



***Dorcatherium* (Mammalia: Tragulidae) from Lower Siwaliks of Dhok Bun Amir Khatoon, Punjab, Pakistan**

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ABSTRACT

Extinct tragulids *Dorcatherium minus* and *Dorcatherium* sp. were recorded from the Chinji Formation of Pakistan. Furthermore, *Dorcatherium minus* is relatively rare in Middle Miocene site of Dhok Bun Amir Khatoon, Chakwal district, Punjab province, Pakistan. The referred specimens comprise isolated dental elements and mandible fragments. The presence of tragulids in Dhok Bun Amir Khatoon during Middle Miocene Chinji Formation of Pakistan suggests a humid habitat with abundant cover.

Article Information

Received 28 march 2016

Revised 28 June 216

Accepted 14 January 2017

Available online 28 April 2017

Authors' Contribution

MAK conceived and designed the study and analyzed and interpreted the data. SGA and MAB acquired the data. SK and AR drafted the manuscript.

Key words

Mouse deer, Tragulids, Chevrotains, Ruminantia, Miocene.

INTRODUCTION

Tragulidae is the most primitive family among existing ruminants (Milne-Edwards, 1864; Carlsson, 1926; Duwe, 1969; Todd, 1975; Dubost, 1978; Webb and Taylor, 1980; Janis and Scott, 1987; Perez-Barberia and Gordon, 2000; Khan *et al.*, 2012). The molecular data also showed evidence that these were the first offshoot of the extant ruminant radiation and the sister group of Pecora (Hassanin and Douzery, 2003). They are mostly present in South East Asia and Africa (Gentry *et al.*, 1999). Previously, this family was only represented by two genera throughout Eurasia and Africa as *Dorcatherium* and *Siamotragulus* but recently *Archaeotragulus* from the late Eocene of Thailand has been added to this family (Pickford, 2001; Métais *et al.*, 2001). *Siamotragulus* is known only from the Early Miocene of Bugti Hills (Pakistan) and Middle Miocene of the Pong Basin (Northern Thailand). *Dorcatherium* instead is known from several Early-Late Miocene localities and mainly from Africa, Europe (Austria, France and Germany) and Asia (Pakistan and India) (Gentry *et al.*, 1999).

Dhok Bun Amir Khatoon is in Chakwal district, Punjab province, Pakistan (Fig. 1). It is located about 308 km far from Lahore, the capital of the province and 155 km far from Islamabad, the capital of the country. The locality is

dominated by red coloured mud/ shale and sandstone that made up the basal part of the Chinji Formation, has a very abundant vertebrate fauna, including fishes, amphibians, reptiles (crocodile and alligator are dominant), birds and mammals (bovids are dominant in mammals). Based on the faunal elements, the locality can be divided into two parts: the first one is most familiar to many workers, locally known as Jallo Aala and dominated by fossils that represent bovids, tragulids and giraffids. The second one, at the opposite is not very familiar and locally known as Loharan Aala, dominated by fossils that represent suids. The tragulid fossils discussed in this paper were collected from both parts of Dhok Bun Amir Khatoon (Fig. 1).

Definitions: *Dorcatherium* fold refers to the fold occurring on the postmetacristid on the lower molars of some primitive ruminants and extant tragulids and the entoconid groove refers to the two parallel folds (thus forming a groove) occurring on the mesial side of the entoconid (Métais *et al.*, 2001). *Tragulus* fold refers to the fold situated on the postprotocristid and basally linked to the prehypocristid (Geraads *et al.*, 1987; Sánchez *et al.*, 2010).

MATERIAL AND METHODS

The tragulid specimens have been collected in more than 20 visits occurred to this locality from April 2011 to February 2013. The surface collection was the basic methodology adopted. Measurements were taken through a digital Vernier caliper and provided in millimeters (mm).

