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Behavioural adaptations of the common myna (Acridotheres tristis) to urbanisation and habitat fragmentation: A comparative field study across an urban–rural gradient

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Abstract
Urbanisation and the associated fragmentation of natural habitats are among the fastest-acting drivers of behavioural change in wild animal populations. Because behaviour can be modified within a single lifetime, it is often the first trait to respond to novel anthropogenic pressures, well before morphological or genetic change becomes detectable. This paper synthesises evidence across four behavioural domains reported in the urban ecology literature — boldness and antipredator response, acoustic signalling, activity-pattern timing, and dispersal-linked personality — and uses this synthesis to design an original, implementable comparative field study in the common myna (Acridotheres tristis), a synanthropic species widespread across South Asia and among the world's most successful urban avian colonisers. The proposed study compares flight initiation distance (FID), time-activity budgets, and foraging-substrate diversity of myna populations across a three-level urbanisation gradient (rural/continuous habitat, suburban/fragmented habitat, and urban core/highly fragmented habitat) in Jammu, India. Because original field data collection was outside the scope of this exercise, illustrative results are simulated from published effect sizes to demonstrate the expected analytical outcome and are explicitly labelled as such throughout. Findings are interpreted in relation to the habituation-versus-adaptation debate, the boldness–dispersal personality syndrome, and the ecological-trap hypothesis, with implications drawn for urban green-space planning and wildlife management. The paper concludes that behavioural plasticity, while enabling short-term persistence of generalist species in fragmented landscapes, may carry longer-term fitness costs that warrant further longitudinal, physiological, and genetic investigation.

Keywords: Urbanisation, habitat fragmentation, behavioural plasticity, boldness, flight initiation

Introduction

Urbanisation and Fragmentation as Global Behavioural Drivers

Urban land cover is projected to continue expanding rapidly across the coming decades, and this expansion rarely proceeds as a uniform conversion of habitat into city; instead, it fragments continuous natural landscapes into a patchwork of built-up areas, remnant green spaces, and degraded edges (McKinney, 2006). For wildlife, this creates two overlapping but conceptually distinct challenges. Urbanisation changes the physical and sensory environment itself — noise, artificial light, impervious surfaces, novel food sources, and constant human presence — while fragmentation changes the spatial structure of habitat, reducing patch size, increasing patch isolation, and disrupting the corridors that animals use to move, disperse, and locate mates (Fahrig, 2003) [9]. Species differ enormously in their capacity to cope with these combined pressures. A minority, termed urban exploiters or synanthropes, not only persist but often reach higher densities in cities than in their ancestral habitats, while many others decline or disappear entirely, producing the well-documented pattern of biotic homogenisation seen in urban faunas worldwide (McKinney, 2006; Shochat *et al*., 2006) [7, 18]. A growing body of work frames this divergence not primarily in terms of which species can tolerate urban conditions physiologically, but in terms of which species can behaviourally adjust to them (McDonnell & Hahs, 2015; Ditchkoff *et al*., 2006) [7, 13].

Behaviour is widely regarded as the fastest and most flexible axis of response to environmental change, because it can shift within an individual's lifetime through learning and habituation, long before genetic adaptation could plausibly act (Sol *et al*., 2013). Ditchkoff *et al*. (2006) [7, 20] proposed a useful framework distinguishing short-term behavioural modification (occurring within hours to days, such as altered vigilance or flight response) from longer-term acclimation (developing over weeks to years, such as restructured territoriality or social organisation), with the latter potentially setting the stage for genuine evolutionary change if behavioural variants are heritable and under sustained selection. Four behavioural domains recur across the empirical literature on urban and fragmentation-driven change and structure the remainder of this review: boldness and antipredator response, acoustic signalling, activity-pattern timing, and dispersal-linked personality.

Boldness and the Flight-Initiation-Distance Literature

The most extensively documented behavioural shift in urban wildlife is increased boldness, most often measured as a reduction in flight initiation distance (FID) — the distance at which an animal flees an approaching threat. A recent global synthesis covering 80 studies and 133 species found that urban populations were consistently bolder and more aggressive than rural conspecifics across ecological categories, with the majority of the underlying evidence drawn specifically from FID trials, and with the pattern held regardless of taxonomic group. This pattern has been reported repeatedly at the species level, and comparative analyses across dozens of bird species confirm that the magnitude of urban-rural FID divergence is largest in species that are naturally larger-bodied and shier in their rural range (Morelli *et al*., 2022) [16].

