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Migratory cranes' ecology and habitat use in District Bhakkar, Punjab, Pakistan

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Abstract. Pakistan's strategic location along the Indus Flyway supports a diverse range of migratory bird species, including cranes, but little is known about their distribution range and ecological factors. The study examined the population structure, behavioral patterns, spatial distribution, and the influence of various environmental and anthropogenic factors on Cranes in District Bhakkar, Punjab, between September 2023 and March 2024. Two crane species were identified through fieldwork at two important locations, Kallurkot and Bhakkar: the Demoiselle Crane (*Grus virgo*, n = 310) and the Eurasian Crane (*Grus grus*, n = 219), totaling 529 individuals. Diversity indices indicated that species distribution was nearly equal (Evenness = 0.9862), with low species richness (Margalef R = 0.1595) and moderate dominance (D = 0.4861). Autumn activity was higher, according to behavioural observations, especially for Demoiselle Cranes (flying: 114 vs. 80; feeding: 21 vs. 11; night sightings: 130 vs. 30). It was also supported by PCA (PC1 = 83.216). At the same time, Eurasian Cranes were found less active in the spring (PC1 = -45.508). Public perception surveys (n = 100) also supported the field data: 77% recognized cranes, 61% identified Demoiselle Cranes as more common, and 60% reported a significant decline in the population. According to the habitat assessment, Kallurkot presented less anthropogenic disturbance (distance to industry: 193.92m; human settlements: 146.02m), but Bhakkar was closer to water sources (rivers/lakes: 15.99m; wetlands: 28.76m). These findings highlight the seasonal and spatial variation in crane populations, behaviors, and distribution, which is driven by both ecological and human factors, and underscore the urgent need for targeted conservation strategies in the region.

Keywords: migratory birds, cranes, Indus Flyway, habitat assessment, population ecology, distribution, anthropogenic and environmental impact.

Introduction

Bird migration is a significant annual journey undertaken by millions of birds in response to environmental changes, ensuring optimal living conditions (Newton 2023, Cox 2010, Somveille et al. 2015, Lisovski et al. 2024). These seasonal movements are often thousands of kilometers long and span various ecological zones (Donnelly et al. 2020, Piersma et al. 2022, Newton 2023, Van Doren et al. 2023). Pakistan is situated at the intersection of Oriental, Ethiopian, and Palearctic zoogeographic zones (Khan & Pervaiz 2001, Roberts & El-Hawagry 2024), and has a middle Asian flight path for migrating birds, the International Migratory Birds Route 4, or the Indus Flyway (Narwade et al. 2021, Khan et al. 2024). It hosts over 400 migratory bird species annually (Galbraith 2014, Al-Sheikhly 2021, Ashraf & Ali 2021), primarily from Siberia. (The Dawn 2016, Khan et al. 2024, Rasool et al. 2024). These birds spend 4–5 months at Ramsar sites and other wetlands of the country along the Indus basin, providing habitat and food (Galbraith 2014). Their migration occurs from September to November and continues until February or March (Sheikh & Kashif 2006, Grimmett et al. 2008, Ahmad 2020, Donnelly et al. 2020, Ilyashenko et al. 2022). Afterwards, they return to their breeding grounds as climatic conditions begin to warm (Newton 2023, Volkov et al. 2024). Cranes, Houbara Bustard, Teals, Geese, Pintails, Spoonbills, Mallards, Waders, and Pelicans make up the majority of the migratory bird species (Ali 2005, Umar et al. 2018, Khan et al. 2024).

Cranes belong to the family Gruidae and are known for their large body size, long legs, neck, and remarkable lifespan (Louchart & Duhamel 2021, Wessling 2022, Girgiri et al. 2022). Locally, Cranes are known as "Koonj" (Canonico Johnson 2023) in Punjab, Pakistan. They possess a unique ability to lift human spirits, as few other wild animals can (Nováková & Robovský 2021). Generally, they are omnivorous and prefer to live in a variety of habitats (Hemminger et al. 2022), such as marshlands, swamps, grasslands, waterlogged areas, wetlands, and paddy fields, where they can breed, rest, and forage primarily on insects and plants (Sarwar et al. 2013, Wamiti 2022, Yang & Shuihua 2024). They form monogamous pairs and remain together until one of them passes away (Roy et al. 2022). In these partnerships, males often assume protective roles, while females are more involved in domestic duties (Perveen 2012, Wang et al. 2025).

There are approximately fifteen Crane species worldwide, except on two continents: South America and Antarctica, due to severe and unsuitable climatic conditions (Baral 2009). Particularly, a few crane species, namely the Demoiselle Crane *(Grus virgo*), Sarus Crane (*Grus antigone*), Siberian Crane (*Grus leucogeranus*), and Eurasian (Common) Crane (*Grus grus*), regularly visited Pakistan in the past (Khan 2004, Mahmood et al. 2011). Currently, two crane species, including the Eurasian and Demoiselle, primarily visit Pakistan, while the other two species are now rarely seen. The Siberian Crane has been almost extirpated from Pakistan (BirdLife

International 2001, Khan 2004).

