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Population structure, distribution pattern and habitat utilization of Yellow-wattled Lapwing, *Vanellus malabaricus* (Boddaert, 1783), in Northern India

Prateek[1], Himanshu Mishra[2], Vikas Kumar[3] and Ashish Kumar[1,4*]

Abstract

This field study investigated the population structure, distribution pattern and habitat utilization of Yellow-wattled Lapwings. The line transect method was used to estimate the density of Yellow-wattled Lapwings. An average of 394 individuals including 77 chicks of Yellow-wattled Lapwings have been registered with an average density of 38 birds per km. The outcome of the GLM analysis exhibited, that Bakshi Ka Talab had the highest lapwing count while, Malihabad had the lowest lapwing count. A significant lapwing count in the year 2021 was confirmed. The winter season had the lowest lapwing counts, whereas the summer season had the highest values. Moreover, the largest lapwing counts were estimated in uncultivated while, the lowest lapwing count was documented in river habitat types. There was a significant difference in the mean flock size across the seasons and the habitat types. Being sighted in flocks of various sizes the distribution pattern was found to be clumped in Yellow-wattled Lapwings. The results of the factorial ANOVA showed a significant difference in the habitat utilization of Yellow-wattled Lapwings across study sites, years, seasons and habitat types. Uncultivated habitat types were the most utilized habitat types during summer seasons.

Keywords Flock range, Habitat types, Seasons, Study sites

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Introduction

The Yellow-wattled lapwing, *Vanellus malabaricus* (Boddaert, 1783) [1] is a sandy brown plover with yellow legs and a wattle [2], belonging to the avian order Charadriiformes [3]. They are medium-sized birds with long legs, a short, straight beak, a slightly big head, and rounded wings [3, 4]. They are primarily restricted in the Indian subcontinent [5]. Yellow-wattled Lapwing is more frequently sighted in wide fields with stubbles, fallow fields and dry places [6]. Termites, beetles and other invertebrates are identified as their main food sources [7]. The Yellow-wattled Lapwing serves an important ecological function in managing many invertebrate (Pests) populations, to keep grassland and agricultural ecosystems in balance [8]. Its presence indicates a healthy ecosystem, whereas its absence typically indicates environmental degradation caused by urbanization and increased agricultural expansion. The population of Yellow-wattled Lapwings ranges from 5000 to 10,000 individuals [9]. It is classified as least concern globally [10], however, assessment of eBird data [11], suggests its population decline and is classified as a species of moderate concern nationally, therefore, protecting it is crucial for maintaining biodiversity.

A population is a collection of interbreeding members of a species that serves as a fundamental unit in evolution and ecology [12]. Populations are characterized by structural characteristics like density, dispersion pattern, age, sex, and genetic makeup, which fluctuates throughout time and space in response to changing environmental conditions [12]. Population structure may indicate future demographic trends and also necessary to understand the association between population structure and changes in population size in response to anticipated environmental changes [12].

Birds with restricted ranges require significant attention from ecologists and conservationists [13]. Furthermore, it is imperative to understand how they use their habitats and how they are distributed geographically [14, 15]. Recently, there has been an increased focus on the macroecological linkages between local abundance and distribution or range size [16].

The spatiotemporal distribution of certain important natural resources has a significant impact on the number of bird species [17]. According to Newton [18], animal dispersion is limited by the availability of suitable feeding places, which are further influenced by predators and diseases.

It is widely recognized that the degree of adequate habitat availability affects the number of waterbirds [19]. Habitat utilization may be defined as how an individual or a species takes advantage of a habitat to fulfill its necessities throughout its life cycle [20]. The selection of habitat for birds depends on food availability, protection from predators and restrictions imposed by morphological features [21]. Birds' chances of surviving, growing and successfully reproducing rely on the availability of food in their natural habitats [22, 23]. Most species of birds are declining due to habitat loss, degradation and overexploitation [24].

This study fills multiple important gaps in the present ornithological research about the Yellow-wattled lapwing. These gaps include insufficient data on the lapwing; population structure, distribution patterns and habitat utilization in Northern India. In this study, we aimed to evaluate: (1) the population structure, (2) the distribution pattern; and (3) the habitat utilization rates of Yellow-wattled Lapwings. We hypothesized that Yellow-wattled Lapwings would evenly distribute across all habitat types. Moreover, they would utilize all habitat categories at an even pace.

Materials and methods

Study area

The fieldwork was conducted in the Lucknow district of Uttar Pradesh, India, covering an area of 2528 km^2 (Fig. 1). We randomly chose five sites and noted their coordinates; (1) Bakshi Ka Talab (BKT): 26°56'47.58"N, 80°56'53.69"E, (2) Post Graduate Institute (PGI): 26°44'37"N, 80°57'15"E, (3) Gosainganj: 26°46'34.56"N, 81°4'36.02"E, (4) Nigohan: 26°33'24.06"N 81°1'1.43"E and (5) Malihabad: 26°50'34.11"N, 80°45'38.73"E to investigate the frequency and distribution pattern of Yellow-wattled Lapwings (Fig. 1).

Based on geographical features and frequent sightings of Yellow-wattled Lapwings, the study area was stratified into four distinct habitat types (uncultivated, cultivated, river, and pond) (Fig. 2). The climate of the research area is subtropical, with annual average temperatures of 25.1 °C (77.2 °F) and an average precipitation rate of 999 mm (39.3 inches) [25]. The dominant type of vegetation found in the study area is sub-tropical vegetation, which includes trees, shrubs and grasses. This region is known for its high avian diversity as well [26].

Field survey and population monitoring

During the study period (January 2019 to December 2023), we utilized the line transect method [27] to record individuals of Yellow-wattled Lapwing along a pre-determined route inside a survey unit. In this strategy, researchers followed a line and identified birds as the target items. The distance between the two transects was about 500 m in each site. The goal of line transect sampling is to estimate the bird counts and average density, D, of specified species in the study area.

According to Bibby [28], the Yellow-wattled lapwing density was calculated using the following formula:

$$\textbf{Density (D)} = \frac{\textbf{\textit{Number of birds observed (N)}}}{\textbf{\textit{Area surveyed (A)}}}$$

Line transect sampling relies on four key assumptions, ranked in decreasing importance: (1) Birds are always detected directly on or near the line; (2) No birds move in response to the observer and none are counted more than once during a given walking of the line (3) All distance and angle data are recorded accurately, and (4) Sightings of different birds are statistically independent. A SToK (ST-LDM100) laser range finder/distance (100 m, accuracy ± 2 mm) was used to estimate the distance and angle of the observed individual of lapwings.

