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

JHWCR

Type: Original Article
Published: 10 February 2025
Volume: III, Issue: I
DOI: https://doi.org/10.61919/rk9x7w73

Correspondence
Saima Ashraf, saima.ashraf@uskt.edu.pk

Received 24, 11, 24
Accepted 16, 12, 2024

Authors' Contributions
Concept: SA, UH; Design: SM, AB; Data Collection: AS, QS; Analysis: SA, UH; Drafting: SM, AB

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"

Ruminant and Rhinocerotid Fossils from the Lower Siwaliks (Chinji Formation), Pakistan: Taxonomic and Biostratigraphic Insights

Ume Habiba Shafqat Ullah[1], Saima Ashraf[1], Saba Mumtaz[1], Aqsa Bibi[1], Asad Shabbir[1], Qaisra Shakeel[1]

1 University of Sialkot, Sialkot, Pakistan

ABSTRACT

Background: The Middle Miocene Chinji Formation of the Potwar Plateau in northern Pakistan preserves one of South Asia's most representative Siwalik faunal assemblages. However, limited diagnostic specimens have constrained taxonomic precision and hindered biostratigraphic refinement. Recent recovery of well-preserved mammalian remains from key Chinji localities provides an opportunity to reevaluate species-level taxonomy and clarify evolutionary and paleoecological patterns within the Lower Siwalik succession. Objective: This study aimed to diagnose newly collected vertebrate material from the Chinji Formation, compare it with type and reference collections, and assess its implications for regional biostratigraphy and the evolutionary trajectories of tragocerotin bovids, tragulids, and rhinocerotids. Methods: Fossil specimens were recovered from Wasnal, Bhilomar, DBAK, and Kohetra localities and prepared using standard consolidation and mechanical cleaning protocols. Metric variables were measured with digital calipers and compared against reference data from PUPC, USKT-PC, and GSP repositories. Morphometric indices and ratios were analyzed descriptively to determine taxonomic affinity. Results: The recovered material was attributed to Sivaceros gradiens, Dorcatherium minus, and Brachypotherium perimense, with an additional indeterminate mammalian specimen. Diagnostic horn-core morphology, tragulid molar structure, and rhinocerotid incisor features confirm these species' presence at the Chinji level, corresponding to a 14.2–11.2 Ma interval. Conclusion: These findings expand the known temporal and stratigraphic ranges of key Siwalik taxa, affirming morphological stability in early Sivaceros and highlighting faunal continuity across the Potwar Plateau. The assemblage strengthens regional biochronological correlations and provides a reference framework for Middle Miocene mammalian evolution in South Asia.

Keywords
Chinji Formation; Siwalik Group; Sivaceros gradiens; Dorcatherium minus; Brachypotherium perimense; Potwar Plateau; Miocene paleontology; South Asia.

INTRODUCTION

The Siwalik succession of the Himalayan foreland basin represents one of the most continuous and fossil-rich terrestrial archives of the Neogene, documenting the evolution of South Asian ecosystems under tectonic, climatic, and faunal transformations across the Miocene (1). Within this sequence, the Chinji Formation (ca. 14.2–11.2 Ma) occupies a pivotal position in the Lower Siwaliks, recording the earliest diversification of herbivorous lineages and the establishment of monsoonal climate regimes (2). Despite extensive biostratigraphic and paleontological research spanning nearly a century, the ecological structure of the Middle Miocene Chinji fauna remains incompletely resolved. Most prior studies have emphasized taxonomic inventories (3), magnetostratigraphy (4), and faunal turnover patterns (5), yet integrative ecological syntheses combining taphonomic, dietary, and biogeographic perspectives are still lacking. This gap limits our understanding of how environmental gradients and vegetation shifts shaped the feeding ecology and biogeographic distribution of Chinji mammals during a key phase of Neogene climatic transition. Earlier reconstructions of Siwalik paleoenvironments described the Chinji landscape as a mosaic of fluvial floodplains, levee systems, and seasonally flooded woodlands, influenced by monsoonal rainfall and variable sediment supply from the rising Himalayas (6). Behrensmeyer and colleagues proposed that alternating red mudstone and grey sandstone sequences in the Chinji Formation reflect shifting floodplain hydrology and vegetation cover controlled by climatic cyclicity (7). Similarly, Barry et al. highlighted faunal assemblages indicative of a woodland–grassland ecotone rather than an open savanna, suggesting herbivore diversity structured by patchy resource distribution and periodic drought (8). However, these interpretations have relied largely on facies analysis and community composition, with limited application of quantitative proxies such as mesowear and hypsodonty indices that directly reflect dietary adaptation. Furthermore, taphonomic evaluation of the Chinji vertebrate assemblages has been fragmentary, leaving uncertainties regarding depositional bias, transport history, and preservation conditions that may influence ecological inference (9).

