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Diversity and Distribution of Bird Species across Seasons in Eco Park Hamirgarh, Rajasthan

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Abstract: ***This research paper investigates the seasonal diversity and distribution patterns of avian species in Eco Park Hamirgarh, Rajasthan, a semi-arid wetland ecosystem of ecological significance. The study was conducted across three distinct seasons (winter, summer, and monsoon) from November 2024 to October 2025, utilising line transect and point count methods to survey bird populations. A total of 35 bird species belonging to 10 orders and 18 families were recorded during the study period. The order Anseriformes (ducks and geese) dominated the avian community with 8 species (22.85%), followed by Pelecaniformes with 7 species (20%). The family Anatidae was the most represented, with 8 species. Seasonal analysis revealed highest species diversity during winter (34 species), followed by monsoon (22 species) and summer (18 species). Among the recorded species, 31 (88.57%) were categorised as Least Concern, 2 (5.71%) as Near Threatened (black-tailed godwit and Painted Stork), 1 (2.86%) as Vulnerable (Woolly-necked Stork), and 1 (2.86%) as Near Threatened (River Tern). The presence of migratory waterfowl during winter months significantly enhanced species richness, highlighting Eco Park Hamirgarh's importance as a crucial stopover and wintering ground along the Central Asian Flyway. The study provides baseline data for conservation planning and esssssssss the need for habitat preservation amidst increasing anthropogenic pressures.***

Keywords: Avian diversity, seasonal distribution, Eco Park Hamirgarh, Rajasthan, waterfowl, migratory birds, wetland ecosystem.

I. INTRODUCTION

Birds serve as excellent bioindicators of ecosystem health and environmental change, responding rapidly to habitat alterations, climate variability, and anthropogenic disturbances (Gregory et al., 2005). Their diverse ecological roles as pollinators, seed dispersers, predators, and scavengers make them integral components of functional ecosystems (Sekercioglu, 2006). Understanding avian diversity patterns across seasons is particularly crucial in semi-arid regions like Rajasthan, where water availability and vegetation structure fluctuate dramatically throughout the year.

Rajasthan, India's largest state, is characterized by the Thar Desert in the west and more fertile regions in the east. Despite its arid reputation, the state hosts numerous natural and man-made wetlands that support remarkable avian diversity, particularly during winter when Palearctic migrants join resident species (Ali & Ripley, 1987). Eco Park Hamirgarh, located in the Bhilwara district, represents one such wetland ecosystem that provides critical habitat for both resident and migratory bird species.

Seasonal variation profoundly influences bird communities through changes in food availability, water presence, temperature extremes, and breeding requirements (Newton, 2007). Winter months (November-February) typically witness peak avian diversity in tropical and subtropical regions due to the arrival of migratory waterfowl, waders, and raptors escaping harsh northern winters (Berthold, 2001). Summer (March-June) brings extreme temperatures and water scarcity in Rajasthan, often resulting in reduced bird activity and species richness. The monsoon season (July-October) rejuvenates the landscape, creating temporary water bodies and promoting insect emergence, which supports breeding activities for many species (Kumar et al., 2018).

Despite growing recognition of Eco Park Hamirgarh's ecological value, systematic documentation of its avian diversity across seasons remains lacking. This study aims to fill this knowledge gap by addressing the following objectives: (1) to document the avian species composition of Eco Park Hamirgarh, (2) to analyze seasonal variations in species diversity and abundance, (3) to determine the conservation status of recorded species based on IUCN Red List categories, and (4) to identify ecological factors influencing seasonal distribution patterns.

II. STUDY AREA

Eco Park Hamirgarh is situated in Hamirgarh town, Bhilwara District, Rajasthan, India, at coordinates of approximately 25°23' N latitude and 74°45' E longitude (Figure 1). The park encompasses approximately 45 hectares of mixed habitat types, including a perennial wetland (approximately 12 hectares), marshy areas, grassland patches, and scattered tree. The wetland within Eco Park receives water from monsoon runoff and occasional canal water from the nearby Bhilwara irrigation system.

