

***Dorcatherium Minus* (Tragulidae-Artiodactyla-Mammalia) From the Nagri Type Area of the Nagri Formation, Middle Siwaliks, Northern Pakistan: New Collection**

*Nagri Formasyonu Tip Lokalitesinden (Orta Siwalik, Kuzey Pakistan)
Dorcatherium Minus (Tragulidae-Artiodactyla-Mammalia): Yeni Koleksiyon*

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ABSTRACT

New tragulid material from the outcrops nearby Nagri type locality, Jhelum, Punjab, Pakistan, is described and discussed. The late Miocene deposits of the Nagri type area yielded fossil remains of *Dorcatherium minus*, associated with *D. majus*, *Dorcabune nagrii*, *Brachypotherium*, *Hipparion*, *Listriodon*, bovids and giraffids. The collected material includes upper and lower dentition, and ascribed to the Siwalik tragulid species *D. minus*. The recovered material greatly improves the sample size of the species *D. minus*, known from the Siwaliks. Information from *D. minus* is consistent with previous interpretations, that the Nagri deposits were formed under swampy and littoral palaeoenvironmental conditions.

Key Words: Tragulidae, *Dorcatherium*, Nagri Formation, Siwaliks, Late Miocene.

ÖZ

Nagri formasyonu tip lokalitesindeki yüzlelerde (Jhelum, Punjab, Pakistan) saptanan yeni tragulid bulguları tanımlanmış ve tartışılmıştır. Nagri tip lokasyonunun geç Miyosen çökellerinde Dorcatherium minus fosil kalıntıları D. majus, Dorcabune nagrii, Brachypotherium, Hipparion, Listriodon, bovid ve zürafa kalıntıları ile birlikte bulunmuştur. Üst ve alt dişlenmelerden oluşan bulgular Siwalik tragulid'e ait D. minus türüne işaret etmektedir. Keşfedilen kalıntılar Siwalikteki bilinen D. minus örneklerinin zenginleşmesini sağlamıştır. D. minus bulgularından elde edilen bilgiler önceki yorumlarla uyumlu olup Nagri çökelleri bataklık ve litoral ortam koşullarında oluşmuştur.

Anahtar Kelimeler: Tragulidae, *Dorcatherium*, Nagri Formasyonu.

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INTRODUCTION

The Tragulidae comprises small nonpecoran ruminants that include the smallest living cetartiodactyls (Janis, 1984; Hassanin and Douzery, 2003; Marcot, 2007; Agnarsson and MayColado, 2008). As the most primitive representatives of the extant Ruminantia, tragulids are less advanced than living pecorans in almost all of their morphological and physiological features (Dubost, 1965; Kay, 1987; Metais et al., 2001; Rössner, 2007). They survive as relics in the Old World tropical belt: the Asian spotted and yellow striped chevrotains of the genus *Moschiola* live in India and Sri Lanka, the mouse deer *Tragulus* inhabits Southeast Asia and the Philippines, and the monotypic water chevrotain *Hyemoschus* ranges in Africa from Sierra Leona to Uganda (Grubb, 1993; Nowak, 1999; Meijaard and Groves, 2004; Groves and Meijaard, 2005; Rössner, 2007).

The majority of fossil tragulids and the totality of fossil Siwalik species have been included in the extinct genus *Dorcatherium*, which was first described from the late Miocene of Europe with the type species *Dorcatherium nauti* (Kaup and Scholl, 1834; Farooq et al., 2007a, b, 2008). This genus embraces the major part of the Miocene-Pliocene diversity of the Tragulidae. *Dorcatherium* is one of the 5 extinct genera of the family Tragulidae along with *Dorcabune*, *Siamotragulus*, *Yunnanotherium*, and *Archaeotragulus*. The dental formula of the genus is 0.1.3.3/3.1.4.3. The first lower premolar is sometimes absent as indicated by Whitworth (1958). Other diagnostic features exhibited are the larger length of the premolar row compared to the selenodont molar row in *Dorcatherium* and the presence of the *Dorcatherium* fold in the lower molars. In larger species of *Dorcatherium*, such as *D. penneckei* and *D. vindobonense*, the cheek teeth are more bunodont. *Dorcatherium* resembles the extant African genus *Hyemoschus* in terms of the presence of a first lower premolar (but it is often absent in *Dorcatherium crassum* (Whitworth, 1958)), less selenodont cheek teeth, a cingulum, more robust jaws, and a contact between premaxilla and nasals (Colbert, 1935). *Dorcatherium* seems to be a specialized genus of the family Tragulidae with higher crowned teeth

