

## Habitat associations of the Brown Shrike (*Lanius cristatus* Linnaeus, 1758) during the non-breeding period in human-modified landscapes of Southeast Asia

Artur GOLAWSKI<sup>ID</sup>, Cezary MITRUS<sup>ID</sup>, Przemysław OBŁOZA<sup>ID</sup>, Santi XAYYASITH<sup>ID</sup>,  
and Zbigniew KASPRZYKOWSKI<sup>ID</sup>

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Land-use changes are a major driver of biodiversity shifts in Southeast Asia, particularly within human-modified landscapes. Understanding how migratory species use habitats during the non-breeding season is important for assessing their tolerance to environmental changes. We examined the non-breeding habitat associations of the Brown Shrike (*Lanius cristatus* Linnaeus, 1758) in Laos by analysing 139 field-detected occurrence sites and comparing them with an equal number of randomly selected background points. Three landscape variables were most strongly associated with the detection of shrikes: road area (positive relationship), and the extent of built-up areas and forest cover (both negative relationships). Brown Shrikes were most frequently recorded in semi-open environments within agricultural mosaics, where structural elements such as perches and open foraging spaces were maintained. Our findings suggest that modified landscapes can provide suitable conditions for the species when structural habitat elements are retained. Our study provides the first fine-scale assessment of the non-breeding habitat associations of Brown Shrikes in mainland Southeast Asia and highlights the importance of maintaining mosaic agricultural landscapes for migratory insectivorous birds.

**Key words:** habitat associations, land-use changes, Laos, mosaic landscapes, non-breeding ecology, tropical ecosystems.

Artur GOLAWSKI<sup>✉</sup>, Przemysław OBŁOZA, Zbigniew KASPRZYKOWSKI, *University of Siedlce, Faculty of Sciences, Prusa 14, 08-110 Siedlce, Poland.*

E-mail: artur.golawski@uws.edu.pl

Cezary MITRUS, *Department of Biology and Ecology of Animals, Institute of Biology, University of Environmental and Life Sciences, Wrocław, Poland.*

Santi XAYYASITH, *Faculty of Environmental Sciences, National University of Laos, Vientiane, Lao PDR.*

Southeast Asia is among the world's most biologically rich and ecologically complex regions that is continuing to undergo rapid landscape transformations. Agricultural expansion, logging, infrastructure development and accelerated urbanisation have led to widespread deforestation, habitat degradation and fragmentation (Tan *et al.* 2022; Yang *et al.* 2022). Although the impact of land-use changes on tropical forest specialists and endemics are well studied (Sodhi *et al.* 2010; Lambert & Collar 2002), the re-

sponses of widespread or tolerant taxa occupying open or semi-open habitats remain underexplored. Studies from other regions, such as the Sahel, where seasonal shifts in habitat choice highlight the importance of maintaining structural elements like refuge trees (Zwarts *et al.* 2023), and in western India, where the landscape composition shapes winter bird assemblages across agriculture-savanna mosaics (Bhagwat *et al.* 2025), suggest that even generalist species can respond strongly and predictably to vari-



ations in the landscape structure. However, equivalent information from mainland Southeast Asia is still limited.

Today, the rural and peri-urban landscapes across much of Southeast Asia form fine-scale mosaics of remnant natural vegetation, smallholder farms, scrubland and anthropogenic features (DeFries *et al.* 2010; Azhar *et al.* 2013). While many bird species, particularly those not restricted to closed-canopy forests, appear capable of persisting in modified environments, their presence does not imply an equal use of all land-cover types. Even generalists may exhibit non-random occurrence patterns linked to the vegetation structure, land-use intensity and level of human disturbance (Foster *et al.* 2011; Hakim *et al.* 2020). Understanding how adaptable species interact with human-modified habitats is important, not only for conservation planning but also for ecological theories on resilience and functional diversity.

Common species can reveal patterns of habitat association and spatial filtering processes in heterogeneous, rapidly changing environments. Their wide distributions, relative abundance and detectability make them useful for assessing fine-scale habitat associations in data-limited tropical systems. Moreover, changes in their abundance or distribution can influence the community structure and ecosystem functioning. Many perform key ecological roles, including insect regulation, and changes in their status may signal broader shifts in the ecosystem's health (Koh 2008). Investigating their habitat associations thus benefits both applied management and the understanding of functional responses to environmental change.

The Brown Shrike (*Lanius cristatus* Linnaeus, 1758), a Palearctic-tropical migrant, winters widely across Southeast Asia (Lefranc 2022). In the non-breeding season, it occupies open and semi-open habitats that are rich in shrubs, trees or artificial structures (Severinghaus 1996). Despite its large numbers, the fine-scale habitat associations of the species in continental Southeast Asia remain poorly known. Although tolerant of a wide range of human-modified habitats at broad spatial scales, the species consistently relies on elevated perches for foraging (Yosef 2004), indicating a fine-scale selectivity for specific features in the landscape. Most of the existing research has addressed its breeding biology, phenology and migratory strategies (Takagi 2003; Kitazawa *et al.* 2022), with its non-breeding ecology largely undocumented (Yosef 2004).

