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Insights into key threats and conservation status of the river lapwing, *Vanellus duvaucelii* (Lesson, 1826) in Northern India

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Abstract The river lapwings are inhabitant of river banks with sand or gravel bars and river islands. In this study, we investigated vital threats (natural and anthropogenic) and the conservation status of river lapwing in the riverine ecosystem of Northern India. In this regard, we frequently visited selected study sites along the banks of the river Ganges in the district of Raebareli (Uttar Pradesh), India, from January 2016 to December 2019. To estimate perceived threats for river lapwing, we developed a questionnaire and collected threat scores. The line transect method was used to estimate the density of river lapwing. Predation and farming activities were the most potent threats influencing the survival and abundance of river lapwing. River lapwings were primarily observed at open unvegetated river banks and open unvegetated islands. They were seen in significant density near the water in the breeding season. We concluded that the population of river lapwing is relatively stable in the Gangetic plains of Northern India. However, it is declining in other parts of the world, for example, in Southern Laos. Though it is a relatively common species, robust scientific information about its population and habitat relation is mainly absent. Therefore, accurate counts from other parts of the world are needed to place the estimate for river lapwing into a comprehensible, inclusive perspective. Furthermore, detailed information on habitat relationships is also necessary to develop conservation strategies.

Keywords density; farming activities; predation; river bank

Introduction

River lapwings, *Vanellus duvaucelii*, are prominent in the heterogeneity of habitats, for example, marshland, lakes, river banks, and sandy islands (Duckworth *et al*., 1998). Due to being sedentary, they are known to be constrained primarily along the sandy river banks (Johnsgard, 1981; Hayman *et al*., 1986). Riverine habitats sustain a range of wader species, which prominently breed on sandbars and river channel habitats (Claassen, 2004). Furthermore, Ali (2002) reported that river lapwings are distributed in the Indian subcontinent. Previous studies firmly suggested a clumped distribution pattern of the river lapwing in the riverine ecosystem. (Mishra *et al*., 2018).

The number of river lapwings has declined globally, and hence, they are categorized as near-threatened species (IUCN, 2018). Regular and enduring ecological monitoring is an essential conservation tool that is endowed with basic information about the current conservation status of target species. Previous studies have indicated that changes in distribution and abundance may disclose the circumstances of different environments and consequently assist in classifying conservation priorities and examining the outcome of enlarged policy or environmental change (Balmford *et al*., 2003).

It has been confirmed that riverine bird populations are diminishing (Duckworth *et al.,* 1998, 2002; Thewlis *et al*., 1998; Stroud *et al*., 2006). Habitat loss, degradation, and overexploitation have been considered to be the leading causes of decline in most species (Kirby *et al*., 2008; IUCN, 2018). Furthermore, increased predation pressure and escalation of agricultural exercises were identified as other remarkable factors pertaining to population decline (Wilson *et al*., 2004). However, causes of decline deviate on a local scale and cannot merely be generalized (Beintema *et al*., 1995).

Reduction in species abundance and distribution is primarily due to anthropogenic-driven climate change (Walther *et al.,* 2002). However, threats distressing the population of waterbirds are pollution, natural system modifications (e.g., dam building), and human disturbance (Kirby *et al*., 2008). The repercussions of anthropogenic factors on avian population dynamics have drawn diminutive attention. Furthermore, anthropogenic factors are known to have great significance for most waterbirds