than that of *Hyemoschus* (Vislobokova, 2001).

The new *D. minus* material, described in this paper, has been unearthed from the Middle Siwalik deposits, namely the Nagri Formation, outcropping nearby the Nagri village, the type area of this formation (lat. 32° 45' N, long. 72° 14' E), district Chakwal, northern Pakistan. Regionally the area is situated in the north of the Gabbir River, Jhelum, Pakistan (Fig. 1). The section from which the remains were excavated represents a typical sequence of fluvial sedimentation and consists of bluish grey, massive and coarse sandstone with purple and orange clay and thick brown sandstone (Barry et al., 2002). The material is described here and compared with other *Dorcatherium* species. The finding of the new remains allows to test the hypothesis that there was a humid closed canopy forest interspersed with temporary and perennial waters.

MATERIALS AND METHODS

The described materials were collected from the outcrops of the village Nagri (Nagri Formation), district Chakwal, Punjab, Pakistan. Most of the specimens were found partly exposed and were excavated, while a few more were found lying completely exposed on the surface. The specimens are housed in the Zoology Department of Government College of Science, Wahdat road, Lahore, Pakistan. The catalogue number of the specimen represents the collection year (numerator) and serial number (denominator) of that year (e.g. 09/04). All measurements are given in mm. The dental length (L) and width (W) were measured at the occlusal level. As tooth height (H) is considered the height of the metacone/metaconid on molars and the height of the protocone/protoconid on premolars. Upper case letters for upper teeth and lowercase letters are used for lower teeth. Tooth cusp terminology follows the nomenclature of Gentry and Hooker (1988), Gentry (1994) and Rössner (2010).

Abbreviations: Ma – Million years ago, PUPC – Punjab University Palaeontological Collection (institutional abbreviation), GCS – Government College of Science (Institutional abbreviation), mm – Millimeters, M – Upper Molar, m – lower molar, L – length, W – width, l – left, r – right.