In this study, we examine the patterns of habitat usage maintained by Brown Shrikes in Laos during

the non-breeding period. Our aim was to identify the landscape features and structural elements associated with the species' occurrence across a heterogeneous, human-modified environment. Using presence data and randomly generated comparison points, we quantify how the land-cover composition, vegetation structure and disturbance gradients are associated with Brown Shrike detections. By analysing the habitat associations in a common yet understudied migratory landbird, this study provides broader insights into landscape filtering and the use of spatial resources in Southeast Asia, an ecologically critical but comparatively under-documented region of the East Asian-Australasian Flyway (Yong *et al.* 2015).

## Material and Methods

### Study species

The Brown Shrike breeds across temperate areas of East Asia, from eastern Siberia and Mongolia through northern China, Korea and Japan. Almost all populations are migratory, wintering south of their breeding range, including in Laos (Lefranc 2022). Ringing studies show a high level of winter site fidelity, with individuals often returning to the same locations (Takagi 2003) and defending their winter territories (Severinghaus 1996). Although classified as a species of 'Least Concern', the species is declining despite its extensive range (BirdLife International 2025). It uses a varied range of habitats throughout the annual cycle, ranging from coastal reedbeds and farmland to urban gardens, while occurring from lowlands up to elevations of about 1,600 m. Its diet consists mainly of insects such as locusts, grasshoppers, crickets and beetles, which are hunted from perches 1–3 m above the ground (Lefranc 2022).

### Study area

Laos is a landlocked country on the Indochinese Peninsula, covering an area of 236,800 km<sup>2</sup> and supporting a population of approximately 6.5 million. Its topography is dominated by mountainous terrain in the northern and central regions; whereas the southern panhandle consists of lower, more gently undulating landscapes. Much of the western border follows the Mekong River, which forms broad floodplains and extensive lowland agricultural zones. The climate is monsoonal, with a humid wet season and a drier period; annual rainfall ranges from roughly 1,000 mm in the north to over 3,000 mm in the south. The mean temperatures vary from around 10°C in January to 38°C in July, with cooler conditions at

higher elevations. Lowland areas are predominantly tropical, whereas upland zones in the centre and north of the country are sub-tropical (Phongoudome & Sirivong 2007; Cosslett & Cosslett 2018). During April 2024 in the capital city of Vientiane, the mean daily temperature averaged across the month was 32.4°C. The mean monthly minimum and maximum temperatures were 25.1°C and 39.6°C, respectively. Precipitation was minimal, with only a single day of rain totalling 1.02 mm in volume (<https://en.tutiempo.net>).

National-scale assessments show that the land use in Laos forms extensive landscape mosaics dominated by agricultural and forest systems. Swidden agriculture occupies roughly 29% of the national territory, and permanent agricultural land accounts for a similar proportion (~29%), while forests cover around 40-42% of the land (Messerli *et al.* 2009). These lowland and foothill mosaics typically include paddy rice, fallow land, open farmland and scattered trees.

#### Avian monitoring data

Fieldwork was conducted from 9 April to 2 May 2024 by three experienced observers (AG, ZK, CM), each covering separate survey routes. This period corresponds to the non-breeding season in mainland Southeast Asia, when Brown Shrikes are still commonly present in wintering areas but some individuals may already be beginning their spring migration. Because each route was surveyed only once, the collected data was used to analyse the spatial associations between shrike detections and habitat characteristics, rather than to estimate the site fidelity or definitive habitat preferences. Data was collected along 43 pre-selected local footpaths and narrow unpaved tracks, each 1.5-2.5 km in length. These routes represented diverse land-cover types and were positioned at least 1 km apart (typically  $\geq 5$  km) to ensure spatial independence. The survey routes were preselected using high-resolution satellite imagery to identify accessible areas dominated by agricultural mosaics and other open or semi-open habitats typical of Brown Shrike non-breeding areas, while large urban areas and extensive closed-canopy forests were avoided because they represent habitats rarely used by the species. The survey routes followed existing paths and tracks only as a means of accessing the landscape, while habitat variables were quantified independently within buffers around the detection and background points. To minimise the risk of recording the same individual more than once, adjacent survey routes were visited simultaneously by different observers. The observers moved

slowly, recording the GPS location of the first detection of each bird (Fig. 1). All surveys were conducted on foot, and each pre-selected route was fully walked regardless of how many shrikes were detected along it. All the birds recorded were single individuals, identified using 10×42 binoculars, between 06:00 and 10:00 ICT (UTC+7), in dry and calm conditions. Due to the high timidity of shrikes and the rather vague differences in colouration between the sexes (see Lefranc 2022), we did not determine the sex of the birds.

During the surveys, we also recorded two other shrike species: Long-tailed Shrike (*Lanius schach* Linnaeus, 1758;  $n = 27$ ) and Burmese Shrike (*Lanius collurioides* Lesson, 1832;  $n = 7$ ). Both were observed far less frequently than the Brown Shrike ( $n = 139$ ), and neither was seen interacting with the species. Owing to their low numbers and limited spatial overlap with our presence locations, they were not included in the habitat-association models but are reported here for the purpose of completeness.

