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Preliminary morphological record and analysis of the oriental rat snake (*Ptyas mucosa*) in Lakki Marwat, Pakistan

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Contribution **Adnan, M.** designed, supervised the study, **S. Anwar** performed the research, wrote the draft paper, **S. A. Khan**, **M. khan**, **A. Ullah, A. Ahmad** & **M. Ishtiyaq** helped in collection, **Tanzeela** & **S. Khan** assisted in the statically analysis and proofreading of the manuscript. All authors read the manuscript and approved the final version.

This study confirmed the first morphological record of the Oriental Rat Snake (*Ptyas mucosa*), in Lakki Marwat District, Khyber Pakhtunkhwa (KPK), and Pakistan, expanding its known geographic range and contributing to regional herpetofaunal databases. In the current study, morphological identification of an adult male specimen collected in June 2025 was done, including detailed meristic counts (dorsal, ventral, and subcaudal scales) and morphometric measurements (snout-vent length, tail length, and cranial dimensions). The specimen was preserved in ethanol and examined using standardized taxonomic protocols. Key diagnostic traits were 17 midbody dorsal scale rows, 193 ventrals, 111 subcaudals, a divided anal plate, elongated tail (TlL/SVL ratio: 0.374), and robust cranial proportions (HL/SVL: 0.031). These features distinctly differentiate it from congeners, which exhibit fewer dorsal rows (15), lower subcaudal counts (74–80), and undivided anal plates. Additionally, the specimen's larger body size (SVL: 976 mm) and unique scalation (8 upper/9 lower labials) suggest potential ecological adaptations or regional phenotypic divergence. The current study emphasize the need for integrating morphological data with molecular analyses to resolve taxonomic uncertainties and inform conservation strategies for colubrid snakes facing habitat degradation and illegal trade.

Keywords: *Ptyas mucosa*, Lakki Marwat, taxonomic differentiation, habitat degradation, conservation

INTRODUCTION:

Snakes belonging to the suborder Serpentes constitute a monophyletic clade deeply embedded within the phylogeny of Squamata (lizards). They can be differentiated from other limbless lizards by their specialized skull and dental morphology. Snakes were first documented in the fossil record during the Middle Jurassic to Lower Cretaceous periods (Caldwell *et al.*, 2015). The current evolutionary hypotheses are that the cranial modifications in snakes preceded the limb reduction such that the early snakes likely originated from short bodied quadrupedal lizards (Caldwell *et al.*, 2015). As opportunistic predators, snakes exploit diverse prey including frogs, lizards, snakes, young birds, and salamanders, reflecting their wide adaptability across the ecosystems (Greene, 1997; Albuquerque and Martins, 2024).

Globally, snakes represent one of the most significant and diversified vertebrate radiations, with over 4120 described species spanning over 24 families (Uetz *et al.*, 2021). In Pakistan, 8 families of snakes are Boidae, Leptotyphlopidae, Typhlopidae, Elapidae, Colubridae, Crotalidae, Viperidae, and Hydrophiidae (Khan, 2006). Despite their ecological importance, distribution data about snakes and the different snake species remain critically limited, mirroring a broader paucity in reptile biogeography. Consequently, snakes are frequently excluded from large-scale biodiversity and macro ecological studies (Moura *et al.*, 2016).

Morphological traits in snakes are generally optimized for habitat-specific performance, influencing their locomotion, foraging and thermoregulation (Aubret *et al.*, 2004). Shine, (1986) theorized that these adaptations reflect niche partitioning, where morphological divergence enables species to exploit distinct environmental resources. Key adaptive responses include but may not be limited to body size plasticity (tail elongation for arboreal locomotion; (Shine, 1991), cranial modifications (e.g., gape expansion for prey handling; (Suliman and Ali, 2022) and scalation variation (keeled vs. smooth scales for substrate interaction; (Fabien *et al.*, 2004; Tanaka, 2011; Koo *et al.*, 2017). Such changes arise from selective pressures including microhabitat heterogeneity, prey/predator dynamics, and climatic gradients (Heo *et al.*, 2014; Bonnet *et al.*, 2021). Intraspecific divergence in snakes is further mediated by developmental rates, age structure, sexual dimorphism, and survival trade-offs (Shine, 1991; Madsen and Shine, 1994).

