

Mapping the Indian Pangolin: Distribution, Habitat, and Conservation Priorities in Punjab, Pakistan

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Abstract: The Indian pangolin (*Manis crassicaudata*) is the only pangolin species native to Pakistan and is currently classified as Endangered on the IUCN Red List, primarily due to illegal hunting for its keratin scales and meat. This review synthesizes field-based evidence on the distribution, habitat use, and burrow ecology and conservation status of the species across Punjab province against comparable reference sites in Khyber Pakhtunkhwa and Azad Jammu and Kashmir, with particular depth of coverage for the well-studied Potohar Plateau districts of Chakwal, Rawalpindi, Jhelum, Attock and Gujrat. Estimated densities of individuals across Potohar landscapes are still low, generally 0.26-0.37 individuals per square kilometer, a pattern reflecting ongoing poaching pressure and habitat fragmentation. However, densities in the reference region elsewhere in northern Pakistan vary much more widely, from below 0.02 to nearly 0.8 individuals per square kilometre, cautioning against taking the Potohar figures as broadly representative. To date, no dedicated field ecological survey has been conducted in the central and southern districts of Punjab, including Faisalabad, Multan, Bahawalpur, and Dera Ghazi Khan. A recent province-comparative mortality study that extends questionnaire-based data collection to several districts of Punjab (Ahmad & Li, 2024) narrows but does not close this evidence gap. Habitat suitability modelling indicates that elevation, soil composition, vegetation density, and proximity to water are the strongest predictors of pangolin occurrence, and that suitable habitat is likely to contract and shift under future climate scenarios. Cultural misconceptions and inconsistent institutional enforcement continue to undermine conservation outcomes despite the species' legal protection under CITES Appendix I and Pakistan's wildlife legislation. The review concludes that province-wide baseline field surveys, extension of illegal-trade-route mapping and ensemble habitat modelling into Punjab, stricter and better-coordinated enforcement, and community-based monitoring are the most urgent priorities for securing the species' long-term persistence in the province.

Key words: *Manis crassicaudata*; Punjab; habitat suitability; poaching; burrow ecology; conservation; Potohar Plateau; MaxEnt modelling

INTRODUCTION

Pangolins (order Pholidota, family Manidae) are the only mammals whose bodies are covered in overlapping keratinous scales, a trait that has made them, collectively, among the most heavily trafficked wild mammals in the world (Heinrich et al., 2016; Challender, 2011). Of the eight extant species, four occur in Asia and four in Africa; all eight were transferred to CITES Appendix I in 2017, prohibiting international commercial trade in wild-sourced specimens.

The Indian pangolin (*Manis crassicaudata*) is the only pangolin species native to Pakistan (Mahmood et al., 2015). A solitary, largely nocturnal, fossorial insectivore lacks teeth entirely, relying on a long, sticky, protractible tongue and powerful fore claws to exploit subterranean ant and termite colonies. Its cryptic, burrow-dependent habits mean that direct sightings are rare, and population data are consequently derived almost entirely from indirect sign, burrows, scratch marks, and scat, rather than direct counts (Waseem et al., 2020a). Its scales, superficially similar to those of the other, more heavily trafficked Asian pangolin species, have made it a target of both domestic consumption and international illegal wildlife trade (Waseem et al., 2020b; Challender, 2011; Heinrich et al., 2016).

Historically, the species was recorded across all four provinces of Pakistan, including the length of Punjab from the Potohar Plateau in the north to districts bordering Sindh in the south (Roberts, 1997). Punjab is therefore, in principle, a major part of the species' national range. In practice, however, published field research on the Indian

pangolin in Pakistan has concentrated almost entirely on a cluster of Potohar Plateau districts around Islamabad and Rawalpindi, where semi-arid scrubland, thorn forest, and the margins of agricultural land provide loamy soils that support the ant and termite colonies on which the species feeds (Mahmood et al., 2012, 2014, 2016, 2017; Irshad et al., 2015; Waseem et al., 2020a).

This concentration of research effort more plausibly reflects proximity to research institutions in Islamabad and Rawalpindi than any confirmed absence of the species elsewhere in the province, and it leaves most of Punjab's land area without a documented, field-verified conservation status. This review synthesizes the available field-based literature on the Indian pangolin's distribution, habitat associations, burrow ecology, and threats across Punjab and adjoining reference regions; critically evaluates the strength and limits of the existing evidence base, rather than treating it as uniformly representative of the whole province; and sets out research and conservation priorities appropriate to a province in which most of the land area remains, ecologically speaking, unsurveyed for this species (Yasmeen et al., 2021).