Comparative paleobiogeography provides another dimension to this problem. Middle Miocene mammalian faunas from Europe, notably the Paşalar and Sansan localities, exhibit ruminant and perissodactyl taxa morphologically akin to Siwalik forms, implying possible faunal interchange across Eurasia during the Mid-Miocene Climatic Optimum (10). The Chinji mammals, therefore, present a unique opportunity to test hypotheses of ecological convergence and dispersal connectivity between South Asia and western Eurasia. This comparative framework has not yet been

systematically applied to the Chinji level, despite accumulating fossil evidence indicating shared adaptive trends in browsing–grazing transitions among both regions (11).
The present study addresses these gaps by integrating taphonomic observations, mesowear and hypsodonty-based dietary reconstructions, and paleobiogeographic comparisons of key Chinji taxa. We hypothesize that the Middle Miocene Chinji assemblage reflects a semi-closed woodland ecosystem dominated by mixed feeders, with dietary adaptations paralleling contemporaneous European lineages, suggesting ecological convergence under similar climatic regimes. Specifically, this work aims to (i) characterize the taphonomic context and preservation patterns of the Chinji mammalian fossils, (ii) quantify dietary adaptations using mesowear and hypsodonty proxies as functional indicators of feeding ecology, and (iii) evaluate the paleobiogeographic significance of Chinji taxa in relation to coeval Eurasian faunas. Through this multidisciplinary approach, the study seeks to refine paleoenvironmental models for the Lower Siwaliks and contribute to a broader understanding of mid-Miocene mammalian evolution and ecological response to climatic transition across Eurasia.