Compounding these threats, unsustainable exploitation through illegal wildlife trade poses grave risks to snake populations globally, with overharvesting directly contributing to the threatened status of numerous species (Alves and Filho, 2007). Alarmingly, a comprehensive assessment of reptile conservation status estimates approximately one in nine snake species faces extinction risk (Böhm *et al.*, 2013). Species inhabiting ecologically sensitive zones particularly freshwater ecosystems, tropical biodiversity hotspots, and isolated oceanic islands are disproportionately imperiled. Population declines are driven by synergistic pressures, including habitat degradation and fragmentation, emerging infectious diseases, anthropogenic climate change, and unsustainable collection for commercial markets (Böhm *et al.*, 2013). Critically, these threats operate against a backdrop of significant knowledge gaps in many regions. The District of Lakki Marwat in Pakistan's semi-arid Khyber Pakhtunkhwa Province (KPK) exemplifies such an underexplored area. Despite its ecologically transitional position and unique habitat matrix, its snake fauna remains virtually undocumented in the scientific literature. No prior morphological diagnosis or population assessment exists for snake species within this district, including potentially significant species like *P.* mucosa. This profound lack of baseline data impedes both regional conservation planning and accurate global threat assessments. Therefore, this study is imperative to provide the first comprehensive morphological documentation of *P.* mucosa within Lakki Marwat, establish foundational data on its occurrence and characteristics in this unstudied region, and directly address this critical gap in Pakistan's herpetological inventory, enabling future ecological and conservation initiativess

OBJECTIVES: To document and systematically analyze the morphological characteristics of *P.mucosa* collected from District Lakki Marwat, Pakistan

MATERIALS AND METHODS:

Lakki Marwat District (32°36'19"N, 70°54'52"E) is situated in southern Khyber Pakhtunkhwa (KPK), Pakistan (figure 1). The district features a hot semi-arid climate. Summer temperatures of the district have a range of 30–48°C (May to September), while winters average 5 to 20°C (November to February). Annual rainfall is 268.7 mm, primarily during monsoons and winter season (Suliman and Ali, 2022).

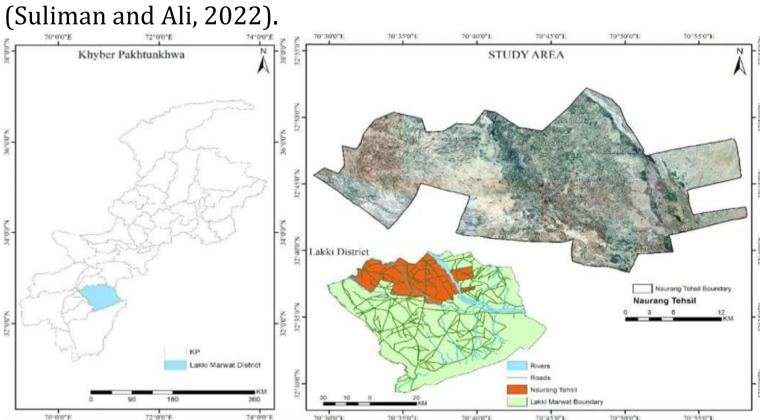

Figure 1: Map of Lakki Marwat district: The map is depicting District Lakki Marwat situated in Southern Khyber Pakhtunkhwa. The Map was acquired from the Department of Conservation and Recreation (DCR) and digitized using ArcGIS 10.8 version.

