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SOME NEW REMAINS OF TRAGULIDAE (MAMMALIA: RUMINANTIA) FROM THE MIDDLE SIWALIKS OF PAKISTAN

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ABSTRACT

New tragulid fossils were collected from the Late Miocene sites of Potwar Plateau in the Punjab province, Pakistan. The studied sites include the classical localities of Dhok Pathan and Nagri from Chakwal district and Padhri from Jhelum district, Punjab, Pakistan. The material belongs to two tragulid species *Dorcatherium majus* and *D. minus*. This paper presents the dental material of both species from the Siwalik Group of Pakistan.

Key words: Taxonomy, *Dorcatherium*, Miocene, Pliocene, Palaeontology.

INTRODUCTION

The family Tragulidae includes small ruminants with primitive morphology and physiology (Rössner, 2007). They are non-pecoran ruminants assigned to the infra-order named Tragulina (Métais and Vislobokova, 2007; Rössner, 2010), representing basal position among the crown ruminants (Janis, 1984, 1987; Janis and Scott, 1987; Hassanin and Douzery, 2003). Currently, the living forms of this family are found in southeastern Asia and western and central Africa, showing discontinuous distribution (Métais and Vislobokova, 2007; Rössner, 2010). However, the extinct members of this family were recorded all over Eurasia, Africa and Indian subcontinent during the Middle Miocene (Whitworth, 1958; Gentry *et al*., 1999; Pickford, 2001; Métais *et al*., 2001; Farooq *et al*., 2008; Hillenbrand *et al*., 2009; Rössner, 2007, 2010; Sánchez *et al*., 2010, 2015; Khan *et al*., 2012a, b; Khan and Akhtar, 2013; Batool *et al*., 2014).

Classically two genera *Dorcatherium* and *Dorcabune* of the family Tragulidae have been reported from the Siwalik Group (Pilgrim, 1910; Colbert, 1935; West, 1980; Gaur, 1992; Farooq *et al*., 2008; Khan *et al*., 2012a, b). The fossil record of *Dorcabune* remains insufficient (Colbert, 1935; Farooq *et al*., 2007). Most of the Siwalik tragulid material has been tagged with the genus *Dorcatherium* (Farooq *et al*., 2007, 2008; Khan *et al*., 2012a; Khan and Akhtar, 2013; Batool *et al*., 2014). The description of *Dorcatherium* shows the abundance of the genus in Pakistan during the Siwalik Late Miocene-Early Pliocene. This paper deals with systematic description and morphological comparisons of the newly collected tragulid specimens.

Geological settings: The studied specimens were assembled from the rocks of Dhok Pathan and Nagri in the Chakwal district and Padhri in the Jhelum district, Punjab, Pakistan (Fig. 1). These classical sites are famous for their Late Miocene vertebrate fauna (Colbert, 1935; Flynn *et al*., 1990, 1995; Akhtar, 1992, 1996; Khan, 2007, 2008; Khan *et al*., 2009, 2012a, b, 2013, 2014; Batool *et al*., 2014; Ghaffar *et al*., 2015) and led to the detailed study of the Siwalik tragulid fauna.

Dhok Pathan: The outcrops (Lat. 33° 07' N: Long. 72° 14' E) in the Dhok Pathan village are located on the both sides of the Soan river (Fig. 1). Most of the sites yielded abundant Late Miocene mammalian fauna of the Middle Siwaliks (Barry *et al*., 2002; Khan *et al*., 2010, 2012b, 2013, 2014). The outcrops consist of the light-colored sandstone alternating with clay and minor layers of conglomerates. The sediments comprise orange shale with red-brown mudstone (Barry *et al*., 1991, 2002). The Dhok Pathan faunal elements can be considered similar to those reported from the Turolian Land Mammal 'Age' of Europe (Vrba, 1995, 2000; Khan *et al*., 2009). The outcrops are of Late Miocene age (Pilbeam *et al*., 1979; Barry *et al*., 2002).

