



New Cervid (Artiodactyla) Fossils from Middle Siwaliks of Pakistan

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ABSTRACT

New dental material of cervids from Middle Siwalik deposits of Potwar Plateau, Pakistan has been described. The remains are recovered from the outcrops, situating in three districts of Punjab, namely Kaulial Kas in Attock district, Dhok Pathan in Chakwal district, and Hasnot and Padhri in Jhelum district, Punjab, Pakistan. The outcrops date to Dhok Pathan formation (Late Miocene – Early Pliocene). The identified cervid species include *Rucervus* cf. *simplicidens*, *Cervus* cf. *triplidens* and *Cervus* cf. *sivalensis*. These specimens provide additional information about the recorded cervid species and contribute to recent work from the Middle Siwalik Hills of Pakistan.

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Authors' Contribution

MAK and MA conceived and designed the study. MAB and SGA acquired, analyzed and interpreted the data. KA, MAB, MA and MH wrote the article.

Key words

Cervidae, Miocene, Pliocene.

INTRODUCTION

Cervids entered in the Siwaliks during the Pliocene time with their similarity to European fossil deer of Pliocene (Barry *et al.*, 2002). The Upper Siwalik rocks of Pakistan have produced several cervid species (Arif and Raza, 1991; Khan *et al.*, 2014). Five cervid species *Rucervus simplicidens*, *Cervus triplidens*, *C. rewati*, *C. sivalensis* and *C. punjabiensis* are reported from the Siwaliks (Azzaroli, 1954; Arif and Raza, 1991; Khan *et al.*, 2014; Ghaffar *et al.*, 2006, 2010, 2015, 2017). The studied specimens are recovered from four localities of Dhok Pathan Formation, Middle Siwalik Subgroup, including Kaulial Kas (Attock district), Dhok Pathan (Chakwal district), and Padhri and Hasnot (Jhelum district).

The Dhok Pathan Formation is characterized by the light-colored sandstone with alternate clay and minor layers of conglomerates. The sediments have orange shale with less compacted gray sandstone bodies and red-brown mudstone with a few thin conglomerate interbeds. Sandstone and superposed red mudstone often form fining-upward couplets where the lower contact is erosional and lined with ripped-up clasts of the underlying mottled and red-brown clay stone. At a few places, thin crevasse-splay sheets, around 30 cm thick, clast-supported conglomerates occur. These conglomerate beds often contain unidentifiable bone and tooth fragments.

Sandstone beds in upper section gradually get thicker and multistoried. These substantially thicker, vertically stacked and laterally extensive individual gray sandstone units, form a fining-upward sequence with thinner dull red to brown siltstones on top (Behrensmeier and Tauxe, 1982). Varicolored, mottled, highly bioturbated paleosol horizons, form distinct and laterally extensive units within the siltstone. The magnetic polarity and stratigraphic dating has constrained the age of the Dhok Pathan Formation to between 10.1–ca. 3.5 Ma. The lower part of the Dhok Pathan Formation is dated 10.1–9.0 Ma and the upper part is dated at ca. 9.0–5.5 Ma (Cande and Kent, 1995; Barry *et al.*, 2002).

Kaulial Kas fossils have been poorly documented. Cervid remains described in the present work, and collected from this area are significant, as they can increase the number of biostratigraphic records of the Siwalik cervids.

MATERIALS AND METHODS

We performed several field visits in order to collect the cervid fossil described. The fossils were collected carefully from the fossiliferous locations of Kaulial Kas, Dhok Pathan, Hasnot and Padhri. The identifiable fossils from the whole collection were catalogued and considered for the taxonomic study. The fossils were thoroughly washed and cleaned in the laboratory with the help of fine needles and brushes and prepared for the study. Damaged parts of the fossils were assembled with some kinds of gums (resins) such as elfy, elite, fixin, araldite and magic stone. The specimens inventory number consists of a

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yearly catalogue number and serially catalogue number, so numbers on the specimen represent the collection year and the serial number of that year (*e.g.* PUPC 15/391). Upper case letters stand for upper dentition and lower case letters for lower dentition. The teeth measurements were taken occlusally, including the cement and separately from the teeth belonging to different stages of wear.