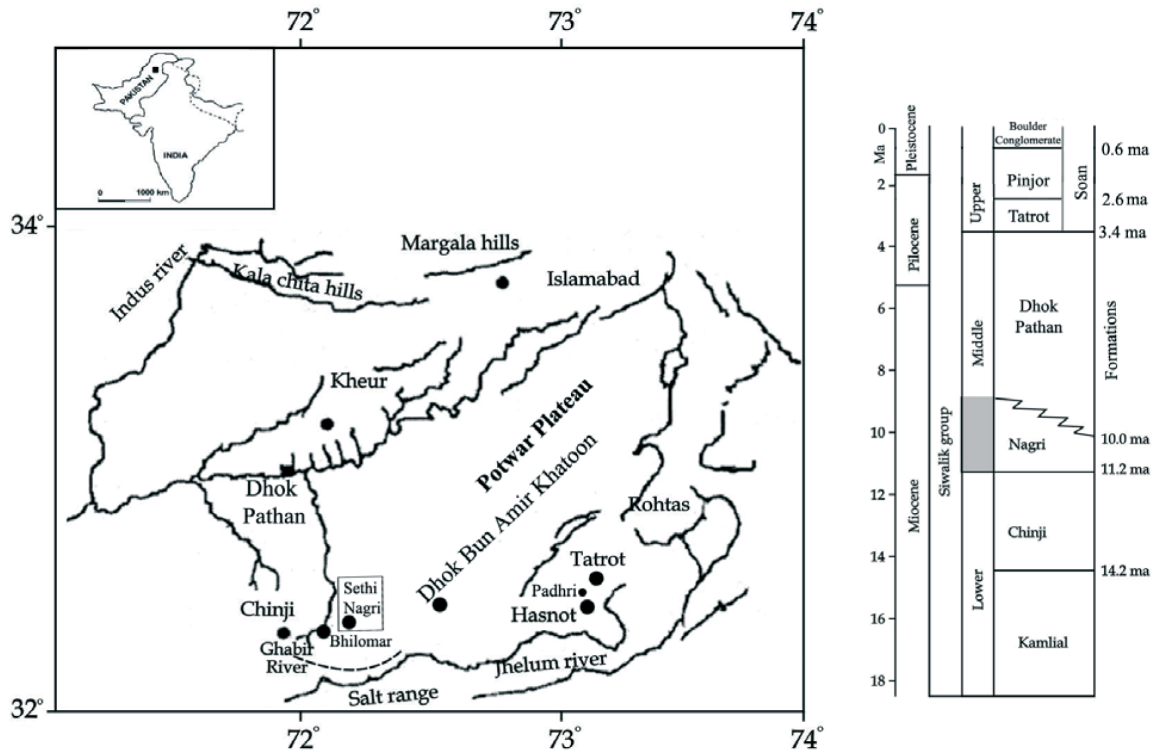


Figure 1. The location of the Nagri where the described material has been found and the generalized stratigraphy of the Siwalik formations (data from Barry et al., 2002; Nanda 2002; Dennell et al. 2006).

SYSTEMATIC PALAEOLOGY

Suborder Ruminantia Scopoli, 1777

Infraorder Tragulina Flower, 1883

Family Tragulidae Milne-Edwards, 1864

Genus **Dorcatherium Kaup and Scholl, 1834**

Type species: Dorcatherium navi Kaup and Scholl, 1834.

Generic Diagnosis: 'Bunoselenodont to selenodont teeth with more or less strong cingula and cingulidae and mostly strong styli and stylidae at the molars. The upper molars increase in size from M1 to M3. The lower molars show a special crest complex called the '*Dorcatherium*-fold'. It is formed by the bifurcation of the posterior slopes of the protoconid and the metaconid resulting in a 'Σ' shape. The premolars are comparatively long and consist mainly of the buccal conids and crests. Lingual crown elements are underrepresented. At the p4 the entoconid fuses with the postprotocristid. The

p3 has only a short lingual entocristid originating at the hypoconid. An exception is the P4, which is shorter and does not have an anteroposterior longish shape (Rössner, 2010: p. 128)'. The cheek teeth are high crowned. The upper molars bear strongly developed buccal styles. The lower molars are characterized, either by well-developed ectostylid or by a vestigial ectostylid (Kaup and Scholl, 1834).

Distribution: *Dorcatherium* is known from the Lower Miocene-Late Miocene of Europe (Kaup and Scholl, 1834; Arambourg & Piveteau, 1929; Rössner, 2010). It is also reported from the Miocene deposits of East Africa by Arambourg (1933), Whitworth (1958) and Hamilton (1973). It is distributed from middle Miocene to early Pliocene in Asia, and late early Miocene to early Pliocene in Africa (Pickford et al., 2004). *Dorcatherium* is recorded from the Siwaliks by Lydekker (1876), Colbert (1935), Prasad (1968), Sahni et al. (1980), West (1980), Farooq (2006) and Farooq et al. (2008).

Dorcatherium minus Lydekker, 1876

Type Specimen: GSI B195, right M1-2, illustrated in Lydekker, 1876: figs. 3, 7.

Type Locality: Kushalgar near Attock and Hasnot, Punjab, Pakistan (Colbert, 1935).

Stratigraphic Range: Lower to Middle Siwaliks (Colbert, 1935; Farooq et al., 2007a, b).

Diagnosis: A small species of the genus *Dorcatherium* with subhypsodont molar and broad crowned molars having well developed cingulum, rugosity, and styles, moderately developed ribs and vestigial ectostylids (Colbert, 1935).