Nagri: The Nagri village is situated in the Chakwal district, northern Pakistan (Fig. 1). The outcrops (Lat. 32° 25' N: Long. 72° 14' E) located near the southern part of the village, are designated as the type locality of the Nagri Formation (Pilgrim 1910, 1913; Shah, 1980). The sediments comprise massive sandstone with occasional shale beds and interclast pebbles. The sandstone is greenish gray to light gray in colour (Barry *et al*., 2002). Johnson *et al*. (1985) and Pilbeam *et al*. (1997) dated the outcrops of the Nagri Formation to 10.8 Ma and 10.7 Ma respectively. Overall, the age of the Nagri outcrops ranges between 11.2 and 9.7 Ma (Barry *et al*., 1982, 2002).

Padhri: The Padhri village is positioned in the Jhelum district, northern Pakistan (Fig. 1). The deposits (Lat. 32° 52′ N: Long. 73° 18′ E) consist of blue-gray, medium-grained, massive sandstones mixed with clays, siltstones

and mudstones (Barry *et al*., 2002). The deposits are mostly located south of the village. The site represents small to very large channels, levees and paleosols. The fluvial deposits correlate with upper part of the Dhok Pathan Formation, estimating the age of the locality at about 7 Ma (Barry *et al*., 2002; Khan *et al*., 2009).

Abbreviations: L, length; W, width; D, deciduous; M, upper molar; m, lower molar; P, upper premolar; p, lower premolar.

Institutional Acronyms: PUPC, Punjab University Paleontological Collection; PC-GCUF, Palaeontological Collection of Government College University Faisalabad; AMNH, American Museum of Natural History, New York, USA.

MATERIALS AND METHODS

The new material came from the studied localities of Dhok Pathan and Nagri formations in northern Pakistan (Fig. 1). The studied sites were visited many times and tragulid fossils that are worth describing were collected. The collected specimens were transported, washed and cleaned in Dr. Abu Bakr Fossil Display and Research Centre, Lahore for taxonomic studies. The tooth length and width were measured at occlusal level. The terminology and measurements of the teeth follow Gentry *et al.* (1999).

SYSTEMATIC PALAEONTOLOGY

Suborder RUMINANTIA Scopoli: 1777
Superfamily TRAGULOIDEA Gill: 1872
Family TRAGULIDAE Milne-Edwards: 1864
Genus *Dorcatherium* Kaup: 1833

Dorcatherium majus Lydekker: 1876
Material: Upper dentition: PUPC 13/39, rdP4; PUPC 13/38, lM2; PUPC 97/14, lM2; PUPC 10/11, lM3; PUPC 13/37, lM3. Lower dentition: PUPC 12/42, right mandible fragment with m2-3; PUPC 09/30, lm3.
Description

Upper Dentition: The deciduous molar displays a quite selenodont appearance with sharp cristae and pointed cusps. The tooth is low crowned with strong lingual cingulum. The postprotocrista represents a spur (Fig. 2 – 1). The upper molars are quadrate in their general appearance. The molars are brachydont to subhypsodont (Fig. 2). The anterior lobe is broader than the posterior one. The cingulum is present lingually. The central cavities are wide and deep. The preprotocrista is longer than the postprotocrista and is linked with the parastyle by a thin ridge of enamel whereas the postprotocrista is unfused. The paracone rib is more developed than the metacone rib. The styles are well developed. The measurements are provided in Table 1.

Lower Dentition: The second premolar is elongated and has two roots (Fig. 2). The enamel is wrinkled and shiny. The paraconid is weak and the protoconid is strong. The medial and posterior valleys are more developed than the anterior one. The contact facet is clearly marked posteriorly. The protoconid is higher than the other conids.

The enamel is rugose in lower molars. The *Dorcatherium* and *Tragulus* folds form an M–shaped structure in lower molars. The metaconid and entoconid are pointed at the top and higher than the protoconid and hypoconid. The entostylid and metastylid are weakly developed. The anterior ribs are strong. The cingulid is weakly developed and the transverse valley lacks the ectostylid. The antero-posterior fossettes are narrow and less deep. The hypoconulid is lower in height than the hypoconid in the third molars. A small back valley on the hypoconulid is present.