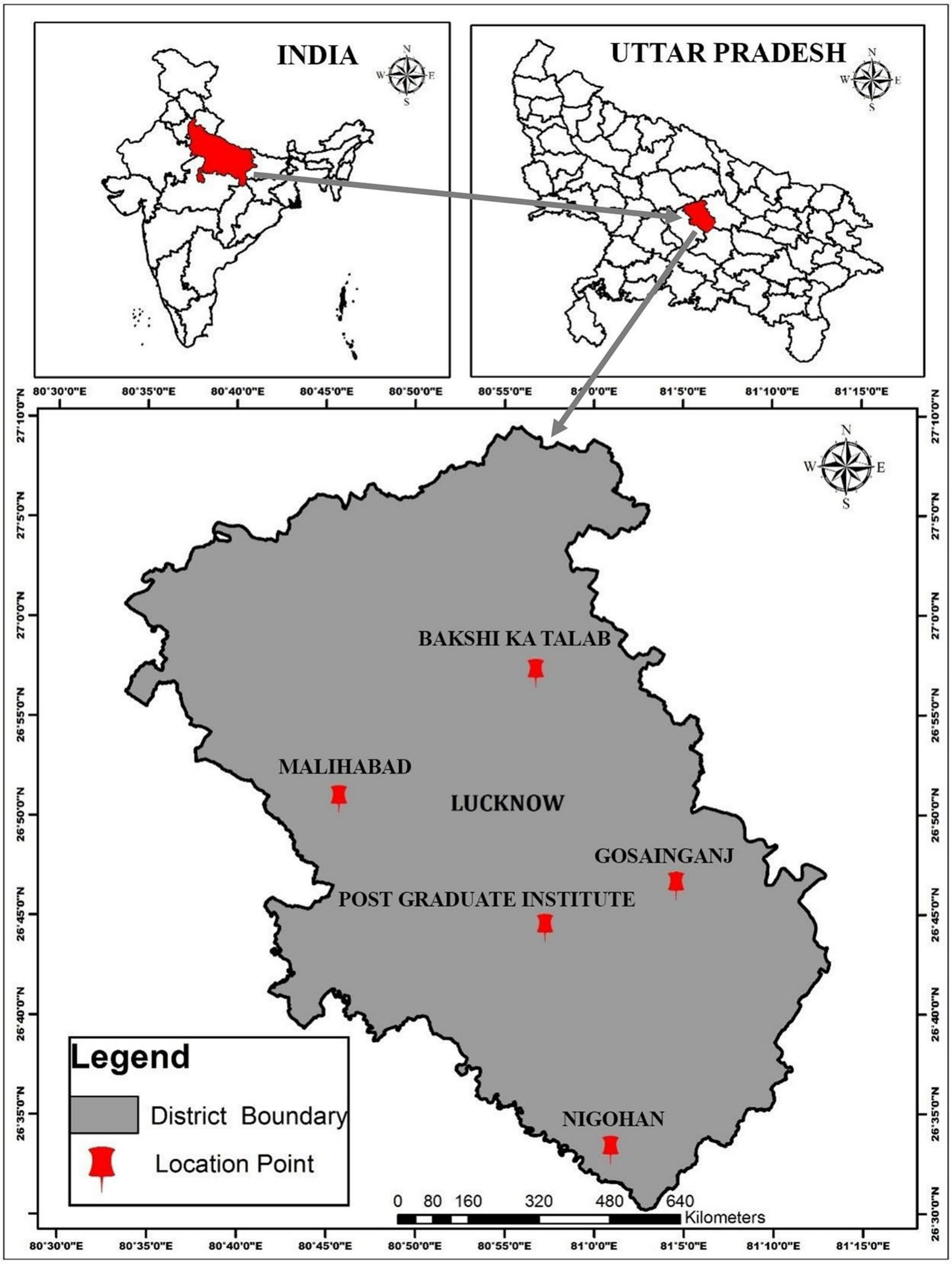

Fig. 1 Geographic Information System (GIS) map of the study area highlighting the spatial distribution of selected study sites during the study period of January 2019 to December 2023

A total of 76 transects (500 m each) were chosen, spanning 38 km in length (Table 1). Study sites were frequently visited to estimate the population structure of Yellow-wattled Lapwings in different habitats (uncultivated, cultivated, pond and river) and seasons: spring (January to March), summer (April to June), rain (July to September), and winter (October to December). Lapwings were observed and counted by the direct observation method aided by binoculars (7 × 40).

In this study, we define a flock of Yellow-wattled Lapwing based on several criteria including the number of individuals (at least two), proximity (within 10 m), synchronized behavior (such as flying together or foraging in the same area), interaction (including vocalizations

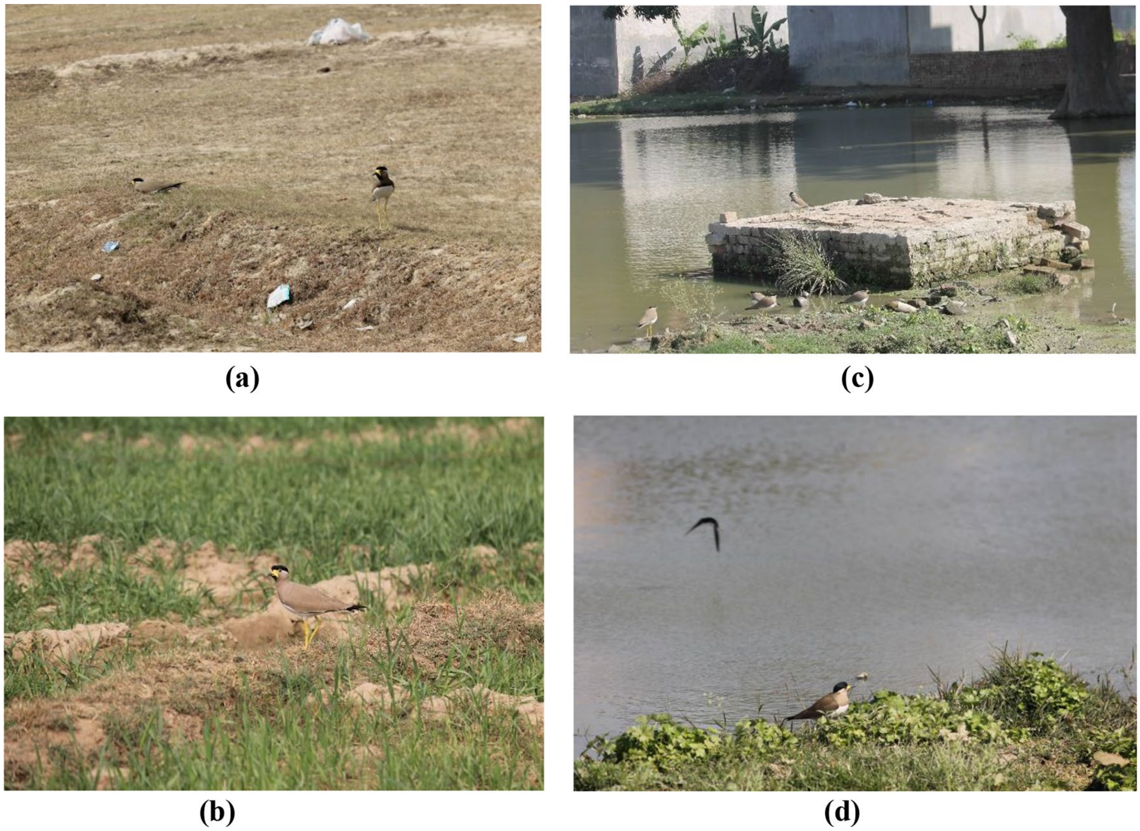

Fig. 2 Occurrence of Yellow-wattled lapwing, *Vanellus malabaricus*, in Northern India in four different habitat types: **a** Uncultivated **b** Cultivated **c** Pond and **d** River

Table 1 Length and number of transects considered during the field investigation (January 2019–December 2023)

S.N.	Study points	Surveyed length (km)	Number of transects
1.	Bakshi Ka Talab	12	24
2.	Post Graduate Institute	10	20
3.	Gosainganj	8	16
4.	Nigohan	5	10
5.	Malihabad	3	6
	Pooled data	**38**	**76**

and cooperative behaviors) and duration (must remain together for at least 5 min) [29, 30].

