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Breeding ecology of the River Lapwing (*Vanellus duvaucelii)* along the Tapi River basin of melghat landscape, Maharashtra, India: Nest characteristics and threats

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Abstract
In the face of vanishing river habitats, understanding the breeding secrets of the River Lapwing has never been more urgent. The River Lapwing **(***Vanellus duvaucelii***)** is a ground-nesting wader commonly found along sandy and gravelly riverbanks of flowing rivers with decline population trend across the Indian subcontinent, it has been uplisted to Near Threatened (NT) criteria by IUCN. This species is known for its distinctive black-and-white plumage and territorial breeding. This study investigates the breeding ecology of the River Lapwing along the Tapi River Basin within the ecologically rich Melghat landscape of Maharashtra, India, during four consecutive breeding seasons (2022-2025). A total of 117 transects, each measuring 500 m, were surveyed along a 60 km stretch of the Upper Tapi River to study the breeding ecology of the River Lapwing. Six potential nesting sites were identified and monitored: Rajakilla, Rangubeli, Mohanballa, Kutanga, Chethar, and Amner Fort. A total of 10 nests were recorded and systematically monitored to document nest characteristics, habitat variables, and threats. Nests were predominantly located on open, unvegetated gravel banks close to the river channel, with nest cup dimensions showing minimal variation, indicating species-specific construction. Clutch sizes ranged from 2 to 4 eggs. Key threats to nesting success included predation by feral dogs, crows, raptors, jackal and snake. Eggs damage by trampling and human activities and natural factors such as unusual rain and flooding. Feral dogs were identified as the most consistent threat across all sites. Statistical analyses revealed significant variation in disturbance types (ANOVA, $F(7,72) = 67.77$, $p<0.001$). Only 3 of 10 nests resulted in successful hatching without chick mortality. This study highlights the importance of habitat selection, nest microstructure, and threats pressures in shaping the breeding success of River Lapwings, emphasizing the need for targeted conservation strategies in riparian habitats.

Keywords: River lapwing, nest characteristics, threats, Tapi river basin, melghat

Introduction
The River Lapwing, *Vanellus duvaucelii* (Lesson, 1826) [9], belongs to the order Charadriiformes and is confined to a broad rank of habitats such as arable and low wet grassland, riverbanks, sandy islands, lakes, reservoirs, ditches, and puddles (Ali and Ripley 1980; Duckworth *et al.* 1998) [2, 20]. They are mostly confined along the sandy banks of larger rivers. Moreover, they are usually constrained near sandbars of slow-moving flowing rivers (Duckworth *et al.* 1998) [20], generally occur in pairs, and have a mostly clumped distribution (Mishra *et al.* 2018) [35]. They are usually observed in groups of 6-8 birds during the breeding season (Pratik *et al.* 2024) [50].

There are 25 known species of lapwings in the world, out of which 7 species are found in the Indian subcontinent and four species of lapwings are found in the Vidarbha region (Wagh *et al.* 2020) [45]. River Lapwing is a globally "Near-threatened" species currently confined to southeast Asia, southern China, and parts of India; in India, it is distributed in a large proportion of northern India (Ali 2002) [3]. Lapwings are ground-nesting plovers that usually lay 3-4 eggs and nest in ground scrapes from March to May, as is patternrned of most waders. Nest is camouflaged to the background formed in such a way that makes a shallow depression in the ground just to keep the eggs from rolling away and avoid predators (Baines 1990) [4]. Among species, there are various ways in which nests are constructed and nest characteristics such as size, shape composition, and site. The size of a nest is often correlated with the bird's

body structure, type of nest (open, cup), and clutch size (Slagsvold 1989) [41]. Moreover, the size of egg varies with clutch size (Christians 2002) [12], laying order (Murphy 1994; Zhao *et al*. 2002) [36, 49], female age, and body mass (Desrochers and Magrath 1993; Nager and Zandt 1994) [18, 37], as well as seasonal change (Coulson 1963; Du *et al*. 2012) [17, 19]. Furthermore, some researchers have reported that egg size differs within and between clutches and between years (Flint and Sedinger 1992) [22]. However, it is also influenced by habitat quality and food resources (Smith and Bruun 1998) [42]. Several studies have shown that hatching success varies with sites, year, and habitat (Teunissen *et al*. 2008; Golawski and Mroz 2019) [44].

Nest-site selection in birds refers to the preference for a specific location among available options based on factors that enhance survival. An ideal site typically offers abundant food, suitable foraging areas, shelter, and protection from predators (Burger 1985; Cody 1985; Colwell *et al*. 2011) [51, 15, 16]. Nesting success in birds can be evaluated across five key stages: nest construction, egg-laying, incubation, hatching, and fledging. Each stage is critical in determining the overall reproductive success of the species (Mayfield Harold 1975) [33].