Studied Material: GCS 09/03, rM1; GCS 09/01, a fragment of right maxilla with M1-3; GCS 09/02, an isolated IM3; GCS 09/04, Im2.

Description: GCS 09/03 is broken labially and in middle wear. The cingulum is moderately developed. The principal cones are well preserved and reflect the basic morphology of *Dorcatherium* (Fig. 2(1)). The enamel is somewhat rugose. GCS 09/01 includes a fragment of right maxilla having the complete molar series (Fig. 2(2)). The first molar is damaged however the second and third show well morphological features. The molars are broad crowned and subhypsodont. The cingulum is present lingually and mesially. The transverse valley is deep and the tubercle is present at the entrance of the valley. The styles are bulky and strong. The anterior median rib is stronger than the posterior one. GCS 09/02 is a third left upper molar. The tooth is complete and perfectly preserved. It is in early wear (Fig. 2(3)). The ribs and styles are heavy.

GCS 09/04 is a subhypsodont and narrow crowned m2 (Fig. 2(4)). The metaconid is pointed and higher than the protoconid and the hypoconid. The entoconid is more pointed and higher than the hypoconid. The rudimentary ectostylid is present. The posterior cavity is crescentic in shape and opening out of the tooth at the lingual side. An anterior cingulid is present. The anterior rib and stylid are well developed. A prominent and narrow posterior rib is present but posterior stylid is weak. The *Dorcatherium*-fold is present and directed posteriorly. It is formed by the bifurcation of the posterior slopes

of the protoconid resulting in a 'Σ' shape, a diagnostic feature of *Dorcatherium*. The comparative measurements are provided in Table 1.

COMPARISON AND DISCUSSION

The upper and lower molars show all the morphological features of the species *D. minus* as described by Lydekker (1876) and Colbert (1935): the small sized upper and lower molars than *D. majus*, the presence of cingula lingually, the strong styles/stylids and *Dorcatherium*-fold. The upper molars are specifically characterized by their finely rugose enamel, a comparatively weak mesostyle and well-developed lingual cingulum, whereas the lower molars are characterized by the slight rugosity, the vestigial ectostylid and the *Dorcatherium*-fold (Colbert, 1935; Farooq, 2006). The described specimens are found to closely resembling to the type specimens regarding the measurements (Table 1). Consequently, the material is assigned to *D. minus*, based on the morphometric features (Fig. 2).

The genus *Dorcatherium* is represented by three species from the Siwaliks of Pakistan: *Dorcatherium majus* Lydekker, 1876, *Dorcatherium minus* Lydekker, 1876 and *Dorcatherium minimus* West, 1980. *Dorcatherium majus* was erected by Lydekker (1876) from the Khushalgarh (Middle Siwaliks), district Attock, Punjab, Pakistan, based on two upper molar and a maxilla. Colbert (1935) reported many isolated teeth of *Dorcatherium majus* from the Chinji Formation (Lower Siwaliks), district Chakwal and the Hasnot (Middle Siwaliks), district Jhelum, Punjab, Pakistan. *Dorcatherium minus* was reported by Lydekker (1876), Colbert (1935) and Farooq et al. (2007a, b) from Chinji, Nathot, Phadial (Lower Siwaliks) and Nagri, Hasnot (Middle Siwaliks). The collection comprises number of fragments of mandibles, maxillas and isolated upper and lower teeth. This species was recognized on the basis of its small size (Fig. 3). In addition its molars are more hypsodont than those of *Dorcatherium majus* (Colbert, 1935). The third species found in the Siwaliks of Pakistan is *Dorcatherium minimus*. It was described by West (1980) on the basis of an upper third molar

