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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
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Cover: A mesmerising Indian Luna moth *Actias selene* is dancing through the starry night (by Vincent van Gogh) moonlit sky, displaying its ballistic display of feather tail. Digital artwork by Vyshnavee Sneha Jaijar.

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COMMUNICATION

Distribution, habitat use and conservation status of Smooth-coated Otter *Lutrogale perspicillata* along the Cauvery and Kabini rivers, Karnataka, India

Allison Amavisca [1], Raghunath Belur [2] & Sugandhi Gadadhar [3]

[1] Royal Zoological Society of Scotland, 34 Corstorphine Road, Edinburgh, EH12 6TS, United Kingdom.
[2,3] Aranya Parva Creations, G304, Adarsh Palace Apartments, 47th Cross, 5th Block Jayanagar, Bangalore, Karnataka 560041, India.
[1] marinebioally@gmail.com, [2] ranabelur@gmail.com, [3] sugandhi.g@gmail.com (corresponding author)

Abstract: We documented the distribution and habitat use of the Smooth-coated Otter *Lutrogale perspicillata* along the Cauvery and Kabini rivers in Karnataka, India. In November–December 2024, we conducted systematic surveys covering approximately 80–100 km of each river using trained volunteer teams. Data collection included direct sightings and indirect signs (spraints, tracks, and holts). The Cauvery survey yielded 68 observations, including 21 direct sightings totalling 76 individual otters (mean group size = 3.3). The Kabini survey documented 42 observations, including 12 direct sightings totalling 39 individuals (mean group size = 2.8). Statistical analyses revealed no significant difference in otter presence between areas with and without fishing activity (p = 0.428), challenging prior assumptions about human-otter conflict. Areas with multiple human activities maintained substantial otter presence, with 44.4% of holts found in areas with three different types of human activity.

Keywords: Citizen science, conflict mitigation, dynamite fishing, freshwater ecosystem, habitat assessment, human-wildlife interactions, otter adaptability, river conservation, sand mining, volunteer surveys.

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Funding: National Geographic Society Explorer-Educator Exchange; Zooreach Conservation Seed Grant (24ZCSG01F).

Author details: Ally Amavisca is a community programmes leader and conservation educator with over a decade of experience in wildlife conservation and environmental education. Recently, Community & Discovery Programmes Manager at the Royal Zoological Society of Scotland, she specialises in community engagement, impact measurement, and inclusive conservation programmes connecting frontline communities with nature. Raghunath Belur is a freelance wildlife cinematographer and a founding partner at Aranya Parva Creations, India. He is a member of the IUCN Otter Specialist Group. Sugandhi Gadadhar is a National Geographic Explorer. She is a wildlife filmmaker and a founding partner at Aranya Parva Creations, India. Her focus is on films related to wildlife and conservation. She is a member of the IUCN Otter Specialist Group.

Author contributions: Conceptualisation: Sugandhi Gadadhar, Raghunath Belur, Allison Amavisca. Methodology, analyses, validation and writing: Allison Amavisca. Supervision and project administration: Raghunath Belur, Sugandhi Gadadhar

Competing interests: The authors declare no competing interests.

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INTRODUCTION

The Smooth-coated Otter *Lutrogale perspicillata* is one of 13 otter species worldwide and among three found in India (Reuther 1999). Listed as 'Vulnerable' on the IUCN Red List (Khoo et al. 2021) and a Schedule 1 species in the Wildlife (Protection) Amendment Act (2022) due to an observed population decline of up to 30% across its range, the species faces multiple anthropogenic threats. In India, *L. perspicillata* occurs in all major river systems south of the Himalaya, where it serves as an apex predator in freshwater ecosystems (Hussain & Choudhury 1997).

The Cauvery River and its tributary, the Kabini, represent critical habitat for *L. perspicillata* in southern India (Image 1). Whilst several studies have documented otter populations within the Cauvery Wildlife Sanctuary (Shenoy et al. 2006; Khan et al. 2009), no systematic surveys have been conducted along the Kabini River. The human-wildlife interaction poses a significant threat to otter populations in this region, with declining fish stocks due to pollution, sand mining, and unsustainable fishing practices intensifying negative interactions between otters and fishing communities (Meena 2002; Anoop & Hussain 2004).