The commonly visiting crane species to Pakistan, including the Demoiselle and Eurasian cranes, are listed as 'Least Concern' on the IUCN Red List of Threatened Species 2013 (Sarwar et al. 2022), and are also listed in CITES Appendix II (Maes et al. 2015). But now these species are also facing different threats, including habitat degradation, climate change, use of pesticides and herbicides (for reducing crop damage) (Rehman et al. 2021, Hemminger et al. 2022, Sunita et al. 2024), predators attack, collision with utility lines and other human infrastructures, illegal hunting and trade (Masaud et al. 2010, Perveen & Khan 2010), leading to decline in their populations worldwide and in Pakistan (Shafiq 1998, Horwich 2001, Hijmans et al. 2005). Preservation measures are necessary to address these rising threats (Perveen 2012, Hewson et al. 2018).

Knowledge about the distribution and populations of cranes in Pakistan, particularly in Punjab Province, is limited due to a lack of comprehensive studies on their seasonal migration patterns, which are crucial for identifying population declines caused by various threats. The present study was designed to assess the population size, behavioral patterns, distribution, and impact of various anthropogenic and environmental variables in District Bhakkar, Punjab, Pakistan. This research will contribute valuable insights for the conservation of migratory crane species in Punjab, while also drawing international attention to the need for conservation efforts for these important species.

Materials and methods

Study area

Bhakkar District, located in Punjab, Pakistan, is the largest district by area in the Sargodha Division, covering over 8,153 square kilometers (Figure 1). It features two prominent landscapes: the arid Thal Desert and the fertile Indus River valley, locally known as 'Katcha.' The district experiences a moderate, warm climate classified as humid subtropical. Positioned along the Indus Flyway, Bhakkar supports a rich diversity of migratory bird species, making it an ecologically significant region.

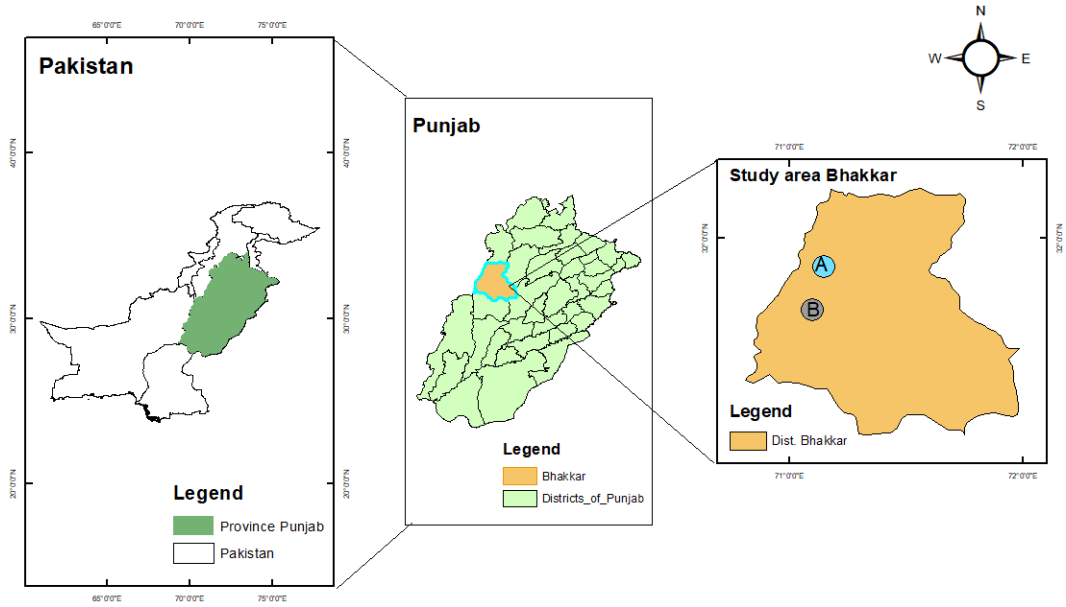

Figure 1. Map of the study area, including the entire District Bhakkar, Punjab, Pakistan.

Study site selection

Potential study sites, i.e., tehsils Kallurkot and Bhakkar, were first identified based on previous reports of crane occurrences and information obtained from residents and wildlife experts from distinct tehsils within District Bhakkar. Both sites are situated in riverine and wetland habitats, where cranes are typically more abundant compared to arid or upland regions of other tehsils. After a comprehensive evaluation, two sampling sites were chosen in the given study sites along their migratory Route (Figure 2).

Study design

The study was conducted between September 2023 and March 2024, spanning two consecutive migration seasons. In-depth field surveys were conducted by a dedicated team of three researchers, with approximately 25 days allocated for data collection in each season. Crane distribution, population trends, behavioral patterns, and the impact of various variables on distribution were all carefully considered in this study. Safety and methodological rigour were given priority when conducting fieldwork. To ensure accurate observations and provide valuable insights into the ecological dynamics and conservation status of migratory crane species, standard ecological research equipment was employed.

Population Size

Population size was estimated using both direct and indirect counts, as well as survey methods conducted during visits.

Direct and indirect count method

We applied the line transect method (Rehman et al. 2021, Ullah et al. 2023, Aticho et al. 2024, Banjade et al. 2024) to estimate population size by establishing three transects at each sampling site, typically in a crane habitat (Aticho et al. 2018, Gyawali 2018). The length of the transect varied, usually 1000 meters long, with widths of 250 meters on each side. The exact length was determined based on the size of the sampling area and its accessibility. Longer transects were examined in vast areas by a vehicle driven at a speed of 20 km/h, while smaller transects were examined by walking. We recorded crane numbers along both sides of the transects directly (Figure 3), using binoculars

and spotting scopes, as well as indirectly through signs such as footprints, droppings, and feathers (Figure 4). We used these data to estimate the total population count, as in other studies (Kaul & Shakya 2001, Zelelew et al. 2020, Smith et al. 2022, Wamiti 2022).

