Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 3, p. 408-422, 2015
http://www.innspub.net

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RESEARCH PAPER
OPEN ACCESS

Dorcatherium from the dhok bun ameer khatoon, chinji formation, lower siwalik hills of Pakistan

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Article published on March 28, 2015

Key words: *Dorcatherium,* Dhok Bun Ameer Khatoon, Chinji, Lower Siwaliks.

Abstract

Several new fossil specimens of *Dorcatherium* have been found and described from the Chinji Formation near Dhok Bun Ameer Khatoon (DBAK). The material comprises upper and lower dentitions and presents the data which is new, also it provide us further information about the distribution of two species *Dorcatherium majus and Dorcatherium minus* from the Lower Siwalik locality. The fossil site has been dated to approximately 14.2 Ma - 9.5 Ma and coincides with the divergence of different mammalian genera. It has well-exposed Chinji and Nagri formations. The genera recovered from this site are mostly the same as in the overlying younger Dhok Pathan Formation of the Siwaliks. Size differences between these and previously described specimens are potentially important for our understanding of intraspecific variation in mammalian lineages. This paper therefore describes the newly recovered specimens, assigns them to species level, and then goes on to examine size differences between these and the type material.

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Introduction

Family Tragulidae is the representatives of the most primitive extant Ruminantia which include the smallest living cetartiodactyls which are less advanced in their morphological and physiological characteristics than living pecorans (Janis 1984, Kay 1987, Metais *et al.* 2001, Marcot 2007, Agnarsson and MayCollado 2008, Khan *et al.* 2011). *Dorcatherium* is extinct genus of family tragulidae and its type species *Dorcatherium naui* is discovered from Germany i.e. deposits of Eppelsheim which belong to Late Miocene (Kaup 1833, Gentry 1978). According to Farooq *et al.* 2008, this genus is one of the 5 extinct genera along with *Dorcabune, Siamotragulus, Yunnanotherium*, and *Archaeotragulus* belonging to family Tragulidae. The several species referred to *Dorcatherium* mainly vary by their size (West 1980). The evolutionary history of tragulids was unknown prior to the Eurasian and African Miocene *Dorcatherium* (Webb and Taylor 1980). So, it is the first undoubted fossil tragulid from African and Eurasian localities.

The tragulid fauna from DBAK (Fig. 1) is represented by two species *Dorcatherium majus* and *Dorcatherium minus* (Ghaffar 2010, Cheema 2003, Khan *et al.* 2008, Samiullah 2011). Previous record on *Dorcatherium* in the Late Miocene of that locality is sketchy and *Dorcatherium* material was not described thoroughly. Determination at species level can be attempted based on extensive and reliably determined dentition material from further Siwalik localities. This paper interprets here new material representing two species *Dorcatherium majus* and *Dorcatherium minus* of the Siwalik tragulids which provide a glimpse into palaeoenvironment of the area during the Late Miocene. Dhok Bun Ameer Khatoon is a small village in Chakwal district, Punjab, Pakistan and Miocene deposits of Lower Siwaliks surround the village. Its geographic coordinates are 32° 47' 26.4" N, 72° 55' 35.7" E. It is situated at about 16 Km, northeast of Chua Seydan Shah. The area contains continuous geological record spanning approximately 18.5ma- 4.5BP (Johnson *et al.* 1982). The Siwalik group in this area is composed of five lithostratigraphic units which are Kamlial, Chinji, Nagri, Dhok Pathan and Soan Formation. The overall lithological composition of these component formations are fairly identical with those described for their type sections but however are relatively less thick and contain more mud stones. Chinji Formation has its good exposure in DBAK area and is in strike continuation with its stratotype in Chinji area.

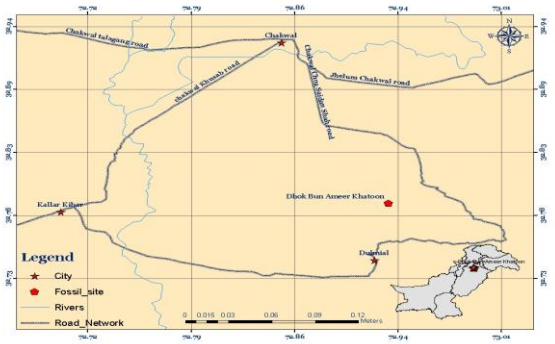

Fig. 1. Map of the studied section Dhok Bun Ameer Khatoon, district Chakwal, Punjab, Pakistan. (Khan *et al.* 2011 and Samiullah *et al.* 2011).