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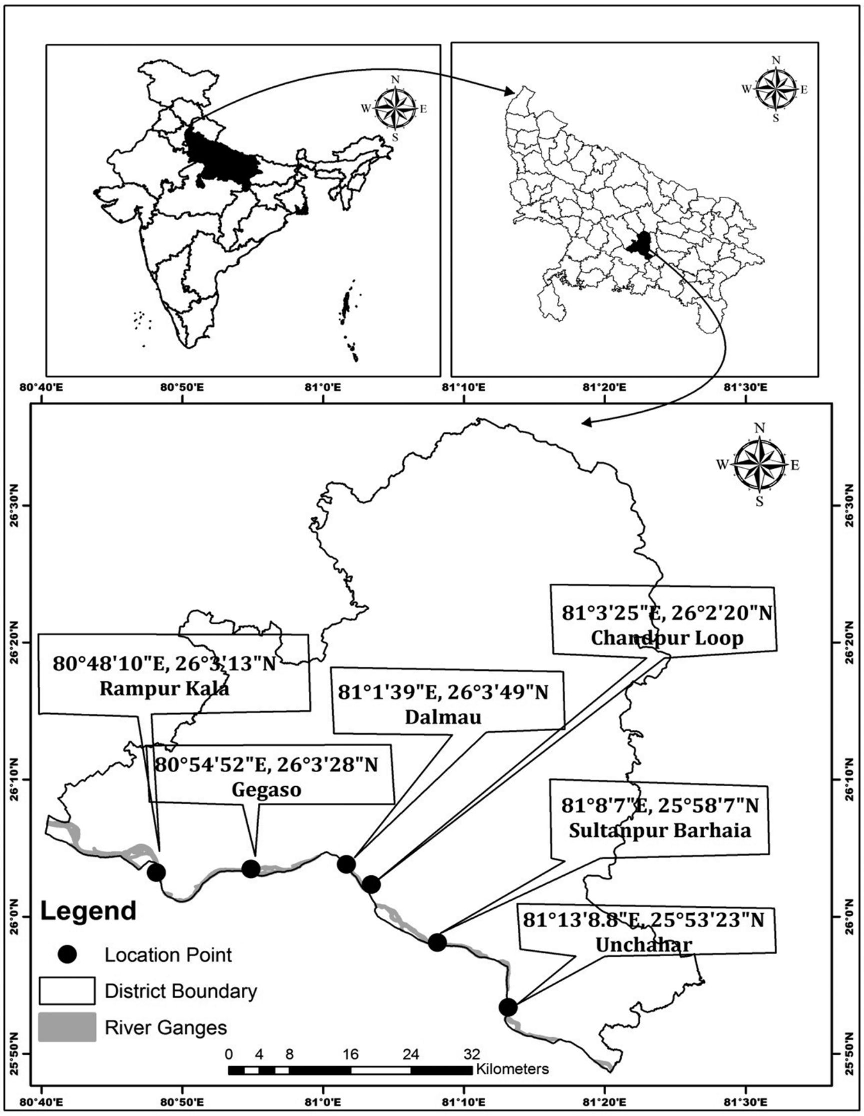

Figure 1. GIS map of the study area showing localities along the river Ganges in critical threats and conservation status of river lapwings were investigated.

since agricultural land is their natural feeding and breeding grounds (Galbraith *et al*., 1987).

The indispensable endeavor in population ecology is to understand how populations are regulated (Newton, 1998). It has been reported that almost all populations may be affected by both density-independent (harsh weather, pollution, and natural disasters, for instance, drought) and density-dependent factors (competition, predation, and disease or parasites) (Baillie and Schaub, 2009). The respective sturdiness of these factors contemplates the fluctuation rate of waders. In addition, density-dependent modulation drives the population to assort around a level executed by prominent environmental resources (Baillie and Schaub, 2009).

The stunning conservation plans are required to be implemented due to a reduction in wader's diversity (Pullin, 2002); hence, the identification of the prime threats to waterbirds is the fundamental element for the development of such plans (Soule and Orians, 2001).The study aimed to assess critical threats (natural and anthropogenic) and document the current conservation status (i.e., stable, declining, or increasing) of river lapwing in the Gangetic Plain of Northern India. Hence, this field study may improve the acquaintance of scantily known near-threatened species, thereby suggesting effective management and conservation plans.

