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Seasonal Variation and Spatial Distribution of Purple Heron (Ardea purpurea) in Urban Wetlands of Kota, Rajasthan, India

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Abstract

The Purple Heron (Ardea purpurea) is a wetland-dependent species and an important indicator of ecosystem health in aquatic ecosystems. This study examines its spatial distribution and seasonal fluctuations across three urban wetlands in Kota, Rajasthan —Abheda Pond, Ummedganj Pakshi Vihar Conservation Reserve (UPVCR), and Right Main Canal—from November 2024 to November 2025. Abundance patterns showed a marked seasonal rhythm, with highest numbers recorded during the pre-monsoon period (April–June) and the lowest during winter. Non-parametric tests (Kruskal–Wallis, Mann–Whitney, and Spearman's correlation) revealed significant temporal and spatial differences in abundance ($p < 0.05$). The pronounced increase in pre-monsoon aligns with the species' nesting activity and the availability of shallow foraging habitats. Overall, the study emphasizes the ecological importance of urban wetlands and canals in sustaining heron populations when hydrological stability and minimal disturbance are maintained.

Keywords: Abundance, Canal, Purple Heron, Seasonal dynamics, Urban wetlands.

Introduction

Urban wetlands serve as crucial refuges for water birds within rapidly transforming landscapes. Their mosaic of aquatic, semi-aquatic and vegetated habitats provide refuge, foraging space, and breeding sites for numerous species[1]. Among these, herons are particularly sensitive to hydrological shifts and habitat alteration due to their reliance on shallow waters for foraging and vegetative nesting substrates[2]. The Purple Heron (Ardea purpurea) is a colonial nester whose abundance fluctuates seasonally, following water availability and prey dynamics[3]. Purple Herons hold significant ecological importance because they serve as indicators of wetland health[4]. Purple Heron populations are closely associated with marshy reed-bed wetlands and depend strongly on wetland integrity for breeding and survival[6,7].

Urban and peri-urban wetlands across India have undergone rapid transformation due to hydrological modification, land-use change and encroachment, all of which affect water bird diversity and abundance[8,9]. In particular, changes in water depth, wetland drainage and disturbance from fishing and tourism can significantly influence heron distribution and breeding success[10,11]. Interestingly, recent observations of Purple Herons nesting on floating mats of Eichhornia crassipes[12] suggest adaptive responses to altered wetland conditions.

Despite Kota's network of ponds, canals and conservation reserves, detailed assessments of Purple Heron abundance in this urban landscape have been limited. This study therefore aims to quantify monthly and seasonal variation in Purple Heron abundance across three key wetland sites in Kota, linking fluctuations to hydrology and anthropogenic influence.

Materials and Methods

Study Area: Kota, located along the perennial Chambal River in southeastern Rajasthan, supports a network of natural and human -modified wetlands, canals and seasonally waterlogged agricultural fields that offer diverse habitats for water birds. The city lies between 24°25' and 25°59' North latitude and 75°37' and 77°26' East longitude.

The study was conducted at in three contrasting wetland sites within urban landscape: i. Abheda Pond – a semi-natural pond characterized by patches of lotus vegetation and moderate human activity. ii. Ummedganj Pakshi Vihar Conservation Reserve (UPVCR)– a protected wetland dominated by reed beds and relatively low disturbance. iii. Right Main Canal – a perennial canal with fluctuating water levels.

Data Collection: Monthly bird counts were conducted from November 2024 – November 2025. Observations were carried out during early morning hours (006-0900), when Purple Heron activity is typically highest. The point-count method was used[13] and the maximum number of individuals observed simultaneously at each site was recorded as the monthly abundance value. This approach minimized the risk of double-counting and ensured comparability across months and sites. All observations were made using standard binoculars and environmental conditions (e.g., water level, disturbance) were noted qualitatively during each visit.

Statistical Analysis: Prior to statistical testing, data were examined for normality using the Shapiro–Wilk test ($p < 0.05$), which indicated non-normal distribution. Therefore, non-parametric tests were applied.

Kruskal–Wallis tests were used to compare abundance among the three sites and across seasons[14].

Mann–Whitney U tests with Bonferroni-correction were performed for pairwise comparisons when significant differences were detected[14].

Spearman's rank correlation (ρ) was used to assess synchrony in monthly abundance patterns between sites[14].

All analyses were performed using standard statistical software and significance was considered at $p<0.05$.

Results and Discussion

Monthly and Seasonal Abundance: Purple Heron abundance varied noticeably across months and seasons at all three study sites. Numbers were lowest during the winter months (November –February) when dam-related water releases increased water depth in canals and ponds, reducing the availability of shallow foraging zones. Abundance began to rise in March and reached a pronounced peak during the pre-monsoon period (April–June), after which number gradually declined (Table-1, Figure-1). The Kruskal–Wallis test revealed significant differences among sites ($H = 6.71$, $df = 2$, $p = 0.035$) and across seasons ($H = 9.84$, $df = 3$, $p = 0.008$). Spearman's rank correlations indicated strong synchrony in monthly abundance trends across sites ($\rho = 0.73–0.82$, $p < 0.01$).

