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Indian Thick-knee (*Burhinus indicus*) and Red-wattled Lapwing (*Vanellus indicus*) interactions with plants at the urban landscapes (Jodhpur, India)

Abstract

Interactions between plants and ground-nesting birds, as well as the breeding behaviour of the Indian Thick-knee (*Burhinus indicus* Salvadori) and the Red-wattled Lapwing (*Vanellus indicus* Boddaert), were documented in an urban landscape in Jodhpur, Rajasthan, India. Field observations focused on nesting habitats, breeding behaviour, and the role of vegetation in supporting these species. Double clutching during the breeding season of *V. indicus* was recorded and documented. The study also examines the coexistence of flora and fauna within a small protected urban habitat and highlights the ecological role of native plant species in enhancing urban biodiversity. The results indicate that ground-nesting birds rely heavily on camouflaged nesting sites, vegetation cover, and active parental defence to maximize reproductive success. Territorial behaviour and spatial separation between nests help reduce intraspecific conflicts, while breeding timing and double clutching appear to represent adaptive responses to predation and environmental conditions. These findings emphasize the importance of native vegetation in providing shelter, nesting substrates, and food resources for birds in arid urban ecosystems.

Keywords: biodiversity, breeding, conservation, habitat loss, nest, predators.
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Introduction

Some bird species are highly social, intelligent, and territorial during the breeding season, when they defend their chicks and food resources. Food availability and safe breeding sites are among the key factors shaping the persistence of bird populations in human-modified environments (Donnelly, Marzluff, 2004). Urban expansion, land conversion for development, and agricultural mechanisation have resulted in widespread habitat loss, negatively affecting many bird species (Jupiter et al., 2014; Urban, 2015; Taylor, Kumar, 2016).

Recent urban development in Jodhpur (Rajasthan, India) has caused substantial habitat loss and fragmentation for ground-dwelling species, forcing them to occupy suboptimal or previously unused areas. Urbanisation often reduces vegetation cover, simplifies habitat structure, and disrupts ecological processes, thereby limiting access to essential resources such as food, nesting sites, and shelter (McKinney, 2002; Marzluff, 2001). Consequently, birds persisting in modified landscapes must either tolerate degraded conditions with reduced resource availability or disperse to alternative habitats.

However, both strategies involve considerable costs. Occupying degraded niches can lower reproductive output and increase mortality (Chace, Walsh, 2006), while dispersal may expose individuals to stronger interspecific competition, unfamiliar predators, and anthropogenic disturbances, further constraining survival (Shochat et al., 2004; Sol et al., 2013). Ground-nesting birds are particularly sensitive to such changes due to their reliance on vegetation structure for concealment and protection from predators (Martin, 1993).

In addition, human activity, domestic animals, and altered microclimatic conditions in urban areas can further influence breeding performance and offspring survival (Partecke et al., 2006). Understanding these responses is therefore crucial for conservation planning. Effective management of urban avifauna requires detailed knowledge of reproductive success, population dynamics, predation pressure, brood parasitism, and the distribution of key resources such as food and nesting substrates (Donnelly, Marzluff, 2004; Evans et al., 2011). Such insights can support strategies aimed at maintaining biodiversity and enhancing population resilience in rapidly changing environments.

Arigela et al. (2023a) documented interactions between 55 bird species and vegetation in Jodhpur, emphasizing the role of urban green patches in supporting avian diversity. The maintenance of wild grasses near agricultural areas may also reduce crop foraging pressure by

providing alternative food sources, thereby contributing to the conservation of native bird communities (Arigela et al., 2023b). Studies addressing these interactions are essential for understanding how birds adjust to urban and peri-urban landscapes and persist within them.

The aim of the present research is to document the interactions between resident birds and the plants growing in their habitats within the urban landscape, using two species as examples: the Indian Thick-knee (*Burhinus indicus* Salvadori, 1865) and the Red-wattled Lapwing (*Vanellus indicus* Boddaert, 1783). Based on these observations, the authors attempted to find answers to the following specific questions: (1) *How do vegetation structure and species composition influence nest site selection in urban arid landscapes?* (2) *Does the presence of native vegetation increase nesting success and chick survival of ground-nesting birds?* and (3) *How do parental defence behaviours vary in response to vegetation cover and other disturbance?* This study is particularly important for bird biodiversity in the context of maintaining vegetated niches in urban areas.

Materials and methods

Study area

Jodhpur is one of the largest cities in the state of Rajasthan (Fig. 1). It lies between 26°00′ and 27°37′ N latitude and 72°55′ and 73°52′ E longitude, with elevations ranging from 250 to 300 m a.s.l. Extremely high summer temperatures, low winter temperatures, very low annual precipitation, and general aridity characterise the climate of Jodhpur. Winter lasts from November to March, followed by summer from April to June. The southwest monsoon season occurs from July to mid-September, with an average annual rainfall of about 360 mm. Temperatures range from about 48 °C in summer to 4 °C in winter.

Studies on the Indian Thick-knee and Red-wattled Lapwing and their interactions with plants were carried out in the garden and residential campus of the Botanical Survey of India (BSI), Arid Zone Regional Centre (AZRC) Jodhpur office. For a long time, gardens with numerous plant species have been maintained at this site. These gardens gradually transition into a sandy plain with a few trees e.g. *Prosopis cineraria*, scrub vegetation, and seasonal successional herbs, including grasses (Fig. 1).

