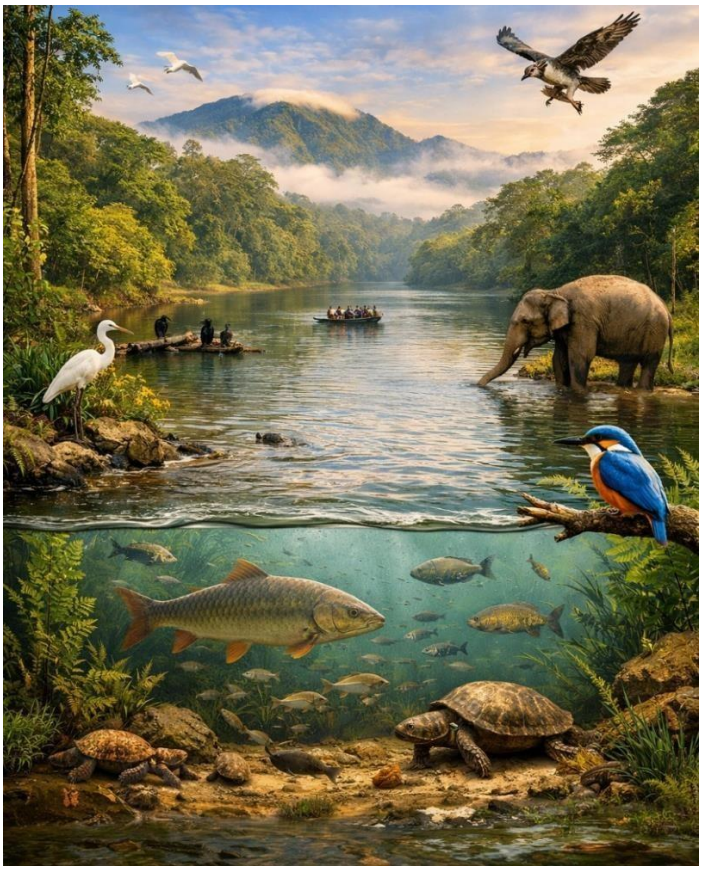
National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development & Ganga Rejuvenation
Government of India

Biological Profile - Periyar



December 2025

Biological Profile

Periyar

National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

www.nrcd.nic.in

Centres for Periyar River Basin Management Studies (cPeriyar)

The Center for Periyar River Basin Management Studies (cPeriyar) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by IIT Palakkad and NIT Calicut, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRCD). cPeriyar is committed to restoring and conserving the Periyar River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

www.cPeriyar.org

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by IIT Palakkad (Lead Institute) and NIT Calicut (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We sincerely acknowledge Dr. Vishal Kapoor, cGanga, for his valuable guidance in the preparation of this report. We gratefully acknowledge the individuals who provided information and photographs for this report.

Team

Dr. Deepak Jaiswal, cPeriyar, IIT PKD
Dr. Athira P, cPeriyar, IIT PKD
Dr. Richa Agnihotri, cPeriyar, IIT PKD
Dr. Neenu K, cPeriyar, IIT PKD
Vismaya, cPeriyar, IIT PKD
Nimya Narayanan, cPeriyar, IIT PKD
Saivinayak Viswanathan, cPeriyar, IIT PKD
Dr. Aswathy E V, cPeriyar, NITC
Niyatha Mohan, cPeriyar, NITC
Nandana V, cPeriyar, NITC
Dr Vinod Tare, cGanga, IIT Kanpur
Dr Vishal Kapoor, cGanga, IIT Kanpur

Preface

The Periyar River is not just a river that flows through Kerala; it is a living system that supports an extraordinary range of life. From its forested origins in the Western Ghats to its lower reaches and estuarine zones, the river creates habitats for countless plants and animals, many of which depend closely on its seasonal rhythms and water quality. Understanding this living network is essential if we are to truly understand the river itself.

The biological richness of the Periyar River Basin reflects the health and continuity of its ecosystems. From microscopic organisms and algae to fishes, amphibians, birds, and mammals, each group contributes to the functioning of the river as a whole. Changes in these biological communities often signal shifts in water quality, habitat condition, and flow patterns. Studying the living components of the river therefore provides valuable insight into its present status and future sustainability.

This report presents a comprehensive biological profiling of the Periyar River and its potentially perennial streams, documenting observed taxa across multiple trophic levels and habitat types. By systematically examining species composition, distribution patterns, and family-level diversity, this work aims to establish a scientific baseline for understanding the river's biological status. Such baseline information is essential for identifying ecologically significant stretches, potential keystone species, and areas requiring focused conservation attention.

More than a collection of data, this work is an attempt to view the Periyar as a living river, one whose future depends on how well we understand and care for the life it sustains. As you read through this report, let it serve as a reminder that the Periyar's story is still being written through the life it carries and the care it receives.

Centre for Periyar River Basin
Management Studies (cPeriyar)
IIT Palakkad & NIT Calicut

Contents

List of Figures

List of Tables

1. Introduction

The Periyar River Basin is one of Kerala's most ecologically and socio-economically significant regions, supporting diverse landscapes, rich biodiversity, and extensive human populations. It plays a crucial role in sustaining agriculture, industry, hydropower generation, fisheries, and domestic water supply, making it a major lifeline for central Kerala (Kerala State Planning Board, 2019). The Periyar river basin has an area of 5216 km2. The catchment area covers 5102 km² in Kerala and the remaining 114 km² in the Anamalai hills of Tamil Nadu. The Periyar River Basin encompasses six districts – Idukki (3025.6 sq km), Ernakulam (1735.3 sq km), Thrissur (358.1 sq km), Pathanamthitta (14.5 sq km) and Kottayam (0.14 sq km), in Kerala, and Coimbatore (114 sq km) in Tamil Nadu. Ecologically, the basin contains protected forests, wildlife habitats, and productive freshwater ecosystems that host numerous endemic, rare, and endangered species characteristic of the Western Ghats biodiversity hotspot (Kottelat & Whitten, 1996; Das et al., 2006). Despite its importance, the basin has experienced increasing anthropogenic pressures, including pollution, land-use change, invasive species introduction, and habitat degradation, leading to declines in water quality and biodiversity (Ranjeet et al., 2010; Status Report on Periyar River, 2004) These emerging challenges highlight the urgent need for detailed ecological assessment, continuous monitoring, and scientifically informed restoration to safeguard the river's ecological integrity and ensure sustainable use of its resources (Gann et al., 2019; Wortley et al., 2013).

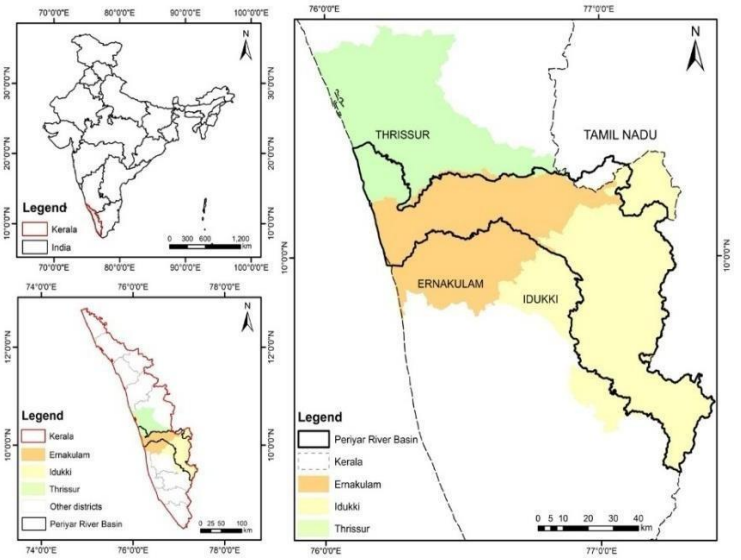


Fig. 1 Periyar River Basin Administrative Divisions (Geographical)

2. Salient features of River

The Periyar basin lies within the Western Ghats, one of the world's foremost biodiversity hotspots, and includes tropical evergreen, semi-evergreen, and moist deciduous forests that support numerous endemic and rare species (Kottelat & Whitten, 1996; Das et al., 2006). Key ecological landscapes such as the Thekkady Wildlife Sanctuary and Periyar Lake harbour unique biological resources, including rare and endangered fish germplasm. The freshwater ecosystems of the river sustain diverse phytoplankton, periphyton, and zooplankton communities, along with high fish diversity, featuring region-specific species like *Garra mullya* and *Garra surendranathanii* (Radhakrishnan & Kurup, 2010; John & Kumar, 2021). Surrounding landscapes support notable wildlife such as Leopard, Sloth Bear, Sambar Deer, and rare bird species (Kerala Forest & Wildlife Department)., escalating anthropogenic pressures—including pollution, habitat degradation, and invasive species—have resulted in notable biodiversity loss and declining water quality across the basin, even within protected areas (Status Report on Periyar River,2004; Ranjeet et al., 2010; Ranjeet et al., 2012). These characteristics underscore the ecological importance of the Periyar River and highlight the pressing need for continuous conservation, monitoring, and sustainable management.

2.1 Periyar River

2.1.1 Origin and course

The Periyar River originates in the Sivagiri hills of the Western Ghats within the Periyar Tiger Reserve at an elevation of about 1830 m MSL and flows through the Periyar National Park into the Periyar Lake before continuing its course towards the Vembanad Lake and finally the Arabian Sea. As it flows northward, the river is impounded at Idukki by an arch dam that supplies water for hydroelectric power generation at the Moolamattom Power Station and Pallivasal. Along its course, the Periyar receives several tributaries, first the Mullayar, then the Muthirapuzha, and later the Idamalayar near Neriamangalam, about 1.5 km upstream of the Bhoothathankettu Barrage, which supports the Periyar Valley Irrigation Project. From here, the river flows through midland regions, passing Malayattoor, Kalady, and Aluva. At Aluva, the Periyar bifurcates into the Mangalapuzha and Marthandavarma branches: the Mangalapuzha branch meets the Chalakudy

River near Purapillikavu before entering the Arabian Sea, while the Marthandavarma branch flows southward and further splits into the Edayar and Muttar stretches near Edamula, encircling the Eloor region and eventually draining into the Cochin backwaters, which form part of the Vembanad Lake and estuarine system.

The Periyar basin, shaped like an inverted "L," contains 17 dams in which 15 are managed by KSEB and 2 by the Irrigation Department with major ones being Mullaperiyar, Idukki, Bhoothathankettu, and Idamalayar. Together, they have a storage capacity of 3278.70 Mm^3 and generate 1264.85 MW of power while supporting flood control and water management. The Idukki-Cheruthoni-Kulamavu complex and Idamalayar are the largest dams. The basin also sustains 136 lift irrigation schemes covering 58.78 km^2 of agricultural land in Ernakulam. Key irrigation initiatives include the Periyar Valley and Idamalayar Irrigation Projects, while major inter-basin transfers occur through the Mullaperiyar Dam (to the Vaigai River, Tamil Nadu) and the Idukki Hydroelectric Project (to the Muvattupuzha River, Kerala) (Periyar at a Glance, 2024).

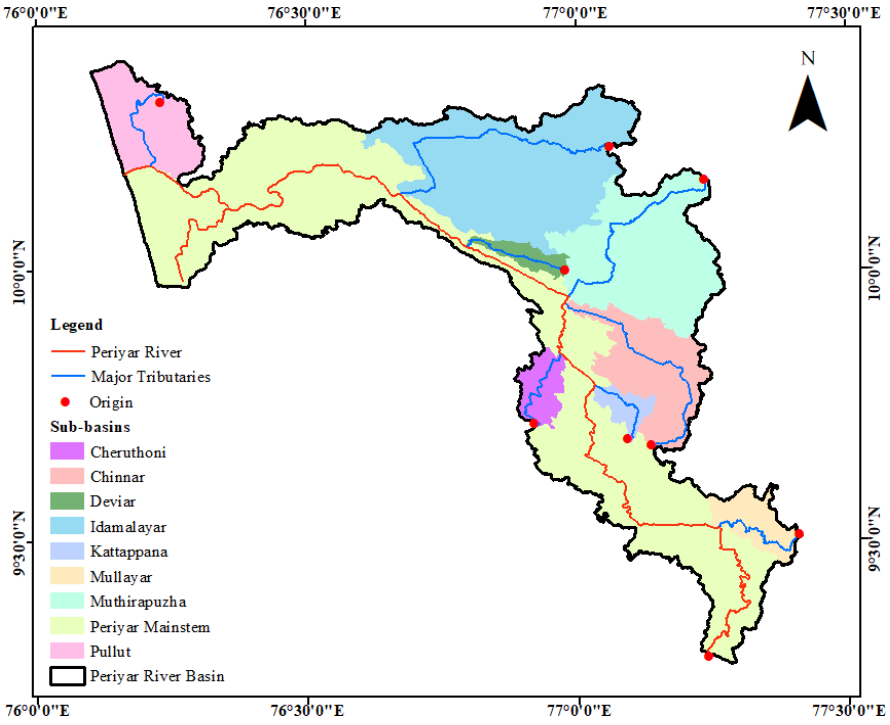


Fig. 2 Periyar River Basin showing the main river course, major tributaries, and delineated sub-basin

