FOSSIL MAMMALS (RHINOCEROTIDS, GIRAFFIDS, BOVIDS) FROM THE MIOCENE ROCKS OF DHOK BUN AMEER KHATOON, DISTRICT CHAKWAL, PUNJAB, PAKISTAN

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ABSTRACT

Fossil site Dhok Bun Ameer Khatoon (32° 47' 26.4" N, 72° 55' 35.7" E) yielded a significant amount of mammalian assemblage including two families of even-toed fossil mammal (Giraffidae, and Bovidae) and one family of odd-toed (Rhinocerotidae) of the Late Miocene (Samiullah, 2011). This newly discovered site has well exposed Chinji and Nagri formation and has dated approximately 14.2-9.5 Ma. This age agrees with the divergence of different mammalian genera. Sedimentological evidence of the site supports that this is deposited in locustrine or fluvial environment, as Chinji formation is composed primarily of mud-stone while the Nagri formation is sand dominated. Palaeoenvironmental data indicates that Miocene climate of Pakistan was probably be monsoonal as there is now a days. Mostly the genera recovered from this site resemble with the overlying younger Dhok Pathan formation of the Siwaliks while the size variation in dentition is taxonomically important for vertebrate evolutionary point of view and this is the main reason to conduct this study at this specific site to add additional information in the field of Palaeontology. A detailed study of fossils mammals found in Miocene rocks exposed at Dhok Bun Ameer Khatoon was carried out. Over all one hundred and twenty specimens were collected during field trips from which ten specimens are being described in this article. Two specimens belonging to Gaindatherium browni, two specimens belonging to Giraffa priscilla, three specimens belonging to Gazella sp. and three specimens belonging to Eotragus sp. Dhok Bun Ameer Khatoon is the new locality which is *discovered in detail first time in Pakistan by the present authors. The collection comprises isolated upper and lower teeth and fragments of maxillae and mandibular ramii.*

Key words: Fossil mammals, Late Miocene, Systematics, Rhinocerotids, giraffids, bovids.

INTRODUCTION

Most of the ungulates (hoofed mammals) that survive today belong to the orders Artiodactyla (even-toed ungulates) or Perissodactyla (odd-toed ungulates), and are known for their herbivorous specializations and for their large body size (Cifelli, 1981, Clauss *et al*., 2003). Artiodactyls are the most geographically and ecologically successful living group of large mammals (Khan and Farooq, 2006). In the ancient time there were more genera of artiodactyls while perissodactyls were hardly dwindling to extinction, and many of these perissodactyls were extremely numerous as fossils and likely highly abundant as individuals in real life. Both groups suffered later extinctions world wide, along with declining high-latitude temperatures, with the end-Pleistocene extinctions (Janis, 2009). The oldest fossil artiodactyls come from early Eocene strata of North America, Europe, and Asia. Their initial appearance seems to coincide with what is increasingly regarded, at least among vertebrate paleontologists, as the beginning of the Eocene on these continents (Rose, 1996). Perissodactyls evolved on the Mesozoic continent of Laurasia, diversifying rapidly in what is now North America. Perissodactyls declined in importance after the middle Eocene, while the artiodactyls maintained a stable "dominance" from the early Oligocene until their apparently enormous Plio-Pleistocene radiation (Cifelli, 1981). Modern Perissodactyls are a last remnant of a once exceptionally successful order. Diversity changes through time of the mammalian ungulate orders Artiodactyla and Perissodactyla have been touted long and widely as exemplifying ordinal level taxonomic (and presumably ecologic) displacement (Simpson, 1953; Stanley, 1974).