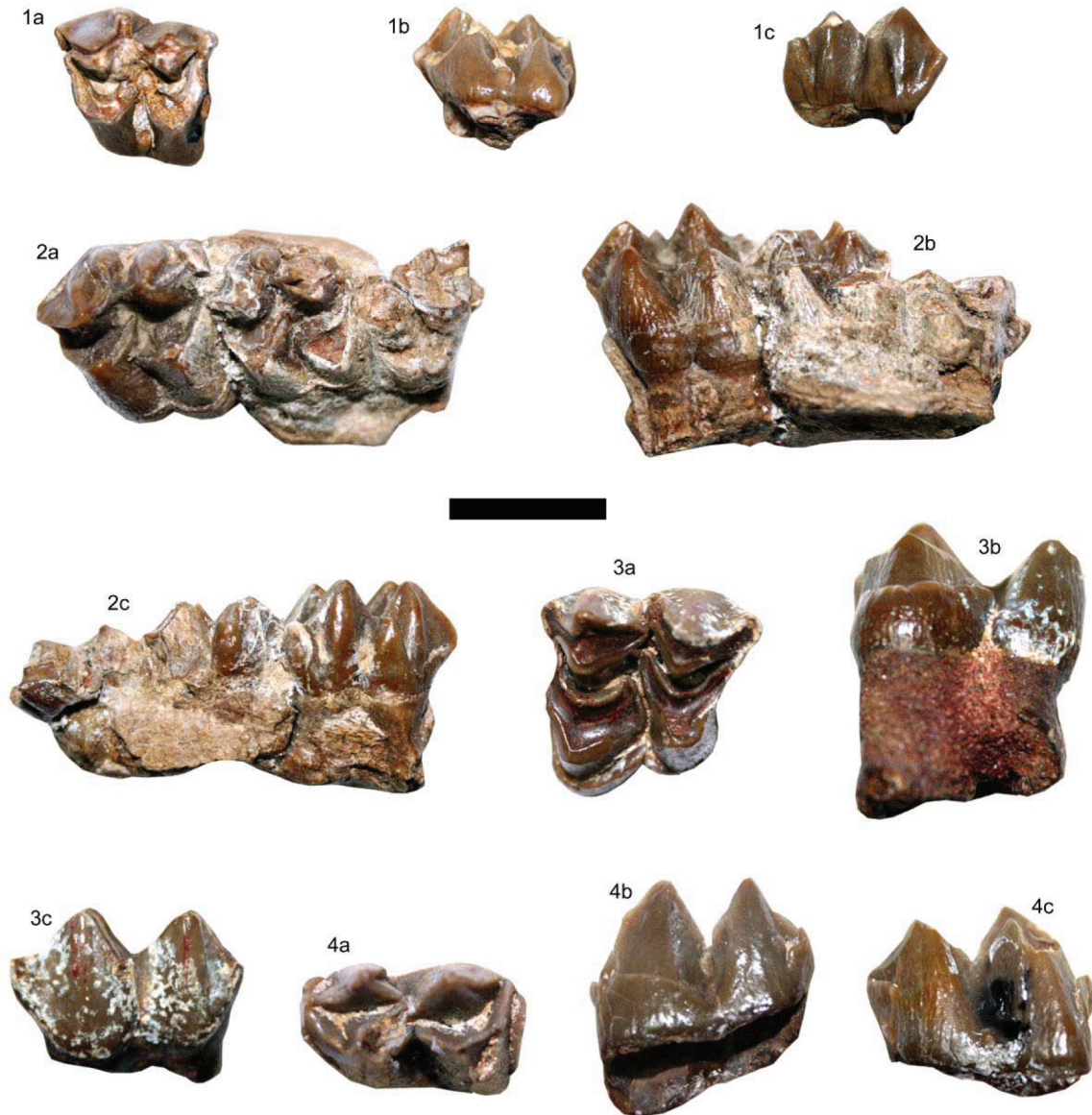


Figure 2. *Dorsocatherium minus*. 1. GCS 09/03 isolated right upper first molar. 2. GCS 09/01 a fragment of right maxilla with molar series. 3. GCS 09/02 isolated left upper third molar. 4. GCS 09/04 isolated left lower second molar. a) occlusal view, b) lingual view, c) labial view. Scale bar equals 10 mm.

from Daudkhel (Lower Siwaliks) of the district Mianwali, Punjab, Pakistan. This species was identified due to its smallest size and relatively low crowned upper third molar, lacking lingual cingulum (West, 1980).

