



Antelopes (Mammalia) from Pabbi Hills of Sardhok, Pakistan

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ABSTRACT

The site of Sardhok in Pabbi Hills (northern Pakistan), well known for its large mammalian remains, dating to middle Pleistocene, yielded fossils of antelopes. The remains are referred to *Kobus porrecticornis*, Reduncini gen. et sp. indet. *Antelope* sp., *Sivatragus* cf. *bohlini*, *Damalops* sp., Caprinae gen. indet. (aff. *Capricornis*) *roylei*. These new findings allowed to calibrate the exact stratigraphic position of the species. *Sivatragus bohlini*, previously recovered from the Upper Siwaliks, and difficult to date. Moreover, antelopes are documented for the first time from this locality.

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Authors' Contribution

MAK and MA present the concept and designed the study. MKS and SGA did acquisition of data. SGA and MAB analysed and interpreted the data. MI, FYD and AG wrote the manuscript.

Key words

Taxonomy, Palaeontology, Bovidae, Pleistocene, Siwaliks.

INTRODUCTION

The fossiliferous locality of Sardhok is known since the 1960's when Sarwar (1977) described proboscidean fossils recovered from the east of the village. The vertebrate fossil site of Sardhok in Pabbi Hills, Punjab, Pakistan has yielded many fossils in previous years. It is evident that Sardhok is of middle Pleistocene age, in agreement with overall similarity of the ungulate fauna. Details about the geology and stratigraphy of the area are given in Dennell *et al.* (2008), Siddiq (2015) and Siddiq *et al.* (2017).

The recorded mammal fauna of Sardhok includes: *Boselaphus* cf. *namadicus*, *Proamphibos kashmiricus*, *Hemibos triquetricornis*, *Bos* cf. *acutifrons*, *Bubalus palaeindicus*, *Kobus porrecticornis*, Reduncini gen. et sp. indet., *Antelope* sp., *Sivatragus* cf. *bohlini*, *Damalops palaeindicus*, Caprinae gen. indet. (aff. *Capricornis*) *roylei*, *Stegodon bombifrons*, *Stegodon ganesa*, *Elephas planifrons*, *Elephas namadicus*, *Rhinoceros* cf. *sivalensis*, *Rhinoceros* cf. *sondaicus*, *Rhinoceros* cf. *unicornis*, *Axis punjabiensis*, Cervidae indet., *Hexaprotodon sivalensis*, *Equus sivalensis*, *Sivatherium* sp. (Pilgrim, 1937; Sarwar, 1977; Khan, 2011; Siddiq, 2015; Ghaffar *et al.*, 2017). The Sardhok fauna is dominated by the large sized mammals. The associations of various large size species (Dennell *et al.*, 2006; Dennell, 2008; Siddiq *et al.*, 2016, 2017) indicate an arid climate with moist conditions in the Sardhok Pleistocene.

The present article is to provide the recorded antelope species for the first time from Sardhok, Pabbi Hills of Pakistan. We have identified specimens of six antelope species. Many new fossils were collected during field surveys. The specimens were collected from the localities nearby the Sardhok village (Lat. 32° 49' 39" N; Long. 73° 43' 51" E), located 14-16 km south of Mandi Bahaud Din-Sarai Alamgir road, district Gujrat, Punjab, Pakistan (Fig. 1). The material analyzed in this work includes upper and lower teeth. The specimens are compared with the equivalent teeth elements of the Siwalik antelopes, earlier reported from the Upper Siwalik Subgroup and stored in various museums and institutions. Specimens with comparative metric values are provided in Table I. The dental terminology used in this article is mostly from Gentry *et al.* (1999) and Bärmann and Rössner (2011). Morphometric measurements according to those adopted by Pilgrim (1937, 1939) and were recorded to the nearest 0.1 mm with a digital caliper.

SYSTEMATIC PALAEONTOLOGY

Family Bovidae Gray, 1821

Subfamily Antilopinae Gray, 1821

Genus *Kobus* Smith, 1840

Abbreviations

PUPC, Punjab University Palaeontological Collection; P, upper premolar; p, lower premolar; m, lower molar; M, upper molar; L, length; W, width; mm, millimeters.