#### Habitat data

For each shrike observation point ( $n = 139$ ), four pseudo-absence points were generated within a 1000-metre radius measured from the shrike observation location, one in each cardinal direction (north, east, south and west). These pseudo-absence points therefore served as background locations describing the range of available habitats in the surrounding landscape rather than as confirmed absences of the species. In many ecological studies, pseudo-absence points are generated when true absences are unavailable (Wisz & Guisan 2009; Marx & Quillfeldt 2018). From these four candidates, one pseudo-absence point was randomly selected for each presence point. The habitat characteristics were assessed within 100-m radius buffers around both the presence and pseudo-absence points. A 100-m buffer is widely used in fine-scale habitat-selection studies and is appropriate for species such as shrikes, which forage from fixed perches and typically use the nearby vegetation and open ground within short distances (Karlsson 2002; Morelli *et al.* 2015) (Fig. 1, Table 1). Within each buffer, the area of each of the following land-use categories (variable name in parentheses) was calculated: built-up areas (Build); roads, both unpaved and paved (Road); water surfaces including ponds and rivers (Water); rice fields (Rice); fallow land (Fallow); open habitat including pastures and other marginal farmland (Open); forests and woodlands (Forest). The number of scattered single shrubs and trees was counted (Tree). These factors were determined based on Google satellite images available through

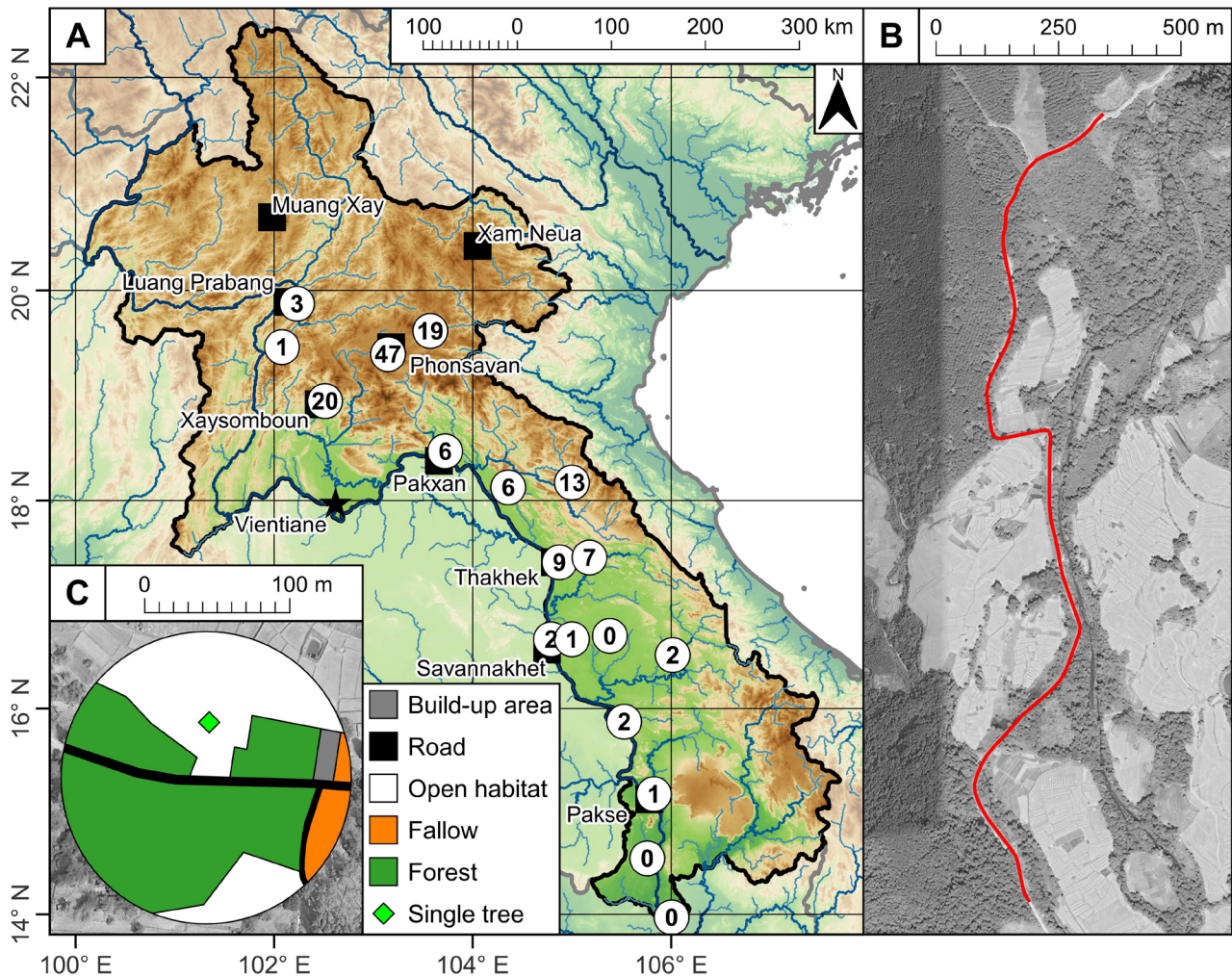


Fig. 1. Map of the study area in Laos (A) with an example site showing survey route (B) and habitat delineations (C) used in the analysis (created in QGIS 3.40.1-Brislava; URL <https://qgis.osgeo.org/>). White dots indicate clusters of Brown Shrike observations, with maximum distance threshold of 20 km between points (the number indicates the count of observations within each cluster), and black squares denote major cities. The following were used as backgrounds: A – Digital Elevation Model (DEM): “SRTM30 colored” by [terrestris.de](https://terrestris.de/) and NASA EOSDIS Land Processes Distributed Active Archive Center ([terrestris](https://terrestris.de/) 2024) and HydroRIVERS database (Lehner and Grill 2013), B and C – Google Earth Satellite.