Comparison: The specimens are characterized by isolated strong styles, basal cingula/cingulids, bunoselenodonty, the presence of M-shaped structure in lower molars and prominent anterior median ribs. These features associate them to the Siwalik tragulids (Farooq *et al*., 2007, 2008; Khan *et al*., 2012a, b; Batool *et al*., 2014). According to Sánchez *et al*. (2010), the genera *Dorcabune, Hyemoschus*, and *Dorcatherium* do not have flat main cusps with cristids, and these cusps are elongated and vertically developed in *Afrotragulus, Siamotragulus, Yunnanotherium, Moschiola* and *Tragulus.* So, it follows that the studied specimens belong to the former three genera.

Dorcabune can be excluded in having bunodont molars and well-developed cingulum. In addition, the 'double fold' on the protocone of the upper molars and the prominent M-shaped structure with a double fold on the posterior side of the protoconid on the lower molars were also absent in the studied specimen (Pilgrim, 1915). The molars of *Dorcabune* are less compressed laterally, with pointed principal cusps and lack the crescent present in ancient eutherians (Sánchez *et al*., 2010).

The materials differ from those of *Hyemoschus* because these have semi - selenodont cusps and the posterior crest of the protocone is oriented posteriorly. Pickford (2002) stated that the crest is directed posteriorly only in *Dorcatherium* whereas in *Hyemoschus* it is directed postero-labially (Pickford *et al*., 2004). The cingulum is well developed in the upper molars of the studied specimens, like *Dorcatherium,* whereas this element is weak or absent in *Hyemoschus* (Morales *et al*., 2003). Morphologically, the studied specimens have a closer relationship to *Dorcatherium* than to *Hyemoschus* (Khan *et al*., 2012a; Khan and Akhtar, 2013; Batool *et al*., 2014).

Four species of *Dorcatherium we*re reported from the Siwaliks: *Dorcatherium majus, Dorcatherium*

minus, Dorcatherium nagrii and *Dorcatherium minimus* (Khan and Akhtar 2011, 2013; Batool *et al*., 2014). The teeth of *Dorcatherium majus* are larger than those of *D. minimus, D. nagrii* and *D. minus,* and these are morphologically different from *D. minimus* and *D. nagrii* in having strong basal cingula and styles (Lydekker, 1876; Pilgrim, 1915; Colbert, 1935; Farooq *et al*., 2007, 2008; Khan *et al*., 2012a). The studied specimens turned out to have close dimensions to the type material as well as the earlier described specimens of *D. majus* (Fig. 3).

Dorcatherium minus Lydekker: 1876

Material: PUPC 13/41, lP3; PUPC 09/84, rm2.

Description and comparison: The premolar is triangular, bears three roots and has thin and shiny enamel (Fig. 2 - 8). The protocone and metacone are well developed. The fossette is compressed and inclined anteriorly. The hypocone is not differentiated. The lower molar is subhypsodont and narrow crowned. The metaconid is more pointed and higher than the hypoconid and protoconid. The median valley is well developed without an ectostylid. The cingulid is present only on the anterolateral side of the molar. The metastylid is less developed than the entostylid. The mesostylid is absent. The anteroposterior ribs are less prominent. The molar presents a *Dorcatherium* fold. The antero-posterior fossettes are narrow. The small size of upper premolar and lower molar when compared to *D. majus,* and then the presence of lingual cingula, the strong style/stylid and *Dorcatherium*-fold, describe all the morphological characteristics of *D. minus* (Lydekker, 1876; Colbert, 1935; Farooq *et al*., 2007; Khan and Akhtar, 2011; Khan *et al*., 2012a).