2.1.2 Channel characteristics

The Periyar River, the longest river in Kerala exhibits distinct geomorphological and hydrological characteristics throughout its 244 km course within Kerala. The channel morphology shows considerable spatial variability, with the maximum recorded width reaching around 405 m in the lower reaches, and the river basin forming an inverted "L" shape with its broadest section located at the junction of the two limbs. The basin's length to width ratio of approximately 6:1 reflects an elongated drainage form typical of rivers originating in the Western Ghats. The river begins at an elevation of about 1,830 m in the Sivagiri hills, flowing steeply through mountainous terrain before entering the plains near Aluva where it bifurcates into two distributaries the Mangalapuzha branch, which joins the Chalakkudi River before entering the Arabian Sea, and the Marthandavarma branch, which empties into the Cochin backwaters. This bifurcation plays a significant role in determining flood spread patterns and sediment distribution in the lower basin. Hydrologically, Periyar has the highest discharge potential of Kerala's rivers, with annual flow estimates ranging between 5,180 Mm^3 and 11,607 Mm^3 depending on monsoon intensity and the influence of major dams such as Mullaperiyar and Idukki. The river maintains a short, swift flowing nature for nearly three fourths of its course, governed by steep gradients that impart a high energy flow regime. In the downstream coastal stretches, tidal variations of 0.5 to 2 m influence salinity intrusion, estuarine mixing, and sediment deposition. Sediment characteristics vary significantly along the river, with gravel dominating the upper reaches due to strong erosional processes, and sand, silt, and clay occurring in variable proportions, sand (17.3%-88.2%), silt (2.3%-58.0%), and clay (7.2%-47.9%) indicating highly dynamic transport conditions. The predominant sediment texture in the basin is sandy clay loam, while geochemical analyses classify the sediments as mainly siliceous with enriched alumina, attributed to weathering of feldspathic rocks in the Western Ghats. Qualitative assessments also highlight a rugged riverbed, the presence of falls and cascades in the upper course, and minimal continuous floodplain development, all of which indicate the youthful geomorphic nature of the river. Overall, the Periyar River's channel characteristics demonstrate the combined influence of its mountainous origin, steep gradients, tidal interactions, and human interventions, reinforcing its ecological, hydrological, and socio-economic significance for central Kerala. These features provide an essential foundation for effective river management, flood mitigation, sediment analysis, and conservation-oriented planning. (Divya & Krishnakumar, 2021)

2.1.3 Tributaries

The Periyar River originates in the serene forested landscapes of the Periyar Tiger Reserve, emerging from the Sivagiri hills at an elevation of approximately 1830 m above mean sea level. After traversing 53.3 km, it receives its first major tributary, the Mullayar, which enters from the right side near the forested area upstream of the Mullaperiyar reservoir. Proceeding downstream, the river reaches Upputhara at 95.7 km, marking an important point along its main course.

Further along, at 114.8 km, the Periyar is joined by the *Kattappana Ar* before entering the Idukki Reservoir. At 124.8 km, the *Cheruthoni Thodu* merges with the Periyar from the left. Continuing downstream, the Chinnar River joins the main stem at 140.4 km, followed by the Muthirapuzha River at 142 km, both entering from the right. Subsequently, the *Devi Ar* at 165.73 km and the *Idamala Ar* at 184.17 km also join the Periyar from the right. As the river flows towards the plains, it approaches Kalady and, near Aluva, bifurcates into two major distributaries. The southern branch, the *Marthandavarma Puzha*, flows toward the Vembanad Lake. Further downstream, the Pullut River joins the Periyar at 254.65 km, and the river finally completes its 259.07 km course by draining into the Arabian Sea at Munambam.

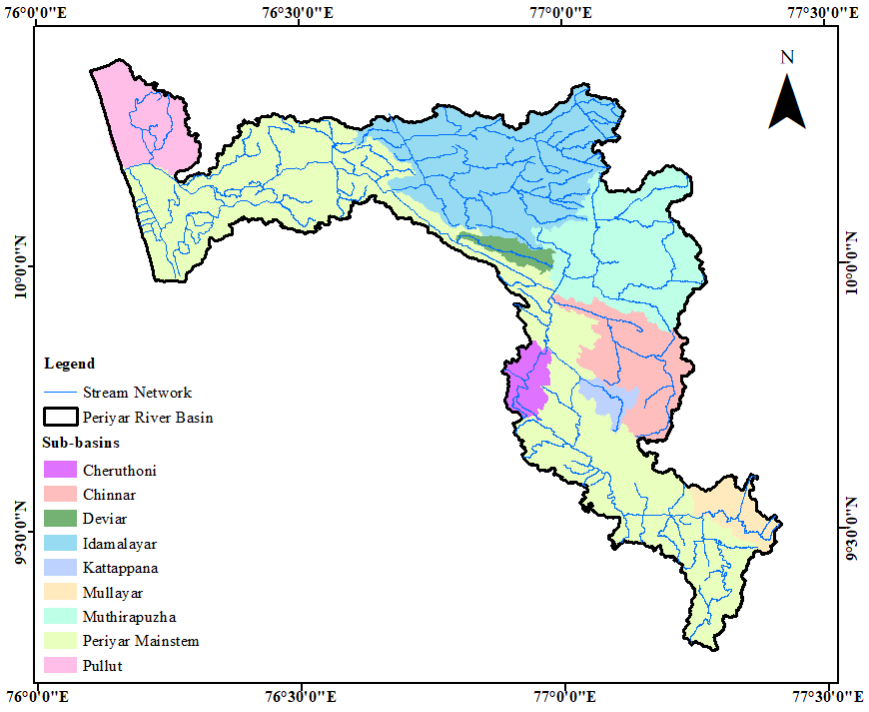


Fig. 3 Periyar Basin with its main tributaries

2.1.4 Biogeography

The Periyar basin displays notable physiographic contrasts, with steep forested highlands, midland plateaus, and densely populated lowlands, and features a major bifurcation at Alwaye into the Mangalapuzha and Marthanadavarma branches. The basin's geology comprises Precambrian crystalline formations overlain by lateritic and alluvial soils, which have become increasingly unstable due to deforestation and land conversion, enhancing erosion and sedimentation. Around 35% of the basin remains under forest cover, including wet-evergreen, semi-evergreen, and deciduous types. Biologically, the Periyar River Basin is one of Kerala's most critical biodiversity hotspots, supporting 56% of the state's endemic fish species, including the Periyar latia (Crossocheilus periyarensis) and the rare Periyar trout (Lepidopygopsis typus). The system also sustains diverse phytoplankton communities ranging from desmids in freshwater stretches to diatoms in estuarine regions and hosts major wildlife sanctuaries such as the Periyar Tiger Reserve and the Thattekad Bird Sanctuary. However, anthropogenic pressures have drastically reshaped the basin. Industrialisation concentrated between Angamaly and Kochi includes over 50 major industries and 2,500 small scale units releasing heavy metals, radionuclides, and untreated effluents into the river. Urban sewage discharge, agricultural runoff, and historic deforestation since the 1870s have further degraded the ecosystem. River connectivity has been severely disrupted by the presence of numerous hydropower structures, including the Idukki, Edamalayar, and Lower Periyar dams, in addition to several minor schemes and irrigation barrages. These have fragmented the river continuum, causing flow interruptions that have eliminated upstream migratory pathways for species such as eels and rendered some downstream stretches hydrologically dysfunctional.

Water quality in the lower Periyar, especially around Eloor. Edayar, is critically poor with reports describing the river as functioning like a "sewage canal." pH values exhibit extreme fluctuations from as low as 1.32 to over 12 and concentrations of heavy metals such as mercury, cadmium, zinc, and even radium exceed acceptable limits. Nutrient loads, especially phosphates and nitrates, are elevated but do not consistently enhance productivity due to toxic interference from pollutants. Salinity intrusion extends up to 15 km upstream during the pre-monsoon period and is exacerbated by deep sand mining pits that allow seawater to percolate inland. The basin contains nearly 39,000 hectares of wetlands, the most significant being the Cochin Backwaters, a productive tropical

estuary supporting both freshwater and euryhaline species but also receiving most of the industrial pollutant load. Environmental concerns are severe: sixteen fish species have disappeared within the last fifty years, recurrent fish kills occur near industrial zones, and studies indicate elevated cancer rates and systemic illnesses among residents of the Eloor region. Conservation proposals include establishing fish sanctuaries in the upper Periyar and implementing strict environmental flow regimes, but comprehensive restoration remains urgently needed to prevent further ecological collapse. (Status Report on Periyar River; The Declining trend of Biodiversity and Fish Production in consequence of pollution in the Lower Reaches of Periyar River)

2.1.5 River connectivity, fragmentation and dam density

The Periyar River exhibits significant hydrological regulation due to the presence of multiple dams and diversion structures distributed along its course. The basin contains 16 dams; however, along the 244 km main channel, only six major dams are located, resulting in an approximate mainstem dam density of one structure every 40 km. This spatial distribution reflects substantial flow regulation and indicates a high potential for river fragmentation. Major control points include the Idukki Hydroelectric Project, comprising the Idukki, Cheruthoni, and Kulamavu dams, which forms one of Asia's largest arch dam complexes, and the Mullaperiyar Dam, commissioned in 1895. Downstream, the Idamalayar, Lower Periyar, and Bhoothathankettu structures further modify natural flow regimes. These dams, together with associated hydroelectric stations such as Pallivasal and Neriamangalam, have enabled substantial power generation, irrigation support, and flood moderation. However, the cumulative presence of structures along the main stem introduces channel fragmentation, alters longitudinal connectivity, and influences sediment continuity and ecological flow patterns. Consequently, while the Periyar River functions as a major renewable energy corridor for Kerala, its structural intensity necessitates careful management to balance water use efficiency with riverine ecosystem integrity (Periyar River Atlas, 2025).

2.1.6 Riverspace

The Periyar River, extending approximately 260.7 km with a basin area of 5216 km², originates in the Sivagiri hills of the Western Ghats and flows westward across the districts of Idukki, Ernakulam and Thrissur before draining into the Arabian Sea at Cochin. The river space is

governed by strong physiographic gradients, marked by elevation variation from 1830 m in the upper reaches to sea level towards the outlet, transitioning across lowlands, midlands, foothills, plateaus and highlands. Spatial heterogeneity is further reflected in the geomorphological composition of the basin, which encompasses structural and denudational hills, residual hills, pediplains, coastal plains, floodplains, marshes, mudflats and backwater systems. The downstream corridor is characterized by broad floodplain environments and marshy tracts, whereas the midland zone displays undulating terrain with narrow valleys that gradually widen downstream, indicating variable lateral channel mobility. River space also includes multiple mid-Channel Islands comprising vegetated sediment bodies, signifying active depositional processes and morphological adjustments controlled by flow, sediment input and channel hydraulics. Collectively, these attributes demonstrate that the spatial structure of the Periyar River is a function of terrain control, longitudinal elevation gradient and geomorphic diversity, which regulate channel form, floodplain development and sediment distribution within the basin (Geomorphological Mapping of the Periyar River, 2025)

2.1.7 River zonation

The Periyar River exhibits a well-defined longitudinal zonation that reflects systematic transitions in valley confinement, channel morphology, and floodplain development from its headwaters to the downstream reaches. In the upper reaches, extending from the origin up to the Idukki and Mullaperiyar reservoir zones, the river is dominantly situated within confined valley settings, where the valley margin closely coincides with the channel margin, resulting in negligible floodplain development and restricted lateral channel movement. These ranges are characterized by steep gradients, bedrock-controlled channels, boulder-dominated beds, cascades, gorges, pools, and riffles, indicating high-energy flow conditions typical of mountainous and pediment landscapes. Downstream of the reservoir influence, the river gradually transitions into partly confined valley settings, where terrace margins allow the formation of discontinuous and occasional floodplain pockets, reflecting moderate lateral adjustment and reduced channel confinement. Further downstream, particularly from *Paniyeli Poru* through Aluva to the coastal reaches near Vypin, the Periyar enters a laterally unconfined valley setting, characterized by low channel gradients, continuous floodplains, fine-grained bed material, increased sinuosity, and

locally anabranching channel patterns. This downstream zonation signifies a progressive shift from structurally controlled, erosion-dominated river segments to deposition-dominated alluvial reaches, thereby defining the spatial organization of river space along the Periyar River continuum (Geomorphological Mapping of the Periyar River, 2025).

2.2 Tributaries (Origin & course)

2.2.1 Mullayar

Mullayar River is a major tributary of the Periyar, flowing through the Mullayar sub-basin with a total length of about 33 km and a basin area of 151.45 km². The river originates from the Kottamalai peak within the Periyar Tiger Reserve in Idukki district. After flowing for around 7.4 km, it receives its first tributary, the *Kottamala Pallam*. Continuing downstream, the river is joined by the *Maddalamkutti thodu* at about 18.5 km from its origin. The Mullayar finally meets the Periyar River at Mullakudi in Idukki after completing its 33 km course.

2.2.2 Kattappanayar

Kattappanayar drains the Kattappana sub-basin, which has a basin area of 69.83 km². The river originates from Kalthotty and flows for a total length of about 20.43 km. After coursing through the hilly terrain of Idukki, the river finally enters the Idukki Reservoir, forming its main confluence point.

