Journal of Health, Wellness and Community Research
ISSN: 3007, 0570

OPEN ACCESS

JHWCR

Type: Original Article
Published: 23 September 2025
Volume: III, **Issue:** XIII
DOI: https://doi.org/10.61919/r73smd89

Correspondence
✉ Corresponding author: Saima Ashraf
saima.ashraf@uskt.edu.pk

Received 28, 09, 25 **Accepted** 10, 11, 2025

Authors' Contributions
Concept: MK; Design: MNK; Data Collection: MRM; Analysis: SSAS; Drafting: MSM, SM

Declarations
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

"Click to Cite"

A rare deciduous premolar (DP3) of Tragoportax punjabicus from the Late Miocene Dhok Pathan Formation (Bhandar Bone Bed), Jhelum, Pakistan: taxonomy and comparative morphology

Heera Bibi[1], Shumaila Kanwal[1], Saima Ashraf[1]

1 Department of Zoology, University of Sialkot, Sialkot Pakistan

ABSTRACT

Background: The Middle Siwaliks of northern Pakistan preserve one of the most important Late Miocene terrestrial mammal records in Asia, with Bovidae—especially boselaphines—forming a dominant component of Dhok Pathan faunas. Deciduous dentition is rarely recovered and remains under-described despite its taxonomic value. Objective: To describe and diagnose a rare isolated deciduous premolar (DP3) attributed to Tragoportax punjabicus from the Bhandar Bone Bed (Dhok Pathan Formation, Jhelum, Pakistan) and evaluate its systematic significance through comparative morphology and morphometrics. Methods: The specimen (USKT-PC 100923) was collected by surface prospecting, mechanically and chemically cleaned, photographed in standardized views, and measured using digital calipers. Qualitative dental characters and quantitative dimensions were compared with published DP3 datasets and systematic accounts of Siwalik boselaphines. Results: USKT-PC 100923 is a well-preserved left DP3 with smooth to mildly rugose enamel, prominent labial styles and ribs, shallow median valley, deep anterior and posterior fossettes, and an anterior shelf-like cingulum. Measurements (L 18.60 mm; W 12.00 mm; W/L 0.65) align with published Tragoportax DP3 values and support referral to T. punjabicus. Conclusion: This DP3 represents a rare juvenile dental record of T. punjabicus from the Bhandar Bone Bed, refining the Siwalik boselaphine dataset and highlighting the systematic value of deciduous dentition for taxonomic reassessment.

Keywords
Siwaliks; Dhok Pathan Formation; Bovidae; Boselaphini; Tragoportax punjabicus; deciduous premolar; DP3; Pakistan.

INTRODUCTION

The Siwalik Group of the Himalayan foreland basin constitutes one of the world's most important continental archives for reconstructing Neogene mammalian evolution, faunal turnover, and terrestrial palaeoenvironmental change across South Asia (1,2). Extending along the Himalayan foothills, the Siwalik succession preserves thick fluvial–alluvial deposits and yields exceptionally rich vertebrate fossil assemblages spanning much of the Miocene through Pleistocene, enabling integrated biostratigraphic and palaeoecological interpretations (2,3). Within this framework, the Middle Siwaliks—classically represented by the Nagri and Dhok Pathan formations—are especially significant for documenting Late Miocene ungulate radiations and providing a reference record for mammalian biochronology in the region (4,5). Magnetostratigraphic calibration across Potwar Plateau sections has allowed robust temporal constraints on these units, with the Dhok Pathan Formation broadly spanning the Late Miocene to Early Pliocene interval and encompassing a high-yield fossil record that is frequently used for interregional faunal correlation (4,5).