Specimen of *P. mucosa* was collected in June 2025 using a noose trap, snake tongs and gloves for handling. Preservation of the specimen involved injecting 95% ethanol at one-inch intervals, followed by storage in 70% ethanol in sealed plastic containers at room temperature. The container was labeled with all the relevant details and kept at room temperature in the Natural history Museum at the

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Institute of Zoological sciences, University of Peshawar (Basit *et al.*, 2024; PoyArkoV, 2025).

Specimen was morphologically identified using regional taxonomic keys and compared with reference collections (Khan, 2002; 2003). The key characters to be examined and recoded for identification of the species included; scalation patterns, body dimensions, dorsal scale rows (counted at neck, midbody, and pre-cloacal regions), ventral scale counts, sub caudal scale counts, head shape and distinctive colour patterns. Measurements of snout-vent length, tail length, and head dimensions were recorded carefully in (mm) using digital calipers (Hussain *et al.*, 2022). All the mentioned measurements were recorded in triplicate for accuracy.

RESULTS: The figure 2 depicts the key diagnostic features that are used in the identification of the snake *P. mucosa*. In the figure as labeled (a) the figure depicts by labeling the key morphological characters of the P. mucosa's head. The characters depicted include prenasal, postnasal, preocular, eyeball, supraocular, postocular, supra labials and infralabials with in the snake's head, (b) is referring to the ventral scutes that stretch across the abdomen, (c) is depicting the broad rostral, its concave projection and deep groove below, (d) is showing the symmetrical scales on the head of the snake, (e) is depicting the large spherical eye pupil and the pointed rostral, (f) showing that the scales on the dorsal side of the sanke are smooth, (g) is showing that the subcaudals of this snake is divided, (h) is showing dorsal side and (i) is showing ventral side of *P. mucosa.*

