**In situ** dental remains of *Deinotherium* from Northwest Indian Siwaliks

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**Abstract:** Present paper reports a mandibular molar (M₃) of *Deinotherium* from the pink clay deposits of the Chinji Formation (Lower Siwalik subgroup) of Rammagar area (Jammu), and two maxillary molars (M²-M⁴) from the sandstone block of the Middle Siwalik subgroup exposed at lower altitude of the Nurpur town (H.P.). The palaeontological and ecological implications of the findings are discussed.

**Keywords:** Deinotheriidae, Chinji Formation, Lower Siwalik, Rammagar, Nurpur, Himachal Pradesh

**INTRODUCTION**

*Deinotherium* Kaup represents a distinct proboscidean clade that evolved to the size of modern elephants. It evolved from the *Prodeinotherium hobleyi* (during Oligocene) which had ancestry in the first lineage of the primitive deinotherid, *Chilgatherium* in eastern Africa (Sanders et al. 2004). The migration of *Prodeinotherium* to the Indian Subcontinent and Eurasia from Africa at ca. 18 Mya is known as “Proboscidean datum event” (Tassy 1990; Huttunen 2002). An isolated premolar (P₃) from the Upper Dharamsala succession (Tiwari et al. 2006) supports early appearance of *Prodeinotherium* in the north-western region of the Indian subcontinent. *Prodeinotherium* evolved into two different species, *P. bavarianum* (Europe) and *P. pentapotamiae* (Asia). Primitive *Prodeinotherium* was a relatively small-bodied form that gradually evolved to *Deinotherium* Kaup. Notable pioneer works on elephants including *Deinotherium* are those of Weinsheimer (1883), Osborn (1936) and Gräf (1957).

Huttunen (2002) observed that *Deinotherium* diversified into several species in the Old World which varied more in size than in morphology, viz., *D. bozasi* Arambourg 1934 (Africa), *D. giganteum* Kaup 1829 (Europe), and *D. indicum* Falconer 1945 (Asia) in the beginning of the late Miocene. In his overview Rai (2004) observed that early Miocene forms of *Deinotherium* and *Prodeinotherium* evolved in Europe and later forms in India and some continued up to Early Pleistocene in Kenya. He noted six species of *Deinotherium* in the Indian subcontinent as recognized by various workers, namely (i) *D. indicum* Falconer 1845 in Khambaat and Kachchh (Gujarat) and Kangra (H.P.) (Sahni & Gupta 1975; Sahni & Gupta 1982); (ii) *D. angustidens* Koch 1845 in Cambay (Gujarat); (iii) *D. pentapotamiae* Falconer &

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**Fig. 1.** (a) Generalized map of the Lower Siwalik area around Rammagar, District Udhampur, and Jammu region showing the fossil locality of *Deinotherium* near Thpalal village (modified from Vasisht et al. 1985, Basu 2004). (b) Geological map of the Siwalik area around Nurpur, District Kangra (H.P.) showing fossil localities of the Upper Facies marked with small star, and of the Lower Facie marked with big star that yielded *Deinotherium* fossils along the Jabbar Khad (modified from Sehgal & Nanda 2002a).
Lydekker 1876 in Kachchh, Perim Island and Cambay (Gujarat) and Indus valley (Attock); (iv) *D. sindiense* Lydekker 1880 in Salt Range; (v) *D. indicum* var. gajense Pilgrim 1912 in Gaj (Bugi); (vi) *D. orlovii* Sahni 1957 in Malal, Attock.

Later, additional deinothere fossils were reported from Indian subcontinent by Sahni & Tripathi (1957); Dehm et al. (1963); Sahni & Misra (1974) and from Nepal by West et al. (1978). But, barring *D. orlovii*, most of the large-sized specimens were allocated to *D. indicum*, regarded an advance type. The small-sized fossils were attributed to *Prodeinotherium* Harris (1973) recognised as less advanced type. There is an additional distinction between them; the proto- and metalophids of the third premolar (*P*₃) are parallel in *Prodeinotherium* compared to those of *Deinotherium* where the anterior conids are fused to form a single anterior lophid (Huttunen 2002: 245).