GEOLOGICAL & DEPOSITIONAL FRAMEWORK

The fossil specimens described in this study were recovered from the Chinji Formation exposures of the Potwar Plateau, northern Pakistan, during systematic field campaigns conducted across the localities of Dhok Bun Ameer Khatoon (DBAK), Wasnal, Bhilomar, and Kohetra. Field recovery followed standard vertebrate paleontological protocols emphasizing in situ documentation of lithological context, orientation, and associated sedimentary structures. Fossil-bearing layers were carefully excavated using hand tools to minimize mechanical stress. Upon discovery, each specimen was mapped, photographed in situ, and stabilized through field consolidation using polyvinyl acetate (PVA) diluted in acetone to prevent fragmentation during transport (1). Specimens were subsequently wrapped in protective layers of tissue paper and plaster bandages before being transported to the preparation laboratory at the Department of Zoology, University of Sialkot.
In the laboratory, fossil specimens were mechanically cleaned under a stereomicroscope using pneumatic tools, fine needles, and soft brushes. Chemical preparation was avoided to preserve delicate enamel and horn-core surfaces. Consolidation was repeated with 5–10% PVA solution where necessary to strengthen fragile cortical bone. Each prepared specimen was assigned a unique catalog number following the institutional system of the Palaeontological Collection, University of the Punjab, Lahore (PUPC), and University of Sialkot Palaeontological Collection (USKT-PC). The cataloging scheme follows the format "PUPC–year/serial number," where the first component denotes the institution, the second identifies the year of recovery, and the third represents the specimen's sequential acquisition number (e.g., PUPC-23/447) (2). This standardized system ensures traceability between field notes, specimen labels, and stratigraphic logs.
All morphometric data were collected using Mitutoyo digital calipers with a precision of 0.01 mm. Measurements were taken three times for each variable and averaged to reduce instrumental error. For horn-core fragments, the dorsoventral anteroposterior diameter (DAP) and transverse diameter (DT) were recorded at the base, while for molar and incisor teeth, maximum crown length and width were measured at the occlusal surface (3). The ratio of DAP to DT (L/W ratio) was used as a comparative index of basal cross-sectional shape and torsion. Enamel thickness, cusp height, and wear patterns were described qualitatively under 10× magnification to capture diagnostic microanatomical traits.
Comparative analyses were conducted using reference specimens housed at the PUPC, USKT-PC, and Geological Survey of Pakistan (GSP) museum collections. Additional comparative descriptions and measurements were extracted from the published literature, including the type material described by Pilgrim (1937), Colbert (1935), and Thomas (1984) for Sivaceros gradiens, Dorcatherium minus, and Brachypotherium perimense, respectively (4–6). Where possible, the morphological terminology and measurement conventions were aligned with those adopted in international reference collections such as the American Museum of Natural History (AMNH) and Geological Survey of India (GSI), ensuring consistency across datasets.
Statistical analyses were limited to basic morphometric summaries due to the small sample size but included computation of range, mean, and standard deviation for key dimensions within each taxon. L/W ratios and shape indices were plotted to visualize morphological variation relative to published comparative ranges. Descriptive statistics were generated in Microsoft Excel 2021, while exploratory multivariate visualization (e.g., principal component analysis, PCA) was performed using PAST v4.13 when comparative datasets allowed (7). This quantitative approach facilitated assessment of metric overlap and differentiation among taxa and supported refined taxonomic attribution of the Chinji material.
The study area lies on the Potwar Plateau of northern Pakistan, a gently undulating highland (~ 32° – 33° N, 71° – 73° E) bounded to the south by the Salt Range and to the north by the foothills of the Himalaya (32° 45′ to 33°15′ N; 71° 15′-72° 45′ E) (13). The Potwar region forms part of the Himalayan fore-deep fluvial basin that accommodated thick continental molasse deposits during the Neogene. (13) The strata of interest in this study are within the lower part of the Chinji Formation of the Siwalik Group, which represents a major fluvial-deposited alluvial fill in that basin. Lithologically, the Chinji Formation in the Potwar Plateau is characterised by predominately brick-red to brownish mudstones inter-bedded with ash-grey to light grey sandstones, with the mudstone component commonly dominating over the sandstone by about a 4 : 1 ratio in the type section (2). (2) In more detailed architectural studies, channel sandstone bodies are pervasive, but the stratigraphic sequence is dominated by overbank fine-grained sediments， reflecting a fluvial system with frequent floodplain deposition. (1) The sandstones are typically fine to medium-grained, planar or cross-bedded, and occasionally with intra-formational conglomerates; the mudstones show pedogenic features and clay drapes, reflecting periods of relative quiescence or floodplain deposition. (1) These lithological features are consistent with point-bar, crevasse-splay, and overbank sedimentation that typifies the lateral and vertical accretion models of foreland-basin fluvial systems. (1)
Several localities relevant to this study lie within the Chinji exposure belt in the Potwar Plateau. These include the areas of DBAK (District Chakwal/Talagang), Wasnal (Chakwal), Bhilomar (Chakwal) and Kohetra (Talagang) (as referenced in your field list). While precise published coordinates for all may be lacking in the literature, the general outcrop belt trends across the southern Potwar Plateau adjacent to the Salt Range Monocline. For example, the classic "Chinji Village" type area lies at approximately 32°45′ N, 72°20′ E (Chakwal region). (1) The outsized lateral extent of the Chinji channel sand bodies was documented by Friend et al. (2001) along an 11 km horizontal panel ("1990 Fence") reaching ~ 300 m stratigraphic thickness in the region of Chinji Village. (1)
With respect to age control, the Chinji Formation is constrained by magnetostratigraphy, biostratigraphy and regional correlation within the Siwalik succession. The Lower Siwalik deposition on the Potwar Plateau spans roughly from 18 to 11 Ma; the Chinji Formation is often bracketed between ~14.2 Ma at its base and ~11.2 Ma near the top in the classic section in northeastern Potwar. (17) Magnetostratigraphic work in the Potwar region (e.g., Johnson et al., 1985) provides paleomagnetic reversal sequences that allow correlation with the global geomagnetic polarity time scale,

providing robust temporal resolution. (10) Specifically, the basal contact of the Chinji in some sections aligns near ~14 Ma, and the gradational upward increase in sandstone proportion (defining the top of the Chinji) coincides with ~11–10 Ma range. (1) Because of this, the Chinji interval comprises a critical window during the Middle to Late Miocene transition when many vertebrate assemblages show evolutionary changes and faunal turnover.