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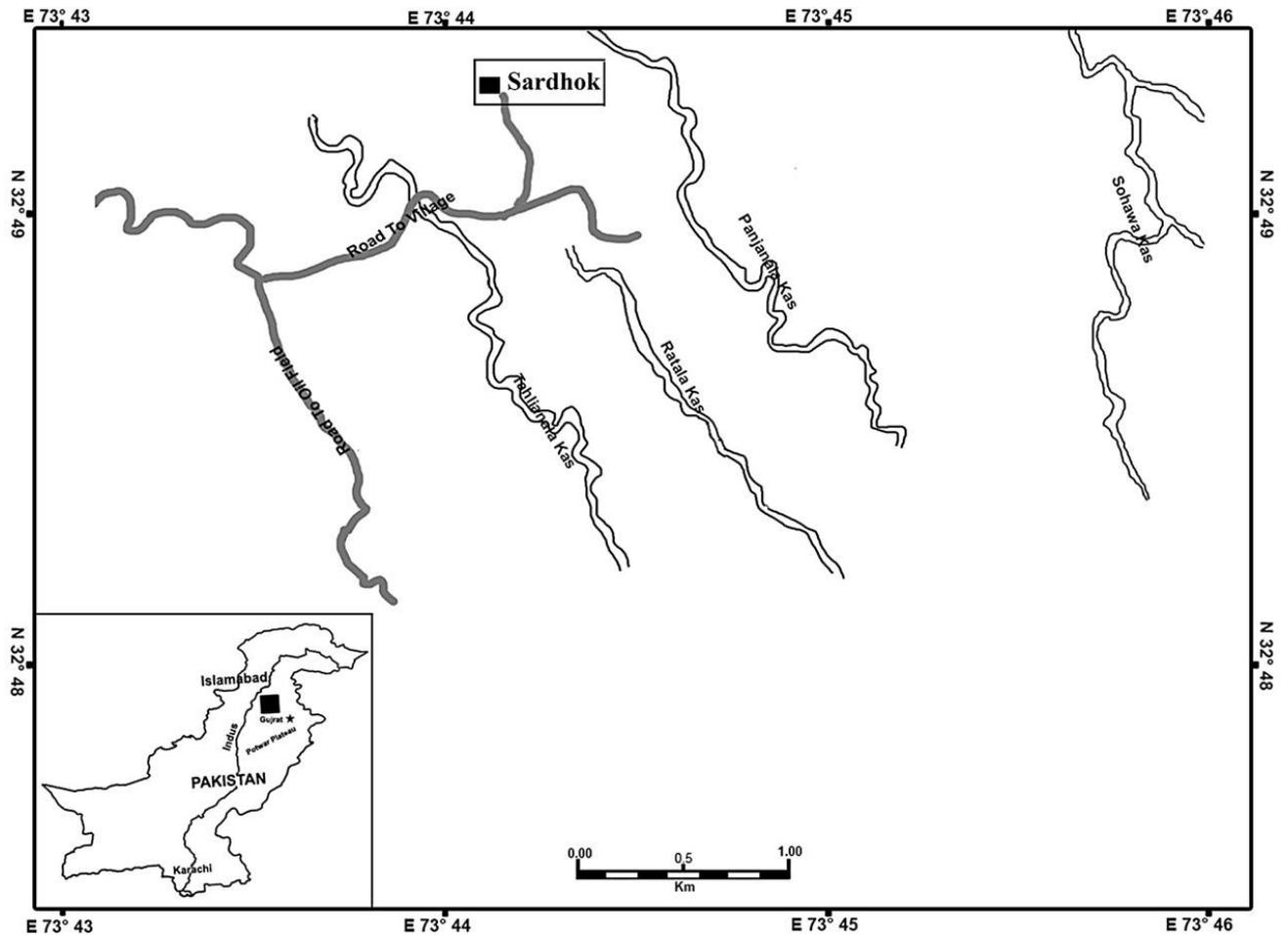


Fig. 1. Geographical position of the Sardhok in the Pabbi hills, northern Pakistan.