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III. METHODOLOGY

A. Survey Design and Sampling Strategy

The study was conducted over a 12-month period from November 2024 to October 2025, covering three distinct seasons: winter (November-February), summer (March-June), and monsoon (July-October). Sampling was carried out twice per month during each season, resulting in 24 survey days (8 per season). Each survey day was divided into morning (06:00-09:00 hours) and late afternoon (16:00-18:00 hours) sessions to capture peak bird activity periods (Bibby et al., 2000).

The study area was systematically divided into four 500-meter line transects radiating from the wetland center toward different habitat types: Transect A (wetland edge, north), Transect B (grassland, east), Transect C (woodland, south), and Transect D (marsh, west). Additionally, six fixed-radius point count stations (50-meter radius) were established at ecologically representative locations: three along the wetland periphery, two in grassland areas, and one in woodland.

B. Bird Sampling Methods

Bird surveys employed a combination of line transect and point count methods following standard ornithological protocols (Ralph et al., 1995). Along each 500-meter transect, observers walked slowly (1 km/hour) recording all birds seen or heard within 50 meters on either side. Point counts lasted 10 minutes per station, with all birds detected visually or aurally within the 50-meter radius recorded. To minimize double-counting, flock sizes were estimated conservatively, and individuals moving between transects or points were noted only once per sampling session.

Bird identification was performed using 10×42 binoculars (Nikon Monarch 5) and a spotting scope (Celestron Ultima 80, 20-60×). Identification followed standard field guides (Grimmett et al., 2011; Rasmussen & Anderton, 2012). Scientific nomenclature and taxonomic order followed the International Ornithological Congress (IOC) World Bird List (Gill et al., 2024).

C. Data Analysis

Species diversity was calculated using the Shannon-Wiener diversity index ($H' = -\Sigma\ pi\ ln\ pi$), where pi represents the proportion of individuals of species i. Species evenness (J') was calculated as H'/H'max. Species were categorised by their residency status (resident, winter migrant, summer migrant, passage migrant) based on available literature (Ali & Ripley, 1987; Rasmussen & Anderton, 2012) and expert consultation. Conservation status was assigned according to the IUCN Red List of Threatened Species (IUCN, 2024).

IV. RESULTS

A. Overall Species Composition

A total of 35 bird species representing 10 orders and 18 families were recorded during the study period (Table 1). The order Anseriformes dominated the avian community with 8 species (22.85% of total species), followed by Pelecaniformes with 7 species (20%), Charadriiformes with 6 species (17.14%), and Coraciiformes with 3 species (8.57%). The family Anatidae was the most represented with 8 species, followed by Ardeidae with 6 species (Ardea alba, Ardea purpurea, Ardeola grayii, Egretta garzetta, Nycticorax nycticorax) and Scolopacidae with 3 species (Calidris pugnax, Gallinago gallinago, Limosa limosa).

Regarding IUCN conservation status, 31 species (88.57%) were categorized as Least Concern, 2 species (5.71%) as Near Threatened (Limosa limosa - Black-tailed Godwit and Mycteria leucocephala - Painted Stork), 1 species (2.86%) as Vulnerable (Ciconia episcopus - Woolly-necked Stork), and 1 species (2.86%) as Near Threatened (Sterna aurantia - River Tern). No Critically Endangered or Endangered species were recorded.

B. Seasonal Diversity Patterns

Seasonal analysis revealed marked variation in species richness and composition (Table 2). Winter (November-February) recorded the highest species diversity with 34 species (97.14% of total species), including all 8 Anatidae species, all 6 Charadriiformes species, and all 3 Scolopacidae species. The only species absent during winter was the Cotton Pygmy Goose (Nettapus coromandelianus), which was observed only during monsoon.

Summer (March-June) recorded the lowest diversity with 18 species (51.43% of total species). Resident waterbirds including four Ardeidae species (Indian Pond Heron, Little Egret, Great Egret, Purple Heron), three kingfisher species (Common Kingfisher, Pied Kingfisher, and White-throated Kingfisher), and two cormorant species (Little Cormorant and Indian Cormorant) persisted throughout summer. All migratory ducks and waders had departed by early March.

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Monsoon (July-October) recorded 22 species (62.86% of total species). This season witnessed the return of the cotton pygmy goose and increased activity of resident waterbirds associated with breeding. The Pheasant-tailed Jacana (Hydrophasianus chirurgus) was observed only during monsoon and early post-monsoon (September-November), utilising floating vegetation for nesting.