In the case of River Lapwings, survival of young chick to 'fledging' would not necessarily be considered part of nesting success as the chicks are out of the nest for a long time (approximately for 10-12 days) before fledging. The incubation and nestling stages of the life cycle are often the periods when birds suffer the highest mortality rates (Ricklefs 1973; Martin 1993) [39, 32]. A study on nesting ecology of River Lapwing has been carried out in southern Asian countries like Bangladesh (Ahmed *et al*. 2018) [1], focused mainly on nest location and clutch size.

There is little information on factors influencing nesting success of the species in the Melghat landscape as this species distribution found in this area. Furthermore, the breeding ecology of River Lapwing is still poorly understood, and basic information is required to develop science-based conservation action plans in this area. In this regard, we aimed to estimate the other dimensions of breeding ecology, nest characteristics and nesting success, the contribution of predation to nest failure, and identifying key predatory species or groups as part of it.

Material and Methods

Study Area

The Tapi River, also known as Tapti, is the second-largest west-flowing river in Peninsular India. It originates from the Satpura Range near Multai in Madhya Pradesh, with nearly 80% of its catchment area located in Maharashtra. The upper basin of the Tapi River lies within the Melghat region of the Amravati district, where the river flows through dense forests and rugged terrain and its tributaries, including the Sipna, Gadga, Khandu, Khapra, and Dolar. This upper stretch is ecologically significant, forming part of the Melghat Tiger Reserve and supporting a variety of riparian and terrestrial biodiversity (CWC, 2015; Pratik *et al*. 2023) [7, 52].

The Melghat region, located in the Satpura Hill Range of central India within the Amravati district, is of significant ecological importance. Melghat landscape features crests that reach an average elevation of about 1000 meters. This region is characterized by Southern Tropical Dry Deciduous forests and experiences a tropical climate, with temperatures ranging from 13 °C to 22 °C in winter and from 23 °C to 42 °C in summer. The annual rainfall in Melghat varies between 1000 mm and 2250 mm, primarily during the southwest monsoon (Pratik *et al*. 2024) [50].

The field study was carried out along the Tapi River flowing through Amravati District in a stretch of about 60 km in the state of Maharashtra, Central India. Prominent study stations along the Tapi River in the Melghat region included Rajakilla (21.712889°N, 77.169200°E), Rangubeli (21.718992°N, 77.138915°E), Mohanballa (21.719954°N, 77.113955°E), Kutanga (21.715140°N, 77.092784°E), Chethar (21°36′27.1″N, 76°54′35.0″E), and Amner Fort (21.529703°N, 76.782990°E). These areas are known for their ecological diversity and rich riparian habitats. During the study period from February 2022 to June 2025, the Tapi River within Melghat was selected as a key site for investigating the breeding patterns of the *V. duvaucelii*. The width of river bank was 178 m. Intensive surveys were conducted between February to June, coinciding with the species breeding season, which helped minimize pseudo replication as the birds remained close to nesting areas. To determine nest characteristic and causes of egg failure, we conducted a field survey in our study site during four successive breeding seasons in March–June, 2022 to 2025. For this purpose, we monitored nests weekly. Moreover, the bank of the Upper Tapi basin provides valuable wildlife habitat and share boundary with Madhya Pradesh (Map 1).

Evaluation of nesting pairs and nest characteristics

A total of 117 transects, each 500 m in length, were surveyed, covering 60 km of the Tapi River. Nikon DSLR cameras D3400, D7000 equipped with zoom lenses were used to capture images and videos. Nesting pairs and nests were identified by direct observations and by behavioral cues, that is, distraction displays, broken wing displays, alarm calls, and raising of the crest by males (Photoplate 1). Each site was surveyed on two to three occasions each month. Successive visits to a site were made at least 6-8 days apart during the breeding season. On each visit, observers carried out a 40 min survey at dawn (06:00-0.9:00 h local time) and at dusk (16:00 19:00 h local time), with the remaining surveys being carried out between (0.9:00 and 16:00 h local time) from a vantage point (*elevated observation site*) from which they could see most of the nesting sites without disturbing birds.

To make it easier to find and observe each nest again, we placed an approx. 20 cm high stack of stones approximately 20 feet away from each nest site. Each stone marker was lightly marked with white lime powder to ensure visibility while minimizing disturbances to the nesting area. Consecutive visits to a nesting place were made at least 5-8 days apart. On every visit, we performed an observation during the three interval periods (6:00–9:00 h, 10:00–13:00 h, and 15:00–17:00 h) from a vantage point using Gosky 10 × 42 Roof Prism Binocular. Nests were monitored early in the morning from the initiation of incubation until hatching occurred using a Cudd back motion-activated, high-resolution wildlife camera. The Garmin GPS will be used to record the latitude and longitude of the Nesting site. The microstructure of the nest was measured using a metal scale and a rolling measuring tape after the incubation period. A digital Vernier caliper (Least Count 0.1 cm) was also used to measure nests and surrounding areas. Measurement of Habitat Variables taken by Bosch GLM 200 m Professional Laser Distance. During monitoring to reduce the chances of predation, nests were scanned from the vantage point or examined by being

approached on foot. All standard protocols for birding and bird studies were followed (Bibby *et al*., 2000; Grimett *et al*., 2011) [5, 27].