Table 1. Comparative measurements (mm) of *D. majus and D. minus.studied specimens. Referred data are taken from Colbert (1935), Farooq *et al.* (2007, 2008), Khan *et al.* (2012a), Khan and Akhtar (2011, 2013) and Batool *et al.* (2014).**

Taxa	Number	Nature/Position	Length	Width	W/L
D. majus	PUPC 13/39*	rdP4	14.50	15.10	1.04
	PUPC 13/38*	lM2	16.10	18.00	1.12
	PUPC 97/14*	lM2	15.90	16.40	1.03
	PUPC 10/11*	lM3	22.10	23.20	1.05
	PUPC 13/37*	lM3	18.60	20.20	1.09
	PUPC 12/42*	rm2	11.90	7.400	0.62
		rm3	25.25	12.10	0.48
	PUPC 09/30*	lm3	24.70	12.20	0.49
	AMNH 19524	P4	14.50	5.000	0.34
	PC-GCUF 10/93	lM1	15.40	15.00	0.97
	PUPC 68/33	M1	13.30	14.50	1.09
	PUPC 68/250	lM2	15.70	16.40	1.04
	PUPC 87/328	M2	17.40	18.50	1.06
	PC-GCUF 10/94	lM2	15.40	18.50	1.20
	PUPC 69/60	lM2	16.00	16.50	1.03
	PUPC 86/46	rM3	20.00	21.60	1.08
	PUPC 87/328	M3	18.20	19.10	1.05
	GSI B198	M3	19.20	20.10	1.05
	PUPC 69/268	lM3	18.60	19.40	1.04
	PUPC 87/197	lM3	22.00	20.50	0.93
	PC-GCUF 10/49	lp3	13.80	5.800	0.42
	PC-GCUF 10/49	lp4	14.20	7.200	0.51
	PUPC 86/5	p4	13.10	5.700	0.44
	PUPC 86/02	p4	13.30	6.000	0.45
	PUPC 68/313	m1	8.900	5.600	0.63
	PUPC 68/312	m1	9.100	5.300	0.58
	PUPC 68/311	m2	10.00	6.600	0.66
	PUPC 68/312	m2	10.00	6.200	0.62
	PUPC 85/59	m2	9.500	7.000	0.74
	PUPC 86/02	m3	25.10	11.00	0.44
	PUPC 84/115	lm3	24.00	11.00	0.46
	PUPC 86/152	lm3	23.00	11.00	0.48

	PUPC 05/1	lm3	26.60	13.00	0.49
	PUPC 86/3	lm3	25.00	11.40	0.46
	PUPC 96/64	lm3	22.00	11.00	0.50
	AMNH 19939	lm3	25.50	12.00	0.47
	PC-GCUF 10/49	lm3	23.30	12.00	0.52
	PC-GCUF 10/52	rm3	27.10	12.10	0.45
D. minus	PUPC 13/41*	lP3	7.800	7.700	0.99
	PUPC 01/13	lP4	8.000	9.500	1.19
	PUPC 09/84*	rm2	10.30	6.200	1.66
	PC-GCUF 12/40	rm1	10.00	5.100	0.51
	PC-GCUF 12/41	lm1	9.300	5.400	0.58
	PUPC 02/158	m1	10.60	6.700	0.63
	PUPC 68/313	m1	8.900	5.600	0.62
	PUPC 68/312	m1	9.100	5.300	0.58
	PC-GCUF 12/41	lm2	8.200	5.500	0.67
	PC-GCUF 10/21	lm2	11.00	7.000	0.63
	PC-GCUF 12/01	lm2	11.00	6.900	62.0
	PUPC 68/311	m2	10.00	6.600	0.66
	PUPC 68/312	m2	10.00	6.200	0.62
	PUPC 85/59	m2	9.500	7.000	0.73
	PUPC 02/158	m2	12.70	8.200	0.64
	AMNH 19365	m2	13.00	12.00	0.92