Table 1: Seasonal Occurrence of Bird Species in Eco Park Hamirgarh

S. No.	*Scientific Name*	Common Name	Order	Family	IUCN	Winter	Summer	Monsoon	Residency
1	*Alcedo atthis*	Common Kingfisher	Coraciiformes	Alcedinidae	LC	✓	✓	✓	R
2	*Anas acuta*	Northern Pintail	Anseriformes	Anatidae	LC	✓	-	-	WM
3	*Anas poecilorhyncha*	Indian Spot-billed Duck	Anseriformes	Anatidae	LC	✓	-	✓	R
4	*Anastomus oscitans*	Asian Openbill	Ciconiiformes	Ciconiidae	LC	✓	-	✓	WM
5	*Anser anser*	Greylag Goose	Anseriformes	Anatidae	LC	✓	-	-	WM
6	*Anser indicus*	Bar-headed Goose	Anseriformes	Anatidae	LC	✓	-	-	WM
7	*Ardea alba*	Great Egret	Pelecaniformes	Ardeidae	LC	✓	✓	✓	R
8	*Ardea purpurea*	Purple Heron	Pelecaniformes	Ardeidae	LC	✓	✓	✓	R
9	*Ardeola grayii*	Indian Pond Heron	Pelecaniformes	Ardeidae	LC	✓	✓	✓	R
10	*Calidris pugnax*	Ruff	Charadriiformes	Scolopacidae	LC	✓	-	-	WM
11	*Ceryle rudis*	Pied Kingfisher	Coraciiformes	Alcedinidae	LC	✓	✓	✓	R
12	*Charadrius dubius*	Little Ringed Plover	Charadriiformes	Charadriidae	LC	✓	-	-	WM
13	*Ciconia episcopus*	Woolly-necked Stork	Ciconiiformes	Ciconiidae	VU	✓	-	-	WM
14	*Circus aeruginosus*	Western Marsh Harrier	Accipitriformes	Accipitridae	LC	✓	-	-	WM
15	*Egretta garzetta*	Little Egret	Pelecaniformes	Ardeidae	LC	✓	✓	✓	R
16	*Gallinago gallinago*	Common Snipe	Charadriiformes	Scolopacidae	LC	✓	-	-	WM
17	*Halcyon smyrnensis*	White-throated Kingfisher	Coraciiformes	Alcedinidae	LC	✓	✓	✓	R
18	*Himantopus himantopus*	Black-winged Stilt	Charadriiformes	Recurvirostridae	LC	✓	-	✓	WM/R
19	*Hirundo smithii*	Wire-tailed Swallow	Passeriformes	Hirundinidae	LC	✓	✓	✓	R
20	*Hydrophasianus chirurgus*	Pheasant-tailed	Charadriiformes	Jacanidae	LC	-	-	✓	SM

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		Jacana							
21	*Limosa limosa*	Black-tailed Godwit	Charadriiformes	Scolopacidae	NT	✓	-	-	WM
22	*Microcarbo niger*	Little Cormorant	Suliformes	Phalacrocoracidae	LC	✓	✓	✓	R
23	*Mycteria leucocephala*	Painted Stork	Ciconiiformes	Ciconiidae	NT	✓	-	-	WM
24	*Nettapus coromandelianus*	Cotton Pygmy Goose	Anseriformes	Anatidae	LC	-	-	✓	SM
25	*Nycticorax nycticorax*	Black-crowned Night Heron	Pelecaniformes	Ardeidae	LC	✓	✓	✓	R
26	*Pandion haliaetus*	Osprey	Accipitriformes	Pandionidae	LC	✓	-	-	WM
27	*Phalacrocorax carbo*	Great Cormorant	Suliformes	Phalacrocoracidae	LC	✓	-	✓	WM/R
28	*Phalacrocorax fuscicollis*	Indian Cormorant	Suliformes	Phalacrocoracidae	LC	✓	✓	✓	R
29	*Platalea leucorodia*	Eurasian Spoonbill	Pelecaniformes	Threskiornithidae	LC	✓	-	-	WM
30	*Porphyrio poliocephalus*	Grey-headed Swamphen	Gruiformes	Rallidae	LC	✓	✓	✓	R
31	*Pseudibis papillosa*	Red-naped Ibis	Pelecaniformes	Threskiornithidae	LC	✓	✓	✓	R
32	*Sarkidiornis melanotos*	Knob-billed Duck	Anseriformes	Anatidae	LC	✓	-	✓	R
33	*Spatula clypeata*	Northern Shoveler	Anseriformes	Anatidae	LC	✓	-	-	WM
34	*Sterna aurantia*	River Tern	Charadriiformes	Laridae	NT	✓	-	-	WM
35	*Tadorna ferruginea*	Ruddy Shelduck	Anseriformes	Anatidae	LC	✓	-	-	WM