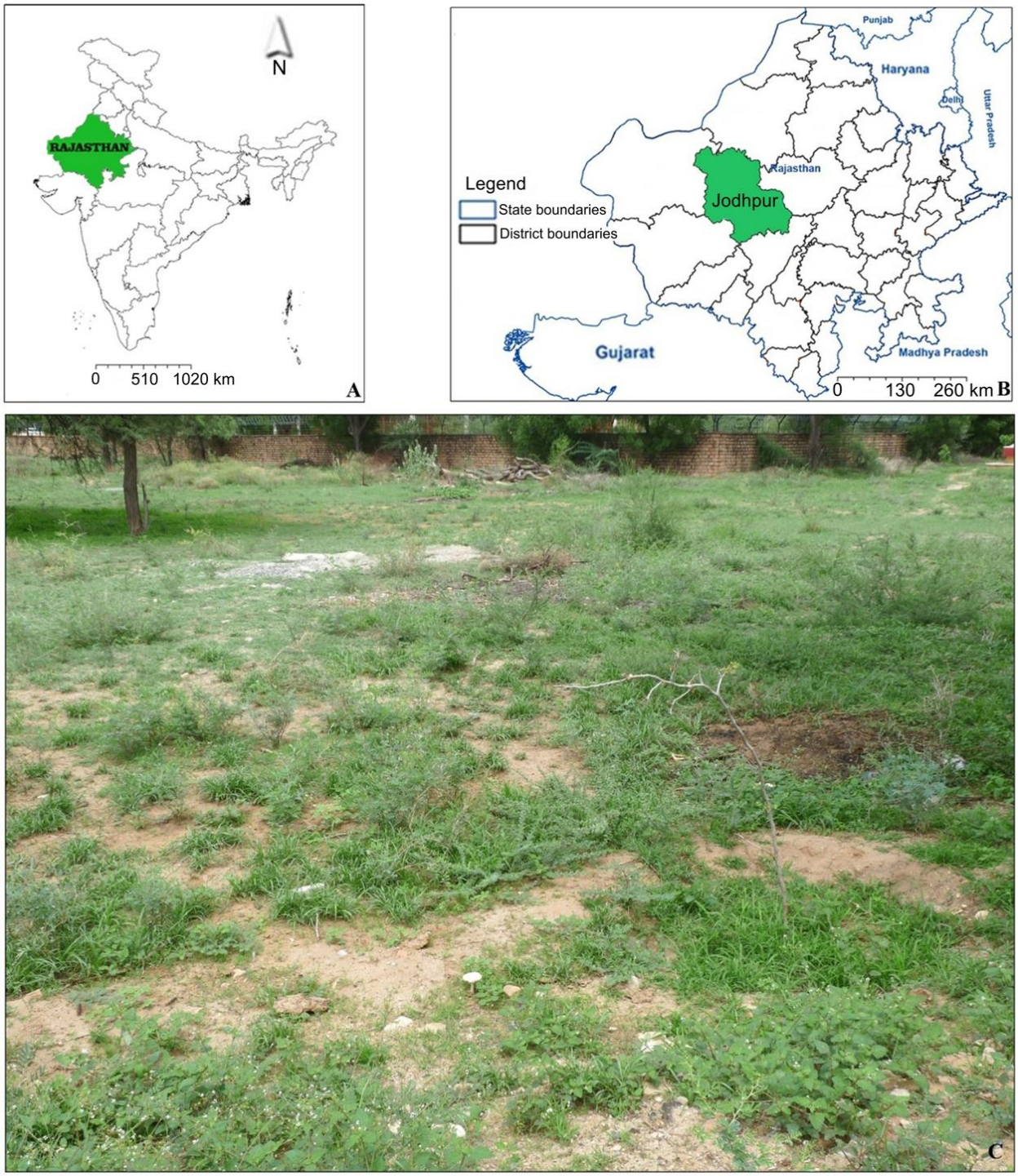

Fig. 1. Study area – Rajasthan (A), Jodhpur (B), Botanical Survey of India: Arid Zone Regional Centre residential area (C) (Photo: Ravi Kiran Arigela)

The dominant plant species in the area include *Gymnosporia heyneana*, *Neltuma juliflora*, *Calotropis procera*, *Leptadenia pyrotechnica*, *Crotalaria burhia*, *Tephrosia purpurea* subsp. *purpurea*, *Tephrosia purpurea* subsp. *apollinea*, *Aerva javanica*, and *Senna alexandrina*.

General distribution of study species

The Indian Thick-knee (*Burhinus indicus*), also known as the Indian Stone-curlew or Stone Plover), is widely distributed in South and Southeast Asia. The species occurs in India (from the plains up to about 1000 m in the Himalayas, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka, Myanmar, Thailand, and Cambodia. In India, it is commonly found in open fallow lands, sparse deciduous forests, thorny scrublands, and in areas near agricultural fields and lateritic plains (Praveen et al., 2017).