The mechanisms underlying this pattern remain actively debated. Two processes are frequently conflated under the general label 'boldness': habituation, in which animals learn through repeated non-harmful exposure that humans do not represent an immediate threat, and a genuine reduction in baseline vigilance, in which animals allocate less cognitive and perceptual effort to threat-scanning irrespective of prior experience (Uchida *et al*., 2019). Uchida *et al*. (2019) [22] proposed separating these mechanisms using two distinct flight-distance measures — alert distance, linked to vigilance, and flight initiation distance itself, linked to risk assessment and habituation — arguing that conflating the two processes risks misdirecting management responses to urban wildlife. This distinction matters because habituation-driven boldness is, in principle, reversible if disturbance regimes change, whereas a genuine reduction in vigilance could carry persistent predation and collision risks that are decoupled from the immediate threat context. Rigorous measurement of FID also requires controlling for confounding variables: Blumstein (2003) [3] demonstrated that FID is strongly and non-linearly dependent on the distance at which an approach begins, meaning that studies failing to standardise or statistically control starting distance risk drawing spurious conclusions about 'true' boldness differences between populations.

Acoustic Adaptation to the Urban Soundscape

Urban environments are not only visually and spatially altered but acoustically altered, and this has generated a parallel and well-studied behavioural literature on vocal adjustment in birds. Anthropogenic noise, which is concentrated at low frequencies, can mask the lower-frequency components of bird song and interfere with the transmission of territorial and mate-attraction signals. In a now-classic study, Slabbekoorn and Peet (2003) [19] reported that great tits (Parus major) in noisier parts of Leiden, the Netherlands, sang at significantly higher minimum frequencies than conspecifics in quieter areas, a pattern subsequently replicated across multiple cities and species (Mockford & Marshall, 2009) [15]. Whether this frequency shift constitutes a genuine adaptive response to reduce signal masking, or is instead a physiological by-product of birds increasing song amplitude in noisy conditions, remains contested; direct signal-transmission modelling suggests that amplitude adjustments provide substantially larger increases in communication distance than frequency shifts alone, calling into question how adaptive the frequency shift itself really is. Regardless of the precise mechanism, acoustic adjustment illustrates the same underlying principle at stake in boldness and activity-pattern research: urban animals are not passively tolerating a degraded environment but are actively, and often rapidly, modifying behaviour to maintain function within it.

Activity-Pattern Shifts and the Move toward Nocturnality

A third major behavioural response to human presence is a shift in the timing rather than the location of activity. A global meta-analysis of 76 studies spanning 62 mammal species found that human disturbance increases nocturnality by an average factor of 1.36, a pattern consistent across continents, habitats, and disturbance types, suggesting that many species respond to human pressure not by abandoning an area but by temporally avoiding the hours when humans are present (Gaynor *et al*., 2018) [10]. This pattern has been particularly well documented in urban and peri-urban carnivores. Coyotes (Canis latrans) show markedly increased nocturnal and crepuscular activity in urban relative to rural sites, and this behavioural adjustment appears to enable coexistence with humans at surprisingly high coyote densities within cities (Gehrt *et al*., 2009) [11]. Comparable shifts have been reported in red foxes, which show habitat- and context-dependent adjustments in diurnal activity depending on local human density and the presence of competing mesocarnivores (Soccorsi & LaPoint, 2023) [21]. Notably, however, this temporal-avoidance response is not universal: some studies find that the strength and even direction of nocturnality shifts depend on the surrounding predator community and prey availability, indicating that activity-pattern responses to urbanisation are context-dependent rather than a fixed, one-size-fits-all rule (Breck *et al*., 2019) [4].