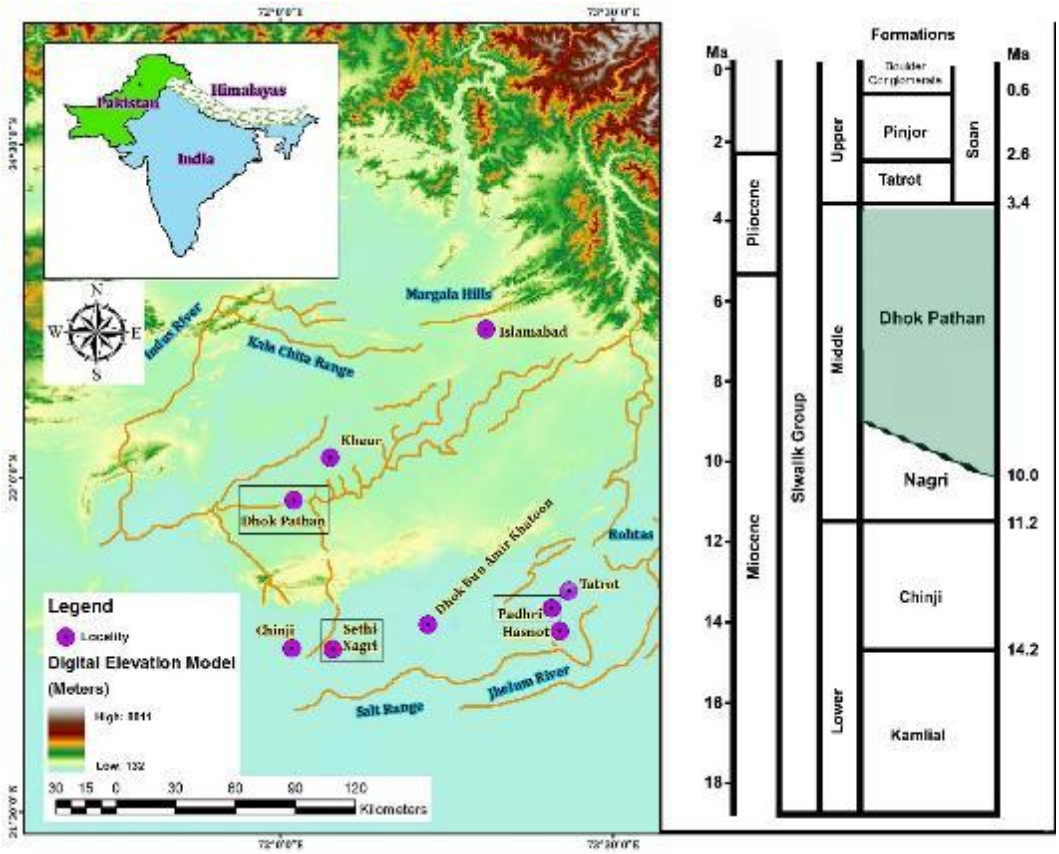

Figure 1. Map of Potwar Plateau northern Pakistan, encircling the studied localities and a generalized stratigraphic section of the major Siwalik Group formations showing succession and ages (modified from Behrensmeyer and Barry, 2005).