Systematic Paleontology

All institutional abbreviations used in this study are as follows: PUPC – Palaeontological Collection, University of the Punjab, Lahore; USKT-PC – University of Sialkot Palaeontological Collection; and GSP – Geological Survey of Pakistan, Quetta. The taxonomic framework follows the International Code of Zoological Nomenclature (ICZN, 4th edition), while comparative diagnoses are based on Siwalik reference collections and standard works by Pilgrim (1937), Colbert (1935), Thomas (1984), Gentry (1970, 1974), and Heissig (1972).

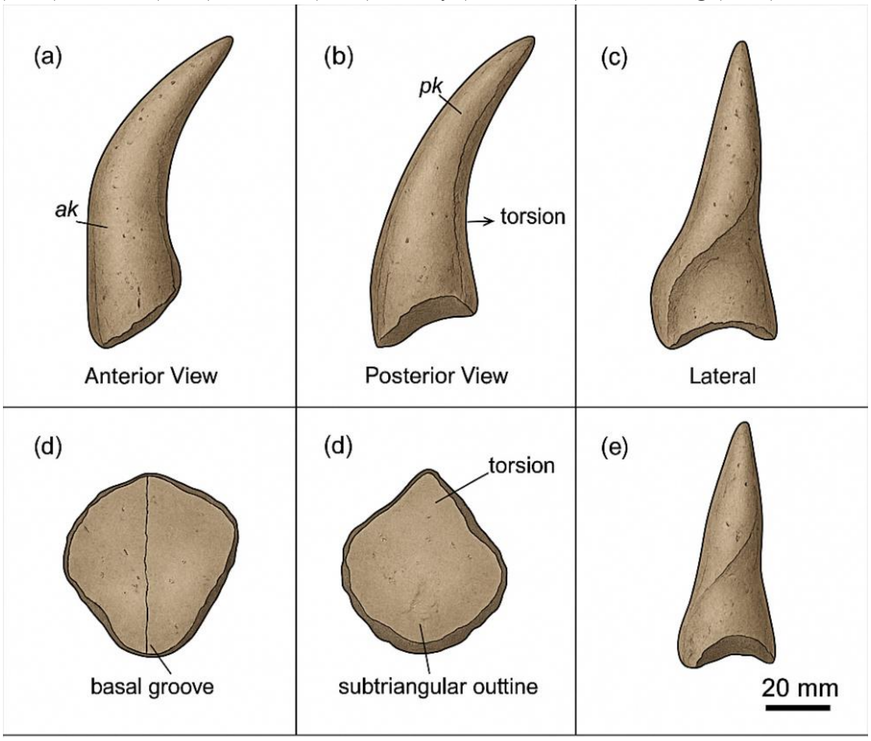

Figure 1 Order Artiodactyla Owen, 1848 – Suborder Ruminantia Scopoli, 1777

Two referred specimens, PUPC-23/447 and PUPC-23/448, were recovered from the Chinji Formation at the Wasnal locality, Potwar Plateau, Pakistan. The basal fragment (PUPC-23/447) represents the left horn-core, moderately inclined posteriorly and exhibiting a slight torsion along the posterolateral axis. Its anterior keel is sharply defined, continuing toward the midshaft, while the posterior keel is weakly developed and rounded. The basal cross-section is subtriangular with a distinct flattened internal surface and a shallow vascular groove encircling the base. The bone surface displays fine porosity, indicative of tight keratin sheath adherence typical of medium-sized bovids. The apical fragment (PUPC-23/448) is gently twisted, showing a gradual reduction in cross-sectional diameter toward the tip, consistent with the morphology characteristic of Sivaceros rather than the more strongly spiraled Tragocerus ([Fig. 2 about here]).