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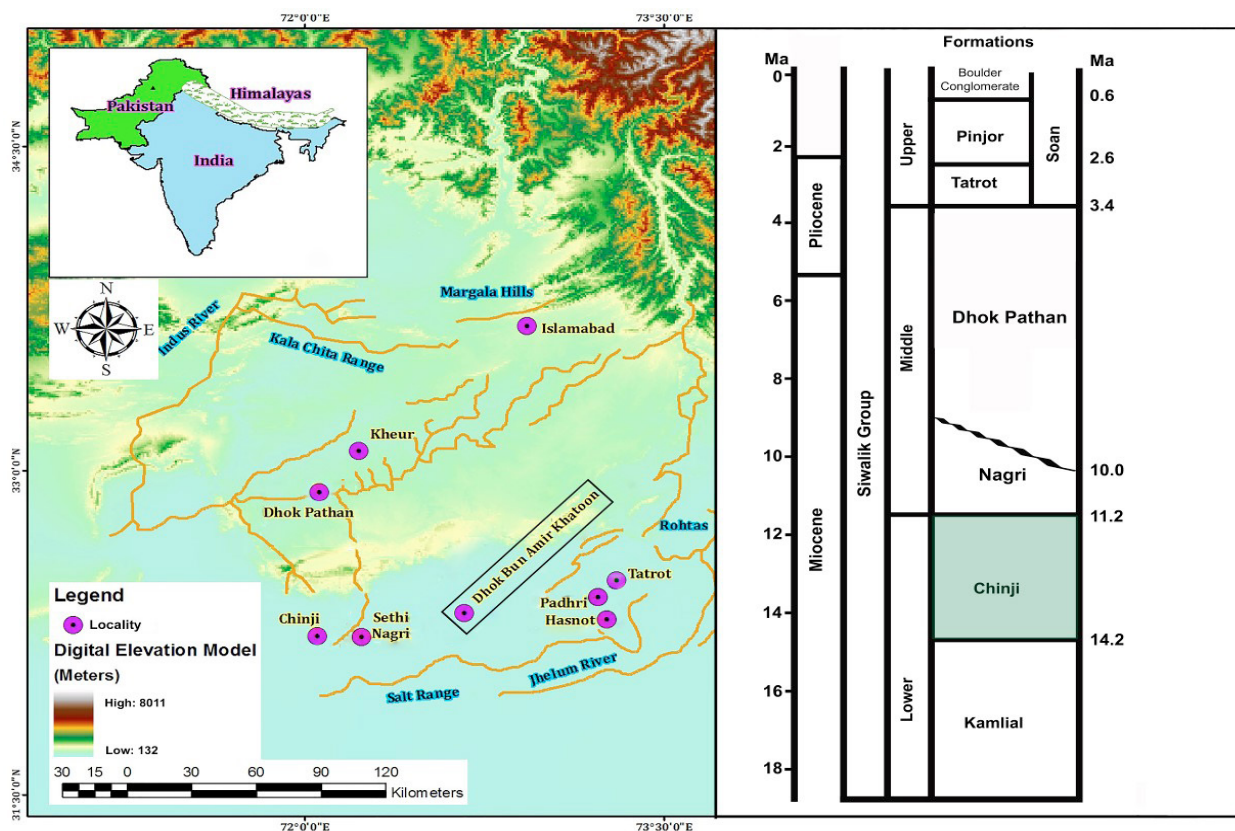


Fig. 1. Map of Potwar Plateau (Northern Pakistan) encircling the study locality and a generalized stratigraphic section of the major Siwalik Group formations showing succession and ages.

Uppercase letter was used for upper dentition (*e.g.* M for upper molar) and lower case for lower dentition (*e.g.* m for lower molar). The catalogue number of the specimens is made up by three elements: the prefix PUPC (institutional abbreviation-Palaeontological Collection of University of the Punjab, Lahore, Pakistan), the collection year (numerator) and serial number (denominator) of that year. So, for example PUPC 12/117 reference the sample with serial number 117 collected in the year 2012. Samples are housed in Dr. Abu Bakr Fossil Display and Research Centre, University of the Punjab, Lahore, Pakistan. The terminology and measurements of teeth followed Gentry *et al.* (1999).

SYSTEMATIC PALAEOLOGY

Family Tragulidae Milne Edwards, 1864

Genus *Dorcatherium* Kaup, 1833

Dorcatherium minus Lydekker, 1876

New material

PUPC 13/08, right P2; PUPC 13/15, left M2; PUPC 13/13, partial left M2; PUPC 13/11, left p3; PUPC 13/18,

right mandible fragment with m1; PUPC 13/17, right mandible fragment with m1; PUPC 13/16, right m1; PUPC 13/19, right mandible fragment with m2; PUPC 14/110, right mandible fragment with partial m3.

Description

Upper dentition

The P2 represents simple cone without styles (Fig. 2A). The molars are broad crown, semiselenodont and rugose with shiny enamel (Fig. 2B, C). The antero-lingual cingulum extends up to the base of hypocone. The entostyle is absent. The major cones are unfused occlusally and inclined towards the median longitudinal line of the molars. The parastyle is broad and thick. The mesostyle is thick, broad and directed anteriorly. The paracone has a strong rib with a vertical groove. The metastyle is weak. The pre- and post-fossettes are somewhat broad posteriorly. The postparacrista and premetacrista are not directly attached to the mesostyle.