Kobus porrecticornis (Lydekker, 1878)

New material

Upper dentition: PUPC 67/196, left M1; PUPC 66/149, right M2; PUPC 67/198, right M2; PUPC 67/40, right M3. Lower dentition: PUPC 14/44, right m3.

Description and comparison

The upper molars are medium size and hypsodont (Fig. 2A-D). The entostyle is present. The enamel is smooth. The antero-posterior fossettes are complex in structure having indentations (with spurs). The lobes are constricted lingually in the upper molars. In the labial view, the styles and ribs are strong (Fig. 2A-D). The lower molars are characterized by caprini folds, ectostylids, strong lingual ribs and stylids (Fig. 2E). The labial lobes of the lower molars are constricted. Morphometrically, the sample resembles the medium size antelope. The molars are essentially different from those of antelopes in having

hypsodony and constricted lobes (in upper molar lingually and in lower molar labially) (Khan and Akhtar, 2014). The overall morphology of the molars is very similar to that of the Siwalik primitive reduncine (Lydekker, 1878; Pilgrim, 1939; Thomas, 1980). The studied molars are very similar in morphology to *K. porrecticornis* (Table I) and can be referred to *Kobus porrecticornis*.

Many African reduncine forms have the same dimensions size and hypsodony as the Siwalik forms. Nevertheless, the African reduncines have stronger basal pillars and less pointed labial lobes (Gentry, 1997). The entostyle is only present on M1 of early reduncines (Gentry, 1997). *Kobus porrecticornis* from the Siwalik beds displays features of early Reduncini. It was considered more primitive than African reduncines (Gentry, 1997).

Discussion

The earlier fossil record of reduncine does not show primitive morphology (Gentry, 1981, 1990). Nevertheless,

reduncine teeth reflect primitive morphology (Gentry, 1981). The reduncines are recorded abundantly in Plio-Pleistocene epochs. Later, the tribe became less diversified, same as the other groups of bovids. In the Late Miocene and Early Pliocene modern tribes of antelopes become recognizable in Africa and the subcontinent Siwaliks (Gentry, 1999).

The reduncines appear in Africa and in the Siwaliks at the same time as the bovine *Proamphibos*, that is, when boselaphines decreased. They continue into the Pinjor Formation of the Upper Siwaliks wherein some more complete remains are known. Here they show quite strong temporal ridges on the braincase roof, reminiscent of boselaphine and possess preorbital fossae, as known in *Menelikia* but not in living reduncines that support a boselaphine ancestry for reduncines (Gentry, 1990). However, the teeth at Langebaanweg apparently associated with reduncine horn cores and the crania are like tragelaphines (Gentry, 1999).

Reduncini gen. et sp. indet.

New material

PUPC 68/60, left mandible fragment with p3-4 (p3 = L, 15.7; W, 7.8; p4 = L, 15.2; W, 10.2).

Description and comparison

The mandible is an antero-posteriorly broken left mandible fragment bearing the third and fourth premolars (Fig. 2F). The root alveoli of p2 and m1 are present but the crown is absent. The p3 and p4 have deep furrow labio-posteriorly. The p4 is heavier than the p3. The premolars represent strong fold labio-posteriorly. The premolars are comparatively small and reduced posteriorly. The premolars taper anteriorly and broad posteriorly. The anterior valley is open whereas the posterior one is narrow. The metaconid is isolated, not united antero-posteriorly. The entoconid and entostylid are not united until the neck of crown.

The studied premolars taper anteriorly with strong fold labio-posteriorly. The p4 is without paraconid-metaconid and entostylid; the entoconid fusion to form a complete lingual wall (Fig. 2F). These features indicate one of the primitive reduncines (Gentry, 1997). The specimen is incomplete to describe at generic and specific level and assigns to Reduncinae gen. et sp. indet. The premolars show morphological similarity with the premolars of *Hydaspicobus*, recovered from the late Miocene of Hasnot by Pilgrim (1939, p. 108, Fig. 11b). The late Miocene premolars are smaller than the early Pleistocene specimens (Table I). There may be tendency to increase in size of the species from the Middle Siwaliks to the Upper Siwaliks.

Nevertheless, a comprehensive sample size is needed for an exact identification and the size confirmation of the species.