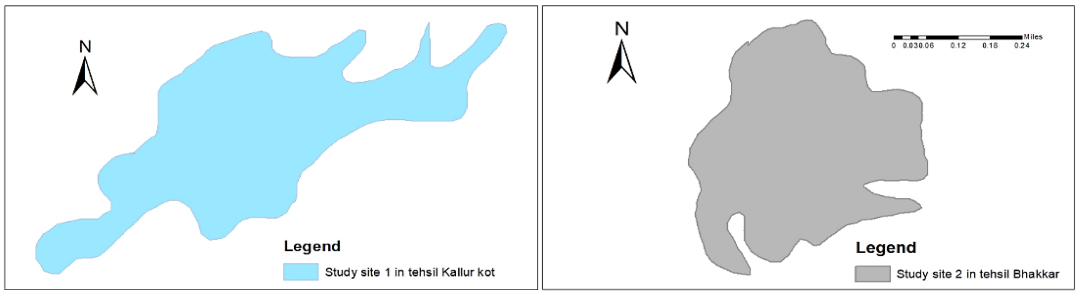

Figure 2. Sampling sites in two different tehsils of the district Bhakkar, i.e., Kallurkot and Bhakkar.

Figure 3. Direct observation of common and demoiselle cranes at sampling sites.

Figure 4. Indirect sighting of common and demoiselle cranes at the sampling sites.

During each encounter with different crane species, we also recorded data on specific crane species, age (juvenile and adult), number of flocks, flock size, other behaviors of cranes (flying, feeding, resting), seen by the naked eye, observed by binocular and spotting scope, number of cranes seen at night and day, and flight pattern (V-shaped or line-shaped). To ensure consistency in our sampling efforts and abundance evaluation, we maintained a standard pitch and a standardized walking pace.

We used high-resolution DSLR cameras to capture detailed photographs, ensuring accurate data collection (Hodgson et al. 2018, Lyons et al. 2019). The use of photographs enabled an objective evaluation of relative bird abundance with minimal bias (Cruz et al. 2015). A data notebook was employed to document periodic reports on crane species.

Visiting survey method

We also used 100 self-designed questionnaires (Supplementary Material – available online) to collect information from stakeholders, including monks, villagers, forestry staff, and hunters, at the study sites about the cranes. This helps to collect accurate information through cross-referencing with field data.

Distribution

Data on the distribution of each species can be obtained from various sources, including museum records, maps, and previously published research focused on the species of interest (Moura et al. 2012, Scambler et al. 2023). When integrated with environmental variables, this information can help assess the anthropogenic impacts on species distribution (Moura et al. 2012, Phillips et al. 2006). In our study, we conducted field surveys to record sightings of each crane species, using a Global Positioning System (GPS) device to capture the precise geographic coordinates and elevation of each location. This approach enabled the accurate documentation of species occurrences across diverse terrains, thereby contributing to a reliable understanding of their spatial distribution. We also used five anthropogenic and environmental variables to analyze their impact on crane distribution:

land use, human activities, land cover, geomorphic types, and water depth. Land use and human activities encompass proximity to populated areas, mills, factories, commercial complexes, institutions, and roads (Mansoori & Kiabi 2003, Zadeh et al. 2011, Latt et al. 2022, Jiang et al. 2024). Land Cover included wetland vegetation types (grasslands, forestlands, croplands), water bodies (lakes, rivers, creeks, reservoirs), and barren land. These variables served as key predictors by representing vegetation structure, habitat type, and food availability (Mansoori & Kiabi 2003, Zadeh et al. 2011, Seoane et al. 2004, Aghainajafi-Zadeh et al. 2010, Aghanajafizadeh et al. 2012, Carrascal et al. 2012, Asadalla et al. 2015, Latt et al. 2022, Singh et al. 2024). Additionally, geomorphic variables, particularly elevation and proximity to water sources such as rivers and lakes, significantly influenced the distribution of cranes. Suitable water depth was also identified as a critical factor for crane foraging (Jia et al. 2019, Li et al. 2024, Shao et al. 2024).

Data analysis

PAST 4.1c was used to analyze crane population data, evaluating species diversity and behavior using PCA and diversity indices (Simpson, Shannon, Evenness, Margalef, and Dominance) (Rahman et al. 2023, Agidie et al. 2024). The effect of anthropogenic and environmental variables on distribution was assessed using linear correlation. Euclidean distances to land use classes were computed using Google Earth, ArcGIS Basic, and ArcMap Spatial Analyst (Franklin 2009, Hou et al. 2021, Zelelew et al. 2021), with land cover data sourced from the USGS. R 4.3.2, SPSS 26, and Microsoft Excel were used to construct the graphs and charts.

Results

Species composition and diversity

Two crane species were identified in District Bhakkar throughout the study period: the Eurasian Crane (*Grus grus*) and the Demoiselle Crane (*Grus virgo*), indicating that the district has low crane species diversity. A total of 529 individuals, comprising 310 Demoiselle Cranes and 219 Eurasian Cranes, were sighted (Figures 3 and 5).