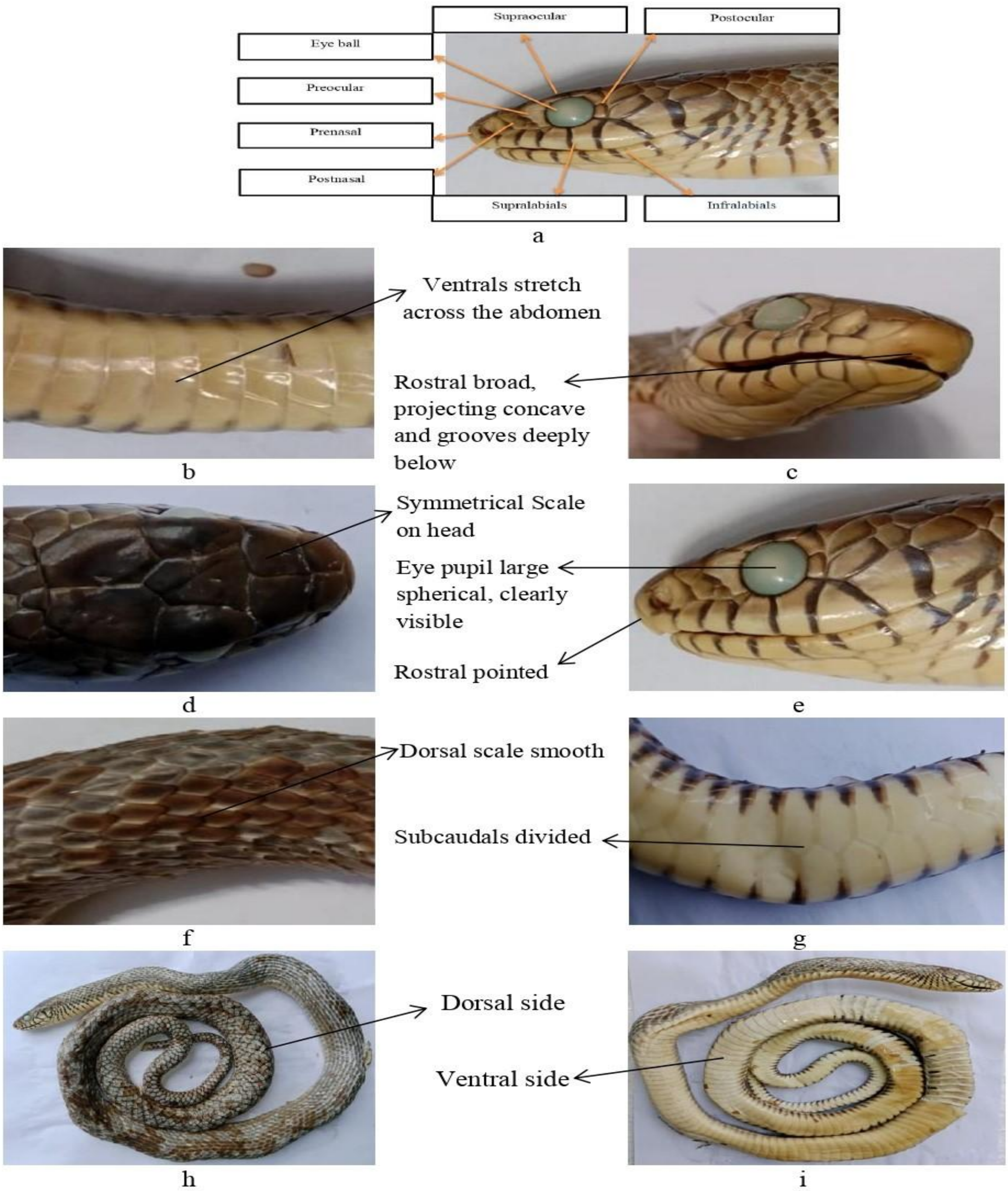

Figure 2: Key diagnostic features of *P. mucosa in* Lakki Marwat, Pakistan.

The table 1 showed the morphometric characters and meristic counts recorded for *P. mucosa*. All the measurable characters were recorded in triplicates and the unit used for measurement is in millimeters (mm).

The table 2 comprised of the available data in literature on the morphology of the snakes belonging to the genus *Ptyas*. It is showing data of *P.mucosa* Lakki Marwat (this study), data of *P. hamptoni* and *P.doriae* (reference given). Data of the same species was not available so data for closely related species belonging to the same genus was added to do a comprehensive analysis of the morphology. A (-) in the table indicates missing data/not present.

The table 3 showed different ratios for the morphological characters recorded in this study for *P. mucosa* and other related species from the literature as per table 2. The characters for which the ratios were derived included TL= Total Length, TlL= Tail Length, HL=Head

Length, HW=Head Width, HH=Head Height, VS= Ventral Scale, SC= Subcaudal Scale, SVL= Snout Vent Length.

The *P. mucosa* specimen from Lakki Marwat demonstrates the longest tail relative to body size among the taxa studied (TlL/SVL ratio of 0.374). This ratio significantly surpasses all comparative specimens of *P. doriae* (range: 0.241–0.302) and *P. hamptoni* (0.257).

S.No	Morphometric and meristics counts	Specimen (*P. mucosa*)
1	Total length	1341mm
2	Snout vent length	976mm
3	Tail length	365mm
4	Head length	30mm
5	Head width	16mm
6	Head hight	16mm
7	Number of ventrals	193
8	Number of subcaudals	111
9	Number of upper labials	8
10	Number of lower labials	9
11	Number of inter nasal scales	2
12	Number of pre ocular scales	2
13	Number of post ocular scales	2
14	Eye diameter	7mm
15	Anal plate	Divided
16	Number of white bands	Nil
17	Rostrals length/width	5mm/7mm
18	Mental length/width	2mm/5mm
19	Dorsal scale rows at mid body	17 rows
20	Nasal scales divided/undivided	Divided
21	Frontals width/length	6mm/9mm
22	Parietal width/length	7mm/10mm
23	Mid body width	19mm
24	Supra ocular width/length	5mm/8mm
25	Supra labial- nasal	2mm
26	Supra labial- eye	4mm
27	Sub cuadals	Divided
28	Prefrontal width/length	7mm/6mm

Table 1: Morphometric and meristic counts of the snake species *P. mucosa* from District Lakki Marwat.