The fossiliferous deposits consist of shale, siltstone and sandstones. Detailed peterographic studies of Chinji sandstones contains abundant quartz with subordinate feldspars, variable proportions of lithic grains accessory amounts of micas and traces of a number of heavy minerals. Feldspar favors the arctic climate, consistent presences of mica, epidot and granite indicates metamorphic rocks while non-undulatory mono-crystalline suggest presence of plutonic and volcanic rocks in DBAK. In general the Chinji Formation is dominantly composed of bright red and brown orange siltstone interbeded with ash gray-sand stone (siltstone to sandstone ratio= 4:1) in the type section (Ullah *et al.* 2006). In spite of adequate exposure of Chinji Formation in the DBAK, fossils are not easily found in this area as compare to Chinji stratotype. It is particularly because of steeper dips and some structural complication, thus reducing the area of exposure per bed and also an increase in mudstone indicates existence of floodplains, which relatively have less potential for fossilization. The locality represents lateral facies associations and

pedogenesis within the fine grained fossil bearing floodplain deposits (Khan *et al.* 2008). The Miocene fossil fauna of DBAK is much interesting. It consists of a number of holdovers of fore-runners of the Chinji Zone. Besides that it exhibits a number of faunal elements, which are its own (table 1).

Table 1. Generalized faunal list collected from DBAK (study area) on the basis of the published and unpublished work by Cheema, 2003, Khan *et al.* 2008, Samiullah, 2011 and this paper.

Rhinocerotidae:	
Chilotherium intermedium	*Gaindatherium browni*
Brachypotherium perimense	
Suidae:	
Listriodon pentapotamiae	*Conohyus sindiensis*
Tragulidae:	
Dorcatherium majus	*Dorcatherium minus*
Giraffidae:	
Bramatherium perimense	*Giraffa Priscilla*
Giraffokeryx punjabiensis	
Cervidae:	
Cervus rewati	*Cervus punjabiensis*
Bovidae:	
Gazella lydekkeri	*Miotragocerus gradiens*
Tragocerus gradiens	*Eotragus noyei*
Sivaceros gradiens	
Chalicotheriidae:	
Chalicotherium intermedium	

The family Tragulidae occurred in both Eurasia and North America since the rocks of Eocene and from the stable warm forests of East Africa, Pakistan, and Europe since 18.0 million years ago, confirms the Asian origin of this group by the primitive structure and a large diversity (Gentry 2000, Khan and Akhtar 2005, Vislobokova 1997, 2001). Six species of tragulids survive today, *Tragulus* spp. in South-East Asia (Meijaard and Groves 2004), 3 or 4 in India and Sri Lanka (*Moschiola* spp.) (Groves and Meijaard 2005) and 1 in tropical Africa (*Hyemoschus aquaticus*) (Meijaard *et al.* 2010) became extinct in Europe in the late Miocene. In Africa they first appeared in the Miocene and have lived there ever since (Pickford 2001, Sanchez *et al.* 2010). At present, they are restricted to some humid environments of the Old World tropical zone (Geraads *et al.* 2010).

Dorcatherium has an extensive biogeographic distribution. Africa, Eurasia, the Greco-Iranian province and the Siwaliks from the early Miocene to the early Pliocene have different species (Gaur 1992, Pickford 2001, Morales *et al.* 2003, Pickford *et al.* 2004, Farooq *et al.* 2007, 2008, Quiralte *et al.* 2008, Rossner 2010). New collections from Napal, Uganda and supplementary study of the dental and postcranial remains of East African tragulids, underscores the effectiveness of tragulids for regional biostratigraphy, at least for the period 19-17 Ma. *Dorcatherium songhorensis* was collected from Sperrgebiet, Namibia (Langental ca 20 Ma) and from Kenya during 17.8-22 Ma (Pickford 2001, Geraads *et al.* 2010) while *Dorcatherium pigotti* was exposed at Arrisdrift (17.5 Ma) *Dorcatherium pigotti* and *Dorcatherium chappusi* at Kenya (9-18 Ma) and also found from Libya, Egypt, Uganda (Pickford and Senut 2000, Pickford 2001, Hill *et al.* 2002, Behrensmeyer *et al.* 2002) and *Dorcatherium moruorotensis* from Moruorot during 17.2 to 17.5 Ma (Pickford 2001, Geraads *et al.* 2010).