CONCLUSION

The presence of the tragulids in the Nagri type area associated with *Hipparion*, *Microstonyx*, *Listriodon*, *Brachypotherium*, *Gazella*, *Tragoportax*, *Miotragoceros*, *Elachistoceros*, *Selenoportax*, *Pachyportax* and the giraffids, which were

Table 1. Comparative measurements (mm) of the cheek teeth of *Dorcatherium minus* and *D. majus*. * The studied specimens. Referred data are taken from Colbert (1935) and Farooq et al. (2007a, b, 2008).

Taxa	Number	Nature/Position	Length	Width	
<i>D. minus</i>	*GCS 09/01	M1	8.20	10.2	
		M2	9.30	11.4	
		M3	11.2	12.7	
	*GCS 09/02	M3	12.5	13.7	
	*GCS 09/03	M1	8.30	10.5	
	PUPC 87/40	M1	10.0	11.7	
	PUPC 87/84	M1	9.30	10.0	
	PUPC 68/41	M2	11.0	13.0	
		M1	9.20	10.2	
			M2	10.5	11.8
	PUPC 68/355	M3	11.7	13.0	
		M2	10.0	12.2	
		M1	9.30	9.00	
	PUPC 95/01	M2	10.0	11.0	
		PUPC 02/01	M1	8.00	10.0
			M2	10.5	11.6
	AMNH 29856	M3	11.7	12.3	
		M1	9.8	10.0	
		M2	11.3	12.0	
	GSI B195	M3	11.5	13.0	
		M1	10.0	10.0	
		M2	11.0	12.0	
	*GCS 09/04	m2	12.2	7.60	
	PUPC 68/294	m2	11.0	6.40	
	PUPC 68/311	m2	10.0	6.60	
	PUPC 68/312	m2	10.0	6.20	
	PUPC 68/313	m2	10.2	6.70	
	PUPC 85/59	m2	9.50	7.00	
	PUPC 02/158	m2	12.7	8.20	
	AMNH 19365	m2	13.0	12.0	
	<i>D. majus</i>	AMNH 19302	M2	18.5	21.5
		AMNH 19354	M3	20.5	23.5
GSI B198		M2	19.6	19.6	
		M3	20.1	19.2	
PUPC 85/15		M2	19.0	20.0	
PUPC 85/21		M2	18.0	22.0	

PUPC 87/328	M2	17.7	19.0
	M3	19.1	18.2
PUPC 67/191	M2	13.3	14.5
	M3	13.6	15.2
PUPC 87/197	M3	20.5	22.0
PUPC 68/33	M1	13.3	14.5
PUPC 68/250	M2	15.7	16.4
AMNH 19524	m2	16.0	11.0
GSI B593	m2	17.5	10.0
PUPC 63/243	m2	17.0	10.1
PUPC 84/115	m2	16.0	12.0
PUPC 86/02	m2	15.6	9.80
PUPC 86/05	m2	15.0	11.1
PUPC 86/152	m2	16.2	12.0
PUPC 98/61	m2	17.0	10.5
AMNH 19520	m2	17.0	10.5