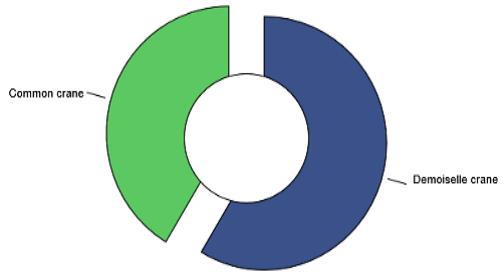

Figure 5. Diversity of crane species in the study area.

According to diversity analysis, there was a balanced chance of encountering either species, as indicated by the Simpson's Index (D = 0.4861) and a Dominance Index (D' = 0.5139), suggesting moderate dominance. While the Evenness Index (E = 0.9862) indicates a nearly equal distribution between the two species, the Shannon-Wiener Index (H' = 0.6792) indicates modest species diversity. The district's crane community exhibits low species richness, as confirmed by the Margalef Richness Index (R = 0.1595) (Table 1).

Table 1. Diversity indices of cranes at District Bhakkar.

Statistical analysis	Mean values
Species number (SN)	2
Individual number (IN)	529
Dominance (D')	0.5139
Simpson (D)	0.4861
Shannon (H')	0.6792
Evenness (E)	0.9862
Margalef /Richness (R)	0.1595

Crucially, during the field observations, neither Siberian Crane (*Leucogeranus leucogeranus*) nor Sarus Crane (*Antigone antigone*) individuals were observed (Figures 3 and 5), suggesting that they may have been extinct in this area.

Site and seasonal observations of crane species

Crane observations in Bhakkar and Kallurkot are compared by site and season in Table 2. Although the average flock size was somewhat greater in Bhakkar (30 vs. 25), Demoiselle Cranes were seen more frequently in Kallurkot (4 flocks) than in Bhakkar (3 flocks) in the autumn of 2023. Both locations had good binocular detection rates, with Bhakkar having somewhat more (65 vs. 60), suggesting comparable visibility and flock distance. Eurasian cranes have fewer flocks, but a greater flock size was observed. Average flock sizes decreased for both species and sites in the spring of 2024, but more birds were detected with the naked eye, particularly in Bhakkar. This suggests that during return migration, the birds may have relocated to more accessible or open areas and benefited from the improved weather clarity associated with the spring season. These temporal and spatial changes are probably depicted in Figures 6-9, which highlight the autumnal larger flocks and higher sightings, especially in Kallurkot, which might be a significant location for migratory congregations.

Table 2. Cranes' behavior during their passage to District Bhakkar, Punjab, Pakistan, in autumn 2023 and spring 2024.

Species names, seasons, and years	Flying (average)	Feeding (average)	Resting (average)	Detection in day (average)	Detection at night (average)	Flocks seen in V-shape (average)	Flocks seen in line shape (average)
Demoiselle crane, Autumn 2023	114	21	55	60	130	6	1
Demoiselle crane, Spring 2024	80	11	29	90	30	4	2
Common crane, Autumn 2023	70	17	43	80	50	3	1
Common crane, Spring 2024	64	13	10	67	20	3	0

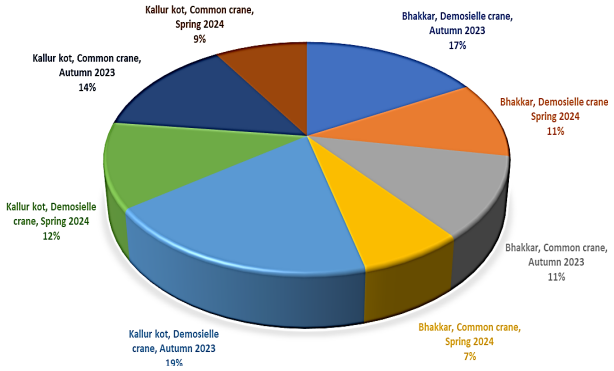

Figure 6. Percentage of crane species at both sampling sites in autumn 2023 and spring 2024.

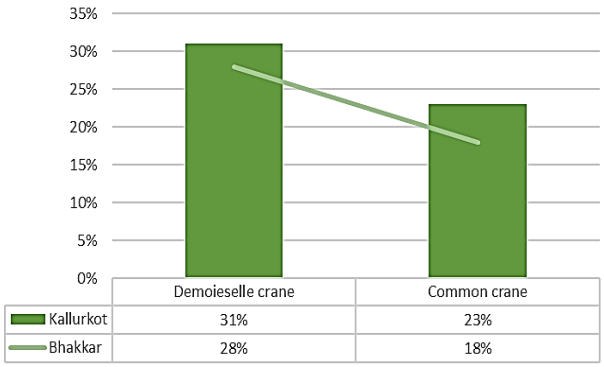

Figure 7. Diversity of crane species at both sampling sites, i.e., Kallurkot and Bhakkar.