Bovidae dominate many Middle Siwalik large-mammal assemblages and play a central role in palaeoecological reconstruction because bovid abundance, tribal composition, and dental functional morphology are strongly linked to vegetation structure and habitat openness (2,6). Among bovids, boselaphine lineages show extensive diversification and ecological breadth during the Late Miocene and are repeatedly reported as key components of Dhok Pathan faunas from northern Pakistan (7–9). This record has provided foundational evidence for understanding the evolution of Siwalik ruminant communities and for reassessing the taxonomy and distribution of major boselaphine taxa, including Tragoportax, Selenoportax, and Pachyportax (8–11). In particular, Tragoportax punjabicus is a well-established Middle Siwalik taxon and has been documented from Dhok Pathan localities, where it contributes to reconstructions of Late Miocene bovid diversity and biogeographic affinities with western Eurasian faunas (9–12).

Despite the long research history on Siwalik bovids, the deciduous dentition of key boselaphines remains comparatively under-described in the regional literature. Juvenile dental elements—especially isolated deciduous premolars—are rarely recovered, are frequently excluded from taxonomic discussions, and are underrepresented in comparative morphometric datasets (10,11,13). This limitation is consequential because deciduous cheek teeth preserve informative morphology, including cusp patterning, styles, ribs, cingula, and enamel relief that can refine species-level diagnoses, document ontogenetic variability, and strengthen taxonomic allocation of fragmentary assemblages (10,11,13). In Siwalik contexts where surface collecting yields abundant isolated teeth and fragmentary material, improved characterization of deciduous morphology is essential for advancing systematic revision and for constraining morphological variation within widely distributed boselaphine lineages (3,10,11).

The Dhok Pathan Formation localities of Jhelum District—including the fossiliferous exposures collectively referred to as the Bhandar Bone Bed—have produced important artiodactyl remains, yet they remain relatively underrepresented in DP3-focused taxonomic documentation for Tragoportax and allied boselaphines (8,9,14). The scarcity of described deciduous dentition from these localities creates a knowledge gap in juvenile morphology, limiting comparative reassessment of Siwalik bovid dental variation and reducing the resolution of taxonomic datasets used for palaeoecological and palaeobiogeographic inference (8–11). The present taxonomic note addresses this gap by documenting and diagnosing a rare isolated deciduous premolar (DP3) attributed to Tragoportax punjabicus from the Bhandar Bone Bed (Dhok Pathan Formation), and by comparing its morphology and measurements with published comparative material to confirm its taxonomic placement and evaluate its systematic significance within the Late Miocene boselaphine record of the Siwaliks (9–11,13,14).

MATERIALS AND METHODS

This study is designed as a descriptive systematic palaeontological taxonomic note integrating qualitative diagnosis and comparative morphometrics for an isolated deciduous premolar (DP3) attributed to a Middle Siwalik boselaphine. The specimen derives from the Middle Siwaliks of northern Pakistan, specifically from the Dhok Pathan Formation exposures in Jhelum District, Punjab, within the fossiliferous localities collectively referred to as the Bhandar Bone Bed near Bhandar village. The Dhok Pathan Formation represents Late Miocene to Early Pliocene fluvial deposits and is widely correlated across Potwar Plateau sections using magnetostratigraphic frameworks that constrain its age and enable regional biochronologic comparison (4,5).

The fossil was obtained through systematic surface collection during field expeditions targeting exposed fossil-bearing horizons and eroding outcrops. The collection strategy followed standardized surface prospecting principles commonly applied to Siwalik vertebrate surveys, emphasizing careful documentation of locality context and selective recovery of informative specimens while minimizing collection bias introduced by differential preservation and exposure (3). Upon recovery, the specimen was assigned a unique accession number using the institutional catalogue format “USKT-PC” followed by a specimen-specific identifier. Cataloguing included recording the collection date and serial number, consistent with regional fossil documentation practices that support traceability and reproducibility of taxonomic work (15).

Specimen preparation combined mechanical and limited chemical cleaning to maximize visibility of enamel morphology while preserving fine surface texture. Adhering sediment matrix was removed using fine brushes and needles under controlled conditions. Where required, weak acid treatment was applied cautiously to remove residual matrix, and the specimen was thoroughly rinsed and dried to prevent chemical alteration of enamel surfaces. Any minor fragmentation was stabilized and repaired using appropriate consolidants and adhesives (including commonly used resins) applied in minimal quantities to avoid obscuring diagnostic features and to maintain the integrity of enamel relief.

