted in the two backwaters of Kerala namely Veli Backwater (Station I-Veli Boat Club within Veli Tourist Village) and Kadinamkulam Backwater (Station II-Madanvila).

Station 1 - Veli Lake Veli is a small inland brackish water lake on the southwest coast of Kerala. Located in the northwest of Thiruvananthapuram District ($08^{0}30'$ to $08^{0}31'$ N and $76^{0}52'$to $76^{0}53'$E). The lake is a shallow one with a mean depth of 2.4 m, length of 1.25 km, and a width of 0.44 km, and is 12 km away from Trivandrum central. A total of 35 species offresh water and marine fishes under 9 orders, 26 families, and 30 genera were recorded from the lake (Regi *et al.,* 2021). The lake was seriously affected by anthropogenic pressure due to industrial waste discharge, municipal waste disposal, tourism activities, developmental activities dredging, and eutrophication.

Station 2 - Kadinamkulam Lake Kadinamkulam lake is the largest among the estuaries in theTrivandrum district. Lies between latitude $08^{0}35'$ to $08^{0}45'$ N and longitude $76^{0}45'$to $76^{0}56'$E. The lake is a shallow one with a mean depth of 1.5 m, a length of 3.25 sq km, and is 25.6 km away from Trivandrum central. A total of 67 species of fishes belonging to 34 families have been recorded from Kadinamkulam Kayal. This area is prone to activities like fishing, aquaculture, tourism, transportation, sand mining, dumping of waste, estuarine reclamation,etc.

Collection of samples

For the present study fish and sediment were collected from both stations. Fishes were collected from both stations using gill nets. Locally available commercial fishes were

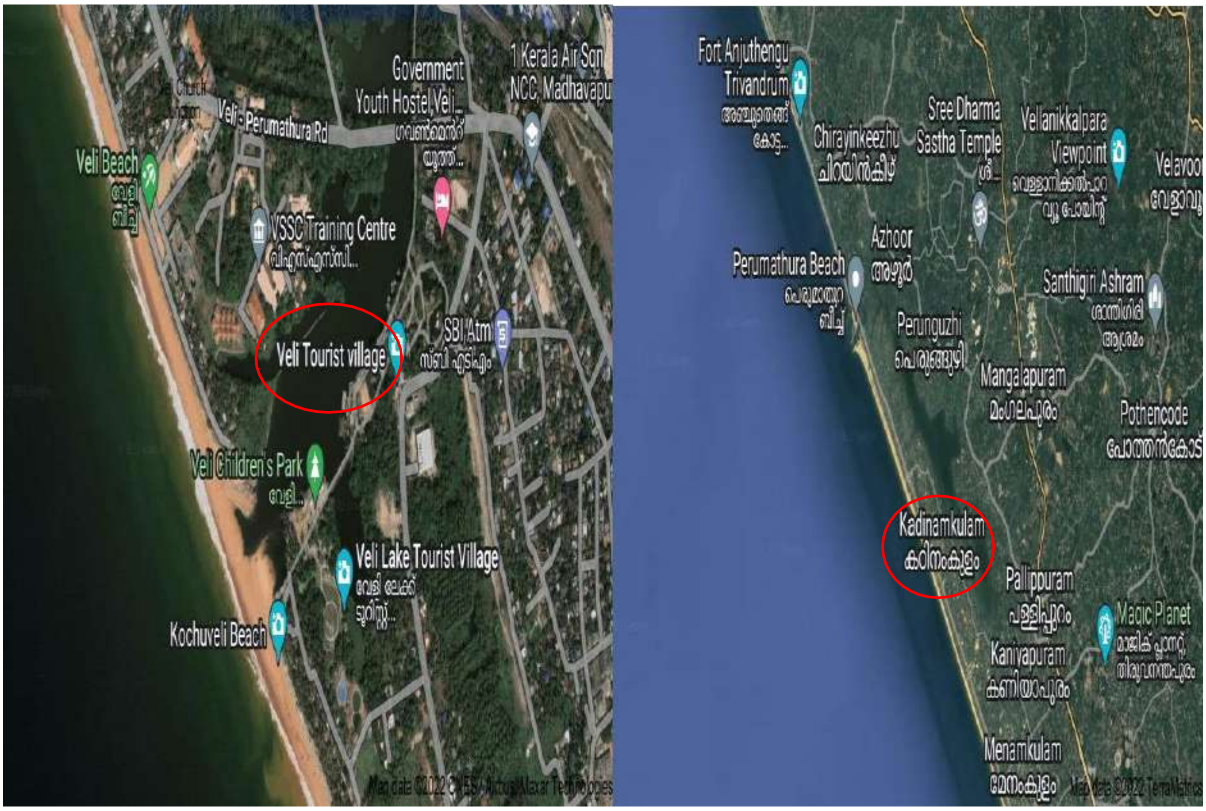


Fig 1: Location map of sample collection sites

collected from the fisherman of Veli and Kadinamkulam lake. From the net fishes were carefully removed and transferred to ice-box containers. Collected fishes were moved to the lab and dissection was performed after identifying and recording its length and weight. Desired parts were dissected and weighted for further study. Sediments from both stations were collected using a hand-held grab sampler. Sediments were collected in a beaker and taken to the lab to perform microplastic detection. The sample collection was done in the early morning from both sites. Samples were collected three times from each site in a period from November 2021 to April 2022.

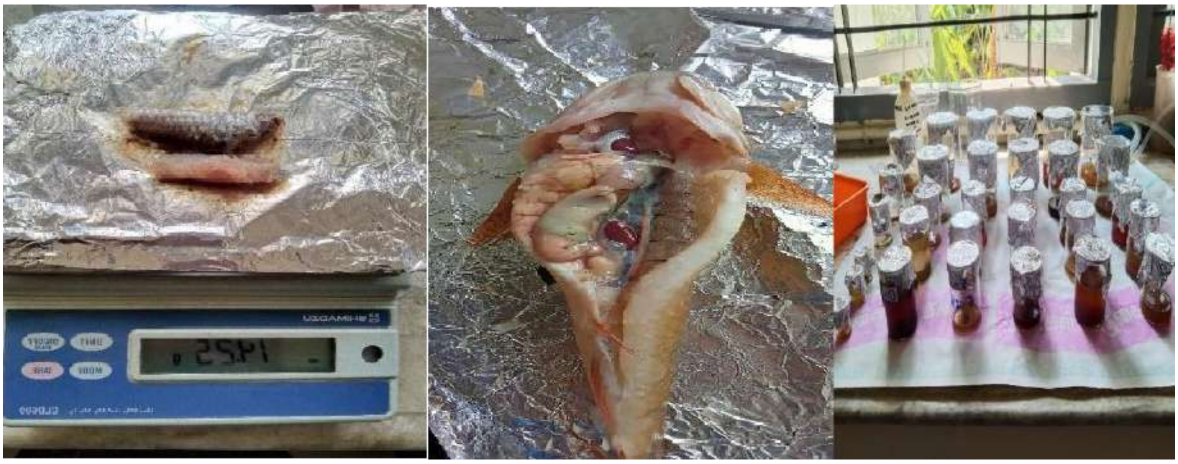
Experimental design

Sample preparation – Sediment Sediment samples were collected using a hand-held grab sampler (Van-Veen grab sampler) (Dai et al., 2018). The samples were collecd in a beaker covered with aluminium foil to avoid airborne contamination. Sediment samples were processed as per the methods of He et al., 2017. The sediment was dried at 65^{0} C for 48-96 hr. for getting a sample with a dry weight of 200-500 gm. Then the samples were digested with 10% KOH at 45ºC and stirred at 70-85 rpm for 48hr in a stirring hot plate using a magnetic stirring bar also cover the sample with aluminium foil. After digestion sieve the sample using a 300µm test sieve. The filtrate from the above stage was vacuum-filtered over through a 70- mm-diameter Whatman cellulose filter (Grade1-pore size138 11µm) to isolate particles < 500µm. Density separation was not done to preserve microplastics of all densities (Abbasi et al., 2018). The sample was transferred to a separate clean petri dish for further examination. The sample was visually examined under a Luxeo 6Z Stereomicroscope (Labomed, USA) and microplastics were counted, measured, and photographed using (Micaps PROHDMIB1080CM). Microplastics were classified according to their morphotypes. Hard angular pieces were classified as fragments, elongated threadlike particles as fibers, flat flexible pieces as filaments (Jabeen et al., 2017), and so on. Particles of size>100µm were randomly selected for FTIR analysis (FTIR Spectrophotometer, clif.ftir@keralauniversity.ac.in, Instruentation support of Central Laboratory for Instrumentation and Facilitation CLIF, University of Kerala, Karyavattom).

Sample preparation

Fish Collected fishes were washed with distilled water twice and with ethanol. The fish is transferred to a dissection tray, by using a lab-identification guide (The Fishes of India by Francis Day, Volume 1 and Volume 2, MJP Publications, 2017) each fish was identified up to the family level. The total length and weight of fish were noted. Dissection of fish started from the anal vent, cutting from the anal fin to the pelvic fin and up to the pectoralfin. Gills, gastrointestinal tract (gut), and dorsal muscle + skin were identified and removed to three labeled beakers. Samples were kept covered to limit airborne exposure to microplastics. Weigh each organ before treatment. To each sample, a volume of 10% Potassium hydroxide solution corresponding to three folds of its weight was added. Gut and dorsal muscle+ skin samples were incubated at 60ºC for 24 h (Dehaut et al., 2016), and gill samples were incubatedat 72 h in a bacteriological incubator (Karami et al., 2017) to digest the organic material. The gills were incubated under other conditions of temperature and time interval because the first one was not fully efficient for treatment. The tissue samples were manually shaken for every 24 h. The digested mixture was cooled and the digestate was filtered by a two-stage process toprevent the clogging of the pores of the filter paper. First, it was filtered through a 500 µm brass sieve, and the retentate (particles>500µm) was transferred to the Petri dish for microscopic examination. Subsequently, the filtrate from the above stage was vacuum-filtered over through a 70-

mm-diameter Whatman cellulose filter (Grade 1-pore size138 11µm) to isolate particles < 500µm. Density separation was not done to preserve microplastics of all densities (Abbasi et al., 2018). The sample will be transferred to a separate clean petri dish for further examination. The sample was visually examined under a Luxeo 6Z Stereomicroscope (Labomed, USA) and microplastics were counted, measured, and photographed using (Micaps PROHDMIB1080CM). Microplastics were classified according to their morphotypes. Hard angular pieces were classified as fragments, elongated threadlike particles as fibers, flat flexiblepieces as filaments (Jabeen et al., 2017), and so on. Particles of size > 100µm were randomly selected for FTIR analysis (FTIR Spectrophotometer, clif.ftir@keralauniversity.ac.in, Instrumentation support of Central Laboratory for Instrumentation and Facilitation CLIF, University of Kerala, Karyavattom).



RESULTS

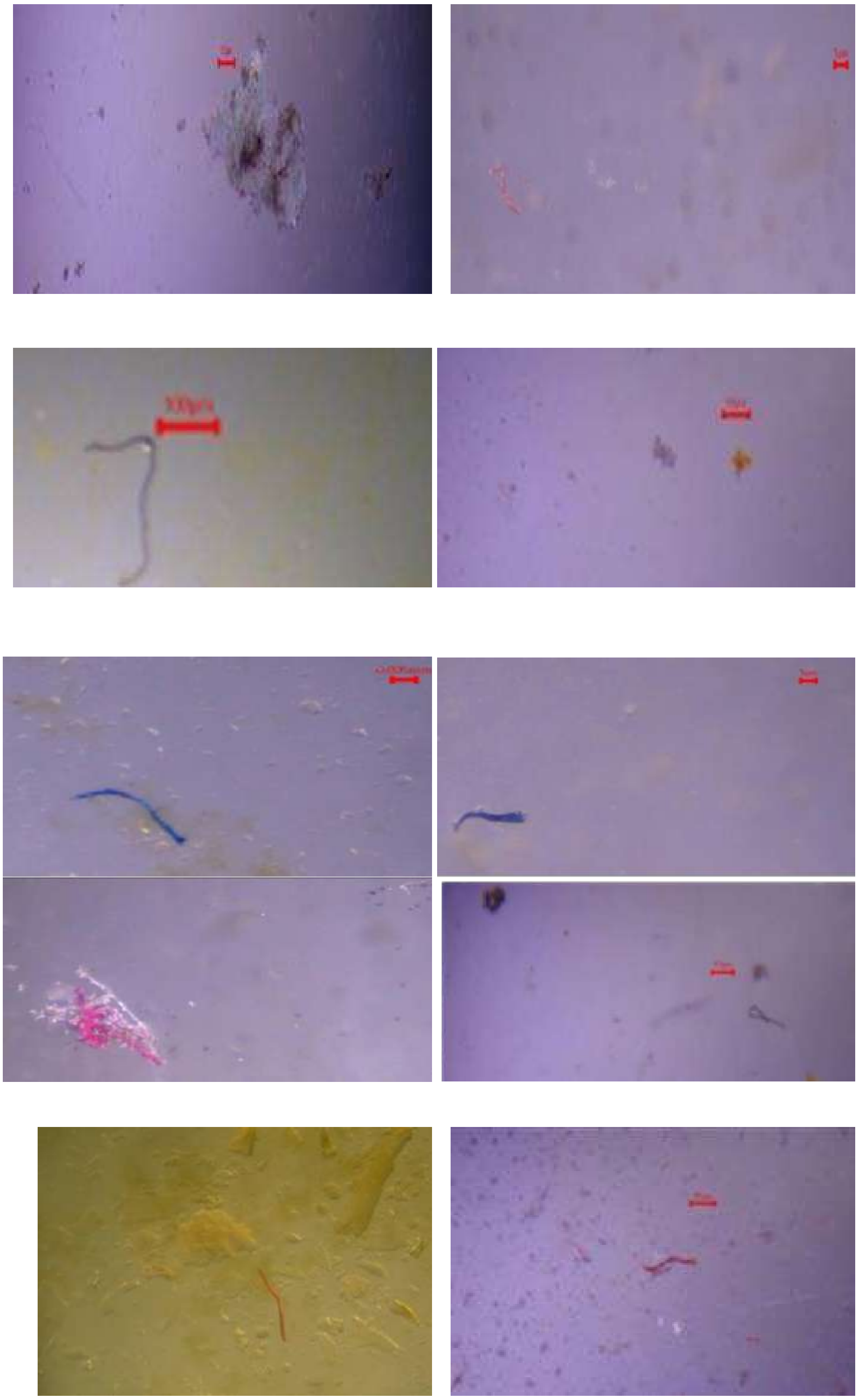
Microplastics in Fishes and Sediments of Station 1 and Station 2

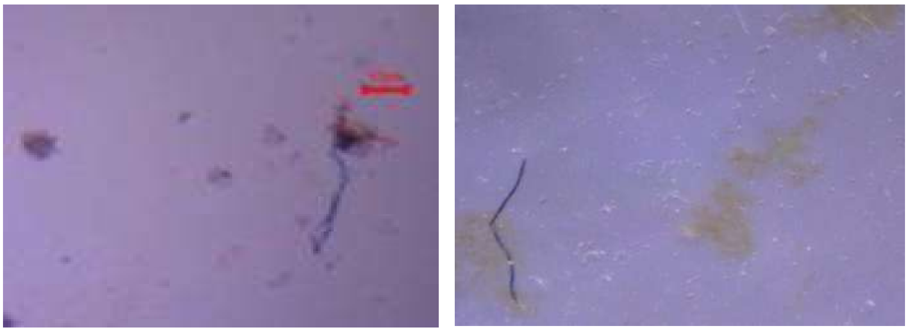
Station 1 Veli Lake: Commercially important fishes and sediment were collected. A total of 10 species of fishes namely *Etroplus suratensis, Pseudetroplus maculatus, Caranx hippos, Amblypharyngdon melettinus, Oreochromis niloticus, Puntius sarana sarana, Megalops cyprinoides, Gerres filamentosus, Platycephalus indicus, and Plicofollis dussumieri* were collected. In which 4 of them were omnivores, 5 were carnivores and the remaining 1 was herbivore in nature. The total length and the total weight, average weight of gill, gut, and dorsal muscle + skin of fishes subjected to study were recorded. Total length of fishes ranging from

7.5 cm to 28.75 cm and weight ranging from 9.38 gm to 205.4 gm. Gill, gut, and dorsal muscle + skin were the target organs for microplastic investigation. A minimum gill weight of 0.18gmwas shown by *A. melettinus*, and maximum by *M. cyprinoides* – 4.77gm. Average gut weight ranging from 0.38gm to 9.88gm was shown by fishes. *P. maculatus* showed the minimum dorsal muscle + skin weight of 2.05gm and a maximum weight was shown by *M. cyprinoides*–41.18gm. While examining the presence of microplastics in the fishes of Station 1, Gills showed a maximum number of microplastic abundance than gut and dorsal muscle +skin. In omnivore fishes, *O.niloticus* showed a maximum abundance of microplastics (6.08). Another omnivore fish *E.suratensis* showed a microplastic abundance of 5.92 on average. Herbivore fish *A.melettinus* showed the most minor microplastic abundance in gills. While considering the gut microplastics only an average of 3.92 was shown by *O.niloticus* and *G.filamentosus* showed 0 abundance of microplastics. The edible part of every commercial fish is the dorsal muscle, so the presence of microplastics in dorsal muscle+skin is much more relevant than thegill and gut which are the inedible parts of a fish. 6 out of 10 species of fish showed 0 abundance of microplastics in their dm+skin portion. *O. niloticus* showed 1.92 and *E. suratensis* showed 0.83 number of microplastics on average. This strongly indicates that omnivore fishes were most prone to microplastic exposure due to their non-selective nature of feeding. Comparing a whole number of microplastics seen in fish organs of Station 1, 64% were gill microplastics, 28% were gut and remaining 8% belong to dorsal muscle + skin microplastics. While comparing the percentage abundance of microplastics and the type of feeding habits of fishes collected there shows a correlation between them, 19% of total microplastic abundance was shown by *O. niloticus*, and 14% by *E. surstensis*, both were omnivore fishes. Other carnivore fishes like *P. indicus, P. dussumieri, and C. hippos* showed a microplastic abundance of 14%, 13%, and 8% respectively. While least abundance by a herbivore fish *A. melettinus* 3%. While investigating the type of microplastics seen in the fishes of Station 1, Fibers were the most abundant type of microplastics in each fish as well as each organ of study. A total of 38 fibers out of 64 microplastics were found in the whole fish sample. Nurdles, pellets, and microbeads were absent in the fish sample of Station 1. The investigation on the presence of microplasticsin the sediments of Station 1, A total of 20 microplastic particles were observed from that fiber (8 out of 20) were the abundant type of microplastic. Nurdles, pellets, and foams were absent in Station 1.

Station 2 Kadinamkulam Lake: Commercially important fishes and sediment were collected. A total of 10 species of fishes namely *Lutjanus indicus, Plicofollis dussumieri, Siganus canaliculatus, Monodactylus argenteus, Etroplus suratensis, Caranx hippos, Gerres filamentosus, Ambassis dussumieri, Oreochromis mossambicus,* and *Lates calcarifer* were collected. In which 2 of them were omnivores, 6 were carnivores and the remaining were herbivores and detritivore in nature. Total length and the total weight, average weight of gill, gut, and dorsal muscle + skin of fishes subjected to study were recorded. Average length of fish ranging from 6.67 cm to 31 cm. Total weight ranging from 2.94gm to 300gm. Gill, gut, and dorsal muscle + skin were the target organs for microplastic investigation. A minimum gill weight of 0.04gm was shown by *A. dussumieri*, and maximum by *L. calcarifer* – 9.25gm. Average gut weight ranging from 0.2gm to 11.2gm was shown by fishes. *A. dussumieri* showedthe minimum dorsal muscle + skin weight of 0.43gm and a maximum weight was shown by *L. calcarifer* – 46.9gm.

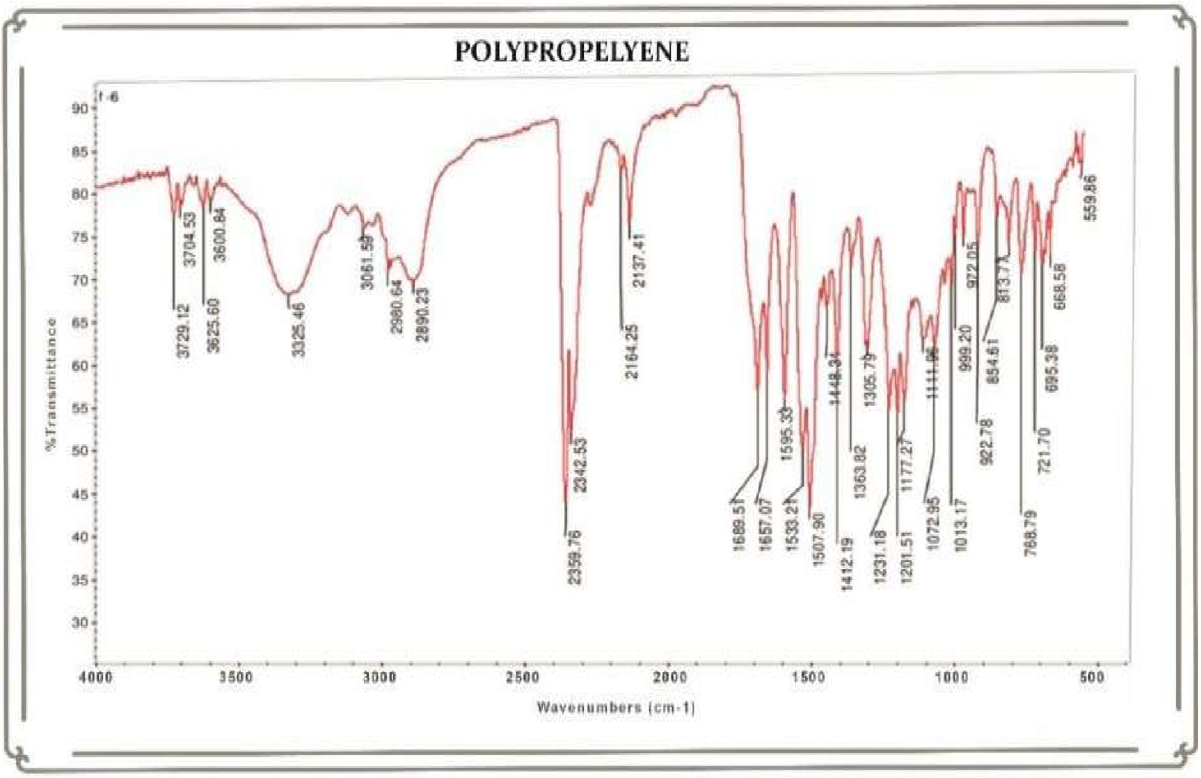
Stereomicroscopic images of microplastic after treatment