Present study reports important in situ recoveries of dentition of *Deinotherium* from the Lower and Middle Siwaliks of north-west Himalayas. One is an excellently preserved left mandibular molar (*M*₂) recovered by ARS from the pink clay deposits exposed near Thaplal village of Ramnagar area (32°49'N:75°19'E) in Udhampur District of J. & K. (Fig. 1a). The other find is of two left maxillary molars (*M'-M*') from the compact sandstone block exposed along the Jabbar Khad 500m north of Nurpur Bus Stand (31°10'N:76°28'E), District Kangra, Himachal Pradesh (Fig. 1b). The fossils bearing catalogue Nos. RNR-1, NPR-1 and NPR-2 are in the repository of the Palaeo Research Society at Ghumarwin, District Bilaspur, Himachal Pradesh, India.

**Stratigraphy:** The pink clays and sandstone beds of Ramnagar area (J & K) are securely attributed to the Chinji Formation of the Lower Siwalik dated to ~12 Mya in later Middle Miocene (Vasishat et al. 1985; Basu 2004) (Fig. 1a). The pink-brown clay deposits alternating with sandstone layers overhanging the Nurpur town (Fig. 2b) are biostratigraphically assigned to the Upper Nagri and Dhol Pathan formations of the Middle Siwalik by Sehgal & Nanda (2002a, b), but the beds on which Nurpur town is situated are
considered as part of the Lower Siwalik (Karunakaran & Ranga Rao 1979) based on lithology.

**SYSTEMATIC PALAEONTOLOGY**

Order Proboscidea Illiger 1811  
Family Deinotheriidae Bonaparte 1845  
Genus Deinotherium Kaup 1829  
Species Deinotherium indicum Falconer 1845  
Discription

**A. Ramnagar Material**

LM$_1$ (RNR-1): It is an isolated second left mandibular molar with excellently preserved crown (Fig. 3e-f); the roots are missing in isolated Deinotherium molar. The tooth is unworn and has typical two crest-like lophids which splay backwards and bevelled anteriorly forming a v-shaped valley between them. The anterior lophid is little shorter (62 mm) than the posterior one (67 mm) tapering to the apex. Both the lophids are rugose. The metaloph has two developed protocristids that extend medially and the labial one ends on the anterior cingulum. The cingulum is less prominent and visible in the middle part of the anterior lophid, but marked and obliquely turning lingually on the posterior lophid. The labial conids are lower than the lingual ones and the maximal lingual height of the crown is on the metaconid (36 mm), which is lesser than of the Prodeinotherium pentapotamiae (40.16) of Thailand (Thasod et al. 2012) and far lesser than that of D. giganteus from Russia (54.2 mm) (Bajgusheva & Titov 2006).

**B. Nurpur Material**

The crown of both maxillary molars (NPR-1 & NPR-2) (Fig. 3a-d) have typical two lophs more curled at the medial and lateral ends forming broad loops unlike that of Prodeinotherium where the lophs are nearly straight and parallel. However, P$_3$ is considered a diagnostic feature of the species (Huttunen 2000, 2002a).

LM$_1$: It is located slightly medially with respect to the M$_1$ and is wider medio-lingually than long mesio-distally (Table 1). The crown is excellently preserved and the occlusal surface exhibits considerable oblique wear indicative of an adult individual. The lophs splay forward and are well preserved and run in a gentle curve. The protoloph makes wider and smooth lingual loop narrowing and slightly hook-like at the posterior aspect of the paracone. The metaloph forms relatively narrower and smooth loops both lingually and buccally. Both the protoloph and the metaloph take smooth round on lingual side and a hook like turn on the labial side. The metaloph rises more obliquely than the protoloph. The labial length is slightly lesser (58 mm) compared to the lingual length (60 mm). The front cingulum is like a well developed 13 mm band emerging from the base of the protocone and running up to the outer margin of the paracone where it forms a more prominent shelf-like cingulum that could have touched the entire border of the missing M$_1$. The posterior cingulum is relatively slender (5 mm) and apparently touching the M$_2$. A faint cingular line connects protocone with the metacone. The labial part of the crown is higher than lingual one, with 35 mm crown height. The enamel exposed is quite thick with maximum thickness (5.5 mm) at the labial cusps.