Over the course of the five-year research period, 300 field surveys (1 survey per site per month, 3 surveys per site per season and 60 surveys annually) were conducted. The fieldwork sessions were conducted from early morning to late evening 06:00 am to 17:00 pm for each count. The Yellow-wattled Lapwings were seen and assessed in the study area without creating any disturbance [31]. Lapwing numbers (chicks and adults) were counted and the number of lapwing individuals in every category of habitat was also ascertained.

Estimation of habitat utilization rate

During the field investigation, field surveys [32] were conducted to identify the habitat availability for Yellow-wattled Lapwings. We identified four major habitat categories; uncultivated, cultivated, pond and river habitats. According to Zhao et al. [33], the habitat utilization rates (U) of all habitat categories by this Yellow-wattled Lapwing were estimated.

$$\mathbf{Ui} = \frac{\boldsymbol{Ni}}{\boldsymbol{N}}$$

Where Ui is the ithhabitat type's utilization rate by Yellow-wattled Lapwings; Ni is the number of Yellow-wattled Lapwings in the ith habitat types and N is the total number of Yellow-wattled Lapwings in all the habitat types.

Statistical analysis

The data were tested for homogeneity and normality using Kolmogorov-Smirnov tests and Levene's test, respectively. A generalized linear model (GLM) was employed to examine the relationship between lapwing counts and dependent variables (seasons, years, types of habitats, and study sites). Two-way ANOVA followed

Table 2 Population census of Yellow-wattled Lapwing during the study period (January 2019–December 2023)

Study locations	Year	Spring	Summer	Rain	Winter	Mean ± SD
Bakshi Ka Talab	2019	23	38	27	20	27 ± 6.81
	2020	7	17	12	9	11.25 ± 3.76
	2021	26	54	37	30	36.75 ± 10.70
	2022	22	41	29	25	29.25 ± 7.22
	2023	23	45	32	27	31.75 ± 8.28
Post Graduate Institute	2019	14	20	15	11	15 ± 3.24
	2020	3	7	4	5	4.75 ± 1.47
	2021	19	27	22	15	20.75 ± 4.38
	2022	15	22	20	13	17.5 ± 3.64
	2023	14	21	16	12	15.75 ± 3.34
Gosainganj	2019	21	32	24	17	23.5 ± 5.5
	2020	5	9	7	6	6.75 ± 1.47
	2021	24	39	27	22	28 ± 6.59
	2022	21	34	22	19	24 ± 5.86
	2023	22	35	23	20	25 ± 5.87
Nigohan	2019	4	9	5	6	6 ± 1.87
	2020	3	5	3	3	3.5 ± 0.86
	2021	11	17	14	10	13 ± 2.73
	2022	10	15	12	9	11.5 ± 2.29
	2023	8	16	11	9	11 ± 3.08
Malihabad	2019	4	7	4	5	5 ± 1.22
	2020	2	4	3	2	2.75 ± 0.82
	2021	10	14	11	9	11 ± 1.87
	2022	7	11	8	7	8.25 ± 1.63
	2023	4	6	5	4	4.75 ± 0.82

Table 3 Results of a generalized linear model (GLM) explaining various factors influencing the Yellow-wattled Lapwing counts during the study period of January 2019 to December 2023

Predictor	Category	Estimate	SE	*P*
Study sites	Bakshi Ka Talab	0.602	± 0.068	< 0.05*
	Post Graduate Institute	0.326	± 0.034	0.022*
	Gosainganj	1.121	± 1.182	< 0.015**
	Nigohan	−0.185	± 0.021	0.032*
	Malihabad	−0.720	± 1.036	0.048*
Years	2019	-0.142	± 0.005	0.042*
	2020	-0.263	± 0.123	0.051*
	2021	0.682	± 0.063	< 0.05*
	2022	-0.104	± 1.384	0.037*
	2023	-1.327	± 1.172	0.032*
Seasons	Spring	-0.061	± 2.048	0.049*
	Summer	0.638	± 0.127	< 0.05*
	Rain	0.127	± 0.152	0.042*
	Winter	-1.935	± 2.056	0.038*
Habitat types	Uncultivated	0.102	± 0.534	< 0.05*
	Cultivated	0.712	± 0.062	0.042*
	Pond	-0.507	± 2.079	0.047*
	River	-0.381	± 1.125	0.049*

S.E. standard error, *p* probability

*<0.05 (significant)

**<0.01 (highly significant)

by a post hoc Bonferroni test was used to analyze flock range size in different habitats and seasons.

Two-way ANOVA was used to statistically analyze the number of chicks counted at different study sites and in different years.

We utilized a multi-way analysis of variance (factorial ANOVA) to examine how habitat utilization fluctuates concerning years, seasons, habitat types and study sites. Additionally, in each case, we checked for interaction in the independent variables (years, seasons, habitat types and study sites). Finally, we applied a one-way ANOVA followed by Tukey's post hoc test to check differences in the habitat utilization rate of Yellow-wattled Lapwings in different habitat types.

All values are expressed as mean ± SD and a p-value were considered significant if < 0.05 and highly significant if < 0.001. Statistical analyses were done using GraphPad Prism (version 5.01, La Jolla, CA 92,037 USA) and SPSS (version 16.4).

Results

Population structure

We recorded a total of 394 individuals (mean number) of Yellow-wattled Lapwings in this field investigation with an average density of 38 birds per km. Counts of the Yellow-wattled Lapwing have been summarized (Table 2). The results of the GLM analysis (Table 3) revealed

