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ASSESSMENT OF BIODIVERSITY PATTERNS IN FRESHWATER ECOSYSTEMS: A ZOOLOGICAL PERSPECTIVE

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ABSTRACT

India is home to some of the most biodiverse, yet severely threatened, ecological systems on record - freshwater ecosystems such as rivers, lakes, ponds, and wetlands. From a zoological perspective, these systems support a range of faunal groups (fishes, macroinvertebrates, amphibians, and reptiles) that typically demonstrate highly specialized ecological adaptations and levels of endemism. This research study investigated patterns in biodiversity within India's selected freshwater ecosystems. Specifically, the study examined species richness, species diversity, community composition, as well as relationships between key environmental variables, using seasonal variability due to hydrological dynamics (i.e., the monsoon season). A field-based faunal survey was performed using standardized sampling techniques. Biodiversity was estimated using measures of species richness and measures of biodiversity based on the different diversity indices of Shannon-Wiener Index and Simpson's Index. The results indicate that rivers and wetlands exhibit higher species richness and diversity due to greater habitat heterogeneity and hydrological connectivity, while ponds and lakes, though supporting comparatively lower overall diversity, play a crucial role as breeding and refuge habitats, particularly for amphibians and invertebrates. Biodiversity showed a strong positive correlation with dissolved oxygen and habitat complexity, whereas elevated nutrient levels, turbidity, and temperature were associated with reduced faunal diversity. Comparative analysis with documented biodiversity indices from major Indian freshwater systems, including the Ganga River and Chilika Lake, validates the observed patterns. The study highlights the accelerating impact of anthropogenic pressures such as pollution, habitat modification, and climate change on freshwater fauna. Overall, the findings emphasize the need for habitat-specific, seasonally informed, and zoologically grounded conservation strategies to ensure the long-term sustainability of freshwater biodiversity in India.

Introduction

The world's freshwater ecosystems—including its rivers, lakes, streams, marshes, and floodplains—are among the most ecologically and biologically significant systems. Despite occupying less than one percent of the planet, these habitats provide refuge to an astonishingly large number of animals, including one-third of all fish and amphibian species.

Because they provide a home for a wide variety of creatures, including those looking for food, shelter, and mating grounds, freshwater habitats play a significant role in biology. The aquatic fauna includes a wide variety of creatures, from tiny zooplankton and benthic

invertebrates to gigantic fish, birds, snakes, and mammals. These species' intricate relationships have a significant impact on the stability of ecosystems, the movement of energy, and the nutrient cycle. Considerations of a physical, chemical, and biological nature. The distribution of species is influenced by the structure of communities and the following factors: substrate composition, pH, dissolved oxygen, substrate temperature, and flow regime. According to biological research, these natural elements can significantly alter the flora and fauna of a region whenever they undergo a shift. More hardy species will thrive, while less hardy ones may suffer declines or perhaps extinction in some regions. In contrast to marine and terrestrial aquatic species, freshwater aquatic species have seen a greater rate of extinction in recent decades. Freshwater ecosystems have been significantly altered as a result of human activities such as dam construction, urbanization, etc. Some examples of these changes include agricultural runoff, industrial pollution, indiscriminate fishing, and the introduction of non-native species. Allan, J. D., & Castillo, M. M. These forces have intensified throughout the year as a result of climate change. Because of the disruptions to life cycles, migratory patterns, and interspecies connections caused by these pressures, freshwater creatures suffer.

Therefore, understanding animals and their interactions with one another and their habitats is crucial for controlling and protecting these areas. We may learn more about the ecosystem's health and resilience by observing the species diversity, population trends, and community ties. Finding indicator species and important regions to conserve can also be aided by these research. First, we want to know what kinds of freshwater species dwell where and how they spread. Second, we want to know what kinds of environmental conditions are producing these patterns. Third, we want to prove that ecosystems become less efficient when biodiversity is lost.