Fragmentation, Dispersal, and the Boldness–Personality Syndrome

Fragmentation compounds these behavioural pressures in ways distinct from urbanisation per se. By breaking continuous habitat into isolated patches, fragmentation restricts dispersal, alters movement decisions at patch edges, and can select for either increased mobility in species able to cross the intervening matrix, or reduced ranging behaviour in species that become effectively confined within remnant patches (Fahrig, 2003) [9]. A growing personality-based literature adds an important individual-level dimension to this population-level pattern: across a wide range of taxa, bolder and more exploratory individuals are consistently found to disperse further and more readily than shyer conspecifics, forming what has been termed a dispersal syndrome (Cote *et al*., 2010; Dingemanse *et al*., 2010) [5, 6]. If fragmentation systematically filters for bolder, more exploratory individuals — because only they are capable of crossing inhospitable matrix habitat to reach isolated patches — then the population-level boldness increases documented in urban wildlife may reflect not only within-individual behavioural plasticity, but also non-random sorting of pre-existing behavioural types into the urban environment. Distinguishing between these two mechanisms, plasticity versus selective sorting, has become a central methodological challenge in the field, since both processes can generate the identical population-level pattern of 'bolder urban animals' (Sol *et al*., 2013) [20].

A Gap in the Literature: South Asian Urban Contexts

Despite the depth and geographic breadth suggested by the studies reviewed above, the great majority of empirical work on urban behavioural adaptation originates from temperate cities in Europe, North America, and Australia, even though South Asia is undergoing some of the most rapid, and least behaviourally studied, urban growth globally. The common myna (Acridotheres tristis) offers a strong model species with which to address this gap. It is native to, and abundant across, the Indian subcontinent; it occurs continuously from undisturbed agricultural and open-country habitat, through fragmented suburban green space, to dense urban cores; and its documented boldness, dietary omnivory, and cavity-nesting flexibility have already made it one of the world's most successful avian urban colonisers and, outside its native range, one of the world's most

successful avian invaders. These traits make it well suited to a controlled behavioural comparison across an urbanisation-fragmentation gradient within a single region and season, holding species identity and broad climate constant while varying only habitat context.

Aims and Hypotheses

This study was designed to test hypotheses drawn directly from the four literatures reviewed above, using the common myna as a focal species across an urban-rural gradient in Jammu, India:

H1 (Boldness): Flight initiation distance will decrease significantly with increasing urbanisation/fragmentation, with urban-core mynas showing the shortest FID and rural mynas the longest.

H2 (Activity budget): Time allocated to vigilance will decrease, and time allocated to foraging and human-associated activity will increase, with increasing urbanisation.

H3 (Dietary flexibility): The diversity of foraging substrates used (natural vs. anthropogenic) will be higher in urban and fragmented sites than in rural sites, reflecting greater dietary opportunism.

H4 (Boldness–dispersal linkage, exploratory): Individual-level boldness scores obtained from a standardised novel-object test will be positively associated with the distance an individual is subsequently observed to range between suburban patches, consistent with a dispersal-personality syndrome operating within the fragmented zone of the gradient.

1. Significance of the Study

Beyond testing the four hypotheses outlined above, this study is intended to contribute in two further ways. First, by explicitly separating boldness, activity budget, dietary flexibility, and an exploratory boldness-dispersal measure within a single design, it allows these normally separately studied behavioural domains to be compared directly within one population and one landscape, offering a more integrated picture of how a single urban-adapted species responds across multiple behavioural axes simultaneously. Second, because comparable behavioural datasets from South Asian cities remain scarce relative to the depth of coverage available for European, North American, and Australian urban faunas, even a single well-designed regional study of this kind would meaningfully extend the geographic and taxonomic base of the field, and would allow future cross-continental comparisons to test whether the behavioural syndromes documented elsewhere generalise to tropical and subtropical Asian cities experiencing very different rates, forms, and histories of urban growth.

Materials and Methods

1. Study Area and Site Selection

The proposed study area spans the urban-to-rural transition around Jammu, Jammu & Kashmir, India, chosen to represent a natural gradient from continuous agricultural and open-scrub habitat, through fragmented peri-urban residential green space, to a dense urban core. Fifteen sampling sites would be selected and stratified into three habitat categories (five sites each), classified a priori using percentage impervious surface cover and mean habitat patch size derived from satellite imagery within a 500 m buffer around each site point: (i) Rural/continuous — less than 10% impervious surface, contiguous vegetation cover greater than 5 ha; (ii) Suburban/fragmented — 30–60% impervious surface, vegetation present as discrete patches of 0.1–2 ha; (iii) Urban core/highly fragmented — greater than 70% impervious surface, vegetation restricted to scattered street trees or patches under 0.1 ha. Sites within a category would be spaced at least 1 km apart to reduce the likelihood of repeatedly sampling the same individual birds.