In Pakistan, tragulids are found in fossil assemblages dated at 18 Ma (Welcomme *et al.* 2001), although they reached their highest diversity during the deposition of the Chinji Formation of the Siwaliks at about 11.5 Myr (Barry *et al.* 1991 and literature therein). They appear to have been more species-rich during the Miocene than now, with, for example, at least 5 different tragulid species of the genus *Dorcatherium* (family tragulidae) are *Dorcatherium majus, Dorcatherium minimus, Dorcatherium nagrii and Dorcatherium minus* are well known in the Siwaliks of Pakistan (Fig. 2) and are reported from the Chinji, Nagri and Dhok Pathan formations (Farooq *et al.* 2007a, 2007b, 2007c, 2007d, 2008, Khan and Akhter 2011, 2013). In the Chinji Formation both genera of the Tragulidae family, *Dorcatherium* and *Dorcabune*, are reported. Two species of *Dorcatherium* are known from this Formation, *D. majus* and *D. minus*, whereas only one species of *Dorcabune*, *Dorcabune anthracotherioides* is reported. The *Dorcatherium* supports a Late Miocene age (Raymond *et al.* 2004). After 7 Myr ago, the tragulids family declined significantly in diversity in southern Asia (Barry *et al.* 1991), because of the evolution of more open vegetation types (Meijaard and Groves 2004). They are now virtually extinct in Pakistan.

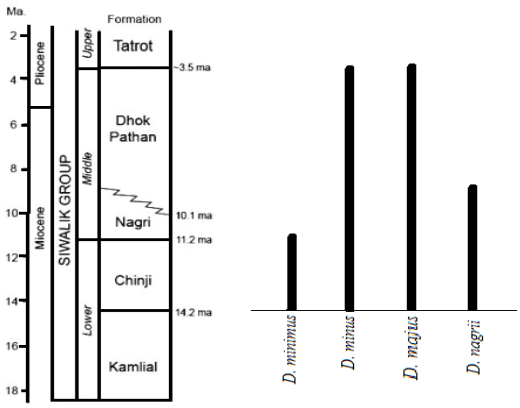

Fig. 2. Chronological distribution of the Siwalik Dorcatherium species (modified from Behrensmeyer & Barry (2005) and the boundry dates are from Denell (2008) and Nanda (2008)). Black bars represent distribution.

Most of the Miocene period in Asia (northern Pakistan, Siwalik sequence) is represented by warm tropical, subtropical forest zones. During that period in Asia, Chinji and Dhok Pathan faunas and late Middle and early Late Miocene of Europe are equivalent regarding the floral and faunal components (Barry *et al.* 1985). The DBAK fauna mainly consists of Artiodactyla (suids, tragulids, giraffids, cervids and bovids) and Perissodactyla (rhinocerose). Giraffids are more common than the other taxa. The association of *Dorcatherium* with *Dorcabune*, *Tragoportax Miotragocerus, Pachyportax, Selenoportax, Giraffokeryx* and *Hydaspitherium* is common in the Siwaliks, implying that they probably had same feeding resources at this time period (Colbert 1935, Pilgrim 1937, 1939, Farooq *et al.* 2007a-d, 2008, Khan *et al.* 2009, 2010). The taxonomic composition indicates the paleoecological conditions of the tragulids compatible with earlier reconstructions of the riverine environment and a covering of woods, bushes and shrubs (Barry *et al.* 2002).

The tragulids are absent in the open environment of the Upper Siwaliks, northern Pakistan (Farooq 2006, Khan *et al.* 2011). Their complete disappearance in the Upper Siwaliks is certainly linked with the expansion of grasslands and this seems to be the main reason why they are not found in the Upper Siwaliks of northern Pakistan. There is increasing evidence for inferring the palaeoenvironment in which *Dorcatherium* lived. The tragulid-associated fauna would rather indicate lush vegetation with substantial food supply for the diversified, mostly brachyodont large mammal fauna. The vertebrate remains suggest a lightly forested environment with the existence of numerous wetlands near which the tragulids might have lived (Khan and Akhtar 2011). The fauna associated with the tragulids suggests a mosaic of both more open and forested landscapes with a vast wetland environment strongly influenced by alternating dry and flood seasons in the vicinity of DBAK.

The main objective is to contribute significant knowledge in the field of vertebrate paleontology at specific level. Other aims are to describe fossil fauna from lower Siwaliks (Late Miocene) of Dhok Bun Ameer Khatoon, district Chakwal, Punjab, Pakistan, to investigate the broad patterns of evolution, taxonomy and biogeographic distribution of Genus *Dorcatherium* family Tragulidae.