The Red-wattled Lapwing (*Vanellus indicus*) is a common terrestrial bird widely distributed in Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka, and parts of North Africa to the Middle East. In India, it is recorded in nearly every region and is often found close to human habitations. It occurs in open areas, near lakes, tanks, agricultural fields, waterlogged forest patches, mudbanks, riverbanks, streams, and occasionally along highways and railway tracks (Grimmett et al., 2011; Patidar, Sharma, 2026).

Methodology

Documentation of observations of *Burhinus indicus* and *Vanellus indicus*, as well as their interactions with plants in Jodhpur, was conducted between November 2022 and November 2025. The study sites were located within the city limits and served as relatively stable, permanent habitats for these species, with minimal anthropogenic disturbance.

Bird activity was monitored daily across all seasons during morning, afternoon, evening, and night sessions at regular intervals, as both species co-inhabit the BSI residential complex. Each observation session lasted 30–60 minutes, while weekend sessions (Saturday and Sunday) were extended to 60–120 minutes. The maximum number of daily observation sessions ranged from 6 to 10, with peak observation frequency recorded during periods of alarm calling in response to predators or during mating activity.

Breeding behaviour, nest site selection, foraging activity, and general behavioural patterns of these species were systematically recorded. Breeding success and chick survival were assessed

directly at nesting sites and within breeding territories. Additionally, plants occurring in the vicinity of nests, as well as those on which birds were observed perching or feeding, were recorded. On this basis, a tabular summary was prepared, covering both plant–bird interactions and behavioural aspects of the studied species in the anthropogenic habitat. Breeding behaviour and defence mechanisms, including alarm behaviours triggered by the presence of predators, were documented photographically (Nikon D5300 DSLR camera with a Nikkor 200–500 mm lens and a Panasonic Lumix FZ-28 digital camera). No birds were captured, trapped, ringed, or otherwise harmed during the observations.

In this study, plant nomenclature followed the *World Flora Online* database (worldfloraonline.org), while species-level information was verified using *POWO* (2026).

Results

The list of the most important plant species constituting the habitat of *Burhinus indicus* and *Vanellus indicus* under urban conditions in the study area is presented in table 1 (Appendix 1).

Indian Thick-knee interactions

Species ecology

This bird usually rests under bushes during the daytime and becomes active at dusk after sunset, producing loud calls after dark (Fig. 2-3 – Appendix 2). It feeds on a wide variety of small animals, mainly lizards and rodents, and occasionally on seeds. Males and females appear similar in morphology, and the species is largely crepuscular and nocturnal.

On the AZRC campus, the Indian Thick-knee was also recorded feeding on the gastropod *Zootecus insularis* (Ehrenberg, 1831), along with various insects and worms. The bird measures about 35 cm in length and is characterised by brown streaked plumage, long thick yellow legs, large yellow goggle-like eyes, a stout black bill with a yellow base, a broad head, and long pointed wings (Fig. 2A-B – Appendix 2). The body plumage provides excellent camouflage within its natural habitat.

Nesting habitat and breeding behaviour

Three breeding pairs of the Indian Thick-knee were studied on the BSI office campus between November 2022 and November 2025 (Tab. 2).

Tab. 2. Summary of basic information on observations of *Burhinus indicus* Salvadori in urban conditions of Jodhpur (Rajasthan, India)

No.	Recorded events	Year of field observations / number of recorded events				Total number of recorded events
		2022	2023	2024	2025	
1.	Nesting pairs	1	1	2	1	5
2.	Eggs laid	-	2	5	3	10
3.	Chicks	-	2	3	3	8
4.	Predation events	-	2	2	-	4
5.	Territorial conflicts	8	10	15	15	48
6.	Other incidental events	10	20	40	50	120

This species was recorded as a permanent resident on the campus, co-occurring with the Red-wattled lapwings. The habitat is dominated by trees such as *Azadirachta indica*, *Prosopis cineraria*, *Tamarindus indica*, *Salvadora persica*, and *Senegalia senegal*, under which the birds typically constructed their nests. Nests consisted of shallow ground scrapes in which 2–3 camouflaged eggs were laid between March and May (Tab. 2; Fig. 2C – Appendix 2). Dried fallen leaves and fruits of these trees contributed to effective egg camouflage, reducing the visibility of nests.

Among the documented breeding pairs, one pair nested under *Prosopis cineraria* and *Butea monosperma* and laid two eggs in March 2023. Another pair nested under *Azadirachta indica* in April 2024 and laid 2 eggs. The third pair nested under *Senegalia senegal*, laid three eggs in March 2024 and April 2025 respectively. During the incubation period, one bird typically guarded the territory (Fig. 3A-B – Appendix 2; Tab. 2) while the other incubated the eggs.

The nests of the three breeding pairs were located approximately 80–120 m apart, and each pair maintained a distinct territory during incubation and chick-rearing. The birds were highly cautious and often left the nest when human disturbance occurred nearby. Egg predation was documented, particularly by House Crows and Asian Koels, which occasionally removed eggs from the nests. The incubation period lasted approximately 24–30 days, with both parents participating in incubation and subsequent parental care.

Associated fauna and predation pressure

Several bird and small mammal species were recorded as common co-inhabitants of the area, including Rock Pigeons, Red Collared-doves, Eurasian Collared-doves, Indian Robins, Large Grey Babblers, Eurasian Wrynecks, Indian Peafowls, Common Mynas, Bank Mynas, White-eared Bulbuls, Red-vented Bulbuls, and Five-striped Palm Squirrels.