The specimen is curated and permanently housed in the palaeontological repository of the Department of Zoology, University of Sialkot, Punjab, Pakistan, under the accession number USKT-PC 100923. Repository storage conditions prioritize physical stability, controlled handling, and long-term accessibility for verification and comparative study.

Photography was conducted using a digital single-lens reflex (DSLR) camera with standardized lighting and scale placement. Diagnostic views were captured in occlusal, lingual, and labial orientations to document cusp architecture, styles, ribs, cingula, and median valley structure. Figure preparation followed common systematic palaeontology standards, including consistent orientation, scale bars, and image quality sufficient for taxonomic assessment.

Morphometric measurements were obtained using a digital vernier caliper and recorded in millimeters (mm). For DP3, maximum anteroposterior length (L) and maximum transverse width (W) were measured in occlusal view, following established dental measurement conventions applied in Siwalik bovid systematics. Measurements were replicated to ensure precision and were rounded to two decimal places. A width-to-length ratio (W/L) was calculated to support comparative assessment. Tooth wear stage was described qualitatively based on occlusal exposure of dentine and cusp tip condition, using standardized wear-stage descriptors suitable for isolated dental specimens.

Comparative assessment was based on published descriptions and measurements of Tragoportax and allied boselaphines from the Siwaliks and western Eurasia, including foundational monographs and revisions relevant to diagnosis and taxonomic placement (9–11,13,14,16). Morphological comparisons focused on cusp patterning, development of styles and ribs, cingulum expression, fossette depth, enamel texture (smooth vs rugose), and median valley configuration—characters that are repeatedly emphasized as taxonomically informative in boselaphine dental studies (9–11,13,14). Analytical interpretation relied on congruence of qualitative morphology and quantitative measurements with published ranges and comparative specimens. Inferential statistics (e.g., p-values, odds ratios) are not applicable to this study design because the work involves a single descriptive specimen and taxonomic interpretation is grounded in comparative morphology and morphometric congruence rather than hypothesis-testing between groups. Quality control included cross-checking measurements across repeated caliper readings, archiving high-resolution photographs, and ensuring that all descriptive statements are supported by observable morphological features documented in figures and tables.

RESULTS

Diagnosis (adapted from published species diagnoses): Tragoportax punjabicus is characterized by moderately hypsodont, selenodont cheek teeth with well-developed styles and ribs, moderate enamel rugosity, and morphological proportions that distinguish it from larger boselaphines (Selenoportax, Pachyportax) and from smaller early boselaphines (Eotragus and related taxa). The species is generally smaller than T. browni and differs in relative proportions of the premolar series and details of enamel relief and accessory structures. (9,16)

Locality and horizon: Bhandar Bone Bed, Jhelum District, Punjab, Pakistan; Dhok Pathan Formation, Middle Siwaliks.

Description of USKT-PC 100923 (left DP3): The specimen is well preserved and lacks major breakage. The tooth is unworn to very lightly worn, with minimal dentine exposure; cusp tips are largely intact though minor tip damage is present. Enamel is shiny and relatively smooth, with crisp relief and well-defined cusp margins. In occlusal view, the anterior lobe is larger than the posterior lobe, and both lingual and labial walls are prominent. A shelf-like cingulum is expressed anteriorly. The main cones are clearly developed and include protocone and hypocone lingually and paracone and metacone labially, producing a strongly selenodont pattern. The median valley is shallow but distinct. Both anterior and posterior fossettes are large and deep, indicating well-developed infolding suitable for fine-scale taxonomic comparison. On the labial side, the parastyle, paraconal rib, mesostyle, metaconal rib, and metastyle are prominent and sharply expressed. Collectively, this morphology reflects a medium-

sized boselaphine DP3 consistent with published Tragoportax patterns and inconsistent with the more extremely hypsodont and robust morphologies typical of Selenoportax and Pachyportax. (9–11,13,16)