LM$_2$: The lingual loops of the protoloph and metaloph are damaged due to exposure and weathering but the rest of the crown is well preserved. Most of the morphological features are similar to the M$_2$; it presents a more square shape though the maximum width (85 mm) slightly exceeds the maximum length (83 mm) as do lingual (75) and labial (73 mm) lengths at mid of the crown (Table1). The occlusal surface of the crown exhibits considerable oblique wear similar to M$_1$ and indicates an older age. Maximum enamel thickness (6.0 mm) is at the hypocone where the metaloph forms a beak-like turn and narrows in the middle but turns in a round curve at the metacone. Cingula are developed on both anterior and posterior aspects; the anterior is relatively wider and emerges from the outer cusps and proceeds obliquely upward and ends up before reaching the lingual margin of the protoloph. The posterior cingulum emerges from the metacone and runs straight for a short distance and broadens and ends up before the hypocone bulge forming a weak talon where a small tubercle emerges mid-caudally to the metaloph.

**Remarks**

Besides the distinction between Prodeinotherium and Deinotherium mentioned above, the Indian species, D. indicum has a robust dentition and the P$_3$-M$_1$ dental series possess intra-valley tubercles. The M$_1$ morphology in European P. bavaricum (Unterzolling) is quite distinctive; it is nearly quadratic in occlusal outline with the two transverse lophids of equal width, presence of cingulum on the anterior, labial, and posterior walls, the metaloph having two protocristids both extending medially and end on the anterior cingulum; such protocristids are less pronounced on the hypolophid (Huttunen 2002a, 2002b).

Deinotherium indicum is found mainly in North-western part of the Indian sub-continent in Perim Island, Gulf of Cambay (Khabat). Gujarat, in the Middle Siwalik beds near Bandel village, Kangra foothills, Himachal Pradesh, and basal conglomerates of Middle Siwaliks (Sahni & Gupta 1982, Sahni & Mishra 1975).

**DISCUSSION**

A review of Deinotherium fossil material from the Siwaliks of Pakistan by Dehn (1963) has favoured presence of a solitary valid species, D. pentapotamiae in the Chinji Formation. West et al. (1978) also allocated a well preserved M$_3$ (MPM N-76-5) from Nepal Siwaliks to D. pentapotamiae on similar size and morphology. The complete right M$_3$ from Kutch (Bhandari et al. 2010) attributed to D. sindiense by Lydekker (1880) is

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similar in size to *Deinotherium pentapotamiae*. Present Nurpur dental material (Table 1) represents a relatively larger species and may be referred to *D. indicum* which is common in Indian Siwalik (Harris 1973). *D. indicum* is intermediate in size between *D. pentapotamiae* and *D. giganteum* from Russia (Bajgusheva & Titov 2006) but has comparable molar enamel thickness (5.2 mm). *D. giganteum* also varies in size between western and eastern European types; the western European type is smaller to the Eastern European (Huttunen 2002a, b). Present Nurpur material, *D. indicum* is smaller to the western European *D. giganteum*.

The lower M₃ from Ramnagar draws a broad size parallel with *Prodeinotherium bavaricum* from Germany (Huttunen & Göhlich 2002), *P. petenyii* from Hungary (Vörös 1989) as well as with *D. bivaricum* from Portugal (Antunes & Ginsburg 2003). However its posterior lophid is conspicuously wider, and the protolophid and the metalophid are more curved than in *Prodeinotherium* and *D. bivaricum* where they run in parallel. Moreover, Ramnagar material belongs to a sub-adult individual apparent from the lack of occlusal wear that would grow in size with age. On these considerations, therefore we assign it to *Deinotherium*, and the common species, *D. indicum*.