2.2.3 Cheruthoniyar

Cheruthoniyar is an important tributary of the Periyar, flowing through the Cheruthoni sub-basin with a basin area of 116.89 km² and a total length of about 26.77 km. The river originates from the Kottamalai peak located within the Periyar Tiger Reserve in Idukki district. After flowing for nearly 9 km, it is joined by the Kavala thodu, which contributes to its course. The river continues its journey through the hilly terrain and finally joins the Periyar River at Cheruthoni in Idukki after covering around 27 km from its source.

2.2.4 Chinnar

Chinnar drains the Chinnar sub-basin with a basin area of 405.34 km² and has a total length of about 58.32 km. The river originates from Chakkupallam in Idukki district. After flowing for around 18.9 km, it is joined by the *Emakkadavu Ar*, followed by the Palar Ar at about 28.5 km. Further downstream, the river receives flow from the Erattayar Dam region at around 38.8 km, and the Kallar Dam is also located along this stretch. The *Tuval Ar* (Karitodu) from the Cardamom Hills joins the Chinnar after approximately 44.4 km. The river then continues its course and finally meets the Periyar at Periyar Valley Chappath in Idukki after completing about 58.5 km.

2.2.5 Muthirapuzha

Muthirapuzha sub-basin, which covers an area of 734.4 km², and flows for a total length of about 57 km. The river originates from Suriyanelli in Idukki district. In its upper reaches, the river passes through stretches influenced by the Kundala Dam and Mattupetty Dam. After flowing for around 24.7 km, the *Gudrale Ar* joins the river, followed by the *Kannimala Ar* at about 29.7 km. The R A Headworks Dam is also located along this section of the river. Further downstream, the *Uppu Ar* joins the river at approximately 42.65 km. After about 46.25 km, the *Panni Ar* merges with the river, and both the Ponmudi Dam and Mukkudill Dam are situated along this tributary. At around 53 km, the Kallar contributes to the flow, after which the river passes the Kallarkutty Dam. Completing its 57 km course, Muthirapuzha finally joins the Periyar at Panamkutty in Idukki.

2.2.6 Deviar

Deviar sub-basin has an area of 69.29 km². The river originates from Randam Mala near Adimali and flows for a total length of about 28.29 km. The river continues its course until it finally meets the Periyar at Chembakuzhy, forming its confluence point.

2.2.7 Idamalayar

Idamalayar drains the Idamalayar sub-basin, which has a basin area of 1,038.79 km², and flows for a length of about 66.79 km. The river originates from the Anamalai Hills in Idukki district. After flowing for around 10.09 km, the *Nadalkal Ar* joins the river, followed by the *Itili Ar* at 12.5 km. The *Karinandu Todu* merges with the river at 15.2 km, and the *Manali Ar* joins at 17.71 km.

Shortly after, at around 18.35 km, the Kallar also contributes to the flow. As the river progresses, the *Nallamalai Ar* joins at 30.79 km, and the *Kaliman Todu* meets the river at 34.54 km. The *Anamalai Ar* joins at about 37.78 km. Further downstream, the *Kulinirkal Todu* and *Anaikayam Todu* join the river at 48.42 km and 49.27 km respectively. The Idamalayar Dam is located along this stretch. After the dam, the *Cherpuram Todu* joins at 52.46 km, followed by the *Cherpuram/Panchankuttu Todu* at 53.64 km. At around 57.66 km, the *Pooyamkutti Ar* meets the river, and the *Kuttampuzha* joins shortly after at 59.05 km. The Idamalayar River completes its course by meeting the Periyar at Bhoothathankettu in Idukki.

2.2.8 Pullut River

Pullut River drains the Pullut sub-basin, which has a basin area of 334.06 km² and a total length of about 27.31 km. The river originates from Mukundapuram in Thrissur district. From its upper course, the *Karupadanna Puzha* flows for about 3.57 km and then joins the *Tachchapalli Todu* that branches from the Pullut River. The *Tachchapalli Todu* continues for another 6.58 km before merging with the *Vallikilli Todu* (also known as Muttika Todu or Penturuthu Todu). This combined tributary joins the Pullut River at around 16.42 km from its origin. After completing a course of approximately 27.37 km, the Pullut River finally joins the Periyar at Munambam in Ernakulam district (Periyar River Basin Atlas, 2025).

2.3 Channel characteristics of Tributaries

2.3.1 Kattappanayar

Kattappanayar is one of the main tributaries of the Periyar. The river has an average channel width of about 10 m. In the upstream stretches, noticeable silt deposition is present along with patches of small vegetation. The estimated sediment accumulation is around 5,000 m³. The riverbed mainly consists of rock. From the origin to the Karimanal Bridge, siltation is observed with an approximate depth of about 0.5 m. The deposited material is composed of nearly 85% silt and 15% clay.

2.3.2 Chinnar

Chinnar River is an important tributary of the Periyar. The channel width of the river varies considerably along its course, with a maximum width of about 100 m observed near Erambadam and a minimum width of around 3 m near the bridge at Nallathanny bhagam. The riverbed mainly consists of rock and silt. Sedimentation is prominent along several stretches, with the depth of deposited material ranging approximately from 1.5 m to 2 m. The sediments are predominantly composed of silt and clay, with an approximate composition of 80% silt and 20% clay at different locations along the river.

2.3.3 Muthirapuzha

Near the origin, the main stream has a comparatively narrow channel with a width of about 7 m. As the river traverses downstream, the channel becomes wider near Periavarai, where the width varies between 35 m and 50 m up to the Munnar Head Works. From the Munnar Head Works onwards, the river flows over a predominantly rocky bed until its confluence with the Panniyar. The right bank of the river mainly consists of rock, while the riverbed is composed of earth, silt, and rock at different locations. Sedimentation is observed along several reaches, with the depth of deposited material varying approximately from 0.3 m to 1.75 m. The sediments include silt, clay, and sand, with an approximate composition of about 80% sand, 10% silt, and 10% clay, though this composition varies at different locations along the river.

2.3.4 Deviar

The channel width of Deviar shows considerable variation along its course, ranging from about 6.5 m in the narrower stretches to nearly 120 m in the wider reaches. The riverbed is mainly composed of rock and silt at different locations along the river. These variations in width and bed material reflect changes in terrain and flow conditions along the length of the Deviar.

2.3.5 Idamalayar River

The river has a length of about 178.33 km, and its channel width generally ranges between 90 m and 100 m. The riverbed is composed of a mixture of clay, silt, rock, laterite, and stones at different locations along its course. Siltation is observed along the channel, with an approximate depth

ranging from 0.2 m to 0.3 m. The deposited sediments mainly consist of about 60% silt, 25% clay, and 15% sand.

2.4 Tributaries

2.4.1 Tributaries of Kattappanayar River

Kattappanayar River has several small tributaries contributing to its flow. Kattappana thodu is a tributary of the Kattappanayar and originates from the confluence of two small streams draining the Pliyanmala and Anakuthy areas. The thodu has a length of about 3.67 km and joins the Kattappanayar near St. John's Hospital.

Valiyakandam thodu is another tributary of the Kattappanayar. It originates near Vellayamkudi and flows for approximately 3.58 km before joining the Kattappanayar upstream of Anjalipalam.

2.4.2 Tributaries of Chinnar River

Chinnar River receives flow from several small sub-tributaries along its course. Passurpara Thodu is a sub-tributary of the Chinnar thodu and joins it at approximately 9.659232° N latitude and 77.012394° E longitude. This thodu has an approximate channel width of about 20 m, and the riverbed is mainly composed of silt.

Elappara Thodu is another sub-tributary of the Chinnar thodu. It joins the Chinnar thodu at around 9.657792° N latitude and 76.997903° E longitude. The approximate width of this thodu is about 15 m.

Arappukadu Thodu is also a sub-tributary of the Chinnar thodu and meets it at approximately 9.667718° N latitude and 76.956572° E longitude. This thodu has a relatively narrow channel, with an approximate width of about 8 m.

2.4.3 Tributaries of Muthirapuzha River

Muthirapuzha River is fed by several major and minor tributaries along its course, particularly in the upper reaches around Munnar.

Kundalayar is one of the major tributaries of the Muthirapuzha River. It originates from the Kundala Hills formed by the ridges of Kundala, Talaimalai, Madavaraimalai, and Thandamalai, about 19 km north of Devikulam at an elevation of around 2,286 m above mean sea level. In its initial reaches, the river is locally known as Kundale or Palar. A major portion of the river flows through the Kundala and Mattupetty reservoirs. Downstream of the Mattupetty Dam, the river flows with an average width of about 25 m. The total length of the Kundalayar is approximately 26.66 km, and it joins the Muthirapuzha River at Munnar. Yellapetti and Chittuvarai are two minor sub-streams of the Kundalayar.

Nallathanniyar is another important tributary of the Muthirapuzha River. It originates from the Kallar Estate Valley and Nallathanni Estate and flows through areas near the Tea Museum and Little Flower Girls High School. The river has a length of about 4 km and joins the Muthirapuzha River at Nallathanni Junction. The stream was historically known for its clean water.

Colony Thodu originates from the upper hill region of MG Colony. It flows for about 1.75 km and joins the Muthirapuzha River upstream of Churchill Bridge. The average width of the thodu is about 4 m. This stream is highly polluted due to household waste and sewage discharge and is affected by encroachments and heavy siltation.

Sevenmalai Thodu, also known as Lekshmi Thodu, originates from the Lekshmi and Sevenmalai Estates. The stream flows through tea plantation areas and receives runoff mainly during the monsoon season, with very lean flow during summer. It has a length of about 9.4 km and joins the Muthirapuzha River upstream of the Munnar R A Headworks. The width of the stream varies from about 3 m at the origin to nearly 15 m at the confluence.

Chokkanadu Thodu originates from the Chokkanadu Estate. It is a small stream with a length of about 1.5 km and a width varying between 3 m and 5 m. The thodu joins the Muthirapuzha River upstream of the Munnar R A Headworks and is affected by siltation and vegetation growth in certain stretches.

Uppar River is one of the major sub-streams of the Muthirapuzha system. It has a length of about 15.34 km and originates from the merging of several streams draining the Muttukadu Hills and the

Old Devikulam Division. The river flows through Bysonvalley Panchayath before joining the Muthirapuzha River. The average width of the Uppar River is about 7.5 m.

Nadayar Thodu is a minor stream with a length of about 0.7 km. It originates from the Nadayar Estate, flows through parts of Munnar township, and joins the Muthirapuzha River upstream of the main junction bridge.

Panniyar River is a major tributary of the Periyar and an important contributor to the Muthirapuzha system. The river flows through Idukki district and receives water released from the Anayirankal Dam. The flow passes through the Kuthunkal and Ponmudi dams, where hydropower is generated. The Panniyar River joins the Muthirapuzha River at Panniyarkutty. Tailwater from the Panniyar powerhouse and spill from the Ponmudi Dam reach the Kallarkutty Dam through the Muthirapuzha before flowing into the Periyar. The Panniyar River has a total length of about 34 km and an average width of around 40 m. It is a major source of drinking water for areas such as Rajakumari, Rajakkad, Santhanpara, and Senapati. Santhanpara River, Cheriyar River, Rajakkad Thodu, and other minor streams are its main tributaries.

Ambazhachal River is a minor tributary of the Muthirapuzha River. It originates from the downstream region of Viripara and joins the Muthirapuzha along its lower stretch, contributing additional flow to the main river.

2.4.4 Tributaries of Deviar River

Deviyar River has two important sub-tributaries.

Polinjapalam thodu is a sub-tributary of Deviyar River. It joins the Deviyar at a chainage 1.600 km from Thottiyar. The stream originates near the Polinjapalam area and flows through a semi-forested and settlement-influenced region before joining the main river.

Padikappu thodu is another sub-tributary of Deviyar River. It joins the Deviyar at chainage 11.000 km of Thottiyar. The stream originates from forested areas near Kattumudy and flows through undisturbed stretches before confluence with the Deviyar.

2.4.5 Tributaries of Idamalayar River

The Idamalayar River receives several tributaries from both the right and left banks. In this stretch, two major tributaries join the river from the right bank and eight tributaries join from the left bank. The major tributaries of Idamalayar River are Nadalkalaar, Nirar, Pooyamkuttyaar and Kuttampuzhaaar.

Nadalkalaar is a right bank tributary of the Idamalayar River. It has an average width of 20–30 m and a length of about 12.6 km. It joins the Idamalayar at a chainage of 12.25 km.

Nirar is another major right bank tributary. The stream has an average width of 20–25 m and a length of about 24.7 km. It joins the Idamalayar at a chainage of 20.5 km.

Pooyamkuttyaar is a major left bank tributary of the Idamalayar River. It has a wide channel with an average width of 80–100 m and a length of about 6.3 km. The confluence occurs at chainage 60.07 km.

Kuttampuzhaaar is a left bank tributary with an average width of 5–15 m and a length of about 10 km. It joins the Idamalayar at a chainage 61.39 km.

Other minor left bank tributaries include forest streams, Koottambarathodu, Karambankudythodu and Vengasserythodu. These streams are short in length and join the Idamalayar at different chainages downstream.