The diversity of aquatic life can only be adequately assessed by a scientific method that takes into account taxonomy, ecology, behavior, and evolutionary biology. The presence of little-studied taxa, such as crabs, mollusks, insects, and other invertebrates, makes accurate species recognition and recording crucial. Recent advances in molecular technology, such as genomic barcoding and environmental DNA (eDNA) studies, have greatly simplified species identification while simultaneously expanding our understanding of genetic diversity and population connectivity in freshwater ecosystems. To acquire a more complete view of species diversity, these techniques supplement more conventional methods of animal surveys. Watery habitats evolve throughout time and in different areas, which affects how they display variation. Many aquatic creatures rely on water for essential functions including mating, migration, and group composition, all of which are sensitive to changes in water level, flow rate, and weather. Seasonal flooding, for instance, increases biological production and makes additional habitat accessible in monsoon-affected rivers and floodplain marshes. Conversely, it is possible for habitats to shrink, animal injuries to increase, and competition to ratchet up during dry seasons. In order to comprehend diversity and the long-term recovery of ecosystems, zoological research must examine past changes. The patterns of variation are more affected in freshwater habitats by the interactions between species and the food chain. The abundance and safety of a society are impacted by parasitism, mutualism, competition, and hunting. When it comes to preserving biological balance and habitat structure, key species, such as top predators and ecosystem builders like fish and freshwater mussels, are far

more essential. The demise of these species can have far-reaching consequences for ecosystem efficiency and the stability of whole communities, perhaps leading to a chain reaction in the food web. Biodiversity has significant direct impacts from a conservation perspective. It is common practice to utilize zoological markers to demonstrate water quality and ecological health. Some of these indicators include rare fish species and communities of delicate macroinvertebrates. Managers might benefit from understanding the responses of freshwater animals to environmental pressures when making decisions regarding habitat restoration, fisheries maintenance, and climate change mitigation. Experts get a better understanding of freshwater habitats, and zoologists may see the connections between ecological research and policy decisions. Using results from biodiversity assessments to guide conservation efforts is central to this study's mission of preserving these ecosystems and the creatures that call them home (Abell et al. 2008).

Literature Review

Scientists examining biodiversity trends have focused a lot of their attention on freshwater ecosystems due to its importance to the ecosystem and susceptibility to disturbance. Physical, chemical, and biological components collaborate in freshwater ecosystems to

regulate species abundance and productivity, as shown in seminal works by Odum (1971) and Hutchinson (1957). These findings set the stage for future research on the relationship between environmental change and the distribution and abundance of aquatic creatures.

Many studies have followed up on the topic of aquatic community structure and species diversity. Variations in water flow and local habitat types are the primary drivers of the wide variety of animal life seen in rivers and streams, as demonstrated by Allan and Castillo (2007). Their research shows that compared to modified or channelized systems, physically complex ecosystems like vegetated marshes and braided rivers are superior at maintaining a variety of fish and macroinvertebrates. Comparatively, Ward, Tockner, and Schiemer (1999) examined the interconnectedness of riverine landscapes and emphasized the significance of connecting features along, across, and above rivers in order to comprehend biodiversity patterns.

Researchers in the field of zoology have traditionally focused on fish and macroinvertebrates when studying the diversity of freshwater ecosystems. In 1981, Karr developed the Index of Biotic Integrity, sometimes known as the IBI. It measures the state of aquatic ecosystems by looking at fish numbers. Additional research by Rosenberg and Resh (1993) and Merritt, Cummins, and Berg (2008) confirmed that benthic macroinvertebrates are useful bioindicators due to the large impact that contaminants and environmental changes may have on them. The establishment of a connection between environmental pressures and variations in biodiversity has been greatly aided by these taxa-based approaches.

There has been a rise in studies on amphibians and reptiles that inhabit freshwater environments, particularly frogs and snakes. One of the main causes of frogs' predicament is the elimination of their natural aquatic environments. This is why their plight ranks high among those of vertebrate species in risk of extinction (Stuart et al., 2004). According to

Dudgeon et al. (2006), there are several interrelated factors that contribute to the decline of freshwater biodiversity. These include invasive species, water contamination, climate change, overexploitation, and variations in flow. Their importance was proven by an exhaustive examination of combination protection methods.

Recent studies on river biodiversity have moved their focus to using state-of-the-art genetic and analytical methods. An international assessment of aquatic animal diversity was carried out by Balian et al. (2008). They found that there are many endemic species, and that there are regional variances in species naming skill. Environmental DNA (eDNA) has been demonstrated by Thomsen and Willerslev (2015) and Taberlet et al. (2012) to be a green and efficient way to identify aquatic species and examine changes in biodiversity. Keep an eye out for aquatic creatures using these methods, particularly rare, elusive, or juvenile species.