An extensive work has been done on the Siwaliks by national and international teams of the palaeontologist (Falconer and Cautley 1836, 1849; Lydekker, 1876, 1882, 1883a, b, 1884, 1886; Pilgrim, 1910, 1912, 1913, 1937, 1939; Bakr, 1969, 1986; Sarwar, 1977; Akhtar, 1995, 1996; Khan *et al.*, 2007, 2008 & 2009 and Metais *et al.*, 2009). Recently a new species of the genus *Microbunodon* (Artiodactyla) has been described from the Miocene of Pakistan (Lihoreau *et al*., 2004). Welcomme *et al.* (2001) reported terrestrial detrital facies from the Bugti Hills in the South-Western Sulaiman geological province (Balochistan, Pakistan). This region has yielded the richest Tertiary vertebrate faunas to be found in Asia thus far. Barry *et al.* (2002), Cheema (2003), Flynn (2003) and Lihoreau *et al.* (2004) published comprehensive papers on the Siwalik mammals and the palaeoenvironments of the Siwalik deposits of the Potwar Plateau. The large mammalian Siwalik fauna has been the focus of many researchers (Savage and Russell, 1983; Nanda and Shani, 1990; Scott *et al.,* 1999; Metais *et al.,* 2000, 2001, 2004, 2009; Geraads *et al.*, 2002; Barry *et al.*, 2002, 2005; Bernor *et al.*, 2003; Kaiser, 2003; Kaiser *et al.*, 2003; Kaiser and Fortelius, 2003; Raymond *et al.,* 2004; Behrensmeyer and Barry, 2005).

The main aim of this study is to provide the first complete citation of the mammalian fossils found in the vicinity of the Dhok Bun Ameer Khatoon by highlighting the aspects of taxonomy and paleontology of the Siwaliks of Pakistan. An important group, the fossilmammals were selected for the study as the collected material presented have notable diversity and thus can provide significant, taxonomical, biostratigraphic and palaeoenvironmental information.

Dhok Bun Ameer Khatoon village is located in the district Chakwal, Punjab, northern Pakistan. The village (32^o 47' 26.4'' N, 72° 55' 35.7'' E) is surrounded by Miocene deposits of the Lower Siwaliks (Figure 1). It is not only rich in fossil vertebrates but also in unique colored shale, containing some amount of unweathered igneous minerals, notable feldspar. It is composed of red brown mudstone with common grey sandstone inter-beds.

The Dhok Bun Ameer Khatoon fauna mainly consists of Artiodactyla (suids, tragulids, giraffids, cervids and bovids) and Perissodactyla (rhinoceros). Giraffids are more abundant than those of the other taxa (Samiullah, 2011) (Plot 1 and Plot 2, table 1).

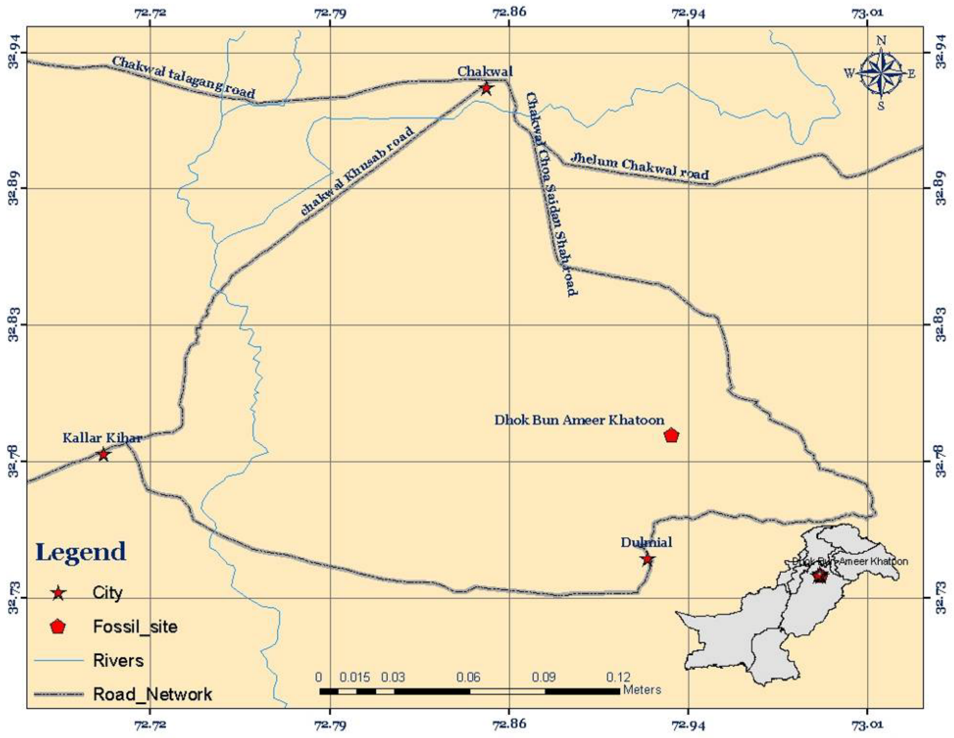


Fig.1 Map of the studied section Dhok Bun Ameer Khatoon, district Chakwal, Punjab, Pakistan.