Materials and methods

Collection way and material

Surface collection was the primary mean of collecting fossil remains of *Dorcatherium*. Excavation was also conducted at some places of the site where dense concentrations of fossil bones were happen in situ within sandstone. The embedded material was carefully excavated with the help of chisels; geological hammers fine needles, penknives, hand lenses and brushes. Each specimen was wrapped with a cotton piece to avoid the shocks of transportation. Eventually the collected specimens were brought in the laboratory for taxonomic and morphological analysis.

Cleaning of fossils

In order to remove dust particles and to prepare the specimens for clear observation, the specimens were carefully washed and cleaned in the Paleontology laboratory of Zoology Department, GC University, Faisalabad. Clay and other hardly adjoined sedimentary particles were removed with the help of fine needles and brushes.

Morphological analysis cataloguing and photography

A hand lens was used for keen observation of very small and ambiguous morphological characters. Measurements were taken with the help of a vernier caliper and are given in millimeters (mm). The terminology and measurement of the teeth follow Gentry and Hooker (1988) and Gentry *et al.* (1999). The catalogue number PC-GCUF was allotted to the specimens who represent the collection year (numerator) and serial number (denominator) of that year (e.g. 2013/05). A digital camera was used to photograph the studied specimens and amended hard copies were prepared by a computer.

Comparisons

Comparisons has been made with specimens from the Natural History Museum, London (BMNH), the American Museum of Natural History (AMNH), the Geological Survey of Pakistan (GSP), the Geological Survey of India (GSI), the specimens from the Paleontology laboratory of the Zoology department of the Punjab University, Lahore, Pakistan (PUPC) and paleontological collections at Government College University Faisalabad (PC-GCUF).

Abbreviations

M, molar; L, maximum preserved length; W, maximum preserved width; W/L, width length ratio; GCS, Government College of Science (Institutional abbreviation)

Results

Systematic Palaeontology

Suborder: Ruminantia Scopoli, 1777

Family: Tragulidae Milne-Edwards, 1864

Genus: *Dorcatherium* Kaup, 1833

Type Species: Dorcatherium naui *kaup, 1833*

1- *Dorcatherium majus* lydekker, 1876

Type Specimen: GSI B 195, two upper molars i.e. right M^{1-2}.

Locality: Khushalgar, near Attock. Also Hasnot and adjacent localities (Colbert 1935)

Stratigraphic range: Lower to Middle Siwaliks

Diagnosis: Dorcatherium majus is equal in size to *Dorcabune anthracotherioides* but larger than *Dorcatherium minus*. It is characterized by sub-hypsodont and broad crowned molars and a strong mesostyle and parastyle, moderately developed ribs; the upper molars have a well-developed cingulum and are extremely hypsodont. In the lower molars a stoutly developed ectostylid and well developed median basal pillar are present (Farooq *et al.* 2008).

Distribution: Chinji, district Chakwal, Nathot and Phadial, district Jhelum, Dhulian and Dhok Bun Ameer Khatoon, district Chakwal, Punjab, Pakistan.

Material: PUPC 08/23, right maxillary fragment having M^{2-3}; PUPC 08/42, left second upper molar, PUPC 08/36, an isolated right second upper molar and PUPC 08/39, right first lower molar.

Locality: Dhok Bun Ameer Khatoon, district Chakwal, Punjab, Pakistan.

Stratigraphic range: Lower Siwaliks (Chinji Formation)

Description

Upper dentition

M2

PUPC 08/36 (Fig. 3) consists of an isolated right upper molar. It is moderately well preserved. Its buccal and posterior sides are broken. It is embedded in bone whose length is 23 mm and width is 22 mm. PUPC 08/42 (Fig. 3) is an isolated left second upper molar. It is very well preserved. In general appearance both teeth look quadrate and are transversely wider anteriorly than posteriorly. Regarding the antero- posterior length, the specimens are more elongated towards the lingual side than the buccal side. The molars are hypsodont with narrow crowns as indicated by the W/L indices. The enamel is wrinkled and uniformly thick with a thickness of 1.0 mm. The cingulum is weakly developed anteriorly and strongly developed posteriorly in PUPC 08/42 while in PUPC 08/36 the posterior side is damaged and the cingulum cannot be observed. It is also present on the inner side especially where it covers the base of the protocone. The central cavities are wide and deep. All four cusps are inclined towards the median longitudinal axis of the molar. This inclination is more prominent in the inner cones than the outer cones.