Geographical and Ecological Context of Punjab

Punjab has a gradient from the dry sub-tropical hills of the Potohar Plateau and Salt Range in the north, via heavily irrigated agricultural plains in the central districts, to the semi-arid and arid areas of southern Punjab bordering Sindh and Balochistan. All published Indian pangolin research in the province has been concentrated on the Potohar Plateau, a region of dissected loess-covered hills, seasonal streams,

and a mosaic of scrub forest, rain-fed cultivation and grazing land, where loamy, readily excavated soils combine with a comparatively high density of ant and termite prey (Mahmood et al., 2013, 2014).

Conversely, central Punjab is an area of canal-irrigated, well-cultivated agriculture with relatively little uncultivated scrub, whereas the southern districts bordering the Cholistan and Thal deserts are more parched and sandy. Whether these differences in soil type, cultivation intensity, and vegetation cover translate into genuinely lower pangolin occupancy in central and southern Punjab, or simply reflect where field researchers have concentrated their effort, is a question this review is not yet able to resolve with the evidence currently available, and it is treated here as a research priority rather than an established conclusion.

Taxonomy and General Biology of the Indian Pangolin

The Indian pangolin belongs to the order Pholidota, family Manidae, and genus *Manis*, which comprises the four extant Asian pangolin species: the Indian pangolin (*M. crassicaudata*), the Chinese pangolin (*M. pentadactyla*), the Sunda pangolin (*M. javanica*), and the Philippine pangolin (*M. culionensis*) (Roberts, 1997). *Manis crassicaudata* was first described by Geoffroy Saint-Hilaire in 1803 and is distinguished from its Asian congeners chiefly by its larger body size and proportionally larger, fewer scale rows. No subspecies are currently recognized as valid across its range, which spans Pakistan, India, Nepal, Bhutan, and Sri Lanka.

Pangolins are unique among mammals in being entirely covered, dorsally and laterally, by overlapping keratinous scales that also form their principal antipredator defence: when threatened, an individual curls into a tight ball, presenting only scaled surfaces to a would-be predator. *Manis crassicaudata* is edentulous, relying on a long, muscular, protrusible tongue, anchored deep in the pelvic region, together with powerful, curved fore claws, to excavate ant and termite colonies; a muscular, keratin-lined stomach substitutes for chewing (Mahmood et al., 2015; Roberts, 1997). The species is predominantly nocturnal and solitary outside the breeding season, sheltering within burrows through the day and foraging at night. Field data from the Potohar Plateau indicate a breeding season concentrated between July and October, with individual burrows showing distinct structural and site-selection characteristics linked to reproductive activity, though comprehensive, population-level reproductive parameters for Punjab as a whole remain limited (Mahmood et al., 2016).

Ecologically, the species performs a pest-regulation role by consuming large quantities of soil-dwelling insects, a service that plausibly benefits agricultural productivity in the farmland surrounding its burrows, although this co-benefit has not, to our knowledge, been directly quantified for Punjab and should be treated as a reasonable ecological inference rather than a measured outcome.

Historical and Current Distribution in Punjab

Field surveys report Indian pangolin presence across several northern Punjab districts, most notably Chakwal, Jhelum, Attock, Rawalpindi, and Gujrat, alongside Margalla

Hills National Park at the province's northern edge (Mahmood et al., 2014; Waseem et al., 2020a). Systematic transect surveys covering the full extent of Chakwal district recorded pangolin sign along road transects in all five tehsils, confirming a wide but patchy distribution (Irshad et al., 2015). Comparable field densities have also been reported from the agricultural fringes of Bhakkar and Layyah districts, extending confirmed field records along the southwestern edge of the Potohar region.

Surveys conducted outside Punjab in Kohat, Malakand, Buner, Mansehra, and Nowshera districts of Khyber Pakhtunkhwa, as well as in Pir Lasura National Park in Azad Jammu and Kashmir, reveal a generally analogous trend of sparse, fragmented habitation throughout northern Pakistan (Muhammad et al., 2020; Akrim et al., 2017; Khattak et al., 2024). Population densities observed in these contiguous areas fluctuate significantly, ranging from an approximate 0.013 individuals per square kilometre in Nizampur National Park, Nowshera district, which represents some of the lowest field-based densities documented for the species, to about 0.77 individuals per square kilometre in Pir Lasura National Park (Khattak et al., 2024; Akrim et al., 2017). This more-than-fiftyfold range illustrates that occupancy in apparently similar semi-arid habitat can vary enormously with local conditions and survey method, a caution against treating the Potohar figures as broadly representative of northern Pakistan as a whole.