Pair wise Mann–Whitney U Tests: Pair wise comparisons were conducted using the Mann–Whitney U test to evaluate differences in abundance between individual sites. The test between Abheda Pond and the Right Main Canal showed a marginally significant difference before correction ($U = 46.0$, $p = 0.044$). Comparisons between Abheda Pond and UPVCR ($U = 69.0$, $p = 0.374$) and between UPVCR and the Right Main Canal ($U = 60.0$, $p = 0.185$) were not significant.

After applying a Bonferroni correction for multiple comparisons (adjusted $\alpha = 0.016$), none of the pair wise differences remained statistically significant.

Kruskal–Wallis test indicated significant differences among the three sites ($H(2) = 6.71$, $p = 0.035$) and across seasons ($H(3) = 9.84$, $p = 0.008$). Spearman's rank correlation coefficients ($\rho = 0.73–0.82$, $p < 0.01$) showed strong synchrony in monthly trends across sites, suggesting that regional hydrological patterns influenced heron numbers similarly throughout Kota.

Seasonal Mean Abundance: Seasonal averages also showed clear differences. Pre -monsoon months consistently supported the highest mean abundance across sites, reflecting favorable foraging conditions and the onset of breeding activity. In contrast, winter showed the lowest mean abundance, followed by moderate numbers during the monsoon and post -monsoon periods. These patterns are summarized in Table-2, with corresponding trends shown in Figure-2.

Table-1: Monthly and Seasonal Abundance.

Month-Year	Abheda Pond	UP VCR	Right Main Canal	Mean Abundance
Nov. 2024	1	1	7	3
Dec. 2024	1	5	3	3
January 2025	2	4	4	3.33
February 2025	4	3	5	4
March 2025	2	7	10	6.33
April 2025	25	20	20	21.67
May 2025	20	13	13	15.33
June 2025	15	8	32	18.33
July 2025	8	7	6	7
August 2025	5	8	6	6.33
Sept. 2025	2	8	8	6
October 2025	0	2	4	2
Nov. 2025	0	2	5	2.33

Table-2: Seasonal Mean Abundance.

Season	Abheda Pond	UP VCR	Right Main Canal	Mean Abundance
Winter	2	3.25	4.75	3.33
Pre-monsoon	15.5	12	18.75	15.42
Monsoon	5	7.67	6.67	6.44
Post-monsoon	0	2	4.5	2.17

Discussion: Seasonal patterns in Purple Heron abundance across the three urban wetlands of Kota appear closely tied to hydrological conditions, prey accessibility, and level of human disturbance. The consistently low numbers recorded during winter coincided with increased water depth due to dam releases, which likely restricted shallow foraging areas preferred by the species. Similar relationships between water depth and heron foraging success have been reported in earlier studies[15], emphasizing the importance of accessible shallow zones during critical feeding periods.

As water levels receded in late winter and early summer, prey became more concentrated and foraging opportunities

improved, resulting in a steady rise in heron abundance. The pre -monsoon peak observed in this study aligns with the species' breeding season, when adults intensify foraging activity to meet higher energy demands.

Despite Kota's growing urban pressures, the studied wetlands - especially Abheda Pond and the Right Main Canal - continued to support notable numbers of Purple Herons. The concentration of individuals at these sites suggests that even modified habitats can remain valuable when basic ecological requirements - such as stable hydrology, emergent vegetation and adequate prey - are maintained.

However, disturbance remains an important limiting factor. Reports of illegal fishing, particularly during summer and monsoon months, reduced access to open- water foraging areas and may have temporarily suppressed heron use of certain zones. Anthropogenic pressures such as these have been widely recognized as constraints on water bird populations in urban wetlands[8,9].

The species ability to adapt to some forms of habitat alteration - such as nesting on floating Eichhornia crassipes mats[12] demonstrates resilience, yet should not be interpreted as tolerance of sustained ecological degradation. Long - term conservation will depend on maintaining suitable water depth, protecting reed-bed vegetation and minimizing disturbance, particularly during breeding and peak foraging periods.

Overall, the trends observed in Kota align with broader findings from wetland ecosystems across India and other regions, reinforcing the sensitivity of Purple Herons to hydrological fluctuations and human activity. The study highlights the ecological importance of even small or modified urban wetlands and underscores the need for targeted management to support these and other wetland - dependent species.