2.5 Biogeography

2.5.1 Mullayar

The Mullayar River originates from the eastern boundary of the Periyar Tiger Reserve and flows entirely through forested areas. The Mullayar sub-basin shows a wide altitudinal variation, with elevations ranging from about 1,280 m to 385 m above mean sea level. This forested setting and elevation gradient strongly influence the biogeographic character of the Mullayar River (Periyar River Atlas, 2025).

2.5.2 Cheruthoniyar

The river basin provides habitat for various wildlife species, including elephants, deer, muntjac, wild boar and foxes. The region also supports rich avifauna such as hornbills, blue-bearded bee-eaters and black bulbuls, along with a notable diversity of butterflies. The area experiences a moderate climate, with temperatures generally ranging from about 22.5°C to 37.5°C, which supports varied terrestrial and riparian ecosystems.

2.5.3 Muthirapuzha

The subbasin receives intense rainfall from both south-west and north-east monsoons, creating moist and water-rich conditions that support diverse terrestrial and riparian ecosystems. Large portions of the catchment are covered with tea estates, while the presence of heavy soil over rocky substratum helps retain moisture, supporting vegetation growth along the basin. The occurrence of rapids and waterfalls further enhances habitat diversity within the river system.

3. Biological diversity of the river

The Periyar River represents one of the most biologically important river systems in Kerala, owing to its origin in the Western Ghats and its longitudinal continuity across forested headwaters, regulated reservoirs, midland river reaches, and densely populated lowlands. This riverine continuum supports a diversity of aquatic and semi-aquatic habitats shaped by variations in flow regime, channel morphology, substrate composition, and riparian land use. Such habitat heterogeneity forms the ecological basis for sustaining diverse biological communities across the main river and its potentially perennial tributary streams.

Biological diversity serves as a critical indicator of river health, integrating the cumulative effects of hydrological regulation, water quality, habitat alteration, and catchment-scale land-use change. In the Periyar River system, natural seasonal dynamics interact with increasing anthropogenic pressures including dam operations, channel modification, and localized pollution to influence species composition and distribution. Evaluating biological diversity therefore provides an essential framework for understanding ecosystem condition, identifying ecological stress, and supporting river basin management and conservation planning.

3.1 Flora

3.1.1 Periphyton

Periphytons are complex communities of algae, cyanobacteria, microorganisms and organic matter that colonize submerged surfaces in freshwater systems, playing a key role in nutrient cycling, primary production and the overall functioning of riverine food webs. Accounting for periphytons is essential in river assessments because these communities respond quickly and sensitively to changes in water quality, hydrological regime, substrate stability and nutrient enrichment, making them valuable biological indicators of ecological health. This becomes especially important in a river like the Periyar, which flows through diverse landscapes ranging from protected forested headwaters to heavily urbanized and industrialized downstream stretches. The river experiences varied environmental pressures including organic loading, flow modifications and land-use changes, all of which directly influence benthic algal communities. Monitoring periphytons in such a dynamic system provides early and reliable signals of ecological alterations, helping to understand spatial variation in river condition and informing effective management and conservation efforts. Periphyton recorded from the Periyar River Basin were found predominantly along the stretches PR_2, PR_3 and PR_4, where the taxonomic composition remained broadly consistent. Periphyton communities displayed high diversity across the observed locations, with representatives from Bacillariophyta (diatoms), Chlorophyta (green algae), and Cyanobacteria (Fig 5).

Among the recorded groups, periphytic green algae formed the most dominant and species-rich component particularly desmids and filamentous chlorophytes. Within the green algae (Chlorophyta), the families Desmidiaceae and Zygnemataceae showed overwhelming diversity. This group was characterised by the extensive presence of desmid genera such as *Cosmarium*, *Euastrum*, *Micrasterias*, *Pleurotaenium* and *Gonatozygon*, along with filamentous forms like *Spirogyra*, *Mougeotia* and *Oedogonium*. Diatoms also contributed substantially to the periphytic assemblage, exemplified by families such as Achnanthaceae, Bacillariaceae, Cymbellaceae, Naviculaceae and Gomphonemataceae with species like *Achnanthes brevipes*, *Cocconeis placentula*, *Gomphonema parvulum*, *Navicula lanceolata*, *Synedra acus*, *Ulnaria ulna* and *Tryblionella plana*.

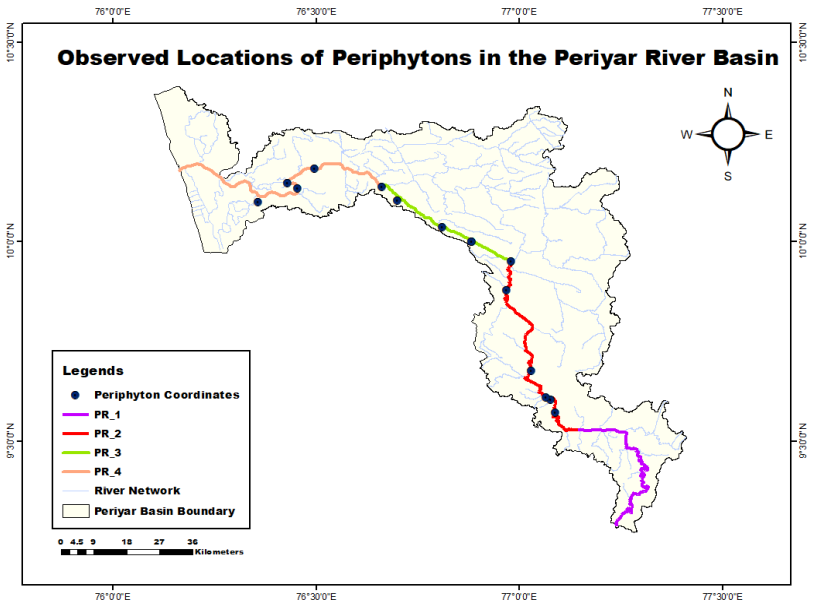


Fig.4 Location Map of Periphyton Observations Across Periyar River Stretches

Among diatoms, Naviculaceae followed by Gomphonemataceae emerged as the most prominent families. Cyanobacterial diversity was notable, with members of Oscillatoriaceae, Nostocaceae, Rivulariaceae, Scytonemataceae and others forming a distinct component of the periphytic layer. Filamentous taxa such as *Oscillatoria limosa, O. tenuis, Phormidium nigrum, Lyngbya dendrobia,* and *Calothrix* species were widely distributed across the stretches from PR_2 to PR_4.

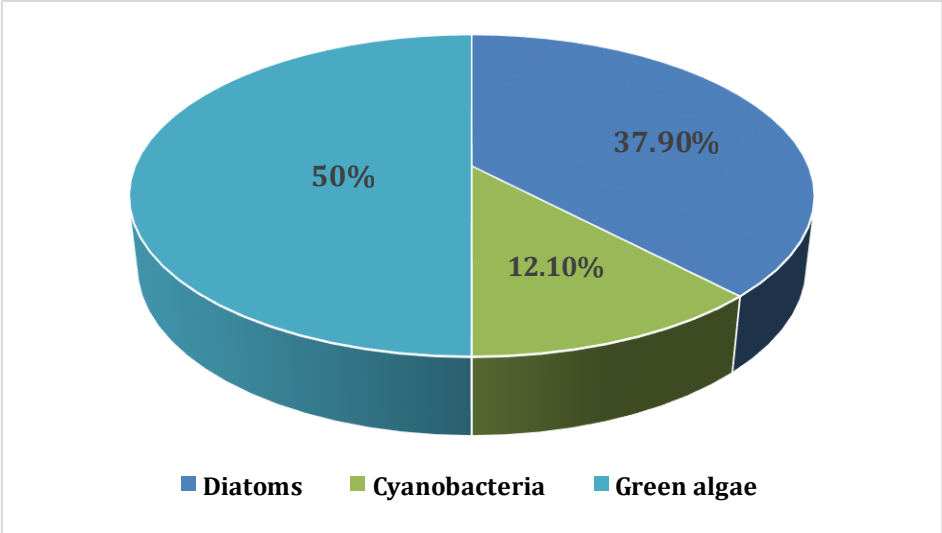


Fig.5 Composition of Periphyton Communities in the Periyar River

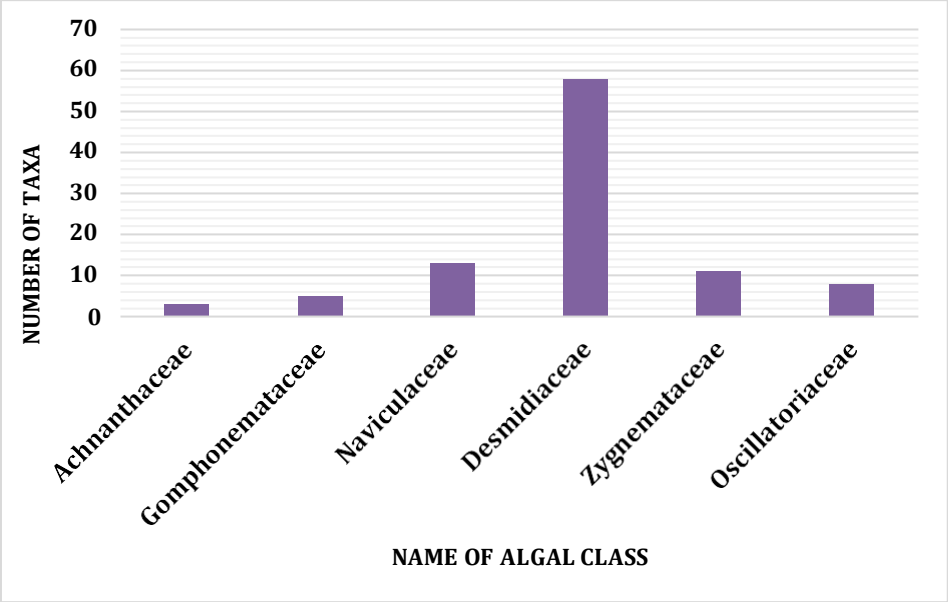


Fig. 6 Species Richness of Major Periphyton Groups in the Periyar River

Figure 6 illustrates the distribution of major periphyton groups in the Periyar River, showing that Desmidiaceae contributes the highest number of species, followed by Naviculaceae, Gomphonemataceae, Zygnemataceae and Oscillatoriaceae. The mapped distribution of periphyton sites further confirms that the central stretches (PR_2 to PR_4) act as ecological hotspots supporting diverse benthic algal communities, whereas PR_1 exhibited no recorded periphyton due to either sampling limitations or unsuitable substrate conditions and is depicted in Figure 4.

3.1.2 Phytoplankton

Phytoplankton form the foundational component of aquatic food webs, driving primary production and influencing nutrient cycling, oxygen dynamics, and overall ecosystem functioning in riverine systems. These organisms typically range in size from approximately 0.2 µm (picophytoplankton) to about 200 µm (large microphytoplankton), encompassing a wide diversity of functional and taxonomic groups. They are highly responsive to environmental changes such as nutrient availability, light conditions, temperature, and hydrodynamics, making them vital indicators of ecological status. Phytoplankton also contribute significantly to the productivity and stability of aquatic ecosystems, forming the base of the food web and supporting a variety of aquatic organisms. Phytoplankton were observed in relatively low numbers in individual stretches, with

occurrences scattered in the Periyar River. Considering this sparse and scattered distribution, the analysis has been carried out for the entire river basin rather than specific stretches.

The recorded phytoplankton community exhibited considerable taxonomic diversity, comprising multiple major groups that perform distinct ecological functions within the river ecosystem. Diatoms (Bacillariophyta) with prominent species including *Amphora ovalis*, *Cyclotella bodanica*, *Melosira granulata*, *Navicula cuspidata*, *Pinnularia acrosphaeria*, and *Stauroneis phoenicenteron* were highly represented. Green algae (Chlorophyta) such as *Ankistrodesmus falcatus* and *Chlorella vulgaris* were present in both unicellular and filamentous forms. Within the green algae, desmids, a specialized subgroup adapted to freshwater environments, including species like *Cosmarium supergranatum*, *Desmidium quadratum*, and *Staurastrum* species. (*Staurastrum dentatum*, *Staurastrum tohopekaligense*) were notably diverse and significantly enhanced overall species richness. Filamentous green algae, including *Ulothrix zonata*, formed a notable component of the community. Cyanobacteria such as *Aphanocapsa* species. and filamentous forms like *Rhizoglonium* species. were observed as both colonial and filamentous forms. Dinoflagellates (Dinophyta), like *Ceratium hirundinella* though less abundant in species number, contributed significantly to community diversity. In addition, euglenoids and other minor phytoplankton groups added further complexity to the community, collectively highlighting the structural and functional diversity of primary producers in the Periyar River Basin.