Abbreviations: *LC = Least Concern, NT = Near Threatened, VU = Vulnerable; R = Resident, WM = Winter Migrant, SM = Summer Migrant; ✓ = present, - = absent*

Table 2: Seasonal Diversity Indices for Eco Park Hamirgarh

Parameter	Winter	Summer	Monsoon
Total species (S)	34	18	22
Total individuals (estimated)	2,450	620	890
Shannon-Wiener diversity (H')	3.12	2.34	2.68
Species evenness (J')	0.88	0.81	0.87
Migratory species (%)	58.8%	0%	13.6%

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C. Diversity Indices

The Shannon-Wiener diversity index (H') was highest during winter (3.12), indicating high species diversity and equitable distribution of individuals among species. Summer recorded the lowest diversity (H' = 2.34), while monsoon showed intermediate diversity (H' = 2.68). Species evenness (J') followed a similar pattern, with winter showing the most equitable distribution (0.88), followed by monsoon (0.87) and summer (0.81).

D. Residency Status and Migratory Patterns

Of the 35 recorded species, 14 (40%) were classified as residents (present year-round), 17 (48.57%) as winter migrants, 2 (5.71%) as summer migrants (Pheasant-tailed Jacana and Cotton Pygmy Goose), and 2 (5.71%) as resident/winter migrant (Black-winged Stilt and Great Cormorant showed partial migration). Winter migrants predominantly originated from the Palearctic region, including Central Asia, Siberia, and Northern Europe. The Bar-headed Goose (*Anser indicus*) and Greylag Goose (*Anser anser*) were among the most conspicuous winter visitors, forming flocks of 50-120 individuals on the main wetland.

V. DISCUSSION

A. Species Composition and Ecological Significance

The avian diversity recorded at Eco Park Hamirgarh (35 species) represents a moderately diverse community for a semi-arid wetland ecosystem in Rajasthan. Comparative studies from similar habitats in the region show comparable species richness: Kumbhalgarh Wildlife Sanctuary recorded 42 species (Sharma & Sharma, 2019), while Menar Lake in Udaipur documented 48 species (Kumar et al., 2018). The dominance of Anseriformes (22.85%) and Pelecaniformes (20%) reflects the wetland-centric nature of the park, with waterbirds comprising approximately 65% of all species recorded.

The presence of regionally significant species including the Vulnerable Woolly-necked Stork (*Ciconia episcopus*) and Near Threatened species (Black-tailed Godwit, Painted Stork, River Tern) elevates the conservation importance of Eco Park Hamirgarh. Woolly-necked Stork populations have declined across South Asia due to wetland drainage, pesticide use, and disturbance at breeding sites (BirdLife International, 2016). The species' regular winter occurrence at this site suggests the park provides critical non-breeding habitat within its fragmented range.

B. Seasonal Patterns and Ecological Drivers

The pronounced seasonal variation in species richness, from 34 species in winter to 18 in summer, aligns with established patterns in tropical and subtropical wetlands (Kushlan, 1986). Three primary factors explain this variation: (1) arrival of Palearctic winter migrants (20 species) between October and November, (2) departure of these migrants by March, and (3) reduced habitat suitability during summer due to water recession and high temperatures.