However, the nesting birds faced threats from several predators, including stray dogs, Jungle Cats, mongooses, monitor lizards, House Crows, Shikras, Spectacled Cobras, Black Kites, and Asian Koels. Parental birds displayed defensive behaviour by spreading their wings widely to threaten ground predators such as stray dogs, mongooses, and monitor lizards, and they also chased aerial predators such as House Crows and Shikras.

Role of vegetation in nesting success

Seasonal vegetation also played an important ecological role in nesting success. Between March and May, dried understory plants such as *Pavonia zeylonica*, *Dicliptera paniculata*, *Sida tiagii*, and *Tephrosia purpurea* provided additional camouflage during incubation. The first breeding pair hatched two chicks in March 2025 (Fig. 2C-G – Appendix 2), although these chicks were later preyed upon by a Shikra. The second pair was unsuccessful because House Crows removed the eggs from the nest. In contrast, the third pair, which nested under *Senegalia senegal*, successfully hatched two chicks in May 2024.

Following intermittent rains, a diverse assemblage of herbaceous plant species emerged, including *Abutilon indicum*, *Acrachne racemosa*, *Achyranthus aspera*, *Amaranthus palmeri*, *Boerhavia diffusa*, *B. erecta*, *Cenchrus ciliaris*, *C. setigerus*, *Cyanthillium cinereum*, *Dactyloctenium scindicum*, *Digitaria ciliaris*, *Eragrostis ciliaris*, *Heliotropium europaeum*, *H. zeylanicum*, *Indigofera cordata*, *Pavonia zeylonica*, *Physalis angulata*, *Portulaca oleracea*, *P. linearifolia*, *Sida tiagii*, *Tetrapogon tenellus* and *Trianthema portulacastrum*, These plants provided both cover for chicks and habitat for insects, which serve as important food resources.

In particular, dried pods of *Senegalia senegal* created additional camouflage and shelter for chicks, enabling them to hide effectively from predators. This species may therefore play an important ecological role in maintaining suitable microhabitats for ground-nesting birds in the arid landscapes of Rajasthan.

The chicks developed into subadults by August 2024 (Fig. 2H – Appendix 2) and were frequently recorded hiding within vegetation such as *Boerhavia erecta* and *Acrachne racemosa* whenever human disturbance occurred nearby (Tab. 2; Fig. 3F-H – Appendix 3).

Species ecology

This species is crepuscular and largely active from morning to evening, showing heightened activity around the full moon. Red-wattled Lapwings feed on insects, snails, other invertebrates, and occasionally grains. Males and females have similar physical appearance and are generally seen in pairs or small groups (Fig.4-5 – Appendix 2).

Breeding habitat and nesting behaviour

Red-wattled Lapwing is a permanent resident in both study sites. Breeding pairs were typically observed between November 2022 and November 2025 (Tab. 3).

Tab. 3. Summary of basic information on observations of *Vanellus indicus* Boddaert in urban conditions of Jodhpur (Rajasthan, India)

No.	Recorded events	Year of field observations / number of recorded events				Total number of recorded events
		2022	2023	2024	2025	
1.	Nesting pairs	2	2	2	1	7
2.	Eggs laid	-	8	7	8	23
3.	Chicks	-	8	7	6	21
4.	Predation events	-	-	5	4	9
5.	Territorial conflicts	15	10	20	40	85
6.	Other incidental events	-	20	20	30	70

A total of five pairs were studied over three years, including three pairs in the BSI residential campus and two pair in the BSI office garden. During the courtship display, males keep their body, wings vertically and opens the wings widely and moves near to female to attract. Once females accepted for pairing, males convey to females with continuous calls, such as “chick-chick-chick,” and follow females for mating. Females accept males by crouching, with the copulation lasting less than 20 seconds (Fig. 4A-D – Appendix 2).

In the BSI residential campus, three breeding pairs selected nesting sites in areas with mixed vegetation dominated by *Aerva javanica*, *Balanites roxburghii* seedlings, *Cenchrus ciliaris*, *Crotalaria burhia*, *Prosopis cineraria*, *Senna italica*, *Senna tora*, *Vachellia tortilis*, *Tephrosia purpurea*, and *Ziziphus nummularia*. Both partners dug shallow pits and decorated them with stones, dried leaves, and sticks to camouflage the nests (Fig. 4E-F – Appendix 2). They laid 3–4 eggs, brownish-grey with blackish blotches (Fig. 4G-H – Appendix 2), and both parents participated in incubation. In 2023, two breeding pairs laid eggs in March and the clutch size of

both pairs was 4. These two pairs were succeeded to hatch their eggs in April 2023 and raised the chicks without any loss (Tab. 3). In 2023 BSI office outer surroundings had some green patches and in 2024 they were cleared converted as residential, coaching centres and hotel construction sites by 2025. This resulted in the high predatory events as monitor lizards, jungles cats and other predator had no other green landscape to hunt the prey other than the BSI premises.