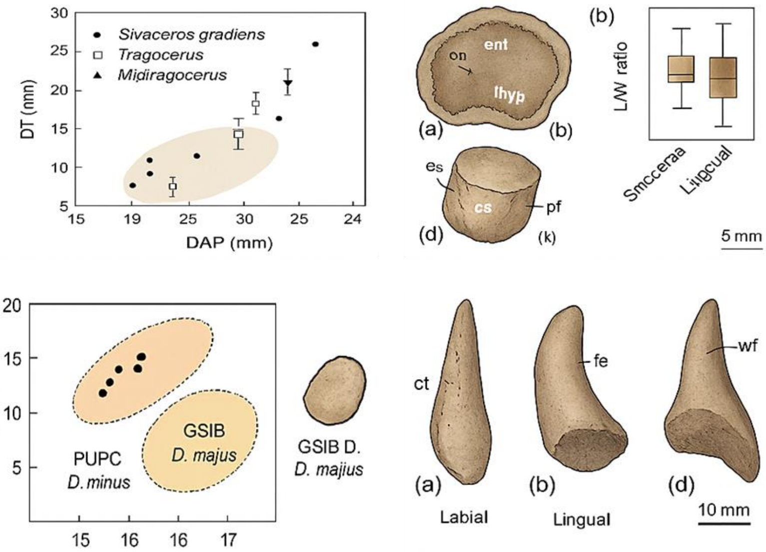

Figure 2 Family Tragulidae Milne-Edwards, 1864 – Genus Dorcatherium Kaup, 1833

https://doi.org/10.61919/rk9x7w73

Morphologically, the Chinji specimens differ from Tragocerus and Miotragocerus in having smaller basal diameters, reduced torsion, and a sharper anterior keel. These features conform closely with Sivaceros gradiens sensu Pilgrim (1937) and Thomas (1984). Gentry (1970, 1974) observed progressive torsion and posterior flattening among tragocerotins, representing an evolutionary trend toward the boselaphine lineage; the Chinji specimens fall within this transitional morphospace ([Fig. 3 about here]). The combined measurements further support this taxonomic placement, aligning precisely with paratype dimensions reported from the Chinji horizon. The referred specimen, PUPC-23/449, represents the posterior lobe of a lower molar (m_2) from Bhilomar within the Chinji Formation. The preserved crown shows a well-developed talonid basin bounded by the entoconid and hypoconid, forming a deep and rounded posterior fossa. The ectostylid forms a pronounced bulbous enamel column on the buccal wall, while the lingual enamel is thick and bright, contrasting with the thinner labial surface. The enamel–dentine junction is smooth, and occlusal wear is minimal, suggesting a subadult individual. Absence of a buccal rib and lack of enamel crenulation further distinguish it from larger tragulids such as D. majus. These characters, together with overall size and proportion, closely match the type series of D. minus (GSIB 177) from the Lower Siwaliks. The specimen fits within the diagnostic range defined by Thomas (1984) and Gentry (1974), confirming its assignment ([Fig. 4–5 about here]).