Methods

Study area

Numerous field visits along the banks of the river Ganges in different selected study sites of district Raebareli (Uttar Pradesh), India, were conducted from January 2016 to December 2019 (Fig. 1). The river Ganges runs close to the district periphery covering the length of about 100 km (Fig. 1). Based on the quantity and allocation of natural vegetation, we considered riverine habitats into four habitat types: (1) Open, unvegetated river bank (OURB), (2) open, unvegetated island (OURI), (3) vegetated river bank (VRB) and (4) crop fields (CF). The nesting habitat for river lapwing comprised of sparsely to moderately-vegetated, seasonally-developing sand bars and fluvial islands (Mishra *et al*., 2020).

Evaluation of key threats

A range of threats were recognized by direct observations and interviewing local people, including farmers. To investigate perceived threats to river lapwing, we prepared a questionnaire. Drafts of the questionnaire and instructions were given to some local people, including farmers. Respondents were asked to provide threat scores (0 = not observed, 1 = low intensity, 2 = medium intensity, and 3 = high intensity). A threat may be defined as a factor that has an opposing force on the population size or the distribution pattern of river lapwings. We followed a simplified version of the threats offered in the amalgamated scheme proposed by Salafsky *et al*. (2008). We also recorded threat score by direct observations. All the data (direct observations and interviewing local peoples) were pooled together.

Determination of conservation status

To establish conservation status (i.e., stable, declining, or increasing), particular survey sites were considered to incorporate a range of riverine habitats and further emulate the regional distribution of river lapwing. Being territorial, they hardly migrated large distances and, therefore, scarcely reported outside the river banks. We estimated the density (individuals/ha) of river lapwing concerning study sites, habitat type, season (non-breeding and breeding season), and distance from water (near or far). In this scenario, we endorsed the line transect method (Burnham *et al.,* 1980) to record river lapwing density (individuals/ha). In this process, a total of 100 transects (500 meters each in length) were considered (Table 1).

Table 1. Length and number of transects surveyed (500 meters of each transect) during the study period between January 2016 and December 2019.

S.N.	Study sites	Surveyed length (km)	Number of transects
1	Rampur Kala	7	14
2	Gegaso	11	22
3	Dalmau	9	18
4	Chandpur Loop	6	12
5	Sultanpur Barhaia	8	16
6	Unchahar	9	18
	Pooled data	50	100

Statistical analysis

The data were subjected to Kolmogorov-Smirnov and Levene test to examine their homogeneity and normality, respectively. To investigate the effect of different factors (study sites, habitat types, season, and distance from water) on the density of river lapwings, data were subjected to a generalized linear model (GLM). During this statistical process, the number of individuals/ha of adult river lapwing was the response variable, and all the factors were equipped as predictors. We used SPSS (version 16.4) for all the statistical analysis.

Results

We identified as well as quantified the intensity of various natural and anthropogenic threats (Table 2). Predation was found to be a major (high-intensity) natural threat to the river lapwing, particularly to eggs and chicks during the breeding season (Table 2). However, other natural threats were also observed with different levels (low or medium) of intensity (Table 2). No disease was apparently diagnosed during the investigation (Table 2). Similarly, various anthropogenic threats were diagnosed, and their intensity was enlisted (Table 2). Farming activities were the most prevalent (high-intensity) anthropogenic threat to the river lapwings (Table 2).We had not observed hunting of river lapwing amid investigation (Table 2).

Outcome of GLM analysis revealed that river lapwings were sighted in prominent density at OURB (GLM: $F = 42.17$, $df = 13$, $p = 0.012$; Table 3) and OURI (GLM: F = 29.38.07, $df = 13$, $p = 0.023$; Table 3) habitat types (Fig. 2). They were recorded in high density (GLM: $F = 75.08$, $df = 13$, $p = 0.001$; Table 3) in Gegaso (0.21 ± 0.09; Fig. 3) and Chandpur Loop (0.18 ± 0.05; Fig. 3) (GLM: F = 69.38.07, $df = 13$, $p = 0.025$; Table 3). Additionally, river lapwings were present in high density (GLM: $F = 28.07$, $df = 13$, $p = 0.004$; Table 3) in the breeding season compared to non-breeding season (Fig. 4). River lapwing density was higher (GLM: F = 79.38.07, $df = 13$, $p = 0.047$) close to water

Table 2. Summary table showing various threats and their intensity affecting the river lapwing in the study area.