Lower dentition

The lower dental elements include premolars and

molars (Fig. 2D, F). The p3 have prominent parastylid and entostylid. The premolar lingually shows three valleys: anterior, median and posterior. The paraconid, metaconid and entoconid can be clearly differentiated. There is no entoconid complex. The premolars are two rooted. The anterior stylid is missing; the anterior conid, the posterolingual conid and the posterior stylid are partially broken in the 3rd premolar (Fig. 2D). The mesolingual conid is well preserved. The antero and posterolingual cristids are thick. There is a small furrow with the posterolabial conid.

The mandible fragments are thin and shallow (Fig. 2F). In lower molars, *Tragulus* fold and *Dorcatherium* fold are present at the protoconid and metaconid, directed posteriorly and representing prominent Σ shape structure. The *Tragulus* fold is present in the protocristid and the postmetacristid show the *Dorcatherium* fold (Sánchez *et al.*, 2014). The trigonid and talonid are not equal in size; the trigonid is narrower than the talonid. The protoconid and hypoconid are crescent whereas the metaconid and entoconid are transversally compressed. The hypoconid is projected forward, directed posteriorly and largest among the conids. The cingulid is present anterolabially. The postfossette is wider than the prefossette. There is a prominent ectostylid in the transverse valley.

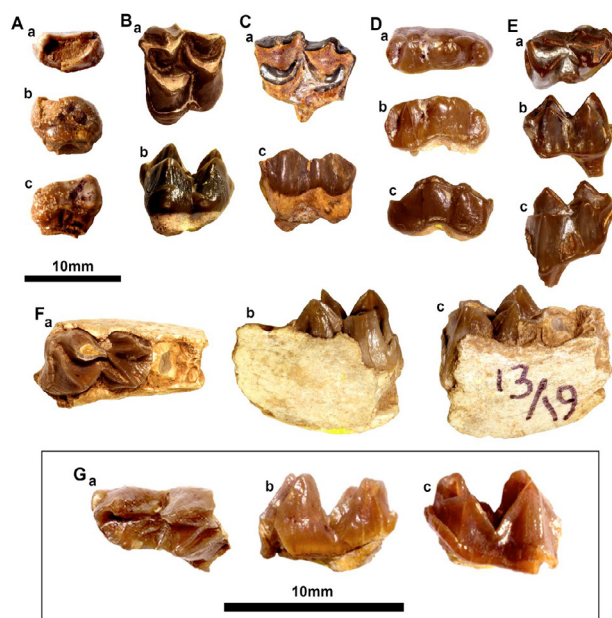


Fig. 2. *Dorcatherium minus*: A. PUPC 13/08, right P2; B. PUPC 13/15, left M2; C. PUPC 13/13, partial left M2; D. PUPC 13/11, left p3; E. PUPC 13/16, right m1; F. PUPC 13/19, right mandible fragment with m2. *Dorcatherium* sp. G. PUPC 13/12, partial right 3rd molar. Views: a, Occlusal; b, Lingual; c, Labial.

Comparison

Teeth are characterized by having strong cingulum, styles and labial ribs. The lower molars represent the M structure (*Dorcatherium* fold and *Tragulus* fold) and this reflects the affinity with the family Tragulidae and the genus *Dorcatherium*. Teeth were assigned to *Dorcatherium* according the buno-seleno-brachyodonty with the M structure. The Siwalik *Dorcatherium* species are mainly differentiated by their size (West, 1980; Farooq *et al.*, 2007a, b, 2008; Iqbal *et al.*, 2011; Khan and Akhtar, 2013; Khan *et al.*, 2011, 2012; Batool *et al.*, 2014). The specimens are smaller than the material assigned to *D. majus*, and larger than *D. nagrii* and *D. minimus* that are common at Chakwal during the Middle-Late Miocene (Colbert, 1935; West, 1980; Farooq *et al.*, 2007a, b, 2008; Iqbal *et al.*, 2011; Khan *et al.*, 2010, 2011; Khan and Akhtar, 2013; Batool *et al.*, 2014). The described teeth features coincide with the characters of the holotype of *D. minus* (Table I; Figs. 2, 3). Hence, the material is assigned to the Siwalik tragulid species *D. minus*.