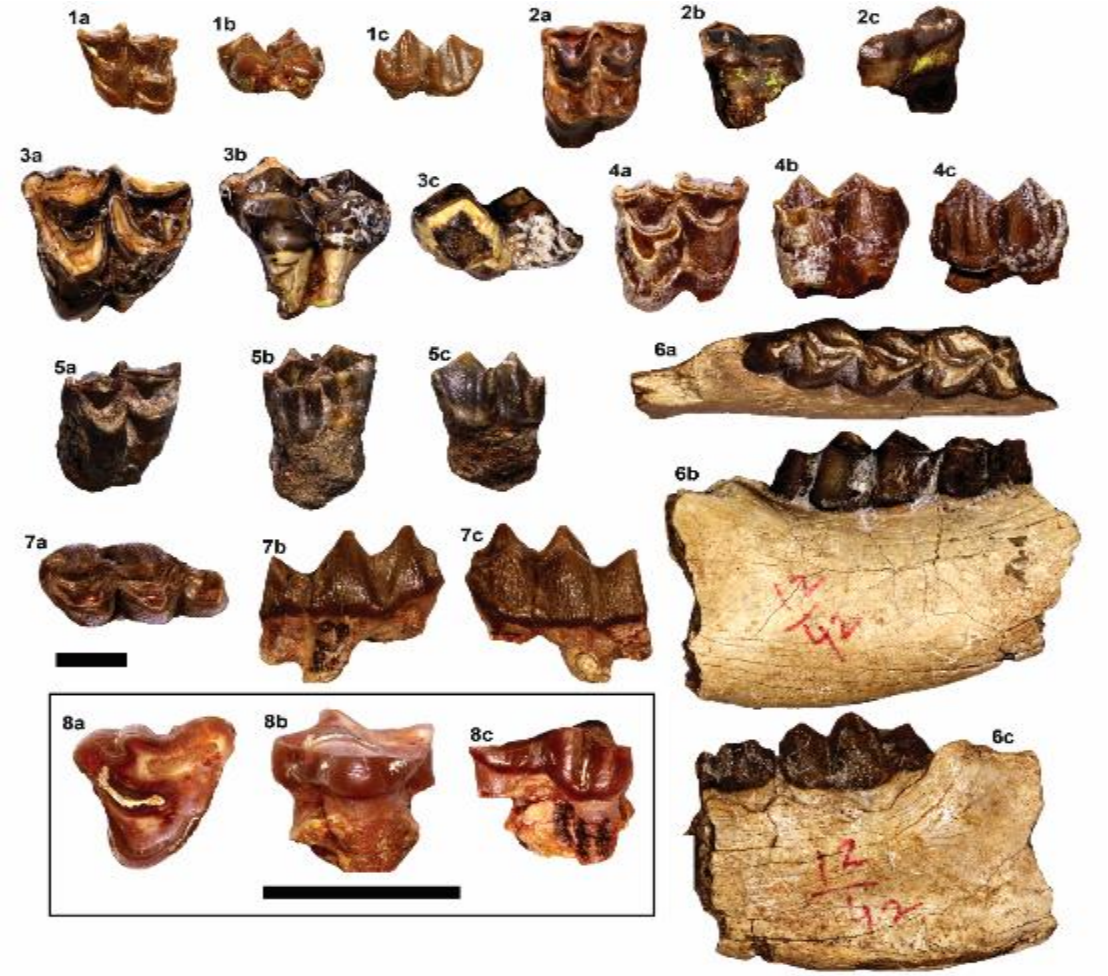

Figure 2. ***Dorcatherium majus*****: 1. PUPC 13/39, rdP4; 2. PUPC 13/38, lM2; 3. PUPC 10/11, lM3; 4. PUPC 97/14, lM2; 5. PUPC 13/37, lM3; 6. PUPC 12/42, right mandible fragment with m2-3; 7. PUPC 09/30, lm3.** ***D. minus*****: 8. PUPC 13/41, lP3. Scale bar 10 mm.**