Methodology

The Miocene hills of the Dhok Bun Ameer Khatoon were investigated thoroughly. Numbers of field trips were carried out to the studied section by 2006 and 2007 and different collecting methods were employed for the collection of fossils. Surface collection has been the primary mean of collecting fossil remains. Excavations were also conducted at some places of the locality where dense concentrations of fossil bones occur in situ within sandstone. The embedded material was carefully excavated with the help of chisels; geological hammers fine needles, penknives, hand lenses and brushes. Then this collected material was transported to the laboratory. As a result valuable and worth identifying specimens of mammalian fossils were discovered. Among them even and odd-toed ungulates were dominant.

In the laboratory, the material was carefully washed, cleaned, and prepared for the taxonomic study. The broken parts were assembled by using various types of gums (resins) such as Araldite, Peligom, Elfy, Elite, Magic stone and Fixin. The catalogue number of the PUPC specimens consists of series, i.e. yearly catalogued number and serial catalogued number, so figures of the specimen represent the collection year (numerator) and serial number (denominator) of that year (e.g. 08/100). All measurements are given in mm, with an accuracy of one decimal digit. The dental length (l) was measured on the occlusal surface. The tooth width (w) is the maximum width. Comparisons were 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), and the specimens from the Palaeontology laboratory of the Zoology department of the Punjab University, Lahore, Pakistan (PUPC). The studied material is stored in the Palaeontology laboratory of the Zoology Department of the Punjab University, in Lahore, Pakistan.

Tooth Morphology

Tooth cusp nomenclature in this article follows that of Akhtar (1992), Janis and Scott (1987a, b), Gentry (1994), Heissig (1972) and Cerdeno (1995. An entostyle can be founded in the center of the lingual side of the upper molar and ectostylid is found in the buccal side of the lower molar, completely or partly separate from the rest of the occlusal surface.

SYSTEMATIC PALAEONTOLOGY

Class:	MAMMALIA Linnaeus, 1758
Subclass:	THERIIFORMES (Rowe, 1988) Mckenna and Bell, 1997
Order:	PERISSODACTYLA Owen, 1848
Family:	RHINOCEROTIDAE Owen, 1845
Subfamily:	RHINOCEROTINAE Owen, 1845
Tribe:	RHINOCEROTINI Owen, 1845
Subtribe:	RHINOCEROTINA Owen, 1845

Genus: *Gaindatherium* Colbert, 1934

Type Species

Gaindatherium browni **Colbert, 1934**

Included species

G. browni Colbert, 1934 and *G. vidali* Heissig, 1972

Diagnosis

An upper tertiary rhinoceros of medium size, with a saddle-shaped skull having a single horn on the nasals and with brachyodont, simple molar teeth. The orbit is located in an approximately central position above the first molar; the occiput is vertical; the postglenoid and posttympanic are fused, forming a closed tube for the external auditory meatus. There are two upper incisors, of which the lateral one is quite small; the upper molars are without an antecrochet or crista, and the crochet is but slightly developed. So the cheek teeth are brachydont and relatively simple, without antecrochet or crista, but with a crochet present in the last molar (Colbert, 1935).

Distribution

Lower to Middle Siwaliks.

Stratigraphic Level

The Chinji Formation.

Gaindatherium browni ***Colbert, 1934***

Type Specimen

AMNH 19409, an almost complete skull.

Locality

Vicinity of Chinji Rest House, south of the Chinji village, Salt Range, Attock District, Punjab (Colbert, 1935).