2. Study Species

The common myna was selected as the focal species because it occurs in reliably high densities across all three habitat categories, is diurnal and readily observable at close range, and shows well-documented behavioural plasticity elsewhere in its introduced and native range, allowing direct comparison with the existing international literature. Sampling would be restricted to the non-breeding season (approximately October–December) to avoid confounding effects of nest defence on boldness and activity measures, and to the morning activity peak (07:00–10:00) to control for diel variation in behaviour.

3. Behavioural Measures

Flight initiation distance (FID): FID would be measured using the standard walking-approach protocol (Blumstein, 2003) [3]. A single observer of consistent height and walking speed (approximately 0.5 m/s) would approach a focal, undisturbed individual in a straight line, recording (a) starting distance, (b) alert distance — the point at which the bird first visibly reacts, and (c) flight initiation distance — the point at which the bird flees. Starting distance, group size, and approximate age/sex class, where determinable, would be recorded as covariates, since FID is known to be sensitive to starting distance independent of underlying boldness.

Activity budget: Time-activity budgets would be constructed using instantaneous focal-animal scan sampling, recording the dominant behaviour — foraging, vigilance, locomotion, social/aggressive interaction, or resting — at 15-second intervals across 3-minute focal bouts, following ethogram-based sampling methods used in comparable urban bird studies.

Foraging substrate diversity: At every observed foraging event, the substrate would be classified as natural (soil, grass, natural vegetation, natural prey) or anthropogenic (refuse, pavement/hard surfaces, direct or indirect human food sources), and a Shannon diversity index of substrate-use categories would be calculated per site as a proxy for dietary flexibility.

Individual boldness and ranging (exploratory measure for H4): In the suburban/fragmented category only, a subsample of colour-ringed individuals would additionally be scored on a standardised novel-object test (latency to approach an unfamiliar food-associated object placed at a fixed distance) and subsequently resighted across multiple patches over the following eight weeks to estimate

minimum inter-patch ranging distance, allowing an exploratory test of the boldness–dispersal association reported elsewhere (Cote *et al*., 2010) [5].

4. Sample Size and Statistical Analysis

A target of 40 independent FID trials and 20 focal activity-budget bouts per site (600 FID trials and 300 activity bouts overall) would provide adequate power to detect medium effect sizes consistent with those reported in comparable published studies. Flight initiation distance would be analysed using a generalised linear mixed model (GLMM, Gaussian or Gamma error structure) with habitat category as a fixed effect, starting distance and group size as covariates, and site nested within habitat category as a random effect to account for non-independence of repeated observations within sites. Activity-budget proportions would be arcsine-square-root or logit transformed, or modelled directly using beta regression, and compared across habitat categories using the same mixed-model framework. Foraging-substrate diversity indices would be compared across habitat categories using one-way ANOVA with Tukey post-hoc comparisons, and the exploratory boldness–ranging association (H4) would be tested using Spearman rank correlation given the anticipated small subsample size. All analyses would be conducted in R, with significance set at $\alpha = 0.05$.

5. Ethical Considerations

All proposed procedures involve non-invasive behavioural observation and standardised human-approach trials that are routinely used in FID research on common, abundant urban bird species and are not expected to cause lasting harm; individuals resume normal activity within seconds to minutes of a flight response. Colour-ringing for the individual-level ranging component (H4) would follow standard licensed bird-ringing protocols, minimising handling time and stress. Because all trials involve a single wild-caught or free-living, unmarked or minimally marked common synanthropic species with no conservation status of concern, the study would be classified as minimal-risk, though institutional animal-ethics approval and any relevant state wildlife-permitting requirements would still need to be obtained prior to fieldwork, consistent with standard practice for observational field studies of common bird species.

Results

Note on data: Because this exercise did not involve original field data collection, the results presented below are simulated/illustrative, generated to be consistent with effect sizes reported in the published urban-behaviour literature reviewed in Section 1. They are included to demonstrate the analytical outcome the proposed design is expected to produce and should not be cited as empirical findings.