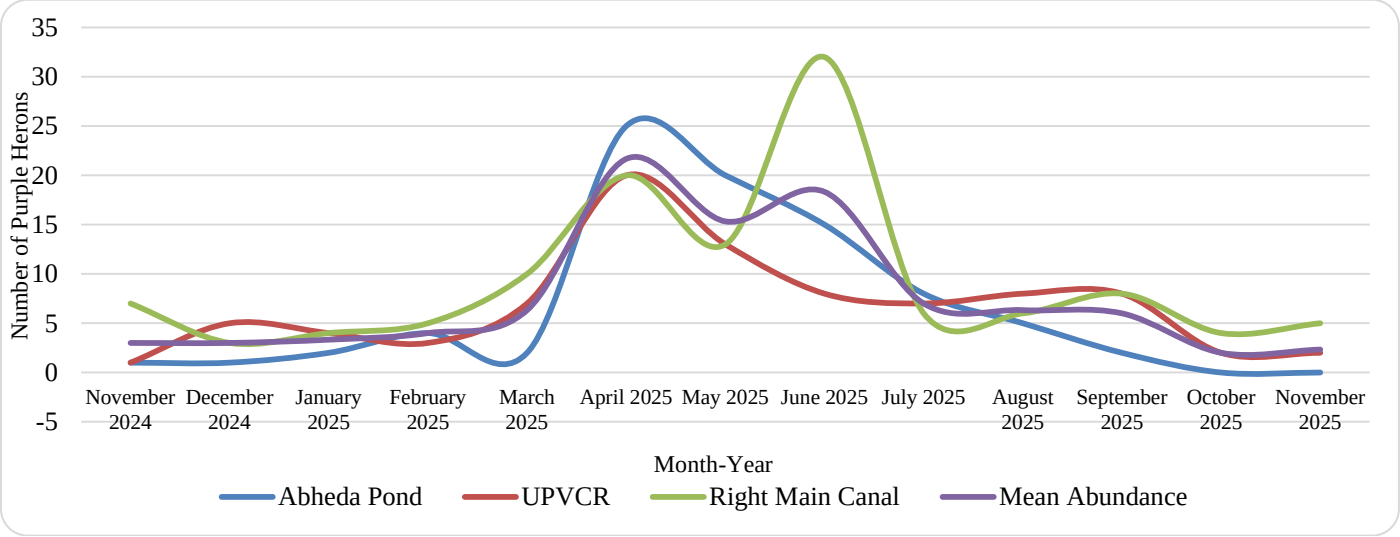

Figure-1: Monthly abundance trends of Purple Heron across three urban wetlands (Abheda Pond, UPVCR, Right Main Canal) in Kota, Rajasthan.

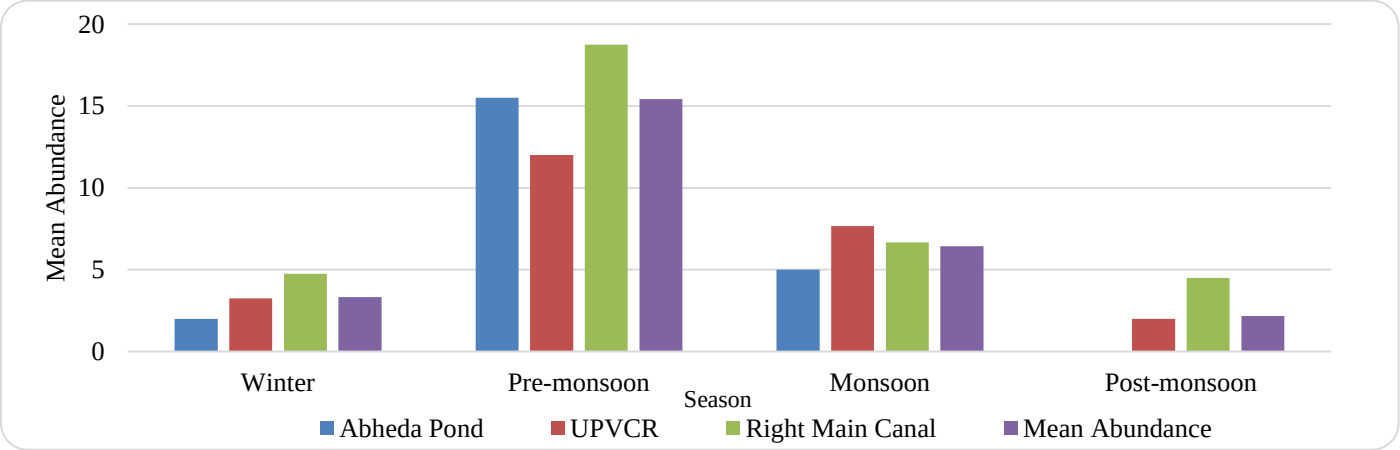

Figure-2: Mean seasonal abundance of Purple Heron at three study sites (Abheda Pond, UPVCR, Right Main Canal in Kota, Rajasthan.

Conclusion

The study demonstrates that Purple Heron abundance in Kota's urban wetlands follow clear seasonal patterns, with the highest numbers occurring during pre-monsoon months. This peak corresponds with favorable hydrological conditions and increased prey availability, both of which are essential for foraging and breeding activity. Conversely, winter releases from upstream dams elevate water levels, reducing shallow feeding areas and leading to lower abundance.

Maintaining stable water depths, preserving vegetated margins and limiting disruptive activities during key breeding and foraging periods will be vital for supporting Purple Heron populations in urban environments.

By highlighting the ecological value of Kota's ponds, canals and conservation reserves, this study reinforces the importance of safeguarding urban wetlands as functional bird habitats, even in rapidly developing landscapes.

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