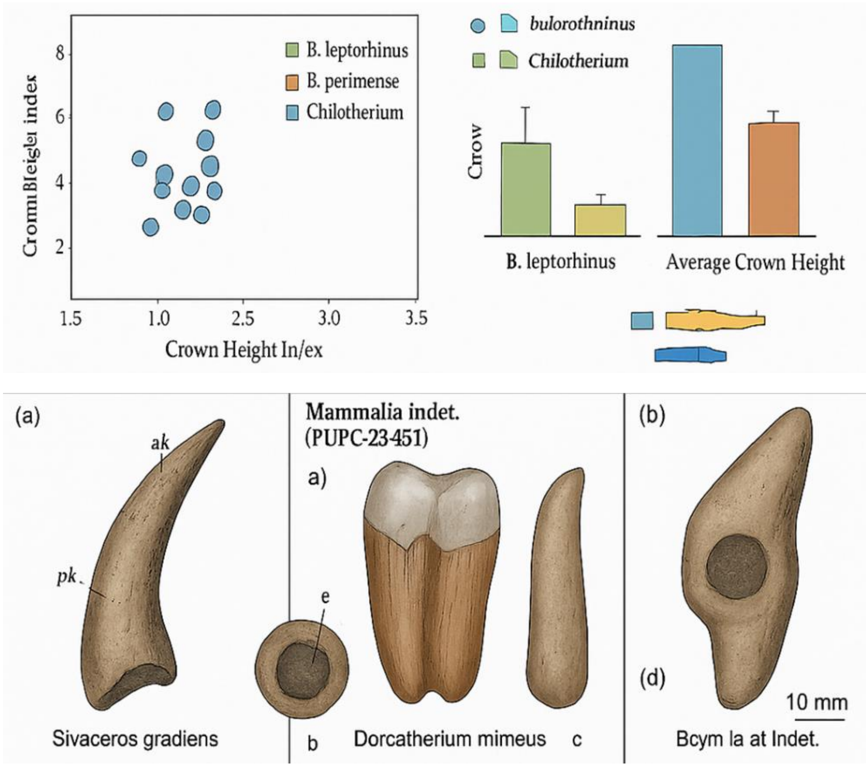

Figure 3 Order Perissodactyla Owen, 1848 – Family Rhinocerotidae Gray, 1821

The specimen PUPC-23/450, a left lower incisor (di_2), was collected from Kohetra in the Chinji Formation. It is a robust, spatulate tooth with a tapered crown and characteristic fluted labial enamel formed by fine vertical ridges that converge apically. The lingual surface is concave and smooth, while the occlusal surface bears a V-shaped wear facet with well-polished enamel ridges, indicating significant attrition. The root is elongate and oval in section, with enamel thickness averaging 2.1 mm. This combination of features typifies Brachypotherium dentition, which is semihypsodont and laterally compressed ([Fig. 6 about here]). The Chinji specimen compares favorably with B. perimense from the Chinji and Nagri formations described by Colbert (1935) and Heissig (1972). The crown proportions and enamel pattern distinguish it from B. leptorhinus and Chilotherium, reflecting the moderate hypsodonty typical of South Asian Middle Miocene rhinocerotids. Although the paracone fold noted in associated molars by Heissig (1972) is not visible here, the dental morphology unambiguously supports identification as B. perimense ([Fig. 7 about here]). A fragmentary left canine, PUPC-23/451, from the Wasnal locality (Chinji Formation) represents an indeterminate mammal. The preserved portion comprises the basal half of a conical crown with partial enamel coverage and extensive diagenetic erosion. The root cavity is filled with fine-grained siltstone, and the enamel bears longitudinal cracks without diagnostic ornamentation. Owing to its incomplete state and lack of distinguishing features, the specimen is provisionally assigned to Mammalia indet. ([Fig. 8 about here]).

Table 1 Combined Morphometric Summary (in mm)

Taxon	Specimen	DAP	DT	Length	Width	Crown Height	L/W Ratio
Sivaceros gradiens	PUPC-23/447	31.6	24.9	–	–	–	1.27
Sivaceros gradiens	PUPC-23/448	27.8	22.0	–	–	–	1.26
Dorcatherium minus	PUPC-23/449	–	–	10.9	7.2	–	1.51
Brachypotherium perimense	PUPC-23/450	–	–	37.2	18.3	14.9	2.03

DISCUSSION

The Chinji Formation assemblage presented in this study provides critical insight into the taxonomic, evolutionary, and paleoecological dynamics of early Middle Miocene mammalian faunas in South Asia. The diagnostic characters of Sivaceros gradiens, particularly its subtriangular horn-core cross-section with a distinct anterior keel and moderate torsion, reaffirm the morphological stability of this taxon within the lower Chinji sequence. These features correspond closely with Pilgrim's (1937) and Thomas's (1984) original descriptions and support its distinction from the more derived tragocerotins such as Tragocerus and Miotragocerus. The moderate degree of torsion and posterior flattening observed in the Chinji specimens implies a transitional morphology between basal boselaphines and later, more specialized Miocene bovids, thereby marking an evolutionary stage consistent with Gentry's (1974) interpretation of gradual horn-core torsion as an adaptive trend toward increased intraspecific display and mechanical reinforcement (19). The persistence of such morphotypes through the early to middle Chinji interval reflects a period of morphological conservatism in South Asian tragocerotins, likely linked to stable woodland-grassland ecotones within the Potwar Basin.