Taxonomic Rank	Details
Order	Artiodactyla Owen, 1848
Suborder	Ruminantia Scopoli, 1777
Family	Bovidae Gray, 1821
Subfamily	Bovinae Gill, 1872
Tribe	Boselaphini Knottnerus-Meyer, 1907
Genus	*Tragoportax* Pilgrim, 1937
Species	*Tragoportax punjabicus* (Pilgrim, 1910)
Holotype	AMNH 19467, skull lacking the posterior occipital region (as designated and described in subsequent treatment of Siwalik antelopes and oxen).
Type locality	Middle Siwaliks, Dhok Pathan, Punjab, Pakistan
Stratigraphic range	Middle Siwaliks; recorded from Dhok Pathan Formation deposits within the Late Miocene interval
Referred material	USKT-PC 100923, isolated left DP3

Differential diagnosis: The DP3 differs from Selenoportax and Pachyportax by its comparatively smaller overall size, less extreme hypsodonty, and a more delicate configuration of enamel pillars and basal structures, whereas the latter genera characteristically show more robust and expanded crowns and stronger development of certain accessory structures in molars and premolars reflecting advanced grazing adaptation. (9–11) Compared with Miotragocerus, the specimen shows a DP3 morphology consistent with Tragoportax and lacks the combination of characters typically emphasized for differentiating Miotragocerus from Tragoportax in broader cranio-dental assessments, noting that horn-core morphology is decisive at the genus level when available but not applicable here due to isolated dental material. (9,11,16) The specimen is also clearly distinguishable from small early boselaphines such as Eotragus and allied taxa by its larger dimensions, more developed styles/ribs, and advanced selenodont patterning consistent with Late Miocene Tragoportax rather than Early–Middle Miocene small-bodied stem boselaphines. (11,14)

QUANTITATIVE RESULTS

The DP3 of USKT-PC 100923 shows a maximum length of 18.60 mm and maximum width of 12.00 mm, yielding a W/L ratio of 0.65 (Table 1). These dimensions fall within the published comparative range for Tragoportax deciduous premolars and show close congruence with reported DP3 specimens attributed to Tragoportax cf. amalthea from comparative datasets, supporting generic-level and species-level assignment by size and morphology. (13) In comparative context, the measurement concordance is strongest with DP3 specimens in the 16.74–19.26 mm length range and 13.0–14.6 mm width range, with USKT-PC 100923 falling near the lower–middle portion of this comparative envelope in width while matching central values in length (Table 2). A diagnostic character matrix further supports allocation to Tragoportax by the combination of medium-sized DP3 dimensions, shallow but distinct median valley, large deep fossettes, prominent labial styles/ribs, and well-defined anterior cingulum (Table 3). These features collectively differentiate the specimen from larger, more robust boselaphines (Selenoportax, Pachyportax) and from smaller boselaphines (Eotragus, Elachistoceras) while remaining consistent with published accounts of Tragoportax dental morphology in the Siwaliks and adjacent regions. (9–11,13,16)

Table 1. Morphometric measurements of DP3 specimen USKT-PC 100923 (Tragoportax punjabicus)

Specimen	Tooth	Side	Length (mm)	Width (mm)	W/L	Wear stage
USKT-PC 100923	DP3	Left	18.60	12.00	0.65	Unworn to very lightly worn

Table 2. Comparative DP3 measurements (mm) used for taxonomic assessment of USKT-PC 100923

Taxon	Catalog no.	Tooth	Side	Length (mm)	Width (mm)
Tragoportax punjabicus	USKT-PC 100923	DP3	Left	18.60	12.00
Tragoportax cf. amalthea	58 HAY09/007	DP3	Left	19.26	13.00
Tragoportax cf. amalthea	58-HAY19/114	DP3	Right	18.54	14.60
Tragoportax cf. amalthea	58-HAY19/209	DP3	Left	16.74	13.92

Table 3. Diagnostic DP3 character matrix for Tragoportax versus related Siwalik boselaphines

