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Acoustic monitoring of bat community assemblages along riparian corridors in fragmented landscapes

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Abstract

How effectively do riparian corridors serve as movement highways for bats in landscapes carved up by agriculture and roads? This research used passive acoustic monitoring to compare bat community composition, species richness, and activity levels across three habitat types—intact riparian forest, degraded riparian strips, and fragmented upland patches—in the Hazaribag Plateau region of Jharkhand, India, from April to September 2023. Ultrasonic recorders deployed at 24 sites captured over 47,000 bat passes across six months. Species richness averaged 8.7 ± 1.8 species per site in intact riparian corridors, dropping to 5.3 ± 1.6 in degraded strips and 3.1 ± 1.2 in fragmented uplands. Vespertilionidae dominated all habitats but showed a 69% reduction in activity from intact to fragmented sites. Shannon diversity index was significantly higher in intact riparian corridors ($H' = 2.14$) than in degraded ($H' = 1.63$) or fragmented habitats ($H' = 1.07$; $p < 0.001$). These findings confirm that intact riparian corridors are disproportionately valuable for maintaining bat diversity in fragmented tropical landscapes.

Keywords: Acoustic monitoring, bat community assemblages, riparian corridors, habitat fragmentation, echolocation, species richness, Shannon diversity, ultrasonic detectors, landscape connectivity, tropical bats

Introduction

Can a narrow strip of trees along a stream make the difference between a thriving bat community and a depleted one? That's not a trivial question—bats pollinate crops, disperse seeds, and suppress insect pests, delivering ecosystem services worth billions of dollars annually ^[1]. Yet bat populations face mounting pressure from habitat loss, and fragmented landscapes force these nocturnal fliers to traverse open gaps that increase predation risk and energetic costs ^[2]. Riparian corridors—the vegetation bands flanking rivers and streams—are widely promoted as connectivity features in conservation planning, but empirical evidence for their value to bat communities in tropical Asia remains thin ^[3].

India's Chotanagpur Plateau region in Jharkhand has experienced rapid land-use conversion over the past three decades, with forest cover declining by roughly 18% between 1990 and 2020 ^[4]. Streams and rivers that once flowed through continuous forest now thread between paddy fields, mining sites, and settlements. Whether the remnant riparian vegetation along these waterways still supports diverse bat assemblages—or whether degradation has reduced them to ecological relics—has not been tested ^[5].

This research deployed passive acoustic detectors along riparian corridors and in adjacent fragmented habitats near Hazaribag, Jharkhand, to compare bat species richness, community composition, and nightly activity patterns. The objectives were to (i) quantify species richness and diversity across intact, degraded, and fragmented habitats, (ii) identify which bat families are most sensitive to corridor degradation, and (iii) assess whether riparian corridors maintain higher bat activity than surrounding upland fragments ^[6].

Study Area Description

The research was conducted in the Hazaribag Plateau region of Jharkhand, eastern India ($23^{\circ}58'N$, $85^{\circ}21'E$), at elevations between 450 and 620 m above sea level. The area experiences a subtropical monsoon climate with mean annual rainfall of 1,280 mm

concentrated between June and September. Natural vegetation is tropical dry deciduous forest dominated by *Shorea robusta*, *Terminalia* spp., and *Diospyros melanoxylon*. Twenty-four sampling sites were selected across three habitat categories: eight in intact riparian corridors (canopy cover >70%, corridor width >30 m), eight in degraded riparian strips (canopy cover 30-50%, corridor width 10-30 m, with cattle grazing and partial clearing), and eight in fragmented upland forest patches (isolated patches of 2-15 ha surrounded by agriculture). Minimum distance between any two sites was 1.5 km to reduce spatial autocorrelation.

Materials and Methods

Materials

Acoustic surveys ran from April to September 2023, covering both pre-monsoon and monsoon periods. Each site was equipped with a Wildlife Acoustics Song Meter SM4BAT-FS full-spectrum ultrasonic recorder (Wildlife Acoustics, Maynard, MA, USA) fitted with an SMM-U2 microphone mounted on a 2 m pole. Recorders were programmed to operate from 30 minutes before sunset to 30 minutes after sunrise. Each site was sampled for six consecutive nights per month over six months, yielding 36 recording nights per site and 864 recording nights in total. Recordings were stored as WAV files on 128 GB SD cards.

Methods

Call analysis used Kaleidoscope Pro 5.6 (Wildlife Acoustics) with the auto-identification module trained on a reference library of 23 Indian bat species from the

Chotanagpur region. Manual verification of a random 15% subset confirmed an auto-ID accuracy of 87.3%. A bat pass was defined as a sequence of two or more echolocation pulses from a single species within a 5-second window^[7]. Species richness was calculated as the total number of species detected per site across all sampling nights. Shannon diversity (H') and Simpson's index ($1-D$) were computed for each site. Activity was measured as mean bat passes per night per site^[8]. Differences between habitat types were tested by one-way ANOVA with Tukey post-hoc comparisons ($p < 0.05$). Non-metric multidimensional scaling (NMDS) based on Bray-Curtis dissimilarity was used to visualise community composition differences. Analyses used R version 4.3.1 with the vegan package^[9].