A detailed examination of the phytoplankton species observed in the Periyar River Basin reveals a highly diverse community spanning multiple taxonomic groups and is illustrated in Fig 7. Diatoms (Bacillariophyta) were the most species-rich group, including genera such as *Achnanthes*, *Amphora*, *Cyclotella*, *Navicula*, *Melosira*, *Stauroneis*, *Pinnularia*, *Cymbella*, *Synedra*, and *Thalassionema*, among others. These organisms contributed significantly to primary production and formed a dominant component of the phytoplankton assemblage. Green algae (Chlorophyta) were also highly diverse, comprising taxa such as *Ankistrodesmus*, *Chlorella*, *Coelastrum*, *Mougeotia*, *Spirogyra*, *Pediastrum*, *Cladophora*, *Clamydomonas*, *Tetraedron*, and *Ulothrix*. These algae were present in both unicellular and filamentous forms. Within the green algae, desmids (Streptophyta, Zygnematophyceae) were particularly diverse, with representatives from genera such as *Cosmarium*, *Euastrum*, *Desmidium*, *Staurastrum*, and *Pleurotaenium*, contributing substantially to freshwater species richness.

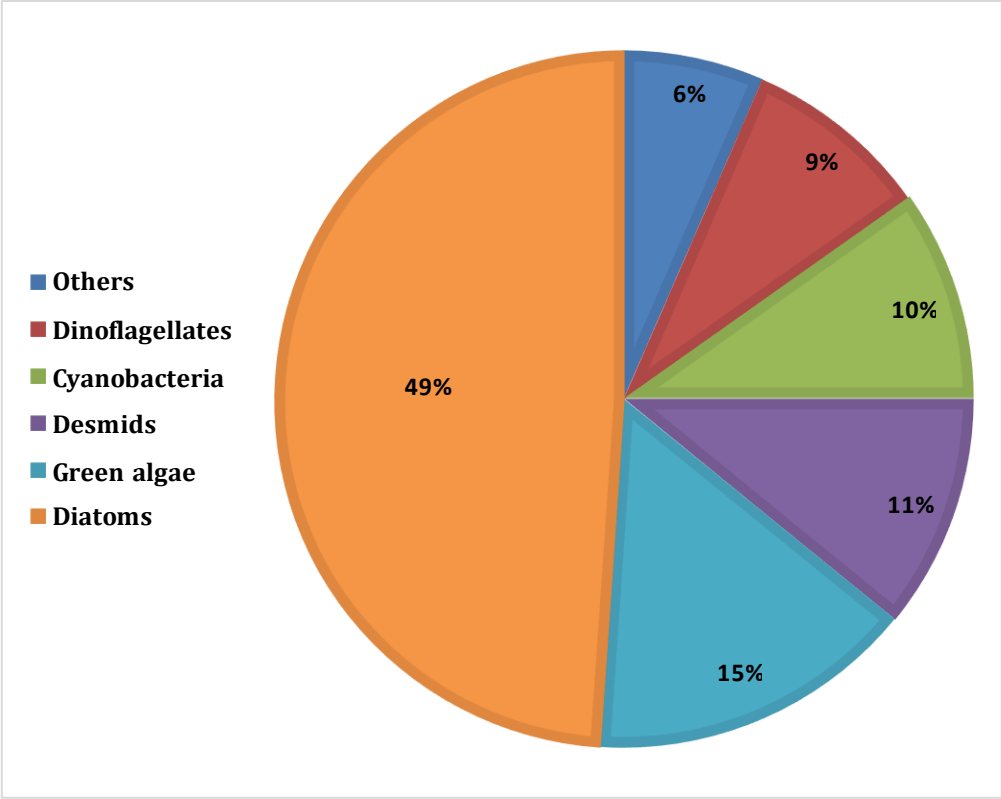


Fig. 7 Composition of Phytoplankton Communities in the Periyar River

The distribution of phytoplankton species in the Periyar River indicated that certain taxa were particularly more dominant, with *Ankistrodesmus falcatus*, *Chlorella vulgaris*, *Melosira granulata*, *Cyclotella bodanica*, *Staurastrum dentatum*, and *Staurastrum tohopekaligense* contributing most substantially to the overall phytoplankton community and is depicted in Fig 5. Overall, the phytoplankton diversity in the Periyar Basin highlights the ecological importance of these primary producers and reflects the structural and functional complexity of aquatic communities within the river system. Diatoms were clearly the most diverse group, followed by green algae and desmids, while cyanobacteria and dinoflagellates, despite lower species diversity, play critical ecological roles. Euglenoids and other minor groups, though less abundant, contribute to overall community richness. Figure 8 illustrates the major phytoplankton groups and their relative contribution.

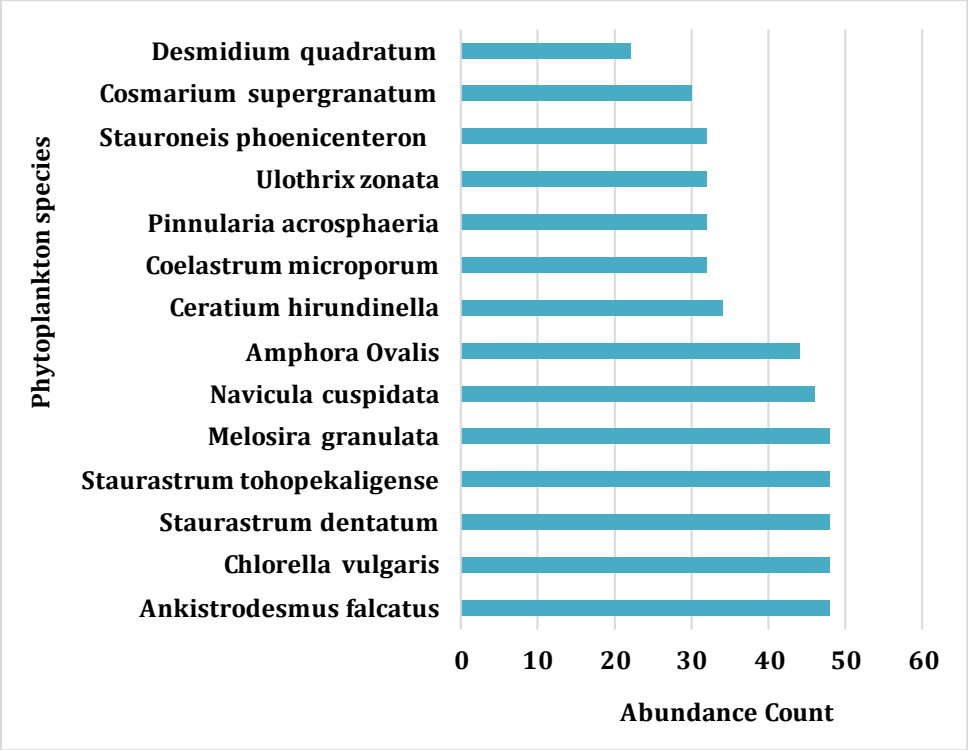


Fig. 8 Species Richness of Major Phytoplankton in the Periyar River

3.1.3 Riparian Vegetation

Riparian vegetation forms a critical interface between terrestrial and aquatic ecosystems, playing a vital role in maintaining riverine ecological integrity. It contributes to bank stabilization, regulation of sediment and nutrient fluxes, moderation of microclimatic conditions, and provision of habitat and food resources for a wide range of organisms. Riparian plant communities also influence channel morphology and hydrological processes while acting as buffers that mitigate anthropogenic impacts from adjacent landscapes. Owing to their close dependence on hydrological regimes, soil moisture gradients, and disturbance patterns, riparian vegetation serves as an important indicator of river health and landscape connectivity.

Across the Periyar Basin, riparian plant assemblages were generally recorded in low densities at individual locations, with species occurrences scattered discontinuously along the river course. Given this sparse and patchy distribution, a stretch-wise interpretation was not considered ecologically representative. Consequently, the assessment of riparian vegetation has been carried

out at the scale of the entire river basin, allowing for a more integrated evaluation within the Periyar riverine system.

The recorded riparian vegetation exhibited high taxonomic and structural diversity, encompassing trees, shrubs, lianas, herbs, grasses, and hydrophyte associated taxa adapted to varying degrees of inundation and soil moisture. Woody riparian species formed a prominent component of the assemblage such as *Barringtonia acutangula*, *Barringtonia racemosa*, *Terminalia catappa*, *Syzygium caryophyllatum*, *Neolamarckia cadamba*, *Pongamia pinnata*, *Lagerstroemia speciosa*, and *Vitex leucoxylon*. Shrubs and lianas such as *Derris trifoliata*, *Entada rheedei*, *Caesalpinia crista*, and *Calamus rotang* further contributed to species heterogeneity. Herbaceous and semi-woody riparian plants were also well represented including species such as *Homonoia riparia*, *Ipomoea carnea*, *Tragia nodiflora*, *Melastoma malabathricum*, *Phyllanthus reticulatus*, and *Morinda citrifolia*. Members of the genus *Impatiens* (balsams) formed a distinctive component of the riparian flora, exhibiting remarkable species richness within the basin including *Impatiens flaccida*, *I. cuspidata*, *I. goughii*, *I. minor*, *I. tomentosa*, *I. wightiana*, and *I. sholayarensis*.

Riparian grasses constituted a major functional group. This group included a wide array of Poaceae and Cyperaceae members such as *Saccharum spontaneum*, *Saccharum arundinaceum*, *Imperata cylindrica*, *Panicum repens*, *Cynodon dactylon*, *Axonopus compressus*, *Isachne spp.*, *Arundinella spp.*, *Brachiaria spp.*, *Cyperus* spp., and bamboo species such as *Bambusa bambos*, *Dendrocalamus stocksii*, and *Ochlandra travancorica* were particularly significant. Ferns and fern allies formed another ecologically important component of the riparian vegetation and species such as *Acrostichum aureum*, *Ceratopteris thalictroides*, *Marsilea minuta*, *Stenochlaena palustris*, *Blechnum orientale*, *Diplazium* spp., *Asplenium* spp., *Adiantum* spp., and *Selaginella* spp. were recorded in the basin.

Overall, the riparian vegetation of the Periyar River Basin reflects a complex and diverse assemblage shaped by hydrology, geomorphology, and regional climatic conditions. While species occurrence at individual sites was limited, the basin-scale assessment reveals substantial taxonomic richness across multiple functional groups, including woody trees, herbs, grasses, balsams, and pteridophytes.

Grasses and herbaceous taxa exhibited the highest diversity, followed by woody riparian plants and ferns, collectively contributing to ecosystem stability and resilience. Figure 9 summarizes the distribution of recorded riparian plant species across major functional groups within the Periyar River Basin.

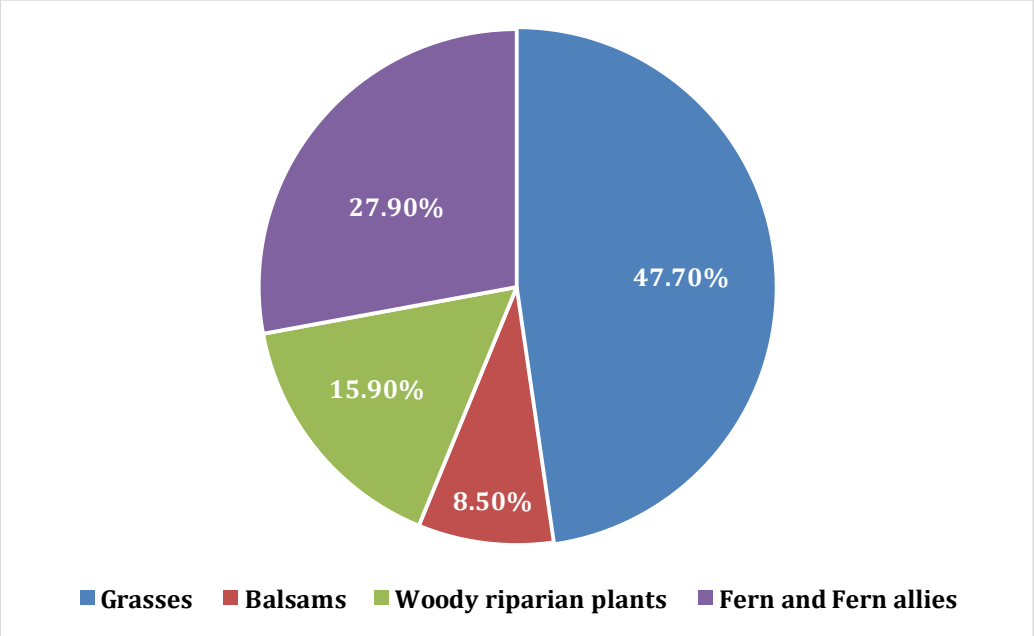


Fig. 9 Major riparian vegetation groups based on species richness

3.2 Fauna

3.2.1 Zooplankton

Zooplankton are heterotrophic, free-floating aquatic organisms that occupy a central position in freshwater food webs, linking primary producers and microbial components to higher trophic levels such as fishes and invertebrate predators. They comprise a diverse assemblage of protozoans and metazoans, including rotifers, cladocerans, copepods, ostracods, and planktonic larval stages. In riverine systems, zooplankton communities are strongly influenced by hydrological conditions, flow variability, connectivity with lentic habitats, and nutrient availability, making them useful indicators of ecological condition and basin-scale processes. Zooplankton exhibited sparse and discontinuous occurrences along the Periyar River; accordingly, the analysis is undertaken at the river-basin scale rather than at individual stretch levels.