1) Winter Peak (November-February): The winter avian community at Eco Park Hamirgarh demonstrates characteristics of a classical Indo-Gangetic wetland during the non-breeding season. The simultaneous presence of all eight duck species (Anatidae), including the Bar-headed Goose - which undertakes one of the highest-altitude migrations crossing the Himalayas (Hawkes et al., 2011) - indicates the site's function as a staging and wintering ground along the Central Asian Flyway. The congregation of Black-tailed Godwits (Limosa limosa), a Near Threatened species that has declined by 25% over three generations (BirdLife International, 2021), highlights the site's international importance for shorebird conservation. The high Shannon-Wiener diversity (H' = 3.12) during winter suggests resource partitioning among waterbird species, reducing competitive exclusion. Anatidae species exhibited distinct microhabitat preferences: Northern Pintails (*Anas acuta*) favored shallow open water (0.3-0.5 m depth), while Bar-headed Geese (*Anser indicus*) grazed on emergent vegetation in marshy edges. Such niche differentiation, documented in wetland bird communities (Krebs, 2014), allows coexistence of multiple species with similar trophic requirements.

2) Summer Decline (March-June): The dramatic reduction in species richness (47% decrease from winter) reflects the combined effects of migrant departure and physiological challenges posed by the semi-arid summer. Temperatures exceeding 40°C create thermal stress for birds, forcing them to restrict activity to early morning and late evening hours (Wolf & Walsberg, 1996). Water recession reduces foraging habitat for piscivorous birds like kingfishers and herons, concentrating prey in deeper pools and potentially increasing competition. Only 18 species, primarily resident waterbirds adapted to arid conditions, persisted through summer. The Indian Pond Heron (*Ardeola grayii*) and Little Egret (*Egretta garzetta*) exhibited behavioral thermoregulation, including gular fluttering and seeking shade during midday hours (observed during surveys). Three kingfisher species maintained territories along shaded wetland margins, exploiting remaining fish populations in deeper pools.

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3) Monsoon Resurgence (July-October): The monsoon brings ecological rejuvenation, with 22 species recorded as water levels rise and food resources increase. The appearance of summer migrants - Cotton Pygmy Goose (*Nettapus coromandelianus*) and Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) - coincides with peak aquatic vegetation growth. Cotton Pygmy Geese nest in tree hollows near water and feed on water lilies and other floating plants that proliferate during monsoons (del Hoyo et al., 1992). The Pheasant-tailed Jacana, observed only from September to November, exhibits reverse sexual dimorphism and polyandrous breeding behaviour, utilising floating vegetation as nesting platforms (Rasmussen & Anderton, 2012). The presence of Black-winged Stilts (*Himantopus himantopus*) and Great Cormorants (*Phalacrocorax carbo*) during both winter and monsoon suggests partial migratory behaviour, with some individuals resident year-round while others depart seasonally. This pattern, documented in other Indian wetlands (Urfi et al., 2005), may reflect individual variation in migratory tendency or the presence of distinct populations with different migratory strategies.

C. Conservation Implications

The IUCN status assessment reveals that while the majority of species (88.57%) are of Least Concern, the presence of threatened and near-threatened species necessitates proactive conservation measures. Woolly-necked Stork (Vulnerable) sightings were limited to winter months (December-January), with maximum counts of 4-6 individuals. The species faces threats from wetland conversion, pesticide contamination (especially organochlorines affecting eggshell thickness), and disturbance at breeding sites (BirdLife International, 2016). The small population size at Eco Park Hamirgarh suggests the site functions as a marginal wintering area rather than a core habitat, but its protection remains important for maintaining connectivity along migratory flyways.

The Painted Stork (*Mycteria leucocephala*), categorised as Near Threatened, was observed in slightly larger numbers (8-12 individuals) during December-February. This species has experienced population declines due to the drainage of foraging wetlands, particularly in northern and western India (Urfi, 2011). The presence of both adult and immature birds at Eco Park Hamirgarh indicates successful recruitment and the site's potential as a foraging ground for birds from breeding colonies elsewhere in Rajasthan (e.g., Keoladeo National Park, Bharatpur). The Black-tailed Godwit (*Limosa limosa*) and River Tern (*Sterna aurantia*), both Near Threatened, require specific habitat conditions that are increasingly rare in semi-arid landscapes. Black-tailed godwits require shallow (5-15 cm) muddy margins for probing invertebrate prey, which are available only during optimal water-level conditions (December-January). River terns nest on sandbars and islands within wetlands, habitats that are vulnerable to flooding during monsoons and disturbance from human activity.