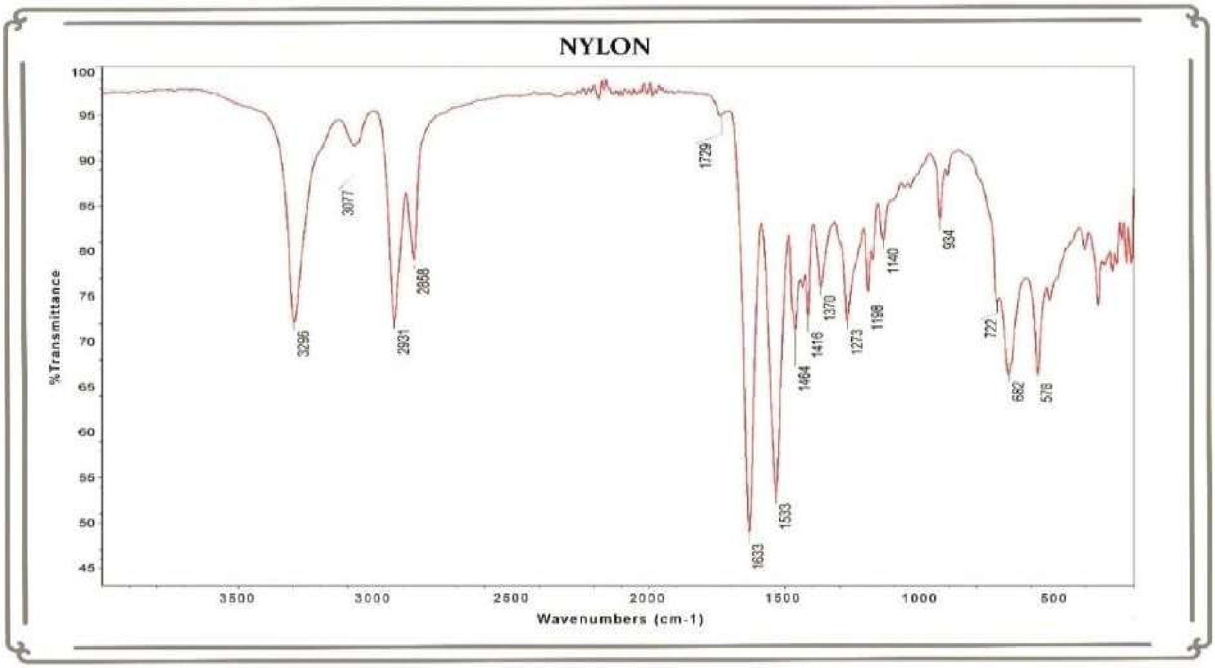




While examining the presence of microplastics in the fishes of Station 2, Gills showed a maximum number of microplastics in fishes. *E. suratensis* and *L.calcarifer* showed a maximum abundance of microplastics (4.92). Another omnivore fish *O. mossambicus* also showed a microplastic abundance of 4.92 on average. Herbivore fish *S. canaliculatus* showed 0 microplastic abundance in gills. While considering the gut microplastics only an average of 2.92 was shown by *G. filamentosus., S. canaliculatus, C. hippos* and *A. dussumieri* showed 0 abundance of microplastics. The edible part of every commercial fish is the dorsal muscle, so the presence of microplastics in dorsal muscle+skin is much more relevant than the gill and gut which are the inedible parts of a fish. 8 out of 10 species of fishes show 0 abundance of microplastics in their dm+skin portion. *G. filamentosus* shows 1.23 and *E. suratensis* 0.83 number of microplastics on average. This strongly indicates that omnivore fishes are more sensitive to microplastic exposure due to their non-selective nature of feeding. Comparing a whole number of microplastics seen in fish organs of Station 2, 74% were gill microplastics, 22% were gut and remaining 4% belong to dorsal muscle + skin microplastics. While comparing the percentage abundance of microplastics and type of feeding habits of fishes collected, there shows a correlation among them. 15% of total microplastic abundance was shown by *E. surstensis*, and 12% by *O. mossambicus*, omnivore fishes. While least by herbivore fish *A. canaliculatus* 0%. Other carnivore fishes like *L. calcarifer, P. dussumieri, C. hippos* showed microplastic abundance of 14%, 8%, and 10% respectively. While investigating the type of microplastics seen in the fishes of Station 2, Fibers were the most abundant type of microplastics in each fish as well as each organ of study. A total of 29 fibers out of 50 microplastics were found in the whole fish sample. Pellets, and microbeads were absent in the fish sample of Station 2. The present investigation on the presence of microplastics in the sediments of Station 2. In total 11 microplastics were found. In which, fibers (6 out of 11) were abundant type of microplastic. Nurdles, filament, foam andfilms were absent in Station 2.

Station 1 & Station 2: While comparing Station 1 and Station 2 in terms of microplastic abundance in fishes, Station 1 (Veli lake) showed highest number (56%) than Station 2 (Kadinamkulam lake, 44%). While comparing both stations in terms of types of microplastics found in fishes, Fibers are the most abundant type of microplastics in fishes of both stations. Number of foams and films are comparatively low while comparing other types. Pellets and microbeads were absent in both the stations. Significant number of fragments and filaments were reported in both the stations. Microfibers were abundant in both stations. Both nurdles and foam were absent in station 1 and station 2. Comparing the microplastic abundance of station 1 and station 2, Station 1 – Veli lake was polluted than station 2 – Kadinamkulam lake. Spectrum obtained after FT-IR Spectroscopic analysis were identified as plastic polymers. Spectrum 1 was identified as Polyvinyl chloride or PVC (mostly used polymer, used in building, transport, packaging, electrical and health care applications). Spectrum 2 was identified as Polyester or PL (is a type of synthetic fiber widely used in clothing fabrics, home furnishing, automobile industry etc.,).





Spectrum 3 was identified as Polypropylene or Polypropene or PP (is the lightest polymer used for making plastic containers, toys, car parts, medical components etc.,). Spectrum 4 was identified as Nylon (is used in clothing industry, for making fish nets, industrial uses also in machine manufacturing units.

DISCUSSION

In this study planktivores fishes from both the stations showed a negligible number of microplastics in both edible and inedible parts. *A. melettinus* was the herbivore fish collected from Station 1 showed 0.83 microplastics in gills and 0 microplastics in the gut and dorsal muscle + skin. Herbivore fish *S. canaliculatus* from Station 2 showed 0 microplastic abundance in gills, gut, and dorsal muscle + skin. So, it is evident that omnivore fishes ingest a higher amount of microplastics than herbivores/planktivores fishes. This finding shows close resemblance with the study conducted by Damaris Benny *et al*., in 2020 in fishes of Baltic Sea. In our study we observed that the number of microplastics seen in fish organs of Station 1, 64% were gill microplastics, 28% were gut, and the remaining 8% belong to dorsal muscle + skin microplastics. And the number of microplastics seen in fish organs of Station 2, 74% were gill microplastics, 22% were gut, and the remaining 4% belong to dorsal muscle + skin microplastics. So, it is clear that edible parts of fishes registered a smaller number of microplastics than inedible parts and this observation shows close resemblance with the findings made by Daniel *et al*., on pelagic fishes of Kerala in 2020. In our finding's fibers were the most abundant type of microplastics from both the stations. 38 out of 64 and 29 out of 50 were the counts of fibers reported in fishes of Station 1 and Station 2 respectively, this finding was the same in the cases of sediments. A study conducted by Rodrigues *et al*., in 2018 on fishes and sediments of Antua river basin, Portugal showed the same.

CONCLUSION

Microplastics are all around us, and yet many people don't know what they are or how prevalent they are. Though studies have yet to reveal a tangible effect on humans, plastic debris can be destructive to ecological habitats. Ultimately, we all sharethis planet, and globalecosystems influence each other what happens in one will eventually find its way to another. Preventing further ecological harm benefits every living being, from zooplankton to humans to blue whales. Microplastics are a major environmental threatdespite their tiny size, but theydon't have to continue affecting the environment if we all think big and act quickly. Plastics and Microplastics are a growing contaminant that is affecting the wholeworld. The urban and suburban area is the main source of plastic pollution which eventually end up in water bodies like rivers, lakes, seas, and oceans. Due to its size andavailability in water bodies, it is often consumed by sea organisms and indirectly consumed by human beings as food. Microplastic is the carrier or transport medium fortoxic elements such as DDT and hexachlorobenzene. Consumption of microplastics fora long period may change our human chromosomes and itmay lead to infertility, obesity, and even cause cancer. Various policies and laws have beenformed by variouscountries and organizations to curb the effect of Plastic and Microplastics on the environment. Many ways to reduce microplastic use come from a larger mindset of weighing outwhat plastic use makes sense versus what simply generates waste with little longevity.

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STUDY OF BIODIVERSITY OF DUNG BEETLES IN GRAZED PASTURE LANDS INKANYAKUMARI DISTRICT,TAMILNADU, INDIA

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ABSTRACT:

Dung beetles (Coleoptera: Scarabaeoidea) play a critical role in regulating ecosystem services. However, little is known about how grazing management affects dung beetle communities. The purpose of this study was to investigate dung beetle abundance and diversity throughout the grazing season in the selected pasture lands in Kanyakumari District, Tamilnadu. The abundance and diversity of dung beetles were measured in the 2021 and 2022 grazing seasons using dung-baited pitfall traps. Dung beetle abundance for each grazing treatment was characterized through four indices: peak abundance, species richness, Simpson's diversity index and Simpson's evenness. A total of 1292 dung beetles were collected through both years of trapping in this study. Peak abundance and species richness were greater in grazed treatments when compared to non-grazed pasture lands in both years. Species richness was 70% (2021) and 61% (2022) higher in grazed lands when compared to ungrazed lands. Thus the current study demonstrated how cow grazing practises can alter dung beetle activity on pasturelands and provided helpful information regarding the effects of grazing practises on dung beetle communities.

Keywords: Dung beetle, grazing, species richness, Simpson's diversity index, Simpson's evenness.

INTRODUCTION

Dung beetles (Coleoptera: Scarabaeoidea) serve an important role in the function of many ecosystems (Perrin *et al.,* 2020). Dung beetles scavenge dung from the soil surface and transport it underground where they then use it as a food resource (Halffter and Matthews 1966, Simmons and Ridsdill-Smith 2011, Nunes et al. 2018). A number of studies have reported that dung beetles can play important roles in nutrient cycling, greenhouse gas mitigation, parasite suppression, and overall trophic regulation (Penttilä *et al.,* 2013, Evans *et al.,* 2019a). In addition, dung beetle activity can increase soil nutrients at the soil surface by incorporating nutrients from the dung into the soil (Evans *et al.,* 2019b). Therefore, dung beetle activity is recognized as being very important for ranch management by promoting and maintaining healthy cattle-grazed rangeland ecosystems (Aarons *et al.,* 2009, Menéndez *et al.,* 2016). The relationships between dung beetle activity and these important ecological functions demonstrate why dung beetles are important for the promotion and maintenance of healthy cattle-grazed ecosystems (Perrin *et al.,* 2020). However, the value of the services provided by dung beetles is greatly affected by their biodiversity, with less diverse communities providing fewer ecosystem functions (Spaak *et al.,* 2017). Hence the purpose of the present study was to investigate dung beetle abundance and diversity throughout the grazing season in the selected pasture lands in Kanyakumari District, Tamilnadu.

MATERIALS AND METHODS

Study Site Description

The selected study site was an open agricultural field of predominantly coconut plantation with the intervening grasslands in and around Kanyakumari District, Tamilnadu,India used for cattle grazing.Theecoregionstudied is composed of grass-covered sand dunes and sub-irrigated (aquifer-fed) meadows with numerous lakes and wetlands spread throughout. The soil organic matter content ranged between 14 and 33 mg/g at the 0- to 10-cm depth and between 4 and 9 mg/g at the 10- to 20-cm depth. The meadows were seasonally wet due to the rising water table and the annual precipitation ranging from 800 to 860mm and temperature averages of 26.6°C ranging from 23.6°C to 30.2.°C

Sampling

Dung beetles were collected using dung baited pitfall traps of the bait-surface-grid type on a seasonal basis during southwest monsoon (June–August), northeast monsoon (September–November), presummer (December–February) and summer (March–May) periods from June 2021 to May 2022. Pit fall traps were made of plastic basins, 10cm in diameter and 15cm deep and a mixture of water-formalin-liquid soap mixture were used as preservative. The basins were buried with their rim in level with the surrounding substrate and each trap was topped with a plastic plate supported on iron bars to prevent desiccation during sunny days and inundation during the periods of rain. Two hundred grams of fresh cow dung was placed on a wire grid between the basin and the tray. Ten such traps at 50m intervals along a linear transect were placed following the standardized dung-beetle sampling design of maintaining a minimum distance of 50m between traps to minimize trap interference (Larsen & Forsyth 2005). Beetles were collected at 0600 and 1600 hr each day. Following collection, samples were taken to the laboratory where dung beetles were counted and identified to species according to Ratcliffe and Paulsen (2008). A voucher collection of dung beetle species was constructed for this study and is housed at the Department of Zoology, Sree Ayyappa College for Women, Nagercoil, Kanyakumari District, Tamilnadu.

Statistical Procedures

Dung beetle activity for each grazing treatment was characterized through four indices: peak abundance per trap, species richness, Simpson's diversity index, and Simpson's evenness. Peak abundance was defined as the maximum number of dung beetles recovered per trap per period for each grazing treatment when cattle were present in the paddock. This was used to counteract the absence of cattle in paddocks that were not being grazed in the rotational grazing treatments. Species richness, or number of species, was expressed as the total number of species that were captured in each grazing treatment. Simpson's diversity index (D) quantifies the diversity in a habitat by accounting for species richness as well as the relative abundance of each species in a sample (Magurran and McGill 2011) by the following equation: $D = \Sigma pi2$ where*p*i represents the proportion of abundance for species i. Simpson's diversity index can be summarized as, 'the probability that two individuals drawn at random from an infinite community would belong to the same species'. The reciprocal of Simpson's diversity index was used to determine dung beetle diversity across each grazing treatment. It ranges on a scale from 1 to the maximum number of species collected, with higher values signifying more diversity in a sample. Lastly, Simpson's evenness, a measure of the relative abundance of species in a community, was estimated as follows: $E = (1/D) /S$ where 1/D represents the reciprocal of Simpson's diversity index, and S represents the total number of species in the community. Simpson's evenness ranges on a scale from 0–1, with 0 indicating maximum unevenness and 1 indicating perfect evenness.

RESULT AND DISCUSSION

Dung Beetle Collection

The overall total number of dung beetles collected through both years of this study in all ranches was 1292.The percent abundance for all species collected at each ranch is presented in Table 2. Across all grazing treatments in 2021, a total of 545 dung beetles were collected ,of which , 390 in the meadow and 155 in the ungrazed land. In 2022, a total of 747 were collected ,of which619 in the meadow and 128 in the ungrazedland.The species composition varied across ranches, with Onthophagus spp. Latreille being the most dominant and consistent dung beetles found across all locations in 2021 and 2022 (Table 2).

Peak Abundance and Species Abundance

Average peak dung beetle abundance under different grazing treatments is shown in Fig. 4. The average peak dung beetle abundances on grazed treatments were consistently higher than ungrazed lands during 2021 and 2022. All treatments over both years were significantly higher than the ungrazedtreatment. In both years, species richness in grazed land was significantly higher than the ungrazed land.

The total number of dung beetles in the experiment was lower than what was reported in previous studies conducted (Jameson 1989, Whipple and Hoback 2012), and nationwide (Alemu *et al.*, 2019,Tonelli *et al.,* 2017, Perrina *et al.,* 2020). The total number of dung beetles collected can vary from one study to another depending on soil type, environmental conditions, dung source, vegetation, grazing management practices, and timing and duration of sampling events. For example, Osberg *et al.,* (1994) reported that differences in soil type caused differences in dung beetle abundance, which was attributed to the sensitivity of several species to water holding capacity. Domínguez *et al.,* (2015) reported that dry environments with little rainfall and high temperature can lead to lower total number of dung beetles. The differences in soil temperature and soil water content may result in differences in the number of dung beetles collected between these two years (Osberg *et al.,* 1994).

This study provides additional evidence that some grazing practices may be favorable for the colonization of dung beetles when compared to others. More specifically, higher peak abundance and species richness of dung beetles under grazed treatment compared to non-grazed treatment were reported in both years of this study. These results support past research that grazing abandonment can have negative effects on dung beetle communities due to their dependency on dung for food and habitat. The high peak abundance and species richness of dung beetles associated with rotational grazing at high stocking density observed in this study could be due to an increase in the concentration and dispersal of dung pits throughout the pasture (Richards and Wolton 1976, Whipple 2011). A larger herd and the resulting increase in dung deposition could be the most influential grazing strategy for attracting dung beetles. Since dung beetles are attracted to dung primarily by odor, higher stocking densities may favor their colonization (Dormont et. al. 2004).

CONCLUSION

The results of this study may give pastureland owners valuable insight into how they can graze their livestock and at the same time promote dung beetle populations. Much research has suggested the benefits of dung beetles as they provide multiple essential ecosystem services. This study contributes useful information to an important knowledge gap regarding the effects of grazing practices on dung beetle communities. Evaluation of the diversity and community structure of the dung beetles associated with the semi-urban agricultural lands revealed that urbanization does cause a decrease in dung beetle diversity compared to regional forests and has affected the community status of dung beetles.Dung beetle biodiversity might be strengthened to help build and maintain more sustainable rangeland and grassland ecosystems by implementing rotational grazing practices.

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Tables

Table 1. Number of individuals collected for each species of dung beetles per site in each habitat

Species	**Grazed lands**			**Ungrazed lands**			**Total individuals**
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	
Onthophagus amphicoma	45	55	65	0	2	3	170
Onthophagus amphinasus	48	46	44	1	0	0	139
Onthophagus bifasciatus	42	32	42	0	2	3	121
Onthophagus bronzeus	35	33	32	2	1	0	103
Onthophagus castetsi	42	21	42	1	0	0	106
Onthophagus cervus	34	26	32	1	1	2	96
Onthophagus dama	54	43	42	0	2	2	143
Copris repertus	24	21	24	1	1	0	71
Paracopris cribatus	27	24	21	0	1	1	74
Paracopris davisoni	12	13	11	2	0	1	39
Sisyphus longipes	26	21	23	1	0	0	71
Caccobius meridionalis	21	21	31	1	1	0	75
Liatongus indicus	12	13	14	0	1	2	42
Onthophagus cavia	11	13	16	1	1	0	42
					Total		1292

Table 2: Checklist of beetles recorded in the study

Sl. No.	Family	Genus	Scientific name
1.	Scarabaeidae	*Onthophagus*	*Onthophagus amphicoma*
2.	Scarabaeidae	*Onthophagus*	*Onthophagus amphinasus*
3.	Scarabaeidae	*Onthophagus*	*Onthophagus bifasciatus*
4.	Scarabaeidae	*Onthophagus*	*Onthophagus bronzeus*
5.	Scarabaeidae	*Onthophagus*	*Onthophagus castetsi*
6.	Scarabaeidae	*Onthophagus*	*Onthophagus cervus*
7.	Scarabaeidae	*Onthophagus*	*Onthophagus dama*
8.	Scarabaeidae	*Copris*	*Coprisrepertus*
9.	Scarabaeidae	*Paracopris*	*Paracopris cribatus*
10.	Scarabaeidae	*Paracopris*	*Paracopris davisoni*
11.	Scarabaeidae	*Sisyphus*	*Sisyphus longipes*
12.	Scarabaeidae	*Caccobius*	*Caccobius meridionalis*
13.	Scarabaeidae	*Liatongus*	*Liatongusindicus*
14.	Scarabaeidae	*Onthophagus*	*Onthophagus cavia*

Table-3 Shannon's-Wiener diversity index, Simpson's diversity index (D) and abundance of dung beetles in the study area during 2021-22.

Species	Number of individuals (n)	Relative abundance (pi)	pi^2	lnpi	pi(lnpi)
Onthophagus amphicoma	170	0.1315	0.0172	-4.0628	-0.5342
Onthophagu samphinasus	139	0.1075	0.0115	-4.4650	-0.5134
Onthophagus bifasciatus	121	0.0936	0.0087	-4.7444	-0.4440
Onthophagus bronzeus	103	0.0797	0.0063	-5.0672	-0.4034
Onthophagus castetsi	106	0.0820	0.0067	-5.0056	-0.0335
Onthophagus cervus	96	0.0743	0.0055	-5.2030	-0.3865
Onthophagus dama	143	0.1106	0.0122	-4.4063	-0.4873
Coprisrepertus	71	0.0549	0.0030	-5.8091	-0.3189
Paracopris cribatus	74	0.0572	0.0033	-5.7138	-0.3189
Paracopris davisoni	39	0.0301	0.0009	-7.0131	-0.2110
Sisyphus longipes	71	0.0549	0.0030	-5.8091	-0.3189
Caccobius meridionalis	75	0.0580	0.0033	-5.7138	-0.3314
Liatongus indicus	42	0.0325	0.0010	-6.9077	-0.2245
Onthophagus cavia	42	0.0325	0.0012	-6.7254	-0.2185
	Total number of captures		1292		
	Shannon – Weiner index(H)		4.7444		
	Simpson's index (D)		11.93317		

OCCURRENCE OF TWO NEW TROCHOIDEAN SNAILS (MOLLUSCA: VETIGASTROPODA) OFF KERALA COAST

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ABSTRACT

This paper reveals new distributional records of two species of top snails namely *Clanculustonnerrei* (G. Nevill & H. Nevill, 1874) and *Pseudominolia nedyma* (Melvill, 1897) collected from the Kerala coast, southwest coast of India.

Keywords: Top snails, Trochidae, *Clanculus*, *Pesudominolia*

INTRODUCTION

Trochoideans are the most diversified group of Vetigastropod molluscs (Hickman, 1996; Williams *et al.,* 2008). Their distribution extends from the tropics to the polar regionsas well as from the shallowintertidal areas to bathyal depths and show diversified morphology from small-sized micromolluscs to large shells collected for trade; the sizes ranging from less than 0.5 cm togreater than 20 cm (Williams *et al.,* 2010). Trochoidea comprises 13 families namely Trochidae, Angariidae, Areneidae, Calliostomatidae, Colloniidae, Conradiidae, Liotiidae, Margaritidae, Phasianellidae, Skeneidae, Solariellidae, Tegulidae and Turbinidae (Bouchet *et al.,* 2017); among them, Trochidae is considered to be the largest as well as most diversified in terms of diet and habitat (Hickman and McLean, 1990). They display a variety of feeding habits consisting of both herbivory and carnivory, while some are suspension feeders. This range of feeding preferences is also reflected in the diverse morphology of their radulae. The two largest families within the superfamily Trochoidea are Trochidae and Turbinidae (Williams *et al.,* 2008). According to Tripathy & Mukhopadhyay (2015), the family Trochidae has 10 subfamilies, 66 genera and 107 subgenera,among them 58 species belonging to seven subfamilies within 14 genera were reported from Indian coast. Trochid shells are renowned for their nacreous pearly interior, and shells of some of the larger species are of commercial value, with the shells being used in the manufacture of buttons, polished objects and ornaments. Trawl by-catch brings large amounts of gastropods including the trochids, and provides an opportunity to study their diversity in the seas. Four species of trochid snails namely, *Clanculus microdon*, *Clanculus scabrosus, Trochusradiatus,Umbonium vestiarium* were previously reported from Kerala coast (Deepthi, 2008; Kumar, 2012; Sary *et al.,* 2013; Preetha, 2016). The present study presents new distributional record for two trochid snails off the Kerala coast.