Biodiversity Assessment

Species accumulation curves were generated for each habitat type to evaluate sampling completeness. The Chao1 estimator indicated that observed richness captured 91.2% of estimated richness in intact riparian corridors, 88.7% in degraded strips, and 84.3% in fragmented uplands—suggesting adequate sampling effort across all habitats. Indicator species analysis (IndVal) identified species with significant fidelity to specific habitat types. *Rhinolophus lepidus* and *Hipposideros lankadiva* emerged as indicators of intact riparian habitat (IndVal > 0.65, $p < 0.01$), while *Pipistrellus coromandra* showed no habitat preference and was ubiquitous across all three types.

Results

Table 1: Bat community metrics across three habitat types in the Hazaribag Plateau, Jharkhand (April–September 2023)

Metric	Intact (n=8)	Degraded (n=8)	Fragment (n=8)	F-statistic	p-value
Species richness	8.7 ± 1.8	5.3 ± 1.6	3.1 ± 1.2	28.41	<0.001
Shannon H'	2.14 ± 0.23	1.63 ± 0.19	1.07 ± 0.16	52.73	<0.001
Simpson 1-D	0.84 ± 0.05	0.72 ± 0.06	0.58 ± 0.08	34.19	<0.001
Passes/night	539.7 ± 87.4	303.1 ± 64.2	147.2 ± 41.8	61.28	<0.001
Total species	14	9	6	—	—

Mean ± SD across eight sites per habitat type. One-way ANOVA.

All community metrics declined sharply from intact to fragmented habitats. Fourteen bat species were detected across intact riparian corridors, compared with nine in degraded strips and only six in upland fragments. Activity levels dropped by 73% from intact corridors to fragments. NMDS ordination showed clear separation of intact riparian sites from the other two habitat types along the first axis (stress = 0.11).

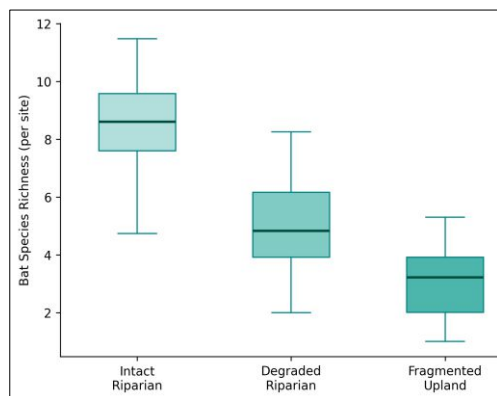


Fig 1: Box-and-whisker plots of bat species richness across three habitat types. Boxes show interquartile range; horizontal lines indicate medians

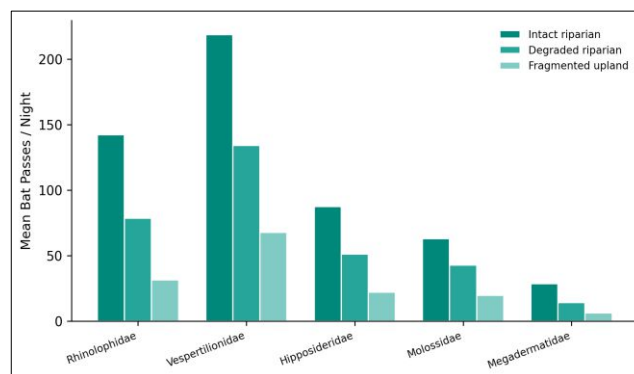


Fig 2: Mean bat passes per night by family across three habitat types. Vespertilionidae dominated all habitats but showed the steepest absolute decline in fragmented uplands

Discussion

The threefold difference in species richness between intact riparian corridors and fragmented uplands underscores the conservation value of stream-side vegetation in this landscape. Rhinolophids and hipposiderids—both clutter-adapted echolocators that rely on dense vegetation for foraging—were virtually absent from fragments, consistent with their known sensitivity to structural simplification^[10].

^{11]}. Vespertilionids, which include more open-space foragers, persisted in degraded habitats but at much reduced activity levels, suggesting that even generalist species suffer when corridor quality declines ^[12].

The indicator species results are actionable for land managers: protecting populations of *R. lepidus* and *H. lankadiva* may serve as a proxy for maintaining corridor integrity. The 69% drop in vespertilionid activity from intact to fragmented sites echoes findings from neotropical fragmentation studies and points to a threshold effect where corridors narrower than ~30 m lose most of their connectivity function for bats ^[13, 14]. A limitation is the six-month sampling window, which missed the winter period when some species may migrate or become torpid ^[15].

Conclusion

Intact riparian corridors in the Hazaribag Plateau supported more than double the bat species richness and nearly four times the nightly activity of fragmented upland patches. Degraded corridors occupied an intermediate position, retaining some species but losing the most habitat-sensitive families. These data argue strongly for prioritising riparian buffer restoration in landscape-level conservation plans for the Chotanagpur region. A minimum corridor width of 30 m with canopy cover above 70% appears necessary to maintain the full complement of bat species found in intact forest.

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