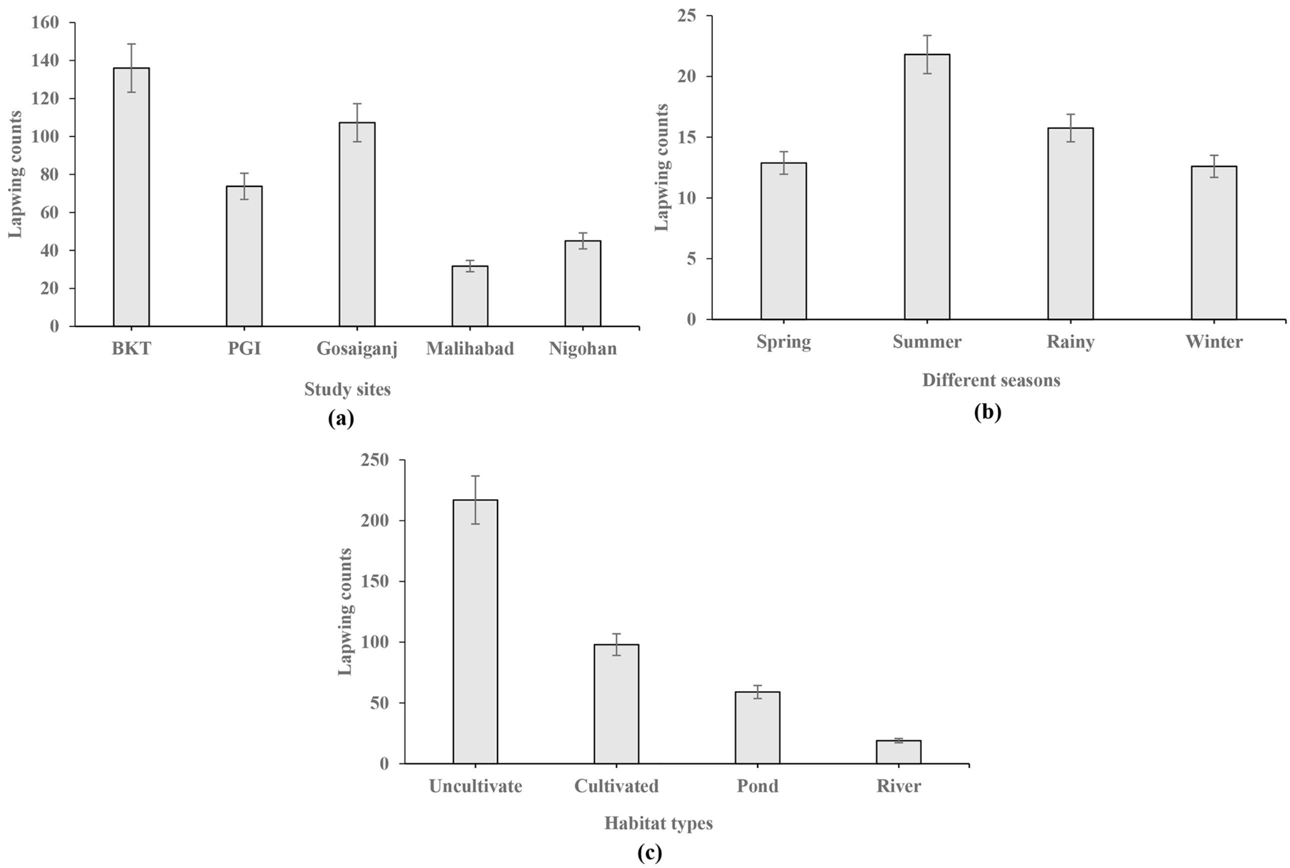

Fig. 3 Variation of lapwing counts (pooled data January 2019 to December 2023) in different; **a** study sites, **b** seasons **c** habitat types

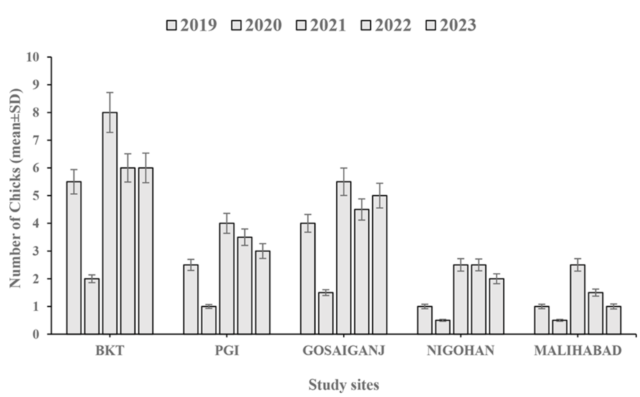

Fig. 4 The number of chicks in the different study sites and years

that Bakshi Ka Talab had the highest (27.2 ± 7.34) lapwing count ($p < 0.05$) while Malihabad had the lowest (6.35 ± 2.16) lapwing count ($p = 0.048$) (Fig. 3a). The highest bird density found in Gosainganj study sites (54 birds per km) while the lowest found in Post Graduate Institute study sites (30 birds per km). We estimated a significant lapwing count in the year 2021 ($p < 0.05$). The winter season had the lowest (12.6 ± 2.79) lapwing counts ($p = 0.038$) (Fig. 3b), whereas the summer season had the highest (21.8 ± 4.35) values ($p < 0.05$) (Fig. 3b). Moreover,

Table 4 Occurrence and detail of flocks of the Yellow-wattled Lapwing in different seasons and habitat types

Habitat types	Mean number of flocks	Range of flock size			
		Spring	Summer	Rainy	Winter
Uncultivated	48	4–8	6–15	4–10	2–8
Cultivated	35	2–7	3–8	3–9	2–5
Pond	11	2–5	2–5	2–5	2–4
River	7	2–4	2–4	2–4	2–3

the largest lapwing counts were estimated in uncultivated habitats ($p < 0.05$) (Fig. 3c) while lowest lapwing count was documented in river habitat types ($p = 0.049$) (Fig. 3c).

The mean number of chick counts (77) was recorded in Fig. 4. There was a significant variation in the chick count across the study sites (F = 35.23, df = 4, $p < 0.05$) and the different years (F = 39.41, df = 4, $p < 0.05$). The Bakshi Ka Talab study site had the highest (8 ± 2.41) chick counts in the 2021 year, whereas Malihabad had the lowest (0.5 ± 0.03) chick counts in the 2020 years (Fig. 4).

Distribution pattern

The mean number of flocks and range of flock size were recorded and tabulated (Table 4). In this field study, we observed 101 flocks of Yellow-wattled Lapwings (Table 4). There was a significant variation in the mean flock size across the seasons (F = 46.31, df = 3, $p < 0.05$) and the habitat types (F = 42.51, df = 3, $p < 0.05$). The river habitats had the lowest range of flock size in the winter season (2–3), whereas uncultivated habitats had the largest range of flock size in the summer seasons (6–15) (Table 4).

Habitat utilization

The results of the factorial ANOVA analysis confirmed a significant difference in the habitat utilization of Yellow-wattled Lapwings across study sites (F = 22.73, df = 4, $p < 0.05$), years (F = 48.32, df = 4, $p < 0.01$), seasons (F = 59.21, df = 3, $p < 0.05$) and habitat types (F = 68.40, df = 3, $p < 0.01$) (Table 5). All the variables, with the exception of between years and seasons, season and study sites showed significant interactions (Table 5). However, one-way ANOVA and a Tukey's post hoc test revealed that the summer season (F = 44.21, df = 3, $p < 0.01$) and uncultivated habitat (F = 63.44, df = 3, $p < 0.01$) had the highest habitat utilization rate (Fig. 5).

Discussion

Population structure

The estimated range of the Yellow-wattled Lapwing population is 5000 to 10,000 worldwide [9]. In this study, we estimated an average of 394 Yellow-wattled Lapwing individuals (317 adults and 77 chicks) and the average density was 38 birds per km. Our results divulged that the Yellow-wattled Lapwing population remained stable in recent years. Similar trends were reported in northern lapwings (*Vanellus vanellus*) [34] and river lapwings (*Vanellus duvacelii*) [13]. Furthermore, the population trend of Yellow-wattled Lapwings was also stable, according to Birdlife International [9].