SYSTEMATIC PALAEOLOGY

Infraorder Pecora Linnaeus, 1758
 sensu Webb and Taylor, 1980
 Suborder Ruminantia Scopoli, 1777
 Family Cervidae Goldfuss, 1820
 Subfamily Cervinae Goldfuss, 1820
 Genus *Rucervus* Hodgson, 1838

Rucervus cf. simplicidens (Lydekker, 1876)

Specific diagnosis

Molar crowns square with small accessory pillars, and with slightly rugose enamel (Colbert, 1935).

Geographic distribution

South Asia (Pilgrim, 1910, 1913; Colbert, 1935; Ghaffar, 2005; Khan *et al.*, 2014; Ghaffar *et al.*, 2015).

Stratigraphic range

Upper part of Middle Siwaliks and Upper Siwaliks (Pilgrim, 1910, 1913; Colbert, 1935; Khan *et al.*, 2014; Ghaffar *et al.*, 2015).

New material (locality names in parenthesis): Lower dentition: PUPC 13/301, right mandible fragment with partial p4, complete m1 and partial m2 (Padhri); PUPC 15/391, right mandible fragment with m1-2 (Dhok Pathan); PUPC 15/331, left m2 (Dhok Pathan); PUPC 15/332, right m2 (Dhok Pathan); PUPC 13/285, right mandible fragment with m2 (Dhok Pathan); PUPC 14/90, right mandible fragment with m2 (Hasnot); PUPC 14/91, left m2 (Hasnot); PUPC 15/324, left m3 (Kaulial Kas).

Description

The material includes lower dentition. The anterior valley is broader than the posterior in p4. The protoconid is slightly lower than the metaconid. The molars are moderately rugose and bear weak stylids and ribs (Fig. 1A-H).

The anterior lobe is higher and wider than the posterior lobe, having anterior and posterior fossettes. The anterior fossette is wider than the posterior one. The median valley is deep. The post-hypocristid is slightly pinched inward (posteriorly). The ectostylid tapers towards apex directed posteriorly. The accessory tubercles are present labially.

Comparison

The studied teeth represent weak stylids and ribs, which distinguish them from the family Bovidae; the teeth show brachydonty, less wrinkled enamel and more prominent enamel foldings. The external longitudinal crest with three internal extensions that can be clearly seen on the labial views that help in their ranking to Cervidae, especially the last character which is universal for cervids (Azzaroli, 1948; Bubenik, 1990; Petronio *et al.*, 2007; Ghaffar *et al.*, 2010). The Siwalik cervids are represented by the three genera *Rucervus*, *Axis* and *Cervus* (Colbert, 1935; Ghaffar *et al.*, 2010; Khan *et al.*, 2010, 2014). The studied teeth are brachydont, which is the character of *Rucervus* (Fig. 1; Table I). The studied specimens lack the basal cingulum, which is prominent in *C. sivalensis* and only moderately developed in *C. triplidens*. Moreover, in the studied specimens the ectostylid is less developed in the median valley whereas in *C. sivalensis* the thick ectostylid is present in the deep valley and a developed ectostylid in *C. triplidens*.

The enamel of the studied material is slightly wrinkled to *C. sivalensis* and *C. triplidens*. *Cervus rewati* is a small species with strongly developed ectostylids. Absence of ectostylid and less deep median valley combine the specimens to *R. simplicidens* and differentiates them to *Axis punjabiensis* (Colbert, 1935). However, due to insufficient data, the specimens are assigned to *R. cf. simplicidens*.

Genus *Cervus* Linnaeus, 1758

Cervus cf. triplidens Lydekker, 1876

Specific diagnosis

Molars hypsodont with large accessory columns and rugose enamel (Colbert, 1935).

Geographic distribution

Eurasia (Lydekker, 1880; Colbert, 1935; Ghaffar *et al.*, 2010).

Stratigraphic range

Upper part of Middle Siwaliks and Upper Siwaliks (Lydekker, 1876; Pilgrim, 1910, 1913; Brown, 1926; Khan *et al.*, 2014).

New material (locality name in parenthesis): PUPC 13/280, left mandible fragment with partial m1-3 (Dhok Pathan).