This significant caudal elongation was observed in *P. mucosa* may indicate ecological or locomotory adaptations that are unique compared to its congeners. A comparable pattern is evident in the TlL/TL ratio, with *P. mucosa* (0.272) consistently exceeding *P. doriae* (0.194–0.232) and *P. hamptoni* (0.205). These findings highlight the diagnostic value of tail proportions in differentiating *P. mucosa* from closely related species. Similarly, *P. mucosa* (0.031) demonstrates a longer head compared to the majority of *P. doriae* specimens (0.0195–0.0315), with slight overlap observed in one female *P. doriae* (0.0315), potentially attributable to sexual dimorphism or ontogenetic variation. The head width of *P. mucosa* (0.016) is within the range observed in *P. doriae* (0.0103–0.0197) although certain female P. doriae display broader head widths (up to 0.0197). *P. mucosa* (0.016) is situated at the upper limit of *P. doriae* (0.0097–0.0176), indicating a potentially more robust cranial structure, which may be associated with feeding mechanics. *P. mucosa* (0.533) is consistent with the narrower range of *P. doriae* (0.530–0.733), although certain female *P. doriae* exhibit significantly broader heads (0.733) highlighting the possibility of sexual dimorphism in the species. *P. mucosa* (0.533) exhibits overlap with *P. doriae* (0.500–0.627) while preserving a balanced cranial profile, in contrast to the more elongated or dorsoventrally compressed morphologies observed in certain congeners.

The ratio of *P. mucosa* (1.74) is significantly lower than that of *P. doriae* (2.225–2.553) and *P. hamptoni* (2.553), which can be attributed to its higher subcaudal count (111) and can be attributed as a critical diagnostic characteristic. The anal plate of *P. mucosa* is divided, in contrast to the undivided condition observed in *P. doriae* and *P. hamptoni*, serving as a reliable taxonomic indicator. *P. mucosa* possesses 17 midbody dorsal scale rows, which clearly differentiates it from *P. doriae*, characterised by 15 rows. *P. mucosa* exhibits 8 upper and 9 lower labials, in contrast to *P. doriae* has 7 upper and 6 lower labials. This distinction supports species-level differentiation.

DISCUSSION

This study presents the first comprehensive morphological documentation of *P. mucosa* in Lakki Marwat District, Pakistan, a semi-arid region where herpetofaunal surveys remain critically deficient. Our analysis reveals profound morphological divergence between the Lakki Marwat specimen and Indian congeners (*P. doriae, P. hamptoni*), it signifies evolutionary adaptations to this unique ecoregion while addressing a significant Wallacean shortfall in South Asian snake distributions.