the web map services (WMS). Two vegetation-related remote sensing indices were calculated: the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Moisture Index (NDMI). The NDVI provides insights into vegetation cover, biomass and photosynthetic activity (Meng *et al.* 2013), while the NDMI is indicative of the vegetation water content (Sankey *et al.* 2021). Both indices were calculated from single, Sentinel-2 Level-2A images, using spectral bands at a 10 m resolution (Copernicus Sentinel 2023). For each bird observation, we selected the individual cloud-free Sentinel-2 scene acquired closest to the observation date. The NDVI and NDMI values were then computed as the mean of all pixels within a 100-m buffer around the observation point. All geospatial analyses were conducted in QGIS 3.40.1 (QGIS Development Team 2024).

### Statistical analyses

Multicollinearity among the variables was checked before proceeding with the analysis. Collinearity was detected between the rice fields and other habitat types, as well as between remote sensing indices. The Rice (VIF = 250.8) and NDMI (VIF = 6.0) variables were omitted. No significant multicollinearity was found for the remaining variables (VIFs < 2.0). Generalised Linear Mixed Modelling (GLMM) with a binomial structure and a logit link function was employed to analyse the habitat associations of Brown Shrike detections during the non-breeding period. The recorded locations of the shrike presence (1) and pseudo-absence points (0) were treated as the dependent variables. The GLMM included seven continuous variables as fixed effects.



Table 1

Characteristics of variables describing Brown Shrike habitat and random sites. Values are presented as mean  $\pm$  SD (Range)

Variable	Abbreviation	Brown Shrike present (n = 139)	Random sites (n = 139)
Built-up areas (ha)	Build	0.03 $\pm$ 0.12 (0-1.19)	0.10 $\pm$ 0.38 (0-2.94)
Roads (ha)	Road	0.08 $\pm$ 0.05 (0-0.20)	0.04 $\pm$ 0.06 (0-0.24)
Water surface (ha)	Water	0.04 $\pm$ 0.10 (0-0.77)	0.05 $\pm$ 0.12 (0-0.88)
Rice fields (ha)	Rice	1.07 $\pm$ 1.07 (0-3.14)	0.75 $\pm$ 1.01 (0-3.14)
Fallows (ha)	Fallow	0.55 $\pm$ 0.75 (0-2.83)	0.47 $\pm$ 0.75 (0-3.14)
Open habitat (ha)	Open	0.84 $\pm$ 1.09 (0-3.14)	0.52 $\pm$ 0.88 (0-3.14)
Forest and woodland (ha)	Forest	0.54 $\pm$ 0.69 (0-3.01)	1.19 $\pm$ 1.17 (0-3.14)
Number of single trees (n)	Tree	3.87 $\pm$ 4.83 (0-30)	2.17 $\pm$ 3.92 (0-20)
Normalized difference vegetation index (average value)	NDVI	0.28 $\pm$ 0.06 (0.16-0.51)	0.33 $\pm$ 0.11 (0.11-0.6)
Normalized difference water index (average value)	NDMI	-0.069 $\pm$ 0.065 (-0.2-0.16)	-0.001 $\pm$ 0.107 (-0.18-0.25)

Interaction terms were not considered, as habitat-cover variables are structurally interdependent and such interactions would be difficult to interpret ecologically. All the sampling locations were grouped into clusters, using a maximum distance threshold of 20 km between points. This resulted in 15 clusters (Fig. 1), which were incorporated into the model as a random factor (1 | Cluster). The random effect variance estimate was low (see the results); however, the model was not classified as singular. Thus, the random effect was retained in the final model. Models were run using the glmer function in the lme4 package (Bates *et al.* 2015). Sets of all possible combinations of the global models were computed using the MuMIn package (Bartoń 2023). The model selection followed an information-theoretic framework using the Akaike Information Criterion (AIC), its small-sample correction (AICc) and Akaike weights (AICwt). Models with  $\Delta\text{AIC} \leq 2$  were considered as equally supported (Burnham & Anderson, 2002). The R-square for models from the candidate model sets was calculated as R-square Nakagawa, as implemented in the MuMIn package (Nakagawa *et al.* 2017). No overdispersion was detected in the final model (DHARMA dispersion test: dispersion = 1.00,  $p = 0.94$ ). All statistical analyses were performed in R Studio (R Core Team 2023).

## Results

Six models were included in the set with  $\Delta\text{AICc} < 2$  (Table 2, see also Table S1 and Fig. S1). By sum-

ming the Akaike weights of all models containing the main predictor in the set of competing models, the most important explanatory variables were distinguished. Modelling of the factors determining Brown Shrike occurrences revealed that the importance of built-up areas, roads and forest cover had the highest values (1.00). In contrast, the importance of other predictors was lower: NDVI (0.23), area of water bodies (0.15), fallow area (0.14) and number of trees (0.14). The best model contained the same three variables that had the highest importance values and explained 34% of the variation in Brown Shrike detections, as estimated by both the marginal and conditional  $R^2$  statistics for the GLMM (Table 3). The road area recorded within circular plots was positively associated with Brown Shrike detections, indicating that birds were more frequently recorded where the area of roads was greater. Conversely, forest cover showed a significant negative association with shrike detections. Built-up areas were also negatively associated with shrike detections, with very few records occurring where the area of the built-up habitat exceeded 1 ha.