Description and comparison

The material is poor and fragmentary. Most of the major conids are badly damaged. The cingulum is present. The fossette are crescent shaped and the anterior fossette is smaller than the posterior one. The stylids are almost

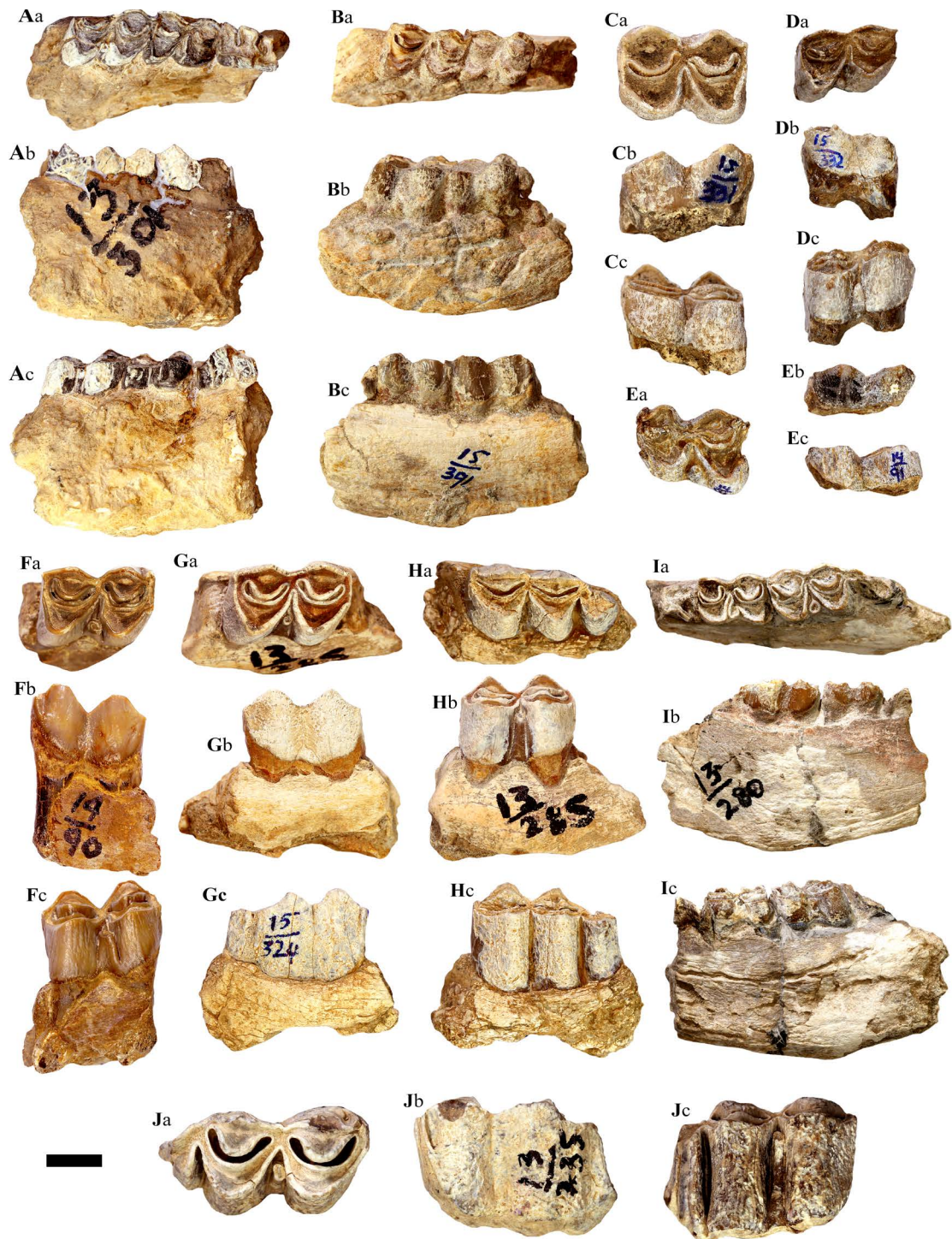


Fig. 1. The representative cheek teeth of the Siwalik cervids from the Middle Siwaliks of Pakistan. *Rucervus* cf. *simplicidens*: **A**, PUPC 13/301, right mandible fragment with partial p4, complete m1 and partial m2; **B**, PUPC 15/391, right mandible fragment with m1-2; **C**, PUPC 15/331, left m2; **D**, PUPC 15/332, right m2; **E**, PUPC 14/91, left m2; **F**, PUPC 14/90, right mandible fragment with m2; **G**, PUPC 13/285, right mandible fragment with m2; **H**, PUPC 15/324, left m3. *Cervus* cf. *triplidens*: **I**, PUPC 13/280, left mandible fragment with partial m1-3. *Cervus* cf. *sivalensis*: **J**, PUPC 13/235, right m3. **a**, occlusal view; **b**, lingual view; **c**, labial view. Scale bar 10 mm.

Table I.- The comparative measurements (mm) of the cheek teeth of *Rucervus cf. simplicidens*, *Cervus triplidens* and *C. cf. sivalensis*.

Taxon	Number	Nature/Position	Length	Width	W/L	
<i>Rucervus cf. simplicidens</i>	PUPC 13/301*	rp4	14.52 (preserved)	9.50		
		rm1	15.80	12.52	0.79	
		rm2	20.10	13.00	0.65	
	PUPC 15/391*	rm1	15.52	11.56		
		rm2	19.00	12.28		
	PUPC 15/331*	lm2	20.45	14.95	0.73	
	PUPC 15/332*	rm2	18.20	12.20	0.67	
	PUPC 13/285*	lm2	18.70	13.00	0.70	
	PUPC 14/90*	rm2	19.15	14.75	0.77	
	PUPC 14/91*	lm2	20.60	15.75	0.76	
	PUPC 15/324*	rm3	24.74	11.65	0.47	
	PUPC 87/276	m1	18.0	12.0	0.67	
	PUPC 86/321	m1	12.0	9.00	0.75	
		m2	14.5	9.00	0.62	
	PUPC 02/5	m1	14.8	9.7	0.66	