METHODS

Study Area

The surveys covered the Cauvery River from downstream of Srirangapatna Town to Sathegala Bridge and the Kabini River from Kabini Dam to T. Narsipura (Image 1). Both rivers flow through agricultural landscapes and human settlements outside protected areas. The climate is semi-arid with average temperatures above 25°C and annual rainfall of 60–100 cm (Jayaram 2000). Riparian vegetation includes *Terminalia arjuna* and *Salix tetrasperma*, with varying levels of human activity such as fishing, sand mining, and recreation. Representative habitat types from both rivers are shown in Image 2.

Data Collection

Surveys were conducted between November–December 2024 using methodology adapted from Hussain & Choudhury (1997), and Anoop & Hussain (2004). We divided the rivers into 1-km segments for walking and boat-based (coracle) surveys. Following standardised protocols (Reuther et al. 2000), observations included:

- direct sightings (location, group size, & behaviour),
- indirect signs (spraints, tracks, & holts),
- habitat characteristics (substrate type, vegetation cover, & water quality), and
- human activities (fishing, sand mining, & recreation)

Habitat assessments were conducted at accessible locations, recording substrate composition, vegetation cover, distance to water, and human activity signs following methods established by Mason & Macdonald (1986). Examples of otter sign documentation methods are shown in Image 3.

Statistical Analysis

All analyses were performed using Python (version 3.8). We used independent t-tests to compare otter presence between areas with and without fishing activity. ANOVA tests evaluated the impact of multiple human activities, while chi-square tests examined relationships between human activities and various otter signs (Zar 1999).

RESULTS

Survey Overview

The Cauvery River survey yielded 68 total observations across approximately 75 km of river length. This included 21 direct sightings totalling 76 individual otters, with a mean group size of 3.3 (± 1.2 SD) otters. We documented 30 instances of otter prints, 20 spraint sites, and 13 tail marking locations (Table 1). Additionally, we identified 16 potential holt sites along this stretch.

The Kabini River survey covered approximately 85 km and produced 42 total observations. This included 12 direct sightings totalling 39 individual otters, with a mean group size of 2.8 (± 0.9 SD). We recorded 33 instances of prints, 24 spraint sites, and 10 tail markings (Table 1). Twelve potential holt sites were identified along this stretch.

While the Cauvery survey documented higher overall abundance compared to Kabini (Table 2), this difference was not statistically significant ($t = -0.796$, $p = 0.428$), suggesting that despite varying levels of human activity between the two rivers, otter populations appear to persist at similar densities.

Human-Otter Interactions

Statistical analyses revealed no significant difference in otter presence between areas with and without fishing activity ($t = -0.796$, $p = 0.428$; Table 2). The

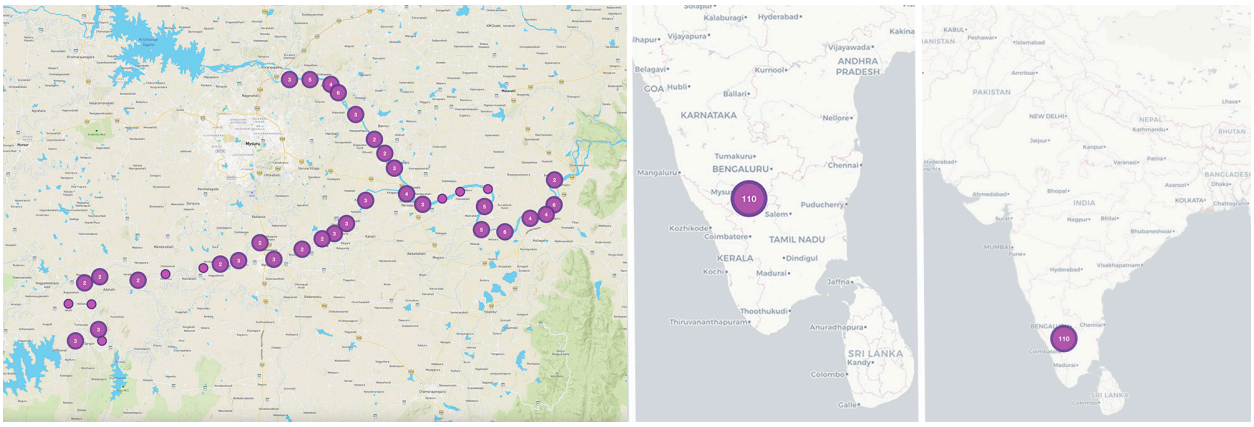

Image 1. The study area locations within Karnataka, India.