Table I.- Comparative dimensions (mm) of the Sardhok antilopes.

Taxa / Specimen No.	Nature	Length	Width	W/L
<i>K. porrecticornis</i>				
PUPC 67/196*	lM1	19.7	13.3	0.67
PUPC 66/149*	rM2	19.4	15.2	0.78
PUPC 67/198*	rM2	18.8	18.8	0.75
PUPC 67/40*	rM3	19.7	12.2	0.61
PUPC 14/44*	rm3	26.6	8.40	0.31
PUPC 82/14	lM1	16.6	16.3	0.98
PUPC 82/13	lM2	17.0	15.0	0.88
PUPC 83/837	lm1	16.5	10.8	0.65
PUPC 88/03	lm2	19.0	11.5	0.60
	rm2	17.4	9.60	0.55
	rm3	23.0	9.00	0.39
PUPC 02/137	rm2	21.0	10.6	0.50
	rm3	23.5	-	-
PUPC 69/67	rm3	25.7	13.0	0.50
PUPC 83/816	lm3	28.0	12.5	0.44
<i>K. aff. porrecticornis</i>				
WM969/92	rM2	17.9	14.9	0.83
WM975/92	lm2	19.0	7.70	0.40
<i>Sivatragus cf. bohlini</i>				
PUPC 13/34	lM2	26.3	22.3	0.84
PUPC67/170	rm2	25.4	12.7	0.50
PUPC67/298	lm3	26.6	14.4	0.54
PUPC 67/21	m2	26.2	16.3	0.62
	m3	33.6	15.5	0.46
<i>Damalops sp.</i>				
PUPC 67/411*	rM3	23.0	13.6	0.59
PUPC 69/395*	rM3	22.6	13.6	0.60
<i>D. palaeindicus</i>				
GSI B 231	M3	27.0	18.0	0.66
BMNH 39594	M3	28.0	19.5	0.69
BMNH 39598	M3	25.0	15.0	0.60
BMNH 39571	M3	25.0	16.0	0.64
Caprinae gen. indet. (aff. <i>Capricornis</i>) roylei				
PUPC 14/45	M1	12.2	8.70	0.71
	M2	14.2	8.80	0.61
	M3	13.3	7.70	0.57

Referred data are taken from Pilgrim (1937, 1939), Akhtar (1992) and Gentry (1997). *, the studied specimens.