For most of Punjab south of the Potohar Plateau, dedicated field ecological surveys, using burrow counts, sign transects, or camera-trapping, remain unpublished. The clearest partial exception is a recent province-comparative mortality study that collected questionnaire- and social-media-based records from four Punjab districts alongside four Khyber Pakhtunkhwa districts between 2019 and 2022, documenting 59 recorded pangolin deaths in Punjab against 179 in Khyber Pakhtunkhwa over the same period (Ahmad & Li, 2024). This study demonstrates that indirect, community-sourced evidence of the species' presence, and of its ongoing killing, extends into districts beyond the core Potohar research sites. It cannot, however, substitute for a systematic ecological assessment, since it relies on interview and social-media data rather than field sign-surveys, and the identity and representativeness of the specific Punjab districts sampled is not established in the sources available for this review. No peer-reviewed, field-based ecological survey of the kind conducted in Chakwal, Rawalpindi, or the Khyber Pakhtunkhwa reference districts has yet been published for Faisalabad, Sargodha, Gujranwala, Sialkot, Multan, Bahawalpur, Dera Ghazi Khan, Rajanpur, or the other districts of central and southern Punjab, despite the species' historically documented range extending across the whole province (Roberts, 1997). Figure 1 maps the approximate locations of confirmed field-survey sites alongside this data-gap zone, and Table 2 summarizes data availability by region.

Habitat Associations and Ecological Requirements

Indian pangolins in the Potohar Plateau show a strong documented preference for semi-arid thorn forest, scrubland, and agricultural fringes with loamy or sandy soils that are easy to excavate (Mahmood et al., 2015).

Vegetation associated with occupied sites were dominated by *Acacia modesta*, *Dalbergia sissoo*, and *Pinus roxburghii*, reflecting a mixed shrub-tree cover that also supports high densities of ants and termites (Mahmood et al., 2015, 2013). Moderate canopy cover sites tend to be preferred above both fully open land and dense, closed canopy forest, perhaps balancing thermal cover with ease of movement, although this exact trade-off has not been experimentally studied. In the Potohar studies analysed, occupancy is highly correlated with elevation, with most of the Punjab records being found at around 400-1300 meters above sea level and near to permanent sources of water (Qasim et al., 2024). A broadly similar elevational range, from about 300 to 1750 meters depending on local terrain, has been reported for reference populations in Khyber Pakhtunkhwa and Azad Jammu and Kashmir (Akrim et al., 2017; Khattak et al., 2024), suggesting a genuinely conserved ecological niche rather than an artefact confined to Potohar survey effort, although this inference remains untested for Punjab's central and southern districts, where elevation and soils differ substantially from the Potohar hills.

The species' documented ecological role in regulating soil insect populations means that its local decline could plausibly have knock-on effects for pest regulation in the farmland surrounding its burrows. This remains, at present, a reasonable ecological inference drawn from its diet rather than a measured outcome anywhere in Punjab, and should be presented to policymakers as a plausible co-benefit of conservation rather than an established one.

Burrow Ecology and Behavioural Characteristics

Indian pangolins construct two structurally distinct burrow types: shallow, temporary feeding burrows dug in pursuit of termite colonies, and deeper, more permanent sleeping burrows used for shelter and breeding (Mahmood et al., 2015). Feeding tunnels in Chakwal and Margalla Hills averaged around 35 centimeters deep; however, sleeping burrows were over a meter deep, suggesting a role in thermoregulation and predator avoidance (Mahmood et al., 2016). Table 3 summaries the main structural differences between the two types of burrows.

Sleeping burrows are usually found beneath dense thickets or near termite mounds, and their use seems to be extremely habitat selective except during the breeding season, which on the Potohar Plateau lasts roughly from July to October (Mahmood et al., 2016). The high fidelity to burrow sites makes the species vulnerable to habitat change: even localised clearance of thicket cover can make an otherwise good location unfit for an individual that may have used the same burrow complex for numerous seasons. Breeding activity has been linked to specific burrow characteristics on the Potohar Plateau, suggesting that burrow ecology should be considered a separate conservation target rather than a secondary habitat feature (Mahmood et al., 2016). In areas where enforcement resources are limited, protecting known burrow clusters in addition to broad habitat types may provide a more targeted intervention, although this has not yet been tested as a management strategy in Punjab.