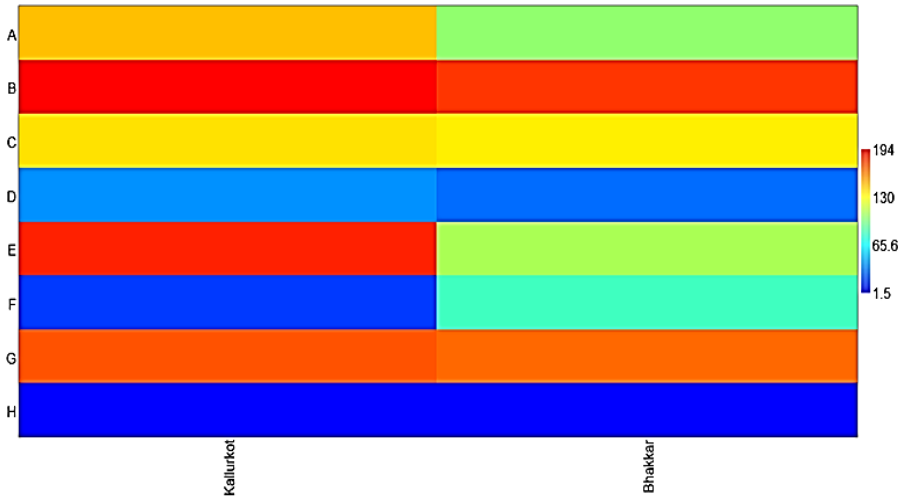

Figure 8. The matrix plot illustrates the effect of various variables (A-H codes are listed in Table 5) on cranes' behavior.

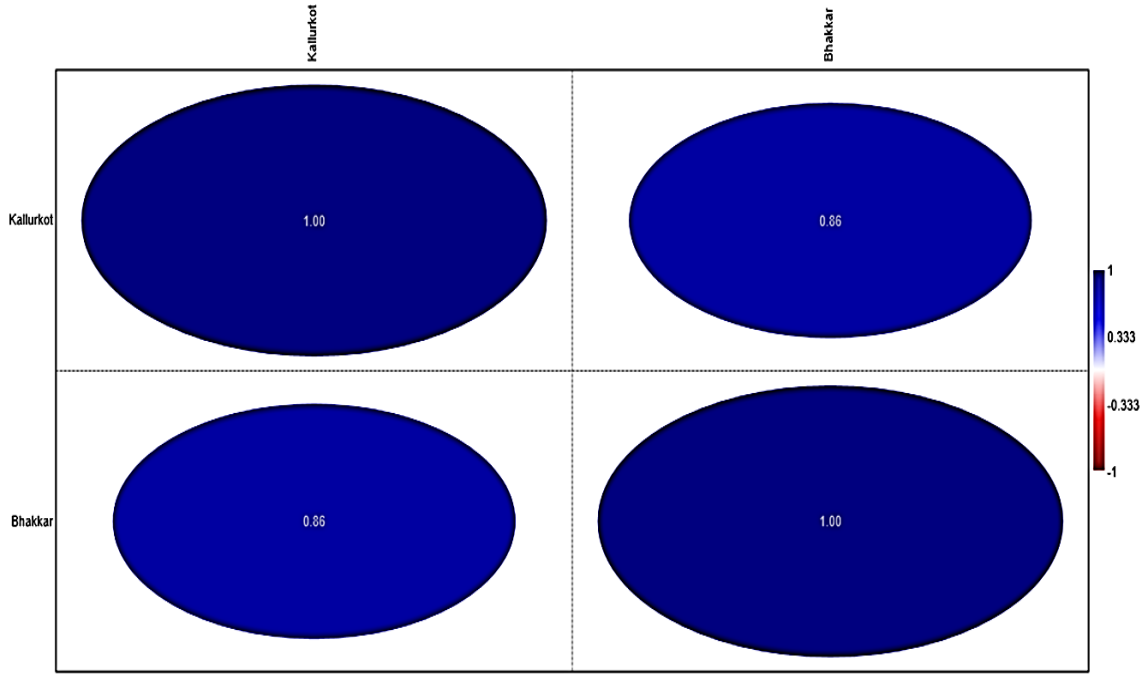

Figure 9. The graph shows a linear correlation of 0.86 between the two sampling sites.

Seasonal and species-specific behavioral patterns

Among Demoiselle and Eurasian cranes, the behavioural data show distinct seasonal and species-specific patterns (Figure 10). When comparing Autumn 2023 to Spring 2024, demoiselle cranes were more active in most behaviours, especially flying (114 vs. 80), feeding (21 vs. 11), and night detection (130 vs. 30) (Figures 11 and 12). This suggests that there is more migratory activity in the autumn. Similar patterns were seen in Eurasian Cranes, which exhibited more noticeable behaviour in the autumn than in the spring. Particularly in the autumn, V-shaped flock formations were more prevalent than line-shaped ones, indicating the existence of migratory movements. Principal Component Analysis (PCA) further emphasized these trends: Demoiselle cranes in the autumn had a large positive PC1 score (83.216), indicating great behavioural intensity. Whereas Eurasian Cranes in the spring had the lowest PC1 score (-45.508), this suggests little activity (Table 3). Overall, the PCA confirms that both species exhibit notable seasonal variations, with lower activity levels in the spring and higher activity in the autumn, and that Demoiselle cranes are more behaviorally dynamic, especially during the autumn migration (Table 4).