Stratigraphic range

Lower Siwaliks, Chinji zone up to lower portion of the Middle Siwaliks.

Diagnoses

The specific diagnosis is the same as the generic diagnosis.

Material

PUPC 08/14, an isolated right second lower premolar and PUPC 08/85, right mandibular ramus with $M_{2\text{-}3}$.

Stratigraphic range

Lower Siwaliks (Chinji Formation).

DESCRIPTION

PUPC 08/14 (Figure 3)

The specimen under study is an isolated right lower second premolar. It is finely preserved and in an early stage of wear. No trace of cement is present. The trigonid is V-shaped with the narrow and short paralophid and have right-angled metalophid. The talonid is U-shaped with the hypolophid and the entoconid. The labial groove is deep. The premolar is triangular in outline. The cingulum is absent. The paralophid is slightly shorter than the metalophid.

PUPC 08/85 (Figure 3)

Mandible

The specimen under study is a broken right mandibular ramus with $M_{2\text{-}3}$. It is damaged anteriorly and having the preserved ascending ramus which is 46 mm, antero-posterior length of bone is 155 mm, height below M_2 is 55 mm and the thickness of bone below M_2 is 30.5 mm. Length of molar series is 75 mm. M_2 and M_3 are well preserved while roots of P_4 are also present and are not enough to show the morphological characters. Many details have been vanished because of major detoriation.

The ramus is well preserved and the teeth are in middle wear. Thick enamel is present in both M_2 and M_3. The trigonid is V-shaped with the narrow and short paralophid and have right-angled metalophid. The talonid is U-shaped with the hypolophid and the entoconid. No trace of cement is present. There are neither lingual nor labial cingula. Posteriorly the ectolophid groove is marked to the base of the crown and is deep. The paralophid is present and crushed in M_2, whereas in M_3 it is completely preserved. Hypolophid is oblique but transverse in occlusal view. In M_2 the enamel is thick 2 mm, thinly wrinkled vertically and broken from anterior side of the molar. The measurements of the described teeth are provided in table 2.