The overall zooplankton assemblage recorded from the Periyar River Basin shows considerable taxonomic diversity, encompassing representatives of several major groups (Fig 10). Rotifers were well represented, particularly taxa belonging to the family Brachionidae (e.g., *Brachionus*, *Keratella*) and Filiniidae (*Filinia*). Cladocerans such as *Daphnia*, *Ceriodaphnia*, *Moina*, *Chydorus*, and *Alona* (families Daphniidae, Chydoridae, and Moinidae) formed another important component. Copepods were represented mainly by cyclopoids (*Mesocyclops*, *Tropocyclops*) and calanoids (*Heliodiaptomus*, diaptomid forms). In addition, ostracods (*Stenocypris*), planktonic cnidarians (*Limnocnida indica*), and a diverse suite of protozoan ciliates and dinoflagellates (e.g., tintinnids, *Strombidium*, *Protoperidinium*) contributed to the overall assemblage, underscoring the structural complexity of the zooplankton community at the basin scale.

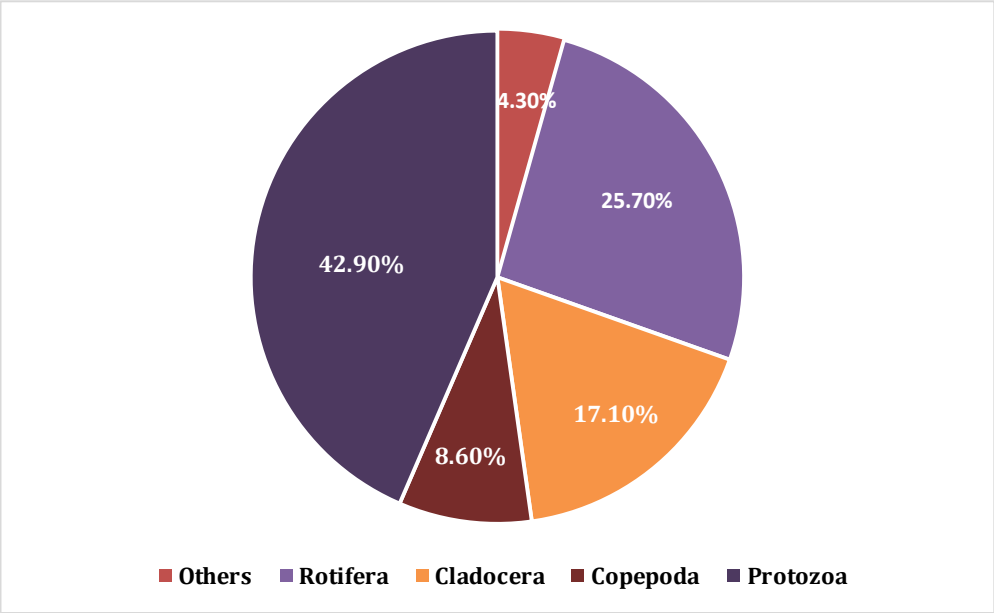


Fig. 10 Composition of Zooplankton Communities in the Periyar River

Family-level classification of the recorded taxa highlights the dominance of a few key groups. Among rotifers, Brachionidae emerged as the most species-rich family, with multiple species of *Brachionus* and *Keratella* recorded. Within crustaceans, Daphniidae (e.g., *Daphnia*, *Ceriodaphnia*) and Cyclopidae (e.g., *Mesocyclops*, *Tropocyclops*) were prominent, while Chydoridae and Moinidae were present with fewer taxa. Protozoan zooplankton were dominated by loricate ciliates belonging to Tintinnidae (*Tintinnidium*, *Tintinnopsis*, *Codonellopsis*), along

with choreotrich and oligotrich ciliates (e.g., *Strombidium*, *Strombidinopsis*, *Halteria*), indicating a substantial microbial plankton component within the basin. Among the more abundant taxa, rotifers such as *Brachionus falcatus*, *Brachionus forficula*, and *Keratella tropica* showed relatively high counts, pointing to the dominance of Brachionidae in the zooplankton community and is depicted in Figure 11.

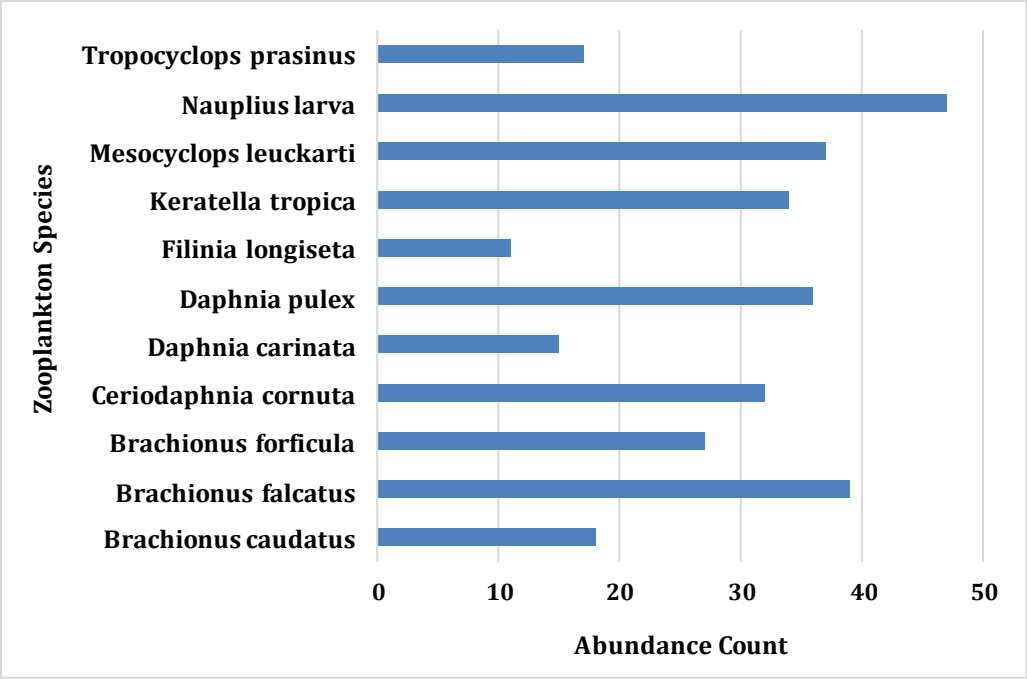


Fig. 11 Abundance of Major Zooplanktons in the Periyar River

Cladocerans including *Daphnia pulex* and *Ceriodaphnia cornuta* were also recorded in notable numbers. Copepods, particularly *Mesocyclops leuckarti* and *Tropocyclops prasinus*, along with a high abundance of nauplius larvae.

3.2.2 Fishes

Fishes are aquatic, ectothermic (cold-blooded) vertebrates that typically possess gills for respiration, fins for locomotion, and a streamlined body adapted for life in water. They represent the most diverse group of vertebrates and occur in a wide range of aquatic environments, including rivers, lakes, wetlands, estuaries, and oceans. Ecologically, fishes play a central role in maintaining the structure and functioning of aquatic ecosystems by regulating food-web dynamics, recycling

nutrients, and linking different trophic levels. In riverine systems, fish assemblages are sensitive to changes in flow regime, water quality, habitat structure, and connectivity, making them reliable indicators of ecological integrity and environmental change.

Across the Periyar River Basin, fish occurrences were documented across four selected river stretches, with species records distributed along the longitudinal continuum of the river. Fish assemblages varied considerably among PR_1, PR_2, PR_3, and PR_4. The spatial distribution of fish observation sites across these four river stretches is illustrated in Figure 12. Stretch wise analysis indicates that PR_1 exhibited the highest fish diversity, recording a wide range of taxa. This stretch supports both rheophilic species such as *Bhavania australis*, *Garra* spp., *Travancoria jonesi*, and *Lepidopygopsis typus*, as well as *Channa* spp., *Oreochromis mossambica*, and *Cyprinus carpio*. In contrast, PR_2 showed extremely low species richness, with only *Dawkinsia filamentosa* and *Opsarius gatensis* recorded, suggesting localized habitat constraints or limited sampling encounters. PR_3 supported moderate diversity, characterized by a mix of hill-stream specialists, large-bodied predators such as *Wallago attu*, and endemic taxa including *Tetraodon travancoricus*. PR_4 recorded comparatively fewer species, dominated by benthic loaches and cyprinids.

A family level examination of the compiled ichthyofaunal data reveals that Cyprinidae emerged as the most dominant and species rich family in the Periyar River Basin (Fig 13). This family was represented by a wide array of genera including *Garra*, *Hypselobarbus*, *Labeo*, *Opsarius*, *Dawkinsia*, *Puntius*, *Rasbora*, *Salmostoma*, and *Tor*. Other well-represented families include Nemacheilidae (*Mesonoemacheilus*, *Schistura*, *Indoreonectes*, and *Travancoria*), Channidae (snakeheads), Bagridae and Siluridae (catfishes), and Cichlidae. The presence of *Clarias gariepinus*, *Oreochromis mossambica*, and *Poecilia reticulata* was also observed and recorded within the basin. Overall, the fish assemblage structure of the Periyar River Basin indicates a system supporting high taxonomic diversity, with strong representation of cyprinids and hill-stream–adapted fishes, particularly in the upstream and midstream reaches.

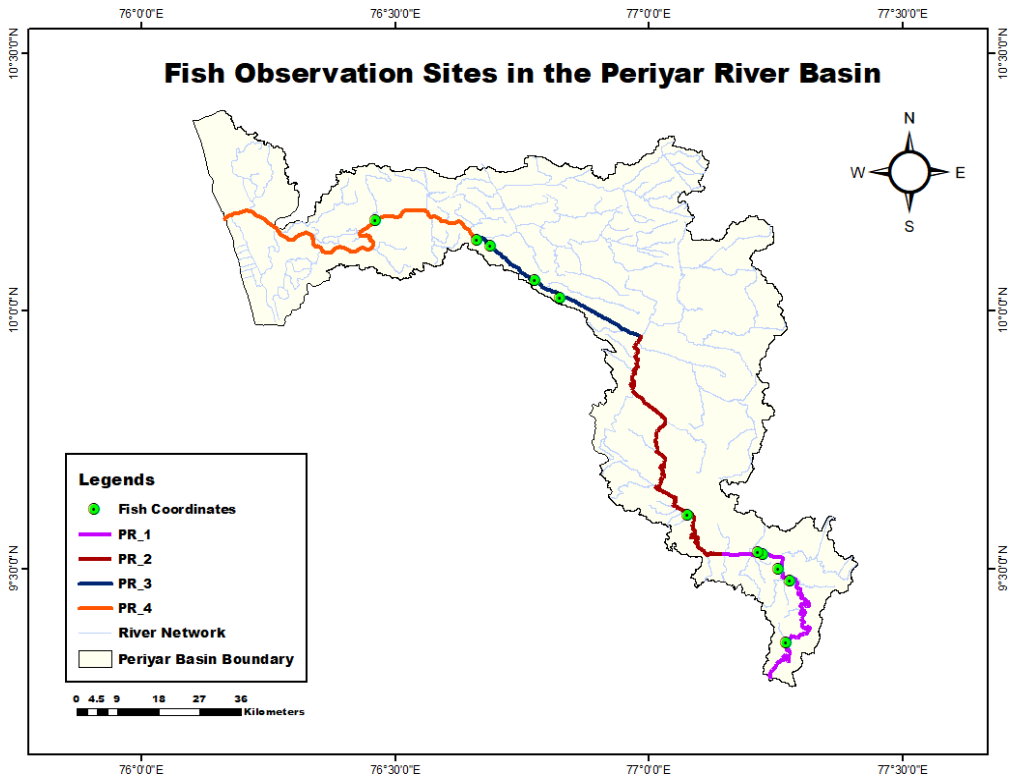


Fig.12 Location Map of Fish Observations Across Periyar River Stretches

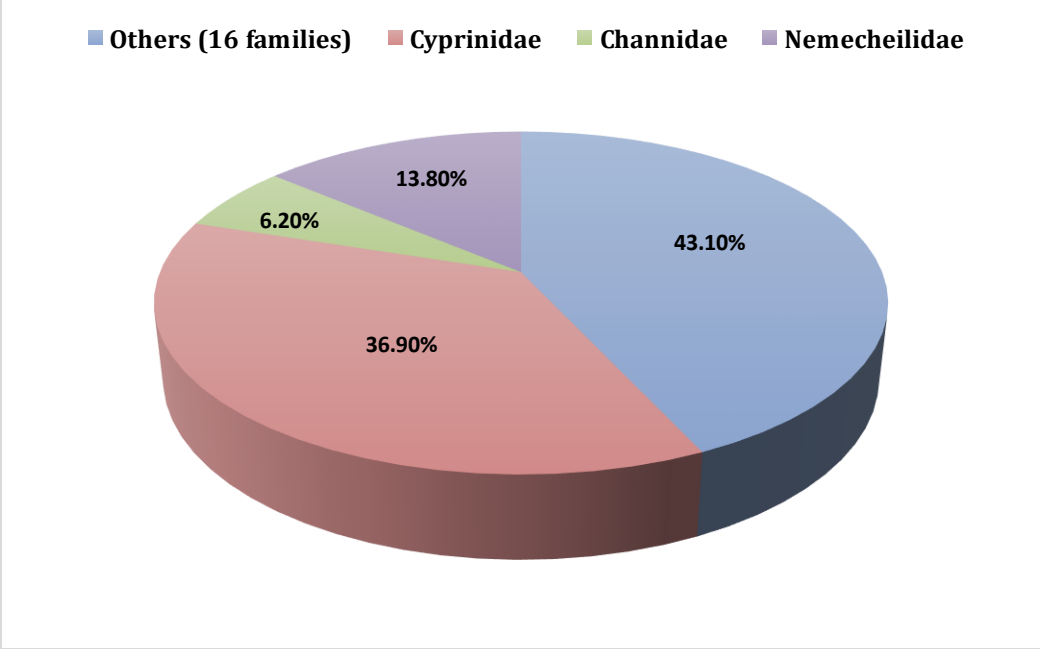


Fig. 13 Composition of Fish Communities in the Periyar River

3.2.3 Higher Aquatic Vertebrates

Higher aquatic vertebrates refer to groups of vertebrate animals that are evolutionarily more advanced than fishes and that depend partly or wholly on aquatic or semi-aquatic habitats for feeding, breeding, or other life-history requirements. Unlike fishes, they possess lungs for respiration and are not permanently confined to water, although many are closely associated with aquatic ecosystems. In freshwater systems, higher aquatic vertebrates mainly include amphibians, aquatic reptiles, aquatic birds, and semi-aquatic mammals. Amphibians (such as frogs and toads) typically rely on aquatic environments for reproduction and larval development, while aquatic reptiles (such as turtles and water snakes) use rivers and wetlands for feeding and thermoregulation. Aquatic birds exploit freshwater habitats for foraging, nesting, or resting, and semi-aquatic mammals (for example, otters) are strongly dependent on riverine and wetland ecosystems for food and shelter. Ecologically, higher aquatic vertebrates occupy upper trophic levels and play key roles as predators, grazers, and bioindicators of ecosystem health. Their presence and distribution are closely linked to habitat quality, prey availability, flow regime, and landscape connectivity, making them valuable indicators in biological profiling and basin–scale ecological assessments.