Statistical analysis

Descriptive and inferential statistics were used to assess the variability in disturbance factors affecting River Lapwing nest sites (RLN1-RLN10). For each disturbance type—such as feral dogs, crows/raptors, snakes, jackals, flooding, and others—the mean, standard deviation (SD), and Coefficient of Variation (CV) were calculated to evaluate both consistency and intensity across the sites. Disturbance types with **CV** < 10% (e.g., feral dogs and trampling) were considered consistent, whereas CV > 100% (e.g., snakes and flooding) indicated highly variable and sporadic threats (Zar, 1999; Sokal & Rohlf, 2012) [48, 53].

To determine whether there were statistically significant differences in mean disturbance levels among the seven categories, a one-way Analysis of Variance (ANOVA) was conducted, yielding $F(6, 63) = 104.89$, $p<0.001$. This confirmed that certain disturbances occurred significantly more frequently than others. Additionally, the range and ±SD were used to assess spatial variability across nesting sites (Motulsky, 2018) [54]. All statistical analyses were performed using GraphPad Prism version 10.0. The study area map was constructed using QGIS.

Result

Ecological Features of Nesting Sites

During the study period (2022-2025), a total of 10 River Lapwing nests were recorded: 2 nests each in 2022 and 2023, and 3 nests each in 2024 and 2025(Map 1). Between 2022 and 2025, 10 River Lapwing nests (RLN1-RLN10) were measured to document key structural parameters (Table 1). The total width of the nests (CR) ranged from 34.8 cm to 40.0 cm, with an average of approximately 36.5 cm. Nest circumferences (AB) were relatively consistent, measuring between 65.8 cm and 67.0 cm. The height of the nest rim above surrounding gravel (FE) varied slightly, from 4.6 cm to 5.4 cm, suggesting minimal elevation differences across nests. The outer stony rim (BR) showed more noticeable variation, with widths ranging from 3.1 cm to 12.2 cm, while the maximum gravel-stone rim width (MB) remained stable at approx. 7.0 cm. The slope from the rim to the nest cup (KL) ranged between 3.5 cm and 4.7 cm, and nest cup depths varied modestly. The minimum depth (LI) ranged from 2.0 cm to 2.3 cm, and the maximum depth (NH) from 2.4 cm to 3.1 cm, indicating a shallow but defined depression. The central excavated cup (KM) ranged in width from 9.0 cm to 11.4 cm, suggesting uniformity in egg-holding space. The stones used for camouflage (PQ) measured between 10.3 cm and 14.6 cm in height, likely offering varying degrees of concealment. Vegetation height near the nests varied greatly, from as little as 1.0 cm to as much as 20.3 cm, with most nests surrounded by sparse vegetation. Clutch size ranged from 1 to 4 eggs per nest, with an average of about 2.6 eggs, reflecting moderate reproductive investment during the breeding seasons studied (Table 1 Fig. 1).

The nest habitat variables of the ten River Lapwing nests exhibited notable variation across years and locations. The distance from the riverbank ranged widely, from 21.69 meters (RLN10) to 106.6 meters (RLN3), with nests generally located within a 20 to 60-meter range, except for RLN3, which was a significant outlier. The distance from human settlements also varied considerably, ranging from 484.3 meters (RLN8) to 2355.67 meters (RLN1). Nests located closer to human activity (such as RLNs 4 - 8) tended to be situated within 500-800 m, while others were more remote. Proximity to river water showed a narrower range, with distances between 5.6 meters and 19.89 meters, suggesting that nests were consistently placed near the active river channel, likely for accessibility and visibility. The river width at nest sites ranged from 130.72 meters (RLN8) to 255.1 meters (RLN3), indicating a preference for broad, open river channels, although some variation in river width was present across sites and years. Regarding the substrate, the pebble pattern at nest sites was mostly categorized as dense, with the exception of RLN1, RLN4 (moderate), and RLN10 (sparse). This indicates a general nesting preference for areas with densely packed pebbles, which may provide better camouflage or structural support for nests (Table 2).

From 2022 to 2025, ten River Lapwing nests were monitored across various sites, including the Tapi River, Khapra-Tapi confluence, and Sipna-Tapi confluence. Out of these ten nests, three nests (RLN1 in 2022, RLN5 in 2024, RLN9 in 2025,) resulted in at least one chick hatching, while the remaining seven nests failed due to egg predation, flooding, or human disturbance. Notably, RLN10 had chick mortality despite producing a chick, resulting in an overall nest failure designation. Egg loss was recorded in eight nests, with complete clutch loss in four of them (RLN2, RLN3, RLN6, and RLN8). Suspected causes of predation included feral dogs (RLN2 and RLN8), human disturbance (RLN3 and RLN6), flooding (RLN4), crows (RLN7), and a raptor (RLN10). Physical evidence of predation ranged from missing eggs, partial eggshells, to feathers at the nest site. Predation and disturbance events occurred more frequently during the daytime, except for RLN4 and RLN6, which failed at night. Despite various threats, three nests (RLN1, RLN5, and RLN9) were categorized as successful, each hatching one chick without observed chick loss. These findings suggest that egg predation, particularly by feral dogs and human interference, along with natural factors like flooding, significantly influence River Lapwing nesting success in these riparian habitats (Table 3, Photoplate 3).