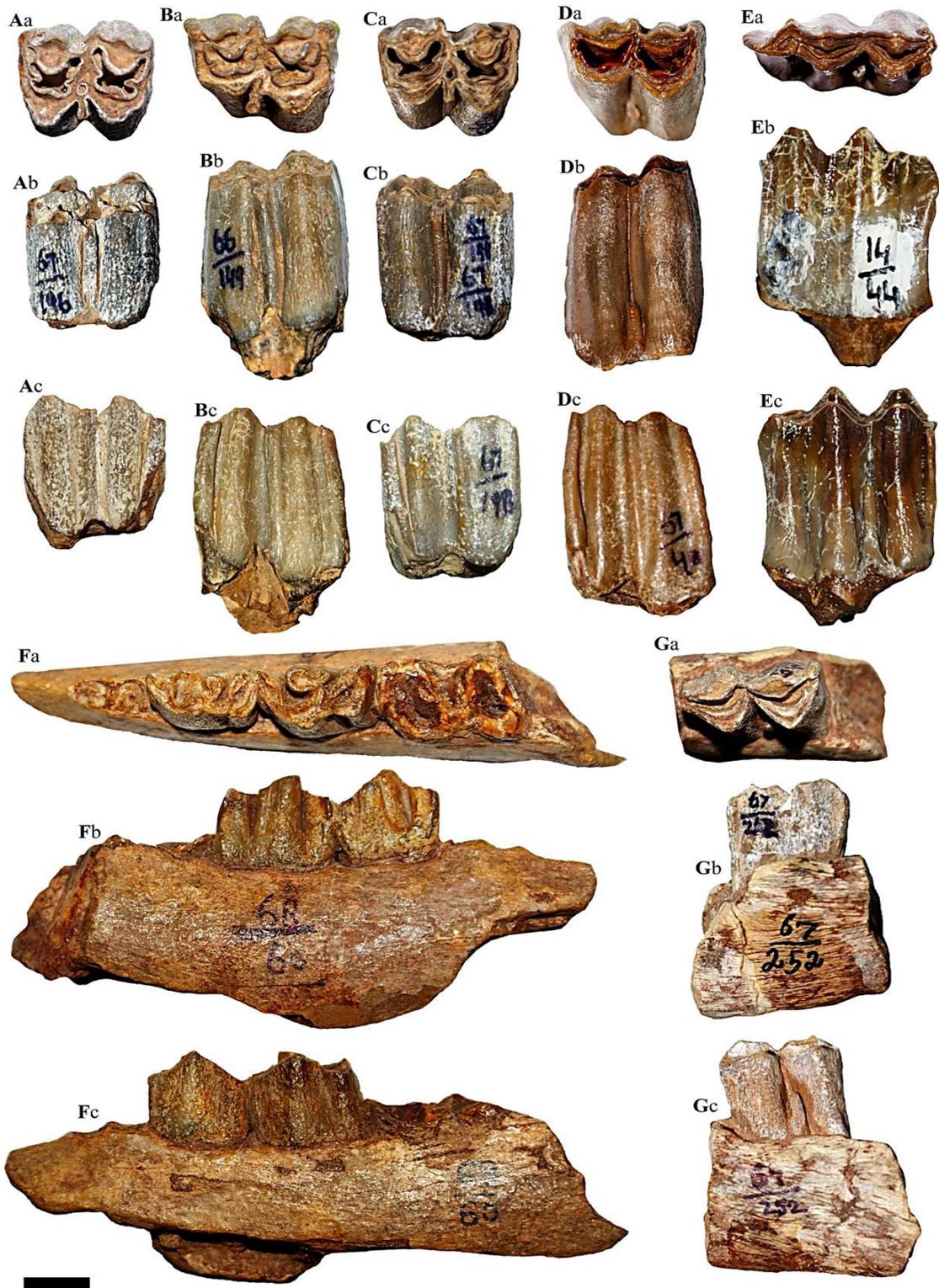


Fig. 2. *Kobus porrecticornis*: A, PUPC 67/196, IM1; B, PUPC 66/149, rM2; C, PUPC 67/198, rM2; D, PUPC 67/40, rM3; E, PUPC 14/44, rm3. *Reduncini* gen. et sp. indet.; F, PUPC 68/60, left mandible fragment with p3-4. *Antelope* sp.; G, PUPC 67/252, Im2. Views: a, occlusal; b, lingual; c, labial. Scale bar 10 mm.

Genus *Antilope* Pallas, 1766
***Antilope* sp.**

New material

PUPC 67/252, left m2 (L, 17.6; W, 8.9).

Description and comparison

The molar is in early wear with shiny enamel and mesodont. Anteriorly, a prominent caprini fold is present (Fig. 2G). A weak ectostylid is present labially. The antero-posterior fossettes are crescent and not transversely compressed. The labial folds are weak. The median ribs and stylids are weak. The entoconid rib is almost flat. Metrically, the molar differs from the large sized bovids and closes to the medium sized bovids like reduncines, hippotragines, caprines, alcelaphines and antilopines (Pilgrim, 1939; Khan and Akhtar, 2014; Gentry *et al.*, 2014). The weak folds, ribs and stylids exclude the sample from reduncines, hippotragines, caprines and alcelaphines. The morphological pattern of the described sample is much more similar to the pattern observed in antilopine. The molar represents comparatively great breadth, weak labial folds, goat fold, small degree of hypsodonty and the presence of ectostylid. The described sample is much more similar to the pattern observed in the genus *Antilope*; due to the insufficient material it is named *Antilope* sp.

Subfamily Hippotraginae Brooke, 1876
Genus *Sivatragus* Pilgrim, 1939
***Sivatragus* cf. *bohlini* Pilgrim, 1939**

Modified diagnosis

Molars moderately hypsodont, median ribs and styles strong, no crown neck, labio-lingual walls inclined to one another, entostyle conical towards apex, fossettes with invaginations, the lower molar with strong ribs and stylids, strong goat fold, weak ectostylid (Pilgrim, 1939).