Higher aquatic vertebrates were recorded in low numbers within individual stretches of the Periyar River, with observations distributed sporadically along the river course. In view of this scattered and discontinuous pattern of occurrence, the present assessment has been undertaken at the scale of the entire river basin rather than at a stretch-wise level, to provide a more representative evaluation of vertebrate diversity and composition. A total of nineteen species of higher aquatic vertebrates were documented, representing amphibians, reptiles, and semi-aquatic mammals. Amphibians formed the most dominant group among the recorded higher aquatic vertebrates, accounting for the majority of species observed in the basin. The assemblage was overwhelmingly represented by frogs belonging to the family Ranidae, followed by Dicroglossidae, Nyctibatrachidae, and Micrixalidae. There was a high representation of ranid frogs within the basin. The Periyar River supports the presence of endemic and habitat-specialist taxa such as *Nyctibatrachus* and *Micrixalus*. Reptilian representation was limited but ecologically notable, with the occurrence of a freshwater turtle and a semi-aquatic snake, while mammalian records included three species of otters. A family-wise examination of the recorded taxa indicates that Ranidae

emerged as the most species-rich family among higher aquatic vertebrates in the Periyar River Basin, while semi-aquatic mammals belonging to the family Mustelidae were also recorded from the basin.

3.2.4 Aquatic Aves

Aquatic aves are bird species that are ecologically associated with freshwater, brackish, or marine environments and depend on aquatic habitats for feeding, breeding, roosting, or other life-history activities. These birds are adapted morphologically, physiologically, and behaviorally to exploit water-based food resources and habitats. Aquatic birds include groups such as ducks, geese, swans, herons, egrets, cormorants, kingfishers, storks, rails, and shorebirds. Their adaptations may include webbed or lobed feet for swimming, long legs and necks for wading, specialized bills for catching fish or invertebrates, and water-repellent plumage. Some species are obligate aquatic foragers, while others use aquatic habitats opportunistically. Ecologically, aquatic aves occupy higher trophic levels and play important roles in regulating fish and invertebrate populations, nutrient transfer between aquatic and terrestrial systems, and energy flow within wetlands and riverine ecosystems. Because their distribution and abundance respond sensitively to changes in water quality, hydrology, and habitat structure, aquatic birds are widely used as indicators of wetland and river ecosystem health in biological profiling studies.

Within the Periyar River Basin, aquatic birds were recorded in relatively low numbers at individual river stretches, with sightings occurring in a scattered and discontinuous manner along the river course. Given this sparse spatial distribution, the present assessment evaluates the aquatic avifaunal assemblage at the scale of the entire river basin rather than analysing stretchwise patterns. The aquatic bird assemblage of the Periyar River Basin is taxonomically diverse, comprising species belonging primarily to the orders Pelecaniformes, Anseriformes, Charadriiformes, Suliformes, Accipitriformes, Coraciiformes, and Gruiformes. A total of 48 aquatic bird species were documented, representing a broad spectrum of ecological guilds including wading birds, waterfowl, piscivorous raptors, plunge-divers, surface feeders, and shoreline foragers. A family-wise analysis of aquatic birds recorded from the Periyar River Basin reveals a pronounced dominance of wading and shallow-water foraging groups. The family Ardeidae emerged as the most species rich group, represented by multiple herons, egrets, and

bitterns. Anatidae, comprising resident and migratory ducks, formed another important component. Families such as Charadriidae and Scolopacidae were represented by plovers and sandpipers. Piscivorous diving and plunge-feeding birds were recorded from the families Phalacrocoracidae, Anhingidae, and Laridae. Large-bodied wetland specialists of the family Ciconiidae were also observed, in addition to apex and near-apex predators such as fish eagles and ospreys from the families Accipitridae and Pandionidae. Additional representation from families such as Alcedinidae, Motacillidae, Podicipedidae, Glareolidae, and Strigidae collectively illustrates the ecological heterogeneity of the Periyar River Basin. The proportional representation of these families is illustrated in Figure 14, which depicts the family-wise proportional composition of aquatic bird species recorded in the Periyar River Basin.

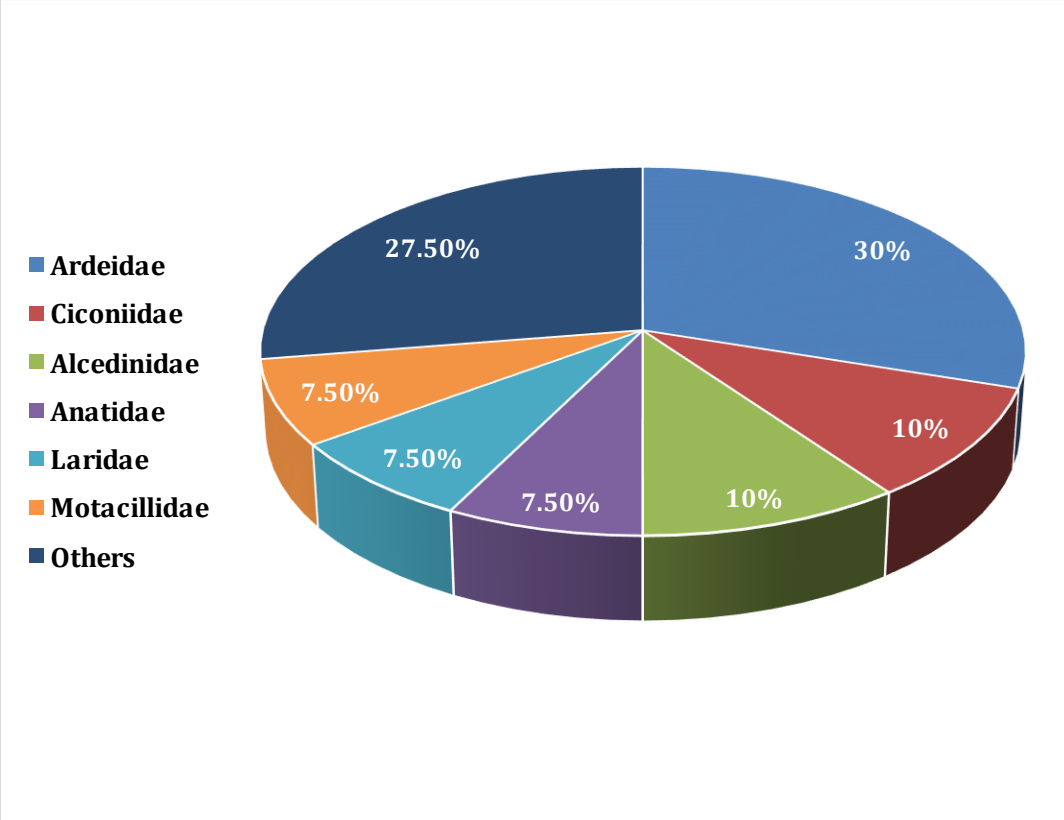


Fig. 14 Family-wise composition of aquatic bird species recorded in the Periyar River Basin

4. Status of major Focal species

Focal species are selected organisms used to represent broader ecological conditions, chosen because their ecological characteristics, habitat requirements, or sensitivity to environmental change provide insight into the overall state of an ecosystem. Depending on the objective, focal species may include indicator species that reflect environmental quality, umbrella species whose conservation supports a wider set of co-occurring taxa through shared habitat requirements, or flagship species that help guide conservation priorities. Among these, keystone species hold particular importance, as they exert a disproportionately strong influence on ecosystem structure and functioning relative to their abundance, and changes in their presence can lead to cascading ecological effects. In this context, this report includes a keystone species–based assessment of the Periyar River Basin, with their occurrence and distribution examined on a stretch-wise basis to capture spatial variation along the river continuum. To support systematic biomonitoring, the Periyar River has been delineated into distinct river stretches using geomorphological, hydrological, and ecological considerations, providing a consistent spatial framework for evaluating riverine ecological condition.

4.1 Biomonitoring for Periyar river

The identified stretches of the Periyar river offer a logical basis for selecting biomonitoring sites that capture the basin's ecological diversity and pollution pressures. In the upper catchment (PR1), locations such as Periyar lake and Thanikudi represent relatively pristine headwater conditions and serve as essential reference sites. The mid-basin segment downstream of the Idukki Reservoir (PR 3), including Panamkutty, reflects the combined influences of major tributaries such as Muthirapuzha and Chinnar as well as regulated flows from the Idukki Dam, making it a priority zone for tracking ecological responses to hydrological alterations. Further downstream (PR 4), Neriamangalam and Malayattoor represent dynamic alluvial and mixed river styles where urban pressures and increased sediment loads begin to influence river health. Collectively, these sites create a representative biomonitoring network that spans headwaters to the river mouth, supporting comprehensive ecological assessment across the entire Periyar basin. The different river stretches along the main stem of Periyar and the bio-monitoring locations in the basin are given in Figure

15. The other significant locations (Anakulam & Mankulam) in the tributaries are also included in the list of biomonitoring points, due to its species abundance.

Table 1: Details of Proposed stretches for biomonitoring in Periyar

Stretch	Start	End	Features
PR 1	Origin (Chokkampatti Malai)	Mullaperiyar Dam	Hilly terrain with slope > 15° River Margin and valley margin coinciding Boulders, cobbles and pebbles Straight and tortuous channel
PR 2	d/s of Mullaperiyar dam	Panamkutty Bridge	Pediment zone with slope 5 to 15° River margin and valley margin coinciding Near to straight channel
PR 3	Panamkutty Bridge	Bhoothathankettu Barrage	Combination of pediment and alluvial fan (slope < 5°) Gorges found Meandering channel Sinuosity – 1 to 1.4
PR 4	d/s of Bhoothathankettu Barrage	Outlet	Alluvial plain and coastal plain Slope <3° Laterally unconfined Meandering channel Sinuosity – 1.2 to 1.48