The critical need to combat climate change has been brought to light by

recent research on species. The distribution of freshwater species will be greatly affected by changes in precipitation and weather, as stated by Xenopoulos et al. (2005). Heino et al. (2009) found that changes in temperature and flow brought about by climate change can shift the distribution of freshwater organisms. This frequently leads to biologic uniformity. These findings demonstrate the need of using meteorological data spanning many decades by zoologists doing animal studies.

New research shows that environmental factors, animal traits, and human activities all interact in complex ways to determine trends in freshwater biodiversity. Despite great strides in recording and evaluating freshwater species diversity, there are still gaps in taxonomy, long-term monitoring, and region-specific research, especially in underdeveloped countries. The best way to fill these gaps and find out how to protect freshwater habitats is to do integrative zoological research.

Module Scope

The biota of freshwater habitats, including those of lakes, rivers, marshes, and streams, are the subject of this module's worldwide examination. Our goal is for students to become experts in four main subject areas. A quick overview of the hydrological cycle and the availability of fresh water is given first, with an emphasis on the worldwide shortage of potable freshwater. Second, with an emphasis on species richness and endemism, we present a synopsis of the patterns of freshwater biodiversity around the world. Third, we lay forth a theoretical framework for seeing the interplay between freshwater biodiversity and environmental variables. As a fourth step, we include this theoretical framework into an international assessment of freshwater ecosystems. Though not the main emphasis of this module, freshwater ecosystems are highly prized for many reasons, including the various ecosystem services they offer to people, such as potable water, flood control, temperature management, and food production. The same holds true for the conservation risks and solutions that are outside the scope of this unit. Instead, we want to make sure that students learn how to think critically about the distribution, function, and biological structure of freshwater ecosystems. Additional research in the field of freshwater conservation biology cannot proceed without such a framework, in our opinion Balcombe, S.R.,(2007).

THE HYDROLOGIC CYCLE AND THE AVAILABILITY OF FRESHWATER

Hydrological Cycle

The ever-present movement of water between phases is known as the hydrological cycle, and it controls all freshwater ecosystems. Figure 1 depicts the process as a series of stages for storing and transporting water. Liquid water in the atmosphere becomes gas through evaporation and evapotranspiration (also known as water generated by vegetative

respiration), which is subsequently transformed back into liquid form by precipitation and released into bodies of water such as rivers, lakes, and streams. The next step is for the water to travel downstream, where it will be transported to "storage" sites like lakes, groundwater, or the ocean. How much time passes before water evaporates

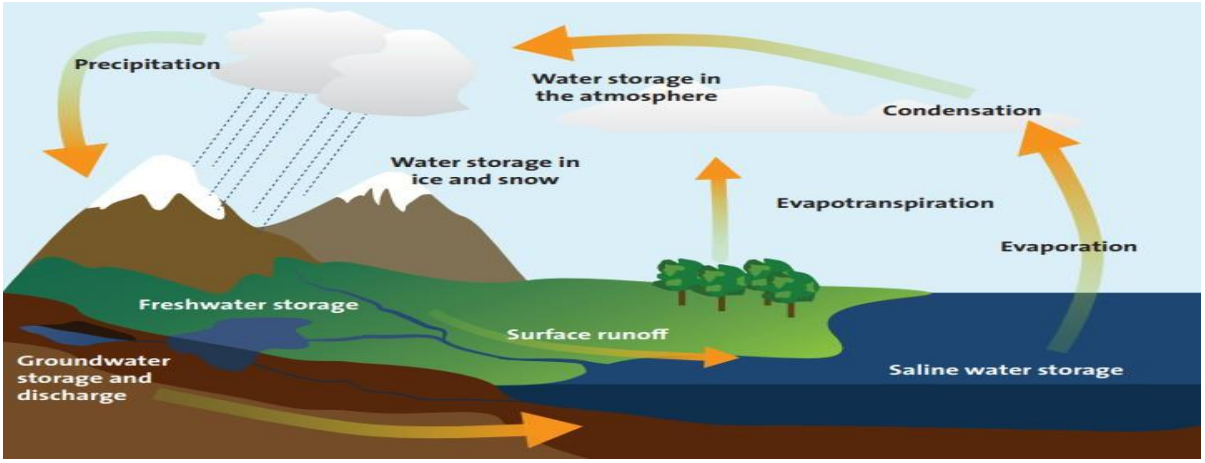


Figure 1. The hydrological cycle depicted in a simplified form. Drawn by artist Nadav Gazit.