MATERIALS AND METHODS

The specimen were collected from the by-catch landed by the shrimp trawlers operating along Neendakara fishing harbour (8º352 N; 75º382 E), in Kollam district along the south-west coast of India. Colouration of the shells was noted and morphometric measurements were recorded to the nearest millimetre using an Aerospace digital caliper. The specimens were cleaned and photographed, sundried and preserved for further study. The collected specimens were identified with the help of FAO sheets (Poutiers, 1998) and identification keys of Melvill (1897), AL-Khayat (1997), Zuschin *et al.,* (2009) and (Herbert, 1996). The identifications were verified and confirmed by taxonomic experts in the field.

RESULTS

Systematics

Superfamily:Trochoidea Rafinesque, 1815
Family: Trochidae Rafinesque, 1815
Subfamily: Trochinae Rafinesque, 1815
Genus: *Clanculus* Montfort, 1810

***Clanculus tonnerrei* (G. Nevill & H. Nevill, 1874) (Fig. 1 a-d)**

Fig. 1. ***Clanculus tonnerrei*a. dorsal, b. apertural, c. apical, d. umbilical**

Material Examined: 50 specimens; **Locality**: Neendakara fishing harbour, Kerala, India; Date of collection: 13.04.2013; Morphometric measurements: Shell length 6.36 - 14.39mm; Shell Width 11.52 - 20.57mm.

Remarks

Clanculus tonnerrei was previously reported from the Karachi coast in the Arabian Sea without any locality data (Herbert, 1996). Based on the published distributional reports, this is the first report of the species from the Kerala Coast.

Superfamily:Trochoidea Rafinesque, 1815
Family: Trochidae Rafinesque, 1815
Subfamily: Umboniinae H. Adams & A. Adams, 1854
Genus: *Pseudominolia* Herbert, 1992

Pseudominolia nedyma **(Melvill, 1897) (Fig. 2 a-d)**

Pseudominolia nedyma **a. dorsal, b. umbilical, c. apertural, d. apical**

Materials Examined: 50 specimens; **Locality**: Neendakara fishing harbour, Kerala, India; Date of collection: 13.04.2013; Morphometric measurements: Shell length 2.82 - 8.48mm; Shell width 3.42 - 3.86mm.

Remarks:

The species was first described by Melvill (1897) in his work “Descriptions of Thirty-four Species of Marine Mollusca from the Arabian Sea, Persian Gulf, and Gulf of Oman”. According to Yaron (1984), the species shows distribution along the various localities in the Red Sea, including the Gulf of Suez and Aqaba, also the Suez Canal. The species was also reported from Quatar waters (AL-Khayat, 1997), Southern Persian Gulf (Ghasemi *et al.,* 2011) and the Red Sea (Zuschin *et al.,* 2009).Herbert (1996) reported the species from the Arabian Sea without specific locality data. Based on these published reports, this is the first report of the species from the south-west coast of India.This species is distinct from *P. gradata* by its bigger size, broadly conical shell, highly variable and pronounced colour pattern and dense spiral sculpture. Aperture rounded with smooth outer lip; umbilicus deep and narrow; base with concentric, close-set shallow depressions.

In Kerala, especially in Sakthikulangara/ Neednakara fishing harbours, this species is landed in large numbers as by-catch which is collected and utilized by the shell craft industries located in Tamil Nadu.

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A STUDY ON THE ASSOCIATION OF BUTTERFLIES AND THEIR HOST PLANTS IN NJARANEELI, A PART OF WESTERN GHATS.

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ABSTRACT

Butterflies play a major role in the ecosystems as they interact with the environment as pollinators, seed dispesers.etc. Since both the adults and caterpillars need the plants for feeding, the distribution and abundance of these fascinating creatures are also dependent on the plants. The present study was carried out in the Njaraneeli ward of Peringammala Panchayath which is a part of Western Ghats with an intention to identify some common butterflies and their host plants. A total of 35 species of butterflies belonging to different families such as Papillionidae, Nymphalidae, Lycaenidae, Hesperiidae and Pieridae, and their host plants were identified in the locality. Since butterflies can be considered as bio indicators as their caterpillars are specific to their food plants, the conservation of these fragile creatures is essential for the conservation of the habitat diversity of a particular region.

INTRODUCTION

Butterflies are a well-studied category all around the world due to their beauty and ecological importance (Ghazoul, 2002). Butterflies plays a essential role in ecosystem, and they are the perfect population of organisms for studying insect phenology because they are relatively conspicuous and more interesting to humans than most other insects due to their size and coloration, which encourages observation and collection (Sparks, 1997). In India, the Himalayas, the hills of the northeast, and the Western Ghats are home to the majority of the butterfly species. Butterflies and moths make up 140,000 of the approximately 1.5 million species of animals that are now recognized. Because of their enticing qualities and prevalence, they have secured a place in the poetry and prose of various cultures. Being good indicators of climatic conditions as well as seasonal and ecological changes, they serve in formulating strategies for conservation. They are economically important as valuable pollinators, important food chain components, good indicators of environmental quality, insect plant interaction and co- evolution, expert colonizers of new types of habitat etc. In spite of all these, butterflies have been neglected by community ecologists and there are very few studies on their community structure, population dynamics and eco-climatic factors, which affect them.

Butterflies are very magnificent and the most colourful and conspicuous among insects. Majority of Indian butterfly species are found in Himalayas, the hills of Northeast and in the Western Ghats. India has around 1,501 species of butterflies (Gay *et al.,* 1992), out of which 334 species are reported from the Western Ghats and 37 species are endemic to the Western Ghats (Evans1932; Kunte 2000). Of the 334 species of butterflies of Western Ghats, 316 species have been reported from Kerala (Palot *et al.,* 2012). The habitat of the butterflies is diverse and it is strictly terrestrial. It is only within this restricted scope that butterflies have evolved and occupied all possible habitats, even those with scanty vegetation. The diverse habitats include tall evergreen forests, shola forests, semi evergreen forests, riparian forests, bamboo forests, grasslands etc. The tall evergreen forests are one of the most important habitats of butterflies.

Virtually all butterflies are associated with plants and therefore their occurrence depends on the presence of plants. Plants in turn depend on butterflies for the pollination. Feeding is a significant activity and food may often be the most decisive factor affecting distribution, abundance and movements of animals. In butterflies, this has a special relevance because food and the mode of feeding are different in the larval and adult stages. Different species of caterpillars feed on a diversity of plant species. However, in a majority of species their food is fundamentally the same, the leaves. Some caterpillars may refuse to eat anything other than tender ones; most prefer to eat tender leaves but otherwise eat whichever are available on the plants where they are placed by their mothers as eggs.

Although most caterpillars feed on leaves, they have strict preferences for specific host plants. These strict preferences are dictated by the chemical composition of the plant parts that the caterpillar eats. Therefore, the caterpillars feeding on a particular plant species or set of species will not eat leaves of other species. For realizing the biology and ecology of butterflies of an area, a long term study and observation is needed because, they show strict seasonal and habitat specificity. The present study was carried out with specific objectives such as to identify the common butterflies in njaraneeli ward in Peringammala panchayath and to study the habit and habitat of these butterflies and finally to identify the host plants of the larva and nectar plants of adult in the locality.

STUDY AREA AND METHOD OF STUDY

The area selected for the present study was Njaraneeli ward in Peringammala Panchayath. The area is situated in the lap of the famous Ponmudi hills, which is a part of the Western Ghats, one of the 25 hotspots of the world. This is a hilly region with evergreen plants, shrubs, grasslands, wetlands and sacred groves. The study area enjoys a moderate eco-climatic condition and harbors habitats having bright sunshine, shade, bushes, hedges and tall trees which are preferred by specific groups of butterflies.

The butterflies and their host plants were identified by walking through some selected areas in the ward by observing them. Since, it was found difficult to identify the butterfly in the field, they were caught using a net and identified and were released. The butterfly species were also photo-documented during the study period. The study was done for a period of one year. The observations were done from 9 am to 4 pm. Species identity was confirmed with the help of the field guides by Kunte (2000) and taxonomy and nomenclature have been updated after Kunte *et al.,* (2011). Chrysalis of butterflies were also collected during the study.

RESULTS

In the present study, a total of 41 species of butterflies were identified in selected areas of Njaraneeli ward in Peringammala Panchayath. Table -1 represent the systematic position and detailed list of these butterflies and their host plants (both larval and nectar plants). Out of the 41 species identified, nine belongs to the family, Papilionidae, four belongs to the family Pieridae, three belongs to the family Hesperidae, two belongs to the family Lycaenidae and the remaining twenty three belongs to the family Nymphalidae .

DISCUSSION

Butterflies and their caterpillars are dependent on specific host plants for food, thus the diversity of butterflies indirectly reflects overall plant diversity especially that of shrubs and herbs in the given area (Padhye *et al.,* 2006). Most of them are strictly seasonal and prefer only particular set of habitats (Kunte 1997).

Table – 1

The systematic Position of the Identified Butterfly Fauna and their Larval Food Plants And Nectar Plants in Njaraneeli.

Sl. No	Common Name	Scientific Name	Family	Larval Food Plants	Nectar Plants

1	Southern Bird Wing	*Troides minos*	Papilionidae	*Aristolocchia indica*	Ixora , Clerodendron,
2	Crimson Rose	*Pachliopta hector*	Papilionidae	*Thottea siliquosa*	Clerodendron, Ixora
3	Common Rose	*Pachliopta aristalochiae*	Papilionidae	*Aristolocchia indica, Thottea siliquosa*	Ixora, Blue snake weed, clerodendrone
4	Common Mormon	*Papilio polytes*	Papilionidae	*Murraya paniculata*	Ixora, Lantana.
5	Blue Mormon	*Papilio polymnestor*	Papilionidae	*Citrus limon*	Hibiscus, Ixora
6	Blue Bottle	*Graphium Sarpedon*	Papilionidae	*Polyalthia longifolia*	Lantana, tridax
7	Tailed Jay	*Graphium agamemmon*	Papilionidae	*Artrabotrys hexapetalus*	Lantana, Terminalia
8	Common Jay	*Graphium doson*	Papilionidae	*Artrabotrys hexapetalus*	Lantana
9	Common mime	*Papilio clytia*	Papilionidae	*Cinnamomum tamala*	Lantana, Terminalia
10	Common Emigrant	*Catopsilia Pomona*	Pieridae	*Cassia fistula*	Lantana, tridax, Ixora
11	Common jezebel	*Delias eucharis*	Pieridae	*Loranthus elasticus*	Lantana, Ixora
12	Psyche	*Leptosia nina*	Pieridae	*Terrminalia travancorensis*	cleome
13	Common Grass Yellow	*Eurema hecabe,*	Pieridae	*Cassia fistula*	Pignut plant
14	Indian palm bob	*Suastus grem ius*	Hesperiidae	*Cocos nusifera*	Bird droppings
15	Indian skipper	*Spialia galba*	Hesperiidae	*Sida cordifolia*	Leucas
16	Coon	*Psolos fuligo*	Hesperiidae	*Zingiber officinale*	Lantana, Clitoria
17	Red Pierrot	*Talicada nyseus*	Lycaenidae	*Bryophillum pinnatum*	Sulphur cosmos

18	Tiny Grass Blue	*Zizula hylax.*	Lycaenidae	*Hygrophila auriculata*	Grass, cleome
19	Common Indian Crow	*Euploea core*	Nymphalidae	*Nerium oleander*	Gomphrina, Ixora, Marigold
20	Commander	*Moduza procris*	Nymphalidae	*Mussaenda frondosa*	Lantana, Ixora
21	Common Sailor	*Neptis hylas*	Nymphalidae	*Melastoma malabathricm*	Gomphrina, Ixora
22	Blue Tiger	*Tirumala limniace*	Nymphalidae	*Calotropis gigantea*	Lantana, golden bloom
23	Dark Blue Tiger	*Tirumala septentrionis*	Nymphalidae	*Calotropis gigantea*	Lantana,Blue snake weed
24	Plain tiger	*Danaus chrysippus*	Nymphalidae	*Calotropis gigantea*	Lantana
25	Stripped tiger	*Danausgenuit a*	Nymphalidae	*Nerium oleander*	Lantana, clerodendrone
26	Tawny coster	*Acraea terpsicore*	Nymphalidae	*Passiflora edulis*	Leucas , grass, Emilia
27	Rustic	*Cupha erymanthis*	Nymphalidae	*Flacourtia jangomas*	Lantana
28	Grey count	*Tanaecia lepidea*	Nymphalidae	*Careya arborea*	Fruit juice from decayed fruits
29	Common baron	*Euthalia aconthea*	Nymphalidae	*Mangifera indica*	Fruit juice from decayed fruits
30	Lemon Pansy	*Junonia lemonias*	Nymphalidae	*Crossandra infundibuliformis*	Lantana, Blue snake weed, yellow creeping daizy
31	Grey pancy	*Junoniaatlites*	Nymphalidae	*Hygrophila auriculata*	Melostoma, osbeckia
32	Peacock pansy	*Junonia almanac*	Nymphalidae	*Crossandra infundibuliformis*	Lantana
33	Chocolate pansy	*Junonia iphita*	Nymphalidae	*Hygrophila auriculata*	Melostoma

34	Nigger	*Orsotrioena medus*	Nymphalidae	Rice plant & Grass	Fruit juice from decayed fruits
35	Great egg fly	*Hypolimnus bolina*	Nymphalidae	*Sida cordifolia*	Ixora, lantana
36	Common Evening Brown	*Melanitis leda*	Nymphalidae	*Oryza sativa, Megathyrsus maximum*	Rotting fruits, Lantana
37	Common Bush Brown	*Mycalesis perseus*	Nymphalidae	*Rotboelia cochinchinensis*	Rotting fruits, Droppings of birds
38	Common Four-ring	*Ypthima huebneri*	Nymphalidae	*Axonopus compressus*	Grass, Billy goat weed
39	White Four-ring	*Ypthima ceylonica*	Nymphalidae	*Axonopus compressus*	Yellow creeping daisy, grass
40	Tamil Yeomen	*Cirrochroa thais*	Nymphalidae	*Hydnocarpus wightianus*	Rotting fruits, Droppings of birds
41	Clipper	*Parthenos sylvia*	Nymphalidae	*Tinospora cordifolia*	Blue snake weed, Lantana

Very little documentation has been done on butterfly fauna in Kerala. Sir George Hampson, Wynter-Blyth (Wynter-Blyth *et al.,* 1957) and T.R.Bell carried out the earlier studies on butterflies in Kerala. The new generation butterfly enthusiast, T.B. Larson recorded 299 species from Nilgiri during 1980s. Some of the earlier documentation on butterfly fauna from Kerala and adjacent areas include Mathew & Rahamathulla (1993), who had reported 100 species of butterflies from Silent Valley National Park, Sudheendrakumar *et al.,* (2000), who reported 124 species of butterflies from Parambikulam Wildlife Sanctuary, Arun (2003), reported 75 species from Siruvani Reserved Forests, Ambrose & Raj (2005) reported 24 species from Kalakkad-Mundanthurai Tiger reserve, Eswaran & Pramod (2005) reported 75 species from Anaikatty near Coimbatore, Prasad *et al.,* (2010) recorded 52 species from Kerala University campus, Thiruvananthapuram, while Toms *et al.,* (2010) reported 109 species from Mahatma Gandhi University campus, Kottayam.

In the present study 41 species of butterflies were identified form selected areas of Njaraneeli Ward in Peringammala Panchayath, which is a part of Western Ghats. The

Western Ghats area is unique in endemism. Three species of endemic butterflies, namely southern bird wing, crimson rose and blue Mormon were recorded during the present investigation. Since the study was confined to a very short period of one year, the species identified and studied were small in number than recorded in the Western Ghats earlier.

The present study revealed the extent to which butterflies are related with plants for their propagation and vice versa. Both the larval host plants and nectar plants were studied. Plants belonging to aristaolochia, thottea, nerium, calopropis, murraya, loranthus, cassia, citrus, mussaenda and, were the most important larval host plants identified. The nectar plants included the flowers of the common plants such as ixora, lantana, tridax, different species of clerodendrone, gomphrina etc. Similar studies on the association of butterflies and plants were reported by Aneesh *et al.,* 2013, Kumar and Murugesan, 2014 and Lekshmi Priya etal, 2017. Butterflies being highly fragile in nature, even minor perturbations in the environment may affect their survival so much so they have been looked upon as biotic indicators to monitor changes taking place in the environment.

It is a fact that butterflies were neglected in the conservation issues. Now-a-days local, national and international concern is generated towards these beautiful creatures. The butterflies can be considered as bio indicators as their caterpillars are specific to their food plants. Therefore, the conservation of butterflies is essential for the conservation of the diversity of the particular area. Studies on butterflies must go beyond limits of interest and/or curiosity; and more thrust has to be placed on their conservation efforts.

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COMPARITIVE STUDY ON THE DIVERSITY OF COLLEMBOLA IN FOREST AND TEA ECOSYSTEMS OF THIRUVANANTHAPURAM FOREST DIVISION, KERALA

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ABSTRACT

Soil is a living entity that serves as the primary nutrient base and unique habitat of amultitude of organisms. Land use change has a significant impact on determining the diversity patterns of soil fauna. Studies on Collembolan diversity and distribution serve as a potential bio-indicator of land use changes and helps develop conformational strategies and monitor natural and human-impacted area. The diversity of collembolan in forest area and tea plantations of the Thiruvananthapuram forest division were studied. Seasonal sampling of soil was done for a period of two years, and Collembolans were extracted with a modified Berlese Tullgren funnel and identified by standard taxonomic keys. Species composition, Diversity analysis, and soil chemo-edaphic factors were studied to establish the impact of different ecosystems on the Collembolan population. A total of 2286 collembolans were obtained from all the study sites and identified upto15 genera.72.62% of total Collembolans belong to the forest ecosystem 27.33% were collected from tea plantations. Species richness, Seasonal diversity, and density of Collembola were recorded to be higher in the forest ecosystem indicating the presence of stable habitats as compared to tea plantations. Correlation studies revealed that the moisture and organic carbon content of soil had a significant positive correlation during different seasons in the two ecosystems studied. It is evident fromthe present study that the Collembolans are good indicators of different land use practices, and hence, their diversity can be explored to understand the gradient of soil disturbances. Knowing this fact, alternative methods of land use practices may be standardized for sustainable soil health management to maintain soil biological communities and ecosystem resilience

INTRODUCTION

Soil is a major life support system that acts as a key source of nutrients and a specific habitat for a variety of organisms. Collembolans, also known as ecosystem engineers, are ideal indicators for soil biodiversity and have positive benefits on the functioning and development of the soil system. Land use activities repeatedly modify soil's structure as well as its physicochemical properties, resulting in a negative influence on soil organisms [Bengtsson, 2002]. Because of their rapid reactivity to diverse environmental changes, including human- induced disruptions, collembolans can be considered a bio-indicator of edaphic environment among soil fauna [Zeppelini, 2009].

Collembolans are wingless hexapods that live on soil and litter. Globally, 8143 collembolan species have been described, classified into 764 taxa and 19 families, but the Indian Collembola fauna is represented by 301 species classified into 109 genera and 19 families [Bhagawati, 2020]. They are good examples of terrestrial faunal diversity, and they play an important role in nutrient recycling, organic matter degradation, and mycorrhizae growth [Bhagawati, 2018].

Collembola diversity was studied in two ecosystems namelyrainforest and tea plantation. This study will look into the relationship between changing land use changes and their potential impact on collembolan biodiversity, which could help with conservation planning and implementation, as well as monitoring natural and human-distorted habitats.

Methodology

The study was carried out at different habitats, i.e, forest and tea plantations of Bonacaud (8.4490770 N, 76.9773090E) at the foot of Agasthya hill range, of Thiruvananthapuram forest division of Kerala. Soil sampling was conducted at each ecosystem during four seasons (pre monsoon, monsoon, post-monsoon and summer) from November 2020 to October 2021.Soil was collected using a soil sampler and taken to the Laboratory for the extraction of micro- organisms. Extraction of micro-arthropods was done by a modified Berlese Tullgren funnel. Collembolans were then examined under a Stereo-zoom Microscope and identified by using standard taxonomic keys proposed by (Christiansen and Bellinger, 1980).Collembolan relative abundance and density, along with seasonal variation of the population, were analyzed in each ecosystem.

Analysis of Soil Physico-chemical Properties

For the analysis of soil parameters, soil samples were collected from ecosystems during different seasons using Standard V-Method. Physico-chemical factors like soil pH (using a digital pH meter), soil temperature, soil moisture by Oven-dry method (Dowdeswell, 1959), and organic carbon content by Walkley-Black procedure (Walkley & Black, 1934), were estimated during the period of study.

Statistical Analysis

Collembolan diversity was estimated using the Shannon-Weiner Index at three different habitats. Simple correlation was used to understand the impact of varying edaphic parameters on the collembolan population, and thep-value for statistical significance was calculated at $p < 0.05$ and $p < 0.01$ using SPSS 20.

RESULTS

I. Species Composition and Relative Abundance

A total of 2286 collembolans were obtained from all the study sites and identified up to 14 genera and 25 species. A notable variation in the composition of collembolans was observed along the land use gradient, with all fifteen genera only being reported in the forest ecosystem while in the tea ecosystem, only seven genera of collembolans were observed. Cyphoderus genera showed the highest relative abundance(19.84%)inforests and Lepidocyrtus(16.98%) showed the highest relative abundance in tea plantations (Fig: 1).