Population Status and Conservation Status

The Indian pangolin was last assessed for the IUCN Red List in 2019 and it remained classified as Endangered; interestingly, this global assessment was co-authored by the same Pakistani researcher, whose Potohar Plateau fieldwork underpins much of the present review, highlighting the close link between Pakistani field data and the species' international status (Mahmood et al., 2019). The species is listed under CITES Appendix I that prohibits international commercial trade and its protected status under national legislation in Pakistan, although the precise schedule and its enforcement varies somewhat by province, should be verified against the current text of the relevant wildlife acts before this manuscript is finalised (Muhammad et al., 2024).

However, enforcement at ground level is patchy and there is no protected area in Punjab that is dedicated only to the conservation of the Indian pangolin. Existing protected areas like Chinji National Park overlap with adequate pangolin habitat in Chakwal district, but do not offer direct, species-specific management strategies (Safi & Varriano, 2024). This disconnect between official legal status and on-the-ground management capacity is a recurring theme in the larger South Asian pangolin literature, and is not unique to Pakistan (Mohapatra et al., 2015).

Regional assessments indicate the limited practical effect of existing legal prohibitions because of poor trans-boundary cooperation and the ongoing commerce in traditional medicine (Yasmeen et al., 2021; Challender et al., 2015). Almost all recent assessments of the species in Pakistan have cited strengthening the link between legal status and on-ground enforcement, and extending survey and protection effort into central and southern Punjab as priorities.

Threats to the Indian Pangolin in Punjab

In Punjab, the greatest regularly documented danger to the Indian pangolin is illegal hunting for scales and flesh, with mass-killing events recorded in the Potohar region driven by local and cross-border demand. This trade was dramatically revealed in 2012 when researchers found the bodies of at least 45 Indian pangolins, without their scales, in sacks hidden in a railway tunnel in the Chakwal district (Mahmood et al., 2012). Market studies indicate that scale prices and live-animal transactions increased significantly during the next decade, and Pakistan became an important hub in the regional pangolin trade network (Waseem et al., 2020b; Challender, 2011).

A recent mortality study comparing provinces attributed direct illegal killing to 33% of pangolin deaths recorded from sampled districts of Punjab and Khyber Pakhtunkhwa. This was followed by mortality due to human settlement expansion (17%), conventional agricultural methods (13%), mite and tick infestation (11%), natural causes (8%), road and other accidents (7%), myth-driven killing (6%) and flooding (5%) (Ahmad & Li, 2024). This is the most complete quantitative breakdown of causes of mortality reported for the species in Pakistan to date. However, because of reliance on questionnaire and social-media reporting, the relative weighting of causes should be regarded as indicative rather than accurate.

This pressure is further exacerbated by habitat degradation due to urban growth, deforestation and pesticide usage that decrease the availability of termites and ants, the species' only food source (Mahmood et al., 2014). Limited species-specific legislation, in conjunction with weak enforcement capacity, has allowed poaching networks to operate with a relatively low risk of prosecution (Khan et al., 2024): between 2019 and 2022, wildlife departments in Khyber Pakhtunkhwa and Punjab prosecuted 140 individuals for pangolin-related offences, 83 in Khyber Pakhtunkhwa and 57 in Punjab with the highest fines being imposed by the Chakwal Wildlife Department, ranging from PKR 20,000 to 60,000, and one-to-four month prison terms (Ahmad & Li, 2024). Indirectly, infrastructure development has also contributed, with wildlife road-mortality surveys on the Potohar Plateau confirming vehicle-strike deaths of slow-moving species, even within pangolin habitat (Akrim et al., 2019). The strain of illegal hunting on other wildlife in the same settings implies that enforcement deficiencies are systemic, not just exclusive to pangolins (Khan et al., 2024). Table 4 shows the major danger categories with their drivers and documented implications.

Collectively, these forces interrelate instead of functioning autonomously: habitat degradation enhances the detectability and capture of individuals restricted to diminished residual areas, but erratic enforcement diminishes the effective cost of poaching despite the presence of legal safeguards. The significant lack of field ecological data from central and southern Punjab indicates that any concurrent threats, whether from agricultural intensification or urban sprawl, are completely unmeasured by direct surveys, despite the 2019–2022 mortality data suggesting that fatalities are not limited to the Potohar region.