Character	Tragoportax (DP3)	Selenoportax	Pachyportax	Miotragocerus	Small boselaphines (Eotragus etc.)
Relative size	Medium	Large	Large	Medium	Small
Hypsodonty (relative)	Moderate	High to extreme	High	Moderate	Low–moderate
Enamel texture	Smooth to moderately rugose	Rugose	Thick/rugose; robust	Variable	Often smoother, simpler
Labial styles/ribs	Strong, prominent	Strong; often robust	Strong; robust	Moderate–strong	Generally weaker
Median valley	Shallow to moderate	Often deep/robust architecture	Often deep/robust	Moderate	Often less developed
Fossettes	Deep and well-defined	Deep	Deep	Well-defined	Less robust
Anterior cingulum	Present; may be shelf-like	Variable	Variable	Variable	Variable
Taxonomic utility (DP3)	High	Moderate	Moderate	Moderate	Moderate

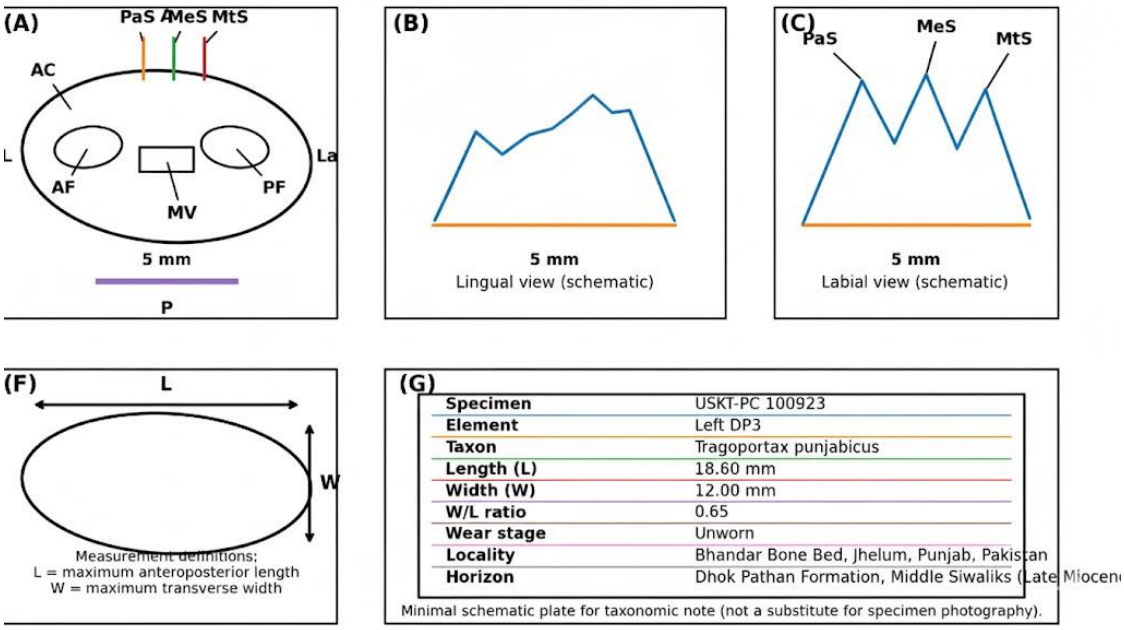

Figure 1 Minimal schematic plate illustrating the left deciduous third upper premolar (DP3) of Tragoportax punjabicus (USKT-PC 100923) from the Bhandar Bone Bed, Dhok Pathan Formation (Late Miocene, Middle Siwaliks). (A) Occlusal schematic showing anterior cingulum (AC), anterior and posterior fossettes (AF, PF), and median valley (MV), with labial styles (PaS, MeS, MtS) and orientation. (B) Lingual view (schematic). (C) Labial view (schematic). (F) Measurement definitions for maximum length (L) and width (W). (G) Specimen metadata and morphometric values. Scale bars = 5 mm.