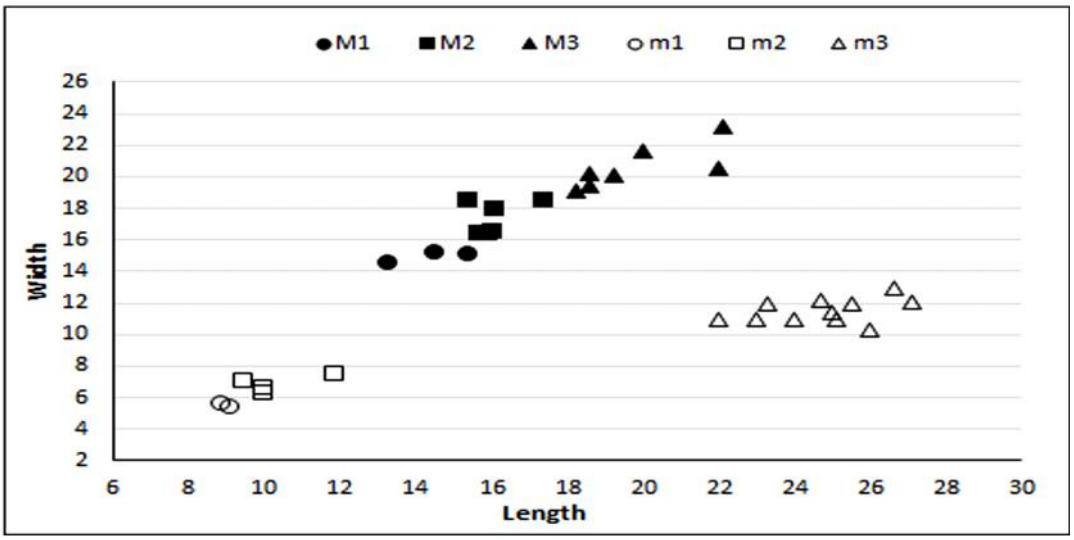

Figure 3. Bivariate showing size variation in upper and lower molars of ***D. majus.***

DISCUSSION

The Middle Siwalik sites of Nagri, Dhok Pathan, and Padhri in northern Pakistan showed a diverse and abundant ruminant fauna such as *Selenoportax, Pachyportax, Tragoportax, Gazella, Bramatherium, Dorcatherium,* and *Dorcabune* (Akhtar, 1992; Pickford, 1988; Farooq *et al*., 2007, 2008; Khan, 2007, 2008; Khan *et al*., 2009; Ghaffar *et al*., 2010). These sites also yielded bovids, giraffids, rodents, carnivores, suids, proboscideans, cercopithecids, rhinoceroses and equids (Colbert, 1935; Pilgrim, 1937, 1939; Khan, 2007; Khan *et al*., 2009; Ghaffar *et al*., 2010). These faunal elements show similar association and correspondence as Late Miocene faunas of Eurasia, Africa, and the Greco-Iranian Province (Solounias, 1981; Bernor, 1986; Harris, 1987; Kohler, 1987; Geraads, 1989; Gentry and Heizmann, 1996; Gentry, 1978, 1999, 2005; Solounias *et al*., 1999; Iliopoulos, 2003). These faunas are aged from Late Miocene to Early Pliocene.

The genus *Dorcatherium* is widely distributed throughout the old world, as it is present in the Miocene beds of Moruorot, Kenya and Sub-Saharan Africa (Whitworth, 1958; Nakaya, 1994); in the Late Miocene of Southwest and Central Europe; Sub-Paratethys, Siwaliks and East Asia (Savage and Russell, 1983), being primarily more significant in the establishment of evidence regarding the Late Miocene faunal interchange between Africa and Eurasia (Pickford, 1981; Thomas, 1984; Pilbeam *et al*., 1979; Barry *et al*., 2002; Bibi and Güleç, 2008; Kostopoulos, 2009). *Dorcatherium* is close to the genus *Siamotragulus* found in the Middle Miocene of Thailand and to the genus *Yunnanotherium* reported from the Late Miocene of China (Vislobokova, 2001).

The presence of *Dorcatherium* advocates very humid environmental conditions with abundant water supply in the form of small ponds and dense pockets of rain forest (Khan *et al*., 2012a, b; Batool *et al*., 2014). Living relatives of *Dorcatherium,* the chevrotains, prefer the dense habitats of the rain forests (Dubost, 1978; Meijaard *et al*., 2010) that provide shady shelters from predators. *Dorcatherium* is also common in the Late Miocene of Pakistan and forms the major part of the Siwalik tragulid diversity in the Mio–Pliocene (Farooq *et al*., 2008; Khan *et al*., 2012b; Khan and Akhtar, 2013; Batool *et al*., 2014).

Conclusions: New remains of the Siwalik tragulids *Dorcatherium majus* and *D. minus* are reported from the Late Miocene of Potwar Plateau, Punjab, Pakistan. The fossils are found from three classic Siwalik localities: Dhok Pathan, Padhri and Nagri of the Middle Siwalik Subgroup of Pakistan. The occurrence of *Dorcatherium* indicates relatively closed and damp habitats in patches in the Siwalik Late Miocene.

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