Source of threats	Category		Intensity of threats (Low/medium/high)
Natural	Predation		High
	Flooding		Low
	Pollution		Low
	Competition	Intraspecific	Medium
		Interspecific	Medium
Anthropogenic	Farming activities		High
	Fairs and other ritual activities		Low
	Human settlement		Medium
	Grazing		Medium
	Trampling		Medium
	Egg collection		Low
	Hunting		–

Table 3. Results of a generalized linear model (GLM) explaining various factors influencing the density (mean no/ha) of river lapwing during the study period between January 2016 and December 2019.

Predictor	Category	Estimate	SE	p
Study sites	RK	0.602	±-0.068	0.051
	GE	-0.326	±0.004	**0.001**
	DL	0.121	±0.182	0.058
	CL	-0.185	±0.021	**0.023**
	SB	0.720	±0.036	0.064
	UN	0.913	±0.346	0.071
Habitat types	UNRB	-0.192	±0.011	**0.012**
	OURI	-0.179	±0.019	**0.025**
	VRB	0.462	±0.294	0.064
	CF	0.869	±0.703	0.091
Season	Breeding	0.105	±0.042	**0.004**
	Non-breeding	0.019	±0.127	0.076
Distance from water	Close (<50 m)	-0.946	±0.512	**0.005**
	Far (>50 m)	0.214	±0.071	0.059

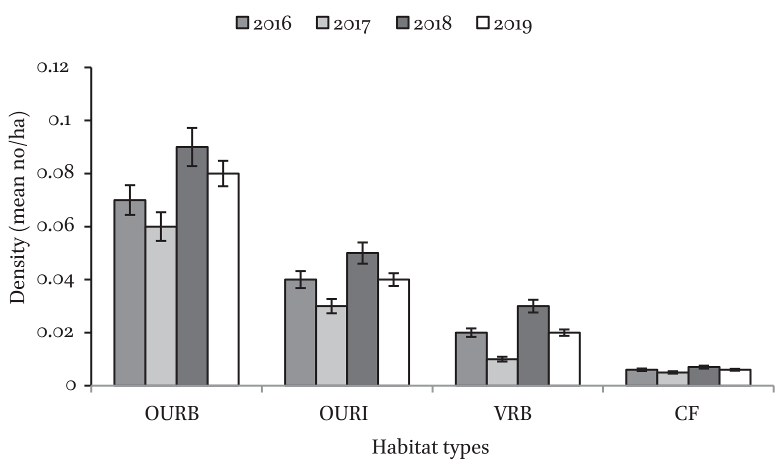

Figure 2. Habitat distribution of river lapwing density (mean ± SD) during the study period between January 2016 and December 2019.

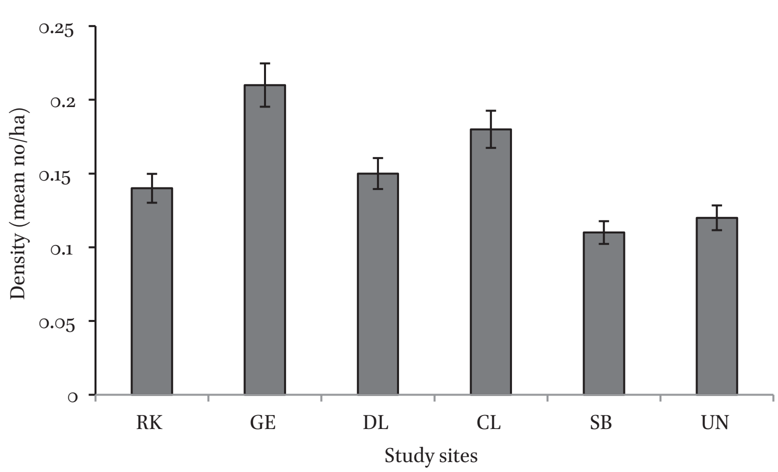

Figure 3. Density (mean ± SD) of river lapwing in different study sites during the study period between January 2016 and December 2019.