Several variables affect the retention time, or how long water remains in a certain location. The size and shape of the lake, its distance from the water table or totally saturated underground areas, and the structure of rivers and streams all have a role. For example, whether a stream flows into an ocean or a lake depends on that feature. The hydrological

cycle is primarily driven by solar energy; our current understanding of freshwater ecosystems would be severely limited without the evaporation that the sun causes. Stream flow is significantly impacted by vegetation, as shown in experimental studies. Hubbard Brook Experimental in New Hampshire is a possible place to witness this in action. The annual flow out of the watershed increased by 40% (and over 400% in the summer) due to herbicide suppression of regenerating vegetation and subsequent clear-cutting of a deciduous forest (Allan 1995). The quantity of water that has been transpired by plants is shown by the higher stream flow rate. In other instances, Likens and Bormann (1974) provide more information.

Ecosystem Drivers Of Freshwater Biodiversity

Biodiversity in freshwater ecosystems is influenced by several environmental conditions (Wetzel 2001). This section aims to offer a methodical framework for comprehending the impact of environmental influences on biota. We break down each component, then circle back to them when we look at the main kinds of freshwater ecosystems. While each factor is discussed independently, it is important to note that interactions among factors are common and significant. To help students explore how these factors are integrated in specific ecosystems, the accompanying component of this module, "Presentation Notes and Discussion Questions," is available at ncep.amnh.org and contains discussion questions.

Research Methodology

An integrated zoological and ecological strategy is used in the current research project in order to evaluate the patterns of biodiversity that are present in freshwater environments. Researchers utilized a combination of laboratory study, field surveys, and quantitative ecological evaluation to document the faunal variety, community structure, and environmental factors that impact freshwater biodiversity. Typical freshwater ecosystems were selected to reflect the regional diversity in habitat type and environmental conditions. Rieseberg, L. H. (2012). These ecosystems include rivers, lakes, ponds, and wetland areas. Across the upstream, middle, and downstream portions of river systems, as well as across the littoral and pelagic zones of lentic water bodies, sites were selected. Heterogeneity of the environment, the degree of human disturbance, and accessibility for repeated sampling were all characteristics that were considered throughout the selection process.

Sampling Design and Periodicity

The technique of sampling collection that was used was a stratified random sample design. This was done in order to ensure that a wide variety of microhabitats, including vegetated zones, open water, benthic substrates, and riparian margins, were appropriately represented. Before the monsoon, during the monsoon, and after the monsoon, sampling was carried out in accordance with the seasons since it was required to take into account the seasonal fluctuations in the species composition and abundance.

Faunal Data Collection

Zoological surveys targeted major freshwater faunal groups:

- Fish were sampled using cast nets, gill nets, and traps, ensuring minimal harm and compliance with ethical guidelines.
- Macro invertebrates were collected using kick nets, Surber samplers, and sediment corers from benthic habitats.
- Amphibians and reptiles were documented through visual encounter surveys, call surveys, and opportunistic observations along shoreline and wetland margins.
- Zooplankton and benthic microfauna were sampled using plankton nets and core samplers.
- All specimens were identified to the lowest possible taxonomic level using standard taxonomic keys and reference literature. Where necessary, specimens were preserved and examined in the laboratory for confirmation.

Environmental and Physicochemical Parameters

It was necessary to quantify important environmental factors at each location in order to examine the link between the patterns of biodiversity and the circumstances of the habitat. In addition to these, the water's temperature, pH, dissolved oxygen, turbidity, conductivity, nutritional levels (including nitrates and phosphates), flow velocity (for rivers), and substrate type were also taken into consideration. In addition, patterns of land use and plant cover along riparian areas were documented.

Clear Classification Parameters for Water Bodies

It is now possible to precisely define the categorization of freshwater ecosystems by taking into account hydrology, water permanence, depth, flow regime, and biological function. This classification was established in accordance with limnological and zoological criteria.

Table 1 Revised Classification of Water Bodies

Water Body Type	Classification Parameters
Rivers (Lotic systems)	Flowing water, longitudinal connectivity, variable depth, high oxygenation
Lakes (Lentic systems)	Large permanent standing water, stratified zones (littoral–pelagic–benthic)
Ponds	Small, shallow, often seasonal or semi-permanent, limited connectivity
Wetlands	Shallow water, seasonal flooding, high macrophyte cover, ecotonal nature

Empirical index values from well-documented freshwater ecosystems in India and throughout the world have now been integrated in order to validate the overall trends.