Fig: 1 & 2 Relative abundance of collembolans at different ecosystems

Fig: 1

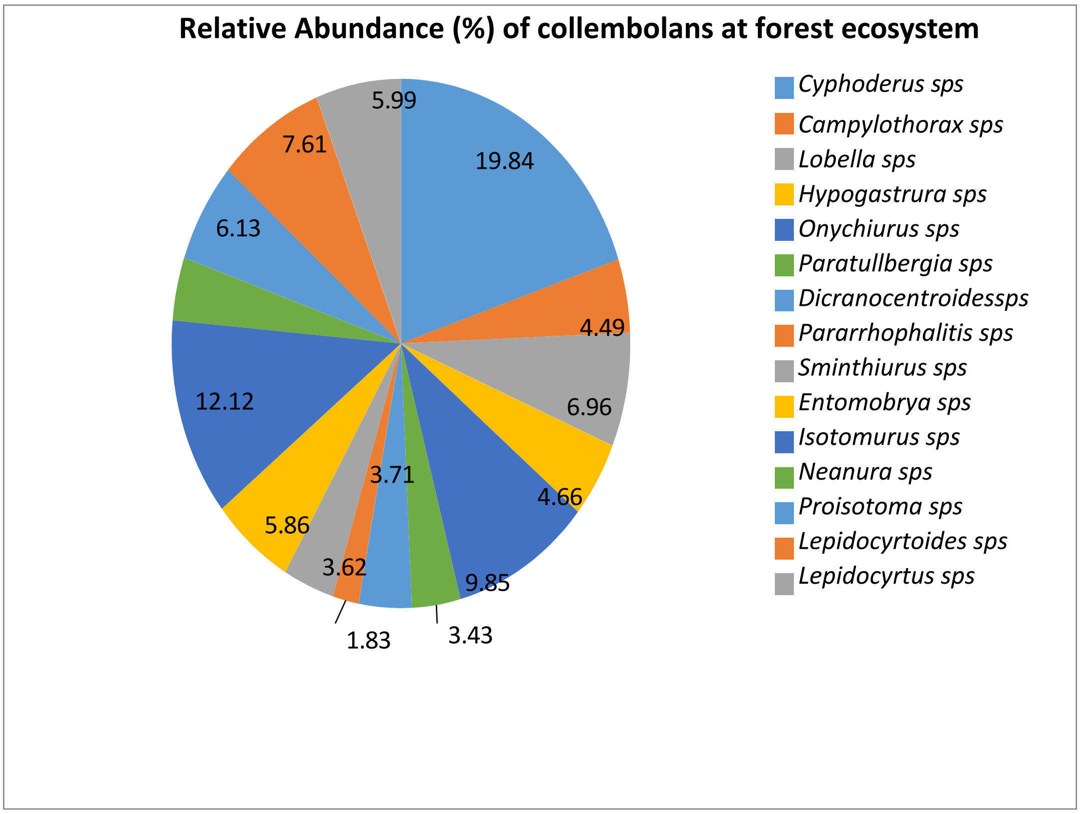


Fig:2

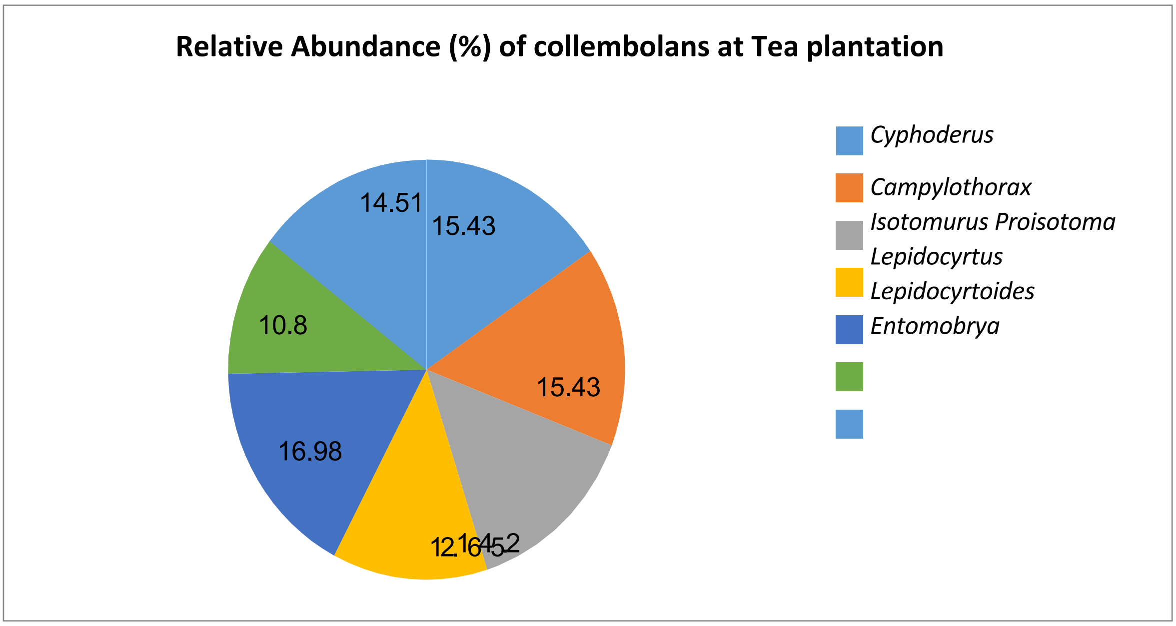
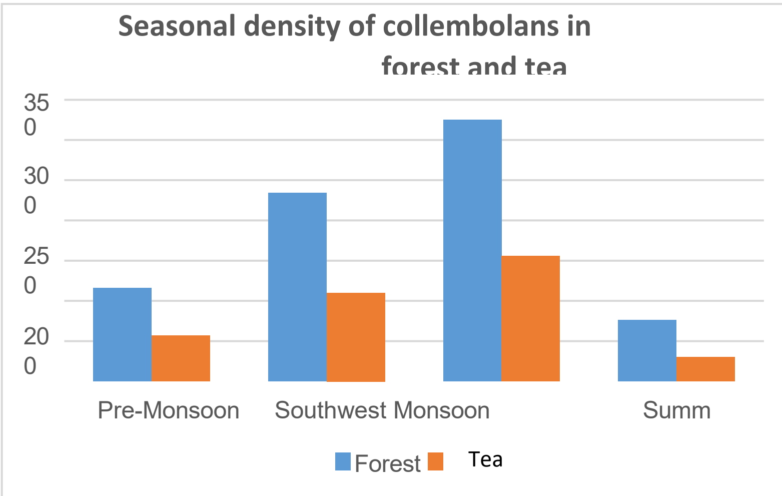


Figure: 3 & 4 Density and diversity of collembolans at different seasons

Fig: 3



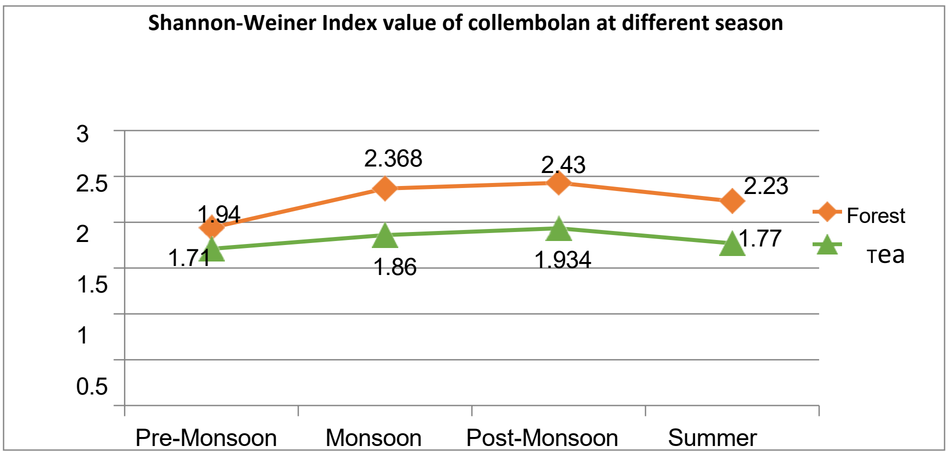


Table (1) shows Correlation between Collembolan Density and Soil properties

Soil Properties	Forest				Tea			
	Pre-Monsoon	Monsoon	Post-Monsoon	Summer	Pre-Monsoon	Monsoon	Post-Monsoon	Summer
Temperature (0C)	NS	NS	0.938*	0.902*	NS	NS	0.928*	NS
pH	NS	NS	NS	NS	NS	NS	NS	NS
Soil Moisture (%)	0.832*	0.914*	0.808*	0.875*	0.912*	0.856*	0.962**	0.837*
Organic Carbon(%)	0.891*	0.823*	0.962**	0.859*	0.933*	0.941*	0.873*	0.903*

II. Seasonal Variations of Collembolan Diversity and Density

In comparison to the forest (H' = 1.94-2.43) and tea plantations (H' = 1.71–1.93), the forest ecosystem had the maximum diversity, indicating a favourable ecological niche for collembolans. Selected habitats, namely forest, and tea plantations, showed a seasonal pattern of increasing values from pre-monsoon to post-monsoon and gradually decreasing values during summer. The highest collembolan density was recorded during post monsoon season, followed by monsoon and summer in forest and tea plantations, respectively. Least collembolan density was recorded during pre-monsoon season in forest and tea plantations, respectively (Fig: 3 & 4).

III. Role of Physicochemical Properties of Soil on Density of Collembola

The density of collembolans in each ecosystem was associated with major soil chemo-edaphicfactors.The density of collembolans had a strong positive correlation ($p \leq 0.05$ and $p \leq 0.01$) with organic carbon and soil moisture in all habitats and seasons. Except for soil temperature (r=0.938, 0.879, 0.928) in the forest, and tea ecosystems during post monsoon, showed a significant positive correlation ($p \leq 0.05$) with collembolan density, other edaphic parameters didn'tshow any significant relationship with collembolan density in the selected ecosystems during the study period.

DISCUSSION

In comparison to rubber and tea plantations, soil in the forest ecosystem had a rich distribution of collembola, which was a significant finding in the study. Furthermore, diversity study revealed that the forest has a higher diversity of collembolan populations than the other two habitats. The availability of moisture, organic matter, and other nutrients for collembolans is often ensured by the presence of generally stable habitats in forests, resulting in increased species richness [Paul, 2011]. Use of chemocentric agricultural practices, as well as excessive use of inorganic pesticides,

disrupts soil chemical properties and threatens collembolan populations [Harta *et.al*, 2020].
The number and diversity of collembolans were observed to be higher in the post monsoon season than in the other seasons at all of the study sites. High soil moisture and temperature during the post-monsoon season speed up the breakdown of litter and organic residue, releasing carbon into the soil more quickly and creating a favourable habitat for collembolan assemblages [Liu *et.al,* 2019]. The number of soil-dwelling collembolans may have been influenced by a short-term incline in edaphic temperature during the post-monsoon period [Holmstrup, 2018].

As shown in Table1 collembolan density had a significantly positive correlation with organic carbon content and soil moisture in all three communities during all four seasons, which is an important finding in our study. The collembolan activity in the degradation of dead organic materials may help to explain the link between organic carbon and soil moisture concentration. The majority of the physiological activities of collembolans are influenced by the top soil moisture content, which has an impact on their growth and development [Hazra, 1978]. Hazra and Bhattacharyya [Hazra, 2003] similarly noticed an increase in the collembolan population when the organic matter and moisture content of the soil increased,as shown in our study. Other Edaphic parameters, however, responded favourably but not significantly to the density of collembolans, regardless of the habitat or season.

Collembolans have a significant ecological connection with both biotic and abiotic components, and they frequently respond strongly to environmental and geographical factors [Widenfalk, 2016]. According tothe present research study, collembolans are an excellent bio-indicator of various land use patterns, and their variety may be analysed to better understand the gradient of soil disturbances.As a result of this understanding,alternative land use methods for sustainable soil health management might be developed in order to maintain biological soil communities and ecosystem balance.

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EFFICACY OF THREE ORGANOPHOSPHORUS INSECTICIDES AGAINST YAM SCALE *Aspidiella hartii* COCKERELL (HEMIPTERA:DIASPIDIDAE) INFESTED TUBERS OF *AMORPHOPHALLUS PAEONIIFOLIUS* UNDER LABORATORY CONDITIONS

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ABSTRACT

Elephant foot yam *(Amorphophallus paeoniifolius* (Dennst.) Nicolson) is an edible tropical tuber crop cultivated popular as food security and a remunerative cash crop. Upon harvest, the tubers areeither marketed directly as a vegetable or stored as seed material. Infestation by the several sucking pests including scale insect & mealy bugs pose serious problem during its long-term storage. Yam scale *Aspidiella hartii* Cockerell (Hemiptera:Diaspididae) is a prominent and noxious pest which attacks the stored tubers and cause desiccation and shriveling of tubers. Insect infestation disfigures the tubers affecting their acceptability and marketability. Proper management of this noxious pest plays a crucial role in avoiding storage damage inflicted by sucking pests. The present study aimed to check the efficacy of three locally available organophosphorus insecticides against this pest under laboratory conditions. All the 1st instars treated with 0.1% of all insecticides completely killed the instars. Malathion, quinalphos and chlorpyrifos, at 0.5% caused more than 80% mortality and can be applied to control this pest effectively. Therefore, dipping the infested tubers for 10 minutes in any of these insecticides is recommended for the management of this pest. To achieve better results, the strategy has to be aimed at controlling the establishment of young crawlers by dipping the tubers several times until crawler production ceases.

INTRODUCTION

Increased healthcare facilities, rapid industrialization, advanced technological breakthroughs have paved way to drastic increase in human population. Owing to this rise in population, a sudden rise in the demand of food and food products is observed. Tuber crops, including cassava, elephant foot yam, yams, taro play a crucial role in providing food security for about 2.2 billion people in the World (Dhaliwal 2017). These crops are less affected by global climatic shift and around 45% of tuber crop production is consumed as food, and the rest converted as animal feed or industrial products (Baiju and Suchitra 2018).

Among tubers, Elephant foot yam, *Amorphophallus paeoniifolius* (Dennst.) Nicolson is an edible aroid cultivated in the tropical countries and in India it is traditionally cultivated in West Bengal, Andhra Pradesh, Tamil Nadu, Bihar, Gujarat, Kerala and Jharkhand (Nedunchezhiyan *et al.,* 2011) with a production potential of 50-80 t/ha (Ravi *et al.,* 2009). The tubers are rich in starch and a good source of vitamins and minerals, therefore used as a vegetable after cooking. Moreover, many indigenous Ayurvedic and unani medicinal preparations were also made using these tubers (Srinivas and Ramanathan 2005) and due to these reasons it's called as the "King of Tubers". On harvest, the tubers were either marketed or stored as seed materials for the next planting season.

Insect pests have always been a menace to man since they started cultivating and often severe pest out breaks minimize the crop production and reduce agricultural outcome (Sreerag *et al.,* 2014). Of these insect pests, sucking pests including scale insects, mealy bugs, thrips, whiteflies, aphids, and mites have now emerged as major pests infesting several horticultural as well as agricultural products. These pests suck the sap resulting in desiccation of plant, color change in leaves and fruits, leaf curling, fruit deformation and finally death of the plant. Thus, the quantitative and qualitative loss of the crops due to pest attack leads to decreased yield and serious economic loss to farmers (Suresh *et al.,* 2010).

The yam scale insect *Apidiella hartii* (Cockerell) is a polyphagous, armored scale insect which has become a major threat for the stored tubers of Elephant foot yam and other yam tubers. Infestation is unidentified initially as their crawlers are very small in size (maxiumum of 2.5mm) and cryptic habit (Salerno et. al. 2018). In addition, the protective covering or scale blends with the color of tubers and infestation is often noticed only when it covers the entire tubers. Severely affected tubers becomes disfigured which the tubers affects the marketability of the tubers. They suck and desap the cell content of the tubers and severely infested tubers shriveled, adversely affecting their cooking quality (Palaniswami 1994).

Initially, the infestation cannot be noticed as the crawlers are microscopic, but while infestation develops, colonies build up quickly and consequently the tuber will be totally covered by this insect. Relentless infestation results in vast crop failure and consequently severe economic loss to the farmers. Large quantities of stored tubers were rendered unfit for human consumption as a result of insect attack. Even though the intensity of infestation by this pest and its economical loss to farmers are indisputable, not much work has been reported on their management. Present study aims in comparing the efficacy of three synthetic organophosphorus insecticides against the yam scale insect under laboratory conditions.

MATERIALS AND METHODS

Maintenance of insect culture:

Medium sized (600- 1500 g) tubers of elephant foot yam, *A. paeoniifolius* totally devoid of any insect infestation were procured from local market. These tubers were then cleaned, washed with water and shade dried for 4-5 hours. The instars of yam scale insect, *A. hartii* were transferred using a sable haired brush for maintaining pure culture. These tubers were kept inside wooden cages (60 cm × 60 cm × 60 cm) having the door in the front and other sides covered with wire mesh supplied with a 15-W fluorescent light for 8 h per day.The insect culture was transferred to the fresh set of tubers according to the decay or damage of infested tubers.

Preparation of insecticidal solutions

Locally available synthetic insecticides belonging to organophosphate groups were purchased and used for the assay (Table 1). The concentrations used were 0.5, 0.1, 0.05, 0.01% for all the insecticides selected for the treatment.

Treatment method

First instars (freshly emerged crawlers) were collected carefully from the tubers with the aid of sable haired brush and transferred to Petri dish. Freshly prepared insecticidal solutions were taken in an atomiser and sprayed onto the insects. For other experiment highly infested tubers were selected and used for laboratory assay. Using a scooper scoops having 3 cm3 diameter were taken from the fully infested tubers using cork borer. These scoops were observed under stereo zoom binocular microscope (Leica M10, Leica Microsystems, Weltzar, Germany - magnification of 80-800X) to confirm that these scoops contain a good population of live insects. These scoops were dipped for 10, 20 & 30 min in the freshly prepared insecticidal solutions taken in a 100-ml plastic container. Then using forceps these pieces of tubers were transferred to filter paper kept in small Petri dishes so that the excess solution was removed. Three replicates were maintained and water was used as control in both experiments.

Observation of mortality

Under the microscopic view, mortality count was observed continuously for three days after treatment (1, 2, and 3 DAT). The mortality percentage was calculated as follows: Mortality percentage (%) = (Number of dead insects - number of live insects) × 100

Statistical analysis

Statistical analysis was done by analysis of variance (ANOVA) in a random block design and pair-wise comparison was carried out by Duncan's multiple range test (DMRT, P 0.05) using SPSS 17.0

Table 1 List of locally available oraganophosphorus insecticides used for the study

Sl. No.	Name of insecticide	Chemical name	Emulsified concentration, EC (%)
1	Killer	Malathion	50
2	Ekalux	Quinalphos	25
3	Regichlo	Chlorpyrifos	20

RESULT AND DISCUSSION

Tubers after harvest were stored for a period of three to nine months and later marketed or used as planting materials for the next season. Stored tubers are more susceptible to insect pest infestation and heavy infestations cause yield and economic loss to the farmers, which indirectly affect the food security globally. Therefore, proper management of insect pest during the storage period of tubers has a crucial role.

Two major sucking pests infesting stored tubers of elephant foot yam are yam scale insect and mealy bug (Palaniswami 1994). Compared with other insect pests, management of these pests was not found easier and was labeled as "hard to kill pests" (Lower 1968). Even though many chemical pesticides were employed for the management various species of scale insects, the selection of appropriate insecticides for the control of yam scale insect have a crucial role for achieving proper control.

Uninfested tubers of Elephant foot yam *Amorphophallus paeoniifolius*

Tubers of Elephant foot yam infested by yam scale insect *Aspidiella hartii*

Organophosphate insecticides have been documented as effective control measures against *A. hartii* (Salerno *et al.,* 2018). Chemical control of insect pests is the most opted method by farmers and management of this insect pest is of great importance for better cropping of this precious crop. The present study checked efficacy of three organophosphate insecticides against yam scale insect.

Treatment of first instars with the organophosphorus insecticides revealed that all the locally available insecticides tested (Table 2) in the present study provide satisfactory control of scale insect instars. Malathion at the concentration of 0.1% was able to achieve complete control over the 1st instars on the second day after treatment. However, quinalphos and chlorpyrifos at the same concentration killed all instars even one day after treatment. Chlorpyrifos at 0.05% also produced significant effect 3 DAT whereas all other treatments were less effective.

Mortality percentage of yam scale insects on the infested tubers dipped in insecticides for 10, 20 and 30 minutes were shown in Table 3, 4 & 5 respectively. When infested tubers were dipped for 10 minutes in Malathion, Quinalphos and Chlorpyrifos, it failed to achieve complete control over the insects. There was no significant mortality even after three days after treatment in the high concentration tested. Here, treatment with chlorpyrifos at 0.5% caused mortality of 50%, which increased to 60.3% in two days. Mortality was only 58.2% and 45.2% for malathion and quinalphos at 0.5% respectively. The lower concentrations produced only negligible effect.

Complete mortality of scale insects was recorded in all tuber pieces dipped for 20 mins in all three test insecticidal solutions at 0.5% even after the first day observation. Mortality was

74.5 and 39.0% for 0.1 and 0.05%, respectively for treatment with malathion and it showed slight increase according to the days after treatment. Similar observation was done in case of infested tubers dipped in 0.1% chlorpyrifos for 20 minutes. Lower concentrations (0.05 and 0.01%) recorded highest mortality percentage of 56 for test solutions and were found less effective in control of the insect.

Dipping the infested tubers for 30 mins in any of the insecticidal solutions at 0.5% was found the effective treatment. There was no mortality recorded for control batches in all treatments and proved to produce no effect on the mealy bugs.

David et. al. (2018) studied various management strategies of scale insects and opined the importance of chemical pesticides on its control. Scale insects have several adaptations against pest control techniques. Their crawlers are microscopic and often hide in the crevices and depressions on the tubers and other they tend to escape from insecticidal spray applications. Based on present study, a high pressure spray of quinalphos or chlorpyrifos at 0.1% before storage of tubers can be recommended for the control of instar populations. This application may be repeated at intervals according to the life cycle of the pest.

In addition, the adult stages of armored scale insects have a protective covering which gives protection against insect sprays (Kondo & Penny 2022). Dipping infested tubers for 30 mins and shade drying to avoid fungal infections is recommended to control the particular pest. But, it should be noted that even after the death of the scale insects the protective covering remains on the tuber for a long period of time which cause disfiguration.

Finally, avoiding the insect infestation at crawler stage itself is best-suited method to be adopted for management of yam scale insect *A. hartii* and for that repeated spray of recommended dose of pesticides has to be done at regular intervals. These pests are difficult to control with a single insecticide application as most crawlers are concealed and not hit by contact sprays and concealed females establish large colonies in a short while (Kabashima & Dreistadt). Therefore, establishment of young insects has to be prevented by applying insecticides several times until crawler production ceases. Heavily infested tubers have to be dipped in insecticidal solutions as per recommended applications and used as seed materials for next season.

Table 2 Mortality percentage (%) of first instars of yam scale insects

Con. (%)	Malathion			Quinalphos			Chlorpyrifos		
	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3DAT
0.5	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}
0.1	80±0^{b}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}	100±0^{c}
0.05	80±0^{b}	80±0^{b}	90±0^{c}	76.6±5.7^{b}	83.3±5.7^{b}	96.6±5.7^{bc}	80±0^{b}	83.3±5.7^{b}	96.6±5.7^{c}
0.01	80±0^{b}	83.3±5.7^{b}	83.3±5.7^{b}	70±10^{b}	76.6±5.7^{b}	80±0^{b}	80±0^{b}	80±0^{b}	80±0^{b}
Control	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}

Means with the same letters are not significantly different by Duncan's multiple test

Table 3 Mortality percentage of yam scale insects on the infested tubers dipped in insecticides for 10 mins

Con. (%)	Malathion			Quinalphos			Chlorpyrifos		
	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT
0.5	45.2±1.6^{f}	45.2±1.6^{f}	45.2±1.6^{f}	46.4±2.6^{f}	46.4±2.6^{f}	58.2±3.2^{g}	50.0±1.1^{f}	51.1±2.3^{f}	60.3±2.5^{g}
0.1	34.8±2.9^{e}	34.8±2.9^{e}	34.8±2.9^{e}	33.54±1.5^{e}	34.8±1.1^{e}	34.8±1.1^{e}	35.2±2.2^{e}	35.2±2.2^{e}	40.5±5.8^{ef}
0.05	11.3±1.4^{b}	11.3±1.4^{b}	11.3±1.4^{b}	10.5±2.8^{b}	10.5±2.8^{b}	12.9±1.2^{b}	22.3±2.2^{c}	22.3±2.2^{c}	28.21±1.8^{d}
0.01	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}
Control	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}	0±0^{a}

Means with the same letters are not significantly different by Duncan's multiple test

Table 4. Mortality percentage of yam scale insects on the infested tubers dipped in insecticides for 20 mins

Con. (%)	Malathion			Quinalphos			Chlorpyrifos		
	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT
0.5	91.4 ± 1.4^{f}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}	100 ± 0^{g}
0.1	74.5 ± 1.4^{d}	74.5 ± 1.4^{d}	81.6 ± 2.6^{e}	85.0 ± 3.3^{e}	85.0 ± 3.3^{e}	85.0 ± 3.3^{e}	84.8 ± 2.4^{e}	84.8 ± 2.4^{e}	88.7 ± 3.4^{ef}
0.05	39.0 ± 3.4^{b}	39.0 ± 3.4^{b}	41.3 ± 3.4^{b}	43.5 ± 2.5^{b}	43.5 ± 2.5^{b}	43.5 ± 2.5^{b}	56.4 ± 5.5^{c}	56.4 ± 5.5^{c}	56.4 ± 5.5^{c}
0.01	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}
Control	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}

Means with the same letters are not significantly different by Duncan's multiple test

Table 5. Mortality percentage of yam scale insects on the infested tubers dipped in insecticides for 30 mins

Con. %	Malathion			Quinalphos			Chlorpyrifos		
	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT	1 DAT	2 DAT	3 DAT
0.5	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}	100 ± 0^{d}
0.1	81.11 ± 3.2^{c}	81.11 ± 3.2^{c}	100 ± 0^{d}	82.33 ± 1.9^{c}	82.33 ± 1.9^{c}	95 ± 4.5^{d}	84.4 ± 3.3^{c}	100 ± 0^{d}	100 ± 0^{d}
0.05	62.44 ± 1.2^{b}	62.44 ± 1.2^{b}	62.44 ± 1.2^{b}	64.5 ± 2.2^{b}	64.5 ± 2.2^{b}	64.5 ± 2.2^{b}	68.3 ± 5.2^{b}	68.3 ± 5.2^{b}	68.3 ± 5.2^{b}
0.01	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}
Control	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}

Means with the same letters are not significantly different by Duncan's multiple test

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STUDIES ON THE ICHTHYOFAUNAL DIVERSITY OF MANAKUDY ESTUARY KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT:

Estuaries constitute essential habitats for diadromous and estuarine resident fish species to complete their life cycle and serve as nursery grounds for fish species owing to the abundance of food availability. Hence an attempt has been made to document the fish diversity and ecological status of Manakudy estuary in the Kanyakumari district of southern Tamil Nadu India during the period 2021-22. During the study period, 43 species of 28 genera belonging to 14 families and 8 orders of fish has been observed. Most dominant fish species mainly belonged to Perciformes, Clupeiformes and Siluriformes orders. Average seasonal species abundance data were used as input for calculating various biodiversity indices including Shannon - Wiener diversity, Margalef's species richness Pielou's evenness. The current study suggested that ichthyo faunal assemblages in this estuary exhibit high degree of species-level similarity across systems and was characterised by relatively stable and abundant fish diversity.