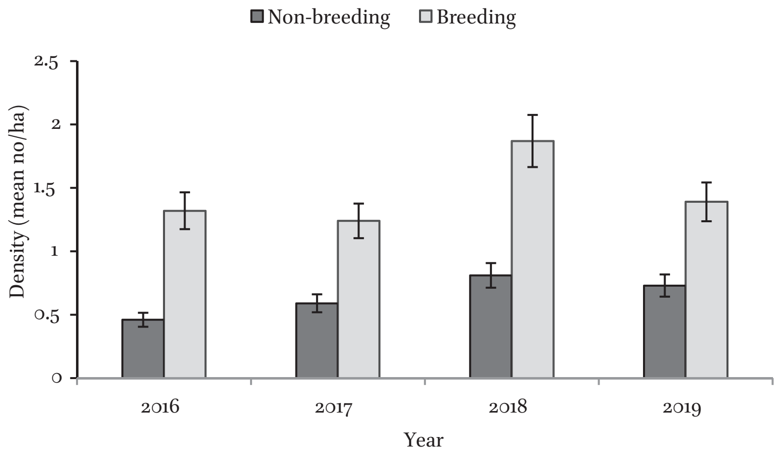

Figure 4. Density (mean ± SD) of river lapwing in non-breeding and breeding season during the study period between January 2016 and December 2019.

(<50 m, density = 0.08 ± 0.01) compared to far from water (>50 m, density = 0.03 ± 0.02).

Discussion

Threats

Threat assessment is an essential component of conservation precedence-setting processes for species and ecosystems (Groves *et al*., 2002). In this study, we examined various natural and anthropogenic threats. We found that predation and farming activities were the most prevalent (with high intensity) threats that significantly affected the survival of eggs as well as chicks. A similar observation was recorded in Sandbar Nesting Birds in Cambodia (Claassen, 2004). During the investigation, other threats (natural and anthropogenic) had a minor effect on river lapwing's survival and abundance. Previous studies have further confirmed that crows were the predominant predators of river lapwing (Mishra *et al*., 2020). Reptiles (snakes) and mammals (dogs and foxes) were other notable predators of the eggs and chicks (Mishra *et al*., 2020).

Evidence suggests that ground-nesting waders are susceptible to the precarious predation of their eggs and chicks (Massey *et al*., 1989). Thus, predation has been confirmed as the most significant restraining factor influencing the waders (Cuervo, 2004). Martin (1993) also confirmed predation is the foremost source of nest failure across different wader species, habitats, and geographic locations. Although predation was mainly observed for eggs and chicks, adults occasionally might have been predated by some predators. The episodic predation events were also documented by Neuman *et al*. (2004). Earlier studies revealed that agricultural landscapes have become homogeneous (Benton *et al*., 2003); hence, the shrinkage of wet habitats has abridged the availability of resources for waders. Additionally, predators may be competent to find clutches and hatchlings despite still flightless more easily in homogeneous landscapes (Schekkerman *et al.*, 2009)

Furthermore, competition, flooding, and pollution were other critical natural threats to river lapwings. Flooding and pollution were identified as low-intensity threats. Competition had moderately affected the river lapwing. They evidently showed intraspecific competition because they shared similar space, food, and water resources for their survival and reproduction. Santos *et al.* (2005) observed a similar pattern in the waders of south-temperate Europe (Mondego, Portugal). Moreover, the congregation of individuals of other wader's species, for example red wattled lapwing (*Vanellus indicus*), common redshank (*Tringa totanus*), and common sandpiper (Actitis hypoleucos), along with the river lapwing, demonstrated interspecific competition.