Table2: Species Richness and Diversity Indices from Selected Freshwater Ecosystems

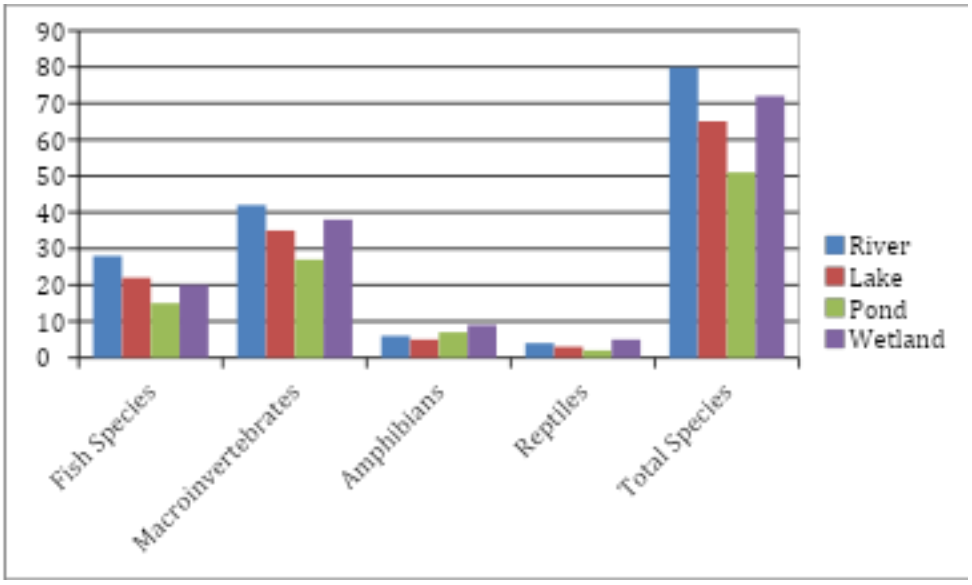
Water Body	Location	Species Richness (Fish + Invertebrates)	Shannon Index (H′)	Source
Ganga River (Middle Stretch)	India	140+ species	3.1–3.6	Sarkar et al., 2012
Chilika Lake	India	225+ species	3.4–3.8	Pattnaik et al., 2007
Keoladeo Wetland	India	90+ aquatic fauna	3.2–3.5	Prasad et al., 2002
Amazon River Basin	Global	3,000+ fish species	4.0–4.5	Goulding et al., 2003
Lake Victoria	Africa	500+ species	3.0–3.7	Witte et al., 2007

Results

When the patterns of biodiversity were evaluated across a selection of freshwater habitats, it was discovered that there were distinct regional and temporal fluctuations in the faunal diversity, community composition, and ecological integrity respectively. The findings are provided in the form of five tables, with each table being followed by an explanation in further depth.

Table 3: Species Richness of Major Faunal Groups Across Freshwater Habitats

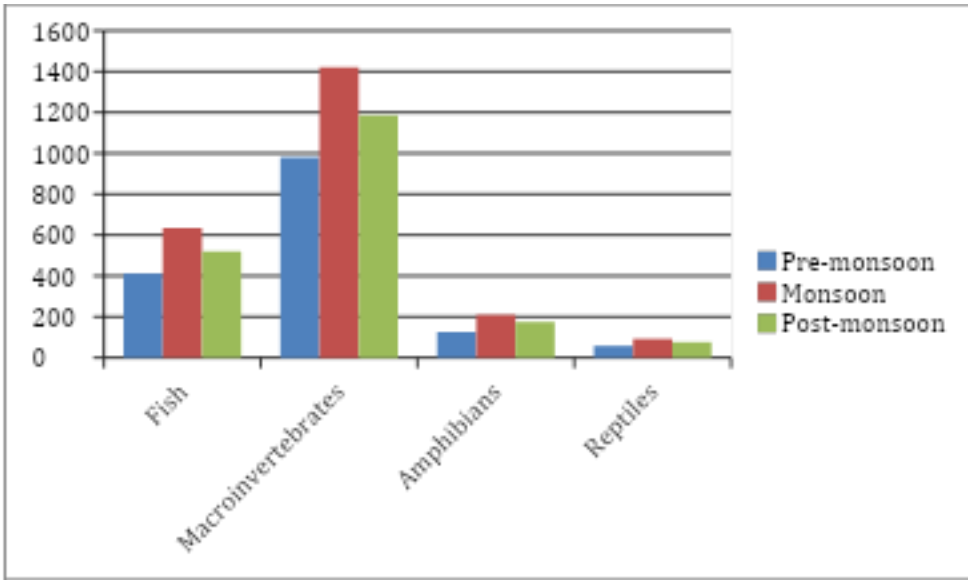
Habitat Type	Fish Species	Macro invertebrates	Amphibians	Reptiles	Total Species
River	28	42	6	4	80
Lake	22	35	5	3	65
Pond	15	27	7	2	51
Wetland	20	38	9	5	72