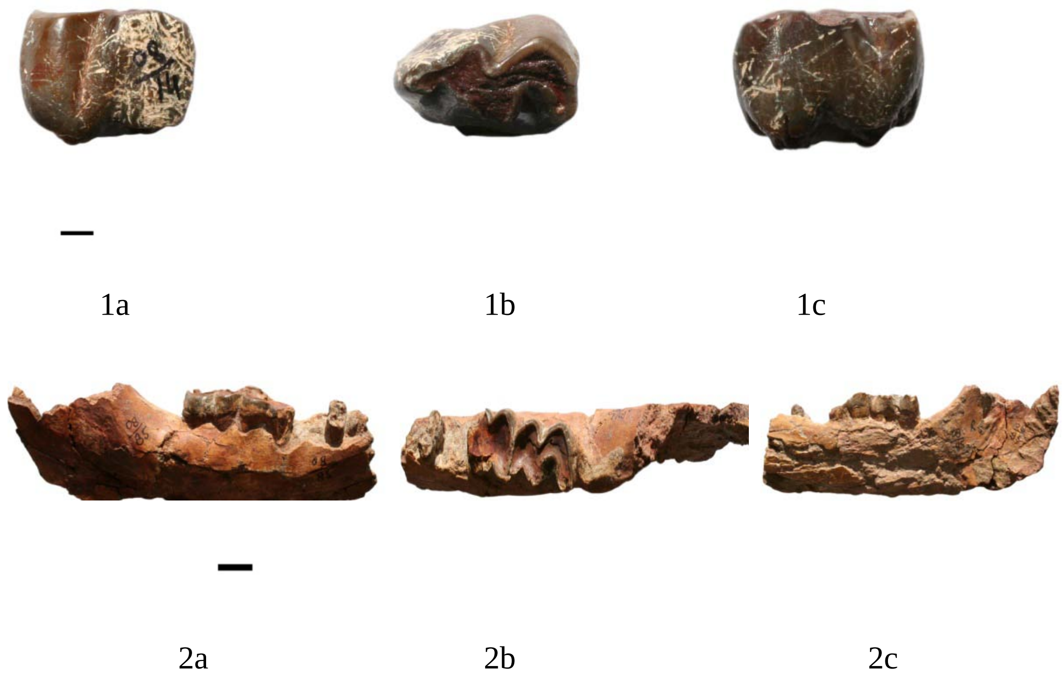
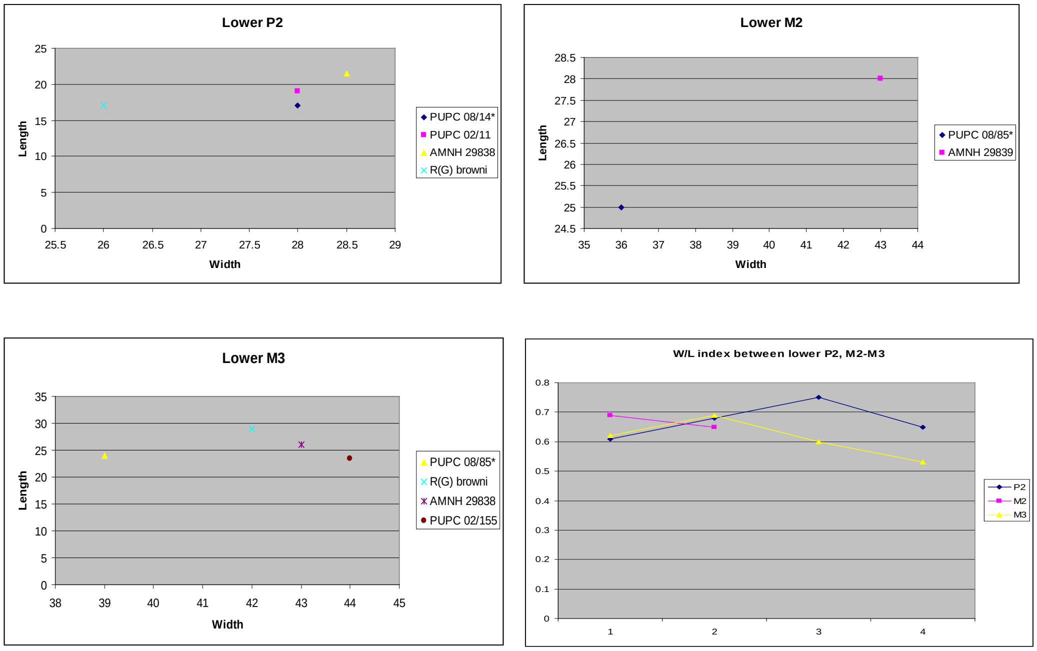


Fig. 3 *G. browni* 1. PUPC 08/14, an isolated lower right second premolar. 2. PUPC 08/85, a right mandibular ramus with $M_{2-3.}$ a) buccal view, b) occlusal view, c) lingal view. Scale bar 10 mm.

Table 2: Comparative Measurements (in mm) of teeth referred to *G. browni* Colbert, 1934. (Data taken from Colbert, 1935 and Hessig, 1972) *The studied specimens.

Species	**Number**	**Position**	**Length**	**Width**	**W/L**
G. browni	PUPC 08/14*	P_2	28	17	0.61
G. browni	PUPC 08/85*	M_2	36	25	0.69
G. browni	AMNH 29839	M_2	43	28	0.65
G. browni	PUPC 08/85*	M_3	39	24	0.62
G. browni	PUPC 02/11	P_2	28	19	0.68
G. browni	AMNH 29838	P_2	28.5	21.5	0.75
R(G) browni	-	P_2	26	17	0.65
R(G) browni	-	M_3	42	29	0.69
G. browni	AMNH 29838	M_3	43	26	0.60
G. browni	PUPC 02/155	M_3	44	23.5	0.53