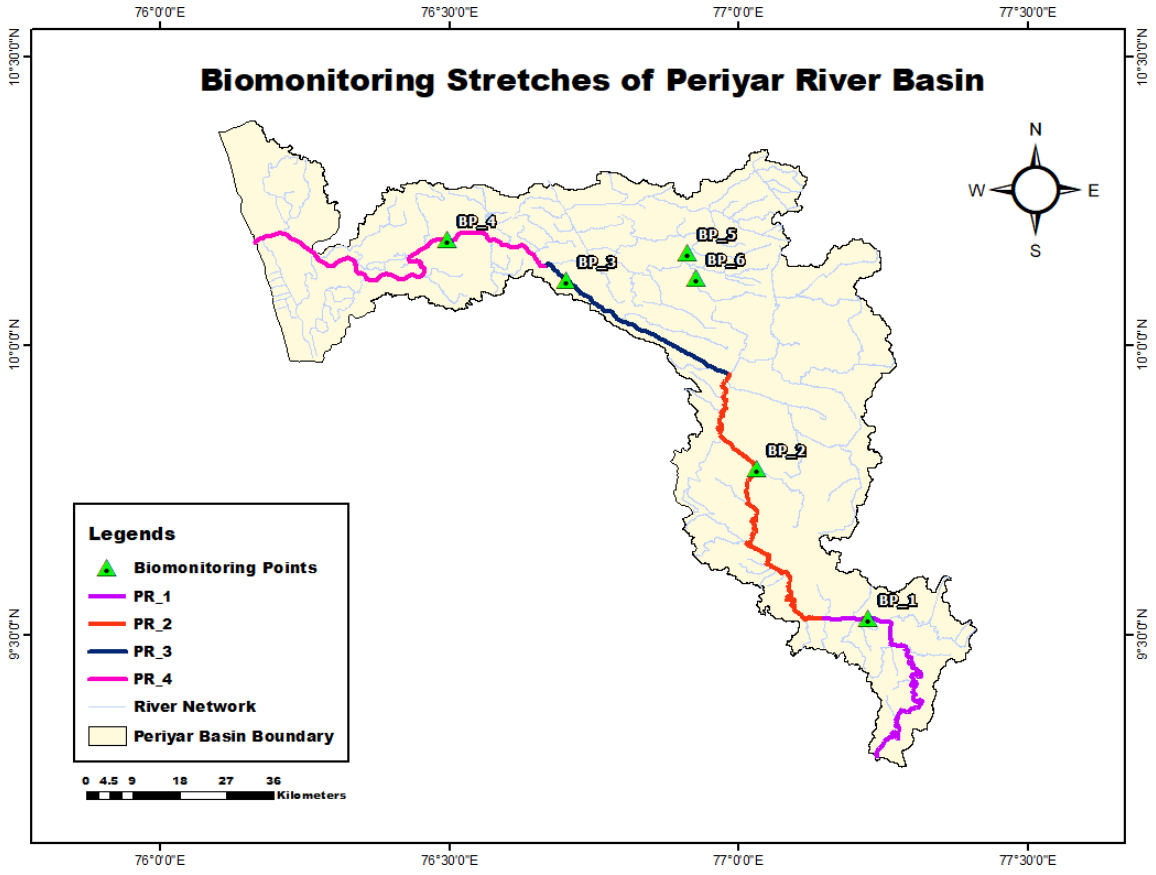


Fig. 15 Proposed stretches for biomonitoring in Periyar

4.2 Identification of ecologically significant species for each stretch

Ecologically significant species were identified for each river stretch based on their functional importance in maintaining ecosystem structure and processes. The identification of probable keystone species was guided by key ecological criteria, including strong control over community structure, regulation of trophic interactions, influence on ecosystem processes such as energy flow and nutrient cycling, and the potential to trigger cascading ecological effects if removed. Additional considerations included the species presence, functional irreplaceability, and its role in linking biotic components within each riverine stretch. Accordingly, *Garra mullya* was identified as the probable keystone species in the Origin (Chokkampatti Malai) to Mullaperiyar Dam stretch, *Opsarius gatensis* in the downstream of Mullaperiyar Dam to Panamkutty bridge stretch, *Wallago*

attu in the Panamkutty bridge – Bhoothathankettu Barrage stretch, and *Bhavania australis* in the d/s Bhoothathankettu Barrage – outlet stretch of the Periyar mainstem (Fig 16).

In the first upstream stretch (PR_1), characterized by steep terrain, high flow velocity, and a tortuous channel with boulders, cobbles, and pebbles, the ecosystem is strongly dependent on algal biofilms developing on rock surfaces. *Garra mullya* functions as the dominant biofilm grazer in this pristine, fast-flowing reach. Despite its relatively small body size, it is abundant and continuously present, playing a critical role in maintaining benthic habitat quality. The removal of *Garra mullya* would likely lead to unchecked algal overgrowth, subsequent decline in macroinvertebrate diversity, reduced food availability for insectivorous fishes, and overall ecosystem imbalance, underscoring its keystone role.

In the second stretch (PR_2), *Opsarius gatensis* was identified as the probable keystone species. This segment is characterized by a near-straight channel, regulated flow conditions, and pediment-zone geomorphology. The aquatic food web in this stretch is strongly dependent on drifting aquatic insects. *Opsarius gatensis* functions as a key mid-trophic insectivorous predator, efficiently transferring energy from drifting invertebrates to higher trophic levels. Its strong association with flow dynamics and high abundance make it integral to maintaining trophic connectivity. Removal of this species would likely disrupt prey regulation and weaken food-web linkages.

The third stretch (PR_3), supports *Wallago attu* as the probable keystone species. This segment exhibits a combination of pediment and alluvial characteristics, with a meandering channel and moderate sinuosity. The ecosystem supports abundant prey fishes and macroinvertebrates, forming the basis for a complex trophic structure. *Wallago attu*, as a large-bodied apex predator, regulates prey populations and prevents trophic imbalance. Its mobility and feeding versatility enable it to exert top-down control across habitats. The absence of this predator would likely result in prey population proliferation, altered community composition, and reduced ecosystem stability.

In the downstream stretch (PR_4), *Bhavania australis* was identified as the probable keystone species. This segment is characterized by alluvial and coastal plains, laterally unconfined channels, and pronounced meandering. The ecosystem here is primarily supported by benthic insects and

detrital energy pathways. *Bhavania australis* is a substrate-associated benthic insectivore that plays a critical role in structuring benthic communities and regulating invertebrate populations. Its consistent presence and specialized feeding behavior contribute to maintaining benthic ecosystem balance.

a) *Garra mullya*

b) *Opsarius gatensis*

c) *Wallago attu*

d) *Bhavania australis*

Fig. 16 Probable Keystone Species in each stretch of the Periyar River Basin

Overall, the identified focal species *Garra mullya*, *Opsarius gatensis*, *Wallago attu*, and *Bhavania australis* represent functionally distinct keystone taxa operating at different trophic levels and habitat interfaces along the river continuum. Their ecological roles highlight the strong linkage between geomorphological setting, flow regime, and biological functioning within the Periyar River system, emphasizing the importance of stretch-specific conservation and management strategies.

4.3 Conservation and Management needs

The identified focal species represent key functional components of the Periyar River ecosystem, and their long-term persistence is closely linked to the maintenance of natural flow regimes, habitat

heterogeneity, and longitudinal connectivity of the river. Conservation and management efforts must therefore adopt a stretch-specific approach that recognizes the distinct ecological roles played by each species while ensuring overall ecosystem integrity along the river continuum.

In the upstream reaches, the conservation of *Garra mullya* is strongly dependent on protecting high-gradient, fast-flowing habitats with coarse substrates. Any alteration to natural flow patterns, sediment dynamics, or water quality, particularly due to impoundments, flow regulation, or catchment-level disturbances may adversely affect biofilm production and benthic habitat quality. Management actions should prioritize the maintenance of environmental flows, prevention of excessive sedimentation, and control of anthropogenic activities that could degrade rocky substrates essential for this species.

For midstream regulated reaches supporting *Opsarius gatensis*, conservation needs are closely tied to sustaining flow variability and prey availability. Regulated discharges from dams and power stations should be managed to mimic natural flow pulses that support drifting aquatic insect populations. Additionally, maintaining water quality and minimizing abrupt flow fluctuations are essential to preserve trophic linkages and prevent disruption of mid-channel habitats that this species relies upon for feeding and movement.

The conservation of *Wallago attu* in the transitional pediment–alluvial stretches require safeguarding habitat connectivity and prey base integrity. As a top predator, this species is particularly vulnerable to overfishing, habitat fragmentation, and loss of lateral connectivity with floodplain and marginal habitats. Management strategies should include regulating fishing pressure, protect spawning and nursery areas, and ensure longitudinal connectivity across barrages and flow-control structures to support natural movement and population stability.

In the downstream alluvial and coastal plain reaches, effective conservation of *Bhavania australis* depends on maintaining benthic habitat quality and natural sediment processes. Activities that alter substrate composition, such as sand mining, channel modification, or pollution induced organic loading, can significantly impact benthic invertebrate communities and, in turn, this focal species. Management measures should focus on regulating substrate-altering activities, maintaining water quality, and preserving natural channel morphology to sustain benthic ecosystem functioning.

Overall, conservation and management of these focal species should be integrated within a basin-scale framework that emphasizes environmental flow management, habitat protection, and connectivity conservation. Protecting these ecologically significant species will not only ensure their survival but also contribute to the resilience and functional stability of the Periyar River ecosystem as a whole.

5. Conclusions and Recommendations

This report presents a comprehensive biological profiling of the Periyar River. The assessment encompasses primary producers (periphyton and phytoplankton), riparian vegetation, zooplankton, fishes, higher aquatic vertebrates, and aquatic birds, thereby providing a basin-scale understanding of biological diversity and river health. The identification of ecologically significant and probable keystone species for distinct river stretches further enhances the management relevance of the biological profiling. These species act as integrators of habitat condition and trophic structure, offering practical focal points for monitoring ecological change and evaluating management interventions. Fish assemblages, higher aquatic vertebrates, and selected algal and invertebrate groups emerge as particularly effective indicators of longitudinal connectivity, environmental flows, and habitat quality.

The assessment demonstrates that biological indicators provide a sensitive and integrative measure of river health, reflecting cumulative impacts of flow alteration, water quality degradation, habitat fragmentation, and invasive species. While upper and selected mid-basin reaches retain comparatively high ecological integrity, downstream sections show clear signs of biological stress, emphasizing the need for targeted conservation and restoration measures. Overall, the report establishes a robust baseline for understanding the biological condition of the Periyar River system and its tributaries, and underscores the importance of basin-scale, long-term biological monitoring to support sustainable river management, biodiversity conservation, and informed decision-making by stakeholders.

When embedded within the proposed monitoring and feedback framework, the biological findings assume a central role in adaptive river basin management. The recommended biomonitoring stretches from headwater reference sites to downstream alluvial and estuarine reaches, provide a

representative network for tracking ecological integrity over time. Integrating biological monitoring with rainfall, streamflow, and water-quality observations enables early detection of ecological degradation, assessment of cumulative impacts, and evaluation of the effectiveness of management actions such as environmental flow releases, pollution control measures, and habitat restoration.

Overall, the combined outcomes of these reports underscore that sustaining the Periyar's ~~River's~~ ecological health requires basin-wide, long-term, and participatory monitoring anchored in biological indicators. Protection of headwater systems, maintenance of environmental flows, conservation of riparian corridors, control of pollution sources, and restoration of degraded reaches are essential to maintaining biodiversity and ecosystem functioning. By establishing a scientifically robust ecological baseline and embedding it within a structured monitoring and feedback system, this integrated framework provides decision-makers, researchers, and communities with a practical and scalable pathway for safeguarding the ecological resilience and long-term sustainability of the Periyar River Basin.

6. References

1. cPeriyar, cGanga, & National River Conservation Directorate (NRCD). *Geomorphological Mapping of the Periyar River*. Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India. (2025)

2. *Periyar River Basin – Room for River*, Irrigation Department, Government of Kerala

3. *Periyar River Basin Atlas*, Centre for Ganga River Basin Management and Studies (cGanga) and Centre for Periyar River Basin Management Studies, IIT Palakkad & NIT Calicut. (March 2025)

4. Joseph,M.L (2004). *Status report on Periyar river*. Kerala, India, 43-48.

5. District Tourism Promotion Council, Idukki District, Government of Kerala (https://www.dtpcidukki.com/)

6. *Periyar River at a Glance*. Ministry of Jal Shakti, Department of Water Resources, National River Conservation Directorate (NRCD). River Development & Ganga Rejuvenation, Centre for Periyar River Basin Management Studies - IIT Palakkad & NIT Calicut, Government of India. (2024)

7. Divya, J & Krishnakumar, A. Soil geochemistry of Periyar river basin, Maria Jovita and Nandhana K. (2021)

8. A Legal Analysis on Water Pollution Pertaining to Periyar River of Kerala, 8 (2) IJLMH Page 2395 - 2407 (2025)

9. Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverria, C., Gonzales, E. K., Shaw, N., Decleer, K., & Dixon, K. W. *International principles and standards for the practice of ecological restoration* (2nd ed.). *Restoration Ecology, 27*(S1), S1–S46. (2019)

10. Wortley, L., Hero, J.-M., & Howes, M. Evaluating ecological restoration success: A review of the literature. *Restoration Ecology, 21*(5), 537–543. (2013)

11. Kottelat, Maurice & Whitten, A. Freshwater biodiversity in Asia with special reference to fish. World Bank Technical Paper. 343. 1-59. (1996)

12. Arundhati Das, Jagdish Krishnaswamy, Kamaljit S. Bawa, M.C. Kiran, V. Srinivas, N. Samba Kumar, K. Ullas Karanth, Prioritisation of conservation areas in the Western Ghats, India, Biological Conservation. (2006)

13. Jayalakshmi, P. S., & John, J. Impact of massive flood in Kerala on the algal biodiversity of Periyar River. *Indian Hydrobiol*, *18*(1-2), 11-18. (2019)

14. Radhakrishnan, K.V. & B.M. Kurup (2010). Ichthyodiversity of Periyar Tiger Reserve, Kerala, India. *Journal of Threatened Taxa* 2(10): 1192-1198

15. John, B., & Kumar, R. S. An overview of periphytic organisms; species composition, substrate specificity and seasonal preference along different stretches of River Periyar, Kerala, India. (2021)

16. Kutty, Ranjeet & Kurup, Madhusoodana. (2012). Anthropogenic Threats to Fish Biodiversity of Periyar Lake, A Western Ghats Hotspot

17. Kerala State Planning Board. (2020). *Economic Review 2019*. Government of Kerala