River lapwing usually dispersed during the flood from the river bank and came back when the water receded. During floods, high water flow was seldom indispensable to abrade sandbar vegetation, develop existing sandbars, and create new sandbars. Nevertheless, unmitigated high flows and varying daily flows shrink the area presented for nesting and foraging habitat (Sidle *et al.,* 1992).

Our results showed that farming activities were the most imperative anthropogenic threats to river lapwing. Similar results were reported in northern lapwing (*Vanellus vanellus*) by Baines (1990). Most shorebirds (Charadrii) have revealed severe population declines due to a diminution in breeding output (Ottvall, 2005; Schekkerman *et al*., 2008). Agricultural intensification is attributed to egg loss, chick mortality, and scarcity of food, which is consequently accountable for the diminution in breeding outcomes in shorebirds (Wilson *et al*., 2004; Schekkerman and Beintema, 2007). Moreover, agricultural intensification also contributed to the diminishing of the area of protective cover for chicks of the river lapwing.

The most prominent cause of population decline in lapwings is reported to be agricultural practices, which primarily include weed control, ploughing, drainage, and extensive livestock grazing (Newton, 2004). Regarding weed control, an earlier study witnessed high mortality of northern lapwing and redshank chicks after hitting the arable areas with herbicides and pesticides (Khokhlov *et al*., 1991). Although, adverse effects were also known for stone curlew (Mezhnev, 1990). Furthermore, Nankinov (1973) found that nests are destroyed by agricultural transport and human disturbance.

Human settlement, trampling, and grazing were the moderate anthropogenic threats to river lapwings. Our results coincided with observations of Claassen *et al.* (2004) in a few sandbar nesting birds. Human settlement may be considered an anthropogenic trap based on how it affects the river lapwing population. In this investigation, anthropogenic traps included intensive agricultural practices, buildings, and proximity to river banks.

Incubating eggs are at high risk of trampling and consumption by grazing animals, hence obstructing the breeding success of ground-nesting waders (Beintema and Muskens, 1987; Nack and Biric, 2005). Additionally, egg loss also has been recorded owing to elevated rates of predation or desertion (Shrubb, 1990). Due to grazing, food availability can be constrained by reducing the invertebrate fauna (Vickery *et al.,* 2001; Evans *et al*., 2005).

The results showed that the local people seldom collected eggs; hence, there were low-intensity threats to river lapwings. However, egg collection by villagers was considered a significant threat to sand bar nesting birds in Cambodia (Claassen, 2004). Fairs and other ritual activities were occasionally seen. Whenever it occurred, river lapwing mostly flew away from that threatened area and settled in the safe and suitable area of the river bank.

Conservation status

Results of GLM analysis showed that river lapwings were mainly observed in high density at OURB and OURI habitat types. Similar results were noticed in riverine sandbar nesting birds in Cambodia (Claassen *et al*., 2018). Generally, animals clearly prefer breeding habitats that enhance their reproductive success (Chalfoun and Schmidt, 2012). Additionally, food, shelter from enemies, and adverse weather may be regarded as ultimate factors in the habitat selection of birds (Baker, 1938). OURB and OURI habitat types endow with suitable feeding and breeding grounds for river lapwing. These habitat types, usually located close to the water, render bare grounds (areas of sand, dry mud) and mud flats for river lapwings.

However, evidence indicated that both habitat types have less vegetation. Claassen *et al.* (2018) have suggested that river lapwings usually select areas with less vegetation because vegetation has a negative impact on reproductive success. Vegetation cover may permit the concealment of nests from predators, hence augmenting the probability of successful hatching. Habitat selection was discernible in river lapwings; consequently, they decided breeding grounds having higher proportions of bare substrates (Claassen *et al.,* 2018). Bare grounds have been used for nest camouflage during the breeding season. Additionally, invertebrate prey is usually found in high-density mud flats (Wilson, 1990).