## Discussion

Our study showed that non-breeding Brown Shrikes in Laos were most frequently recorded in areas with a higher road density, reduced forest cover and a lower proportion of built-up areas compared with the background locations. These patterns suggest an association with semi-open habitats and indicate that

Table 2

Ranking of candidate GLMMs ( $\Delta\text{AICc} < 2$ ) showing habitat factors associated with Brown Shrike detections during the non-breeding period in Laos. Abbreviations: df – degrees of freedom, LL – log-likelihood, AICc – corrected AIC,  $\Delta\text{AICc}$  – AIC difference, AICwt – model weight,  $R^2\text{m}$  – marginal  $R^2$  (fixed effects),  $R^2\text{c}$  – conditional  $R^2$  (fixed + random effects)

Model (fixed effects)	df	LL	AICc	$\Delta\text{AICc}$	AICwt	$R^2\text{m}$	$R^2\text{c}$
Intercept + Build + Forest + Road	5	-156.084	322.4	0.00	0.140	0.336	0.293
Intercept + Build + Forest + Road + NDVI	6	-155.264	322.8	0.45	0.112	0.351	0.308
Intercept + Build + Forest + Road + Water	6	-155.828	324.0	1.58	0.064	0.336	0.294
Intercept + Build + Forest + Road + Trees	6	-155.835	324.0	1.59	0.063	0.341	0.299
Intercept + Build + Forest + Road + Fallow	6	-155.876	324.1	1.67	0.061	0.339	0.297
Intercept + Build + Forest + Road + NDVI + Water	7	-154.958	324.3	1.94	0.053	0.351	0.309

Table 3

Model coefficients for the best GLMM describing associations between habitat variables and Brown Shrike detections during the non-breeding period in Laos

Fixed effects	Estimate	SE	z value	p value
Intercept	-0.054	0.246	-0.218	0.827
Road	13.754	2.594	5.302	0.005
Forest	-0.780	0.168	-4.641	< 0.001
Build	-2.646	0.942	-2.808	< 0.001

the species can persist in human-modified environments when suitable structural features are present.

The positive association with roads should be interpreted with some caution because the survey routes followed existing paths and tracks, which may have increased the probability of detecting birds near these linear features. Nevertheless, roadside structures are widely used by shrikes as foraging sites, as is corroborated by earlier research (Severinghaus 1996). Features that occur along the road corridor, such as fences, single shrubs, utility poles or tall weeds, provide elevated perches for prey detection by the birds. Local and unpaved roads may also create open strips of ground that enhance visibility; such behaviour is well documented in the Red-backed Shrike (*Lanius collurio* Linnaeus, 1758) (Morelli 2013; Morelli *et al.* 2015). This is aligned with the species' 'sit-and-wait' hunting strategy from elevated perches, a foraging mode that is widely characteristic of shrike species, including the Brown Shrike (Severinghaus & Liang 1995; Yosef 2004). Shrike species favour grasslands when perch sites are available (Morelli *et al.* 2015), while densely forested areas lack the open structure they need for efficient foraging (Soobramoney *et al.* 2004; Golawski & Kasprzykowski 2018). The lim-

ited use of built-up areas by the Brown Shrike likely reflects a combination of sensitivity to human disturbance and elevated anthropogenic risk. In Laos, birds are frequently trapped or shot in agricultural and peri-urban settings (Xayyasith *et al.* 2020), which may lead individuals to avoid these areas or to reduce their usage. These patterns indicate that, despite ecological generalism, the Brown Shrike tends to occur along structural and disturbance gradients that are typical of shrike species (Brambilla *et al.* 2017) and is less frequently recorded in areas dominated by infrastructure.

Although common and not of conservation concern, the Brown Shrike's predictable response to the habitat structure may make it a useful indicator for studying landscape filtering in agroecosystems. While urbanisation or agricultural simplification can degrade these systems, retaining vegetated margins, isolated trees or unmanaged roadside vegetation may preserve essential habitat elements for shrikes and other open-habitat insectivores (Brambilla *et al.* 2009; Morelli 2013). The non-breeding habitat quality is critical for the condition of breeding individuals and population dynamics in migratory passerines (Sherry & Holmes 1996; Newton 2007). Maintaining mosaic landscapes with open areas and sparse roadside vegetation is therefore important, and the conversion to urban areas or monocultures like rice or cassava should be minimised in order to preserve ecological complexity and overall biodiversity (Kehoe *et al.* 2017). Given the species' high winter site fidelity (Takagi 2003), maintaining optimal habitat conditions is crucial. Thus, road development and urban planning should adopt biodiversity-friendly measures, such as retaining shrubs, trees and small vegetated patches along roadsides, thereby benefiting not only Brown Shrikes but also other species with similar requirements.