After mating in January, one pair selected a nesting site under a *Senna fistula* tree in the BSI office campus and laid three eggs in 2024. The peak breeding season was observed between April and June. Another pair nested in an open grassland dominated by *Cenchrus ciliaris* and *C. setigerus* and laid 4 eggs in February 2024. The proximity of these two nests (~40 m) and the nest of Indian Thick-knee in the same habitat resulted in occasional territorial conflicts (Tab. 3; Fig. 5A-E, 6A-H – Appendix 2). Only one pair was successful to protect their 2 chicks among the four chicks and the other breeding pair 3 chicks were lifted by house crows roosting on the *Azadirachta indica* trees in the garden.

Existing resident breeding pairs did not allow new pairs of Red-wattled Lapwing and also breeding pairs of Indian Thick-knee to nest nearby, leading to territorial disputes (Fig. 5A-E, 6A-H – Appendix 2). Double clutching was observed in one pair at the AZRC residential campus. In the first clutch, the female laid four eggs between March 17–22, 2025; two were predated by a monitor lizard, while the remaining two hatched on April 19, 2025. The chicks disappeared by April 30, likely due to predation by cats, monitor lizards, or Shikras. The parents relocated 20–40 m from the previous site and laid a second clutch of four eggs between May 18–24, 2025. All four eggs hatched on June 21, 2025, and chicks had access to sufficient insects in the herbaceous flora after intermittent rains in June and July 2025.

Parental care and defensive behaviour

During incubation and chick-rearing, parents were highly vigilant and made incessant alarm calls upon detecting movement. Mating was observed at various times, including day, night, and even during chick-rearing. Both parents participated in guarding the territory and defending the brood. Common cohabitant avifauna included Grey Francolin, Indian Blue Robin, Indian Peafowl, Eurasian Wryneck, Large Grey Babbler, Eurasian Collared-dove, House Sparrow, and Red Collared-dove.

Predation threats included stray dogs (Tab. 3; Fig. 5D-E – Appendix 2), Jungle Cats, mongooses, monitor lizards, House Crows, Shikras, Spectacled Cobras, Black Kites, and Asian Koels. Parents chased these predators to protect eggs and chicks. Sometimes, these birds were also chasing our kids when they played near their nests or chicks. Incubation lasted 26–30 days, and chicks were highly camouflaged with the surrounding environment. Chicks had a black cap, white collar with blackish markings, white throat, and dull white sides of the neck (Fig. 5F-I – Appendix 2).

Both parents cared for the chicks and provided continuous alarm calls when predators were nearby. Chicks hid in vegetation such as *Achyranthes aspera*, *Boerhavia diffusa* (Fig. 5 – Appendix 2), and *Zygophyllum indicum*, or directly on bare soil, relying on their camouflage. During predator attacks, chicks quickly hid in bushy plants such as *Aerva javanica*, *Balanites roxburghii*, *Crotalaria burhia*, and *Ziziphus nummularia*, responding to parental alarm calls.

Role of vegetation and food resources

Intermittent showers induced germination of herbaceous plants, including *Achyranthus aspera*, *Amaranthus palmeri*, *Boerhavia diffusa*, *B. erecta*, *Cenchrus ciliaris*, *C. setigerus*, *Chloris flagellifera*, *Cleome viscosa*, *Corchorus depressus*, *Croton bonplandianus*, *Cynodon dactylon*, *Dactyloctenium scindicum*, *Euploca bracteata*, *Indigofera obcordata*, *I. linifolia*, *I. tsiangiana*, *Pupalia lappacea*, *Polygala erioptera*, *Portulaca oleracea*, *P. linearifolia*, *Tragus mongolorum*, *Trianthema portulacastrum*, and *Urochloa ramosa*. These plants provided hiding cover and a rich supply of insects, forming the primary diet for the chicks (Fig. 7 – Appendix 2).

Chicks developed into juveniles within ~40 days and reached subadult stage in 70–80 days, demonstrating that vegetation structure and insect availability are critical for the successful rearing of Red-wattled Lapwing chicks.

Discussion

The findings of this study should be interpreted within the broader context of ongoing habitat transformation and ecological pressures affecting ground-nesting birds. The presence of *Burhinus indicus* in the study area contrasts with reports indicating that the species is declining in parts of its range due to habitat loss (Sureshan et al., 2022; Abraham, Subramanian, 2025). The studied urban green space may therefore function as a locally important habitat supporting persistence of the

species in a modified landscape, although broader regional comparisons would be required to confirm this interpretation.

The observed camouflage in both *Burhinus indicus* and *Vanellus indicus* is consistent with previous studies indicating that cryptic plumage reduces detectability and may contribute to lower predation risk in ground-nesting birds (Troscianko et al., 2016; Volkmer et al. 2024). In the present study, nest concealment appeared to be associated with substrate conditions, including leaf litter and herbaceous vegetation (Fig. 2, 4H – Appendix 2), suggesting that microhabitat features may play a role in nesting site selection and visibility reduction.

Spatial distribution of nests and observed territorial behaviour in both species aligns (Fig. 6 – Appendix 2) with established concepts of avian territoriality. Nest spacing between breeding pairs may reduce direct interference and intraspecific interactions, consistent with previous findings on ground-nesting birds (Nice, 1941; Smith, Edwards, 2018). However, the direct contribution of spatial separation to reproductive success in this system remains to be quantified.

Parental defence behaviours, including alarm calling and aggressive responses toward predators, were frequently recorded (Fig. 5 – Appendix 2). These behaviours are consistent with previously described anti-predator strategies in ground-nesting birds and are considered important components of brood protection under predation pressure (Gómez-Serrano, López-López, 2017; Smith, Edwards, 2018).