Analysis of disturbance factors across nesting sites revealed significant variation in both frequency and consistency. Feral dogs emerged as the most consistent and prominent threat, with the highest mean disturbance value (14.1) and the lowest coefficient of variation (CV < 10%), indicating minimal variability and a widespread impact across all sites. This was further supported by its low standard deviation (SD = 0.88) and narrow range (range = 2), suggesting uniform pressure across the study area. In contrast, snakes showed an exceptionally low mean (0.4), but a very high CV (>100%), reflecting rare, inconsistent occurrences and localized impact. Similar high variability was observed for flooding and human disturbance, both showing high CVs and standard deviations (e.g., flooding SD = 2.53), implying sporadic but severe impacts when they do occur. Trampling was another significant factor, with a high mean (13.3) and relatively consistent presence, indicating a regular physical threat to nests. However, other threats such as crows and raptors showed a high standard deviation (SD = 3.73) and broad range (range = 15), pointing to strong site-specific variation in predation intensity. (Table 4 and fig. 2). A one-way ANOVA confirmed that the variation in disturbance frequency across the seven disturbance types was statistically significant (F

(7,72) = 67.77, p<0.001). This result led to rejection of the null hypothesis, demonstrating that some disturbance types particularly feral dogs and aerial predators (crow and raptor) occur significantly more frequently than others, such as snakes or flooding. In summary, feral dogs exert a widespread and consistent threat, while other factors like snakes, flooding, and crows/raptors demonstrate high variability, suggesting their effects are localized and episodic. This variation in both frequency and consistency across sites highlights the need for site-specific management strategies to mitigate nest disturbance and improve breeding success (Photoplate 5).

Table 1: Microstructural Nest Parameters with Vertical Section Structure of

S. no.	Nest Parameters	Abbreviation (Ref. Fig.)	Measurement/Range in cm									
			RLN1	RLN2	RLN3	RLN4	RLN5	RLN6	RLN7	RLN8	RLN9	RLN10
			2022		2023		2024			2025		
1.	Total width of nest (rim to rim across gravel)	CR	37.2	34.8	38.1	34.9	36.8	35.1	34.9	40.0	35.3	37.6
2.	Circumference of nest (outer rim, circular)	AB	66.8	66.2	65.9	66.7	67.0	66.1	66.6	66.5	65.8	66.9
3.	Height of nest rim above surrounding gravel	FE	5.4	4.9	4.6	5.2	4.7	5.0	4.9	5.0	5.1	5.1
4.	Width of outer stony rim (gravel-pebble zone)	BR	12.2	8.0	8.1	8.3	9.2	8.5	8.5	9.1	4.9	3.1
5.	Maximum width of gravel-stone rim	MB	7.0	6.9	7.2	7.1	7.0	7.3	6.8	7.2	7.1	6.9
6.	Slope from rim to nest cup (gravel gradient)	KL	4.7	3.5	4.5	4.6	4.5	4.7	4.5	4.6	4.7	4.5
7.	Minimum depth of nest cup (shallowest excavated point)	LI	2.2	2.1	2.3	2.0	2.1	2.3	2.2	2.3	2.1	2.3
8.	Maximum depth of nest cup (deepest part of excavation)	NH	2.6	2.5	2.7	2.4	2.5	2.7	2.9	2.8	2.6	3.1
9.	Width of central excavated cup (egg-holding depression)	KM	11.4	9.0	11.0	11.2	11.0	11.4	11.0	11.2	11.4	11.0
10.	Height of natural stone used as camouflage/hide	PQ	13.9	11.3	13.6	12.9	12.8	13.8	10.3	13.7	13.3	14.6
11.	Nearby vegetation height	-	20.3	2.0	9.5	7.3	1.0	9.0	1.0	9.3	1.0	10.2
12.	Clutch size /No. of Eggs	-	02	01	02	02	03	02	03	04	04	03

*RLN- River Lapwing Nest, * Abbreviation (Ref. Fig. 1) River Lapwing (*V. duvaucelii*) Nests (RLN1-RLN10) Recorded During 2022-2025.

