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Ecological drivers of anuran diversity and microhabitat use in the wetlands of Alappuzha, Keralam

Sandeep K Das, Dr. Suresh K K
Research, Department of Zoology, NSS Hindu College, Changanacherry, Keralam, India

Abstract
Wetlands are highly productive ecosystems increasingly threatened by habitat degradation, land-use change, and climate change, particularly in low-altitude landscapes outside protected areas. Amphibians are highly sensitive to environmental variation, making them useful indicators of wetland ecological condition. This study investigated the environmental and microhabitat factors associated with anuran occurrence in the wetlands of Alappuzha, Keralam. Field surveys recorded anuran occurrences along with substrate temperature, air temperature, soil moisture, canopy cover, humidity, and associated microhabitat characteristics. A total of 63 anuran individuals were recorded across five microhabitat categories: herbaceous vegetation, leaf litter, open ground, shrub layer, and open water surface. A binomial generalized linear model was used to evaluate the influence of environmental and microhabitat variables on anuran occurrence. Soil moisture and substrate temperature emerged as significant predictors, with anuran occurrence increasing with soil moisture but decreasing with substrate temperature. Other environmental and microhabitat variables showed no significant effects. These findings highlight the importance of moisture availability and near-ground thermal conditions in supporting anuran populations in low-altitude wetlands. Maintaining moisture regimes and conserving structurally diverse microhabitats can therefore contribute to anuran persistence and strengthen conservation management in human-dominated wetlands outside protected areas.

Keywords: Anuran diversity, wetland ecology, microhabitat, soil moisture, Alappuzha, Keralam

Introduction

Climate change is a major concern regarding the loss of global biodiversity in the current time period. The IPCC report of 2023 indicates that within 20 years from now there would be biodiversity loss and habitat degradation as a result of significant fluctuations in global surface temperature [1]. Organisms of different ecosystems are adapting to this change by adjusting their life cycle or shifting their range of distribution to make use of resources effectively [2, 3]. Wetlands represent highly productive ecosystems that support high levels of biodiversity and provides critical ecosystem services. Despite their ecological and socio-economic importance, wetlands are increasingly threatened by land-use change, pollution, hydrological alterations, and climate change, leading to habitat degradation, biodiversity loss, and diminished ecosystem services, particularly in lowland landscapes [4, 5]. Wetlands of the Western Ghats (WG) are affected by human-induced disturbances such as poor waste management, landfilling associated with developmental activities, and pollution, resulting in habitat degradation and biodiversity decline [6, 7]. Nevertheless, most ecological studies in the region have focused on high-elevation ecosystems, with limited attention given to wetland environments. These pressures are often influencing sensitive taxa that inhabit such wetland ecosystems. Amphibians are considered as indicator species due to their ecology and physiology [8]. The conservation of anuran communities presents in wetland habitats require the understanding of how microhabitat factors influence the presence of anurans i.e. their ecology.

This study investigates the relative importance of environmental and microhabitat factors driving anuran presence in the Alappuzha wetlands, with the objective of elucidating the influence of abiotic conditions and habitat characteristics on species distribution and habitat use.

Materials and Methods

The study area included coastal wetlands of Alappuzha district of Keralam, India (Fig. 1). This habitat is predominantly made up of waterbodies with both fresh water and brackish water (Fig 2.). The study area does not fall under any designated protected area and are seen mixed with human habitations.

Anurans were observed in their natural habitat and environmental variables were noted down. The surveying of anurans was conducted through Nocturnal Visual Encounter Survey technique [9]. Each individual anuran was photographed and their microhabitat variable was recorded using appropriate instruments. The variables recorded were substrate temperature, air temperature, soil moisture, relative humidity, canopy cover; microhabitats classified as: herbaceous, leaf litter, open ground, shrub, open water.

Substrate temperature was measured using non-contact infrared thermometer [10]. Soil moisture was measured using handheld soil moisture probe [11]. Humidity and air temperature were recorded using a digital thermohygrometer. Canopy cover was calculated using photographs through the GLAMA software [12].

Generalized Linear Models (GLMs) with binomial response was used to analyze the influence of environmental variables on anuran community. All statistical analyses were done using Stat package in R [13].