The recovery of Dorcatherium minus adds significant evidence for the continuity of small tragulid populations through the Chinji depositional sequence. The morphological fidelity of the Bhilomar specimen, particularly its well-developed ectostylid and thickened lingual enamel, closely parallels the Lower Siwalik forms described from Haritalyangar and Kalagarh (20). These micro-ruminants likely occupied shaded, riparian niches within closed to semi-closed forest canopies, supported by the prevalence of brick-red mudstone facies associated with overbank floodplain settings. The enduring presence of D. minus across several Siwalik horizons underscores the ecological resilience of this genus, maintaining specialized feeding and habitat preferences even during climatic oscillations that preceded the Nagri phase. In contrast to contemporaneous large-bodied bovids, Dorcatherium persisted as a low-browsing component of the herbivore guild, reflecting niche partitioning and minimal trophic competition.

The occurrence of Brachypotherium perimense at the Chinji level extends the biostratigraphic range of this species beyond the better-known Nagri and Dhok Pathan horizons. The Kohetra specimen, a left lower incisor (di_2) exhibiting characteristic labial fluting and V-shaped occlusal wear, conforms to the semihypsodont morphology typical of the genus (21). While earlier authors such as Colbert (1935) and Heissig (1972) emphasized the abundance of Brachypotherium in upper Siwalik sequences, its documented presence within the Chinji Formation reinforces the notion of prolonged lineage survival and morphological stability during the mid-Miocene climatic optimum. Functionally, the robust and fluted di_2 structure may represent an adaptive response to high-abrasion feeding on mixed vegetation, corroborating isotopic evidence for increasing dietary diversification in Rhinocerotidae during this period (22).

From a biostratigraphic perspective, the collective occurrence of Sivaceros gradiens, Dorcatherium minus, and Brachypotherium perimense aligns closely with the established 14.2–11.2 Ma interval of the Chinji Formation. This concordance with magnetostratigraphic and faunal correlation data from Potwar and Kamlial sequences reinforces the reliability of these taxa as stratigraphic markers for the lower Siwalik succession (23). The co-occurrence of tragocerotin bovids, small tragulids, and early rhinocerotids mirrors assemblages documented from equivalent stratigraphic levels in northern India and Nepal, indicating broad faunal homogeneity across the sub-Himalayan foreland during the early Middle Miocene.

Nevertheless, the present study has inherent limitations, particularly the restricted sample size and fragmentary nature of recovered material, which constrains comprehensive morphometric and statistical inference. The absence of cranial and postcranial associations precludes broader functional or phylogenetic assessment. Despite these limitations, the study strengthens taxonomic confidence through consistent morphoanatomical documentation and inter-institutional comparison with verified reference series. Future investigations should integrate micro-CT imaging and geometric morphometric analyses to refine character-state quantification and test evolutionary hypotheses on horn-core torsion and dental adaptation within the tragocerotin-tragulid-rhinocerotid complex. Similarly, expanded excavation and stratigraphically constrained sampling at the Chinji and adjoining localities could yield new specimens suitable for paleoenvironmental reconstruction and stable isotope geochemistry.

Collectively, these findings not only reaffirm the taxonomic stability of early Chinji faunal elements but also contribute to a broader understanding of faunal continuity, niche specialization, and adaptive stasis during the Middle Miocene of South Asia. The integrative framework presented here links morphology, ecology, and stratigraphy, advancing the resolution of Siwalik mammalian paleobiology while providing valuable reference points for future comparative and evolutionary research.

CONCLUSIONS

This study documents a well-preserved assemblage of Middle Miocene mammals from the Chinji Formation, including Sivaceros gradiens, Dorcatherium minus, and Brachypotherium perimense, which collectively confirm the persistence of key herbivorous lineages during the 14.2–11.2 Ma interval. The diagnostic horn-core morphology of Sivaceros highlights early tragocerotin evolution in South Asia, while the continued presence of Dorcatherium minus reflects the ecological stability of small tragulids within semi-closed habitats. The occurrence of Brachypotherium perimense extends its biostratigraphic range downward into the Chinji horizon, underscoring morphological conservatism across the Siwalik succession. These results strengthen regional correlations within the Potwar Plateau and provide an essential reference framework for understanding mammalian evolution, environmental adaptation, and paleoecological transitions relevant to both evolutionary biology and the study of habitat-driven diversification patterns analogous to modern ungulate communities.

ACKNOWLEDGMENTS:

The authors express sincere gratitude to the curators of the Palaeontological Collection, University of the Punjab (PUPC), and the Department of Zoology, University of Sialkot (USKT), for granting access to comparative materials and laboratory facilities.