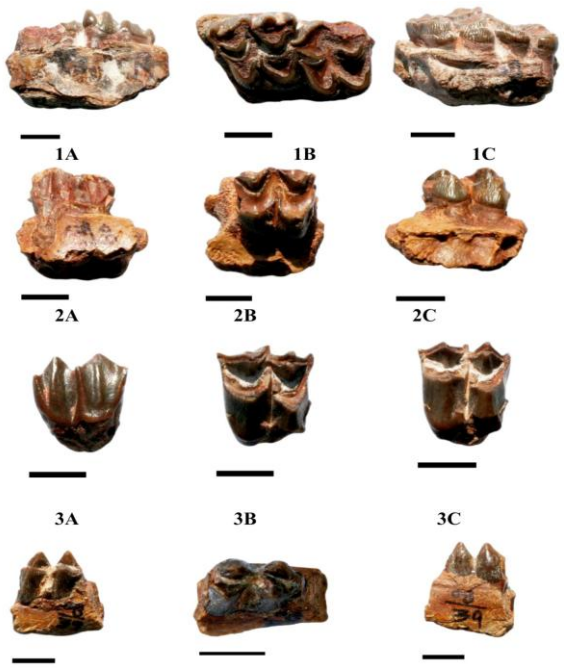

Fig. 3. *Dorcatherium majus,* PUPC 08/23, right maxillary fragment having M^{2-3}, 1A- buccal view, 1B- occlusal view, 1C- lingual view; PUPC 08/36, an isolated right second upper molar, 2A- buccal view, 2B- occlusal view, 2C- lingual view, PUPC 08/42, an isolated left second upper molar, 3A- buccal view, 3B- occlusal view, 3C- lingual view, PUPC 08/39, right first lower molar, 4A- buccal view, 4B- occlusal view, 4C- `lingual view. (Scale bar 10 mm).

The protocone is more worn than all other cones. The protocone is almost L-shaped, and its posterior end does not join at the middle of the hypocone. The inner most lingual part of the protocone is rounded. The protocone is semi-crescentic in shape and its anterior arm is longer than the posterior arm. Its anterior arm is joined with the parastyle by a thin ridge of enamel while the posterior arm is free. The paracone is relatively smaller in antero-posterior length compared to the metacone. The parastyle and mesostyle cannot be observed in PUPC 08/36 because its buccal and posterior sides are broken. The metacone is the highest among all the cones. It is broken anteriorly and posteriorly in PUPC 08/36 while in PUPC 08/42 it is very well preserved. The posterior half of the paracone is thicker than the anterior half. The parastyle is well developed and connected to the base of the anterior rib. The

hypocone is more crescentic and both of its outer ends are narrow. It is less worn than the protocone. Both of its arms are equal in length, exhibiting a V-shaped structure. Its anterior arm is joined with the posterior half of the paracone while its posterior arm remains free. PUPC 08/23 (Fig. 3) is an excellent part of the right maxilla bearing M^{2-3}. The whole part of the maxilla is broken away in front of the teeth. The antero-posterior length of the teeth is 32 mm. The jaw length in which M^{2-3} is embedded is 35 mm and the width is 19 mm. The molars are finely preserved and are almost half worn. The teeth are squarish in general appearance.

M3

The molar is well preserved and is almost half worn. The enamel is rugose at all sides and its average thickness is 1.1 mm. A strong horizontal fold forms a cingulum at the lingual side. The cingulum is moderately developed at the anterior and posterior face of the molar but is comparatively well developed towards the inner side, especially at the entrance of the transverse valley between the protocone and hypocone. The central cavities are wide and deep. The molar is brachydont and narrow crowned as shown by measurements in Table 2. The central cavities are broad and deep.

Table 2. Comparative dental measurements of the cheek teeth of the *Dorcatherium majus* in mm (millimeters).* The studied specimens. Referred data are taken from Matthew (1929), Colbert (1935), Bhatti (2005), Akhter and Khan (2005), Farooq *et al.* (2007), Khan *et al.* 2011, 2013.