Table 5 Results of factorial ANOVA showing variations of habitat utilization in relation to years, seasons, habitat types and study sites

Dependent variables	F	df	p
Years	48.32	4	< 0.01**
Seasons	59.21	3	< 0.05*
Habitat types	68.40	3	< 0.01**
Study sites	22.73	4	< 0.05*
Years * seasons	19.40	8	0.08
Years * habitat types	24.32	8	0.07
Years * study sites	29.13	9	< 0.05*
Seasons * habitat types	25.11	7	0.04*
Seasons *study sites	27.41	8	0.08
Habitat types * study sites	31.26	8	< 0.05*
Years * seasons * habitat types * study sites	36.31	17	< 0.05*

F likelihood ratio, *df* degrees of freedom, *p* probability

*<0.05 (significant)

**<0.01 (highly significant)

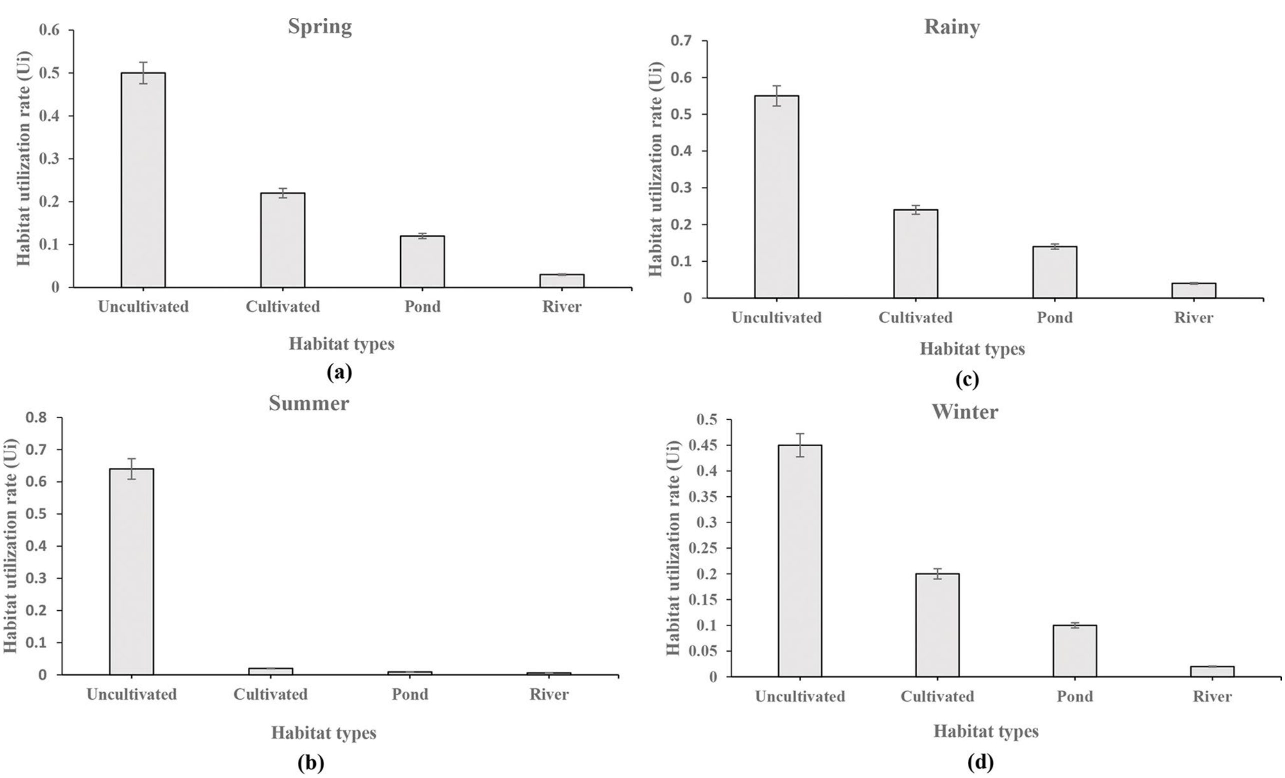

Fig. 5 Habitat utilization rate of Yellow-wattled Lapwing in different seasons; **a** spring **b** summer **c** rainy and **d** winter during the study period (January 2019 to December 2023)

Since, Malihabad had the most tree-covered and cultivated area, they had the lowest bird count, but we had anticipated that the largest number of Yellow-wattled Lapwings in Bakshi Ka Talab, may be attributable to the higher uncultivated land cover offering optimal grounds for feeding and breeding. Large trees were home to a high concentration of tree-nesting species, while high woody canopy cover was avoided by ground-nesting Yellow-wattled Lapwings [35].

The GLM analysis showed that 2021 was the year with the largest number of Yellow-wattled Lapwings. Comparable outcomes were noted for river lapwings [13] and spur-winged lapwings [36]. It's likely that in 2021, the COVID-19 lockdown period created good environmental circumstances for Yellow-wattled Lapwing population growth and development. The COVID-19 lockdown period might have a favourable impact on the distribution, behaviour, productivity and survival of many faunal species [37]. The degree of disturbance, the availability of resources, and bird breeding success are some of the reasons that might be causing the difference in bird counts between years [38].

Yellow-wattled Lapwings were sighted more frequently in the summer season due to the pervasiveness of their breeding period (April to July) [39, 40]. This study coincided with Mishra et al. [13] in river lapwings and Charalambidou et al. [41] in spur-winged lapwings (*Vanellus spinosus*). Moreover, the food availability may constrain the number of birds, especially during the mating season [42, 43]. Due to singing, displaying and foraging, the most of bird species are frequently easier to see in the summer [44]. Out of four seasons, the chicks are mainly found near the nests and adults during the summer and rainy seasons.

The winter season had the lowest lapwing counts, according to our data. Pfeifer et al. [44] reported a similar outcome. Numerous resident bird species were negatively impacted by the severe winter weather [18]. Birds will quickly perish from low temperatures if they are unable to modify their thermal regulation to match their increased energy demands [45]. Birds need more food throughout the winter to make up for the extra energy they need to keep their bodies at a constant temperature [46].

Food accessibility may be decreased in the winter because of the low temperatures, which cause prey to hide in layers of habitats to prevent freezing [47]. Prior research has also demonstrated a substantial seasonal link between changes in resource availability and the quantity and composition of waterbirds [48]. The quantity of waterbirds changes greatly across years and seasons due to both natural and manmade influences [49].

The results of the GLM analysis showed that uncultivated habitat types were the primary habitat types where Yellow-wattled Lapwings were found in the highest numbers. This is because uncultivated habitat offers optimum conditions for the birds to breed and feed [50]. Numerous waterbirds showed comparable outcomes [51, 52]. During the breeding season, Yellow-wattled Lapwings prefer dry, open fallows or wasteland [39, 40]. Chalfoun and Schmidt [53] suggested that animals typically select breeding environments that maximize the likelihood of successful reproduction.