Vegetation structure appears to be associated with nesting and chick-rearing sites of both species. Seasonal herbaceous vegetation and shrub cover (Tab. 1 – Appendix 1; Fig. 2-3, 7 – Appendix 2) were frequently present in areas used for nesting and chick shelter. Previous studies have highlighted that vegetation provides concealment, microclimatic buffering, and foraging resources (Martin, 1993; Jones, 2001). In this study, vegetation cover may therefore represent an important habitat component supporting ground-nesting birds in urban arid landscapes, although its effects were not experimentally tested.

More broadly, behavioural patterns observed in *Vanellus indicus*, including variation in breeding attempts and territorial interactions (Tab. 3; Fig. 5-6 – Appendix 2), are consistent with previously reported responses of ground-nesting birds to environmental variability and predation risk (Lima, Dill, 1990; Martin, 1995; Cresswell, 1997; Whittingham, Evans, 2004). Overall, the results suggest that habitat structure (Fig. 1-7 – Appendix 2) and behavioural flexibility jointly contribute to reproductive outcomes in urban ecosystems.

Conclusions

Urban green spaces containing native arid and semi-arid vegetation appear to support nesting and breeding activity of ground-nesting birds such as *Burhinus indicus* and *Vanellus indicus*. The present study indicates the following:

(1) Vegetation structure and species composition are associated with nest site selection by providing concealment, heterogeneous ground cover, and foraging opportunities. Nest locations documented in the study suggest that structurally diverse plant communities may facilitate nesting in urban environments.

(2) Nesting success and chick survival appear to be associated with vegetation cover, particularly herbaceous and shrub layers that provide concealment and insect resources. Successful breeding events recorded in the study area indicate that vegetated patches may contribute to reproductive outcomes, although further quantitative analyses are needed.

(3) Parental defence behaviour and territorial interactions were frequently observed in relation to nest proximity and habitat structure. These behaviours likely reflect responses to predation risk and spatial constraints in urban habitats.

The results highlight the potential importance of maintaining native vegetation in urban and peri-urban landscapes in arid regions of Rajasthan. Indigenous plant species such as *Prosopis cineraria*, *Salvadora persica, S. oleoides, Tecomella undulata, Senegalia senegal*, *Ziziphus mauritiana*, and associated shrub and herb communities may contribute to habitat heterogeneity and support urban biodiversity. Further research should quantify the strength of relationships between vegetation structure, predation pressure, and reproductive success in ground-nesting birds in urban ecosystems.

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Conflict of interest

The authors declare no conflict of interest related to this article.

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Tab. 1. List of the most important plant species constituting the habitat of *Burhinus indicus* Salvadori and *Vanellus indicus* Boddaert in urban conditions

No.	Name of species	Family	Life form	Occurrence
1.	*Abutilon indicum* (L.) Sweet	Malvaceae	small shrub	gardens, sandy plain
2.	*Achyranthus aspera* L. =*A. sicula* Roth.	Amaranthaceae	annual or subshrub	gardens, sandy plain
3.	*Acrachne racemosa* (B.Heyne ex Roth) Ohwi	Poaceae	annual, herbaceous	gardens
4.	*Aerva javanica* (Burm.f.) Juss. ex Schult. = *A. persica* (Burm.f.) Merr.	Amaranthaceae	subshrub	sandy plain
5.	*Aerva javanica* var. *bovei* Webb =*A. tomentosa* Forssk.	Amaranthaceae	subshrub	gardens, sandy plain
6.	*Ailanthus excelsa* Roxb.	Simaroubaceae	deciduous tree	gardens, sandy plain
7.	*Aloe vera* (L.) Burm.f.	Asphodelaceae	perennial herb	gardens
8.	*Amaranthus palmeri* S.Watson	Amaranthaceae	annual herb	gardens, sandy plain
9.	*Azadirachta indica* A.Juss.	Meliaceae	tree	gardens
10.	*Balanites roxburghii* Planch.	Zygophyllaceae	evergreen tree	gardens, sandy plain
11.	*Barleria prionitis* L.	Acanthaceae	shrub	gardens
12.	*Blepharis scindica* Stocks ex T.Anderson	Acanthaceae	annual herb	gardens, sandy plain
13.	*Boerhavia diffusa* L.	Nyctaginaceae	perennial herb	gardens, sandy plain
14.	*Boerhavia erecta* L.	Nyctaginaceae	annual or perennial	gardens, sandy plain
15.	*Calotropis procera* (Aiton) Dryand.	Apocynaceae	shrub	gardens, sandy plain
16.	*Capparis decidua* (Forssk.) Edgew.	Capparaceae	low shrubs or small trees	gardens, sandy plain
17.	*Cenchrus ciliaris* L.	Poaceae	perennial herb	gardens, sandy plain
18.	*Cenchrus setiger* Vahl	Poaceae	perennial herb	gardens, sandy plain
19.	*Chloris flagellifera* (Nees) P.M.Peterson	Poaceae	perennial	gardens, sandy plain
20.	*Cleome viscosa* L.	Cleomaceae	annual herb	sandy plain
21.	*Cocculus hirsutus* (L.) W.Theob**.**	Menispermaceae	slender climber, liana	gardens, sandy plain
22.	*Corchorus depressus* (L.) Peterm.	Malvaceae	perennial or subshrub	gardens, sandy plain
23.	*Crotalaria burhia* Buch.-Ham. ex Benth.	Fabaceae	low undershrub	sandy plain
24.	*Crotalaria medicaginea* Lam.	Fabaceae	herbs, shrublets, or shrubs	gardens
25.	*Croton bonplandianus* Baill.	Euphorbiaceae	subshrub or shrub	gardens, sandy plain
26.	*Cyanthillium albicans* (DC.) H.Rob.	Asteraceae	subshrub	gardens, sandy plain
27.	*Cyanthillium cinereum* (L.) H.Rob. =*Vernonia cinerea* (L.) Less.	Asteraceae	annual or perennial herb	gardens, sandy plain

