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

1M. Asim, 1M. A. Babar, 2K. Aftab, 1M. A. Khan, 1S. G. Abbas, 1R. Shahid, 1M. K. Nawaz and 1M. Akhtar

1Dr. Abu Bakr Fossil Display and Research Centre, Department of Zoology, University of the Punjab, Quid-e-Azam Campus, Lahore, Punjab, Pakistan, 2University of the Gujrat, Gujrat, Punjab, Pakistan.

*Corresponding author email: asim413@gmail.com

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; Faroq et al., 2008; Hillenbrand et al., 2009; Rössner, 2007, 2010; Sánchez et al., 2010, 2015; Khan et al., 2012a, b; Khan and Akhter, 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; Faroq et al., 2008; Khan et al., 2012a, b). The fossil record of Dorcabune remains insufficient (Colbert, 1935; Faroq et al., 2007). Most of the Siwalik tragulid material has been tagged with the genus Dorcatherium (Faroq 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 Turonian 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, IM2; PUPC 97/14, IM2; PUPC 10/11, IM3; PUPC 13/37, IM3. 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 subhypsidont (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 cingulums. 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* were 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 13/39, 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 subhypodond 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).

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*D. minus*

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. *Dorcattherium majus*: 1. PUPC 13/39, rdP4; 2. PUPC 13/38, IM2; 3. PUPC 10/11, IM3; 4. PUPC 97/14, IM2; 5. PUPC 13/37, IM3; 6. PUPC 12/42, right mandible fragment with m2-3; 7. PUPC 09/30, lm3. *D. minus*: 8. PUPC 13/41, IP3. 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 *Selenoparax*, *Fachyparax*, *Tragoporax*, *Gazella*, *Brahamatherium*, *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, cervalitheres, 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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