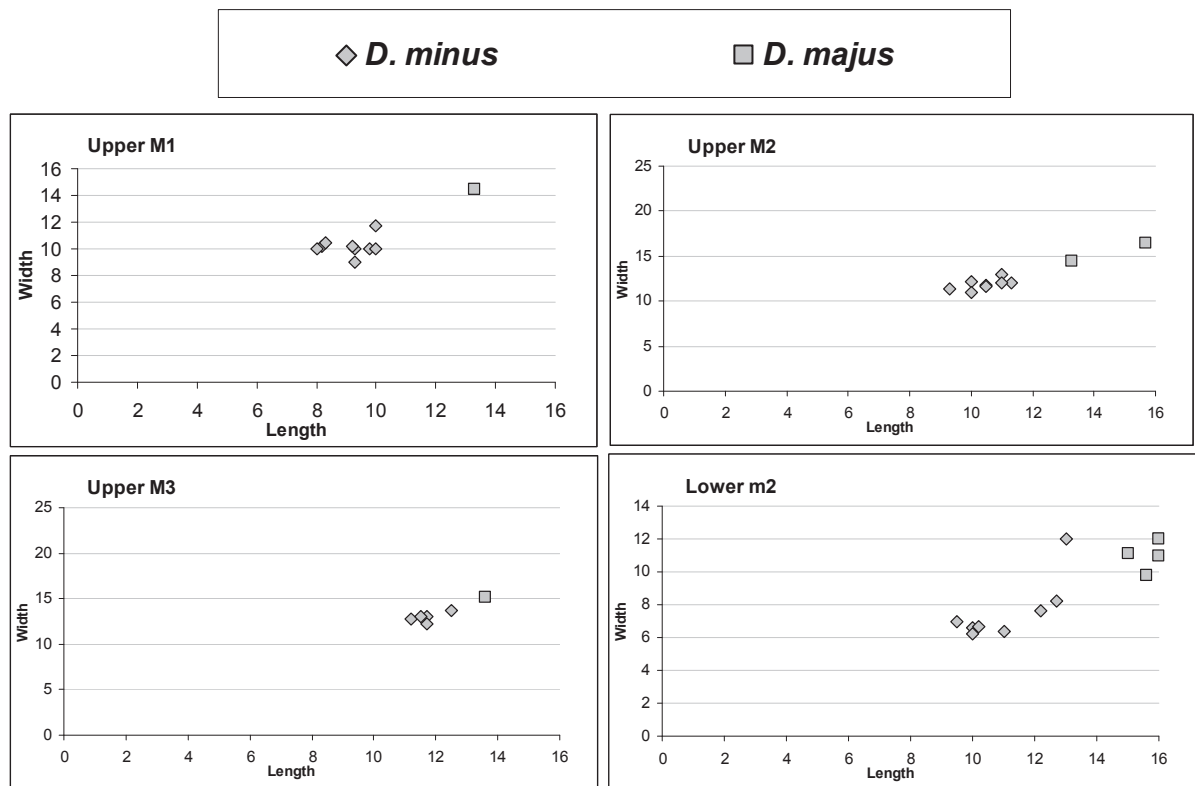


Figure 3. Scatter diagram showing dental proportions of the Siwalik *D. minus* and *D. majus*. Referred data are taken from Colbert (1935) and Farooq et al. (2007a, b, 2008).

certainly browsers, definitely speaks in favour of wet forested environments (Pilgrim, 1937, 1939; Heissig, 1972; Thomas, 1977, 1984; Van der Made and Hussain, 1989; Farooq et al., 2007a, b, 2008; Rössner, 2007, 2010). *Hipparion* fauna suggests a sclerophyllous evergreen woodland environment in the Nagri type area, similar to today's mixed monsoon forest and grassland glades of north central India (Solounias, 1999). The presence of *Microstonyx major* and *Listriodon pentapotamiae* in the type area of the Nagri Formation confirm that the environment appears to have been more humid than the latest late Miocene (Pickford, 1988; Van der Made and Hussain, 1989; Pickford et al., 2004). It should be noted that the Nagri has some hypsodont members (*Elachistoceros*, *Selenoportax*, *Pachyportax*, *Gazella*). This provides evidence for an open environment (Thomas, 1977; Akhtar, 1992; Bibi, 2007). Köhler (1993) reconstructed *Gazella* as a browser inhabiting more open country. *Dorcatherium* and *Miotragocerus* are familiar for more or less closed and humid habitats (Köhler, 1993; Gentry, 2005; Eronen and Rössner, 2007). This supports the assumption of an earliest Late Miocene Siwalik humid habitat with abundant cover. The presence of *Dorcatherium* in the Nagri type section can be assumed a strong attachment to wet, forested habitats with dense understorey, where the animals could hide in vegetation or water from predators (Rössner, 2010). A significant representation of the tragulids with adaptations to ecotonal wet and swampy habitats indicates humid conditions of the Nagri type area.

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