DISCUSSION

The DP3 specimen USKT-PC 100923 is best attributed to Tragoportax punjabicus based on the congruence of its diagnostic selenodont cusp architecture, prominent labial styles and ribs, deep anterior and posterior fossettes, and overall medium-sized proportions consistent with Tragoportax from the Middle Siwaliks. (9,10,16) The measured length (18.60 mm) aligns closely with published DP3 values attributed to Tragoportax in comparative datasets, and the combination of size and morphology excludes allocation to the larger and more robust boselaphines Selenoportax and Pachyportax, which are typically characterized by greater crown robustness and more advanced hypsodont configurations at comparable tooth positions. (9–11,13) Although horn-core morphology is often required for decisive separation among some boselaphine lineages and has been emphasized in broader systematic reassessment, isolated dental specimens remain taxonomically informative in the Siwaliks because the fossil record frequently consists of disarticulated teeth recovered through surface collecting and stratigraphic survey. (3,11) Within this context, DP3 morphology constitutes a particularly valuable but underutilized resource for refining taxonomic datasets, documenting juvenile morphology, and capturing morphological variability otherwise masked when analyses rely predominantly on adult molars and cranial material. (11,13)

The rarity and underreporting of deciduous dentition in Siwalik boselaphines likely reflect both taphonomic filtering and collection practice. Juvenile teeth are smaller, more fragile, and more susceptible to destruction during transport and exposure, and their isolated recovery may be overlooked in field settings focused on adult diagnostic elements. Systematic surface survey frameworks developed for the Siwaliks emphasize standardized recovery and documentation of fragmentary surface assemblages to counteract such biases and to maximize biostratigraphic and palaeoecological interpretive value. (3) The present DP3 record therefore contributes not only a taxonomic datapoint but also highlights the scientific yield of careful surface collecting and the importance of documenting juvenile dentition for comprehensive systematic treatment of Siwalik bovids.

Comparatively, the DP3 of USKT-PC 100923 resembles published Tragoportax deciduous premolars in the presence of strongly expressed styles and ribs, deep fossettes, and a clear median valley, supporting its assignment to the Tragoportax lineage rather than to small early boselaphines such as Eotragus, which are typically smaller and exhibit more primitive dental configurations in early Miocene contexts. (11,14) The specimen also complements prior systematic work demonstrating that Tragoportax and related medium-sized boselaphines form an important component of Late Miocene Siwalik faunas and display geographic and morphological affinities with Eurasian assemblages of similar age, consistent with broader palaeobiogeographic patterns in which Siwalik artiodactyl records show strong links to Eurasian and African faunal provinces during the Late Miocene. (2,11,13)

The Bhandar Bone Bed and other Dhok Pathan localities in Jhelum District have been repeatedly shown to preserve a diverse artiodactyl fauna dominated by bovids, supporting reconstructions of a mosaic environment including woodland–grassland components and localized standing water bodies. (2,7,8) Such interpretations are consistent with the broader view that Dhok Pathan sedimentary environments represent fluvial systems capable of preserving dense vertebrate assemblages and that boselaphine abundance reflects productive habitats supporting mixed feeding strategies. (2,3) The documentation of T. punjabicus DP3 from this locality contributes to refining the taxonomic inventory of the Bhandar Bone Bed and reinforces its importance as a productive locality for future targeted sampling of juvenile and adult bovid dentition.

This taxonomic note has limitations inherent to its scope, primarily because the interpretation is based on a single isolated DP3 and does not include associated cranial or postcranial material that could further strengthen species-level diagnosis. Nonetheless, the specimen's preservation, distinct morphology, and measurement congruence with published comparative material provide sufficient evidence for confident referral, especially given the established presence of Tragoportax in Middle Siwalik Dhok Pathan assemblages and the diagnostic value of DP3 morphology in boselaphine taxonomy when described in detail. (9–11,13,16) Future work should prioritize systematic recovery and description of deciduous

dentition and associated juvenile material from Dhok Pathan localities, ideally integrated into a broader cranio-dental revision and morphometric synthesis of Siwalik boselaphines to improve diagnostic resolution and to quantify morphological variability across ontogenetic stages. (11)

CONCLUSION

The isolated deciduous premolar USKT-PC 100923 from the Bhandar Bone Bed (Dhok Pathan Formation, Middle Siwaliks) is confidently referred to Tragoportax punjabicus based on congruent DP3 morphology and morphometric consistency with published comparative material, representing a rare documented instance of Tragoportax deciduous dentition from Jhelum District. This record expands the documented juvenile dental morphology of Siwalik boselaphines, contributes to the taxonomic inventory of a productive but underrepresented locality, and supports ongoing reassessment of Late Miocene bovid variability and palaeobiogeographic patterns in the Siwalik Group through improved characterization of deciduous dental characters.