Human Dimensions: Hunting, Trade, and Cultural Perception

Survey-based research across Jhelum, Chakwal, Rawalpindi and Islamabad suggests that an overwhelming majority of rural respondents see pangolins adversely, often connecting them with bad omens or misconceived threat (Umar et al., 2020). While these beliefs appear to be more a consequence of ignorance of the species' ecology than of lived experience of injury, they result in opportunistic killing outside of the commercial poaching context (Umar et al., 2020). Awareness of ongoing poaching is prevalent in studied communities, showing that social tolerance of illicit hunting is as large a barrier to conservation as enforcement capabilities (Umar et al., 2020).

The illegal trade itself has recently been mapped in more detail for adjoining Khyber Pakhtunkhwa. Using interviews with hunters, dealers, and local communities, a 2026 study traced the flow of illegally trafficked pangolins from local capture sites to regional trading hubs, providing the first empirically mapped illegal trade network published for the species in Pakistan (Ahmad et al., 2026). No equivalent trade-route mapping exercise has yet been published for Punjab, despite the province recording more than a third as many documented pangolin deaths as Khyber Pakhtunkhwa in the same 2019–2022 period (Ahmad & Li, 2024).

Comparable human-wildlife conflict patterns, driven by similar mixtures of misinformation and economic incentive, have also been documented for other species in northwestern Pakistan, suggesting the underlying social dynamics are not unique to pangolins (Khattak et al., 2021). Community-based education campaigns targeting school-age children and farmers have been proposed as a cost-effective route to shifting entrenched perceptions, and recent field reporting from Potohar suggests conservation practitioners consider awareness-driven enforcement to be improving trade conditions there, though this remains an expert impression rather than a peer-reviewed, quantified trend. It has been reported that where local communities have been offered structured incentives to participate in monitoring, willingness to engage in conservation stewardship has been greater than under top-down approaches alone (Umar et al., 2020) and suggests a practical entry point for outreach programmes across all regions of Punjab, not just the well-studied north.

Existing Conservation Measures

Formal protection status for the Indian pangolin in Pakistan is based on three overlapping instruments: its Endangered status on the IUCN Red List (Mahmood et al., 2019), its listing in Appendix I of CITES since 2017, and protected status under national and provincial wildlife laws. None of these instruments, however, is backed by a Punjab protected area established specifically for the species; Chinji National Park in Chakwal district overlaps with documented pangolin habitat but manages for the landscape as a whole rather than for pangolin-specific outcomes (Safi & Varriano, 2024).

Enforcement activity is recorded, not assumed: Punjab and Khyber Pakhtunkhwa wildlife departments jointly recorded 140 pangolin-related prosecutions between 2019 and 2022, and the Chakwal Wildlife Department imposed some of the highest fines recorded for the offence (Ahmad & Li, 2024). Academic research groups and, more have conducted community awareness programs recently, by international conservation organisations working in the Potohar region to educate the rural populations about the ecological importance and legal status of the species (Umar et al., 2020). Whether these efforts have significantly, reduced poaching pressure at the population level has not yet been fully studied in the peer-reviewed literature and thus remains an important open topic for the province.

Geospatial Habitat Suitability Modelling

The maximum entropy (MaxEnt) modelling has become a typical approach to estimate the distribution of Indian pangolin in Pakistan, identifying elevation, distance to water, plant density and soil composition as the primary predictors of occurrence (Qasim et al., 2024). When this approach is applied in Chakwal district, much of the terrain is classified as highly appropriate habitat, centered between around 450 and 1200 meters elevation (Safi & Varriano, 2024). Figure 2 illustrates the relative suitability of different elevation bands as synthesized from these modelling studies.

Forward-projected models under future climate scenarios indicate that suitable habitat is likely to contract and shift toward higher elevations as temperature and rainfall

patterns change (Qasim et al., 2024), with direct implications for protected-area planning, since several currently suitable zones are projected to fall outside future climatically stable ranges. A more recent modelling effort in Khyber Pakhtunkhwa has moved beyond MaxEnt alone, combining it with Random Forest and Support Vector Machine algorithms in an ensemble framework to improve predictive accuracy (Ahmad et al., 2026).