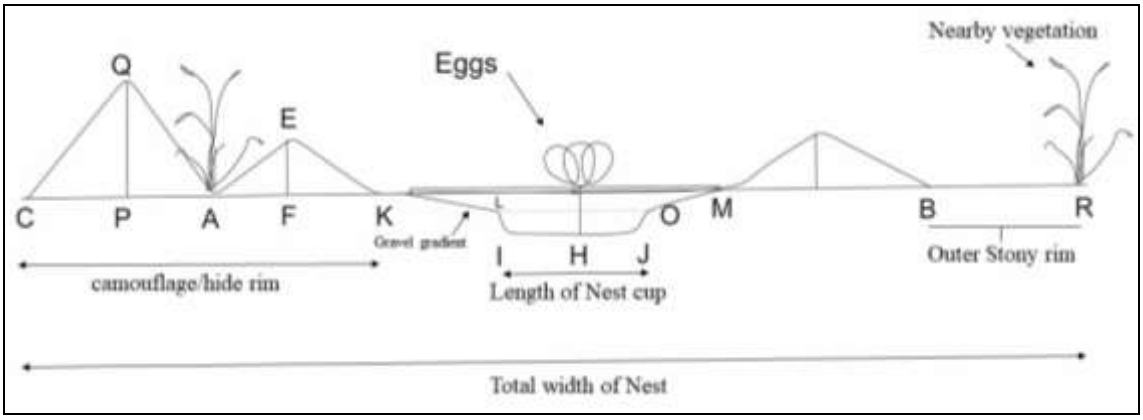


Fig 1: Vertical Section of Nests structure of River Lapwing (*V. duvaucelii*) in Tapi River Basin, Melghat.

Table 2: Measurement of Habitat Variables Around River Lapwing Nests Across Three Breeding Seasons (2022-2025).

S. no.	Nest Habitat Variables	Measurement/Range in meter									
		RLN1	RLN2	RLN3	RLN4	RLN5	RLN6	RLN7	RLN8	RLN9	RLN10
		2022		2023		2024			2025		
1	Distance from River Bank	39.04	60.32	106.6	38.07	63.78	23.03	59.30	38.12	38.64	21.69
2	Distance from Human Settlement	2355.67	1295.11	757.94	749.54	790.42	592.29	740.13	484.3	2088.9	2066.51
3	Distance from River Water	5.6	18.91	17.05	8.16	15.20	18.34	19.64	19.67	19.89	16.44
4	Distance from nearest RLN	295.4	301.7	287.2	310.8	298.6	300.0	302.4	297.1	306.10	302.89
5	Nest Site River Width	179.28	194.23	255.1	178.91	193.6	180.3	169.2	130.72	205.84	173.16
6	Nest Site Pebbles Pattern	Moderate	Dense	Dense	Moderate	Dense	Dense	Dense	Dense	Dense	Sparse

*RLN- River Lapwing Nest

Table 3: Summary of Predation Events, Suspected Predators, and Nest Success of River Lapwing.

Year	Nest ID	Study Site/River	No. of Eggs	Eggs Lost	No. of Chicks	Predation Signs	Suspected Predator	Day/Night	Outcome
2022	RLN1	Tapi river	02	01	01	None	—	—	Successful
	RLN2	Khapra-Tapi Confluence	01	01	00	Feral dog	Feral dog	Day	Nest failed
2023	RLN3	Tapi river	02	02	00	Eggs missing	Human disturbance	Day	Nest failed
	RLN4	Tapi river	02	00	00	Flooding	—	Night	Nest failed
2024	RLN5	Tapi river	03	02	01	None	—	—	Successful
	RLN6	Sipna- Tapi Confluence	02	02	00	Eggs missing	Human disturbance	Night	Nest failed
	RLN7	Tapi river	04	00	00	Partial shell	Crow	Day	Nest failed
2025	RLN8	Tapi river	04	04	00	Eggs missing	Feral dog	Day	Nest failed
	RLN9	Tapi river	03	02	01	None	—	—	Successful
	RLN10	Tapi river	03	02	00	Feathers	Raptor	Day	Nest failed

Table 4: Frequency of Predators and Disturbance Factors as Threat for River Lapwing Nests Success Across Study Sites.

Disturbance Factor	Mean	± SD	Min	Max	Range	CV (%)
Crows/Raptors	13.6	3.73	10	25	15	27.43
Feral Dogs	14.1	0.88	13	15	2	6.24
Snakes	0.4	0.67	0	2	2	167.5
Jackals	7.8	1.86	1	8	7	23.85
Human Activity	9.1	2.06	5	12	7	22.64
Flooding	0.8	2.53	0	8	8	316.25
Trampling by Livestock	13.3	1.25	11	15	4	9.40