New material

Upper dentition: PUPC 13/34, left M2. Lower dentition: PUPC 67/170, right m2; PUPC 67/21, left mandible fragment with m2-3; PUPC 67/298, partial left m3.

Description

The upper dentition includes only a second molar which is in middle wear (Fig. 3A). The tubercle like cingulum is present antero-lingually. The goat fold is prominent. The enamel is highly rugose. The preprotocrista is smaller than the postprotocrista. The pre- and posthypocristae are of same size. A conical entostyle is present in the transverse valley. A narrow vertical groove is present between the

paracone and parastyle labially. Another vertical groove is present between the metacone and metastyle. The metastyle is slender, close to the metacone at base and away towards the apex. The pre- and postfossettes with antero-posterior invaginations appear “U” shape.

Lower dentition

The lower dentition comprises second and third molars (Fig. 3B-D). The caprini fold is strong. The conids are more distinct lingually. A narrow and shallow vertical groove is present on the anterior side of the protoconid. A rudimentary ectostylid is present in the deep transverse valley. A narrow vertical groove is present between the metaconid and metastylid. The preentocristid is smaller in size as compared to the postentocristid. The prehypocristid is larger than the posthypocristid. A deep and narrow vertical groove is present between the entoconid and entostylid. The pre- and postfossettid are deep. A wide and deep vertical groove is present between the metaconid and entoconid. The premetacristid is smaller in size as compared to the postmetacristid. The metastylid is slender and rugose. The mesostylid is present on the posterior side of the metastylid. The hypoconulid in third molar is small and massive.

Comparison and discussion

The described upper molars are characterized in having mesodonty, prominent median ribs, strong styles, rugose enamel, basally prominent entostyle and “U” shaped fossettes. The lower molars have strong goat folds, labial lobes with strong ribs and stylids, weak ectostylids. Overall, the molars are labio-lingually narrow (Fig. 3A-D). The molars pattern agrees to Aegodont group of bovids (Pilgrim, 1939; Gentry, 1999). The samples with the above mentioned features are clearly differentiated from those of Alcelaphini and Reduncini and associated to Hippotragini (Pilgrim, 1939).

The Siwalik hippotragines are represented by the following species: *Tragoreas potwaricus*, Hippotraginae gen. indet. sp. indet., *Sivatragus brevicornis*, *Sivoryx cautleyi*, *Sivoryx sivalensis*, *Sivatragus bohlini* (Pilgrim, 1939). *Tragoreas potwaricus* is reported from the late Miocene of the Nagri Formation (Middle Siwaliks) whereas Hippotraginae gen. indet. sp. indet. is recorded from the Dhok Pathan Formation of the Middle Siwaliks. *Sivatragus brevicornis* is recovered from the Tatrot Formation of the Upper Siwaliks. The Pinjor Formation of the Upper Siwaliks is represented by three hippotragine species: *Sivoryx cautleyi*, *Sivoryx sivalensis* and *Sivatragus bohlini* (Pilgrim, 1939).

The studied molars differ from *Sivoryx* in having large size quadrate upper molars with strong entostyles.



Fig. 3. *Sivatragus cf. bohlini*: **A**, PUPC 13/34, lM2; **B**, PUPC 67/170, rm2; **C**, PUPC 67/298, partial lM3; **D**, PUPC 67/21, left mandible fragment with m2-3. *Damalops* sp.; **E**, PUPC 67/411, rM3; **F**, PUPC 69/395, rM3. Caprinae gen. indet. (aff. *Capricornis*) *roylei*; **G**, PUPC 14/45, a right maxillary fragment with complete series of molars M1-3. Views: **a**, occlusal; **b**, lingual; **c**, labial. Scale bar 10 mm.