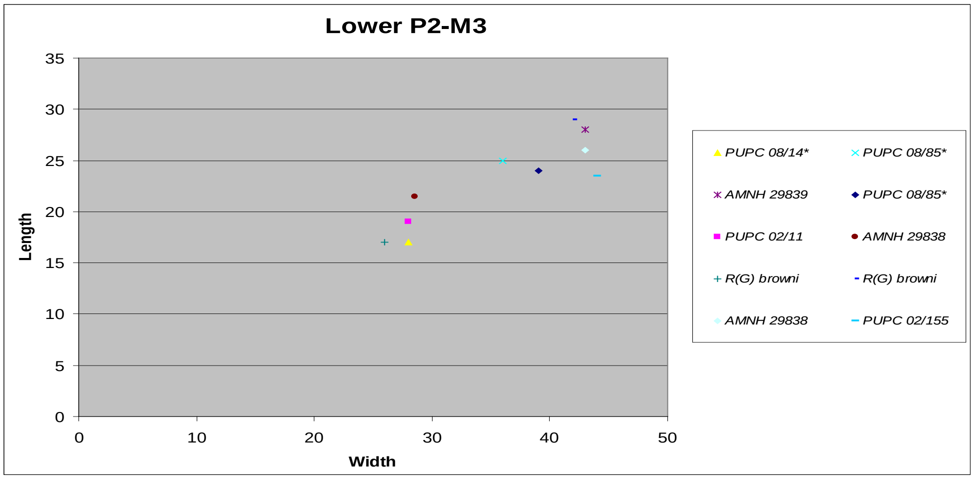
Lower P2

Lower M2

Lower M3

W/L index between lower P2, M2-M3

Plot 3: Bivariate scatter graphs of *G. browni* showing comparison of the studied specimens with the type specimens.



Lower P2-M3

Plot 4: Size variation of lower dentition of *G. browni*.

DISCUSSION

Colbert (1934) defined the genus and species *Gaindatherium browni* as a rhinoceros with several homologies with the extant species *Rhinoceros sondaicus* and *R. unicornis* and Heissig (1972) included it as a subgenus of *Rhinoceros*. *Gaindatherium* has been considered as a smaller genus when compared with *R. sondaicus* (Colbert, 1942). *Gaindatherium* has a middle-late Miocene distribution with two successive species i.e. *G. browni* and *G. vidali* described in the Siwaliks (Heissig, 1972; Sehgal and Nanda, 2002). *G. browni* share certain resemblances in the dental morphology with *G. vidali* from the Nagri Formation (Hessing, 1972). The resemblance lies in the presence of anterior posterior cingula, absence of lingual cingulum in the molars and absence of crista. However both the species have marked differences. *G. vidali* differ from the *G. browni* in having the well developed crochet, smaller size; well developed parastyle and parastyle fold, and funnel shaped postfossette. Dimensions of *G. browni* are larger than *G. vidali*. *G. browni* is known from the Lower Siwaliks (Chinji Formation) to the Middle Siwaliks (Nagri Formation) and other pre-hipparion localities of the Siwalik hills of Pakistan (Tang and Zong, 1987).

According to Colbert (1935) *Gaindatherium* is a form more or less directly ancestral to the modern Asiatic rhinoceros and that it represent an intermediate link between the stem *Caenopus* type of true rhinocerine and the modern one horned rhinoceroses. The check teeth are brachyodont and relatively simple, without anterrochet or crista, but with a crochet present in the last molar. The present studied specimens have same character as mentioned for *Gaindatherium* by Colbert (1935).

The present specimens when compared to *Chilotherium intermedium* were found smaller in size and different in morphology. The paralophid is very short and weak in P_2 of *C. intermedium,* whereas paralophid in the specimen under study is short but thick as compared to *C. intermedium*. In the present specimen the posterior valley is narrow as compared to the *C. intermedium*, however posterior valley is U-shaped in both the species. Contrary to the present P_2, a weak labial cingulum is present in P_2 of the *C. intermedium*. Anterior cingulum is present in the *C. intermedium,* which is absent in the present collection, and the posterior cingula are present but very much reduced in both the species.

Anterior cingulum is present in lower molars of *C. intermedium,* whereas in the present specimens it is absent. The posterior valley is widely V-shaped lingually whereas it is U-shaped in the present specimens. In M_3 trigonid is angularly V-shaped with the narrow and short paralophid and a right angled metalophid which is quite similar to the *C.* intermedium. No trace of cement is present. There is no labial cingulum. Contrary to the *C. intermedium* the ectolophid groove is deep and marked to the base of crown in the present collection.