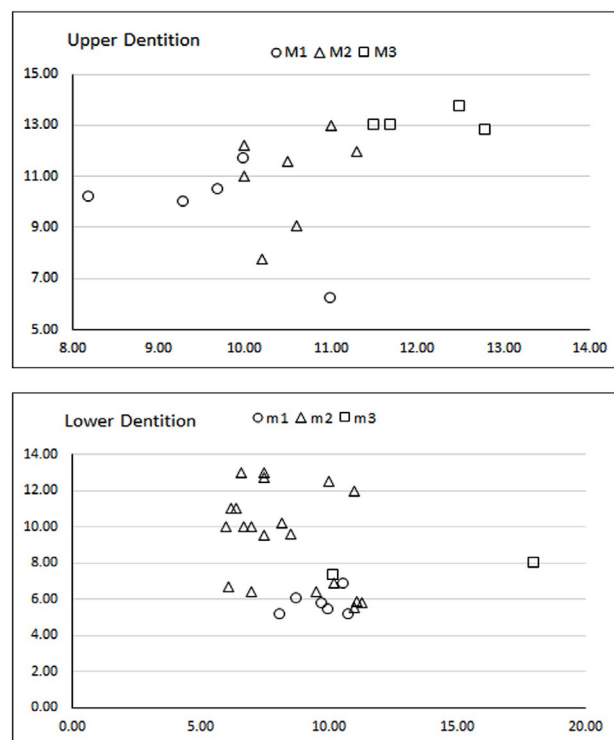


Fig. 3. Bivariate plots showing size variation in the cheek teeth of *D. minus*.

Dorcatherium sp.

New material

PUPC 13/12, partial right 3rd molar.

Table I.- Comparative measurements of the cheek teeth of the Siwalik *Dorcatherium* (in mm).

Taxa	Number	Nature/ Position	Length	Width	W/L
D. minus	PUPC 13/08*	rP2	7.60	3.90	0.51
	PUPC 13/13*	lm2	10.20	7.75	0.75
	PUPC 13/15*	lm2	10.60	9.05	0.85
	PUPC 13/11*	lp3	10.50	4.87	0.45
	PUPC 14/109*	rp3	8.52	4.32	0.50
	PUPC 13/14*	rm1	9.77	5.74	0.58
	PUPC 13/16*	rm1	8.75	6.00	0.68
	PUPC 13/17*	lm1	8.15	5.10	0.61
	PUPC 13/19*	rm2	11.30	5.83	0.51
	PUPC 13/18*	rm1	11.10	5.88	0.52
	PUPC 14/110*	rm3	10.20	7.31	0.71
	PUPC 01/13	lp4	8.00	9.50	0.84
	PC-GCUF 11/178	lm1	9.70	10.50	1.08
	PC-GCUF 12/39	M1	11.00	6.20	0.54
	PC-GCUF 11/184	rM3	12.80	12.80	1.00
	PUPC 87/84	M1	9.30	10.00	1.07
	PUPC 87/40	M1	10.00	11.70	1.17
	GSI 09/01	M1	8.20	10.20	1.25
	GSI 09/02	M3	12.50	13.70	1.09
	PUPC 68/355	M3	11.70	13.00	1.11
	PUPC 68/41	M2	11.00	13.00	1.18
	PUPC 86/81	M2	10.00	12.20	1.22
	PUPC 95/01	M2	10.00	11.00	1.10
	PUPC 02/01	M2	10.50	11.60	1.10
	AMNH 29856	M1	9.80	10.00	1.02
		M2	11.30	12.00	1.06
		M3	11.50	13.00	1.13
	PUPC 02/158	rm1	10.60	6.70	0.63
	GSI B594	rm1	10.80	6.80	0.62
	PC-GCUF 12/40	rm1	10.00	5.10	0.51
	PC-GCUF 12/41	lm1	9.30	5.40	0.58
	PC-GCUF 12/12	lm1	-	-	-
		lm2	8.20	5.50	0.67
	PC-GCUF 12/01	lm2	11.00	6.90	0.62
	PUPC 68/294	m2	11.00	6.40	0.58
	PUPC 68/313	m2	10.20	6.70	0.65
	PC-GCUF 09/18	rm2	7.00	10.00	0.70
	PUPC 05/3	rm2	6.10	9.60	0.63
	PUPC 04/2	rm2	6.00	11.00	0.54
	PUPC 87/25	rm2	8.50	13.00	0.65
	PUPC 68/294	rm2	6.40	11.00	0.58
	PUPC 68/311	rm2	6.60	10.00	0.60
	PUPC 68/312	rm2	6.20	10.00	0.62
	PUPC 68/313	rm2	6.70	10.20	0.65
	PUPC 85/59	rm2	7.00	9.50	0.73
	PUPC 02/158	rm2	8.20	12.70	0.64
	AMNH 19365	rm2	7.50	13.00	0.57
	AMNH 19366	rm2	7.50	12.00	0.62
	GSI B594	rm2	7.50	12.50	0.60
	PUPC 68/294	m2	11.00	6.40	0.58
	PUPC 68/311	m2	10.00	6.60	0.66
	PUPC 85/59	m2	9.50	7.00	0.74
	PC-GCUF 10/54	rm2	-	7.00	-
		rm3	-	7.00	-
	PUPC 68/210	lm3	18.00	8.00	0.44
D. sp.	PUPC 13/12*	rm3	7.66	4.00	0.52

*The studied specimens. Referred data are taken from Colbert (1935), Gaur *et al.* (1983) and Farooq *et al.* (2007a, b, 2008).