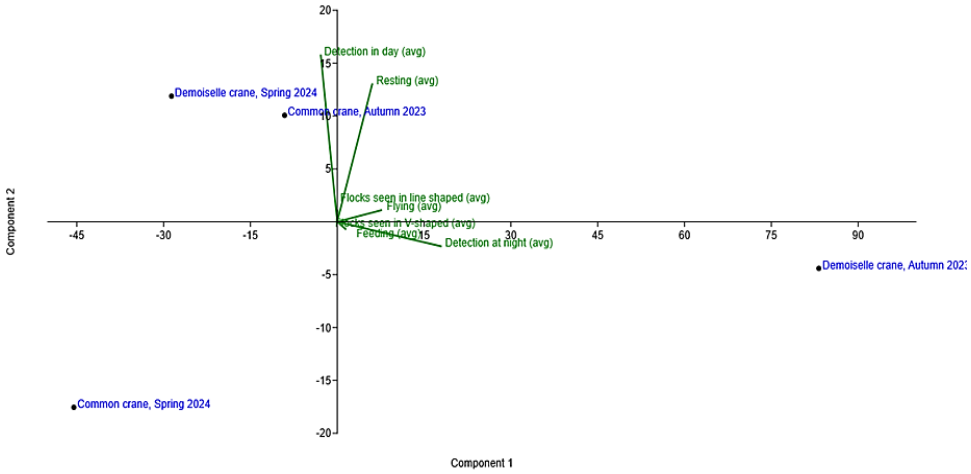

Figure 10. Principal Component Analysis (PCA) reveals distinct behaviors of Crane species during their migration through District Bhakkar in autumn 2023 and spring 2024, as depicted in Table 2. The positions of the arrows about components 1 and 2 demonstrate a strong correlation between the independent variables.

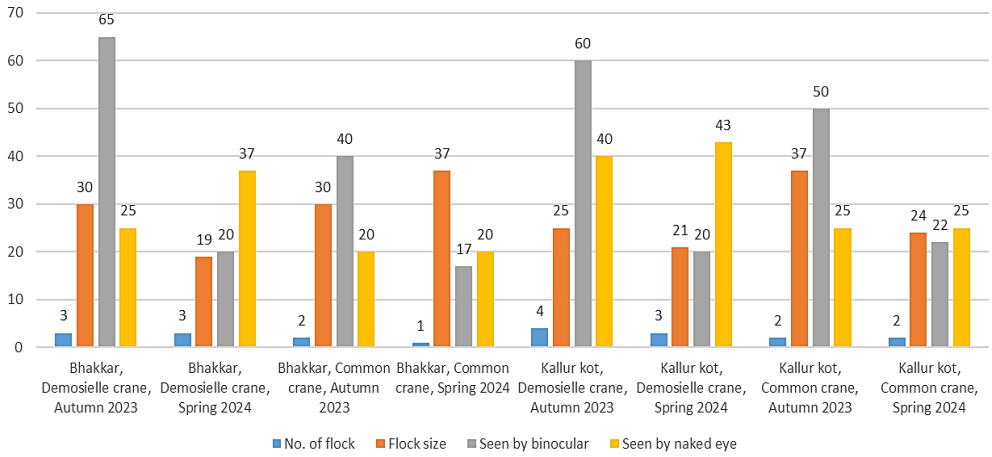

Figure 11. Comparative study of two crane species having total flocks, their size, and visibility through binoculars, spotting scope, and with the naked eye at study sites (Kallurkot and Bhakkar) in autumn 2023 and spring 2024.

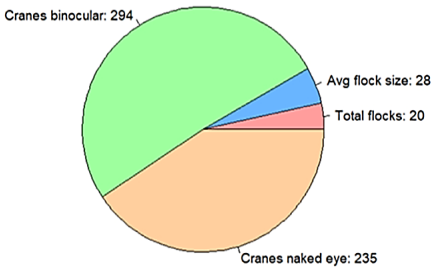

Figure 12. No. of flocks of crane species, average flock size, and cranes visible through binoculars and the naked eye.

Table 3. Principal Component Analysis (PCA) used to show the values between PC1 and PC2.

Data	PC 1	PC 2
Demoiselle crane, Autumn 2023	83.216	-4.4086
Demoiselle crane, Spring 2024	-28.629	11.889
Common crane, Autumn 2023	-9.0789	10.069
Common crane, Spring 2024	-45.508	-17.549

Table 4. Number of flocks, flock size, seen by binoculars, and seen by the naked eye at study sites (Kallurkot and Bhakkar) in autumn 2023 and spring 2024.

Site name, Species name, Season name	No. of flock	Flock size	Seen with binoculars	Seen by the naked eye
Bhakkar, Demoiselle crane, Autumn 2023	3	30	65	25
Bhakkar, Demoiselle crane, Spring 2024	3	19	20	37
Bhakkar, Common crane, Autumn 2023	2	30	40	20
Bhakkar, Common crane, Spring 2024	1	37	17	20
Kallurkot, Demoiselle crane, Autumn 2023	4	25	60	40
Kallurkot, Demoiselle crane, Spring 2024	3	21	20	43
Kallurkot, Common crane, Autumn 2023	2	37	50	25
Kallurkot, Common crane, Spring 2024	2	24	22	25

People's perceptions about cranes

Direct Field observations were aligned with local perceptions of cranes. According to a survey of 100 people, 23% were unaware of cranes, whereas 77% were familiar with them (Figure 13A). According to 61% of respondents, the Demoiselle Crane is more abundant than the Common Crane, which is stated by 39% of respondents (Figure 13B). Figure 13C shows that the majority observed 1–2 flocks (52%), followed by 3–5 flocks (38%), with fewer reporting larger numbers. Figure 13D shows that flocks of a single species were more prevalent (71%) than flocks of mixed species (29%).