To date, published habitat suitability models have focused on the Potohar Plateau, Azad Jammu and Kashmir, and adjoining Khyber Pakhtunkhwa districts; no equivalent suitability model, ensemble or otherwise, has yet been published for central or southern Punjab. Extending this modelling framework province-wide, and overlaying the results with administrative and protected-area boundaries, would allow conservation planners to identify priority corridors before habitat shifts occur, rather than reacting after local populations have already declined.

Research Gaps and Knowledge Priorities

Significant knowledge gaps persist regarding Indian pangolin reproductive biology, juvenile dispersal behaviour, and long-term population trends across Punjab, limiting the precision of current conservation planning (Yasmeen et al., 2021). Existing density estimates are drawn from short-term, spatially disjointed surveys concentrated on the Potohar Plateau, making it difficult to establish reliable province-wide population trajectories (Mahmood et al., 2023).

The most striking gap identified in this review remains geographic: no peer-reviewed, field-based ecological survey of the Indian pangolin has yet been conducted in central or southern Punjab, despite historical range records covering these areas (Roberts, 1997) and despite a 2024 questionnaire-based mortality study demonstrating that the species is still being killed in Punjab districts beyond the Potohar core (Ahmad & Li, 2024). Closing this gap will require field methods, not further reliance on interview or social-media data alone. Few studies integrate habitat suitability modelling directly with field-based enforcement or trade-route data, despite the demonstrated value of combining these approaches in Khyber Pakhtunkhwa to prioritize patrol effort in the highest-risk, highest-suitability zones (Ahmad et al., 2026).

Further priorities include extending baseline field surveys to Faisalabad, Multan, Bahawalpur, Dera Ghazi Khan, and other unsurveyed districts; establishing long-term camera-trap and burrow-monitoring programs; assessing genetic connectivity between Potohar and adjoining Khyber Pakhtunkhwa and Azad Jammu and Kashmir populations; formally evaluating community-based monitoring pilot schemes; and extending illegal-trade-route mapping and ensemble habitat suitability modelling into Punjab. Establishing a centralized, standardized pangolin-monitoring database across all of Punjab's districts would substantially improve the comparability of future studies and support more responsive, adaptive conservation management.

Conservation Priorities and Future Directions

Table 5 summarizes priority conservation and research actions arising from this review, ranked according to how

directly they address the two most consistently documented weaknesses in the current evidence base: the near-total absence of field survey data from central and southern Punjab, and the gap between the species' formal legal protection and its enforcement on the ground.

CONCLUSION

The Indian pangolin in Punjab faces a convergence of pressures, including illegal hunting, habitat degradation, inconsistent enforcement, and persistent cultural misconceptions, that collectively threaten its long-term persistence in the province. Field evidence consistently points to low, geographically variable population densities concentrated in a handful of semi-arid and hill-forest landscapes across the Potohar Plateau, while vast areas of central and southern Punjab remain unsurveyed by field methods despite the species' documented historical range across the province. A 2024 province-comparative mortality study confirms that the species is still being killed well beyond the Potohar core, but questionnaire and social-media data cannot substitute for the systematic field surveys that are still lacking.

Habitat suitability modelling further suggests that climate change will compound existing threats by shifting suitable habitat away from currently protected areas, a projection that has, to date, only been tested for the Potohar Plateau and adjoining reference regions. Addressing this convergence of pressures will require coordinated action combining stricter and better-evaluated enforcement, community engagement extended beyond the well-studied north, targeted awareness campaigns, province-wide baseline field surveys, and the extension of trade route and habitat-suitability modelling into Punjab's unsurveyed districts. Without such integrated intervention, the species' already fragmented Punjab populations remain at considerable risk of further local extirpation, and the province's true, whole-territory conservation status will remain, in large part, unknown.

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TABLES AND FIGURES

Table 1. Summary of Indian pangolin density, burrow characteristics, and threats across confirmed field-study sites in and near Punjab.