28.	*Cynodon dactylon* (L.) Pers.	Poaceae	perennial herb	gardens, sandy plain
29.	*Dactyloctenium scindicum* Boiss.	Poaceae	perennial herb	gardens, sandy plain
30.	*Dichrostachys cinerea* (L.) Wight & Arn.	Fabaceae	shrub or tree	gardens
31.	*Dicliptera paniculata* (Forssk.) I.Darbysh.	Acanthaceae	annual or perennial herb	gardens, sandy plain
32.	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	annual or perennial	gardens, sandy plain
33.	*Diplocyclos palmatus* (L.) C.Jeffrey	Cucurbitaceae	climbing perennial	gardens
34.	*Echinops echinatus* Roxb.	Asteraceae	annual herb	gardens, sandy plain
35.	*Eragrostis ciliaris* (L.) R.Br.	Poaceae	annual or perennial	gardens, sandy plain
36.	*Euphorbia caducifolia* Haines	Euphorbiaceae	succulent shrub	gardens, sandy plain
37.	*Euphorbia hirta* L.	Euphorbiaceae	annual herb	gardens, sandy plain
38.	*Euphorbia hypericifolia* L.	Euphorbiaceae	annual or subshrub	gardens, sandy plain
39.	*Euphorbia jodhpurensis* Blatt. & Hallb.	Euphorbiaceae	annual herb	gardens
40.	*Euploca bracteata* (R.Br.) M.W.Frohl. & M.W.Chase	Boraginaceae	herb plant	sandy plain
41.	*Gmelina arborea* Roxb. ex Sm.	Lamiaceae	tree	gardens
42.	*Gymnosporia heyneana* (Roth) M.A.Lawson	Celastraceae	tree	sandy plain
43.	*Heliotropium europaeum* L.	Boraginaceae	annual herb	gardens, sandy plain
44.	*Heliotropium zeylanicum* Lam.	Boraginaceae	perennial herb	gardens, sandy plain
45.	*Holoptelea integrifolia* (Roxb.) Planch.	Ulmaceae	tree	gardens
46.	*Indigofera cordifolia* B.Heyne ex Roth	Fabaceae	herb	gardens
47.	*Indigofera linifolia* (L.f.) Retz.	Fabaceae	annual, perennial or subshrub	gardens, sandy plain
48.	*Indigofera tsiangiana* Metcalf	Fabaceae	subshrub or perennial	gardens, sandy plain
49.	*Ipomoea pes-tigridis* L.	Convolvulaceae	climbing annual or perennial	gardens, sandy plain
50.	*Leptadenia pyrotechnica* (Forssk.) Decne.	Apocynaceae	shrub or tree	sandy plain
51.	*Neltuma juliflora* (Sw.) Raf.	Fabaceae	shrub or tree	sandy plain
52.	*Pavonia zeylonica* (L.) Cav.	Malvaceae	perennial or subshrub	gardens, sandy plain
53.	*Physalis angulata* L.	Solanaceae	annual herb	gardens, sandy plain
54.	*Polygala erioptera* DC.	Polygalaceae	annual or subshrub	gardens, sandy plain
55.	*Portulaca oleracea* L.	Portulacaceae	semisucculent annual	gardens, sandy plain
56.	*Portulaca linearifolia* (Sivar. & Manilal) D.Panwar	Portulacaceae	annual or subshrub	gardens, sandy plain
57.	*Prosopis cineraria* (L.) Druce	Fabaceae	shrub or tree	gardens, sandy plain
58.	*Pupalia lappacea* (L.) Juss.	Amaranthaceae	perennial	gardens, sandy plain