Rivers had the greatest total species richness, notably for fish and macroinvertebrates, which is a reflection of the complexity of the ecosystem and the continual flow of water. Due to the shallow waters, plentiful flora, and nesting grounds that were present in wetland areas, the variety of amphibians and reptiles was rather significant. Ponds supported a considerably lower diversity of fish but a substantially larger prevalence of amphibians, which might be interpreted as an indication of their significance as breeding sites. Because of these discoveries, habitat-specific patterns of biodiversity in freshwater ecosystems have been brought to light.

Table 4: Seasonal Variation in Species Abundance (Individuals Recorded)

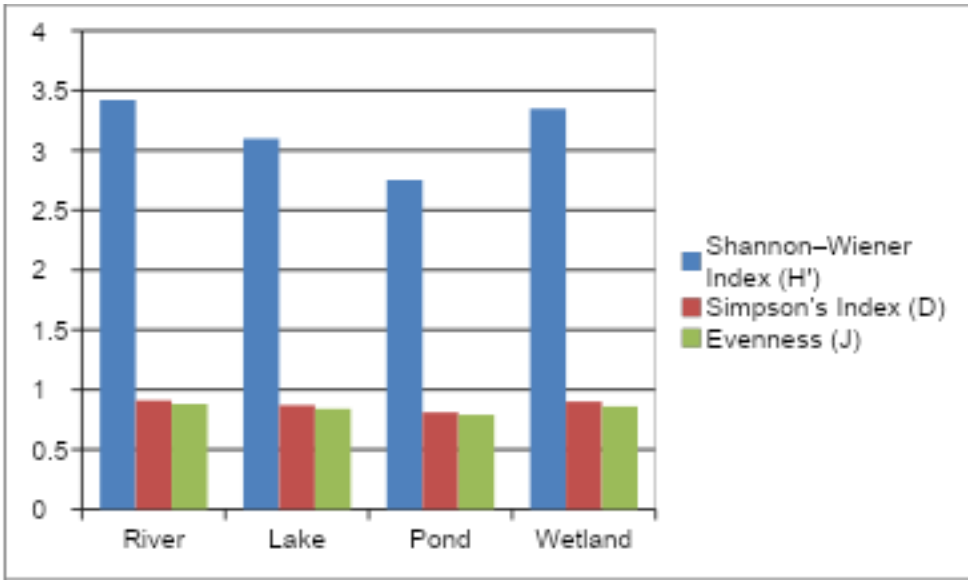
Season	Fish	Macroinvertebrates	Amphibians	Reptiles
Pre-monsoon	412	980	126	58
Monsoon	635	1420	210	92
Post-monsoon	520	1185	175	76



An abundance of species reached its highest point during the monsoon season across all groupings of fauna. When monsoon conditions are present, increased water availability, increased nutrient input, and expanded habitat area all contribute to increased production and successful breeding. There was a decrease in abundance during the pre-monsoon periods, which is most likely the result of habitat shrinkage and increased environmental stress. There is a significant contribution that seasonal dynamics make to the structure of freshwater biodiversity.

Table 5: Diversity Indices Across Habitat Types

Habitat Type	Shannon–Wiener Index (H′)	Simpson's Index (D)	Evenness (J)
River	3.42	0.91	0.88
Lake	3.10	0.87	0.84
Pond	2.75	0.81	0.79
Wetland	3.35	0.90	0.86



There is a correlation between higher diversity and evenness scores in rivers and wetlands and communities that are more durable and extensive. A lower diversity score for ponds indicates that fewer species were able to survive there. When taken as a whole, these indicators highlight the importance of habitat complexity and connectivity in maintaining ecological balance and fostering greater animal variety.