Although Southeast Asia faces rapid land-use changes and biodiversity losses (Sodhi *et al.* 2010), maintaining mosaic landscapes can support diverse wildlife communities (Foster *et al.* 2011). Conservation frameworks should integrate species-specific habitat requirements into regional planning, so as to mitigate habitat loss and degradation (Fischer & Lindenmayer 2007; van Strien *et al.* 2018). While the priority should be given to the most threatened species and habitats, particularly tropical forests (Hughes 2017; Atikah *et al.* 2025), common species like the Brown Shrike can also serve as indicators of an ecosystem's health.

Although this study provides important insights into the habitat associations of the Brown Shrike, it has certain limitations. Each survey route was visited only once, and therefore the results should be interpreted as patterns of habitat association rather than as definitive evidence of habitat preferences. The use of satellite imagery, while providing valuable broad-scale data, limits the resolution of the habitat analysis, particularly for fine-scale features that are crucial for many bird species, including shrub- and perch-dependent taxa (Gottschalk *et al.* 2005). Moreover, focusing solely on Laos restricts the generalisability of our findings across the expansive non-breeding range of the species. Future research should be expanded to include other countries within the Brown Shrike's non-breeding range and the study period should be extended, as well as including other bird species, such as additional shrike species. Insights from other *Lanius* species, such as the Great Grey Shrike (*Lanius excubitor* Linnaeus, 1758) (Kuczyński *et al.* 2009), show the importance of a wider geographic coverage. Studies on prey availability, microhabitat features and seasonal changes would also refine the understanding of the species' needs. In addition, the relatively short survey period, conducted in April–May, provides only a snapshot of the habitat usage during the non-breeding season, and longer-term studies covering a broader part of the annual cycle would allow for a better understanding of temporal variations in the habitat usage by shrikes and other migratory species (Zwarts *et al.* 2023). Despite these limitations, the study provides useful insight into the landscape features associated with Brown Shrike detections in the human-modified environments of Southeast Asia and offers a baseline for more detailed future studies to be conducted across a broader temporal and spatial scale.

## Conclusions

Brown Shrikes were frequently recorded in human-modified environments, especially open and semi-natural agricultural mosaics. However, these habitats are vulnerable to urbanisation, agricultural intensification and infrastructure expansion. Regional planning should aim to preserve key structural features in order to support adaptable, functionally important species. Incorporating such ecological knowledge into land-use policy can promote coexistence between human development and biodiversity, benefiting the Brown Shrike as well as other generalist and migratory birds in Southeast Asia.

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## Author Contributions

Research concept and design: A.G., S.X., Z.K.; Collection and/or assembly of data: A.G., C.M., Z.K.; Data analysis and interpretation: P.O.; Writing the article: A.G., C.M., P.O., S.X., Z.K.; Critical revision of the article: A.G., C.M., P.O., S.X., Z.K.; Final approval of the article: A.G., C.M., P.O., S.X., Z.K.

## Conflict of Interest

The authors declare no conflict of interest.

## Supplementary Materials

Supplementary Materials to this article can be found online at:

<http://www.isez.pan.krakow.pl/en/fovia-biologica.html>

Supplementary files:

SM.01. Supplementary materials\_Table S1. Full

set of candidate GLMM models and  $\Delta\text{AICc}$  values.  
xlsx

SM.02. Supplementary materials\_Fig. S1. Univariate\_plots.docx

## References

- Atikah S.N., Yahya M.S., Ong K.W., Sanusi R., Norhisham A.R., Azhar B. 2025. Continuous forests and non-IBA forest patches provide a safe haven for the tropical bird community in highly fragmented urban landscapes. *Biodivers. Conserv.* **34**: 971-986. <https://doi.org/10.1007/s10531-024-03004-7>
- Azhar B., Lindenmayer D.B., Wood J., Fischer J., Manning A., McElhinny C., Zakaria M. 2013. The influence of agricultural system, stand structural complexity and landscape context on foraging birds in oil palm landscapes. *Ibis* **155**: 297-312. <https://doi.org/10.1111/ibi.12025>
- Bartoń K. 2023. MuMIn: Multi-model inference. R package version 1.47.5. <https://cran.r-project.org/web/packages/MuMIn/>. (last accessed on 23 March 2023).
- Bates D., Maechler M., Bolker B., Walker S. 2015. Fitting linear mixed-effects models using lme4. *J. Stat. Softw.* **67**: 1-48. <https://doi.org/10.18637/jss.v067.i01>
- Bhagwat T., Rufin P., Kuemmerle T., Kamp, J. 2025. Landscape composition drives winter bird assemblages in agriculture-savanna mosaics of western India. *Ecol. Appl.* **35**: e70016. <https://doi.org/10.1002/eap.70016>
- BirdLife International 2025. Species factsheet: Brown Shrike *Lanius cristatus*. <https://datazone.birdlife.org/species/factsheet/brown-shrike-lanius-cristatus> (last accessed on 10 January 2025).
- Brambilla M., Casale F., Bergero V., Crovetto G.M., Falco R., Negri I., Siccardi P., Bogliani G. 2009. GIS-models work well, but are not enough: Habitat preferences of *Lanius collurio* at multiple levels and conservation implications. *Biol. Conserv.* **142**: 2033-2042. <https://doi.org/10.1016/j.biocon.2009.03.033>
- Brambilla M., Gustin M., Fulco E., Sorace A., Celada C. 2017. Coarse landscape features predict occurrence, but habitat selection is driven by specific habitat traits: implications for the conservation of the threatened Woodchat Shrike *Lanius senator*. *Bird. Conserv. Int.* **27**: 58-70. <https://doi.org/10.1017/S0959270916000034>
- Burnham K.P., Anderson D.R. 2002. Model selection and multi-model inference. Springer, New York. <https://doi.org/10.1007/b97636>
- Copernicus Sentinel. 2023. Retrieved from <https://browser.dataspace.copernicus.eu> (last accessed on 29 September 2023).
- Cosslett T.L., Cosslett P.D. 2018. The Setting of Mainland Southeast Asian Countries: Cambodia, Laos, Thailand, and Vietnam. In: Sustainable Development of Rice and Water Resources in Mainland Southeast Asia and Mekong River Basin. Springer, Singapore. [https://doi.org/10.1007/978-981-10-5613-0\\_2](https://doi.org/10.1007/978-981-10-5613-0_2) (last accessed on 15 January 2025).
- DeFries R.S., Rudel T., Uriarte M., Hansen M. 2010. Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nat. Geosci.* **3**: 178-181. <https://doi.org/10.1038/ngeo756>
- Fischer J., Lindenmayer D.B. 2007. Landscape modification and habitat fragmentation: a synthesis. *Global Ecol. Biogeogr.* **16**: 265-280. <https://doi.org/10.1111/j.1466-8238.2007.00287.x>
- Foster W.A., Snaddon J.L., Turner E.C., Fayle T.M., Cockerill T.D., Ellwood M.D.F., Broad G.R., Chung A.Y.C., Eggleton P., Khen C.V., Yusah K.M. 2011. Establishing the evidence base for maintaining biodiversity and ecosystem function in the oilpalm landscape of South East Asia. *Philos. Trans. R. Soc.* **366**: 3277-3291. <https://doi.org/10.1098/rstb.2011.0041>
- Golawski A., Kasprzykowski Z. 2018. Comparative foraging behaviour of three species of shrike in southern Africa. *Afr. Zool.* **53**: 69-74. <https://doi.org/10.1080/15627020.2018.1493704>
- Gottschalk T.K., Huettmann F., Ehlers M. 2005. Thirty years of analyzing and modeling avian habitat relationships using satellite imagery data: a review. *Int. J. Remote Sens.* **26**: 2631-2656. <https://doi.org/10.1080/01431160512331338041>
- Hakim L., Abdoellah O.S., Parikesit, Withaningsih S. 2020. Impact of agricultural crop type and hunting on bird communities of two villages in Bandung, West Java, Indonesia. *Biodiversitas* **21**: 57-66. <https://doi.org/10.13057/biodiv/d210109>
- Hughes A.C. 2017. Understanding the drivers of Southeast Asian biodiversity loss. *Ecosphere* **8**: e01624. <https://doi.org/10.1002/ecs2.1624>
- Karlsson S. 2002. Analyses on prey composition of overwintering Great Grey Shrikes *Lanius excubitor* in southern Finland. *Ornis Fenn.* **79**: 181-189. <https://ornisfennica.journal.fi/article/view/133585>
- Kehoe L., Romero-Muñoz A., Polaina E., Estes L., Kreft H., Kuemmerle T. 2017. Biodiversity at risk under future cropland expansion and intensification. *Nat. Ecol. Evol.* **1**: 1129-1135. <https://doi.org/10.1038/s41559-017-0234-3>
- Kitazawa M., Senzaki M., Matsumiya H., Hara S., Mizumura H. 2022. Drastic decline in the endemic brown shrike subspecies *Lanius cristatus superciliosus* in Japan. *Bird Conserv. Int.* **32**: 78-86. <https://doi.org/10.1017/S0959270920000556>