Image 2. Representative habitat types from both rivers: top left—Cauvery River showing typical sandy/rocky substrate and vegetation | top right—Kabini River showing characteristic riparian habitat. © Shreehari N (top left) | Sugandhi Gadadhar (top right) | Darshini MB (bottom left) | Raghunath Belur (bottom right).

pattern varied between rivers. In the Cauvery River, areas without fishing activity showed slightly higher mean otter sightings (1.42 ± 2.51 SD) compared to areas with fishing (0.60 ± 1.32 SD). Conversely, in the Kabini, areas with fishing activity showed higher mean otter sightings (1.20 ± 2.09 SD) compared to areas without (0.68 ± 1.64 SD) (Table 3, Figure 1).

Habitat Use

We recorded distinctive patterns in habitat selection across both river systems (Table 4). Riparian vegetation areas accounted for 51.8% of all otter signs, followed by

Image 3. Examples of otter sign documentation: a—Spraint site | b—Student volunteers collecting data | c—Tail markings | d—Typical holt entrance | e—Otter pug marks. © a, c, e—Raghunath Belur | b—Renu Priyadarshani M | d—Athira A Sajan.

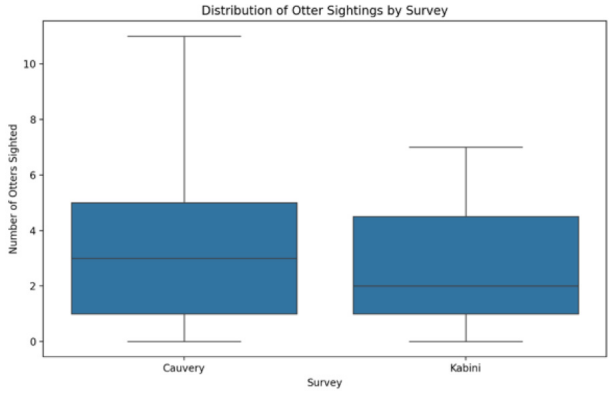

Figure 1A. Distribution of otter sightings by river.

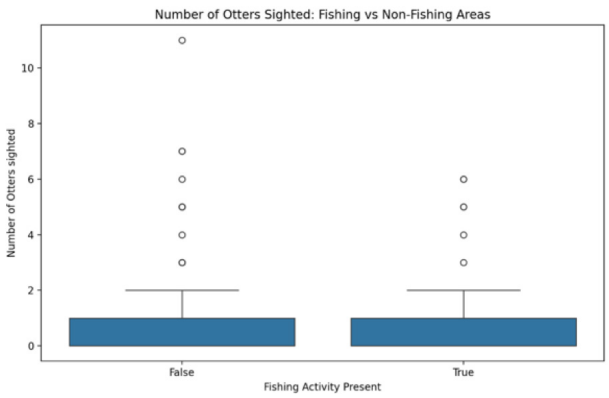

Figure 1B. Comparison of otter sightings in areas with/without fishing activity.

sandy banks (39.3%) and water/pool areas (27.7%). Holts were primarily constructed in loose sand ($\chi^2 = 12.4$, $p < 0.001$) with thick vegetation cover (mean canopy cover 76.3% ± 12.5 SD). The distribution of otter evidence varied with human activity levels, as shown in Image 4. Breeding populations were confirmed in both river systems through observations of pups and family groups. Mean group sizes were 3.3 (± 1.2 SD) for Cauvery and 2.8 (± 0.9 SD) for Kabini, comparable to those reported in other studies (Hussain & Choudhury 1997; Anoop & Hussain 2004).

DISCUSSION

Otter Distribution and Adaptability

Our findings challenge common assumptions about otter avoidance of human-modified landscapes. The lack of a significant correlation between human activities and otter presence ($p > 0.05$; Table 2) suggests that *L. perspicillata* may be more adaptable to anthropogenic disturbance than previously documented (Hussain & Choudhury 1997; Anoop & Hussain 2004). Several key observations from our surveys evidence this adaptability:

First, the presence of active den sites in areas with multiple human activities (44.4% of dens found in areas with three different types of human activity) indicates that otters are not completely avoiding high-disturbance

Table 1. Summary statistics for both rivers showing: Number of observations | Direct sightings | Indirect signs | Mean group sizes | Survey effort.