Morphologically the molars are similar to the genus *Sivatragus*. The Siwalik *Sivatragus* is represented by the two species: *Sivatragus brevicornis* in the Tatrot Formation and this species is comparatively small in size, and *Sivatragus bohlini* in the Pinjor Formation and this species is large in size. The dentition of *Sivatragus brevicornis* is reported but *Sivatragus bohlini* is erected only based on the skull and its dentition is not reported. Morphometrically, the molars are larger than *Sivatragus brevicornis* (Table I), reported from the Tatrot Formation of the Upper Siwaliks which is geologically younger Formation to the Pinjor Formation. Moreover, the skull of *Sivatragus bohlini* is larger than *Sivatragus brevicornis* (Pilgrim, 1939). Therefore, the sample can be assigned to *Sivatragus bohlini*. However, the sample is incomplete and refers *Sivatragus cf. bohlini*.

The holotype of *S. bohlini* described by Pilgrim (1939, p. 81) is of unknown origin. The skull was collected by Cautley and reported by Lydekker in 1885 without identification. Pilgrim (1939) tagged the Formation based on the matrix color. Nevertheless, the new discovery of *S. bohlini* from the Pinjor Formation of the Sardhok outcrops allowed to calibrate the exact stratigraphic position of this species. Thus, the significance of this sample is to confirm the age of *S. bohlini*. Furthermore, the dentition of *S. bohlini* is reported for the first time from the Siwaliks.

Genus *Damalops* Pilgrim, 1939
***Damalops* sp.**

New material

PUPC 67/411, right M3; PUPC 69/395, right M3.

Description

The dentition includes only two upper molars (Fig. 3E, F). The traces of cement are present and the cingulum is absent in the molars. The tooth enamel is rugose. The hypocone is heavy, rugose and shows slight concavity. The paracone is slender and shows convexity. The pre- and postparacristae are of same size. A narrow and shallow vertical groove is present between the paracone and parastyle. The parastyle is thick in the middle but slender antero-posteriorly. A wide and shallow vertical groove separates the metacone from metastyle.

The protocone is projected forward. The molars are hypsodont and narrow crowned. The molars are elongated. The entostyle is absent. In the labial view, the styles and ribs are strong. The paraconus rib is stronger than the metaconus rib. The metaconus rib is broader than the paraconus rib. A spur is present in the antero-posterior fossettes. The labial lobes of the molars are comparatively compressed.

Comparison and discussion

The molars are hypsodont and slendrical (Table I). The distinction features of the molars are having no anterior transverse flange and entostyle. The molars are characterized in having prominent styles and ribs, fossettes with spurs and narrow crown. The hypsodonta, relatively narrow crown, strong labial styles and ribs, enamel spur in a central fossette, having slight convexity posteriorly and slight concavity anteriorly refer them to Alcelaphini (Pilgrim, 1939).

Morphometrically (Fig. 3E, F; Table I), the molars are similar to the Siwalik alcelaphine *Damalops palaeindicus*. The molars belong to the large species of the Siwalik alcelaphine. Nevertheless, the sample is not complete enough to provide a specific determination and it is difficult to assign at specific level. Therefore, the sample is assigned to *Damalops* sp.

Subfamily Caprinae Gray, 1821
Caprinae gen. indet. (aff. *Capricornis*) roylei
Pilgrim, 1939

New material

PUPC 14/45, a right maxillary fragment with complete series of molars (M1-3).

Description and comparison

The molar series of the upper dentition is 43 mm in length. The molars have neither cingulum nor cement and in early wear (Fig. 3G). The molars are hypsodont and somewhat elongated antero-posteriorly (= narrow crown). The cusps are more distinct lingually than labially. The hypocone is slendrical, slightly concave and narrow at the base, and wide towards apex. The molars are furnished with sharp folds labially. The entostyle is absent. The paraconus rib is present and the metaconus rib is absent, representing flat posterior lobe. The styles are narrow, sharp and strong. The styles are not straight showing undulation towards apex. The mesostyle is prominent than those of the parastyle and metastyle. The fossettes are deep and devoid of spurs. The third molar inclines a bit inward lingually.