REFERENCE

1. Zuchora-Walske C. The Hominid Fossil Record: Ardipithecus Ramidus, Australopithecus Afarensis, and Early Homo. New York: Chelsea House; 2008.
2. Barry JC, Morgan ME, Flynn LJ, Pilbeam D, Behrensmeyer AK, Raza SI, et al. Faunal and environmental change in the late Miocene Siwaliks of northern Pakistan. Paleobiology. 2002;28:1-72.
3. Behrensmeyer AK, Barry J. Biostratigraphic surveys in the Siwaliks of Pakistan: a method for standardized surface sampling of the vertebrate fossil record. Palaeontologia Electronica. 2005;8(1):1-24.
4. Johnson NM, Opdyke ND, Johnson GD, Lindsay EH, Tahirkheli RAK. Magnetic polarity stratigraphy and ages of Siwalik Group rocks of the Potwar Plateau, Pakistan. Palaeogeogr Palaeoclimatol Palaeoecol. 1982;37(1):17-42.
5. Johnson NM, Stix J, Tauxe L, Cerveny PF, Tahirkheli RAK. Palaeomagnetic chronology, fluvial processes and tectonic implications of the Siwalik deposits near Chinji village, Pakistan. J Geol. 1985;93:27-40.
6. Flynn LJ. Small mammal indicators of forest paleo environment in the Siwalik deposits of the Potwar plateau, Pakistan. Deinsea. 2003;10:183-196.
7. Khan MA. Fossil bovids from the Late Miocene of Padri, Jhelum, Pakistan. Pak J Zool. 2008;40:25-29.
8. Draz O, Ni X, Samiullah K, Yasin R, Fazal RM, Naz S, et al. New fossil remains of artiodactyla from Dhok Pathan Formation, Middle Siwaliks of Punjab, Pakistan. Pak J Zool. 2020;52(5):1955-1967.
9. Pilgrim GE. Siwalik antelopes and oxen in the American Museum of Natural History. Bull Am Mus Nat Hist. 1937;72:729-874.
10. Akhtar M. Taxonomy and Distribution of the Siwalik Bovids. PhD Dissertation (unpublished). Lahore: University of the Punjab; 1992.
11. Bibi F, Bukhsianidze M, Gentry AW, Geraads D, Kostopoulos DS, Vrba ES. The fossil record and evolution of Bovidae: state of the field. Palaeontologia Electronica. 2009;12(3):10-11.
12. Khan MA, Akhtar M, Rohi G, Iqbal M, Samiullah K. The Late Miocene Artiodactyls in the Dhok Pathan type locality of the Dhok Pathan Formation, the Middle Siwaliks, Pakistan. Pak J Zool. 2010a;10:1-90.
13. Bibi F, Güleç E. Bovidae (Mammalia: Artiodactyla) from the late Miocene of Sivas, Turkey. J Vertebr Paleontol (or relevant journal as per their published source in your dataset). 2008;[details as in thesis reference/citation].
14. Solounias N, Barry JC, Bernor RL, Lindsay EH, Raza SM. The oldest bovid from the Siwaliks. Pak J Vertebr Palaeontol. 1995;15:806-814.
15. Abbas SG, Babar MA, Khan MA, Aftab K, Riaz A, Ghaffar A, et al. Fossil Bovidae from Late Miocene Dhok Pathan Formation of Siwaliks, Northern Pakistan. Pak J Zool. 2018;50(1).
16. Pilgrim GE. The fossil bovidae of India. Palaeontologia Indica. 1939;26(1):1-356.