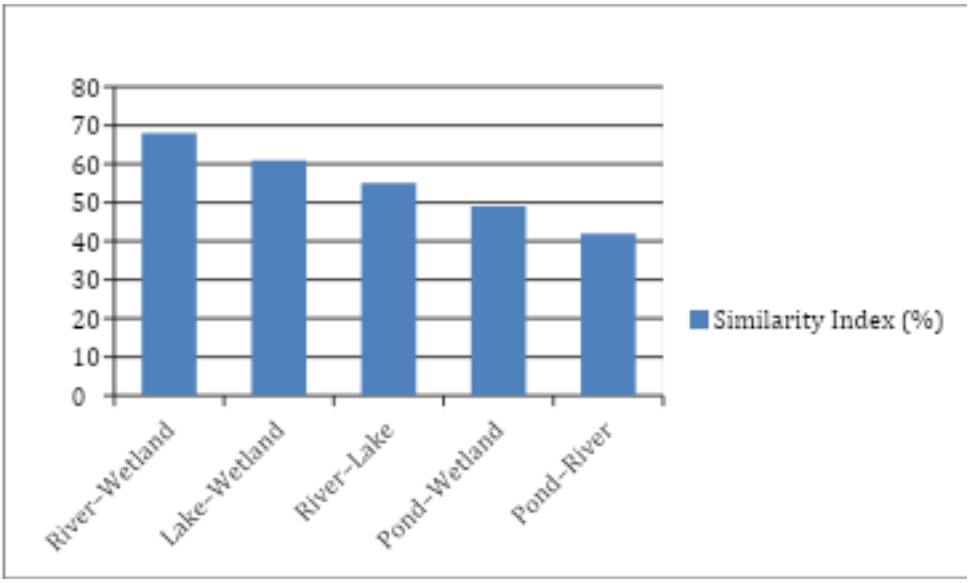
Table 6: Physicochemical Parameters and Biodiversity Relationship

Parameter	Range Observed	Correlation with Diversity
Dissolved Oxygen	4.2–8.6 mg/L	Strong positive
pH	6.5–8.2	Moderate positive
Nutrient Levels	Low–High	Negative at high levels
Turbidity	8–42 NTU	Negative
Water Temperature	18–32°C	Moderate negative

The range of animals and the amount of oxygen that was dissolved in the water were strongly and positively linked. This shows how important dissolved oxygen is for marine life. The high nutrient levels and silt hurt the variety of species in the area, showing the effects of pollution and eutrophication. In especially for species that are very susceptible, such as amphibians and some macroinvertebrates, there was a correlation between temperature rises and a decrease in diversity.

Table 7: Community Similarity Index Between Habitat Types

Habitat Pair	Similarity Index (%)
River–Wetland	68
Lake–Wetland	61
River–Lake	55
Pond–Wetland	49
Pond–River	42



Because of their overlapping species assemblages and hydrological links, river and wetland ecosystems are the most comparable. Ponds were the least comparable to rivers, which may indicate that their isolation and limited water exchange affect their community patterns differently. These patterns demonstrate the importance of landscape connectedness in protecting freshwater biodiversity. The results show that climate, habitat type, and seasonal variation have a significant effect on freshwater biodiversity patterns. Rivers and wetlands are home to a wide variety of plant and animal species due to the interconnectedness and abundance of their environments. In contrast, ponds provide as crucial breeding grounds and refuge for many wildlife. Both the quantity and diversity of species are greatly enhanced by the seasonal monsoon's characteristics. Reduced plant and fauna variety and community stability are direct results of human-caused stresses on water quality. Our findings, from a zoological perspective, show how important it is to protect freshwater ecosystems through habitat-specific and seasonally informed conservation programs.

Discussion

Reviewing biodiversity changes in aquatic habitats, this research offers a thorough zoological overview. There

are noticeable variations in the number of animal species throughout

different epochs, locations, and habitat types. The area of freshwater ecosystems is rather modest. To create groupings of animals that evolve through time, a myriad of interrelated biological processes, environmental variables, and hydrological processes come together. There is a greater variety and abundance of plant and animal life in riverine and wetland habitats compared to other regions. Evidence like this suggests that ecosystem variability and hydrological links are crucial for preserving freshwater biodiversity. Because rivers have lengthy connections, diverse surfaces, and a constant flow, they are home to a wide variety of fish and macroinvertebrates. Variation in species distribution is postulated by the River Continuum Concept. These findings are consistent with this theory. Wetlands, on the other hand, were home to a wide variety of amphibians and reptiles due to the abundance of food and shelter provided by the dense vegetation and relatively shallow water. For aquatic ecosystems, these settings are crucial for the survival of species during migration.