		m2	16.2	10.7	0.66	
	PUPC 02/20	m2	21.0	13.0	0.62	
		m3	27.0	12.5	0.46	
	PUPC 85/97	m2	18.0	12.0	0.67	
		m3	27.0	14.0	0.52	
	PUPC 83/104	m3	20.00	13.00	0.65	
	<i>Cervus cf. triplidens</i>	PUPC 13/280*	lm1	13.30 (preserved)	11.36	
			lm2	22.25	16.40	0.74
lm3			39.75	16.85	0.42	
PUPC 69/146		lm1	19.00	14.00	0.74	
		lm2	20.00	20.00	1.00	
		lm3	25.00	16.00	0.64	
<i>C. cf. sivalensis</i>	PUPC 13/235*	rm3	31.88 (preserved)	17.80		
	PUPC 87/279	m3	31.00	18.00	0.58	
	PUPC 66/9	m3	43.00	21.00	0.48	
	PUPC 04/21	m3	19.0	11.6	0.61	
	PUPC 66/9	m2	29.0	20.0	0.68	
		m3	43.0	21.0	0.48	
	PUPC 83/286	m2	18.0	9.50	0.52	
		m3	26.0	11.5	0.44	
	PUPC 00/92	m2	24.0	15.0	0.62	
		m3	32.0	13.5	0.42	
	GSI B215	m2	25.0	17.5	0.70	
		m3	35.0	-	-	

*The studied specimens. Referred data are taken from Colbert (1935), Ghaffar *et al.* (2010) and Khan *et al.* (2010, 2014).

not discernible. The ectostylid is joined to the protoconid and hypoconid. The basal cingulum is well developed and the median valley is deep with strong ectostylid. These characteristics correspond (Fig. 11a-c; Table I) to *C. triplidens* from the Siwalik Group (Colbert, 1935; Khan *et al.*, 2014), and this recovered cervid remains can be assigned

to *C. cf. triplidens*.

***Cervus cf. sivalensis* Lydekker, 1876**

Specific diagnosis

A large cervid with relatively hypsodont molars. The

skull and antlers resembles the one of *Cervus duvaucelli*. The skull is by virtue of the frontal concavity at the orbits and the forward swells at the pedicles. The lacrymal vacuity is smaller than in *Cervus duvaucelli*. The brow tine of the antlers arises immediately, burr and form an obtuse angle with the beam (Colbert, 1935).