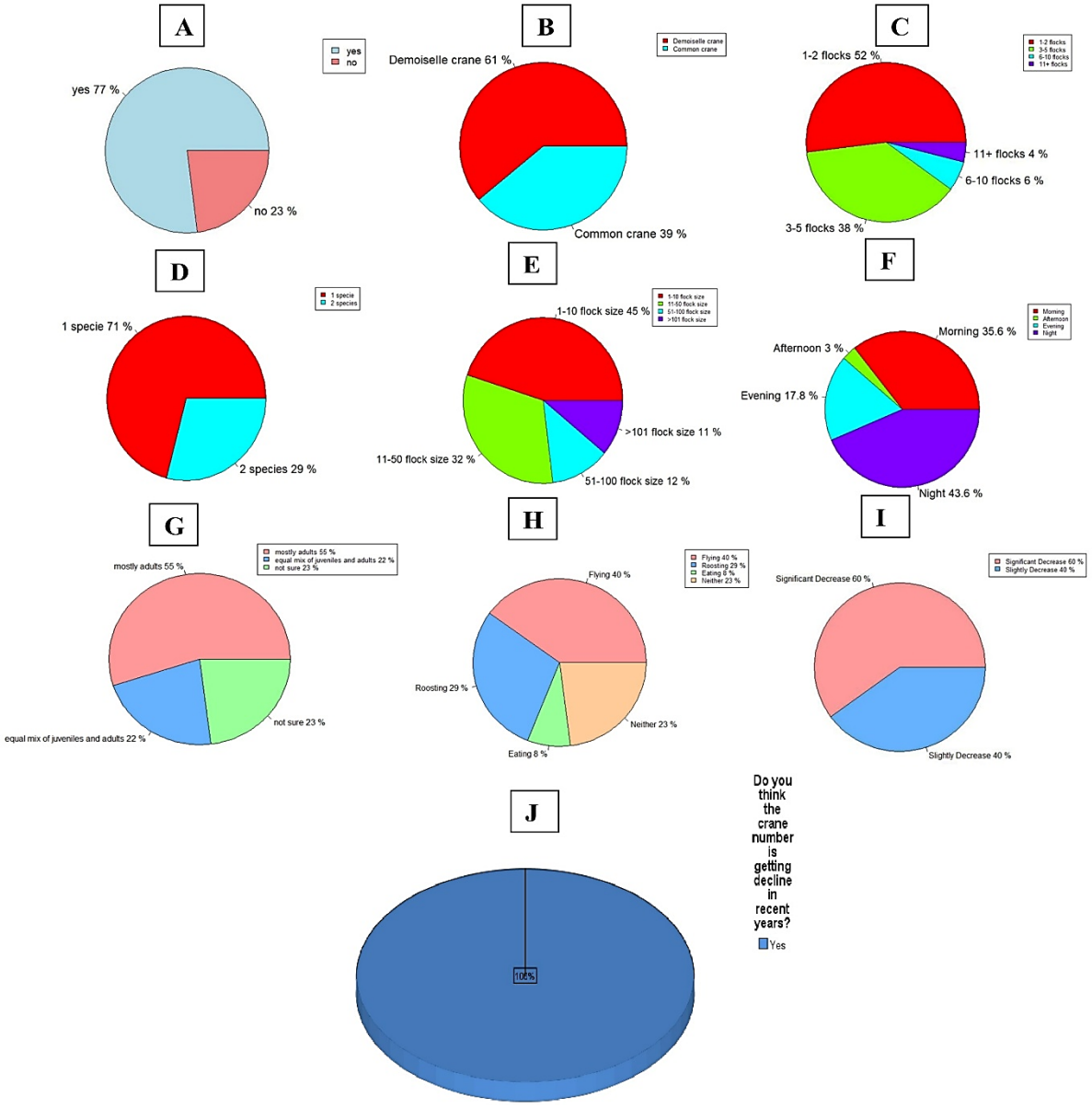

Figure 13. People's perceptions about cranes (A); abundance of crane species (B); passage of average crane flocks (C); crane species in a flock (D); average flock size (E); exact timing of crane sightings (F); composition of cranes flock (G); cranes mode of observation (H); decline in cranes number during back migration (I); overall decline in cranes population (J).

According to Figure 13E, flock sizes varied from 1 to 10 individuals (45%) to over 100 individuals (11%). Due to improved vision and reduced disturbances at night, cranes were most frequently observed during complete moon phases (Figure 13F). Although 22% of the flock consisted of mixed-age groups, adults made up most of the flock (Figure 13G). In terms of behavior, cranes were most frequently observed roosting (29%), flying (40%), or feeding (8%), as shown in Figure 13H. About reverse migration, 40% reported a modest population decline, while 60% reported a significant decrease (Figure 13I). These validate our field data.

Cranes' distribution and influence of various environmental variables

The overall distribution of cranes across the entire district was observed at two sites: Kallorkot and Bhakkar. We measured the distances between crane sighting sites and various environmental and habitat variables (Table 5). Significant ecological variations exist between Kallurkot and Bhakkar, as evident in the habitat evaluation data, which could impact the distribution and behavior of cranes in these regions. Kallurkot is further away from industrial buildings (193.92m) and human settlements (146.02m) than Bhakkar (102.1m and 180.42m, respectively), which suggests that Kallurkot may provide a more undisturbed environment that cranes prefer during sensitive times, such as migration. Roads are comparable in both locations, although Kallurkot is a little further away (137.09m vs. 133.73m), suggesting somewhat less anthropogenic impact. Kallurkot lies farther away from the wetlands than Bhakkar (37.88m vs. 28.76m), which may make Bhakkar more advantageous in terms of quick access to roosting and feeding grounds. Yet, Kallurkot is much further away from arid terrain (185.7m vs. 108.5m), which might be helpful because cranes tend to avoid arid regions with limited food or cover. Notably, Bhakkar is closer to rivers and lakes (81.46m) than Kallurkot (15.99m), suggesting that Bhakkar may have superior access to water. Kallurkot has a slightly greater elevation (173.12 m vs. 167.78 m), although the difference is not noticeable. The water depths in the two locations are comparable (1.7 m in Bhakkar, 1.5 m in Kallurkot), indicating equivalent hydrological circumstances. Bhakkar offers better proximity to wetlands and water supplies, which may draw more cranes, particularly for roosting and foraging. Kallurkot presents a more isolated and less damaged habitat. These characteristics may influence Crane habitat selection and seasonal dispersion.