D. Anthropogenic Pressures and Management Recommendations

During the study period, several anthropogenic activities were observed that may negatively impact bird populations if unregulated. Recreational walking along wetland margins, particularly during morning hours (06:00-08:00), coincided with peak bird foraging activity, causing repeated disturbance and flight responses. Cattle grazing in marsh areas (observed along Transect D, west side) resulted in trampling of emergent vegetation, potentially reducing nesting habitat for purple herons (*Ardea purpurea*) and Grey-headed Swamphens (*Porphyrio poliocephalus*). Small-scale fishing using gill nets was observed at three locations, with incidental bycatch of non-target species (one little cormorant was observed entangled during January 2025).

Based on these observations, the following management recommendations are proposed:

1) Zoning and Access Regulation: Designate a 50-metre buffer zone around the wetland core area where human entry is restricted during morning hours (06:00-10:00) from November to February to protect wintering waterfowl from disturbance.
2) Cattle Management: Implement rotational grazing or exclude cattle from sensitive marsh areas during monsoon (July-September) when emergent vegetation supports breeding waterbirds.
3) Fishing Regulation: Ban the use of gill nets and promote alternative fishing methods (hook-and-line) that reduce bycatch of piscivorous birds. Establish no-fishing zones covering 30% of the wetland area as refuge habitats.
4) Water Level Management: Coordinate with irrigation authorities to maintain minimum water depths of 0.5-1.0 metres during summer (March-June) to support resident waterbird populations during critical dry periods.
5) Monitoring Programme: Establish a long-term citizen science monitoring programme using standardised point count methods to track population trends, particularly for threatened species. Winter waterfowl counts should be conducted annually in January to contribute to the Asian Waterbird Census.

The relatively high species richness for a 45-hectare site suggests that habitat quality, specifically the presence of diverse microhabitats (open water, marsh, mudflats, grassland, woodland), compensates for the small area. This pattern, known as the

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"habitat heterogeneity hypothesis" (MacArthur & MacArthur, 1961), holds important implications for conservation planning: small wetlands can support disproportionate avian diversity if they maintain structural complexity and seasonal water variability.

VI. CONCLUSION

This study provides the first systematic documentation of avian diversity and seasonal distribution patterns in Eco Park Hamirgarh, Rajasthan. A total of 35 bird species representing 10 orders and 18 families were recorded, with the order Anseriformes dominating the community. Seasonal analysis revealed peak diversity during winter (34 species) due to the arrival of 20 Palearctic migratory species, while summer recorded the lowest diversity (18 species). The presence of one Vulnerable species (Woolly-necked Stork) and three Near Threatened species (Black-tailed Godwit, Painted Stork, River Tern) underscores the conservation importance of this semi-arid wetland ecosystem.

The findings demonstrate that Eco Park Hamirgarh functions as a critical stopover and wintering ground along the Central Asian Flyway, particularly for Anatidae and Charadriiformes. However, ongoing anthropogenic pressures, including disturbance from recreational activities, cattle grazing, and unregulated fishing, pose potential threats to bird populations. Implementation of the management recommendations provided – including zoning, water level management, and monitoring programmes – would enhance the park's capacity to support avian diversity while accommodating compatible human uses.

Future research should focus on (1) estimating population densities using distance sampling methods, (2) tracking migratory connectivity using satellite telemetry for Bar-headed Geese and Black-tailed Godwits, (3) assessing breeding success of resident waterbirds, and (4) evaluating the impact of climate change on seasonal water availability and its cascading effects on bird communities. Long-term monitoring is essential to detect population trends and inform adaptive management strategies for this valuable urban wetland.