Cauvery River	Number of Otters sighted	Number of print instances	Number of spraint instances	Number of tail mark instances
Sample Size	76.0	30.0	20.0	11.0
Mean	1.118	1.867	1.381	1.154
Median	0.0	1.5	1.0	1.0
Mode	0.0	1.0	1.0	1.0
Std Dev	2.159	1.024	0.898	0.769
Min	0.0	1.0	0.0	0.0
Max	11.0	4.0	4.0	3.0
95% CI Lower	0.591	1.478	0.962	0.67
95% CI Upper	1.644	2.256	1.8	1.638
Kabini River	**Number of Otters sighted**	**Number of print instances**	**Number of spraint instances**	**Number of tail mark instances**
Sample Size	39.0	13.0	14.0	6.0
Mean	0.929	2.062	1.412	1.111
Median	0.0	1.5	1.0	1.0
Mode	0.0	1.0	1.0	1.0
Std Dev	1.844	1.853	1.191	1.1
Min	0.0	0.0	0.0	0.0
Max	7.0	6.0	4.0	3.0
95% CI Lower	0.347	1.043	0.781	0.214
95% CI Upper	1.51	3.082	2.043	2.008
Total Survey	**Number of Otters sighted**	**Number of print instances**	**Number of spraint instances**	**Number of tail mark instances**
Sample Size	115.0	43.0	34.0	17.0
Mean	1.045	1.935	1.395	1.136
Median	0.0	1.5	1.0	1.0
Mode	0.0	1.0	1.0	1.0
Std Dev	2.047	1.374	1.04	0.919
Min	0.0	0.0	0.0	0.0
Max	11.0	6.0	4.0	3.0
95% CI Lower	0.657	1.522	1.048	0.719
95% CI Upper	1.434	2.347	1.741	0.554

Table 2. Statistical comparison between areas with and without human activity.

	Mean (Human Activity)	Mean (No Activity)	Sample Size (Human Activity)	Sample Size (No Activity)	t-statistic	p-value	Cohen's d	Chi-square	df
Number of Otters sighted	1.164383562	0.810810811	73	37	0.851068861	0.396614152	0.173189299	1.448414599	1
Number of prints	1.931034483	1.941176471	29	17	-0.02363883	0.98124758	-0.007379626	0.037784729	1
Number of spraints	1.391304348	1.4	23	15	-0.02452817	0.980566774	-0.008371945	0.282092752	1
Number of tail marks	1.230769231	1	13	9	0.556234201	0.584221084	0.251557647	0.175558181	1

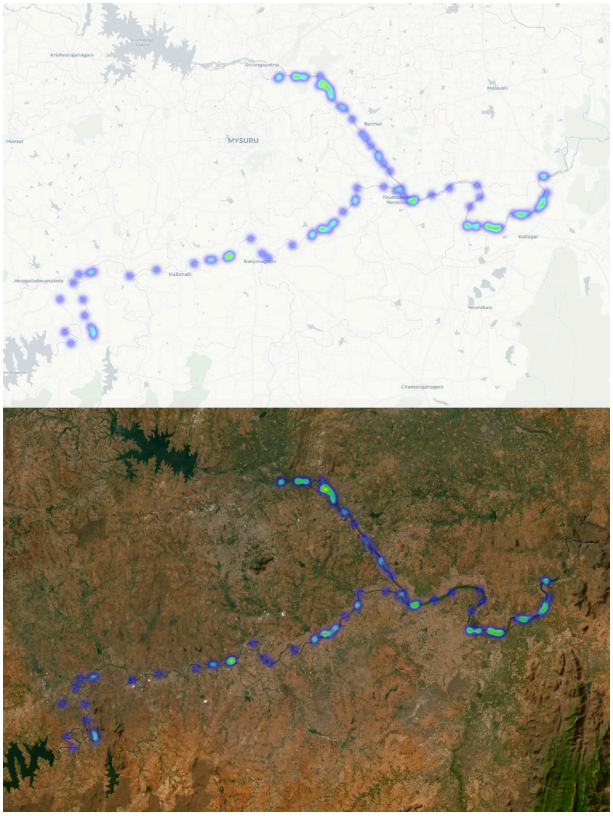

Image 4. Heat maps showing percentage of sites with different types of otter evidence and number of human activities present.

zones. Rather than abandoning these areas, otters appear to modify their behaviour, potentially becoming more nocturnal or adjusting their activity patterns to minimize direct contact with humans. Our findings align more closely with recent work suggesting behavioural adaptation to human presence (Anoop & Hussain 2004; Khan et al. 2009).