The Yellow-wattled Lapwing has an edge over other species in uncultivated habitats when it comes to concealment and early predator detection. Many studies on various avifauna species have found similar findings [54, 55]. Furthermore, uncultivated habitat types may provide appropriate feeding grounds and plentiful surface-active prey items for birds [50]. Being insectivore, Yellow-wattled Lapwings are more common in uncultivated habitats and prefer to use pecking-feeding strategies to capture surface-active prey items [56, 57]. According to the speculations by Chapman and Reich's [58], the vegetation's structure could be the reason behind a habitat's higher bird population. Wastelands or dry, open fallows with short swards can improve feeding by increasing food accessibility, reducing the risk of predation and reducing transportation costs [55, 59].

The GLM analysis's findings also demonstrated that riverine habitat types had the lowest populations of Yellow-wattled Lapwings. A decrease in the number of Yellow-wattled Lapwings in riverine habitats may be attributed to the less availability of surface-active insect species, high water levels and the height of vegetation. Prateek et al. [60] found similar outcomes in Yellow-wattled Lapwings. Since, have more aquatic invertebrates than surface-active invertebrates, they avoid feeding in river environments since it is time and energy-consuming [57]. Reduced habitat heterogeneity, a lack of food and the increased danger of predators in natural settings could all be contributing causes to the reduction in species populations observed with rising vegetation height [61]. It has been documented that certain bird species may grow, decline in number, or vanish when the habitat shifts owing to vegetation changes along intricate geographical and environmental gradients [62].

Distribution pattern

In this field investigation, flock range size varied significantly in different seasons and habitat types. When two or more members of the same species stay together for a prolonged length of time and actively seek each other out to interact, they are said to form a flock [63]. The mean number of flocks was largest in uncultivated habitats during the summer season because of pair formation and grouping of birds, while it was lowest in river habitats during the winter season with scattered flocks. Similar findings were reported in river lapwing [13] and in Yellow-wattled Lapwing [64]. In addition, a previous field study also addressed similar findings in American coots (*Fulica americana*) [65].

Since Yellow-wattled Lapwings were primarily observed in flocks; hence, they exhibited a clumped distribution pattern. A similar observation was reported in river lapwings [13]. Habitat conditions and food availability have a significant effect on the distribution pattern of waterbirds [66–68]. Individuals in a clumped distribution tend to congregate in specific regions of the ecosystem. Several factors may lead to clumped distribution; for example, social behaviour, the surrounding environment, and resources like suitable habitats could be distributed in patches across the greater area [69].

Waterbirds have specific habitat preferences and their geographic distribution is dependent on the availability of food supplies [70–72]. Birds' distribution is significantly influenced by seasonality [61]. Seasonality affects the bird population's food supply and cover, which influences breeding success and, ultimately, species survival [73]. The availability of different food items for birds is known to be impacted by seasonal variations in temperature, precipitation and spatial and temporal habitat conditions [74]. Hutto [75] found similarities in the seasonal distribution patterns of many insectivorous bird species.

Habitat utilization

In this field study, we documented that uncultivated habitat was most utilized by Yellow-wattled Lapwings in all seasons. However, our findings suggested that uncultivated habitat was used more frequently in the summer than in other seasons since Yellow-wattled Lapwings were found in higher abundance in the study area. The ideal combination of temperature, food availability and nesting opportunities might allow ground-nesting birds to raise their young throughout the summer season.

The lowest habitat utilization rate was estimated from river habitat type, particularly in winter due to the low density of this species. This might be because the season (winter) and habitat (river) combination were not used by Yellow-wattled Lapwings. Similar results for cattle egrets (*Bubulcus ibis*) and little egrets (*Egretta garzetta*) were reported by Lombardini and Tourenq [76].

Morrison et al. [77] found differences in the habitat utilization of bird species in the Blodgett Forest of the Sierra Nevada, California, between the summer and winter seasons. Hutto [75] also discovered notable variations in habitat utilization across the seasons in a study of migratory insectivorous birds in the Chiricahua Mountains. The number and distribution of birds in the habitat, which indicates the specific habitats they utilize, are influenced by seasonality and habitat types [61]. Due to ecological factors including climate, vegetation and elevations found in the region, certain bird species utilize particular habitats [61].

Furthermore, food, protection from predators and unfavorable weather might be considered the most essential factors for the habitat selection of birds [78]. While looking at broad spatial scales, numerous other studies have also reported a positive association between bird abundance and invertebrate prey density [79, 80].

Conclusion

In conclusion, our study found an average of 394 individuals including 77 chicks with an average density of 38 birds per km. The largest number of Yellow-wattled Lapwings was recorded in 2021, which might have been due to the COVID−19 lockdown. During this period, the environment was more conducive to the improved growth and development of Yellow-wattled Lapwings. They were sighted more frequently in the summer season, while the winter season had the lowest lapwing counts. Finally, we conclude that the Yellow-wattled Lapwing population remained stable in recent years. Their distribution was not even, the lowest number of individuals were recorded in river habitats whereas uncultivated habitats had the highest count. Being sighted in flocks of various sizes, the distribution pattern was found to be clumped. Additionally, there was an uneven habitat utilization, with uncultivated habitat being the most utilized, particularly in summer seasons.

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Author contributions

Prateek (conceptualization, performed field survey, data collection, statistical analysis, and writing), H.M. (data collection, and interpretation), V.K. (data collection and interpretation), A. K. (conceptualization, planning research and interpretation).

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

The authors declare no competing interests.