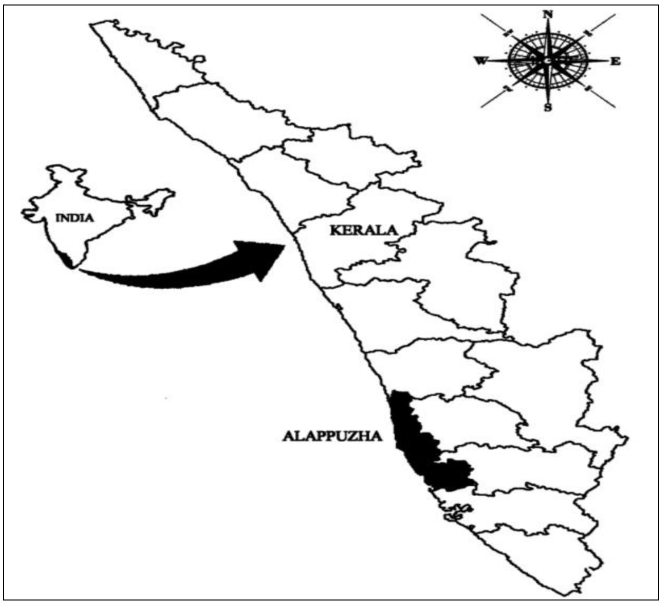

Fig 1: Map of the study area showing Alappuzha district

Fig 2: Wetlands of Alappuzha

Results

The field survey results recorded a total of 63 individual anurans from the study sites. A GLM was fitted to assess the environmental and microhabitat variables associated with anuran occurrence across the 63 individuals recorded (Table. 1). Substrate temperature had a significant negative association with anuran occurrence ($\beta = -0.188 \pm 0.078$ SE, $z = -2.39$, $p = 0.0167$), with an odds ratio of 0.83. In contrast, soil moisture showed a significant positive association with occurrence ($\beta = 0.306 \pm 0.104$ SE, $z = 2.95$, $p = 0.0032$), corresponding to an odds ratio of 1.36. Air temperature ($\beta = 0.067 \pm 0.120$ SE, $z = 0.56$, $p = 0.578$), canopy cover
($\beta = 0.020 \pm 0.015$ SE, $z = 1.31$, $p = 0.189$), and humidity ($\beta = 0.010 \pm 0.021$ SE, $z = 0.48$, $p = 0.634$) were not significantly associated with anuran occurrence.

Table 1: Results of GLM showing the effects of environmental and microhabitat variables on anuran presence–absence in the wetlands of Alappuzha, Keralam. Estimates, standard errors, z-values, p-values, and odds ratios are presented. Asterisks (*) indicate statistically significant effects ($p < 0.05$)

	Estimate	Std. Error	z value	p-value	Odds Ratio (exp (Estimate))
Substrate temperature	–0.188	0.078	–2.39	0.0167*	0.83
Soil moisture	0.306	0.104	2.95	0.0032	1.36
Air temperature	0.067	0.120	0.56	0.578	1.07
Canopy cover	0.020	0.015	1.31	0.189	1.02
Humidity	0.010	0.021	0.48	0.634	1.01
Herbaceous vegetation	–0.210	0.704	–0.30	0.766	0.81
Leaf litter	–0.552	0.857	–0.65	0.519	0.58
Open ground	0.453	0.671	0.68	0.500	1.57
Open water surface	–1.549	0.892	–1.74	0.083	0.21
Shrub layer	0.550	0.670	0.82	0.412	1.73

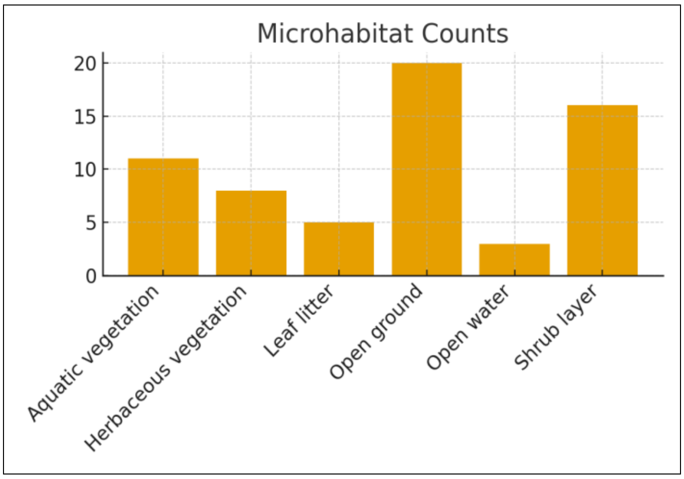

Fig 3: Count of microhabitat usage by anurans

Fig 4: Karaavali skittering frog (*Phrynoderma karaavali*) observed in the herbaceous vegetation of the study area

Soil moisture is the strongest predictor of anuran presence and substrate temperature has a negative influence on anuran presence. Microhabitat counts for each individual anuran observation indicates that vegetated habitats are the preferred microhabitats across two categories namely: herbaceous vegetation and shrub layer (Fig. 3 & 4). Ranking of microhabitat use: Herbaceous vegetation > Leaf litter > Shrub > Open water > Open ground.

Discussion and Conclusions

Our study finds that anuran community of the coastal wetlands of Alappuzha are influenced mainly by microclimatic variables. Soil moisture and substrate temperature drives the anuran presence in this landscape while structural vegetation supports moisture buffering. Similar observations have been made on anuran ecology in other studies [14, 15]. The results highlight that microclimatic variables, especially soil moisture and substrate temperature are central to whether anurans occupy patches within these wetlands. Vegetation provides thermal and moisture buffering, explaining the preference for herbaceous and leaf litter microhabitats. Given many Alappuzha wetlands lie outside formal protection and face drainage, land conversion and climate stress, these findings raise concern for both biodiversity and ecosystem services. Anurans serve as indicators of ecosystem health and provide natural pest control; their decline could cascade into agricultural impacts locally.

These findings highlight the importance of practical, site-level conservation measures for sustaining anuran populations, particularly in wetlands outside protected areas. Maintaining or restoring local moisture regimes through small water-retention features and avoiding unnecessary drainage can help preserve breeding and refuge habitats [16]. Similarly, conserving vegetated microhabitats, including herbaceous vegetation and leaf-litter cover, can provide essential shelter and moisture-retaining environments for anurans [17]. Establishing buffer zones and promoting low-intensity land-use practices around wetlands can further reduce habitat degradation and maintain ecological connectivity [18]. Collectively, these targeted and feasible interventions can be implemented by local managers and farmers and offer a practical pathway for strengthening anuran persistence in human-modified wetland landscapes, particularly under increasing climatic stress.

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