Keywords: Estuary, fish species, Perciformes, Clupeiformes, Siluriformes, Shannon - Wiener diversity, Margalef's species richness, Pielou's evenness.

INTRODUCTION

An estuary is a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it and with a free connection to the open sea (Balasubramanian and Kannan 2005, Day *et al.,* 1981). The inflows of both sea water and fresh water provide high levels of nutrients in both the water column and sediments, making estuaries among the most productive natural habitats in the world. Estuaries are economically important ecosystem for fisheries in tropical regions and they act as a transitional zone between land and sea. Estuaries are known in many parts of the world as breeding and nursery grounds for a wide variety of fishes (Jhingran,1991; Kurup and Samuel, (1987).). Although, estuaries provides a rather harsh environment because of change in salinity, many species of fish have found them to be an ideal place for spawning, development and growth during early life, that way productivity tends to be high here. A large variety of fishes inhabit the estuarine environment. Most of them are migratory marine species, which use this habitat in their early life cycle as a necessity (Karthikeyan, 2007). Some others are permanent residents of the estuaries, which spend their entire life cyclein this ecosystem.

Manakudy estuary is located on the southern extremity of Indian Peninsula (Lat 8^0 2'N Long 77^0 3^0'E) along the south west coast of India, about 10 km from Kanyakumari. Manakudy estuary which has an area of about 150 ha is situated about 8 kilometers northwest of Cape Comorin in Kanyakumari District. It is the confluence of river Pazhayar, which has its origin from the Western Ghats. The Manakudy mangroves is abound with varied habitats that include shallow open waters, sandy beaches, muddy flats, mangrove forest, river delta and sea grass. Mangroves are a significant ecosystem in the estuary with a luxuriant growth on the mud flats. The litters on the mangrove floor undergo humification and mineralisation and the nutrients are leached into the mangrove water due to surface run-off adding to the productivity of the estuary. There is luxuriant growth of mangroves on the mud flats of Manakudy mangroves.

There may be other such impacts on fish communities that have not yet been noticed. Accumulated debris of boulders and broken coral can simulate 'reefs' in shallow coastal waters that can lead to a temporary increase in local fish diversity (Balasubramanian and Kannan, 2005; Kurup and Samuel, 1987). Such a diverse fish community is however unstable and may soon succumb to predation. Some of the newer fish habitats and communities that the tsunami created in mangrove in particular are likely to adapt locally and diversify. Such mangroves are 'natural experiments' and would offer a lot of scope for the scientific study of succession in marine and coastal fish communities (Bell *et al., ., .,*1988; Indhrani and Natarajan, 2005). A comprehensive study on the distribution pattern and faunal composition of fishes from upstream to the estuarine section in the Manakudy estuary was lacking. In view of the paucity of such information, the present communication was conducted to investigate distribution and diversity of fishes for conservation, management and sustainable utilization of fishery resources. Therefore the present study was undertaken to assess the diversity of fish species inhabiting Manakudy estuary for conservation, management and sustainable utilization of fishery resources.

MATERIALS AND METHODS

Study site

Kanyakumari District is located on the southern extremity of the Indian Peninsula between lat 8 ^{0}2 ' and 8^{0} 4 'N and between long 77^{0} 26' and 77^{0} 30'E. Pazhayar is one of the main river systems in the District and this river takesits origin at the Westernghats. From the place of its origin it traverses 23.1km before entering the Arabian Sea through the Manakudy estuary. The Manakudy estuary is the confluence of river Pazhayar and has an area of about 150ha. It is a sand built estuary connected to the sea during the rainy season. Manakudy estuary is endowed with diverse aquatic habitats including shallow open waters, sandy beaches, muddy flats mangrove forest, and river-delta and sea grass ecosystems.

Sampling

Fish sampling was conducted during low tide by using cast net (18 mm mesh) from selected three stations .The fish samples were sorted in field itself and identified up to species level in Laboratory. The representative specimens for each fish species were preserved in formalin for further reference in Department of Zoology museum at Sree Ayyappa College for Women, Chunkankadai, Nagercoil. The collected fishes were identified without any ambiguity using standard keys and books. Acheck list of estuarine fish species available in the Manakudy estuary of southern Tamil Nadu along with their systematic position was prepared based on the species recorded during the present study. The surface water temperatures were obtained using mercury-in-glass and the pH was measured by using pH paper as well as pH meter The species composition and abundance data were recorded during summer (April-June) Pre-monsoon (July-September), Monsoon (October-December) and Post-monsoon (JanuaryMarch) seasons The collected data were pooled together and made into four seasons and the seasonal data were used for the biodiversity assessment studies. The average seasonal species abundance data used as input for calculating various biodiversity indices such as Shannon – Wiener diversity (H'), Margalef s species richness ('d')'Pielou's evenness (J'), Taxonomic diversity (Dando, 1984)' Average taxonomic distinctness index (Haedrich, 1983)

RESULTS AND DISCUSSION

In the present investigation, an intensive study was undertaken to document the Ichthyo faunal diversity of Manakudy estuary The collected fishes were identified up to species level and checklist of identified estuarine fish species was prepared (Table-'1) Various biodiversity indices were estimated by using PRIMERV6 software.Based on the biodiversity indices estimates of estuarine fishes, conservation strategies' were proposed to study the ichthyo faunal diversity of Manakudy estuary.

Checklist of Fishes:

The present ichthyofaunal investigation revealed presence of 43 species of 28 genera belonging to 14 families and 8 orders of fish has been observed. The most dominant fish species mainly belonged to Perciformes,

Table 1. Check list of fishes recorded during the study period

Order	Family	Scientific name	Total no of fishes
Mugiliformes	Mugilidae	*Mugil cephalus*	25
Perciformes	Gerridae	*Gerres abbreviates*	76
Cichliformes	Cichlidae	*Etroplus maculates*	121
Perciformes	Terapontidae	*Terapon jarbua*	132
Mugiliformes	Mugilidae	*Liza parsia*	87
Elopiformes	*Elopidae*	*Elops machnata*	56
Gonorynchiformes	Chanidae	*Chanos chanos*	78
Anguilliformes	Anguillidae	*Anguilla bengalensis*	45
Cichliformes.	Cichlidae	*Oreochromis mossambica*	123
Cichliformes	Cichlidae	*Tilapia nilotica*	143
Channiformes	Channidae	*Ophiocephalus punctatus*	119
Siluriformes	Ariidae	*Arius thalassinus*	123
Siluriformes	Ariidae	*Arius dussumieri*	87
Anguilliformes	Anguillidae	*Anguilla bicolour*	65
Perciformes	Ambassidae	*Ambassis ambassis*	245
Perciformes	Lutjanidae	*Lutjanus gibbus*	156

Pleuronectiformes	Cynoglossidae	*Cynoglossus lingua*	45
Perciformes	*Sillaginidae*	*Sillagosihama*	376
Carangiformes	Menidae	*Menemaculata*	67
Perciformes	*Channidae*	*Channa orientalis*	257
Perciformes	*Channidae*	*Channa punctatus*	198
Anabantiformes	*Anabantidae*	*Anabas testudineus*	56
Clupeiforms	*Chirocentridae*	*Chirocentrus nudus*	53
Clupeiforms	*Clupeidae*	*Sardinella albella*	75
Clupeiforms	*Clupeidae*	*Tenualosa ilisha*	78
Clupeiforms	*Clupeidae*	*Anodontos tomachacunda*	98

Clupeiformes and Siluriformesorders. The lower number of species might be due to less area of present study. The higher number of fishes reported during the present study might be due to good water flow, comparatively lower salinity and better sampling in comparison with the results of fish diversity of the above mentioned estuaries, the fish diversity along the estuarine area of southern Tamil Nadu reveals to be satisfactory. During the present study, the numbers of fishes collected were invariably lower during monsoon period and higher during summer period. The present study has recorded several important environmental factors that are influencing the estuarine waters. In general, higher air and surface water temperatures were recorded during the summer season. The highest numbers of fishes were recorded in the monsoon season followed by pre monsoon, post monsoon and summer respectively. Earlier study by Devi and Rao (2007) of the mangrove regions recorded 290 fish species where the mangrove ecosystems of the whole islands was taken into consideration however the present study was restricted to a mangroves. In general high diversity and richness was recorded in monsoon season, while lowest was recorded in post monsoon season during the study period. Dry season was dominated by few fishes hence it was less diverse compared to the monsoon seasons where species of all origin are evenly represented.

The average seasonal species abundance data were used as input for calculating various biodiversity indices including Shannon - Wiener diversity, Margalef's species richness Pielou's evenness. The current study suggested that ichthyo faunal assemblages in this estuary exhibit high degree of species-level similarity across systems and was characterised by relatively stable and abundant fish diversity (Suseelan, 1975).

CONCLUSION

Considering the fishery potential of the Manakudy estuary with special reference to their conservation, it can be concluded that the system is a valuable source for the seeds of a number of cultivable species of fishes and crustaceans. Further, it offers a good support to the livelihood of fishermen residing in the adjoining villages by offering a considerable quantity of fish and crustacean protein. The plantation of mangrove has increased the fish production in the estuary, as revealed in the present study. It was concluded that the mangrove was endowed with diverse and rich fish community and was found influenced by environmental variables at a significant level. From the present study, it could be concluded that the hydrography, nutrients and pollution are the major factors responsible for fluctuation in fish assemblages in the study area. Water temperature and salinity were the major parameters influencing the fish assemblage of the mangroves. Moreover it provides food source to the coastal community residing near the mangroves. Hence it is very much essential to monitor proper condition of the mangrove for better sustainable fishery in the future as well. The findings of present communication may serve as baseline information for planning, conservation and management of fisheries resources of Manakudy estuary in the future.

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VARIATION OF BENTHIC INSECT FAUNA COMPOSITION IN ACHENKOVIL RIVER, WESTERN GHATS, KERALA, INDIA

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ABSTRACT

Water, the prime natural resource forms an indispensable constituent of the ecosystem. About 71% of the Earth's surface is covered by water. Water plays a vital role in every corner of the economy like agriculture, industrial activities, animal husbandry, hydropower generation, etc. The byproducts of all these activities result in pollution and degradation of the available water resources. Globally surface water deterioration due to pollution and climate change has become a serious threat. As a result, understanding the status of waterbodies is very essential for their long-term use. The use of aquatic organisms as indicators of water quality serves as an efficient tool in water quality monitoring programs. A study on the water quality parameters and variation in the aquatic insect fauna composition was therefore carried out in the Achenkovil River basin. The length of this River is 128 km, the basin size is 1,484 km^2 and the average water flow is 2287 million cubic meters. Samples were collected bimonthly and early in the morning hours throughout the study period. Water samples for physical-chemical analysis were carried to the laboratory in clean polyethylene bottles. Aquatic insect fauna were collected using Van Veen Grab. A total of 3566 individuals belonging to 9 orders, 32 families, 32 genera, and 32 species were identified. The most dominant order was Ephemeroptera followed by Coleoptera and Trichoptera and the least dominant was Zygoptera. Similar studies concerning the variation of the macrobenthic insect community and the hydrochemistry of waterbodies were carried out in different rivers around the world. No one has yet attempted to study the aquatic insect fauna of the Achenkovil River. This made an inspiration in us to undertake the present study on the river to ascertain the variation in the composition and structural diversity of insect fauna, the environmental factors and anthropogenic impacts responsible for the community patterns, the present ecological condition of the river and to determine the water quality using aquatic insect as indicators to establish the pollution status of the river to create a baseline data.

Keywords: Biodiversity indices, Trichoptera, Ephemeroptera, PCA, CCA.

INTRODUCTION

Benthos serve as important constituents of aquatic food webs as both consumers and prey (Covich *et al.,* 1999; Vanni, 2002; Moore, 2006). The conglomeration of benthic fauna mainly depends on the physical and chemical parameters, which in turn define the habitat and biological parameters that influence their reproductive success (Abdelsalam and Tanida, 2013). They are the most important indicators of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ravera, 1998, 2000). The distribution, abundance, and species composition of various invertebrate taxa are influenced by seasonal variability (Brooks 2000; Leung *et al.,* 2012; Sporka *et al.,* 2006). The temporal distribution of freshwater communities is also influenced by the life histories of various species (Ferdinand *et al.,* 2006).

Benthic insect fauna are indispensable organisms in the aquatic ecosystem. Benthic insect faunal diversity is dominant in both lentic and lotic freshwater habitats. Ephemeroptera, Odonata, Plecoptera, Coleoptera, Diptera, and Trichoptera are predominant groups of aquatic insects found in many streams and Rivers. EPT (Ephemeroptera, Plecoptera, and Trichoptera) is commonly used in biomonitoring studies due to the presence of intolerant taxa. A high number of EPT represents undisturbed streams and rivers with rich species diversity (Barbour *et al.,* 1999). Studies identified with benthic fauna are principally centered on lotic environments, yet not many works are leading in freshwater bodies. Along these lines, there is no adequate data is accessible concerning the distribution, diversity, and abundance of freshwater benthic insect fauna of the Achenkovil River. The present investigation reveals the variation in aquatic insect fauna composition, abundance, and distribution in the Achenkovil River basin.

MATERIALS AND METHODS

Study area

The Achenkovil River is created towards the Southern tip of the peninsula by the confluence of the Rishimala, Pasukidamettu, and Ramakkalteri Rivers originating from Devarmalai of Western Ghats. The length of this River is 128 km, basin size of 1,484 km^2. For the present investigation, the study area is divided into three segments- upstream (S1,S2, S3), midstream (S4, S5, S6), and downstream (S7, S8, S9) with three stations in each segment (Figure 1).

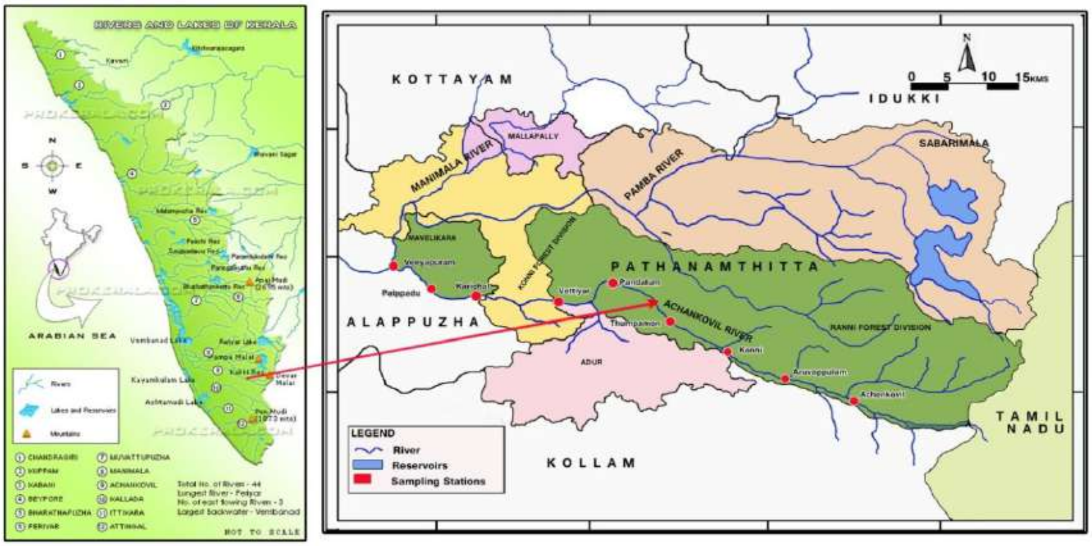

Figure 1: Location map of the study area

Sample Collection

Samples were collected bimonthly from the upstream, midstream, and downstream regions. The collection was made from February 2019 to January 2020 covering pre-monsoon, monsoon, and post-monsoon seasons. At each sampling station, three replicate samples were collected between 8 a.m. and 12.00 noon using Van Veen Grab ($0.025m^2$). The samples were pooled and then sieved through a 500 µm mesh and the sediments in the mesh were fixed with 5% formalin for further identification. The preserved organisms were identified under a stereomicroscope and counted. The identification was carried out using standard taxonomic keys (Day *et al.,* 1989, Catherine and Yong. 2004).

Physicochemical Analysis

Water temperature (°C) was measured *in situ* by using a Mercury thermometer (with ± 0.1°C accuracies). The water samples were collected using clean polyethylene bottles and carried immediately to the laboratory for further analysis. DO (mg/L), BOD (mg/L), pH, turbidity (NTU), conductivity (µS/cm), salinity (ppt.), alkalinity (mg/L), hardness (mg/L), TDS (mg/L), phosphate (mg/L), silicate (mg/L) and Nitrate (mg/L) was carried out using standard references (APHA 2012).

Data Analysis

Univariate analysis for studying the variation in benthic community structure using Shannon- Weiner diversity index (H^1), Simpson's Dominance index (D), Simpson's diversity index (1-D), Shannon equitability or evenness index, and Margalef index of species richness were carried out.The variation of environmental parameters and their relationship with the macrobenthic fauna was analyzed using multivariate statistical analysis (PCA & CCA). Biodiversity indexes and CCA were carried out using PAST (version 4.09) software. PCA was carried out using SPSS (version 22). Relative abundance was calculated using Excel 2019.

RESULTS

The variation in the environmental parameters was analyzed using the multivariate statistical technique (PCA). The PCA showed three principal components, which explained 89.17% of the total variance. PC1 explained 51.79% of the total variance and had a significant contribution from turbidity, TDS, conductivity, salinity, pH, phosphate, alkalinity, hardness with a strong positive loading value of >0.75, and a moderate correlation with water temperature and nitrate (>0.50- 0.75). PC2 accounted for 25.08% of the total variance and has a strong positive correlation with BOD, a strong negative correlation with DO, and a moderate negative correlation with silicate. PC3 accounted for 12.30% of the total variance and had a strong positive correlation with depth (Table 1). Absolute loading value >0.75 is of strong significance and these parameters can be used to monitor the variations in water quality (Liu *et al.,* 2003).

	Components		
Parameters	1	2	3
Depth	-.107	.288	**.893**
water temperature	**.693**	.453	.463
DO	-.217	**-.933**	-.057
BOD	.171	**.915**	.267
Turbidity	**.782**	.511	.278
TDS	**.889**	.426	-.071
Conductivity	**.859**	.482	-.064
Salinity	**.887**	.418	-.051
pH	**.826**	.063	.371
Nitrate	**.649**	.000	.463
Phosphate	**.913**	.175	-.124
Silicate	-.448	**-.722**	-.193
Alkalinity	**.891**	.209	.349
Hardness	**.907**	.256	-.146
Eigenvalue	7.251	3.512	1.722
% of Variance	51.79	25.08	12.30
Cumulative %	51.79	76.87	89.17

Table 1: shows the variation in the environmental parameters analyzed using Principal Component Analysis.

The composition and distribution of macrobenthic fauna in the present study include a total of 3566 individuals belonging to 9 orders, 32 families, 32 genera, and 32 species identified (Table. 2). The 9 orders include Ephemeroptera, Plecoptera, Zygoptera, Anisoptera, Coleoptera, Diptera, Hemiptera, Megaloptera and Trichoptera. The species composition of different orders of macrobenthic fauna revealed that the largest group was Ephimeroptera comprising 8 species, followed by 7 species of Coleoptera, 4 species each for Diptera, Hemiptera, 3 species each for Anisoptera and Trichoptera and 1 species each of Megaloptera, Plecoptera and Zygoptera. The order Ephemeroptera accounted for 24% of the total macrobenthic fauna and was the most dominant, diverse, and abundant group studied and the least represented was Zygoptera.