Description and comparison

PUPC 13/12 represents two unusual *Dorcatherium* folds and two *Tragulus* folds directed anteriorly (Fig. 2G). These folds are located on the prehypocristid and preentocristid. The anterior folds are more prominent than the posterior one. The *Tragulus* fold is thicker than the *Dorcatherium* fold. The tooth has thick shelf like cingulid. The antero-transverse cingulid is broken whereas the postero-transverse cingulid is complete. The pre- and postfossettes are narrow and deep.

The molar shows peculiar structure with Σ/M structures directing anteriorly. The specimen looks to be a primitive member of the genus *Dorcatherium*, showing affinity with a primitive tragulid *Archaeotragulus* (Métais *et al.*, 2001), in having *Dorcatherium* fold, *Tragulus* fold and entoconid groove. Anteriorly directed folds are present in genus *Krabimeryx* (Métais *et al.*, 2001), which is also a primitive member of tragulids.

DISCUSSION

The majority areas where *Dorcatherium* has been found indicate wetlands, dominated by pockets of dense forests (Meijaard and Groves, 2004; Groves and Meijaard, 2005; Rössner, 2007; Khan *et al.*, 2012; Khan and Akhtar, 2013; Sánchez *et al.*, 2010, 2014; Batool *et al.*, 2014). The presence of *D. minus* and *D. sp.* with *D. nagrii*, *D. minimus* and *D. majus* in the Chinji Formation suggests a strong connection to wet, forested habitats with dense understory, where the animals could hide from predators in vegetation or water (Colbert, 1935; West, 1980; Farooq *et al.*, 2007a, b; Badgley *et al.*, 1998; Khan *et al.*, 2008). A significant representation of tragulids with adaptations to ecotonal wet and swampy habitats indicates humid conditions in Dhok Bun Amir Khatoon, Northern Pakistan.

The associated large mammals might suggest that a savanna-like environment could be present in the surroundings of Dhok Bun Amir Khatoon. Moreover the presence of large mammals (*e.g.* *Chilotherium*, *Deinotherium*) indicates that, open areas covered by grass, should also exist nearby the wetlands of Dhok Bun Amir Khatoon. This kind of environment was rather specific for the Chinji Formation of the Siwaliks (Khan and Akhtar, 2013) and might be interpreted as a representation of a more open habitats upward and more closed habitats to the lower level (Khan *et al.*, 2008).

Miotragocerus, *Eotragus* and *Hypsodontus* recorded from the lower level of the site (Khan *et al.*, 2008, 2013), might have been semi-aquatic in habit (Köhler, 1993; Rössner, 2007), and the high abundance of *Dorcatherium* at the lower level of Dhok Bun Amir Khatoon might be indicative of wetlands. The lower level of the locality

may have comprised relatively more humid and closed habitats, based on the ecomorphology of their dominant taxa, particularly *Dorcatherium*, which may have been an inhabitant of the wetlands (Rössner, 2007; Khan *et al.*, 2012; Batool *et al.*, 2014). The presence of *Dorcatherium* indicates more or less closed and humid habitats (Kohler, 1993; Gentry, 2005; Eronen and Rössner, 2007). The faunal association suggests a humid habitat pocket with abundant cover indicating the dominance of forested landscapes during the Middle Miocene time of the Chinji Formation in the Lower Siwalik Subgroup (Pakistan).

CONCLUSIONS

Dorcatherium were discovered in the Middle Miocene site of Dhok Bun Amir Khatoon (Pakistan), including two species *D. minus* and *D. sp.* In Middle Miocene, there is a variety of *Dorcatherium* in the Lower Siwalik Subgroup, having the basic pattern of *Dorcatherium* fold and *Tragulus* fold, but these species differ in size. Palaeoenvironmental conditions coincide with wet and swampy habitats under a humid climate.

ACKNOWLEDGMENTS

We are highly thankful to Mr. Iftikhar Hussain, Mr. Atif Mehmood, and Mr. Muhammad Khan, residents of DBAK for their guidance and help in the fieldwork.

Statement of conflict of interest

Authors have declared no conflict of interest.

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