parameters	*P. mucosa* (Lakki Marwat)	*P. hamptoni* ♀	*P. doriae* ♂	*P. doriae* ♀	*P. doriae* ♂	*P. doriae* ♀	*P. doriae* ?
Total length	1341mm	1060.0 mm	807.0 mm	485mm	702mm	964mm	—
Snout vent length	976mm	843.0 mm	620.0 mm	375 mm	544 mm	760 mm	423 mm
Tail length	365mm	217.0 mm	187.0 mm	110 mm	158 mm	204 mm	102 mm
Head length	30mm	16.4 mm	13.2 mm	11.8 mm	13.2 mm	15 mm	12 mm
Head width	16mm	8.7 mm	8.8 mm	7.4 mm	8.4 mm	11 mm	8.1 mm
Head height	16mm	8.2 mm	7.8 mm	6.6 mm	7.5 mm	9.4 mm	7 mm
Number of ventrals	193	194	176	178	181	184	191
Number of subcaudals	111	76	76	80	74	75	76
Number of upper labials	8	7	7	7	7	7	7
Number of lower labials	9	6	6	7	6	6	6
Number of inter nasal scales	2	—	—	—	—	—	—
Number of pre ocular scales	2	1	1	1	1	1	1
Number of post ocular scales	2	2	2	2	2	2	2
Eye diameter	7mm	3.6 mm	3.7 mm	3	3.1	3.5	3
Anal plate	Divided	single	single	single	single	single	single
Number of white bands	Nil	—	—	—	—	—	—
Rostrals length/width	5mm/7mm	—	—	—	—	—	—
Mental length/width	2mm/5mm	—	—	—	—	—	—
Dorsal scale rows at mid body	17 rows	15rows	15rows	15rows	15rows	15rows	15rows
Nasal scales divided/undivided	Divided	—	—	—	—	—	—
Frontals width/length	6mm/9mm	—	—	—	—	—	—
Parietal width/length	7mm/10mm	—	—	—	—	—	—
Mid body width	27mm	—	—	—	—	—	—
Supra ocular width/length	5mm/8mm	—	—	—	—	—	—
Supra labial- nasal	2mm	—	—	—	—	—	—
Supra labial- eye	4mm	—	—	—	—	—	—
Sub caudal scales	Divided	—	—	—	—	—	—
Prefrontal width/length	7mm/6mm	—	—	—	—	—	—

Table 2: Morphological data of the snakes belonging to the genus Ptyas.

The Lakki Marwat specimen exhibited exceptional body size (SVL: 976 mm; TL: 1,341 mm) that exceeds the maximum measurements of Indian P. doriae (SVL ≤760 mm) and P. hamptoni (SVL: 843 mm) by >28%. This aligns with Bergmann's cline, where larger body sizes in thermally variable semi-arid zones reduce surface-area-to-volume ratios thus enhancing heat and water conservation (Ashton and Feldman, 2003). Lakki Marwat's climatic extremes of 5–48°C (Suliman and Ali, 2022) likely drive this divergence, as larger ectotherms may buffer temperature fluctuations more effectively. Most strikingly, the caudal elongation (TlL/SVL: 0.374) surpasses ratios in Indian congeners (0.194–0.302).

Ratio Parameter	***P. mucosa*** **Lakki Marwat**	***P. hamptoni ♀*** **India**	***P. doriae ♂*** **India**	***P. doriae ♀*** **India**	***P. doriae ♂*** **India**	***P. doriae ♀*** **India**	***P. doriae ? India***
TlL/SVL	0.374	0.257	0.302	0.293	0.290	0.268	0.241
HL/SVL	0.031	0.0195	0.021	0.0315	0.0243	0.0197	0.0284
HW/SVL	0.016	0.0103	0.014	0.0197	0.0154	0.0145	0.0191
HH/SVL	0.016	0.0097	0.013	0.0176	0.0138	0.0124	0.0165
TlL/TL	0.272	0.205	0.232	0.2268	0.2251	0.2116	0.194
VS/SC	1.74	2.553	2.32	2.225	2.446	2.453	2.513
HW/HL	0.533	0.530	0.667	0.627	0.636	0.733	0.675
HH/HL	0.533	0.500	0.591	0.559	0.568	0.627	0.583

Table 3: Comprehensive morphological and diagnostic analysis.

This adaptation may optimize locomotion in sparse vegetation, where elongated tails enhance arboreal maneuverability during the pursuit of prey (Shine, 1991). Similarly, the robust cranial proportions (HL/SVL: 0.031; HW/SVL: 0.016) and enlarged ocular diameter (7 mm vs. ≤3.7 mm in Indian specimens) may be reflecting niche-specific hunting strategies i.e broader gape facilitate consumption of larger rodents prey that are likely to dominate the agroecosystems (Khan, 2006) while expanded eyes may help improve low-light foraging efficiency in crepuscular periods (Greene, 1997).