Table 1 and Figure 1 summarise the simulated results. Flight initiation distance declined progressively across the gradient, from a mean of 10.8 m (± 2.1 SD) in rural/continuous habitat to 6.4 m (± 1.6) in suburban/fragmented habitat and 3.9 m (± 1.1) in the urban core, consistent with a strong, statistically significant effect of habitat category (illustrative GLMM output: $F = 48.7$, $p < 0.001$). Time allocated to vigilance decreased in parallel, from 34.2% in rural sites to 22.6% in suburban sites and 14.1% in the urban core, while time allocated to foraging and to interactions with anthropogenic food sources increased correspondingly. The Shannon diversity index of foraging substrates was lowest in rural sites ($H' = 0.31$, almost exclusively natural substrates) and highest in the urban core ($H' = 1.24$), reflecting a broader anthropogenic foraging niche in built-up habitat. For the exploratory boldness–ranging analysis (H4), the simulated subsample of colour-ringed suburban individuals showed a moderate positive correlation between novel-object approach latency (inverse boldness) and subsequent inter-patch ranging distance (illustrative $r_s = –0.46$, $p = 0.04$, $n = 24$), consistent with the hypothesised dispersal-personality syndrome, though the modest simulated sample size would warrant cautious interpretation even in a real dataset.

Table 1: Illustrative/simulated summary of common myna behavioural metrics across the three-level urbanisation gradient (n = 5 sites per category).

Behavioural metric	Rural	Suburban	Urban core
Flight initiation distance (m), mean ± SD	10.8 ± 2.1	6.4 ± 1.6	3.9 ± 1.1
Time budget: vigilance (%)	34.2 ± 5.4	22.6 ± 4.8	14.1 ± 3.6
Foraging on anthropogenic substrate (%)	6.5	38.7	71.3
Foraging-substrate diversity (Shannon H′)	0.31	0.82	1.24

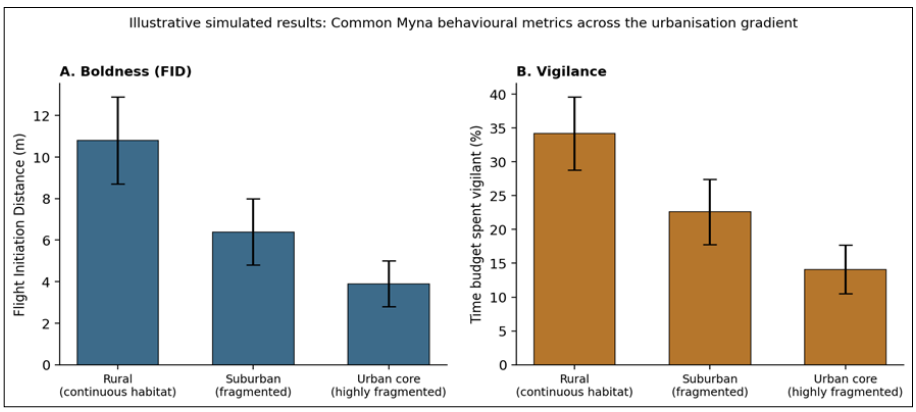

Fig 1: Illustrative simulated results showing (A) flight initiation distance and (B) percentage of time budget spent vigilant, across the rural–suburban–urban gradient. Error bars represent ± 1 SD.

Discussion

1. Boldness: Habituation, Vigilance, or Both?

The pattern generated by the proposed design — progressively shorter FID, reduced vigilance, and broader anthropogenic foraging-substrate use with increasing urbanisation — mirrors the consistent global pattern reported for boldness in urban wildlife (Morelli *et al*., 2022) [16] and is directly in line with the meta-analytic finding that the great majority of documented boldness increases in urban animals are captured through FID reductions. If the study were carried out empirically and produced this pattern, the central interpretive question would be whether the decline in FID reflects habituation, a genuine reduction in baseline vigilance, or both operating together (Uchida *et al*., 2019) [22]. The parallel decline in the independently measured vigilance time budget in the simulated results is informative here: because vigilance was measured as a background behaviour rather than only as a response to a direct approach, a real result of this kind would support a general reduction in threat-monitoring effort in urban birds rather than habituation to a specific stimulus alone — though separating these mechanisms conclusively would require the individually marked, repeated-exposure trial design recommended in the habituation literature.