Taxa	Number	Nature/Position	Length (L)	Width (W)	W/L
D. majus	PUPC 08/23*	M^3	17.0	17.5	1.02
	AMNU 19354	M^3	20.5	23.5	1.14
	GSI B 198	M^3	20.1	19.2	0.95
	PUPC 69/268	lM^3	19.4	18.6 (1st Lobe)	0.95
				17.0 (2nd Lobe)	0.87
	PUPC 69/193	rM^3	20.0	18.5 (1st Lobe)	0.92
				17.4 (2nd Lobe)	0.87
	PUPC 67/191	M^3	13.6	15.2	1.12
	PUPC 87/328	M^3	19.1	18.2	0.95
	PUPC 87/197	M^3	20.5	22.0	1.07
	PUPC 08/42*	M^2	15.5	13.0	0.84
	PUPC 08/36*	M^2	16.0	14.0	0.88
	PUPC 08/23*	M^2	16.0	17.0	1.06
	AMNH 19302	M^2	18.5	21.5	1.16
	GSI B 198	M^2	19.6	19.6	1.00
	PC-GCUF 10/94	lM^2	18.5	15.4(1st Lobe)	0.83
				13.6(2nd Lobe)	0.73
	PUPC 69/60	IM^2	16.5	16.0 (1st Lobe)	1.00
				14.0 (2nd Lobe)	0.87
	PUPC 69/5	rM^2	18.5	17.3 (1st Lobe)	0.93
				14.0 (2nd Lobe)	0.75
	PUPC 68/33	lM^2	13.3	14.5	1.09
	PUPC 67/191	M^2	13.3	14.5	1.09
	PUPC 68/250	M^2	15.7	16.4	1.04
	PUPC 85/15	M^2	19.0	20.0	1.05
	PUPC 85/21	M^2	18.0	22.0	1.22
	PUPC 87/328	M^2	17.7	19.0	1.07
	PUPC 05/2	lM^2	19.0	22.8	1.20
	PUPC 09/46	M^2	19.4	19.0	0.98
	PUPC 08/39*	M_1	13.0	8.0	0.62
	PUPC 86/02	M_1	14.3	9.0	0.63
	PUPC 86/05	M_1	13.0	9.30	0.71
	AMNH 19520	M_1	14	9.0	0.64
	AMNH 19524	M_1	13.5	9.0	0.67
	GSI B 593	M_1	15.7	9.5	0.60

The protocone is more worn than all the other cones. It is almost L-shaped. Its posterior end does not join at the middle of the hypocone. The inner most lingual part of the protocone is rounded. The protocone is semi-crescentic in shape and its anterior arm is longer than the posterior arm. Its anterior arm is joined with the parastyle by a thin ridge of enamel while the posterior arm is free. The inner most lingual part of protocone is blunt and is almost rounded at this stage of wear. The paracone is relatively smaller in antero-posterior length compared to the metacone. The parastyle is very well developed. It is not vertical but inclined. The median rib is stoutly developed. The mesostyle is well developed and divergent. The metacone is very thin on its upper end and becomes thick towards its base. Its anterior and posterior arms are inclined towards the labial side. Its median ribs are moderately developed. It is not vertical but slightly inclined towards the anterior rib. All four cusps are inclined towards the median longitudinal axis of the molar, although the degree of inclination is greater in the lingual cusps than the buccal cusps. The metacone is roughly concave at the outer side. The metastyle is weakly developed. The hypocone is more crescentic and both of its outer ends are narrow. It is less worn than the protocone. Both of its arms are equal in length, giving a V-shaped structure. Its anterior arm is joined with the posterior half of the paracone while its posterior arm remains free. The median ribs are well developed with the anterior rib being the strongest among the styles.

Lower dentition

M1

PUPC 08/39 (Fig. 3) is a very well preserved first right lower molar and is in an early stage of wear. Moderately thick and rugose enamel can also be observed. Under the M_1 maximum preserved height of bone is approximately 14 mm while thickness can be calculated about 9 mm (Table 2). The antero-posterior length of bone beneath first lower molar is 19 mm. First and anterior conid is protoconid which is more worn than the other conids and moderately developed ectostylid is also connected with the posterior side of it. We may observe very fine placations on the buccal and lingual sides of the molar with uniform thickness and its average thickness is 0.9 mm. Antero-posteriorly narrow central cavities are present in molar. A small, unworn ectostylid is present and show association with the postprotocristid. The protoconid is longer than the metaconid antero-posteriorly. It is crescentic in shape along with a preprotocristid and a postprotocristid. In the molar we can observe dorcatherium fold. The lingual cuspids are metaconid and the entoconid which are higher than their opposite cuspids. The metaconid at its apex is sharp with anterior and posterior inclined ridges. The slightly bifurcated postmetacristid due to a vertical groove can be observed which is slightly more worn than the premetacristid. A very narrow but elongated dentinal islet has been formed by the premetacristid. Posterior to metaconid, entoconid is present which is well developed. Posterior to the protoconid, hypoconid is present and is more crescentic than the protoconid. Very well developed hypoconulid is line up with the conids of lingual side. Shallow median valley opens towards the buccal side. The cingulid is strongly developed and high antero-posteriorly while it is lacking lingually. The dorcatherium fold is also present in the postprotocristid. Selenodont buccal conids can be observed, whereas the lingual ones are conical form.