Table 5. Distance (m) of various variables to the crane sighting sites.

Code	Evaluation	Kallurkot	Bhakkar
A	Distance to human settlements	146.02	102.1
B	Distance to any mills, factories, commercial complexes, and institutions	193.92	180.42
C	Distance to roads	137.09	133.73
D	Distance to any wetland vegetation (grassland, forestland, and croplands)	37.88	28.76
E	Distance to barren land	185.7	108.5
F	Distance to river or lakes	15.99	81.46
G	Elevation	173.12	167.78
H	Water depth	1.5	1.7

Discussion

By systematically tracking cranes across two full migration seasons using multiple observation methods, we ensured reliable population estimates. Advanced statistical analyses objectively confirmed behavioral patterns and habitat preferences, while community surveys independently validated our field observations. The strong correlation between crane presence and wetland habitats provides particularly compelling evidence for conservation planning. These converging lines of evidence—ranging from direct counts to statistical patterns to local knowledge—give us high confidence in our conclusions about crane ecology in the region.

The study employed the line-transect method by establishing straight transects within the study area, following established methodologies previously applied in crane research (Rehman et al. 2021, Jia et al. 2019, Tiwari et al. 2017, Kong et al. 2018, Fraixedas et al. 2020, Meena et al. 2021). Among the 529 cranes observed, 310 were Demoiselle Cranes. At the same time, the remaining 219 were Eurasian Cranes, which aligns with the study of Khan et al. (2011), who recorded 710 Demoiselle Cranes and 1,250 Eurasian Cranes in autumn 2010 and 35,688 Demoiselle Cranes and 2,652 Eurasian Cranes in spring 2011. Moreover, Ullah et al. (2023) reported 1,874 cranes, comprising 1,052 demoiselle cranes and 822 common cranes, indicating that Demoiselle cranes are more abundant than common cranes.

The PCA analysis from our study, which captured 98% of the variance in behavioral patterns of demoiselle and common cranes during autumn 2023 and spring 2024, highlighted distinct seasonal and species-specific behavioral responses. These included variations in flying formations, resting periods, and feeding behaviors, reflecting the cranes' adaptive strategies across migratory phases. These results are consistent with those of Altaf et al. (2018), who reported that avian diversity and distribution patterns varied significantly across different habitat types, from forested to urban landscapes, due to anthropogenic pressures and habitat fragmentation. Together, these insights underscore the crucial role of habitat heterogeneity and ecological connectivity in shaping avian behavior, particularly during energetically demanding migratory periods.

Our study revealed that crane distribution in Kallurkot and Bhakkar was significantly influenced by proximity to key environmental variables, including wetlands, barren land, rivers, and human settlements. For instance, the distance to wetland vegetation was 37.88m in Kallurkot and 28.76m in

Bhakkar, while the distance to rivers or lakes was 15.99m and 81.46m, respectively. A strong linear correlation of 0.86 was observed between environmental variables and the presence of cranes. These findings align with the research by Fang et al. (2020), which highlighted that in the Shengjin Lake wetland reserve, land use changes, particularly in marshland, grassland, and water bodies, were closely linked to crane population dynamics. Notably, the highest habitat retention rate was found in marshland (34.44%), underscoring the critical role that wetland quality and landscape transformation play in sustaining crane populations across both regions.

Furthermore, Ilyashenko et al. (2022) reported that the long migration routes of Demoiselle Cranes, as observed in studies across Ukraine, Russia, and Kazakhstan, demonstrate the importance of suitable stopovers and habitats along migration flyways, which is similarly reflected in the habitat preferences and distribution patterns observed in our study.

During our survey, we observed 20 more flocks of Demoiselle Cranes than Common Cranes, with an average flock size of 28 recorded for both autumn 2023 and spring 2024. These findings align with the study of Meena et al. (2021), who reported large flocks of 1,200–1,600 Demoiselle Cranes arriving between September and October and departing by February to March, reflecting similar seasonal migration patterns and site fidelity across regions, revealed a higher abundance of Demoiselle Cranes compared to Common Cranes, consistent with findings from other regional studies highlighting their strong migratory presence. Crane populations are significantly threatened by habitat degradation and climate change; however, these threats can be mitigated with targeted interventions that promote alternative farming techniques and create incentives for ecotourism and conservation strategies. To build on our findings, future research should focus on long-term monitoring by genetic analysis and satellite tracking to evaluate population health and migratory connections. Expanded surveys in Punjab may reveal the habitat preferences of these species. While addressing challenges like illegal hunting and expanding agriculture through integrated flyway management with other countries, conservation efforts must focus on conserving significant wetlands through legislative modifications and community-based preservation programs.

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