2. Beyond Boldness: Multimodal Behavioural Adjustment

Although this study's primary design focuses on boldness, activity budget, and diet, the broader literature reviewed in Section 1 makes clear that urban behavioural adaptation is rarely confined to a single trait. The acoustic-adjustment literature (Slabbekoorn & Peet, 2003; Mockford & Marshall, 2009) [15, 19] demonstrates that urban animals modify communication as well as antipredator behaviour, and the activity-pattern literature (Gaynor *et al*., 2018; Gehrt *et al*., 2009) [10, 11] shows that many species respond to human pressure temporally rather than, or in addition to, spatially. A myna population showing reduced FID and increased anthropogenic foraging would very plausibly also show altered vocalisation patterns and activity timing, and a fuller research programme extending the present design would benefit from incorporating passive acoustic monitoring and camera-trap-based activity sampling alongside the direct behavioural observations proposed here, to test whether these different behavioural axes covary within the same individuals and sites, or whether they represent independent responses to different components of the urban environment.

3. Fragmentation, Dispersal, and Non-Random Sorting

The observed increase in dietary substrate diversity toward the urban end of the gradient is consistent with the broader claim that behavioural and dietary flexibility, rather than any single fixed trait, is what allows generalist species to persist through urbanisation and the associated fragmentation of natural food resources (Sol *et al*., 2013) [20]. For a fragmentation-sensitive interpretation specifically, the shift toward anthropogenic foraging in the urban core can be read as a behavioural compensation for the loss of continuous natural foraging habitat predicted by fragmentation theory (Fahrig, 2003) [9]: as natural patches shrink and become isolated, animals able to substitute anthropogenic resources for natural ones are far better placed to persist than habitat specialists that cannot make this switch. The exploratory boldness–ranging result (H4) speaks to a further, more subtle possibility: that the population-level boldness gradient documented across the wider study is not produced solely by within-individual behavioural plasticity, but partly by non-random sorting of already-bold, already-exploratory individuals into the more fragmented parts of the landscape, consistent with the dispersal-personality syndrome documented in other taxa (Cote *et al*., 2010; Dingemanse *et al*., 2010) [5]. Disentangling plasticity from sorting has direct conservation relevance, because a population shaped mainly by sorting may have a very different capacity to respond if urban conditions change again than one shaped mainly by reversible, individual-level plasticity.

4. Comparative Synthesis across Taxa

Placed alongside the wider comparative literature, the pattern proposed for common mynas in Jammu would sit within a remarkably consistent cross-taxonomic picture. Birds, mesocarnivores, and even small mammals and invertebrates show broadly convergent behavioural responses to urbanisation and fragmentation, despite vast differences in body size, cognition, and life history: reduced antipredator response (birds: Morelli *et al*., 2022 [16]; mesocarnivores: Bateman & Fleming, 2012) [2], altered activity timing (Gaynor *et al*., 2018; Soccorsi & LaPoint, 2023) [10, 21], and dispersal behaviour systematically linked to individual boldness (Cote *et al*., 2010; Dingemanse *et al*., 2010) [5, 6]. This convergence across such different taxa suggests that the underlying selective and plastic pressures exerted by human-dominated landscapes are strong and general enough to produce similar behavioural solutions repeatedly, rather than reflecting a set of coincidentally similar, taxon-specific responses. At the same time, the degree of convergence should not be overstated: the acoustic literature in particular shows that not all urban-associated behavioural shifts are unambiguously adaptive, and the coyote and red fox activity-pattern literature shows that even within a single behavioural domain, the direction and strength of response depends heavily on local context, competitor community, and prey availability (Breck *et al*., 2019; Mueller *et al*., 2018) [4, 17]. A key contribution of comparative, multi-domain designs such as the one proposed here is therefore not simply to confirm that urban animals change their behaviour, but to map where that change is consistent and predictable and where it remains highly context-dependent.