Order/Family	**Genus/Species**	Upstream		Midstream		Downstream	
		NO.	RA	NO.	RA	NO.	RA
Ephemeroptera							
Leptophlebidae	*Notophlebia jobi*	190	8.3	121	11.3	2	0.8
Caenidae	*Caenis* sp.	3	0.1	5	0.4	37	16.3
Teloganodidae	*Dudgeodes* sp.	135	5.9	24	2.2	*	*
Baetidae	*Baetis* sp.	71	3.1	23	2.1	19	8.4
Tricorythidae	*Sparsorythus gracillis*	95	4.1	2	0.1	*	*
Heptageniidae	*Afronurus kumbakkaraiensis*	65	2.8	24	2.2	3	1.3
Ephemerellidae	*Torleya nepalica*	*	*	19	1.7	*	*
Ephemeridae	*Aethephemera nadiinae*	18	0.7	4	0.3	*	*
Plecoptera							
Perlidae	*Neoperla*	125	5.4	40	3.7	10	4.4
Diptera							
Chironomidae	*Chironomus* sp.	31	1.3	151	14.1	80	35.3
Athericidae	*Atherix* sp.	37	1.6	31	2.9	11	4.8
Tipulidae	*Tipula* sp.	70	3	11	1	*	*
Tabanidae	*Tabanus* sp.	41	1.8	10	0.9	*	*
Hemiptera							
Notonectidae	*Micronecta* sp.	71	3.1	19	1.7	3	1.3

Vellidae	*Microvelia douglasi*	87	3.8	17	1.5	1	0.4
Belostomatidae	*Lethocerus indicus*	115	5	2	0.1	*	*
Nepidae	*Nepa* sp.	59	2.5	*	*	*	*
Zygoptera							
Euphaeidae	*Euphae* sp.	59	2.5	4	0.3	*	*
Anisoptera							
Gomphidae	*Stylogomphus* sp.	75	3.2	101	9.4	6	2.6
Aeshnidae	*Anax* sp.	51	2.2	60	5.6	3	1.3
Libellulidae	*Crocothemis* sp.	97	4.2	3	0.2	1	0.4
Megaloptera							
Corydalidae	*Corydalus* sp.	42	1.8	48	4.5	*	*
Coleoptera							
Dytiscidae	*Agabus* sp.	58	2.5	11	1	3	1.3
Psephenidae	*Eubrinax* sp.	63	2.7	64	6	*	
Elmidae	*Cylloepus* sp.	68	2.9	23	2.1	5	2.2
Scarabaeidae	*Rhyssemus* sp.	45	1.9	12	1.1	*	*
Hydraenidae	*Hydrena* sp.	35	1.5	20	1.8	*	*
Hydrophilidae	*Hydrophilus* sp.	51	2.2	57	5.3	*	*
Noteridae	*Hydrocanthus* sp.	43	1.8	10	0.9	*	*
Trichoptera							
Economidae	*Economous* sp.	177	7.7	36	3.3	3	1.3
Philopotamidae	*Chimarra* sp.	71	3.1	34	3.1	18	7.9
Hydropsychidae	*Hydropsyche* sp.	127	5.5	79	7.4	21	9.2
Total no.		2275		1065		226	
Family taxa		31		31		17	

Table 2: Relative abundance of aquatic insect fauna in the Achenkovil River basin

The variation in the water quality status can be revealed from the values recorded for species diversity, richness, dominance, and evenness indices(Table: 3).The highest values for Simpson's diversity, Shannon, and Simpson equitability were noted in Upstream and Margalef was noted in Midstream and Simpson Dominance in downstream.

Stations	Total no. Of individuals	Taxa	Shannon-Wiener index	Simpson Dominance index	Simpson's Diversity Index	Shannon equitability index	Margalef diversity index
Upstream	2275	31	1.923	0.162	0.838	1.418	3.8811
Midstream	1065	31	1.815	0.176	0.824	1.2436	4.3037
Downstream	226	17	1.498	0.275	0.725	1.384	2.9517

Table 3: Variation in diversity indices of benthic insect fauna in Achenkovil River

The relationship between the macrobenthic fauna and environmental variables (Figure 2) was depicted using multivariate statistical analysis (CCA). The first canonical axis explained over 51.59% and the second 48.41% of the variation in the macrobenthic fauna data set. The Monte Carlo permutation test performed on the first two axes showed no significant differences (p>0.05).

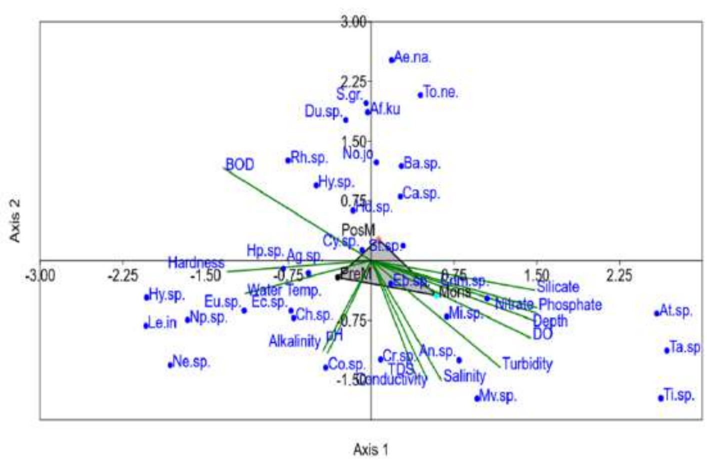

Figure 2: CCA ordination plot showing the relationship between aquatic insect fauna and water quality parameters

[***Abbrevations used:*** *Notophlebia jobi (No.jo), Caenis* sp. (*Ca.*sp*.), Dudgeodes* sp. (*Du.*sp.), *Baetis* sp. (*Ba.*sp), *Sparsorythus gracillis (S.gr.), Afronurus kumbakkaraiensis (Af.ku), Torleya nepalica (To.ne.), Aethephemera nadiinae (Ae.na.), Neoperla (Np.*sp), *Chironomus* sp. (*Cnm.* sp.), *Atherix* sp. (*At.*sp.), *Tipula* sp. (*Ti.*sp), *Tabanus* sp. (*Ta.*sp.), *Micronecta* sp. (*Mi.*sp.), *Microvelia douglasi (Mv.*sp.), *Lethocerus indicus (Le.in), Nepa* sp. (*Ne.*sp.), *Euphae* sp. (*Eu.*sp.), *Stylogomphus* sp. (*St.*sp.), *Anax* sp. (*An.*sp.), *Corydalus* sp. *(Co.*sp.), *Crocothemis* sp. *(Cr.*sp.), *Agabus* sp. (*Ag.*sp.), *Eubrinax* sp. (*Eb.*sp.), *Cylloepus* sp. (*Cy.*sp.), *Rhyssemus* sp. (*Rh.*sp.), *Hydrena* sp. *(Hy.*sp.), *Hydrophilus* sp. (*Hd.*sp*.), Hydrocanthus* sp. (*Hy.*sp.), *Economous* sp. (*Ec.*sp.), *Chimarra* sp. (*Ch.*sp.), *Hydropsyche* sp. (*Hp.*sp*.)*].

The CCA reveals that *Athrix* sp. *(At.), Tipula* sp. *(Ti.), and Tabanus* sp. *(Ta.)* show a strong positive correlation with silicate, phosphate, nitrate, depth, and DO while *Chironomus* sp. *(Cnm.*), shows a strong correlation with phosphate, nitrate and depth. *Neoperla* sp. *(Np.),Lethocerus indicus (Le.in),Nepa* sp. *(Ne.), Euphaea* sp. *(Eu.), Agabus* sp. *(Ag.), Hydrena* sp. *(Hy.), Economous* sp. *(Ec.), Chimarra* sp. *(Ch.), Hydropsyche* sp. *(Hp.)* shows a positive correlation with water temperature and hardness. *Notophlebia jobi (No.jo), Caenis* sp. *(Ca.), Dudgeodes* sp. *(Du.), Baetis* sp. *(Ba.), Sparsorythus gracillis (S.gr.),Afronurus kumbakkaraiensis (Af.)*, *Torleya nepalica (To.), Aethephemera nadinae (Ae.na), Rhyssemus* sp. *(Rh.)*, *Hydrophilus* sp. *(Hd), Hydrocanthus* sp. *(Hc)* shows a negative correlation with turbidity, TDS, conductivity, salinity, pH and alkalinity. *Micronecta* sp. (Mi.) and *Eubrinax* sp. show a positive correlation with turbidity. *Corydalus* sp. *(Co.)* shows a positive correlation with pH and alkalinity, and *Crocothemis* sp. *(Cr.)* shows a positive correlation with TDS and conductivity.

DISCUSSION

The demand for water for its different uses has increasing day by day, which has a negative influence on the availability of this resource. Temperature is an important factor that plays a major role in the physical, chemical, and biological characteristics of water. The increase in temperature may be due to high solar radiation, low rainfall, low water levels, and clear skies (Abilash & Mahadevaswamy 2021). A high temperature during the premonsoon season causes a decrease in the DO level which is a natural phenomenon since warmer water is more easily saturated with oxygen and thus holds less DO (Yang *et al., .,* . 2021). The increase in pH value may be due to high photosynthetic activity (Craft *et al.,* 2018). The pH value shows a clear trend toward alkalinity which may be due to anthropogenic impacts, wastewater discharge, and agricultural activities (Azouzi *et al.,* 2017). The high DO value noted during the monsoon season may be due to water turbulence resulting from heavy rainfall (Kannel *et al.,* 2007). Heavy rain in the monsoon season causes surface runoff accompanied by sand, silt, clay, organic matter, etc. may be the reason for high turbidity during the monsoon season (Sanalkumar *et al.,* 2014). An increase in turbidity is considered a limiting factor in the biological productivity of aquatic ecosystems (Mahajan & Billore, 2014). Agricultural runoff resulting from heavy rainfall may be the reason for an increase in the value of nitrate and phosphate during the monsoon season (Varol *et al.,* 2012). The input of more silicious sediments along with surface runoff may be the reason for the high silicate content in the water body (Jaji *et al.,* 2007). Low values of silicate may be due to high primary productivity and the non-biological removal of dissolved silicate by adsorption onto suspended sediments (Desouza *et al.,* 1981). The minimum mean water temperature was noted in the headwater station. The headwater station has a thick canopy cover that prevents the direct heating of the surface water. There were no significant ($p>0.05$) differences found for salinity, hardness, depth, conductivity, and TDS.

The presence and abundance of aquatic insects help to indicate a relative degree of purity or pollution of water. The structure and composition of biotic communities change with the Physico-chemical and hydrobiological characteristics of the environment which is often reflected in the distribution, diversity, and abundance pattern of species (Abhilash & Mahadevaswamy 2021).According to Abhilash *et al.,* aquatic insects are generally considered the dominant macro-invertebrates in freshwater ecosystems.Most species of Ephemeropterans are sensitive to environmental stress and their presence marked a relatively positive condition (Merrit and Cummins 1996). The increase in the diversity of insects in the upstream region of the Achenkovil River is an indication of larger microhabitat diversity and better water quality. The most dominant species in the midstream is also Ephemeroptera but plecopteran is very scarce. The order Plecoptera is highly sensitive to environmental degradation (Fore *et al.,* 1996, Maxted *et al.,* 2000). In the downstream region, the total recorded benthic insect population was low and chironomids dominated in the region. Moreover, the smaller number of other aquatic insects may be due to some ecological imbalance of certain factors that govern the abundance and distribution of benthic insect communities. The presence of chironomids indicates the influence of pollution in the lower reaches of the river. Many of the dipterans inhabit heavily polluted water bodies with a wide range of tolerance (Abhijna *et al., 2013*). Studies have shown that Dipterans commonly chironomids as one of the dominant taxa in natural (Copatti *et al.,* 2013) or non-natural environments (Hepp *et al.,* 2010). Most of the members of EPT and Coleoptera are commonly known for their pollution-sensitive nature. The Coleopterans are abundantly seen in sites with good vegetation as they provide food and breeding places. They can also tolerate moderate levels of pollution (Popoola *et al.,* 2019). They are absent from highly disturbed habitats. The diversity and abundance of Odonates in an area depend on the habitat heterogeneity formed due to the complexity of vegetation, the nature of the substrate, and physicochemical characteristics (Wijesooriya *et al.,* 2022). The seasonal analysis of macrobenthic fauna reveals that maximum diversity and abundance were noted during the post-monsoon season followed by the pre-monsoon season. The least diversity and abundance were noted during the monsoon season because of heavy rainfall and increased flow that results in wash-off and dislodgement of taxa with no adhesive features. This was following the reports given by Arimoro *et al.,* (2010)**.**

The decrease in the macrofaunal composition towards the midstream and downstream stretch of the river is an indication of pollution load and the corresponding deterioration of the water quality (Kumar *et al.,* 2012). Plecoptera and Trichoptera are sensitive to water quality degradation and occur only in clean and well-oxygenated water (Priyanka & Prasad, 2013). They are abundant in the reference site. Specific families within the EPT help to monitor various types of disturbance in the water body (Abhijna *et al.,* 2013). The variation in the water quality status can be revealed from the values recorded for species diversity, richness, dominance, and evenness indices.The highest values for Simpson's diversity, Shannon, and Simpson equitability were noted in Upstream, and Margalef was noted in Midstream and Simpson Dominance in downstream. High dominance in the downstream may be due to the disappearance of more sensitive taxa replaced with more tolerant species like Chironomous, thus reducing species richness and diversity (Copatti *et al.,* 2013).

The Shannon index value for stations 5 (Midstream) to station 9 (Downstream) and the Margalef index value for stations 8 and 9 (Downstream) were below three, which is an indication of the polluted water body. Similar reports were given by Kabir and Offioong 2016, in the Alaro stream, Ibadan. The low relative abundance of pollution-sensitive organisms, in the midstream and downstream segments, indicates that the river Achenkovil is already stressed across its reaches.

The CCA revealed that most taxa were sensitive to environmental changes. More sensitive macrobenthic fauna was found in the upstream stations than in the midstream and downstream stations, as these species are favored by more DO levels and lower levels of conductivity, nitrate, and phosphate. It is clear from the CCA plot that most of the Hemipterns are associated with high water temperature and less dissolved oxygen, indicating their less dependency on oxygen. Moreover, the Hemipterans possess additional respiratory structures such as plastron, siphon, etc. that help us to use atmospheric oxygen (Abhilash and Mahadevaswamy*,* 2021). Similar reports were given by many scientists about the dominance of Hemiptera in different freshwater lakes.

The rich diversity and abundance of aquatic insects at the upstream region which was in the eastern end of Western Ghat, an unpolluted dense forest without any pollution. The diversity and distribution pattern of the aquatic insect group is not uniform along the river. Anthropogenic activities greatly influence the number, diversity, and abundance of aquatic insects noted in the study. Eutrophication decreases the benthic species diversity (Fernanda Blauth de Lima *et al.,* 2013). The obvious change is due to fluctuation in water bodies. The fluctuation was due to the seasonality of rainfall and dilution factor as well as anthropogenic activities. Besides these natural environmental conditions play a significant role in the diversity of benthic organisms (Yap *et al.,* 2003). The distribution pattern of benthic organisms frequently changes in response to pollution stress in predictable ways (Barbour *et al.,* 1999).

CONCLUSION

The present study on the variation of macrobenthic fauna and water quality parameters of the Achenkovil River basin revealed the diversity, distribution pattern, and abundance of macrobenthic fauna. They dominated in undisturbed habitats. Physicochemical parameters play a major role in the distribution of macrobenthic fauna. Some species of macrobenthic fauna are pollution sensitive and some are pollution tolerant. So, their presence or absence can be used to predict water quality. To conclude, Macrobenthic fauna has the potential to act as biological indicators of pollution status. Thus, keeping in mind the importance of the study, steps should be taken for the maintenance and conservation of freshwater ecosystems.

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DISTRIBUTION OF CULTURABLE BACTERIA IN MANGROVE SEDIMENTS OF NORTH KERALA

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ABSTRACT

In tropical and subtropical regions, mangroves are transitional coastal ecosystems that are biologically significant and productive. Mangroves make up nearly 75% of the tidal vegetation in tropical areas. Microbial communities in mangrove sediments play a critical role in the biogeochemical cycles of coastal ecosystems. Understanding ecosystem functioning requires a detailed examination of microbial communities. The present study focussed on isolating and characterising mangrove sediment bacteria from eight different mangrove habitats in North Kerala. 526 bacterial isolates from 31 distinct genera were isolated and identified based on morphological and biochemical characterization using Bergey's manual of determinative and systematic bacteriology, and the data were analyzed using PRIMER v7 software. *Bacillus* sp, *Enterococcus* sp, and *Xanthobacter* sp. were the most common culturable bacteria isolated from the habitat and several extremophiles have been discovered. Majority of the isolates obtained belonged to gram positive. Sulphur oxidizers, diazotrophs, phosphate solubilizers and known bioremediators were among the bacteria identified, making them prospective candidates for a variety of industrial applications.

Keywords: Bergey’s manual, Distribution, Mangrove bacteria, North Kerala, Primer v7, Seasons

INTRODUCTION

A coastal mangrove ecosystem is a region that has the potential to supply a variety of natural resources. The sea tides are constantly affecting this area, resulting in the integration of physical, biological, and chemical aspects of land and sea (Zubair et al., 2019). Mangrove ecosystem has representation from almost all phyla and class. These species require high nutrition in the food web, which is provided by bacteria that have adapted to salinity fluctuations and low oxygen availability in mangrove sediments. Bacterial diversity from these ecosystems has been studied worldwide to understand their role in unique biochemical processes. PRIMER v7 provides a wide range of univariate, graphical and multivariate routines for analysing arrays of species-by-samples data from community ecology.

Microorganisms have a significant role in the decomposition and mineralization of organic materials in the mangrove ecosystem, as well as providing nutrients to plants (McGuire, 2011). Bacteria are also in charge of decomposing and recycling important components like carbon, nitrogen, and phosphorus (Alongi,1994) that are utilized by other living beings. Against this back drop, in the present study isolation and morphological characterization of bacteria using standard methods and data interpretation using PRIMER v7 software was done. Due to lack of research done on the bacterial population in mangrove sediments in Northern Kerala, the present study provides a baseline data on the diversity of bacteria and crucial information for managing biological resources in the mangrove ecosystem.

METHODOLOGY

Sediment samples were collected from the mangroves of the five districts along North Kerala coast from 8 locations, Chandragiri (KGD)-12°05'32" N 75°13'39" E (Kasaragod Dt), Edat (EDT)- 12°05'32" N 75°13'39" E, Pazhayangadi (PYD)- 12°02'72" N 75°29'31" E, Valapattanam (VPT)- 11°93'45" N 75°35'35" E, (Kannur Dt), Elathur (ELR)- 11°19'43" N 75°45'2" E, Kadalundi (KDI)- 11°07'43" N 75°49'48" E (Kozhikode Dt), Ponnani (PON)- 10°47'1" N 75°55'3" E (Malappuram Dt) and Chettuva (CTV)- 11°1'41" N 75°52'6" E (Thrissur Dt) (Fig. A.1). Samples were collected from the same spot during three seasons of the year viz., monsoon (July – September), post monsoon (November – January) and pre monsoon (April-May). Sub surface (0-15cm) samples (approximately 10-20gm) were collected using hand core method and transferred aseptically in sterile polythene bags, transported in ice boxes and processed within 4 hrs of collection. The collected sediment samples were serial diluted (10^{-1} to 10^{-3}) and plated to nutrient agar medium employing spread plate method. The plates were incubated at 28±2° C for 24 hours. The colonies developed were purified by quadrant streaking and transferred to nutrient agar slants for further analysis. Morphological studies were done by gram's staining technique. Identification of the bacterial isolates was done as per Bergey's

Manual of Determinative Bacteriology (Bergey and Holt). Distribution of the bacterial isolates were analysed and plotted using Primer v7 software (Clarke and Gorley, 2015).

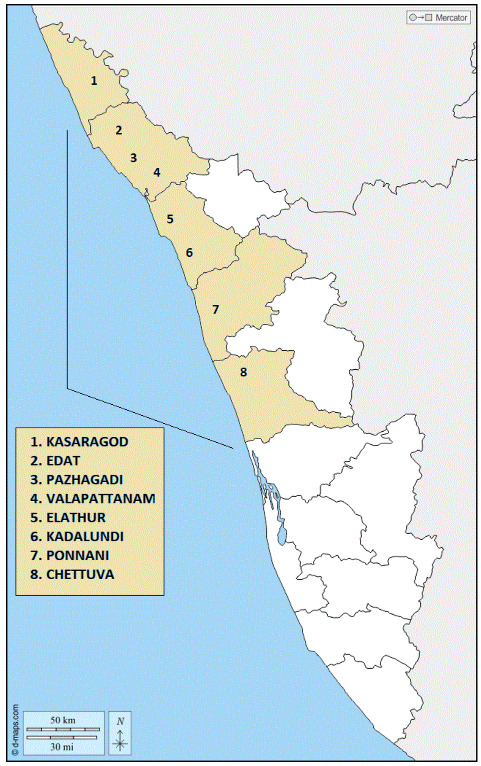

Fig. A.1. Sampling locations in Northern Kerala

RESULTS

Isolation and purification of mangrove sediment bacteria from Northern Kerala was done from 8 locations. 526 isolates were obtained and successfully purified. The presence of bacteria in sediments was quite varied with discovery of various types of bacteria.

The line plot (Fig. A. 2) shows difference in genera distribution of the bacterial isolates obtained. 31 different genera were identified out of total of 526 isolates obtained. The genera identified belonged to *Bacillus* (166), *Enterococcus* (49), *Xanthobacter* (39), *Klebsiella* (31), *Lysobacter* (30), *Pseudomonas* (27), *Staphylococcus* (20), *Serratia* (17), *Vibrio* (15), *Lactobacillus (*12), *Macrococcus* (12), *Providencia* (11), *Beggiatoa* (11), *Alcaligenes* (10), *Enterobacter* (9), *Aeromonas* (9), *Geobacillus* (7), *Proteus* (7), *Thiothrix* (5), *Plesiomonas* (5), *Micrococcus* (5), *Escherichia* (4), *Listeria* (4), *Xanthomonas* (4), *Citobacter* (4), *Listonella* (4), *Alteromonas* (3), *Acinetobacter* (2), *Thermomonas* (2), *Salmonella* (1) and *Achromobacter* (1) respectively. *Bacillus* was the predominant genera obtained. 54% of the isolates obtained were gram positive and 46 % were gram negative.

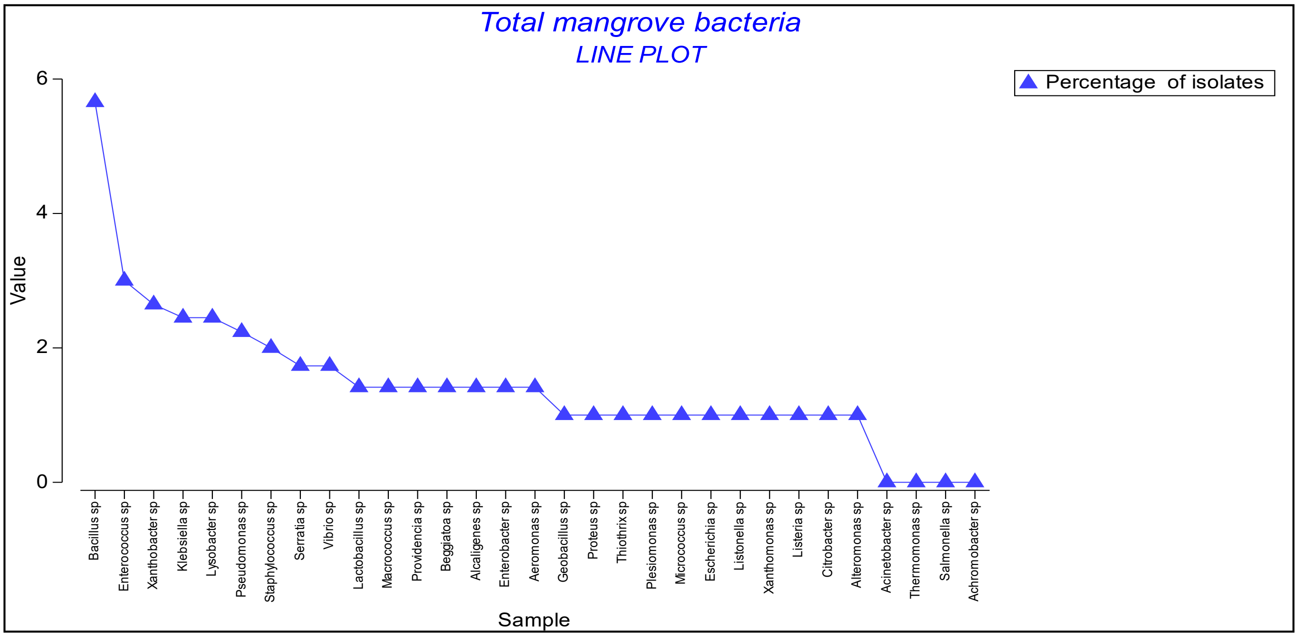

Fig. A. 2. The total percentage of bacterial isolates from different mangrove stations from Northern Kerala

Number of bacterial isolates obtained during monsoon, post monsoon and pre monsoon sediment sampling were 208, 190 and 121 respectively. *Bacillus*, *Xanthobacter* and *Enterococcus* were the predominant genera among bacterial isolates obtained from monsoon, post monsoon and pre monsoon season (Fig. A. 3). *Bacillus* (31%), *Xanthobacter* (12%), *Enterococcus* (9%), *Klebsiella* (8%) and *Lysobacter* (7%) were the genera predominantly obtained during monsoon season. During post-monsoon season *Bacillus* (28%), *Enterococcus* (10%), *Lysobacter* (7%) and *Pseudomonas* (7%) were the major genera obtained. In premonsoon season, *Bacillus (*40%), *Enterococcus* (9%) and *Klebsiella (*8%) were the genera predominantly isolated. Pre-monsoon is the only season where *Achromobacter* and *Salmonella* were obtained. *Bacillus* was the predominant genera obtained during all the three seasons followed by *Enterococcus*. From the line plot it can be inferred that *Bacillus* sp is predominant in pre-monsoon season compared to monsoon and post-monsoon, whereas *Xanthobacter* shows opposite pattern having maximum isolates in monsoon. *Enterococcus* sp shows equal percentage of distribution in all seasons. The prevalence of bacteria didn't follow any stable pattern; the percentage varied according to species and seasons. The number of bacterial isolates obtained was higher in monsoon than in other seasons.