Second, while areas without fishing showed slightly higher mean otter sightings (1.17 compared to 0.87 in fishing areas), this difference was not statistically significant. This suggests that otters can maintain viable populations even in areas with regular fishing activity, contrary to previous assumptions about fishing-otter conflict driving local extinctions.

Third, the documentation of successful breeding, evidenced by observations of pups and family groups in both river systems, indicates that these populations are not just persisting but reproducing in human-modified landscapes. The mean group sizes observed (3.3 in Cauvery and 2.8 in Kabini) are comparable to those reported in less disturbed habitats, suggesting that human activity is not significantly impacting social structure or reproductive success.

Table 3. Comparison of otter presence in fishing vs non-fishing areas by river.

	mean	count	std	
Cauvery fishing absent	1.42	43	2.51	T-statistic: -1.7595779613762803 P-value: 0.0831459021468832
Cauvery fishing present	0.6	25	1.32	
Kabini fishing absent	0.68	22	1.64	T-statistic: 0.886289848030455 P-value: 0.3813371725366115
Kabini fishing present	1.2	20	2.09	

This adaptability to human presence has important implications for conservation strategies, suggesting that management efforts should focus on reducing direct threats (such as snares and dynamite fishing) rather than attempting to completely separate otter, and human activities. This apparent tolerance of human presence should not be interpreted as resilience to all forms of disturbance, as significant threats from habitat modification, particularly sand mining, and river bank alterations, continue to impact these populations.

Human-Wildlife Interaction

To address ongoing negative interactions between fishing communities and otters, we convened a workshop in November 2024, bringing together experts on species and human-wildlife interaction specialists. Participants included representatives from the IUCN Otter Specialist Group, Royal Zoological Society of Scotland (RZSS), Institute for Wildlife Conservation (ICAS), Budongo Conservation Field Station (BCFS), and several Indian research institutions. The workshop findings, when combined with our survey data, reveal important insights for conservation planning.

Our statistical analyses found no significant correlation between fishing activities and otter presence ($p = 0.428$; Table 2), challenging common assumptions about human-wildlife negative interactions in these systems. This aligns with workshop discussions that identified broader ecosystem threats rather than direct human-otter competition as key conservation challenges. While fishermen often perceive otters as a significant threat to their livelihood (Trivedi & Variya 2023), our data suggests a more complex reality. This aligns with workshop discussions that identified broader ecosystem threats rather than direct human-otter competition as key conservation challenges (Figure 2).

The workshop identified five interconnected areas for mitigation (Image 5):

Improvements to fishing technology and practices: Our survey documented the widespread use of