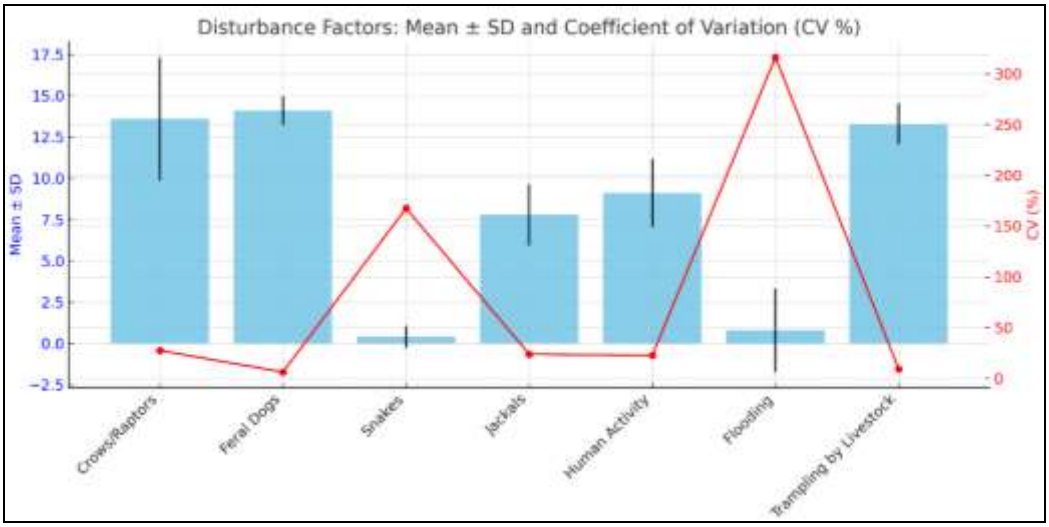
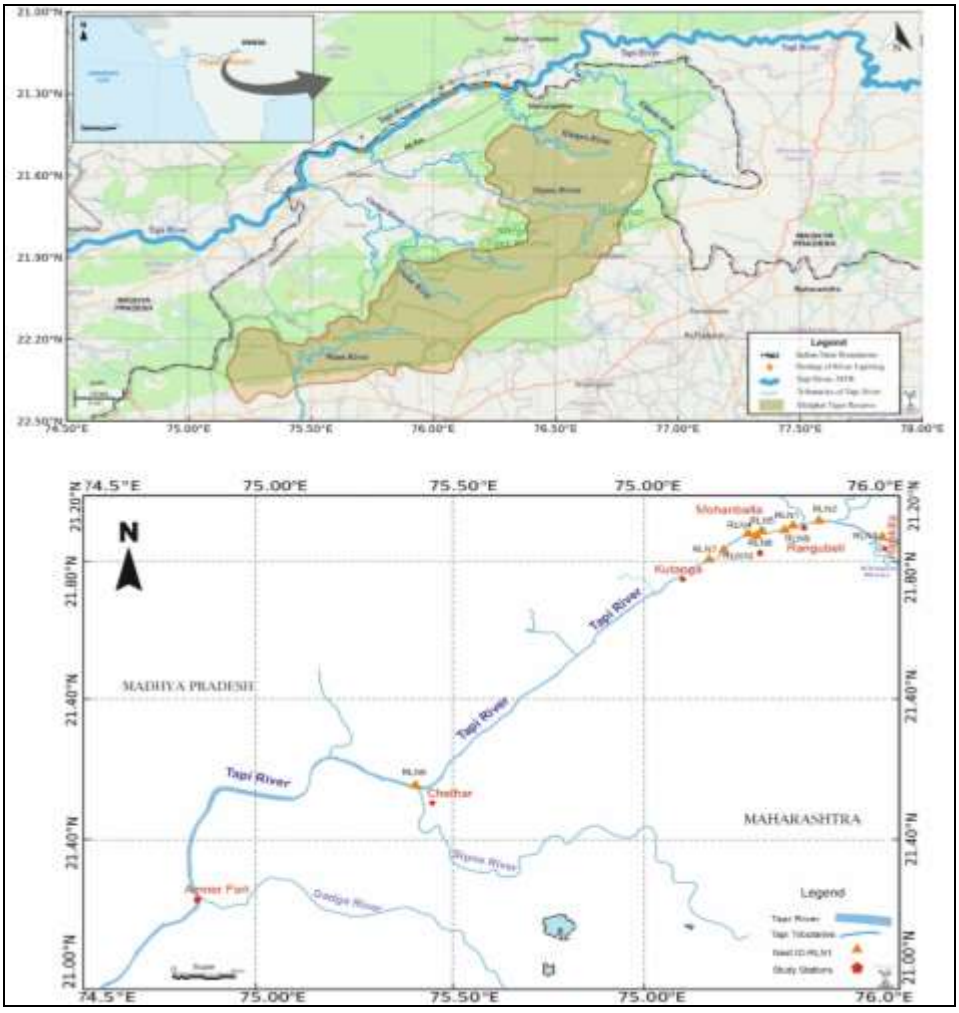


Fig 2: Mean disturbance levels (± Standard Deviation) and Coefficient of Variation (CV%) for different disturbance factors affecting nest sites (RLN1-RLN10).



Map 1: Map showing nesting sites of the River Lapwing (*V. duvaucelii*) along the Tapi River at the study area (Melghat).

Photoplate 1: River Lapwing in its breeding habitat showing alertness at the nesting site.

Photoplate 2: Images (A-D), showing various positions of the River Lapwing during incubation at the nest site.