Study location	Density (ind./km ²)	Burrow type / depth	Threats identified	Key vegetation
Chakwal	0.28–0.37	Feeding: ~35 cm; sleeping: ~110 cm	Poaching, agricultural encroachment	Acacia modesta, Dalbergia sissoo
Rawalpindi / Margalla Hills	0.30–0.34	Feeding and sleeping burrows documented	Habitat clearing, low community awareness	Pinus roxburghii scrub forest
Jhelum	~0.27	Similar burrow pattern to Chakwal	Poaching, agricultural expansion	Semi-arid scrub, thorn forest
Attock	~0.26	Feeding burrows in termite-rich soil	Habitat fragmentation, low reporting	Mixed thorn scrub
Gujrat	~0.29	Low burrow density recorded	Urbanization, deforestation	Mixed shrub-tree (Lantana camara)
Bhakkar	~0.31	Similar to Chakwal pattern	Medium poaching, agricultural expansion	Semi-arid scrub
Layyah	~0.30	Shallow burrows in termite-rich soil	Habitat degradation, pesticide use	Thorn forest, termite mounds
Pir Lasura NP (AJK, reference)	~0.77	Patchy distribution, 590–1540 m elevation	Habitat loss, poaching	Sub-tropical forest
Kohat district (KP, reference)	~0.29	Similar declining trends	Weak enforcement, community unawareness	Forest-shrub borders
Malakand (KP, reference)	37 active burrows recorded	25 feeding, 12 sleeping burrows	Poaching, perception-based killing	Agricultural fringe
Nizampur NP, Nowshera (KP, reference)	~0.013	56 signs (burrows and digging) over 156 km ²	Poaching, very limited suitable habitat	Forest-scrub mosaic
Central & southern Punjab	No field survey published	Not surveyed	Unassessed by field methods; questionnaire-based mortality data exist	Not documented

Table 2. Regional summary of Indian pangolin data availability across Punjab province.

Punjab region	Representative districts	Data availability	General pattern
Northern Punjab / Potohar Plateau	Chakwal, Rawalpindi, Jhelum, Attock, Gujrat	Well studied (multiple field surveys since 2012)	Low, variable densities (0.26–0.37 ind./km ²); high poaching pressure
South-western fringe of Potohar	Bhakkar, Layyah	Moderately studied	Densities comparable to Chakwal; agricultural-fringe habitat
Central Punjab	Faisalabad, Sargodha, Gujranwala, Sialkot	No field ecological survey located; questionnaire-based mortality data	Presence plausible but ecologically unconfirmed; high agricultural land conversion
Southern Punjab	Multan, Bahawalpur, D.G. Khan, Rajanpur	No field ecological survey located	Historic range reported by Roberts (1997); current status unknown
Adjoining reference regions	Kohat, Malakand, Buner, Mansehra, Nowshera (KP); Pir Lasura NP (AJK)	Well studied	Provide comparative context; densities vary by more than fiftyfold across sites

Table 3. Comparison of feeding and sleeping/permanent burrow characteristics of the Indian pangolin.

Burrow type	Average depth	Typical location	Functional role
Feeding burrow	~35 cm	Adjacent to active termite mounds	Short-term foraging access
Sleeping / permanent burrow	~110–117 cm	Beneath dense thickets, near water	Shelter, thermoregulation, breeding

Table 4. Principal threat categories affecting the Indian pangolin in Punjab, their drivers, and documented impacts.

Threat category	Primary drivers	Documented impact	Key source
Illegal hunting and trade	Demand for scales in traditional medicine; live-animal and meat trade	33% of recorded mortality; mass-killing events in Potohar; rising black-market prices	Mahmood et al., 2012; Ahmad & Li, 2024; Waseem et al., 2020b
Habitat degradation	Deforestation, urban expansion, agricultural conversion	Reduced termite/ant availability; loss of thicket cover for burrows	Mahmood et al., 2014
Weak enforcement	Limited species-specific legislation, low prosecution rates	140 prosecutions across both provinces in 2019–2022	Khan et al., 2024; Ahmad & Li, 2024

Cultural misconception	Beliefs linking pangolins to bad omens or danger	6% of recorded mortality; opportunistic killing independent of poaching	Umar et al., 2020; Ahmad & Li, 2024
Road mortality and accidents	Vehicle collisions on plateau roads crossing habitat	7% of recorded mortality; documented wildlife road-kill on roads	Akrim et al., 2019; Ahmad & Li, 2024
Other non-anthropogenic	Mite and tick infestation, natural mortality, flooding	Combined 24% of recorded mortality in the 2019–2022 sample	Ahmad & Li, 2024
Climate change	Rising temperature, shifting rainfall patterns	Projected contraction and elevational shift of suitable habitat	Qasim et al., 2024

Table 5. Priority conservation and research actions for the Indian pangolin in Punjab, Pakistan.