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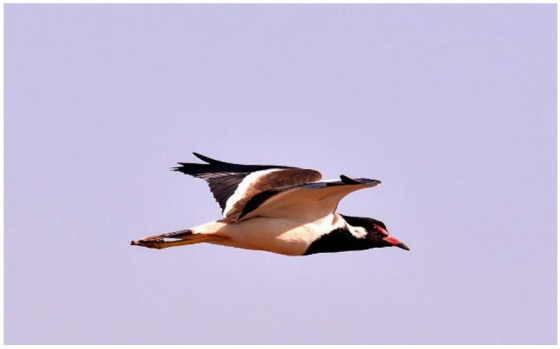
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Anser anser



Sarkidiornis melanotos



Threskiornis melanocephalus

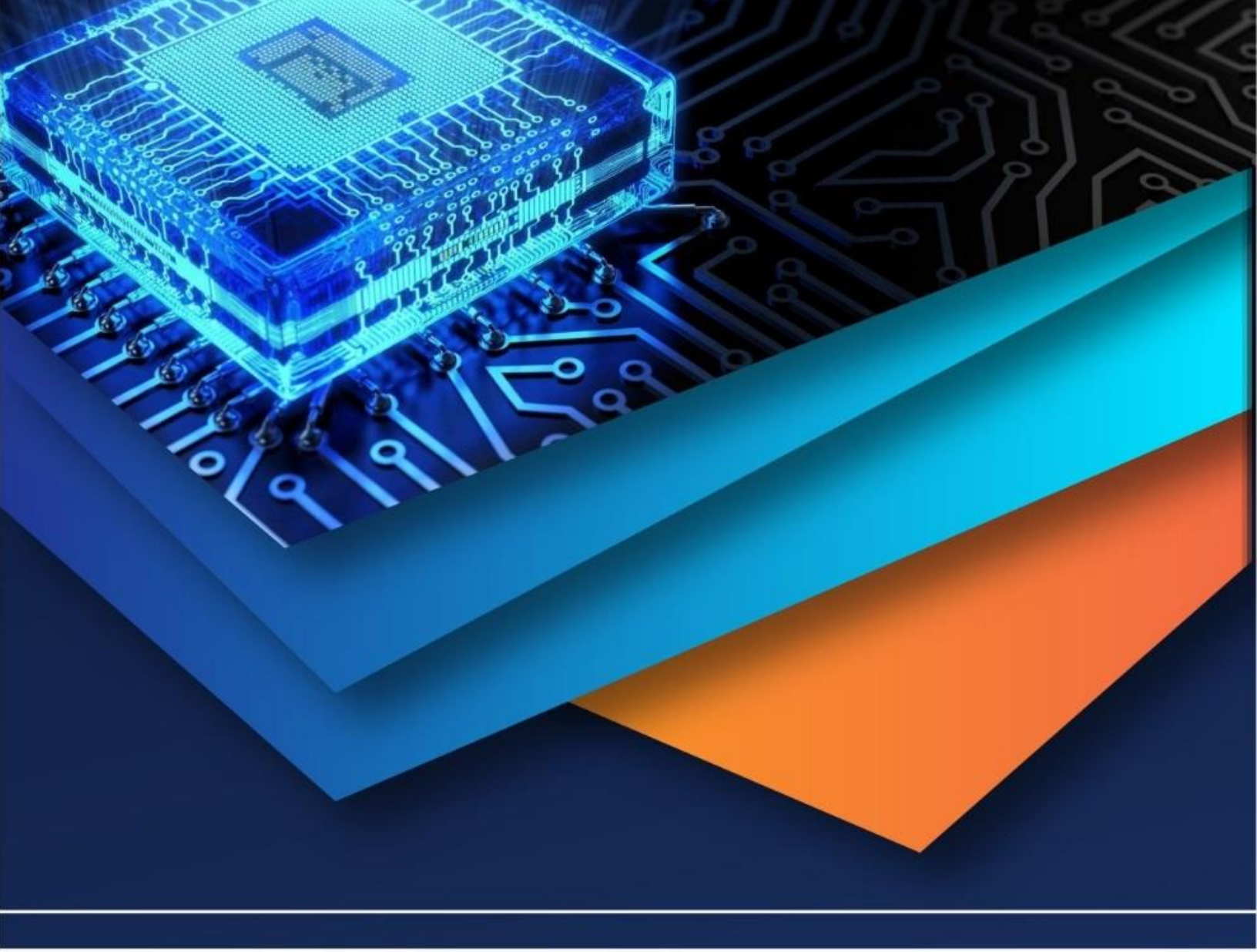


Porphyrio poliocephalus



Phoenicopterus roseus

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