Photoplate 3: Nests of River Lapwing (V. duvaucelii) (RLN1-10), in Upper Tapi River basin, Melghat, showing clutch size and nest ecology.

Photoplate 4: Images showing sub-adult stages of River Lapwing at the study sites.

Photoplate 5: Various predators and disturbances documented near River Lapwing nesting sites. a-1, a-ii. A feral dog prowling near nesting territory; b-1. A raptor; b-2. Jungle Crow (Large-billed), observed inspecting the nesting zone; c-1. Golden jackal on a crepuscular patrol near nesting grounds; d-1, d-2. Trampling by cattle. e-i. A villager attempting to locate eggs, f-1. A snake movement near an active nest and defensive postures are shown by the River Lapwing and the Red-wattled Lapwing.

Discussion

This study to present information on breeding ecology such as nest characteristics, clutch size, threats and as well as factors that are responsible for egg failure of River Lapwing, while (Claassen *et al*. 2017) [55] reported reproductive success in Cambodia and (Ahmed *et al*. 2018) [1] documented nesting ecology in Bangladesh, (Mishra *et al*. 2020) [56] observed nest distribution across four habitat types. Nests were predominantly concentrated in open unvegetated riverbanks and river islands. Furthermore, more than 90% of nests were

found in colonies, mostly in medium-sized colonies (2–3 nests) whereas others were solitary. This pattern of nesting was reported in northern lapwing (Seymour *et al*. 2003) [57].

Lapwings are ground-nesting plovers that usually breed close to river water at, or close to, flooded fields (Berg *et al*. 1992) [58]. River banks along with other microhabitats, particularly near water, hold varied and abundant prey for River Lapwings (Kumar *et al*. 2018) [35], which are supposed to be important dietary requirements for lapwings during the breeding season. Yamazaki *et al*. (2001) [59] documented a similar scenario in Gray-headed lapwing *Vanellus cinereus*. In the present study, the mean distance of nest to water was 15.89 m, whereas the mean distance of the nearest nest was 300 m. However, Ahmed *et al*. (2018) [1] also observed similar results of a mean distance of nearest neighbouring nest, while the nest to water was slightly higher than that in our study, this happens due to river width variation.

The breeding season of River Lapwing starts in March and lasts until June, with a peak in May. Moreover, nest initiation occurred in the middle of March, with a peak in April. However, Claassen *et al*. (2017) [55] observed nest initiation in February. Incubation in River Lapwing starts just before the last egg has been laid and lasts 28-32 days, with a median of 28 days. Furthermore, the incubation period declined as the breeding season progressed, probably due to increasing temperature and nest attendance by birds. Hatching may be achieved in a period of hours, usually 6–8 h, or it may take several days, depending on egg laying order and clutch size; for example, a clutch of 2 eggs takes a short time to hatch compared to a 4-egg clutch that is seen in our study that nest with 2-3 egg hatch successfully. It is interesting to note that hatching mostly took place during early morning times, sometimes in the evening, and never during the hot midday times to avoid heat stress (Photoplate 2).

Lapwing eggs have a shape that is typical of those laid by plovers, being pear-shaped with olive yellow or dusky brown colour, which perfectly camouflages the surroundings and provides defence against predators (Col well *et al*. 2011) [16]. They have a variable number of black blotches and spots, often heavier towards the broad end, and their shade and marking camouflage them well under the background surface. The clutch size of most vanellidae is 3-4 eggs (Wiersma and Kirwan 2016) [60], and the results of the present study confirm that the same applies to River Lapwing. The clutch sizes recorded with a mean of 2.66±0.90, ranging from 1 to 4 eggs, were slightly higher than those found in Cambodia (3.20±0.48, range = 2-6) by Claassen (2004) [13]. Clutch size increased marginally from nests initiated early to nests initiated mid-season but then declined for nests initiated late. The smaller clutch size during both early and late laying periods may be due to reduced food availability during the early laying period, whereas late in the laying season, it may be due to engagement in incubation by adults (Perrins 1966).

River Lapwings are usually calm until egg laying, but become aggressive as incubation starts until the hatchling stage. They are largely seen in medium-sized colonies and prefer nesting in larger open habitat areas, particularly bare pebble ground of the riverbank, to minimize predation risk. Similar nest site selection was observed by (Claassen *et al*. 2017) [55]. Most wader species nest in open areas with little or no vegetation, relying on the cryptic coloration of eggs and chicks to avoid predators (Martin, 1998). Moreover, the rate of predation decreases when birds nest on open sandy riverbanks with short or no vegetation, as they are easily able to detect approaching predators and thus guard their nests more efficiently (Galbraith 1988a; Berg *et al*. 1992) [61, 58]. Similar result in this study observed that stages of *V. duvaucelii* chick development during the breeding season include: an early-stage juvenile with a forming beak exhibiting instinctive crouch-run behaviour for camouflage; a chick hiding beneath a wild brinjal (eggplant), utilizing natural vegetation for concealment from predators; and a ~25-day-old chick with well-developed plumage, showing increased mobility and early signs of independence (Photoplate 4).