Geographic distribution

Eurasia (Lydekker, 1880; Colbert, 1935; Ghaffar *et al.*, 2010).

Stratigraphic range

Upper part of the Middle Siwaliks and Upper Siwaliks (Lydekker, 1876; Pilgrim, 1910, 1913; Brown, 1926; Khan *et al.*, 2014).

New material (locality name in parenthesis): PUPC 13/235, right m3 (Dhok Pathan).

Description and comparison

The apices of metaconid and entoconid are broken and hypoconulid is missing (Fig. 1J). The first lobe is higher and broader than the second one. The anterior and posterior fossettes are prominent and they are crescent shaped. The ectostylid covers the entire median valley. The partially broken metastylid is present whereas the other stylids are absent (Fig. 1J; Table I). Presence of auxiliary columns, basal cingulid, well-developed anterior flange, heavy ectostylid, less sculptured enamel and orientation of the major conids in straight line make their assessment to *C. sivalensis* (Lydekker, 1880; Colbert, 1935; Ghaffar *et al.*, 2010; Khan *et al.*, 2014).

DISCUSSION

The fossil record of the Siwalik cervids belonging to Plio-Pleistocene is rare (Ghaffar *et al.*, 2010, 2012, 2017). The work of Lydekker work concerned the early history of the Siwalik cervids. In 1876, three species were erected by Lydekker (1876), based on the fragmentary material including *Cervus latidens*, *C. triplidens* and *C. simplicidens*. Later, Lydekker (1884) placed *Cervus latidens* into the genus *Oreas* (Bovidae) excluding it from the family Cervidae and adding as a new species, *Cervus sivalensis* to the genus *Cervus*. *Cervus punjabiensis* was erected by Brown (1926). The described species came from the Upper Siwaliks (Lydekker 1876, 1880, 1884; Brown, 1926). Pilgrim (1910) and (1913) assigned to the Middle Siwalik horizon for *Cervus triplidens* and *C. simplicidens* but Brown (1926) confirmed the Upper Siwalik horizon for these species.

Early Pliocene to Late Pleistocene sites in Pakistan have yielded the cervid fossils (Savage and Russell, 1983;

Barry and Flynn, 1990; Arif and Raza, 1991; Arif *et al.*, 1991; Barry *et al.*, 2002; Khan *et al.*, 2014; Ghaffar *et al.*, 2010, 2012, 2015, 2017). The ascribed species of the Siwalik cervid from the material at British Natural History Museum include *Cervus triplidens*, *C. sivalensis*, *C. punjabiensis*, *C. colberti*, *Rucervus simplicidens*, *Rucervus* sp.1, *Rucervus* sp.2, *Rucervus* sp.3 and *Euctenoceros* sp. (Azzaroli, 1954; Randi *et al.*, 1998; Di Stefano and Petronio, 2003; Ludt *et al.*, 2004). Arif *et al.* (1991) added a new species *Cervus rewati* from the Upper Siwaliks of Rewat near Rawalpindi, Punjab, Pakistan.

In the Siwaliks there are no deer in pre-Hipparion levels but recently a specimen of *Cervus sivalensis* was collected from the Chinji formation of the Middle Siwaliks (Ghaffar *et al.*, 2006). Also a late Oligocene to early Miocene indeterminate large cervoid (fragmentary mandible) was found from the Zinda Pir sequences in Pakistan (Barry *et al.*, 2005). Several cervid species have been described mainly from the Upper Siwalik rocks of the Western Himalayas including the Siwalik Hills and adjoining ranges in India and southern Kashmir, Potwar and Trans-Indus Hill ranges of Pakistan.

CONCLUSIONS

The cervid assemblage recovered from the Dhok Pathan Formation of the Siwaliks includes *Rucervus* cf. *simplicidens*, *Cervus* cf. *triplidens* and *Cervus* cf. *sivalensis*. This paper document the first cervid fossil record from the Kulial Kas outcrops of the Siwaliks. These new finds also add geographic and biostratigraphic data for known Siwalik cervid species.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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