Several other studies have also revealed a positive correlation between bird abundance and invertebrate prey density while investigating across large spatial scales (Goss-Custard, 1970; Meire and Kuyken, 1984). Furthermore, the OURI habitat types were geographically isolated from the mainland. Therefore, it might have protected river lapwings from terrestrial predators and other human disturbances.

River lapwings were usually observed in significant density in all the selected study sites; however, they were relatively estimated in high density in Gegaso and Chandpur Loop. The river Ganges has extensive sand bars and contiguous stretches, particularly in this study site, as compression to others. Hence, the river Ganges has great conservation significance for riverine birds, predominantly for resident waders.

Owing to the addition of numerous chicks to the existing adult population, we documented that river lapwings were mainly noted in high density during the breeding season. According to Mishra *et al*. (2018), river lapwing displayed a clumped distribution pattern; hence, they were breeding in semi-colonial aggregations. Thus, it was evidently effective as protection against avian nest predators that turned to the increased reproductive success of river lapwing. This subsequently increased the numerical abundance of river lapwings in the breeding season. There has been a wealth of research on waders or shorebirds (Charadrii) on the breeding grounds (Nethersole and Thompson, 1986) as well as off them (Goss-Custard and Durell, 1990). Earlier studies revealed that food availability may constrain the population of birds, and this consequence may be persuasive in the breeding season (Newton, 1980; White, 2008).

During this study, river lapwing density was high close to the water due to ample food availability for river lapwings. The similar results were reported in sandbar-nesting birds in Cambodia (Claassen *et al.,* 2018). Previous field studies displayed that high water tables were an appropriate foraging habitat for breeding waders (Hotker, 1991; Berg, 1992). Additionally, Mishra *et al.* (2018) documented high nesting success close to the water, which increased the number of river lapwings. Dolgushin (1962) also suggested the preference for breeding sites close to the water by sociable lapwing (*Vanellus gregarious*) as adults and chicks frequently visited waterbodies on hot days. Furthermore, several cattle might be present at river shores. This might turn into higher grazing pressure that subsequently provides a more convenient habitat closer to river banks.

A previous study (IWS, 2003) indicated that most of the wader species are declining globally. Newton (1998) suggested that the distribution pattern of suitable habitat, as well as the amount and quality of habitat, might have influenced populations of many bird species. Mishra *et al*. (2018) found that the river lapwing population represents 0.021 % of the world river lapwing population of <25,000 estimated by Perennou *et al.* (1994). Despite river lapwing having substantially declined in Southern Laos (Duckworth *et al*., 1998), our results revealed that they are relatively stable in the Gangetic plains of Northern India.

Conclusion

This study identifies various natural and anthropogenic threats affecting the population of river lapwing. Predation and farming activities are the most potent threats to eggs and chicks, particularly in the breeding season. River lapwing can be indubitably traced, identified, and counted along the banks of the Ganges River. Hence, we highlight the relationship between different factors (study sites, habitat types, season, and distance from water) and bird density. We conclude that river lapwing preferably resides in open, unvegetated river banks and islands. They present in high-density near water, especially in the breeding season. In summary, our results suggest that the population of river lapwing is relatively stable in the Gangetic plains of Northern India. However, this is declining in other parts of the world, for example, in Southern Laos (Duckworth *et al*., 1998). A review of the literature reveals that though it is quite a common species, robust scientific information about its population and habitat relation is mainly absent. Therefore, accurate counts from other parts of the world need to deposit the estimate for river lapwing into an intelligible global context. Additionally, detailed information on habitat relationships is also indispensable to preparing conservation strategies.

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Author contributions

HM designed this study, collected the data in the field, analyzed the data, wrote and reviewed the manuscript. VK collected the data in the field, analyzed it, and reviewed the manuscript. FB analyzed the data statistically and reviewed the manuscript. PK and AM reviewed the manuscript. AK designed this study, analyzed the data, and reviewed the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

The authors have no further conflicts of interest to declare.

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