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References

1. Boddaert P. Table des planches enluminéez d'histoire naturelle de M. D'Aubenton. Avec les denominations de MM de Buffon, Brisson, Edwards, Linnæus et Latham. Précédé d'une notice des principaux ouvrages zoologiques enluminés. The Field; 1874.
2. Mukherjee S, Nath P, Aditya G. Observations on Yellow-Wattled Lapwing *Vanellus malabaricus* (Boddaert, 1783) in South West Bengal, India. Proc Zool Soc. 2015;68:222–226. Springer India. https://doi.org/10.1007/s12595-014-0117-4.
3. Kumar C. First record of a regularly occupied nesting ground of Yellow-wattled Lapwing *Vanellus malabaricus* (Boddaert) in agricultural environs of Punjab with notes on its biology. J Entomol Zool Stud. 2015;3(1):129–34.
4. Kazmierczak K, Perlo BV. A field guide to the birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives. 2000.
5. Sethi VK, Bhatt D, Kumar A. Hatching success in Yellow-wattled Lapwing *Vanellus malabaricus*. Indian Birds. 2010;5(5):139–42.
6. Ali S, Ripley SD. Yellow-wattled lapwing *Vanellus malabaricus* lesson, 1826. In: Handbook of the birds of India and Pakistan. New Delhi, India: Oxford University Press; 1980.
7. Jerdon TC. Birds of India, vol. 2(2). Calcutta: George Wyman; 1864.
8. Adesh K, Amita K. Unusual sighting of Yellow-wattled Lapwing *Vanellus malabaricus* in Lucknow District, Uttar Pradesh, India. Int J Life Sci. 2015;3(2):181–4.
9. https://datazone.birdlife.org/species/factsheet/yellow-wattled-lapwing-vanellus-malabaricus.
10. Birdlife, IUCN. Iucn red list for birds. 2024. https://www.iucnredlist.org.
11. https://www.stateofindiasbirds.in/species/yewlap2/.
12. Schowalter TD. Insect ecology: an ecosystem approach. Academic; 2022.
13. Mishra H, Kumar V, Kumar A. Population structure, behavior, and distribution pattern of the River Lapwing *Vanellus duvaucelii* (Lesson,1826). J Asia-Pac Biodivers. 2018;11(3). https://doi.org/10.1016/j.japb.2018.06.001.
14. Morris DW. How can we apply theories of habitat selection to wildlife conservation and management? J Wildl Res. 2003;30(4):303–19. https://doi.org/10.1071/WR02028.
15. Klar N, Fernández N, Kramer-Schadt S, Herrmann M, Trinzen M, Büttner I, Niemitz C. Habitat selection models for European wildcat conservation. Biol Conserv. 2008;141(1):308–19. https://doi.org/10.1016/j.biocon.2007.10.004.
16. Gaston KJ, Lawton JH. Effects of scale and habitat on the relationship between regional distribution and local abundance. Oikos. 1990;329–35. https://doi.org/10.2307/3545224.
17. McCain CM. Global analysis of bird elevational diversity. Glob Ecol Biogeogr. 2009;18(3):346–60. https://doi.org/10.1111/j.1466-8238.2008.00443.x.
18. Newton I. Population limitation in birds. Academic press; 1998.
19. Sampath K. Studies on the ecology of shorebirds (Aves: Charadriiformes) of the Great Vedaranyam Salt Swamp and the Pichavaram mangroves of India [Doctoral dissertation]. Centre of Advanced Study in Marine Biology, Annamalai University; 1989.
20. Jones J. Habitat selection studies in avian ecology: a critical review. Auk. 2001;118(2):557–62. https://doi.org/10.1093/auk/118.2.557.
21. Hildén O. Habitat selection in birds: a review. InAnnales Zool Fennici. 1965;2(1):53–75. Finnish Zoological and Botanical Publishing Board. https://www.jstor.org/stable/23730835.
22. Dodge KM, Whitmore RC, Harner EJ. Analyzing foraging use versus availability using regression techniques. Stud Avian Biol. 1990;13:318–24.
23. Hutto RL. Measuring the availability of food resources. Stud Avian Biol. 1990;13:20–8.
24. Kirby JS, Stattersfield AJ, Butchart SH, Evans MI, Grimmett RF, Jones VR, O'Sullivan J, Tucker GM, Newton I. Key conservation issues for migratory land-and waterbird species on the world's major flyways. Bird Conserv Int. 2008;18(S1):S49–73. https://doi.org/10.1017/S0959270908000439.
25. Prateek, Mishra A, Mishra H, Kumar V, Kumar A. Status and diversity of butterfly fauna in Joggers Park, Lucknow, Uttar Pradesh, India. J E O H. 2023;23(1):43–9. https://doi.org/10.18311/jeoh/2023/3117.
26. Kanaujia A, Kumar A, Kushwaha S, Kumar A. Diversity of Waterbirds in Lucknow District, Uttar Pradesh, India. IJSR. 2015;4(1):862–6.
27. Burnham KP, Anderson DR, Laake JL. Estimation of density from line transect sampling of biological populations. Wildl Monogr. 1980;72:3–202. https://www.jstor.org/stable/3830641.
28. Bibby CJ, Burgess ND, Hill DA, Mustoe S. Bird Census techniques. Academic; 2000.
29. Morrison ML, Block WM, Strickland MD, Collier BA, Peterson MJ. Concepts for Wildlife Science: design application. In: Wildlife Study Design. 2008. p. 37–75.
30. Krause J, Ruxton GD. Living in groups. Oxford University Press; 2002.
31. Hagemeijer WJ, Blair MJ. The EBCC atlas of European breeding birds. London: Poyser; 1997. p. 479.
32. Gichuki N. Influence of breeding on foraging behaviour and diet of crowned cranes. Ostrich. 2000;71(1–2):74–9. https://doi.org/10.1080/00306525.2000.9639873.
33. Fengting ZH, Lizhi ZH, Wenbin XU. Habitat utilization and resource partitioning of wintering hooded cranes and three goose species at Shengjin Lake. Avian Res. 2013;4(4):281–90. https://doi.org/10.5122/cbirds.2013.0032.
34. Cranswick PA. The Wetland Bird Survey 1997-98 Wildfowl and Wader counts. WWT; 1999.
35. Söderström B, Kiema S, Reid RS. Intensified agricultural land-use and bird conservation in Burkina Faso. Agric Ecosyst Environ. 2003;99(1–3):113–24. https://doi.org/10.1016/S0167-8809(03)00144-0.
36. HATZOFE O, YOM-TOV YO. Global warming and recent changes in Israel's avifauna note. Isr J Zool. 2002;48(4):351–7.
37. Kowarik I. Novel urban ecosystems, biodiversity, and conservation. Environ Pollut. 2011;159(8–9):1974–83. https://doi.org/10.1016/j.envpol.2011.02.022.
38. Mishra H, Bano F, Prateek, Mishra A, Kumar V, Kumar A. Elucidation of Diversity and Habitat utilization of Waterbirds in Khajuha Wetland, Northern India Biol. Bull. 2024. https://doi.org/10.1134/S1062359023605542.
39. Ali S, Ripley SD. Handbook of the birds of India and Pakistan. Megapodes to Crab Plover, vol. 2, 2nd ed. Delhi (Sponsored by Bombay Natural History Society): Oxford University Press (Oxford India Paperbacks); 1998.
40. Richard G, Carol I, Tim I. Birds of the Indian Subcontinent. 1998.
41. Charalambidou I, Kassinis N, Gűcel S, Fuller W. The status and breeding population of the spur-winged lapwing *Vanellus spinosus* in Cyprus. Journal homepage: www.wesca.net. 2012;7(1/2).
42. Newton I. The role of food in limiting bird numbers. Ardea. 1980;55(1–2):11–30.
43. White T. The role of food, weather and climate in limiting the abundance of animals. Biol Rev. 2008;83(3):227–48. https://doi.org/10.1111/j.1469-185X.2008.00041.x.
44. Pfeifer R, Stadler J, Roland B. Is the seasonal variation of abundance and species richness in birds explained by energy availability? Acta Ornithol. 2018;52(2):167–78. https://doi.org/10.3161/00016454AO2017.52.2.005.
45. Bakken GS, Murphy MT, Erskine DJ. The effect of wind and air temperature on metabolism and evaporative water loss rates of dark-eyed Juncos, *Junco hyemalis*: a standard operative temperature scale. Physiol Zool. 1991;64(4):1023–49.
46. Reif J, Telenský T, Šťastný K, Bejček V, Klvaňa P. Relationships between winter temperature and breeding bird abundance on community level: importance of interspecific differences in diet. Folia Zool. 2010;59(4):313–22. https://doi.org/10.25225/fozo.v59.i4.a7.2010.
47. Rolstad J, Rolstad E. Influence of large snow depths on Black Woodpecker *Dryocopus martius* foraging behaviour. Ornis Fenn. 2000;77(2):65–70. https://ornisfennica.journal.fi/article/view/133527.
48. Mundava J, Caron A, Gaidet N, Couto FM, Couto JT, Garine-Wichatitsky MD, Mundy PJ. Factors influencing long-term and seasonal waterbird abundance and composition at two adjacent lakes in Zimbabwe. Ostrich. 2012;83(2):69–77. https://doi.org/10.2989/00306525.2012.692726.
49. Aarif KM, Nefla A, Muzaffar SB, Musammilu KK, Prasadan PK. Traditional fishing activities enhance the abundance of selected waterbird species in a wetland in India. Avian Res. 2017;8:1–0. https://doi.org/10.1186/s40657-017-0073-6.
50. Devereux CL, Mckeever CU, Benton TG, Whittingham MJ. The effect of sward height and drainage on common starlings Sturnus vulgaris and Northern Lapwings *Vanellus vanellus* foraging in grassland habitats. Ibis. 2004;146:115–22. https://doi.org/10.1111/j.1474-919X.2004.00355.x.
51. Froneman A, Mangnall MJ, Little RM, Crowe TM. Waterbird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. Biodivers Conserv. 2001;10:251–70. https://doi.org/10.1023/A:1008904421948.
52. McKinstry MC, Anderson SH. Creating wetlands for waterfowl in Wyoming. Ecol Eng. 2002;18(3):293–304. https://doi.org/10.1016/S0925-8574(01)00088-X.
53. Chalfoun AD, Schmidt KA. Adaptive breeding-habitat selection: is it for the birds? Auk. 2012;129(4):589–99. https://doi.org/10.1525/auk.2012.129.4.589.