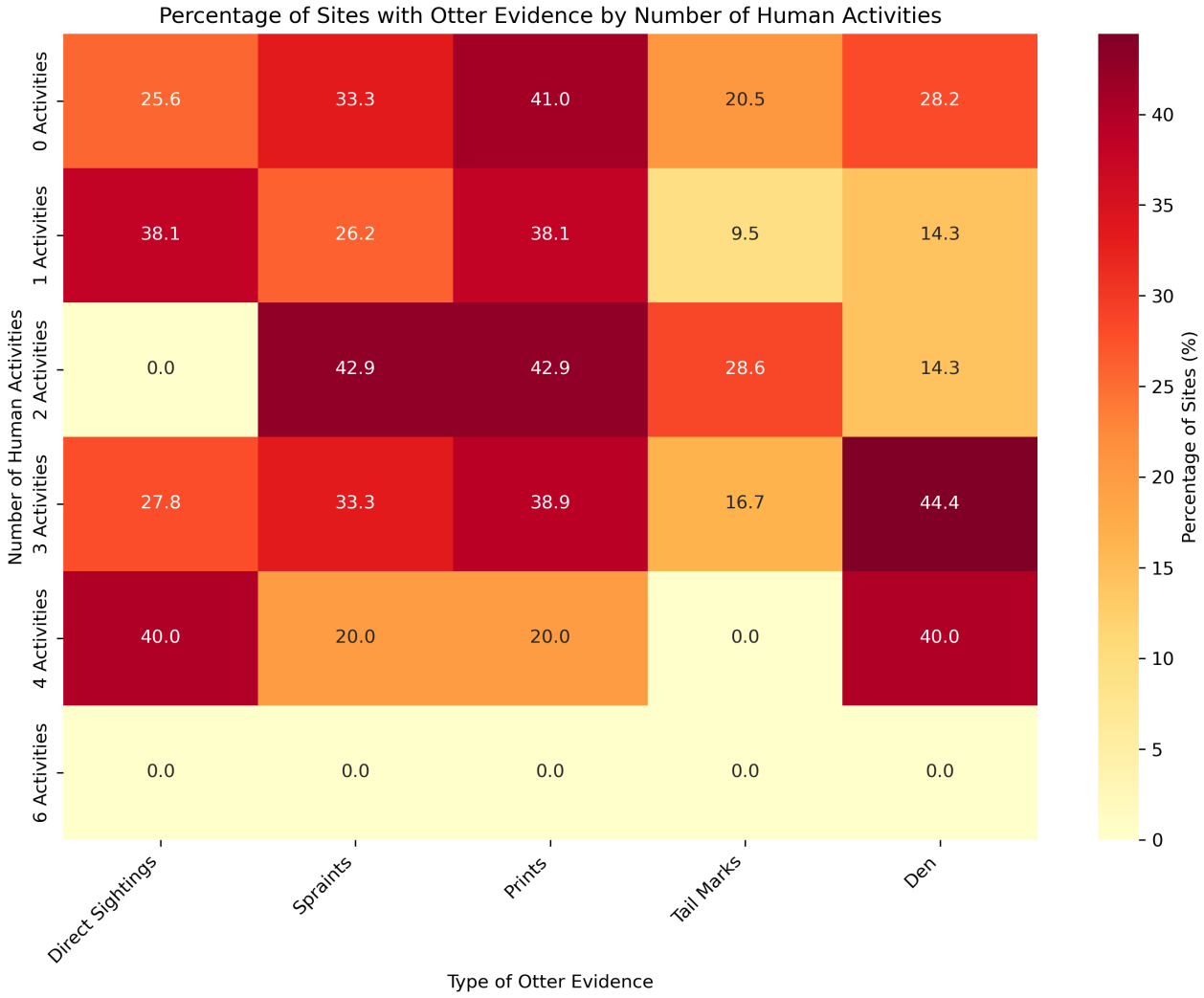

Figure 2. Conceptual model showing relationship between human activity types and otter presence.

Table 4. Habitat characteristics at otter presence sites vs random sites: Substrate composition | Vegetation cover | Distance to water.

Habitat Type	Total Sites	Sites with Direct Sightings	Sites with Spraints	Sites with Prints	Sites with Tail Marks	Total Sites Percentage	Sites with Direct Sightings Percentage	Sites with Spraints Percentage	Sites with Prints Percentage	Sites with Tail Marks Percentage
riparian vegetation	58	58	16	24	7	51.8	51.8	14.3	21.4	6.2
sandy bank	44	44	20	26	17	39.3	39.3	17.9	23.2	15.2
water/ pool	31	31	7	5	2	27.7	27.7	6.2	4.5	1.8
human settlement area	12	12	4	7	3	10.7	10.7	3.6	6.2	2.7
rocky area	12	12	7	1	0	10.7	10.7	6.2	0.9	0
other	5	5	2	2	1	4.5	4.5	1.8	1.8	0.9