Priority action	Rationale	Suggested lead / partners
Province-wide field baseline surveys in central and southern Punjab	No field ecological data currently exist for the majority of Punjab's land area	University research groups; Punjab Wildlife and Parks Department
Extend illegal-trade-route mapping into Punjab	Trade routes have been mapped for Khyber Pakhtunkhwa but not for Punjab	University research groups; wildlife enforcement agencies
Extend ensemble habitat suitability and climate-projection modelling province-wide	Existing suitability models cover only the Potohar Plateau and reference regions	University research groups; GIS/remote-sensing specialists
Formalize burrow-cluster protection at known high-density sites	Burrow-site fidelity makes localized clearing disproportionately damaging	Punjab Wildlife and Parks Department
Genetic assessment of population connectivity	Connectivity status is currently unknown and has direct implications	University research groups; genetics laboratories
Community-based monitoring and incentive-linked awareness programmes	Structured community incentives have shown higher engagement	Wildlife Department; NGOs; local communities
Formal evaluation of existing enforcement and awareness measures	Whether current prosecutions have measurably reduced poaching has not been assessed	University research groups; wildlife enforcement agencies

Fig. 1. Schematic map of reported Indian pangolin records across Punjab and adjoining regions (not to scale; illustrative only)

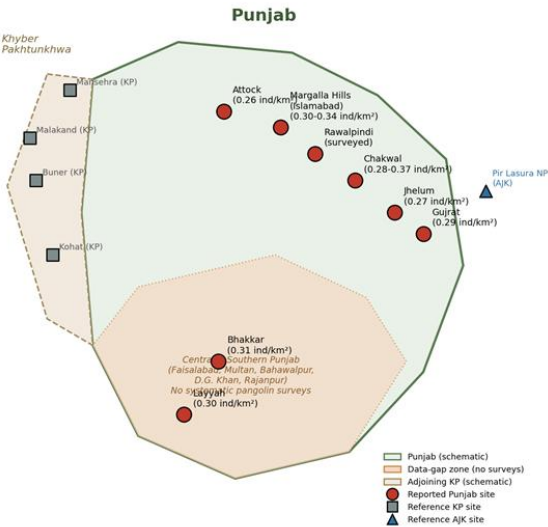


Figure 1. Schematic map of reported Indian pangolin records across Punjab and adjoining regions (Please insert original illustrative map here).

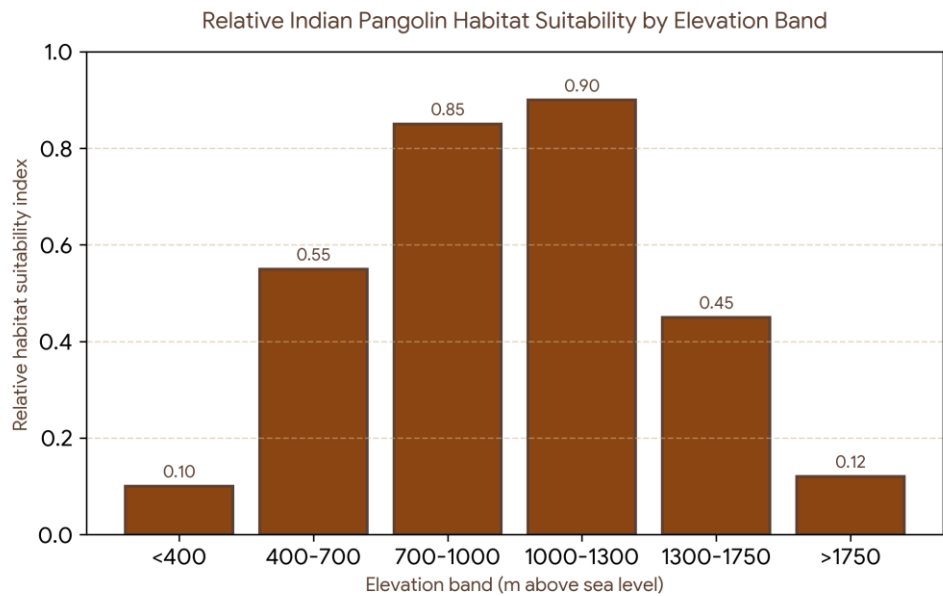


Figure 2. Relative Indian pangolin habitat suitability by elevation band, synthesized from MaxEnt-based studies (Qasim et al., 2024; Safi and Varriano, 2024).