54. Fuller RJ, Youngman RE. The utilisation of farmland by Golden plovers wintering in southern England. Bird Study. 1979;26(1):37–46. https://doi.org/10.1080/00063658109476721.
55. Fuller RJ, Lloyd D. The distribution and habitats of wintering Golden plovers in Britain, 1977–1978. Bird Study. 1981;28(3):169–85. https://doi.org/10.1080/00063658109476721.
56. Jadav PC, Pathak RD, Borad CK, Parasharya BM. Community structure of insectivorous birds of cabbage fields. J Biol Control 2013;135–8. https://ischolar.sscldl.in/index.php/jbc/article/view/45589.
57. Prateek, Mishra H, Kumar V, Kumar A. Temporal pattern in foraging behaviour of *Vanellus malabaricus* in relation to different seasons and habitats. Avian Biol Res. 2024;17(1–2):22–30. https://doi.org/10.1177/17581559241237725.
58. Chapman KA, Reich PB. Land use and habitat gradients determine bird community diversity and abundance in suburban, rural and reserve landscapes of Minnesota. USA Biol Conserv. 2007;135(4):527–41. https://doi.org/10.1016/j.biocon.2006.10.050.
59. McKeever CU. Linking grassland management, invertebates and Northern Lapwing productivity. University of Stirling (United Kingdom); 2003.
60. Prateek, Mishra H, Kumar V, Kumar A. Comparative analysis of diet and prey preference of Yellow-wattled Lapwing *Vanellus malabaricus* (Boddaert, 1783). Curr Sci. 2024;7(00113891). https://doi.org/10.18520/cs/v127/i7/841-848.
61. Girma Z, Mamo Y, Mengesha G, Verma A, Asfaw T. Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south-central Ethiopia. Ecol Evol. 2017;7(10):3397–405. https://doi.org/10.1002/ece3.2926.
62. Lee PY, Rotenberry JT. Relationships between bird species and tree species assemblages in forested habitats of eastern North America. J Biogeogr. 2005;32(7):1139–50. https://doi.org/10.1111/j.1365-2699.2005.01254.x.
63. Lidfors LM. Living in groups. 2018.
64. Prateek, Mishra H, Kumar V, Kumar A. Effect of group size and period of the day on daily activity patterns of *Vanellus malabaricus*; (Boddaert, 1783) in Northern India. Ornithol Res. 2024; 1–10. https://doi.org/10.1007/s43388-024-00189-x.
65. Lam DQ, Rizal SP, Cota R, Sicaja M, Cox G, Wakefield B, Nisani Z. Investigating the effect of flock size on vigilance in the American coot (*Fulica americana*) in relationship to Habitat. Am J Undergrad Res. 2020;17(3). https://doi.org/10.33697/ajur.2020.022.
66. Goss-Custard JD, Jenyon RA, Jones RE, Newbery PE, Williams RL. The ecology of the Wash. II. Seasonal variation in the feeding conditions of wading birds (Charadrii). J Appl Ecol. 1977;701–19. https://doi.org/10.2307/2402804.
67. Fonseca VG, Grade NU, Cancela da Fonseca L. Patterns of association and habitat use by migrating shorebirds on intertidal mudflats and saltworks on the Tavira Estuary, Ria Formosa, southern Portugal. Wader Study Group Bull. 2004;105:50–5.
68. Green AJ, Elmberg J. Ecosystem services provided by waterbirds. Biol Rev. 2014;89(1):105–22. https://doi.org/10.1111/brv.12045.
69. Thomas SM, Robert SL. The element of ecology. 8th ed. U.K.: Pearson Education Limited; 2015, p. 182–3.
70. Frederickson LH, Reid FA. Impacts of hydrologic alteration on management of freshwater wetlands. 1990.
71. Skagen SK, Knopf FL. Toward conservation of midcontinental shorebird migrations. Conserv Biol. 1993;7(3):533–41. https://doi.org/10.1046/j.1523-1739.1993.07030533.x.
72. Pandiyan J, Asokan S. Habitat use pattern of tidal mud and sand flats by shorebirds (charadriiformes) wintering in southern India. J Coast Conserv. 2016;20:1–1. https://doi.org/10.1007/s11852-015-0413-9.
73. Mengesha G, Bekele A. Diversity and relative abundance of birds of alatish national park, north Gondar, Ethiopia. Int J Ecol Environ Sci. 2008;34(2):215–22.
74. Mengesha G, Mamo Y, Bekele A. A comparison of terrestrial bird community structure in the undisturbed and disturbed areas of the Abijata Shalla lakes national park, Ethiopia. I J B C. 2011;3(9):389–404. http://www.academicjournals.org/IJBC.
75. Hutto RL. Seasonal changes in the habitat distribution of transient insectivorous birds in southeastern Arizona: competition mediated? Auk. 1985;102(1):120–32. https://doi.org/10.2307/4086827.
76. Lombardini K, Bennetts RE, Tourenq C. Foraging success and foraging habitat use by Cattle Egrets and little egrets in the Camargue, France. Condor. 2001;103(1):38–44. https://doi.org/10.1093/condor/103.1.38.
77. Morrison ML, With KA, Timossi IC. The structure of a forest bird community during winter and summer. Wilson Bull. 1986;214–30. https://www.jstor.org/stable/4162227
78. Baker JR. The evolution of breeding seasons. In: Evolution: essays on aspects of evolutionary biology. 1938. p. 161–77.
79. Goss-Custard JD. The responses of redshank (*Tringa totanus* (L.)) to spatial variations in the density of their prey. J Anim Ecol. 1970;91–113. https://doi.org/10.2307/2891.
80. Meire P, Kuyken E. Relations between the distribution of waders and the intertidal benthic fauna of the Oosterschelde, Netherlands. 1983.

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