- Koh L.P. 2008. Birds defend oil palms from herbivorous insects. *Ecol. Appl.* **18**: 821-825. <https://doi.org/10.1890/07-1650.1>
- Kuczyński L., Rzępała M., Golawski A., Tryjanowski P. 2009. The wintering distribution of Great Grey Shrike *Lanius excubitor* in Poland: predictions from a large-scale historical survey. *Acta Ornithol.* **44**: 159-166. <https://doi.org/10.3161/000164509X482731>
- Lambert F.R., Collar N.J. 2002. The future for Sundaic lowland forest birds: long-term effects of commercial logging and fragmentation. *Forktail* **18**: 127-146.
- Lefranc N. 2022. *Shrikes of the World*. Bloomsbury Publishing, London.
- Marx M., Quillfeldt P. 2018. Species distribution models of European Turtle Doves in Germany are more reliable with presence only rather than presence absence data. *Sci. Rep.* **8**: 16898. <https://doi.org/10.1038/s41598-018-35318-2>
- Meng J.H., Du X., Wu B.F. 2013. Generation of high spatial and temporal resolution NDVI and its application in crop biomass estimation. *Int. J. Digit. Earth* **6**: 203-218. <https://doi.org/10.1080/17538947.2011.623189>
- Messerli P., Heinemann A., Epprecht M. 2009. Finding homogeneity in heterogeneity – a new approach to quantifying landscape mosaics developed for the Lao PDR. *Hum. Ecol.* **37**: 291-304. <https://doi.org/10.1007/s10745-009-9238-1>
- Morelli F. 2013. Are the nesting probabilities of the red-backed shrike related to proximity to roads? *Nat. Conserv.* **5**: 1-11. <https://doi.org/10.3897/natureconservation.5.4511>
- Morelli F., Mróz E., Pruscini F., Santolini R., Goławski A., Tryjanowski P. 2015. Habitat structure, breeding stage and sex affect hunting success of breeding Red-backed Shrike (*Lanius collurio*). *Ethol. Ecol. Evol.* **28**: 136-147. <https://doi.org/10.1080/03949370.2015.1022907>
- Nakagawa S., Johnson P.C.D., Schielzeth H. 2017. The coefficient of determination  $R^2$  and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. *J. R. Soc. Interface* **14**: 20170213. <https://doi.org/10.1098/rsif.2017.0213>
- Newton I. 2007. Population limitation – breeding and wintering areas. In: Newton I. (ed.). *The Migration Ecology of Birds*. Elsevier, London: 751-75.
- Phongoudome C., Sirivong K. 2007. Forest restoration and rehabilitation in Lao PDR. *Keep Asia Green* **1**: 57-84.
- R Core Team. 2023. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.
- QGIS Development Team. 2024. *QGIS Geographic Information System*. Open Source.
- Sankey T., Belmonte A., Massey R., Leonard J. 2021. Regional-scale forest restoration effects on ecosystem resiliency to drought: a synthesis of vegetation and moisture trends on Google Earth Engine. *Remote Sens. Ecol. Conserv.* **7**: 259-274. <https://doi.org/10.1002/rse2.186>
- Severinghaus L.L. 1996. Territory strategy of the migratory Brown Shrike *Lanius cristatus*. *Ibis* **138**: 460-465. <https://doi.org/10.1111/j.1474-919X.1996.tb08065.x>
- Severinghaus L.L., Liang C.T. 1995. Food and foraging behavior of the Brown Shrike *Lanius cristatus* in Taiwan. *Proc. West. Found. Vertebr. Zool.* **6**: 194-199.
- Sherry T.W., Holmes R.T. 1996. Winter habitat quality, population limitation, and conservation of Neotropical-Nearctic migrant birds. *Ecology* **77**: 36-48. <https://doi.org/10.2307/2265652>
- Sodhi N.S., Posa M.R.C., Lee T.M., Bickford D., Koh L.P., Brook B.W. 2010. The state and conservation of Southeast Asian biodiversity. *Biodivers. Conserv.* **19**: 317-328. <https://doi.org/10.1007/s10531-009-9607-5>
- Soobramoney S., Downs C.T., Adams N.J. 2004. Variability in foraging behaviour and prey of the Common Fiscal Shrike, *Lanius collaris*, along an altitudinal gradient in South Africa. *Ostrich* **75**: 133-140. <https://doi.org/10.2989/00306520409485424>
- Takagi M. 2003. Philopatry and habitat selection in Bull-headed and Brown shrikes. *J. Field Ornithol.* **74**: 45-52. <https://doi.org/10.1648/0273-8570-74.1.45>
- Tan Y.L., Chen J.E., Yiew T.H., Habibullah M.S. 2022. Habitat change and biodiversity loss in South and Southeast Asian countries. *Environ. Sci. Pollut. Res.* **29**: 63260-63276. <https://doi.org/10.1007/s11356-022-20054-y>
- van Strien M.J., Axhausen K.W., Dubernet I., Guisan A., Grêt-Regamey A., Khiali-Miab A., Ortiz-Rodríguez D.O., Holdegger R. 2018. Models of Coupled Settlement and Habitat Networks for Biodiversity Conservation: Conceptual Framework, Implementation and Potential Applications. *Front. Ecol. Evol.* **6**: 41. <https://doi.org/10.3389/fevo.2018.00041>
- Wisn M.S., Guisan A. 2009. Do pseudo-absence selection strategies influence species distribution models and their predictions? An information-theoretic approach based on simulated data. *BMC Ecol.* **9**: 8. <https://doi.org/10.1186/1472-6785-9-8>
- Xayyasith S., Douangboubpha B., Chaiseha Y. 2020. Recent surveys of the bird trade in local markets in Central Laos. *Forktail* **36**: 47-55.
- Yang C., Liu H., Li Q., et al. 2022. Human expansion into Asian highlands in the 21st century and its effects. *Nat. Commun.* **13**: 4955. <https://doi.org/10.1038/s41467-022-32648-8>
- Yong D.L., Liu Y., Low B.W., Española C.P., Choi C.-Y., Kawakami K. 2015. Migratory songbirds in the East Asian-

- Australasian Flyway: a review from a conservation perspective. *Bird Conserv. Int.* **25**: 1-37.  
<https://doi.org/10.1017/S0959270914000276>
- Yosef R. 2004. Perch-site use and inter- and intraspecific aggression of migratory Brown Shrikes (*Lanius cristatus*) in Southern Taiwan. *Biol. Lett.* **41**: 113-118.
- Zwarts L., Bijlsma R.G., Van Der Kamp J. 2023. Seasonal shifts in habitat choice of birds in the Sahel and the importance of 'refuge trees' for surviving the dry season. *Ardea* **111**: 227-250.  
<https://doi.org/10.5253/arde.2022.a23>