The River Lapwing begins its nest construction with careful site selection. The nest microstructure of *V. duvaucelii* is formed from three main parts; 1. Nest shallow cup at the center (IJ), 2. slope around the shallow nest cup (KL) and 3. Outer camouflage/hide stony rim (CK). The pair typically chooses a bare patch of gravel or stony rim located on open riverbanks. These sites offer good visibility, are close to water, and have minimal vegetation, which allows birds to easily detect approaching predators. Once a suitable location is chosen, the nest cup is a central depression in the ground, which is achieved by one or both birds shuffling their breast and body against the surface and scraping with their feet while rotating in a circle (IJ). The resulting depression is usually 10 to 15 cm wide and 1 to 3 cm deep, depending on the nature of the terrain. In some cases, birds may line the nest with small stones, bits of dry leaves and grass, although this is not always the case. The decision to line a nest often depends on the availability of materials or the need for additional camouflage. It is very difficult to locate the nest of this lapwing, and it requires careful observation on the ground by slow walking. During the nesting period, the chance of getting the nest is high in the area where the RL is frequently found on the ground. Care was taken not to disturb the position of the laid eggs and nesting material. It was difficult to distinguish the male from the female of this lapwing species, but both parents constructed the nest and were involved in the incubation of eggs laid in the nest.

The results showed that feral dogs and crows were predators of River Lapwing nests. Moreover, predation by nests was also observed because of unknown predators. Our study suggests that snakes are relatively infrequent predators in the nests of River Lapwings. A similar result was reported by (Seymour *et al*. 2003) [57]. The results of field observations have suggested that nests were lost due to the application of pesticides or herbicides, and the use of these chemicals is increasing due to intensification of agricultural practices in the study area in 2022 and 2023. Changes in agricultural practices, such as the increased use of insecticides and herbicides, may decrease the insect food supply available to breeding birds, leading to an increased incidence of chick malnourishment and nest abandonment (Potts GR, 1986). River Lapwings faced the risk of nest damage due to trampling by domestic animals, that is, buffaloes and cows in our study. (Claassen *et al*. 2018) [14] also documented trampling of River Lapwing nests by domestic water buffaloes in Cambodia.

Based on our field study, we suggest that the Upper Tapi River Basin, Melghat is an important breeding site for River Lapwing. Currently, these sites are mostly unprotected by the Madhya Pradesh site as it share a boundary. We strongly propose that the Tapi River is very important to the globally declining River Lapwing and should be given a protected

status, such as riverine protected area designation. It has been observed that the presence of livestock roaming all day deters lapwings from settling on the ground for nesting; therefore, we recommend the exclusion of livestock from some areas as a viable option. Removal or redistribution of existing trees or other perches away from important breeding sites may reduce predation risk, particularly from avian predators such as crows and raptors. Habitat destruction due to intensification of land use for farming activities in riverbanks increases the risk of threats due to changes in the density of the breeding birds or predators or the amount of cover where nests or chicks can be concealed. Furthermore, breeding birds have to spend more time aging, leaving the nest unattended for longer periods.

Based on our field observations along the Tapi River, it is evident that predation remains a significant threat to the nesting success of River Lapwing. While the direct removal of predators from breeding sites might seem like a straightforward solution, it is unlikely to provide long-term effectiveness. Instead, we recommend exploring landscape scale management approaches, such as modifying land use patterns around key nesting habitats to reduce predator access and disturbance. For example, limiting human activities, livestock grazing, and vegetation encroachment in known nesting zones could help create safer breeding conditions. Therefore, further research into the relationships between habitat quality, behaviour and predation is needed. Such insights will be crucial for developing more targeted and sustainable conservation strategies for River Lapwing populations along the Tapi River in the study area.

Conclusion

This study highlights the critical breeding ecology of the River Lapwing (*Vanellus duvaucelii*) along the Tapi River from 2022 to 2025, showing the importance of the species preference for open, gravel rich riverbanks near flowing river water. Despite some successful hatching events, overall nesting success was low due to frequent and consistent threats. Key threats to nesting success included predation by feral dogs, crows, raptors, jackal and snake. Eggs damage by trampling and human activities and natural factors such as unusual rain and flooding. These findings underscore the urgent need for targeted, site-specific conservation strategies, including habitat protection by limiting farming practices, livestock exclusion, and predator deterrence, to safeguard these vulnerable nesting grounds for globally “Near-threatened” River Lapwing. Designating parts of the Upper Tapi River Basin as a riverine protected area could be a vital step in securing the future of River Lapwing populations in the region.

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Author Contribution

Pratik Chaudhari (performed field survey, data collection and Photography, statistical analysis, writing and interpretation), Dr. Gajanan Wagh (conceptualization, interpretation, and planning research and editorial suggestion).

Conflict of Interest

The author declares that there is no Conflict of Interest.

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