The general pattern of the molars reflects the morphology of Aegodont group (Alcelaphini, Hippotragini, Reduncini, Caprini) of bovids (Pilgrim, 1939). The reduncines differ from the studied molars by being more transversely compressed and having a less pronounced posterolateral angle (Gentry *et al.*, 1999). The absence of enamel spur in a central fossette excludes them from Alcelaphini (Pilgrim, 1939). The hippotragines differ from the molars in having supplementary cusps (Dmitrieva and Serdyuk, 2011). The molars are characterized in having

sharp folds labially, narrow styles, narrow crown, deep fossettes and no spurs. These features associate them to Caprini and species Caprinae gen. indet. (aff. *Capricornis roylei*). The length of the molar series described by Pilgrim (1939) is 48 mm. The size of the studied molars indicates some variation within a species (Table I). Nevertheless, the metric variation is within a taxonomic range of the species and assign to Caprinae gen. indet. (aff. *Capricornis roylei*).

Discussion

The caprine remains recovered from the Pleistocene of the Upper Siwaliks represents primitive forms (Pilgrim, 1939; Akhtar, 1992). Nevertheless, the Siwalik record of the caprines is very poor. Earlier researchers ascribed a few species from the Siwaliks, based on the poor fossil records (Lydekker, 1878; Pilgrim, 1939). These species are *Sivacapra sivalensis*, Caprinae genus (cf. *Sivacapra crassicornis*, Caprinae gen. indet. (aff. *Capricornis roylei* and *Pantholops hundsensis* (Pilgrim, 1939). Most of these species were erected on the base of the skulls and horn-cores, but the dentition is yet to be discovered.

The described dentition is devoid of entostyle/ectostylid, showing more close affiliation with the living species than those of the primitive Eurasia species (Hooijer, 1958). The dentition remains found from the Sardhok Pleistocene are devoid of entostyle and narrow crown. The specimens show more *Capricornis* characters than those of the other Siwalik caprine species. Unfortunately, insufficient material can't support the determination of the exact occurrence of *Capricornis roylei* in the Pleistocene outcrops of Sardhok. However, the characterized features of the sample associate it to the genus *Capricornis*.

DISCUSSION AND CONCLUSIONS

There is an evidence of at least six species of antelopes in the Sardhok sites of the middle Pleistocene age. The antelope Sardhok material includes: *Kobus porrecticornis*, Reduncini gen. et sp. indet. *Antilope* sp., *Sivatragus* cf. *bohlini*, *Damalops* sp. and Caprinae gen. indet. (aff. *Capricornis roylei*). The antelope species represent reduncines, antilopines, hippotragines and caprines groups; it has large species of *Kobus*. The reduncines and hippotragines are equal in number, being represented by two species each; antilopines and caprines are rare, being represented by one species each. It has not alcelaphines and tragelaphines.

Kobus porrecticornis appears in the late Miocene of the Siwaliks and is known to extend in the Pabbi Hills of Sardhok. The age range of the species in the Siwaliks extends from the late Miocene to the middle Pleistocene. Overall, the reduncine fossil record of the Siwalik is

good and most of the species have been collected from the Pinjor formation of the Siwaliks (Bibi, 2011; Present study). Antilopes are reported by two species from the Plio-Pleistocene of the Siwaliks: *Antilope subtorta* and *A. intermedia* (Pilgrim, 1937, 1939; Khan and Akhtar, 2014). The living antilopine *A. cervicapra* is still present in Pakistan. Hippotragines show short span in the Siwaliks and restrict their presence only in the Pinjor Formation of the Siwaliks. The fossil record of the Siwalik caprines is patchy and numerous records Caprini gen. et sp. indet. from the Pinjor Pleistocene of the Siwaliks (Pilgrim, 1939).

The Pinjor Formation of Sardhok has yielded Middle Pleistocene fauna of the Siwalik Group. The faunal assemblages of Sardhok are similar to those of the middle Pleistocene localities of Siwaliks. The Sardhok fauna is clearly of Middle Pleistocene age, being similar in overall composition of to the fauna of Pinjor formation (Middle Pleistocene) of Siwalik Group (Nanda, 2002; Dennell *et al.*, 2006; Dennell, 2008; Siddiq, 2015; Siddiq *et al.*, 2016, 2017). Indeed, Sardhok antelope assemblages represent significant endemic taxa. It is assumed that the Sardhok fauna represents a variety of antelopes.

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Statement of conflict of interest

The authors declare no conflict of interest.

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