Discussion

Dorcatherium majus and *Dorcatherium minus* show the same characteristics but vary in their size, with *Dorcatherium majus* being larger than *Dorcatherium minus*. In the genus *Dorcatherium* the protocone is an incomplete crescent and the median ribs of the paracone are forwardly directed producing a notch anterior to it. The premolar row is comparatively larger than the molar row. Compared to modern tragulids the molar teeth in the large *Dorcatherium* species are more bunoid, and the premolars are usually longer relative to their breadth (Whitworth 1958). *Dorcatherium* seems to be the genus of the family Tragulidae that has developed analogously to

the recent African genus *Hyaemoschus* (Farooq *et al.* 2006). The basal cingulum is well developed in *Dorcatherium*, and at least a vestige of an ectostylid remains in the lower molars.

The specimens PUPC 8/23, PUPC 08/42 and PUPC 08/36 bearing second right and left molars are smaller in size with regards to width and length compared to those of the type specimen (AMNH 19302), although their indices of W/L ratio are very close to the type specimen. Second upper molars comprise both worn and unworn teeth. Morphological characters and dental measurements have been studied and checked for a resemblance with the type specimen in the structure of the cusps, development of styles, cingula and antero-posterior length. The differences in these dental measurements are quite insignificant because their indices show that all specimens resemble each other. A common feature of these teeth is the development of a mesostyle as mentioned by Colbert (1935), which is a very strong isolated pillar. M^3 measurements exhibit a close relationship with the type specimen AMNH 19354 and GSI B 198. The upper last molar resembles the type specimen in the structure of the cusps, cingula, rugosity of enamel, antero-posterior length and the development of styles. The specimen is different in its length and width from both AMNH 19354 and GSI B 198, but the W/L index lies close to specimen AMNH 19354 (i.e. both are broad crowned). The specimens under study show all the morphological features of the cheek teeth cited by Lydekker (1876) and Colbert (1935).

The upper molars are distinguished by their squarish appearance and their stronger development of parastyles, mesostyles and cingula. The metastyle is always weakly developed. The lingual cusps seem to be more inclined towards the median longitudinal axis than the buccal ones. The enamel is plicated and the central cavities are well developed. Characteristics above mentioned are also present in the present collection of the upper dentitions (PUPC 08/23, PUPC 08/42 and PUPC 08/36) indicating that the studied specimens belong to *Dorcatherium majus* (Lydekker 1876). The comparisons of the dental measurements of the specimens under study with those of the type specimens also show a resemblance and very slight differences. The molars compare very closely to those of specimens AMNH 19302, AMNH 19354 (Colbert 1935) and GSI B 198 (Pilgrim 1915) (table 1). They are therefore referred to the genus *Dorcatherium* and species *Dorcatherium majus* (Lydekker 1876).

According to Colbert 1935 "lower molars of *Dorcatherium majus* are comparatively high and narrow crowned having ectostylids between the protoconids and hypoconids. Among all the conids metaconid is recognized as the highest one. Their anterior median ribs are well pronounced while stylids are weakly or improperly developed. All above discussed characteristics are also exhibited by the present specimen of the lower dentition and indicate very clearly that it belongs to the species *Dorcatherium majus*". Close resemblance of PUPC 08/39 regarding its length and width to specimens AMNH 19524 (Colbert 1935) of the type material and AMNH 19520 also reveals this aspects (table 2). Their measurements with respect to length and width indices compare well with those of specimens of Colbert, 1935 i.e. AMNH 19520, AMNH 19524, and Pilgrim 1910 collection i.e. GSIB 593.

2- *Dorcatherium cf minus Lydekker 1876*

Type Specimen: Right M^{1-2} (GSI B 195).

Specimen Examined: PUPC 08/90, an isolated first left upper molar.

Locality: Dhok Bun Ameer Khatoon, Chakwal district, Punjab, Pakistan.

Stratigraphic range: Lower Siwaliks (Chinji Formation).