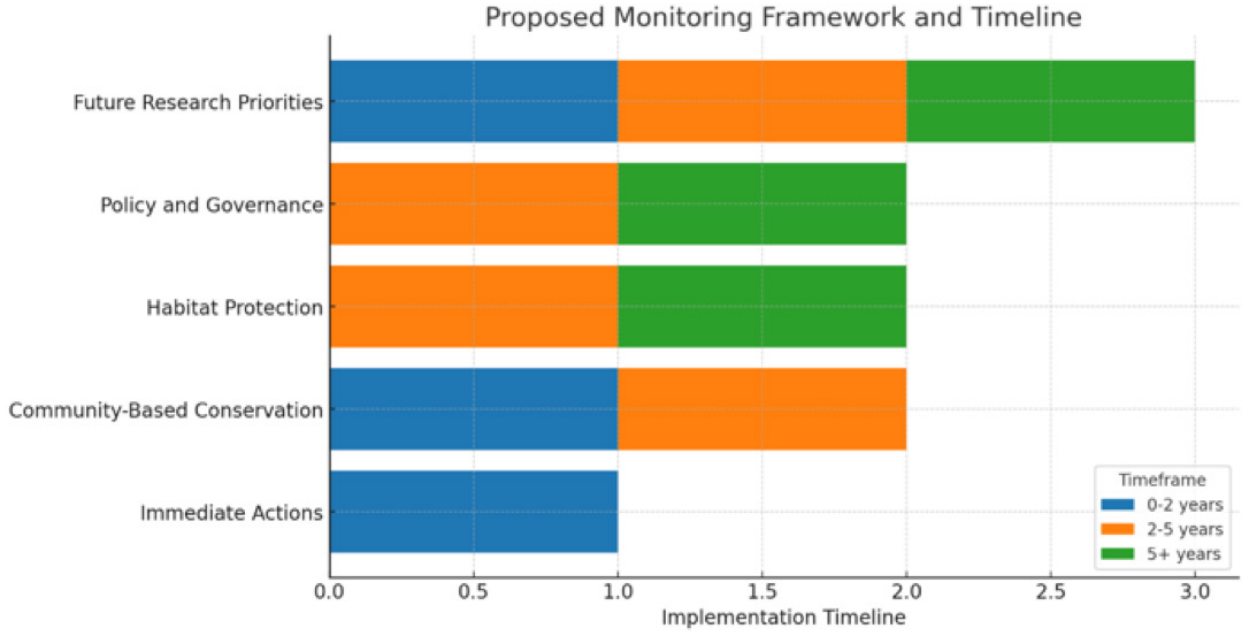

Figure 3. Proposed monitoring framework and timeline.

traditional fishing nets which are vulnerable to otter damage. Workshop participants proposed testing acoustic deterrents and stronger nets – solutions that could be particularly relevant along the Cauvery River where we recorded higher instances of human-otter negative interactions than the Kabini River.

- Legal/legislative changes: Survey data revealed ongoing sand mining and dynamite fishing, particularly along the Cauvery. Workshop participants emphasized the need for stronger inter-state regulations, as rivers often form state boundaries, complicating enforcement.

- Alternative livelihoods/compensation: The finding that areas with multiple human activities still maintain otter populations (44.4% den presence in areas with three activities) suggests potential for sustainable coexistence through properly managed alternative livelihoods, like ecotourism.

- Stakeholder relationship building: Our observation that otters adapt rather than avoid human presence (mean group size 3.3 in Cauvery despite higher human activity) supports workshop recommendations for engaging fishermen as conservation allies rather than adversaries.

- Education and awareness: The successful engagement of university students in our surveys demonstrates the potential for citizen science to build local capacity and awareness. Workshop participants emphasized expanding such programs to fishing communities.

These findings collectively suggest that successful conservation of *L. perspicillata* in human-modified landscapes requires an integrated approach addressing both immediate human-wildlife negative interactions and broader ecosystem threats. Our survey results indicate otters can persist alongside human activities when properly managed, while workshop recommendations provide practical pathways for improving coexistence.

Conservation Implications

Based on our survey findings and workshop outcomes, we developed a comprehensive monitoring framework to guide future conservation efforts (Figure 3). This framework emphasizes the need for both immediate interventions and long-term strategies, with clear timelines, and responsible stakeholders identified for each action. The framework particularly highlights the importance of integrating community-based monitoring with systematic scientific surveys, allowing for adaptive management as new information becomes available. Drawing from this framework and previous research (MacDonald & Mason 1990; Hussain 1993), we recommend:

Immediate actions:

1. Addressing direct threats

- increased enforcement against dynamite fishing, which has been documented as a threat to otters in the Cauvery system (Shenoy et al. 2006),

Image 5. Mural collaboration results.

- protection of documented holt sites (n = 28 across both rivers), and
- regulation of sand mining operations.

2. Community-based conservation

- implementation of fishing gear improvements based on successful models (Khan et al. 2009),
- development of community-managed insurance schemes, and
- engagement of local fishermen in otter monitoring.

Long-term strategies:

1. Habitat protection

- preservation of dense riparian vegetation,
- protection of sandbanks used for denning, and
- maintenance of river connectivity following Hussain & Choudhury's (1997) recommendations

2. Policy and governance

- inter-state coordination for river protection,
- integration of otter conservation into river management plans, and
- implementation of evidence-based sand mining regulations.

Future research priorities building on current findings, we recommend:

- expansion of surveys to additional river systems,
- long-term monitoring of identified populations,
- assessment of genetic connectivity between populations, and
- evaluation of mitigation measure effectiveness

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