Scalation patterns provide unequivocal diagnostic characters separating *P. mucosa* from regional congeners. The 17 midbody dorsal scale rows contrast sharply with the consistent 15 rows in Indian *Ptyas* spp., a divergence exceeding typical intraspecific variation in colubrids (Khan, 2002). More significantly, the divided anal plate and high subcaudal count (111 vs. 74–80 in Indian specimens) represent phylogenetically conserved traits rarely subject to environmental plasticity (Dowling, 1951). These features when combined with unique labial formulae (8 upper/9 lower vs. 7 upper/6–7 lower) reinforce species-level distinctiveness. The specimen's cephalic scalation further supports divergence: two internasals, two preoculars and divided nasals differentiate it from the Indian congeners. A detailed metrics (e.g., rostral: 5×7 mm; frontal: 6×9 mm) establishes a quantitative baselines for future comparisons. Such meristic stability underscores their value in resolving taxonomic uncertainties within this morphologically cryptic genus (Meetei *et al.*, 2018).

The occurrence and documentation of *P. mucosa* in this previously unexplored district may be extending its northwestern range limit in Pakistan. The distinct morphology is likely to arise from its peripheral isolation, genetic drift and localized selection at range margins. The reduced scale counts (e.g., ventrals: 193 vs. 194–201 in lowland populations) may minimize cutaneous water loss and may be pointing towards aridity adaptations in the species (Lillywhite, 2006). Agricultural expansion (wheat/sugarcane) results in elevated rodent abundance, favoring larger-bodied predators is likely to result in anthropogenic niche shifts (Khan, 2006) Notably, no prior studies documented snakes with such details in Lakki Marwat's semi-arid environment consisting of dunes, dry river bed and cliffs (Sheraz *et al.*, 2024). This gap in turn exemplifies broader deficits in Pakistan's herpetological inventory, where <15% of potential snake habitats have been surveyed (Khan, 2006). This study may represent an evolutionary significant unit meriting for urgent conservation of *P.mucosa* which is facing threats like illegal trade, overharvesting for traditional medicine (gallbladders) and skin which in turn is causing the population collapses in Southeast Asia (Auliya, 2010). Agricultural encroachment has reduced native vegetation by 23% since 2000 resulting in habitat fragmentation (Suliman and Ali, 2022). The semi-arid Pakistan is warming 0.5°C/decade which is 50% faster than global averages thus potentially compressing thermal niches (Change, 2001) and with 11% of global snake species threatened (Böhm *et al.*, 2013) such studies become even more important. This study is about the morphology of the species and its comparative analysis to other congeners but the findings are raising questions for future studies to answer *i.e* Does phenotypic variation reflect genetic differentiation? The whole-genome resources for *P. mucosa* (Wang *et al.*, 2023) surely will enable for future phylogenetic testing. The single-specimen data preclude sex/age-based analyses; population surveys on large scale are required. Studies about prey composition or dietary analysis can clarify dietary drivers of the observed cranial enlargement. We strongly advocate integrating morphometrics with RAD-seq to test for cryptic speciation and recommend community-based monitoring to quantify trade impacts.

CONCLUSION: The Lakki Marwat *Ptyas mucosa* exemplifies how peripheral isolation and arid-zone pressures sculpt phenotypic divergence in wide-ranging snakes. Its exceptional size, elongated tail, unique scalation, and cranial proportions distinguish it from Indian congeners, highlighting the evolutionary dynamism of colubrids in understudied ecoregions. This study underscores the imperative to document biogeographic "blind spots" like semi-arid Pakistan, where biodiversity faces accelerating anthropogenic threats. By establishing the first morphological baseline for *P. mucosa* in North-Western Pakistan, we bridge a critical knowledge gap and empower future conservation of South Asia's neglected herpetofauna.

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LIFE SCIENCE REPORTING: In current research article no life science threat was reported

ETHICAL RESPONSIBILITY: This is original research, and it is not submitted in whole or in parts to another journal for publication purpose.

INFORMED CONSENT: The author(s) have reviewed the entire manuscript and approved the final version before submission.

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