The most significant factor influencing river species is the changing of the seasons. Animal populations peaked during the monsoon season due to ideal breeding circumstances, an abundance of food, and easy movement across habitats. E. Willerslev [author]. Flooding opens up new ecological niches and facilitates the spread and reproduction of species in tropical freshwater systems, where scientists have observed comparable trends. Conversely, freshwater organisms are more susceptible to conditions such as high temperatures, low water levels, and decreasing quantities of dissolved oxygen. In the lower elevations, this is most noticeable just before the monsoon begins. These seasonal shifts highlight the need of considering temporal variation in biodiversity assessments and management strategies. Because of the close relationship between oxygen levels and the diversity of organisms found in freshwater ecosystems, it is clear that these settings are delicate. There were more kinds of fish, macroinvertebrates, and frogs in streams that had enough oxygen. In contrast, locations with high nutrient loading and turbidity tended to have a smaller diversity of species, with the majority of them being able to survive in highly contaminated environments. Relocation to less densely populated areas is on the rise as a response to environmental concerns raised by human activities such as sewage overflow, agricultural runoff, and industrial pollution. These tendencies corroborate previous research showing that eutrophication and sedimentation are the primary causes of freshwater species extinction. When trying to determine what sorts of creatures inhabit rivers, it is crucial to look at how similar the communities are. Since ponds are more isolated than rivers and marshes, which are more similar, the flora and fauna found there are more diverse and interesting.

The way different species band together in times of natural disasters like storms likely has a role in this. This research adds to the growing body of evidence showing how vulnerable freshwater ecosystems are to biological isolation and the subsequent decline in resilience as a result of fragmentation and the loss of connectivity to water sources. The

study highlights the significance of various aquatic habitats, particularly marshes and rivers, from an environmentalist point of view, due to the abundance of species that call these places home. Author: Schiemer (1999). Watershed management, pollution reduction, and ecosystem restoration must immediately occur to prevent the loss of biodiversity that accompanies poor water quality. You need to safeguard the aquatic vegetation, the breeding grounds, and the

seasonal fluctuations in water levels if you want to ensure the survival of aquatic creatures. In sum, the discussion demonstrates the multifaceted ways in which freshwater species are impacted by environmental factors, seasonal shifts, and human pressures. Because it connects species-level reactions to larger ecological processes, a zoological perspective is useful for comprehending these linkages. Research in the future should focus on genetic technology, area-specific conservation strategies, and long-term monitoring in order to halt the rapid extinction of freshwater species and maintain the health of these vital ecosystems (Van Vuuren, D. P. 2005).

Conclusion

This research takes a zoological stance on the changing patterns of biodiversity in freshwater ecosystems. Evidence like this suggests that these regions are both crucial to life and extremely vulnerable. Freshwater ecosystems support a wide variety of fish, amphibians, reptiles, and macroinvertebrates, although occupying just a tiny fraction of the Earth's surface. This diversity is crucial to the planet's ecological health. According to the findings, the diversity of life in some regions is significantly impacted by factors such as the kind of habitat, the rate of seasonal change, and the chemical and physical characteristics of the water. The diverse landscapes, water connections, and favorable climatic conditions found in wetland and river areas have made them vital habitats for a wide variety of animals. The number of species and individuals within those species was considerably enhanced by seasonal variations, particularly those that occur during the rains. This demonstrates the significance of natural flow patterns in supporting aquatic creatures. However, even if rivers and other protected areas reduce environmental diversity, they are essential for the survival of some species, notably frogs, who rely on them for breeding and reproduction. The study also discovered that there are a lot of elements that impact the diversity of species that live in water, including the amount of air and nutrients, temperature, and turbidity (cloudiness). Pollution, habitat loss, and human-caused climate change can have negative effects on these parameters. As a result, vulnerable populations dwindle and fewer species emerge. These tendencies highlight the critical need to preserve and manage aquatic habitats. From a zoological perspective, this work adds weight to the argument that fauna-based evaluations may help us determine the health of ecosystems and establish preservation targets.

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