Discription

M^1

PUPC (Punjab University Paleontological collections) 08/90 (Fig. 4) is an isolated first upper left molar. It is very well preserved. It is subhypsodont and broad

crowned (table 3). In general appearance, it is quadirate and transversely wider anteriorly than posteriorly. The enamel is 0.4 mm thick and very nicely plicated all around the specimen. The cingulum is well developed around the protocone. The outer cones are higher vertically than the inner ones. The protocone situated anteriorly, lingually and more worn as compared to all other cones. It is almost L-shaped and less crescentic because its inner border is rounded and outer one is straight. Its anterior arm is longer than the posterior one and joined with parastyle with the help of a thin ridge of enamel while posterior arm is free and does not join at the middle of hypocone. The parastyle is well developed and connected to the base of the anterior rib. The mesostyle is well developed and is more associated with the metacone. Hypocone is more crescentic and the anterior side is slightly pinched due to pressure of the posterior end of the protocone. It is less worn than the protocone. Both of its arms are equal in length, exhibiting V-shaped structure. Anterior median rib is stronger as compared to posterior one.

Table 3. Comparative dental measurements of the cheek teeth of the *Dorcatherium minus* in mm (millimeters).* The studied specimens. Referred data are taken from Matthew (1929), Colbert (1935), Bhatti (2005), Akhter and Khan (2005), Farooq *et al.* (2007), Khan *et al.* (2011), (2013).

Taxa	Number	Nature/Position	Length (L)	Width (W)	W/L
D. minus	PUPC 08/90*	M^1	9.4	10.0	1.06
	AMNH 29856	M^1	9.8	10.0	1.02
	AMNH 19517	M^1	12.0	11.0	0.91
	GSI B 195	M^1	10.0	10.0	1.00
	PUPC 68/355	M^1	9.2	10.2	1.10
	PUPC 87/40	M^1	10.0	11.7	1.10
	PUPC 87/84	M^1	9.30	10.0	1.00
	PUPC 95/01	M^1	9.30	9.00	0.96
	PUPC 04/30	M^1	8.00	7.00	0.88
	PUPC 04/60	M^1	9.00	9.00	1.00
	PUPC 04/3	M^1	9.60	6.10	0.63
	GCS 09/01	M^1	8.20	10.2	1.24
	GCS 09/03	M^1	8.30	10.5	1.26

A **B** **C**

Fig. 4. *Dorcatherium minus,* PUPC 08/90, left first upper molar, buccal view, B-occlusal view, C- lingual view. Scale bar 5 mm.

Discussion

In American museum collection, two variations of *Dorcatherium minus* can be observed:

1. Most of the upper molars have smaller mesostyle while the internal cingulum is strongly developed.
2. Few molars have heavy mesostyle while the cingulum is poorly developed (Colbert 1935).

Isolation of protocone from hypocone, the presence of styles, the anterior median rib is stronger than the posterior one, the absence of entostylid are the characters

of genus *Dorcatherium* while finely rugose enamel, comparatively weak mesostyle and well developed lingual cingulum is the specific character in the upper molars of *Dorcatherium minus* (Colbert 1935).

The specimen under study (PUPC 08/90) is a left M^1 (molar). It is not so large enough that may be included in the species *D. majus*. According to size and morphologically the specimen under study agrees with the *D. minus*. It compares favorably with AMNH (American Museum of Natural History) 19517, AMNH 29856 and GSI B 195 and has similar antero-posterior length and crown width and W/L indices (table 3). The slight difference in the measurements is due to the individual variations.

It is, therefore, concluded that on the basis of features like tooth morphology, over all contour of the tooth, size of the tooth, enamel constriction and development of the different crown structures, that specimen under study is referred to the genus *Dorcatherium* and the species *Dorcatherium minus*.

Conclusions

Tragulids are common at Dhok Bun Amir Khatoon villages, district Chakwal, Pakistan; *Dorcatherium* is represented by 4 species, *D. minimus*, *D. nagrii*, *D. minus* and *D. majus*, in the late middle Miocene of the Chinji Formation. It is also present in the late Miocene of the Nagri Formation and the late Miocene-early Pliocene of the Dhok Pathan Formation of the Siwaliks. The tragulids are absent from the Soan Formation of the Siwaliks.

Acknowledgements

We thank Phil Jardine (University of Birmingham, UK) for his help with proof reading and many suggestions to improve manuscript. Mr. Abd-ur-Rehman, is also thanked about work in computer lab regarding preparation of scales and Map.

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