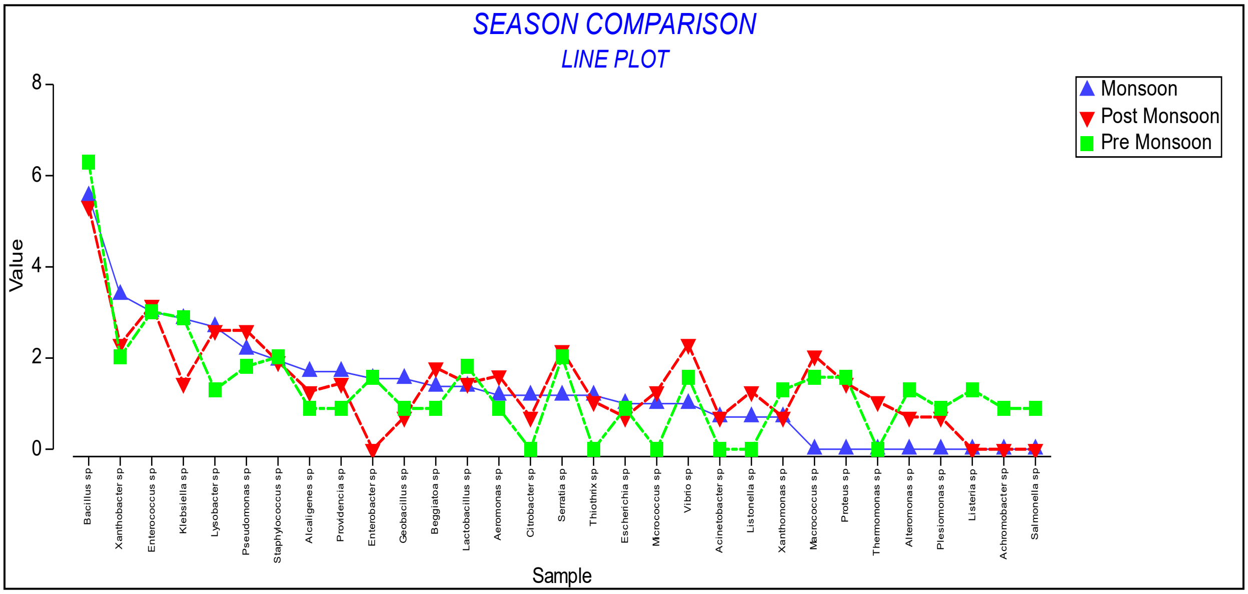

Fig. A. 3. Line plot of season wise representation of bacterial isolates

In eight different mangrove stations, the cluster analysis (Fig. A. 4) of environmental sediment sample revealed group average. Using square root analysis, the data are normalized and transformed. The D1 Euclidean distance is used to calculate the resemblance. Distance between each was clustered in a hierarchical manner. Link tree was used to divide clustering algorithms bound by environmental variables. SIMPROF showed 12 important nodes (green line) that can be classified as 5 bacterial groups (A-E) using hierarchical cluster analysis. The significance levels for clusters A, B, C, D and E are 34, 35, 0.1, 100, and 0.1 percentages, respectively. The cophenetic correlation is 0.87, indicating that bacterial genera have similar abundance profiles. The overall significant level found in the group average study is 5%. The vertical axis (y axis) represents the distance between bacterial groups. The distance between the right and left sub branch clusters can be thought of as the node's height. The dendrogram's highly correlated clusters are near the bottom. The bacterial genera *Achromobacter* and *Salmonella* are highly correlated in the B cluster. *Xanthobacter* and *Lysobacter* in cluster C also shows great co-relation. Bacterial genera that are separated by the same distance have similar characteristic abundance. Similar bacterial genera in terms of distribution are easily seen in the cluster analysis graph. The E cluster node indicates the clustering of *Bacillus* sp and *Enterococcus* sp, with a greater distance than the others. The relative distribution of bacterial genera is primarily clustered into three groupings (Blue box), from which each individual node is sorted. Multidimensional scaling was performed for detailed study with this data. MDS (Fig. A. 5), divided genera into three groups based on their similarities. The related structures among the rated items are revealed by the MDS plot (2D Stree value-0.11). Square root analysis was used to standardise and convert the environmental data, and S 17 Bray-curtis similarity was used to compare them. The percentages of different species are categorised separately using the ordination technique. On MDS plots, Bootstrap was used to display the confidence regions. Clustering of bacteria in three different group is represented clearly using various symbols. Bacteria were randomly spread over the area of study, with some crowding together.

Table B. 1 shows the bacterial distribution among various mangrove stations in Northern Kerala. Bacterial analysis of sediment sample from 8 different mangrove stations showed 34%, 58%, 29%, 33%, 30%, 34%, 30% and 33% of *Bacillus* at Kasaragod, Valapattanam, Edat, Chettuva, Pazhayangadi, Elathur, Kadalundi and Ponnani respectively. The Kasaragod mangrove area was rich with *Bacillus, Xanthobacter* and *Enterococcus* species. *Geobacillus*, *Micrococcus*, *Vibrio*, *Providencia*, *Beggiatoa*, *Citrobacter* and *Acinetobacter* were also isolated from the region. But Valapattanam area was found to be rich with the presence of *Bacillus, Klebsiella* and *Vibrio.*

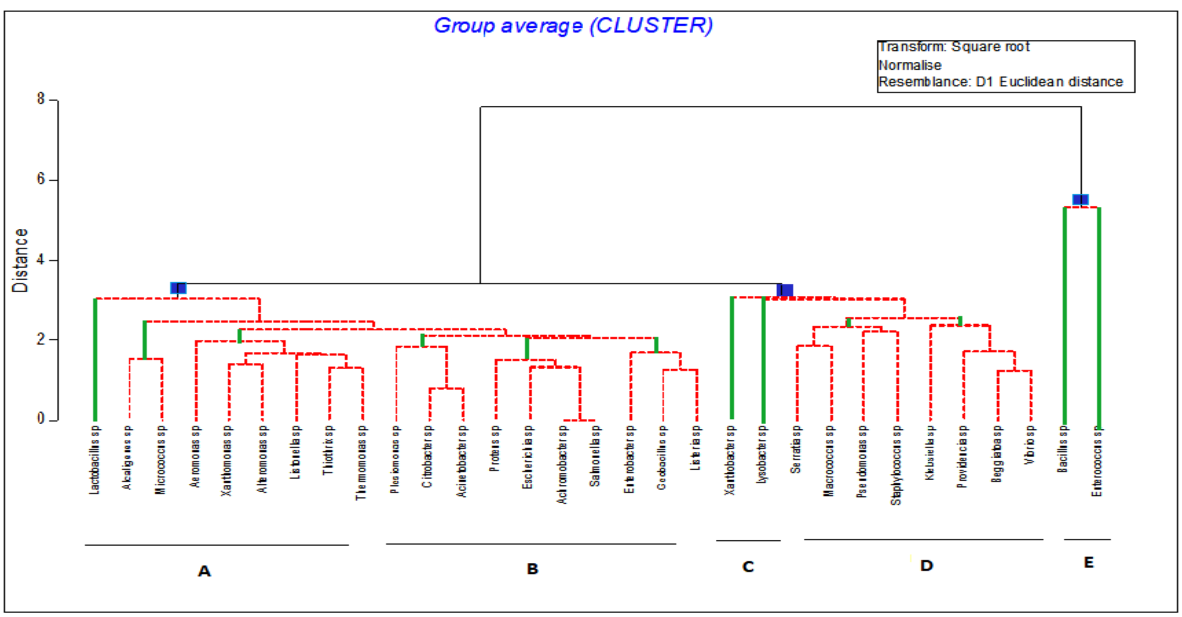

Fig. A. 4. The cluster analysis showing the distance between the genera of mangrove bacteria

At Edat region, along with *Bacillus*, *Xanthobacter*, *Staphylococcus*, *Enterococcus*, *Pseudomonas*, *Vibrio*, *Micrococcus*, *Serratia*, *Alteromonas*, *Beggiatoa*, *Klebsiella* and *Aeromonas* were present. *Bacillus, Pseudomonas, Enterococcus, Providencia, Xanthobacter, Alcaligenes, Vibrio, Lysobacter, Thiothrix, Aeromonas* and *Thermomonas* were among the bacterial species found in the Pazhayangadi region. *Bacillus, Pseudomonas, Klebsiella, Staphylococcus, Lactobacillus* and *Lysobacter* was obtained from the Elathur mangrove ecosystem during the study. In addition to the species found in the Elathur area, the Kadalundi area was rich in *Proteus, Xanthobacter, Alcaligenes* and *Enterococcus. Bacillus, Enterococcus, Pseudomonas, Serratia* and *Lysobacter* were the most common bacterial isolates obtained from Ponnani and Chettuva. Out of the 31 genera obtained, 21 distinct genera were isolated from Kadalundi showing maximum diversity, followed by 19 genera from Elathur and Valapattanam.

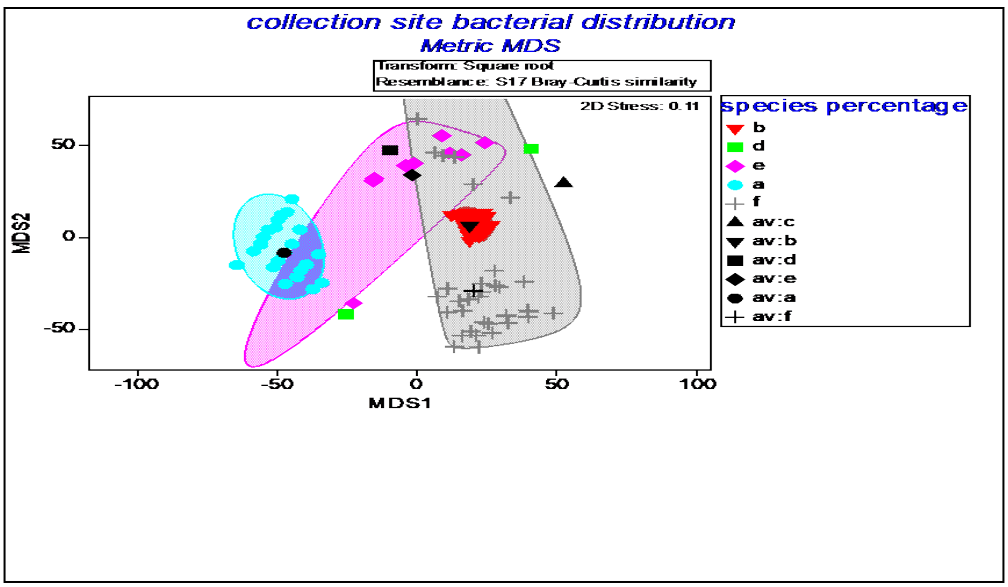

Fig. A. 5. Metric MDS analysis of Mangrove bacterial distribution

Bacillus, Xanthobacter, Enterococcus, Klebsiella, Serratia, Pseudomonas and *Beggiatoa* were commonly isolated from all of the selected mangrove stations. *Achromobacter* and *Salmonella* were isolated exclusively from Kadalundi mangrove station only. When comparing the distribution, PCA shows that *Bacillus* has a greater percentage, while *Enterococcus* stands second. Because of their low abundance, the other genera are far from the plot. Three different colours were used to depict the quantity of distribution. Green, red, and blue are the colours in ascending order of abundance.

Table B. 1. The culturable bacterial isolates obtained from the selected study stations

Sl. No.	Isolate	KGD	EDT	PYD	VPT	ELR	KDI	PON	CTV
1.	*Bacillus*	34	29	30	29	34	30	33	33
2.	*Xanthobacter*	18	11	7	5	4	7	3	6
3.	*Enterococcus*	16	9	11	5	3	5	18	12
4.	*Lactobacillus*	7	-	-	-	6	-	-	4
5.	*Enterobacter*	3	-	2	3	2	1	-	-
6.	*Lysobacter*	3	-	5	3	6	11	5	9
7.	*Klebsiella*	3	4	2	14	7	9	3	3
8.	*Citrobacter*	2	-	-	-	1	-	3	-
9.	*Acinetobacter*	2	-	-	-	-	-	2	-
10.	*Serratia*	2	4	2	2	2	1	5	9
11.	*Pseudomonas*	2	5	11	5	8	1	5	6
12.	*Beggiatoa*	2	4	2	3	2	1	2	1
13.	*Providencia*	2	2	9	2	1	2	-	1
14.	*Vibrio*	2	5	5	7	1	3	2	-
15.	*Macrococcus*	2	5	-	-	4	-	3	3
16.	*Geobacillus*	2	-	-	2	3	1	-	1
17.	*Micrococcus*	-	-	-	5	-	1	2	-
18.	*Listonella*	-	2	-	5	-	-	-	-
19.	*Staphylococcus*	-	9	2	2	6	5	3	3
20.	*Plesiomonas*	-	-	-	2	-	-	3	3

21.	*Aeromonas*	-	4	2	2	4	-	-	1
22.	*Alcaligenes*	-	-	5	2	-	6	2	1
23.	*Thiothrix*	-	2	2	2	-	-	2	-
24.	*Alteromonas*	-	4	-	-	-	1	-	-
25.	*Xanthomonas*	-	2	-	-	2	-	-	-
26.	*Thermomonas*	-	2	2	-	-	-	-	-
27.	*Listeria*	-	-	-	-	2	1	-	1
28.	*Proteus*	-	-	-	-	-	8	-	-
29.	*Escherichia coli*	-	-	-	-	-	2	3	-
30.	*Achromobacter*	-	-	-	-	-	1	-	-
31.	*Salmonella*	-	-	-	-	-	1	-	-

DISCUSSION

The findings of the study revealed that the distribution of bacteria in mangrove sediments from Northern Kerala was quite variable, with several species of bacteria being isolated. Bacteria were more abundant in the sediments because the process of fixing organic material[6] was more widespread in the mangrove region through the provision of oxidising agents, and other organic components such as phosphate and nitrogen as a source. This is related to sediment composition that promotes and aids the establishment of aerobic and anaerobic microenvironment support. For example, in an environment rich in organic matter, a drop in oxygen levels owing to microbial activity will create an anaerobic microenvironment that supports facultative and obligate anaerobic microbes. This results in the formation of groups of microorganisms with distinct physiological traits that are adapted to the microenvironmental parameters[7].

The current study shows that the mangrove habitat is rich with various kinds of bacteria. The percentage of gram-positive bacteria is slightly higher than gram negative. Results obtained by Zubair *et al.,* .[1] at coastal area in Pangkep South Sulawesi supports the current finding. Different scientists from distinct geographical area isolated various bacteria that were found in the current study. According to Yulma *et al., .,* .[8] sixteen bacterial genera were found in sediments from the Mangrove and Bekantan Conservation Area, which includes *Enterobacteria, Eubacterium, Listeria, Actinobacillus, Bacteriodes, Streptococcus, Plesiomonas, Corynebacterium, Pseudomonas, Aeromonas, Bordetella parapertussis* and *Micrococcus*. The study of Ihsan *et al., .,* .[6] confirmed the presence of *Bacillus, Plesiomonas, Enterobacteria, Corynebacterium, Listeria, Aeromonas, Micrococcus, Actinobacillus* and *Clostridium* in the mangrove forest in Mamburungan, Tarakan City. *Bacillus* is the most prevalent genera found in the mangrove forest area by Ihsan *et al., .,* .[6], which co-relates with the present study. Endophytic bacteria[9], such as *Pseudomonas* and *Bacillus*, are found naturally in healthy plant organs and soil sediments. *Bacillus* also has a quick growth cycle and is a bacterium that decomposes phosphorus organic materials. Zubair *et al., .,* .[1], found 7 genera in a total of 35 isolates; 10 species of *Alteromonas*, 10 *Bacillus* isolates, 5 *Staphylococcus* isolates, 7 *Vibrio* isolates, 1 isolate of *Micrococcus*, *Listeria* and *Escherichia* respectively from mangrove sediment at coastal area in Pangkep South Sulawesi. The other bacterial community isolated in the current study has also been found by previous researchers at different mangrove habitats: the genus *Vibrio* in the mangrove sediments of *Avicennia germinans*[10]; the genus *Macrococcus*[11] in mangrove sediments in Odisha, India, *Alcaligenes*[12], *Achromobacter*[13]; *Salmonella*[14]; *Micrococcus*[15] and *Providencia*[16] from Santa Catalina islands; *Citrobacter*[17]; *Listeria*[18]; *Xanthobacter*[14]; *Bacillus, Staphylococcus, Escherichia, and Macrococcus*[19] communities from India.

Several type of autotrophic and heterotrophic bacteria were isolated in the current research, some of them are ecologically important in biogeochemical cycling, bioremediation and various industrial applications etc. For diverse bacterial communities, mangroves provide a unique ecological environment. Heterotrophic bacteria[20] are critical in mangrove habitats because they breakdown mangrove waste, recycle nutrients, and generate detritus food for a variety of fishes. In the mangrove habitat, numerous physicochemical conditions[21- 22] regulate the bacterial abundance and activity. N_2 fixing bacteria[23] are the most efficient heterotrophic bacteria which uses a variety of mangrove substrates. N_2 fixation has been reported in marine *Vibrios*[24] and *Staphylococcus*[25]. Nitrogen fixing bacteria such as members of the genera *Azospirillum, Azotobacter, Rhizobium, Pesudomonas, Clostridium, Vibrio, Listonella,* *Phyllobacterium* and *Klebsiella* were isolated from the sediments, rhizosphere and root surface of various mangrove species by Sahoo & Dhal[26]. Nitrogen fixing bacteria are efficient at using a variety of mangrove substrates despite the variation in carbon content and phenol concentrations. However, their abundance may be dependent on physical conditions and mangrove community composition[23].

Jean *et al.,., .*[27] isolated two new *Beggiatoa* species inhabiting marine mangrove sediments in the Caribbean and support their behaviour as sulphur oxidising bacteria and diazotrophs[28]. Bacteria of the genus *Thiothrix* are filamentous and also are sulfur-oxidizing organisms; Gillan & Dubilier[9] isolated the genus from marine habitat. The phosphate-solubilizing bacteria provide soluble phosphorus that can be easily utilized by growing seedlings, and the bacteria thus enhance growth. Kathiresan & Selvam[30] reported the presence of *Bacillus* as phosphate solubilizing bacteria in mangrove habitat. Vazquez *et al., ., .*[31] isolated different strains of phosphate solubilizing bacteria such as *Bacillus, Paenibacillus, Xanthobacter, Enterobacter, Kluyvera* and *Pseudomonas* from an arid mangrove ecosystem in Mexico. Phosphate solubilizing bacteria which act as potential suppliers of soluble forms of phosphorus have great advantage for mangrove plants[32]. Chandrika *et al., ., .*[33] isolated *Beggiatoa, Thiopedia* and *Leucothiobacteri* from Cochin. It has been reported about the presence of anoxygenic photosynthetic bacteria in mangrove environments and one reason behind this may be that some of these bacteria are slow growers and difficult to handle in the laboratory. The bacteria use hydrogen sulphide instead of water as an electron donor[26] in the photosynthetic reaction. Annamalai *et al.,*[34] described the production of enterocin from a mangrove strain, *Enterococcus faecium.* Behera *et al.,*[12]; Glew[15] reported the alkaline phosphatase activity of species of *Alcaligenes* and *Micrococcus* from mangrove habitat. The oil degradation ability of different mangrove isolates confirmed in various papers; *Acinetobacter* sp[35]; *Bacillus subtilis*[36]; *Pseudomonas*[37] and *Alteromonas*[38].

Among the microbial population, bacteria are dominant in all seasons, but the composition slightly varies. Denitrifying bacteria and asymbiotic N_2 fixing bacteria were abundant in all seasons and in all sites, despite the increased salinity of mangrove soils. Salinity[39] is not the determining element of microbial dynamics in mangroves. In saline sediments, sulphate[40] may act as an electron acceptor during mineralization. As a result, more sulphuroxidizing bacteria may help other microorganisms survive and proliferate in saline sediments. During monsoon, increased nutrition (N, P, K) would boost the microbial population[10]. According to previous research, the culturable bacterial composition of mangrove sediments[41] isolated from various locations exhibits a high degree of similarity. The bacterial community compositions differed between mangrove locations and seasons, according to the findings of this study. Higher bacterial populations and genetic diversity could be found in the sediment of the Northern Kerala mangrove ecosystem. The population of free-living nitrogen fixers, nitrifiers, denitrifiers, phosphate solubilizers, cellulose degraders, several hydrolytic enzyme producers and sulphur oxidizers in mangrove soil is higher, which is responsible for key biogeochemical cycles.

CONCLUSION

From the Northern Kerala mangrove ecosystem, 31 different bacterial genera were obtained with Kadalundi station showing maximum diversity. The study revealed that the area is rich with potential bacteria such as nitrogen fixers, phosphate solubilizers, oil degrading bacteria, bioremediators, novel enzyme producing strains etc. The data about the composition of bacteria provides better understanding about the habitat and processes taking place in the ecosystem. The bacteria in the ecosystem are unique because of the adaption acquired from such versatile environment, hence the proper manipulation and utilisation of potential mangrove bacteria gives a promising future for human life betterment.

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STUDIES ON THE DISTRIBUTION AND ABUNANCE OF BUTTERFLIES IN KADAVANMOOLA, THIRUVANANTHAPURAM (DIST)

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ABSTRACT

The study was carried out in Kadavanmoola in Thiruvananthapuram district. One of the famous freshwater lake, Vellayani near Kadavanmoola is a good picnic spot for urban people, having concrete benches in the roadside to attract tourists. Butterflies are one of the most beautiful creatures that always seem to delight, sparkling awe and joy as they flutter by.Migration of butterflies induces genetic variation and resistance to diseases in various plants. The abundance and distribution of butterflies were studied from 21 – day long study that took place in 26 January 2023. 10 species of butterflies were identified during the study period and 84 field hours were spent in the field. Out of 10 species, 7 species were abundant during the study period and about only one species was rarely found.