59.	*Rostellularia procumbens* (L.) Nees =*Justicia procumbens* L.	Acanthaceae	annual	gardens, sandy plain
60.	*Salvadora oleoides* Decine.	Salvadoraceae	tree	gardens, sandy plain
61.	*Salvadora persica* L.	Salvadoraceae	tree	gardens, sandy plain
62.	*Senegalia senegal* (L.) Britton	Fabaceae	shrub or tree	gardens, sandy plain
63.	*Senna alexandrina* Mill.	Fabaceae	subshrub, shrub or tree	sandy plain
64.	*Senna italica* Mill.	Fabaceae	annual, perennial or subshrub	gardens, sandy plain
65.	*Senna tora* **(**L.) Roxb.	Fabaceae	annual, perennial or subshrub	gardens, sandy plain
66.	*Sida rhombifolia* L.	Malvaceae	perennial or subshrub	gardens, sandy plain
67.	*Sida tiagii* Bhandari	Malvaceae	perennial or subshrub	gardens, sandy plain
68.	*Tecomella undulata* (Sm.) Seem.	Bignoniaceae	tree	gardens, sandy plain
69.	*Tephrosia purpurea* (L.) Pers. subsp. *purpurea*	Fabaceae	annual, perennial or subshrub	gardens, sandy plain
70.	*Tephrosia. purpurea* (L.) Pers. subsp. *apollinea* (Delile) Hosni & El-Karemy	Fabaceae	annual, perennial or subshrub	gardens, sandy plain
71.	*Tetrapogon tenellus* (J.Koenig ex Roxb.) Chiov.	Poaceae	annual or perennial	sandy plain
72.	*Tragus mongolorum* Ohwi	Poaceae	annual	sandy plain
73.	*Trianthema portulacastrum* L.	Aizoaceae	annual or biennial	sandy plain
74.	*Trichodesma zeylanicum* (Burm.f.) R.Br.	Boraginaceae	annual or subshrub	gardens, sandy plain
75.	*Urochloa ramosa* (L.) T.Q.Nguyen	Poaceae	annual	sandy plain
76.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	Fabaceae	shrub or tree	gardens
77.	*Ziziphus mauritiana* Lam.	Rhamnaceae	tree	gardens, sandy plain
78.	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Rhamnaceae	shrub or tree	gardens, sandy plain
79.	*Zygophyllum indicum* (Burm.f.) Christenh. & Byng	Zygophyllaceae	subshrub	gardens, sandy plain

Fig. 2. Indian Thick-knee: breeding pair (A), female bird acceptance for mating (B), nest with eggs (C), hatching (D), hatchlings (E), chick with parent bird (F), chick (G), juvenile (H) (Photo: Ravi Kiran Arigela)

Fig. 3. Indian Thick-knee: breeding pair hatching and guarding the nest (A-B), adult birds hiding to avoid the human contact (C-D), vigilant mode against Shikra movement (E), protecting the eggs from cattle (F), hiding in the camouflaged locations (G-H) (Photo: Ravi Kiran Arigela)

Fig. 4. Red-wattled Lapwing: male (A), female (B), male performing courtship displays (C), breeding pair mating (D), nest building (E-F), nest with eggs (G-H) (Photo: Ravi Kiran Arigela)

Fig. 5. Red-wattled Lapwing: hatching (A-B), fight for territory (C), parent bird chasing away the stray dogs from the nest (D), parent bird chasing away the Monitor Lizard from the chicks (E), chicks with parent bird (F), chickling (G), juvenile (H), subadult (I) (Photo: Ravi Kiran Arigela)

Fig. 6. Territorial conflict between Indian Tick-knee and Red-wattled Lapwing (A-H) (Photo: Ravi Kiran Arigela)

Fig. 7. Red-wattled Lapwing association with plants: collecting insects on *Polygala erioptera* (A), chicks hiding in *Boerhavia erecta, Calotropis procera, Achyranthus aspera* and *Tephrosia purpurea* after parents bird's alert calls (B-E, chicks are feeding on the insects existing on *Cenchrus setigerus, Crotalaria burhia* and *Balanites roxburghii* (F-H) (Photo: Ravi Kiran Arigela)

Interakcje kulona indyjskiego (*Burhinus indicus*) i czajki indyjskiej (*Vanellus indicus*) z roślinami w krajobrazie miejskim (Dźodhpur, Indie)

Streszczenie

Interakcje między roślinami a ptakami gniazdującymi na ziemi, a także zachowania lęgowe kulona indyjskiego (*Burhinus indicus* Salvadori) i czajki indyjskiej (*Vanellus indicus* Boddaert) zostały udokumentowane w krajobrazie miejskim w Dźodhpurze w Radżastanie w Indiach. Obserwacje terenowe koncentrowały się na siedliskach lęgowych, zachowaniach lęgowych i roli roślinności w utrzymaniu tych gatunków. Zaobserwowano i udokumentowano podwójne lęgi w sezonie lęgowym *V. indicus*. Badanie analizuje również współistnienie flory i fauny w niewielkim chronionym siedlisku miejskim i podkreśla ekologiczną rolę rodzimych gatunków roślin w zwiększaniu bioróżnorodności miejskiej. Wyniki wskazują, że ptaki gniazdujące na ziemi w dużym stopniu polegają na zakamuflowanych miejscach lęgowych, pokryciu roślinnością i aktywnej obronie rodzicielskiej, aby zmaksymalizować sukces reprodukcyjny. Zachowania terytorialne i separacja przestrzenna między gniazdami pomagają ograniczyć konflikty wewnątrzgatunkowe, podczas gdy czas lęgów i podwójne lęgi wydają się być reakcjami adaptacyjnymi na drapieżnictwo i warunki środowiskowe. Wnioski te podkreślają znaczenie rodzimej roślinności w zapewnianiu schronienia, podłoża do gniazdowania i zasobów pokarmowych dla ptaków w suchych ekosystemach miejskich.

Słowa kluczowe: różnorodność biologiczna, rozmnażanie, ochrona, utrata siedlisk, gniazdo, drapieżniki.

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