Several workers have contributed to the understanding of Ramnagar palaeontology, stratigraphy and palaeoecology (Vashishat et al. 1978; Gaur & Chopra 1983; Nanda & Sehgal 1993, 2005; Verma & Gupta 1997; Sehgal 1998; Sehgal & Nanda 2002a, b; Basu 2004, 2005; Parmar & Prasad 2006).

Because of these sustained efforts, a diverse fossil assemblage is now known from the upper 350 m of the Ramnagar section (Fig. 3). These workers have also equated the Ramnagar mega terrestrial fauna and lithology with the Chinji type area of Potwar Plateau of Pakistan and place it between 11 and 13 Mya, though based on certain microfauna (*Kanisamys cf. potwarensis*) Parmar & Prasad (2006) and Sehgal & Patnaik (2012) place the date of Ramnagar deposits between 14.3-13.2 Mya.

The typical Chinji pink clays of Ramnagar area coupled with other faunal remains reported from there by several authors (Gaur & Chopra 1983; Vasishat et al. 1985; Sehgal & Nanda 2002b; Basu 2004; Sehgal & Patnaik 2012) *D. indicum* is also indicative of a wet woodland forested habitat and tropical warm climate. The fine-grained and compact sandstone bed yielding the Nurpur *Deinotherium* also indicates similar wet wood-land palaeoecology and warm low energy environment as reconstructed by Sehgal & Nanda (2002b).

Even though it occupied a different habitat, *Deinotherium* was synchronous with the hominoid species of *Sivapithecus* in the Chinji and Nagri formations of the Siwaliks (Chopra 1978; Sahni & Gupta 1982; Sankhyan 1985; Verma & Gupta 1997; Pickford 1998; Sehgal & Nanda 2002; Nelson 2003; Patnaik & Cameron 2007; Gaur 2007; Pickford & Tiwari 2010; Sehgal & Patnaik 2012). The earliest large hominoids in India are from Ramnagar deposits ca.13-11.5 Mya and the youngest from Haritalyangar area, ca.8-7 Mya.
(Pickford & Tiwari 2010) where they also diversified. The Bharari specimen (Sankhyan 1985) positioned stratigraphically higher to Haritalyangar is the rare late survivor. Both hominoids and Deinotherium had extended their econiches in the central and eastern Siwaliks, viz., Kalagarh in Nainital (Sahni et al. 1983; Tiwari & Kumar 1984; Cameron et al. 1999), Dang Valley in Nepal (West et al. 1978; Munthe et al. 1983), and down to Myanmar and Thailand (Jaeger et al. 2011) including southern China (Wu 1987). Both flourished in similar wet woodland forest ecology and disappeared from Siwalik when ecology was predominated by C4 grasses and sedges (Nelson 2003; Pickford 1998; Sehgal & Nanda 2002; Bhandari et al. 2010; Vörös 1989; Huttunen & Göhlich 2002). All measurements are in millimeter.

**Table 1.** Measurements of the left maxillary molars (M2-M3) and left mandibular molar (M1) of Deinotherium from the Middle Siwalik of Nurpur (H.P.) and Lower Siwalik of Ramnagar (J. & K.) area, respectively.

<table>
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<td>Nurpur (NPR-01)</td>
<td>LM²</td>
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<td>81.1</td>
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<td>RM²</td>
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1= molar, 2= species, 3= site, 4= maximum antero-posterior length, 5= anterior loph width, 6= posterior loph width

![Fig. 4. Left maxillary molars M2-M3 of Deinotherium indicum from Jabbar Khad section, Nurpur (H.P.): a-b occlusal view, c-d labial view.](image_url)
Edward et al. 2010) after 7 million years ago. Expectedly, the evolution and dispersal of Deinotherium may have some significance in understanding the evolution, dispersal and extinction of the Siwalik hominoids.

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