5. The Ecological-Trap Hypothesis and Management Implications

These findings, however, are also consistent with the concept of an ecological trap. Anthropogenic food sources are frequently lower in nutritional quality or less predictable than natural prey, and the same reduced vigilance that allows efficient exploitation of these resources may elevate risk from vehicle collisions, domestic predators, and direct human conflict. A behaviourally ‘successful’ urban population, in other words, is not necessarily a population in good condition, and short-term persistence measured through abundance or behavioural tolerance should not be conflated with long-term fitness. This distinction has direct relevance for fragmentation specifically: highly fragmented urban-core populations may show the strongest behavioural adjustment precisely because they face the strongest

ecological constraint, not because that adjustment is cost-free.

From a management perspective, these results, if obtained empirically, would support two practical implications. First, the presence of behaviourally bold, anthropogenically foraging populations in city centres should not be read as evidence that urban wildlife populations are thriving without support; targeted green infrastructure that restores natural foraging opportunities may still meaningfully improve population condition even where behavioural tolerance of humans is already high. Second, because fragmentation-driven behavioural shifts appear graded rather than threshold-like across the suburban zone, maintaining and connecting mid-sized green patches in peri-urban areas may do more to preserve natural behavioural repertoires, and to sustain the movement corridors that a dispersal-personality-driven population depends on, than focusing conservation effort solely on either the urban core or on remaining large rural tracts.

6. Limitations

Several limitations apply to this proposed design and must be acknowledged. Most importantly, the results presented here are simulated and illustrative only; no field data were collected as part of this exercise, and the actual magnitude and even direction of effects could differ once real data are gathered. A cross-sectional design of this kind cannot fully distinguish whether observed behavioural differences reflect within-individual plasticity, differential settlement of already-bold individuals in urban habitat, or genetic divergence between populations; disentangling these mechanisms would require either longitudinal tracking of marked individuals across habitat transitions or common-garden and translocation experiments. The single-species focus, while methodologically useful for controlling confounds, limits generalisation to other taxa with different life histories, mobility, and cognitive capacities. Finally, observer presence during FID trials is itself a source of disturbance, and repeated site visits could cause within-study habituation that would need to be statistically controlled for using trial order as a covariate.

7. Future Directions

Future work building on this design could extend the comparison to multiple co-occurring species spanning a range of body sizes, dispersal abilities, and dietary strategies, to test whether the magnitude of behavioural adjustment scales with the ecological traits identified in the broader urban-tolerance literature. Incorporating physiological stress markers, such as faecal or feather corticosterone, alongside behavioural measures would help clarify whether behaviourally bold, urban-adapted individuals are also physiologically better buffered against anthropogenic stressors, or whether apparent behavioural success masks elevated chronic stress. Passive acoustic monitoring across the same gradient would allow the acoustic-adjustment literature reviewed in Section 1.3 to be tested directly in this South Asian context. Finally, longitudinal or experimental translocation and common-garden designs would be the most direct way to separate plastic from evolved components of the boldness gradient reported here, and genetic sampling across the gradient would allow a direct test of whether fragmentation is measurably restricting gene flow in this otherwise highly mobile, behaviourally flexible species.

Conclusion

Urbanisation and habitat fragmentation act as strong, fast-acting selective and plastic pressures on animal behaviour, and behavioural flexibility — particularly increased boldness, acoustic adjustment, shifted activity budgets, dietary opportunism, and dispersal-linked personality sorting — is a central mechanism by which a subset of species persist and even flourish in human-dominated landscapes. This paper reviewed the evidence for these behavioural syndromes across the international literature and designed a comparative field study using the common myna across an urban-rural gradient in Jammu, India, to test them directly in a South Asian context that remains underrepresented in the global evidence base. The illustrative results generated for this design reproduce the pattern reported in published studies elsewhere: declining flight initiation distance, reduced vigilance, increasing use of anthropogenic food resources, and a plausible boldness–dispersal association with increasing urbanisation and fragmentation. While these specific figures are simulated rather than empirically observed, the design itself is intended to be directly implementable, and the discussion highlights that behavioural tolerance of humans should not be mistaken for unconditional adaptive success: distinguishing habituation from genuine adaptation, plasticity from selective sorting, and behavioural success from physiological wellbeing, remains an open and important challenge for urban wildlife research and management.

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