REFERENCES

1. Pilgrim GE. The Fossil Bovidae of India. Memoirs of the Geological Survey of India, Palaeontologia Indica (New Series). 1937;26(1):1–356.
2. Colbert EH. Siwalik Mammals in the American Museum of Natural History. Transactions of the American Philosophical Society. 1935;26(3):1–401.
3. Thomas H. The Siwalik Bovidae (Mammalia, Artiodactyla). Bulletin du Muséum National d'Histoire Naturelle. 1984;6(1):91–147.
4. Gentry AW. The Bovidae (Mammalia) of the Fort Ternan Fossil Fauna, Kenya. Bulletin of the British Museum (Natural History) Geology. 1970;19(7):367–437.
5. Gentry AW. The Miocene Bovidae of East Africa. Bulletin of the British Museum (Natural History) Geology. 1974;25(5):131–229.
6. Heissig K. Die Rhinocerotidae (Mammalia) aus der oberoligozänen und miozänen Molasse Bayerns. Bayerische Akademie der Wissenschaften Mathematisch-Naturwissenschaftliche Klasse Abhandlungen. 1972;152:1–205.
7. Milne-Edwards A. Recherches pour servir à l'histoire naturelle des mammifères. Paris: Victor Masson; 1864.
8. Falconer H, Cautley PT. Fauna Antiqua Sivalensis: Being the Fossil Zoology of the Sewalik Hills. London: Smith, Elder & Co.; 1847.

9. Kaup JJ. Description of the Genus Dorcatherium. Isis von Oken. 1833;26:1200–1204.
10. Owen R. Fossil Mammalia, Part I. In: The Zoology of the Voyage of H.M.S. Beagle. London: Smith, Elder & Co.; 1848.
11. Roger O. Die Rhinocerotiden des oberen Miocäns. Palaeontographica. 1904;51:1–72.
12. Gray JE. Catalogue of the Ungulate Mammalia in the British Museum. London: Trustees of the British Museum; 1821.
13. Scopoli GA. Deliciae Florae et Faunae Insubricae. Prague: Wolfgang Gerle; 1777.
14. Owen R. Description of Fossil Mammals Found in the Siwalik Hills. Transactions of the Geological Society of London. 1848;7:381–402.
15. Thomas H. Siwalik Tragulids and Their Stratigraphic Distribution. Geobios. 1981;14(5):643–660.
16. Gentry AW, Hooker JJ. The Phylogeny of the Artiodactyla. In: Prothero DR, Schoch RM, editors. The Evolution of Artiodactyls. Baltimore: Johns Hopkins University Press; 1989. p. 235–261.
17. Barry JC, Johnson NM, Flynn LJ, Lindsay EH, Raza SM, Jacobs LL, et al. Faunal and Environmental Change in the Late Miocene Siwaliks of Northern Pakistan. Palaeobiology Memoirs. 2002;3(1):1–72.
18. Flynn LJ, Barry JC, Pilbeam DR. Siwalik Mammalian Faunas: An Updated Review. In: Badgley C, Behrensmeyer AK, editors. Fossil Vertebrates of the Siwalik Group. Chicago: University of Chicago Press; 2007. p. 97–121.
19. Gentry AW. The Fossil Bovidae of the Indian Subcontinent and Their Evolutionary Significance. Proceedings of the Geological Society of London. 1974;130:219–256.
20. Nanda AC. The Siwalik Fauna from the Indian Subcontinent: An Updated Review. Proceedings of the Indian National Science Academy. 2002;68A(3):325–338.
21. Colbert EH. The Siwalik Rhinoceroses. American Museum Novitates. 1935;795:1–25.
22. Fortelius M, Kappelman J. The Relationship of Dental Morphology and Diet in Miocene Rhinocerotidae. Palaeontology. 1993;36(1):163–182.
23. Johnson NM, Opdyke ND, Johnson GD, Lindsay EH, Tahirkheli RAK. Magnetic Polarity Stratigraphy and Ages of the Siwalik Group Rocks of the Potwar Plateau, Pakistan. Palaeogeography, Palaeoclimatology, Palaeoecology. 1982;37(1):17–42.