Key words: Kadavanmoola, Butterflies, Lepidoptera

INTRODUCTION

Butterflies are the adult flying stage of certain insects belonging to an order or group called Lepidoptera. Butterflies are valued for their beauty and play an important role in ecosystems by pollination of different species of plants. Butterflies are considered superior indicators of environmental changes. They are cold blooded insects so they have to consider dealing with climate. Butterflies are found nearly all parts of the world where climate is neither too hot nor to cold Adult butterflies have brightly colored wings and conspicuous, fluttering fight. Many butterflies are attacked by parasites including wasps, protozoans, flies and other invertebrates or are preyed up on by other. There are no studies related with butterfly diversity in Kadavanmoola region. So this study focuses on the abundance and distribution of butterflies in Kadavanmoola locality. Objectives of the studies are :- 1. To investigate the butterfly species and their abundance and distribution near Kadavanmoola locality. 2. To find out interesting details about different butterflies near our society. 3. To find out best ways to watch butterfly without disturbing their habitat.

MATERIALS AND METHODS

Observation were made by direct visual methods for much specification. Digital cameras of 3x optical zoom were added. Cameras used were, Samsung 6.0mega pixels with 3x optical zoom and digital control. It is the act of observing butterflies without disturbing them or their habitats. This study was carried out from 26-01-2023 to 18-02-2023 evening 3pm to 6pm till in the Kadavanmoola village of Thiruvananthapuram. In Kadavanmoola village near Vellayani Lake, it is the ideal location for observing butterflies at dusk and dawn. 3 different families of butterflies were observed in 10 different species of butterflies were recorded using counting method.

OBSERVATIONS

Graphium sarpedon (common blue bottle)

Both forewings and hindwings are marked by a central spot in the form of a blue or blue greentriangle, with apex pointing toward the body. Antennae, head, thorax and abdomen brown, the head and thorax suffused with greenish grey; beneath: the palpi, thorax and abdomen touched with dingy white,the abdomen with two whitish lateral lines.

Ypthima baldus (common five-ring)

Forewing with a large, slightly oblique, ova, bi-pupilled, yellow ringed black, pre-apical ocellus. Hindwing with two postdiscal, round, uni-pupilled similar but smaller ocelli and very often one or two minute tornal ocelli also.

Tirumala limniace (common blue tiger)

Tirumala limniace is a large butterfly with wide wings. It has a wingspan of 90 to 100 millimeters, with the males being smaller than the females. The upper side of the wing is dark brown to black and patterned with bluish-white, semi-transparent spots and lines. The blue of the bluish-white spots consists of the pigment pterobilin

Jamides celeno (common cerulean)

The common cerulean is a small butterfly found in Indomalayn realm belonging to the blues family. It is grayish blue in colour, while the sub-marginal areas of both wings are relatively brighter. The black outer margin is of uniform width along the forewing. The hindwing has a submarginal row of black spots

Elymnias hypermnestra (common palmfly)

Termens of both wings are prominently scalloped. Above, the wings are dark brown. On the forewing, there is a series of pale bluish submarginal spots, becoming larger in subapical area and then smaller again along the coastal area border. The hindwing is reddish brown with rather pale postdiscal spots. Underneath, the wings are strongly mottled brown.

Neptis hylas (common sailor)

Hindwing: a sub-basal band, discal and subterminal obscure pale lines; a postdiscal series of well separated square spots.

Cirrochroa thais (Tamil yeoman)

Cirrochroa thais, is also known as Tamil yeoman. Wet-season form: Male. Upperside rich bright fulvous, somewhat deepest basally. Forewing with a slender dusky lined discocellular streak, a transverse discal more or less prominent black sinousinterrupted line, its anterior portions from upper median dilated and bend inward; the inner dilating broadly inward to the costa, the outer partly merged into the black of outer border. Hindwing crossed by a more or less prominent black inner discal slender broken line, anteriorly bordered by an outer costal quadrate white patch, followed by a medial row of black spots, two submarginal sinuous Hues and a marginal even line.

Bicyclus anynana (squinting bush brown)

Bicyclus anynana is commonly known as squinting bush brown. It is primarily found in eastern Africa from southern Sudan to Eswatin. The bush brown is a small butterfly with a wingspan of 35-40 mm for males and 45-49 for females. Males have sexual traits on their wings called androconia that release pheromones during courtship. The butterflies are characterized by their unusually short front legs and their rather non-descript brown wings. Bush browns, however, are known for having several large eyespots in the wet season.

Hypolimnas bolina (Blue moon butterfly)

Its dorsal wing surface is jet black but features three prominent spots, two on the forewing and one on the hindwing. Numerous small white spots fringe the fore and hindwings.

Pseudozizeeria maha (pale grass blue)

The terminal black edge much narrower proportionately than in wet-season specimens, most often reduced to a slender black ante ciliary line with a series of black spots on the inner side, bordering and sometimes coalescing with the line. Underside: as in the wet-season brood but the ground color paler, in some specimens much paler, the markings on both forewings and hindwings similar, with frequently the terminal markings obsolescent.

DISCUSSION

These results can be attributed to the presence of host and larval plant species, whose occurrence impacts distribution of butterflies (Tiple et. al, 2007). There are many studies that have shown higher butterfly diversity in disturbed habitat or forest gaps than that in dense forest or closed canopy (Wood & Gillman, 1998). Thus the study shows some sort of contradictory results which might be due to different levels of disturbance among these habitats, more in open scrub in terms of human interference.. The worldwide population of insects including butterfliesare declining, becoming an urgent conservation priority across the globe. This decline in insectpopulation can lead to catastrophic effects on various ecosystems.

CONCLUSION

The studies on the 10 different species has given us an immense knowledge about the various species of butterflies that are present in Kadavanmoola near Vellayani lake, place of God"s own country capital. So, butterfly habitats should be well conserved. Even though remarkable work has been done in some particular areas, still attempts should be made to start in areas where it has not been initiated yet. Different butterflies require different suitable plant species for mating, breeding, and nectaring, so all habitats should be protected well and avoid using chemicals that harm the butterfly larvae and butterflies for a healthy lifestyle for butterflies.

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ASSESSMENT OF MACROINVERTEBRATES AS BIOINDICATORS OF WATER QUALITY IN SELECTED PONDS OF KANYAKUMARI DISTRICT, TAMILNADU

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ABSTRACT

Macroinvertebrate metrics are helpful tools for water quality assessment and investigation of overall health of any aquatic ecosystem. The globe is currently facing problems with water quality in fresh water ecosystems due to severe and rising water contamination in both developed and developing nations. Aquatic macroinvertebrates are used to assess the water quality in an aquatic ecosystem because of their great diversity. This research paper presents a study of bioindicators of water quality using the macroinvertebrate communities present in Vembanoor, Putheri and Parvathipuram ponds of Kanyakumari District during Pre monsoon, SW monsoon and NE monsoon periods of 2021. Samples were collected using a D-framed net with prescribed standards. The organisms were examined in the laboratory with the support of experts from the Centre for Marine Science & Technology at Rajakkamangalam. The water quality was evaluated using Biological Monitoring Working Party (BMWP) results which reflects the understanding of macroinvertebrates. From the BMWP results, the pollution range of water was observed for the selected ponds. The water quality was found to be deteriorating and conservation measures should be taken to protect its health.

Keywords: Macroinvertebrates, Bioindicators, Vembanoor Pond, Putheri Pond, Parvathipuram Pond, BMWP, Pollution, Water Quality.

INTRODUCTION

Freshwater environments are confronting high paces of decrease in biodiversity because of loss of territories and catchment corruption coming about because of human exercises, including land transformation for agribusiness, settlement, metropolitan turn of events, modern foundations, dam development and contamination (Munir *et al.,* 2016; Dudgeon, 2019). The weakening in freshwater environments working is exacerbated by the effect of obtrusive species, environmental change and other arising dangers (Friberg, 2014; Reid *et al.,* 2019).

Therefore, solid checking and evaluation programs are essential for supporting viable administration of water quality and protection of freshwater biological systems (Park and Hwang, 2016). The benefits in utilizing macroinvertebrates for biomonitoring incorporate, being heterogeneous, pervasive, plentiful, generally simple to gather, recognize and list Further, the stationary nature and long-life patterns of different species work with spatial investigation of contamination impacts and discernibility of such impacts north of quite a while (Bonada *et al.,* 2006; Deborde *et al.,* 2016). Biotic indices, such as, the Biological Monitoring Working Party Score System (BMWP) were used for biomonitoring riverine ecosystems. The BMWP was developed in 1976 (Biological Monitoring Working Party, 1978), and revised to a final version, 1980 (National Water Council, 1981) in England, as a simplified system to assess water quality, using benthic macroinvertebrates (Hawkes, 1997).

MATERIALS AND METHODS

Study area and selection of sites

Kanyakumari district has a varied topography with sea on three sides and the mountains of the Western Ghats bordering the northern side. Geologically, the landmass of the district is much younger when compared to the rest of state – faulted as late as 2.5 million years during the Miocene, after which numerous transgression, as well as regression of sea, had shaped the western coast of the district. In Kanyakumari district, there exist 2,123 major ponds. Among them, 1,105 ponds have reached their full capacities and 538 ponds have attained 75% of their capacities.Ponds are frequently manmade or expanded beyond their original depths and bounds by anthropogenic causes. Vembanoor wetland has an average depth of 12-13 m with the surface area of the lake fully covered by floating and rooted vegetation((Priyatharsini *et al.,* 2016)..

Site No	Pond Name	Location	Area	Perimeter
1	Vembanoor Pond	8.181355, 77.376212	176,945.69 m^2 (1,904,627.54 ft^2)	2.21 km (1.38 mi)
2	Paarvathipuram Pond	8.190200, 77.398790	15,128.67 m^2 (162,843.68 ft^2)	529.51 m (1,737.25 ft)
3	Putheri Pond	8.206700, 77.431459	378,503.51 m^2 (4,074,177.85 ft^2)	2.80 km (1.74 mi)

Table 1. Description of the three sampling sites showing their GPS readings and their respective physical parameters

Vembanoor is a small Village/hamlet in Rajakkamangalam Block in Kanyakumari District of Tamil Nadu State, India (Fig.1) .It is located 8 KM towards west from District headquarters Nagercoil, 4 KM from Rajakkamangalam, 736 KM from State capital Chennai. Parvathipuram pond is located on NH 66 about five KM from Nagercoil central and 60 km from Thiruvananthapuram (Fig. 2). .

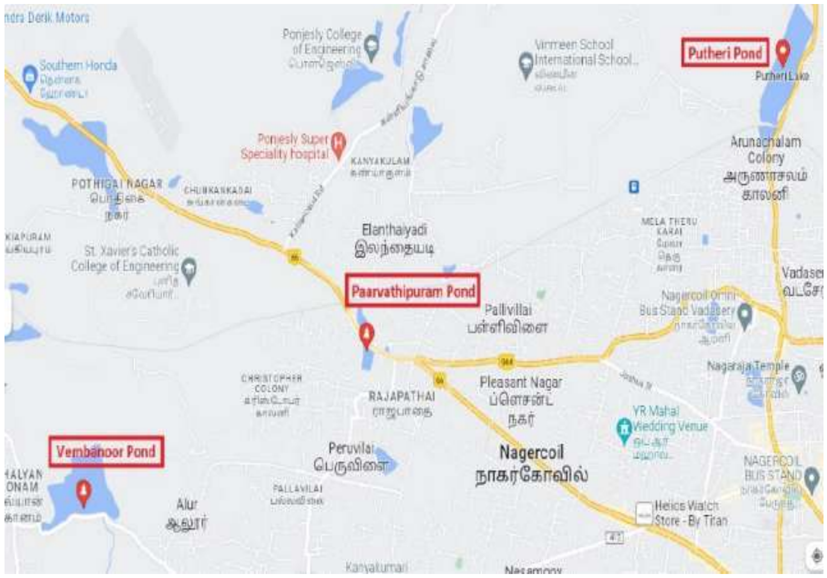

Fig.1. Location Map of Study Area

Fig.2. Vembanoor Pond (Site1)

Fig.3. Parvathipuram Pond (Site 2)

Fig. 4. Putheri Pond (Site 3)

Putheri Lake receives water from a canal outlet of Pechiparai Dam meant for irrigation. Much local agricultural runoff is also received by this lake (Fig.3). .It partially fulfills drinking water needs of the locals, is used for irrigation and also helps to recharge the ground water aquifer (Esakkimuthu *et al.,* 2015).

Field and laboratory work

Sample collections were made in three different seasons (Pre monsoon, SW monsoon and NE monsoon) in each season a sampling effort of 30 minutes was made. Water samples were collected in 5-L sterile plastic containers for physicochemical analysis from each sampling station. And also samples were collected using 500 µm D-net. The samples were then placed in labelled bottles with screw caps and preserved in 96% alcohol. These were transferred to the laboratory where they were processed. When we settled in, we examined the collected material thoroughly, under optical equipment, for the process of cleaning and separation into larger groups. And we proceeded to make the identification at the taxonomic level of the family. The data of the identified organism were grouped by season, so we obtained a few families, genera, and individuals for each sampling season.Water quality was determined at each point in the Vembanoor, Parvathipuram and Putheri ponds, using Biological Monitoring Working Party.

Physicochemical Study

Physicochemical analysis like pH, electrical conductivity, turbidity and DO fixing werecarried out in-situ. Digital handy multiparameter was used to determine pH, temperature, turbidityand EC((WHO, 2011). The chemical parameters like dissolved oxygen, nitrate, nitrite, sulphate, phosphate,nitrogen,ammonia,chemicaloxygendemand,biologicaloxygendemand,totalandfaecalco liformwere analyzed with the adaptation of standard methodologies (CPCB, 2021).The water quality levels werecorrelated with water quality guidelines from World Health Organization and Central PollutionControlBoard India.

Biological Monitoring Working Party (BMWP) Study

The Biological Monitoring Working Party (BMWP) Score is a method to measure the biological quality of rivers using invertebrates as indicators. This score is widely used by organisations such as the Environment Agency to monitor water quality in rivers. Any invertebrates caught are identified to family level. Each family is then given a score between 1 and 10. The index does not take into account the abundance of each family, simply the presence or absence of each family at the site. The score each family gets reflects their tolerance of pollution (different aquatic invertebrates have different tolerances to pollutants). The overall BMWP Score for a site is the sum of all of the scores of each family present at that site. Values greater than 100 are associated with clean water bodies, whilst heavily polluted rivers score less than 10.

Class	BMWP score	Category	Interpretation
I	>150	Good	Very clean water
	101-150		clean or not significantly altered
II	61-100	Acceptable	Clean but slightly impacted
III	36-60	Questionable	Moderately impacted
IV	15-35	Critical	Polluted or impacted
V	<15	Very critical	Heavinly polluted

Source: Fredrick and Hudson (2016)

Table 2. BMWP Score

RESULTS AND DISCUSSION

PHYSICOCHEMICAL AND BIOLOGICAL CHARACTERISTICS OF SELECTED PONDS DURING 2021

Only during the southwest monsoon season, the turbidity value of Parvathipuram Pond is noticeably greater. The results in the other two ponds are within acceptable bounds, demonstrating that the water is clean. It's possible that rainfall and surface runoff water from adjacent places are to blame for the rise in turbidity readings in Parvathipuram Pond during the south-west monsoon season. A measurement of both suspended and dissolved solids is provided by total dissolved solids. These levels can be significantly raised by human activity. When comparing the three ponds, Putheri Pond had readings that above 300 mg/l during the pre-monsoon and north-east monsoon seasons.

The pH levels fall within the permitted ranges. In three ponds, pH peaks during the northeast monsoon season.Premonsoon season is when the pH of Putheri Pond was discovered to be decreasing. Aquatic insects become less abundant as pH falls below 6.5. Water becomes alkaline owing to the presence of several ions like carbonate, bicarbonate, hydroxyl, etc. The results are also within acceptable bounds. Premonsoon and North East monsoon seasons are when Putheri and Parvathipuram ponds show a rise in alkalinity.

Everywhere in the world, water contains the sodium ion. In three ponds, the values are higher during the premonsoon and northeast monsoon seasons. Premonsoon and northeast monsoon seasons are when Putheri Pond's potassium content is at its highest. All other ponds' readings during other seasons were discovered to be lower. In the southwest monsoon season, Vembanoor Pond and the northeast monsoon season, Parvathipuram Pond, respectively, have the highest iron values. In the premonsoon and northeast monsoon seasons, Putheri Pond had no iron.High ammonia levels can cause aquatic species to develop more slowly and be more susceptible to illness. Temperature changes brought on by high nitrite concentrations in the autumn and spring lead the nitrogen cycle to break down because there is less plankton or bacterial activity. Nitrite value is highest in Parvathipuram pond during Northeast monsoon season. Excess nutrients can artificially stimulateplant growth, resulting in algal blooms which speed up the aging process of aquatic systems. The values are within the acceptable limits of WHO standards.

The presence of oxygen is mainly due to the algae and water plants found in pond water. Oxygen is found to be more or less similar in all the three ponds in Pre monsoon and Monsoon seasons. Dissolved oxygen is a critical water quality parameter for characterizing the health of an aquatic ecosystem. The levels of DO will determine the ability of ponds and other water bodies to support aquatic life. Good water should contain adequate oxygen. During premonsoon and monsoon seasons Vembanoor, Putheri and Parvathipuram pond shows adequate dissolved oxygen values.Biological oxygen demand is a measure of oxygen required by microorganisms to decompose organic waste .During monsoon season, organic wastes create more demand for oxygen. BOD values for premonsoon season are relatively low compared to south west and north east monsoon seasons.

Coliform bacteria in aquatic environment indicate that the water is contaminated with faecal material of man and other animals. The presence of this contamination is an indicator that potential health risks associated with water. Coliform is found high during Pre-Monsoon season and North East Monsoon season. It is found less in other ponds during all other seasons.

There were a total of 48 macroinvertebrate species identified, grouped into 18 orders and five classes. The six orders of the Class Insecta, which includes the Coleoptera (scarabs), Hemiptera (bugs), Megaloptera (alderflies), and Odonata (damselflies and dragonflies), received the greatest attention.Vembanoor Pond has BMWP values in the range of 13 to 23, which is categorised as having exceedingly poor water quality and indicated the least wealth of families throughout three decades. The Parvathipuram Pond, in contrast, showed low extravagance of families at different times of the year and with strength to those that are lenient to contamination. This pond included the most reduced lavishness of families for three periods and received a range of 50 to 60, in comparison to respectably dirty waters.

The study's evaluation of ponds revealed a dearth of certain macroinvertebrate family diversity. Pollution-tolerant aquatic macroinvertebrates are observed to predominate. For three monsoon seasons, Stations VE003 in VembanoorPond had the lowest level of family wealth.In Parvathipuram pond, low family richness is found in different seasons. Dominant species are more tolerant to pollution. In station PA003 lowest family richness were observed for three monsoon periods. It ranges between 50 to 60 which showed moderately polluted water.In Putheripond PU002 shows the water is highly polluted and shows lowest family richness.

It was discovered that the number of taxa dropped during wet seasons. Insects are more prevalent when there is less rainfall, and their number gets worse as rainfall increasesAraz *et al.,* (2000). He also noticed a low abundance of EPT during periods of heavy rainfall. Similar results were recorded in the Garachiné river (Del *et al.,* 2013).This was produced by an increase in water flow, which in turn results in a shift in the population's numerical composition.The quantity of insects in that specific location decreased as a result (Flecker *et al.,*1994).Nowadays, it has been seen that the amount of rubbish being dumped in tributaries close to urbanised regions and commercial malls has grown.This demonstrates how the local communities lack an environmental culture. They throw the wastes directly into the waterbodies. Due to the surface runoff during rainy seasons also this happens. This showed the indirect influence of rainfall which automatically changes the chemical parameters of water (Rincón, 2002).

The insects were directly pulled by water current at several riverbed locations, which affected their dispersal (Araz *et al.,* 2000). This was seen at sampling sites that provide water to Pacora's water treatment facility, where commercial activity is established. Additionally, choices must be made about the removal of vegetation from riverbeds, the quarrying of stone, and the management of solid and wastewater. (Cornejo 2010). The findings were shown to be consistent with Cornejo's (2010) findings. Here BMWP score was 62, which is considered to be of average water quality. During our investigation, a score of 49 was found during the rainy season, 53 during the dry season, and 30 during the transitional time were the results of the current examination. The transitional phase is severely impacted, and in a short amount of time, rather noticeable deteriorations were also seen.

	Vembanoor Pond								
	PreMonsoon			**SW Monsoon**			**NE Monsoon**		
	VE001	**VE002**	**VE003**	**VE001**	**VE002**	**VE003**	**VE001**	**VE002**	**VE003**
	Upper	**Middle**	**Lower**	**Upper**	**Middle**	**Lower**	**Upper**	**Middle**	**Lower**
Family richness	34	27	7	7	15	9	33	28	6
Number of individuals	438	546	241	40	160	115	288	363	74
BMWP Score	151	103	15	23	50	27	76	86	13
Significance	Very Clean Water	CleanWater	Polluted or impacted	Polluted or impacted	Moderately impacted	Polluted or impacted	Clean but slightly impacted	Clean but slightly impacted	Heavily polluted

Table 3: Biological Water Quality at Vembanoor Pond in 2021

	Parvathipuram Pond								
	PreMonsoon			**SW Monsoon**			**NE Monsoon**		
	PA001	**PA002**	**PA003**	**PA001**	**PA002**	**PA003**	**PA001**	**PA002**	**PA003**
	Upper	**Middle**	**Lower**	**Upper**	**Middle**	**Lower**	**Upper**	**Middle**	**Lower**
Familyrichness	26	18	16	19	17	14	34	23	12
Number of individuals	318	220	365	170	165	239	282	106	150
BMWP Score	103	76	53	62	58	49	88	61	30
Significance	Clean Water	Clean but slightly impacted	Moderately impacted	Clean but slightly impacted	Moderately impacted	Moderately impacted	Clean but slightly impacted	Clean but slightly impacted	Polluted or impacted

Table 4: Biological Water Quality at Parvathipuram in 2021

	Putheri Pond								
	PreMonsoon			SW Monsoon			NE Monsoon		
	PU001	PU002	PU003	PU001	PU002	PU003	PU001	PU002	PU003
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Family richness	8	8	4	4	2	2	9	2	8
Number of individuals	88	65	58	83	9	9	37	3	68
BMWP Score	22	17	5	14	3	3	20	3	11
Significance	Polluted or impacted	Polluted or impacted	Heavily polluted	Heavilyp olluted	Heavily polluted	Heavilyp olluted	Polluted or impacted	Heavily polluted	Heavily polluted

Table 5: Biological Water Quality at Putheri Pond in 2021

CONCLUSIONS

Due to the mild pollution of the aquatic environment, Vembanoor Pond, Putheri Pond, and Parvathipuram Pond's water quality is not particularly clean. This might be harmful to aquatic life, which depends on highly clean water to exist. These ponds might potentially offer health problems to those who utilise the stream water for various home uses if they are not properly supervised. This study thus suggests that the concerned authorities should constantly check on and manage the sources of pollution. In addition, the chosen ponds need to be maintained and constantly checked on account of the recent rise in nearby communities and trash dumping.

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