If the skull of *G. browni* is considered in its entirety, and all of its anatomical characters are evaluated, we see that it is seemingly more closely related to the modern Rhinoceros than to any other genera of the Rhinocerotidae. The lower dentition of *G. browni* follows the general rhinocerotids pattern. PUPC 08/14 and PUPC 08/85 compare favorably with AMNH 29838 (Paratype) (Colbert 1935). They have similar antero-posterior length and crown width and W/L indices (Table 2) with American Museum collection. The specimens morphologically resemble to the species *G. browni* and metrically the measurements are overlapping the already studied specimens. The slight difference in the measurements is due to the individual variations. It is also clear that measurements lie within the limits of variation.

On the basis of above mentioned characteristics it is evident that specimens PUPC 08/14 and PUPC 08/85 belong to genus *Gaindatherium*. It is, therefore, concluded that on the basis of above mentioned characters like tooth morphology, over all contours of the teeth, size of the teeth, enamel constriction and development of the different crown structures these specimens are referable to the species *Gaindatherium browni*. Bivariate scatter graphs showing comparison of the studied specimens with the type specimens, Width/length indexes, Size variation of lower dentition are also provided (Plots 3 and 4).

Family GIRAFFIDAE Gray, 1821

Subfamily GIRAFFINAE Zittel, 1893

Genus *Giraffa* Brisson, 1762

Type Species

***Giraffa camelopardalis* Linnaeus 1758**

Included Species

G. camelopardalis Linnaeus 1758, *G. sivalensis* Falconer and Cautley 1843, *G. punjabiensis* pilgrim 1910 and *G. priscilla* Mathew 1929

Distribution

The genus *Giraffa* is known from Upper, Middle and Lower Siwaliks (Pilgrim, 1910; Mathew, 1929 and Colbert, 1935). It is also known from Africa (Simpson, 1945).

Diagnosis

Medium sized giraffids with extremely elongated neck and limbs, skull with a moderately larger post orbital development; basicranial and basifacial axes inclined at a small angle. Paired parieto-frontal bony processes of small size and a median naso-frontal protuberance in both sexes; in some species paired occipital processes. A pre-lachrymal vacuity is present.

Dentition very brachyodont, enamel very rugose, enamel folds pertaining deeply into the crown and enamel islands not formed until a late wear stage, lobes very oblique to the axis of the tooth. External ribs of upper teeth very strongly marked, outgrowths of enamel from the crescents into the central cavity. Length is not in excess of breadth, tubercles variable, but generally rudimentary, cingulum absent.

Lower molars not elongated, tubercles in external valleys variable but a large one always present in M_1 and M_3, cingulum absent (Colbert, 1935).

Giraffa priscilla *Mathew, 1929*

Type specimen

GSI B 511, a left M^3.

Locality

Chinji, Salt range, Chakwal district, Punjab, Pakistan (Colbert, 1935).

Stratigraphic range

This species is only found in the Lower Siwaliks (Chinji formation) of Pakistan.

Diagnosis

Distinguished from *Giraffokeryx* by the broad and more brachyodont teeth, prominent styles (especially metastyle). Prominent anterior rib; in M_3 the more oblique-set inner crescent, broad third lobe with strong accessory basal cusps in front of it, as well as shorter crown (Colbert, 1935).

Material

PUPC 08/29, an isolated right second lower molar and PUPC 08/10, left mandibular ramus having $M_{1\text{-}2}$.

DESCRIPTION

PUPC 08/10 (Figure 4)

The specimen under study consists of left mandibular fragment. Specimen is very well preserved. The mandible is missing anteriorly as well as posteriorly and having $M_{1\text{-}2}$. The ascending ramus is missing in the specimen under description. It is moderately thick transversely and deep vertically. The depth below M_1 is 34 mm and the width below M_1 is 21 mm. Actual preserved mandible is 70 mm.

M_1

It is in an early stage of wear. It is hypsodont and narrow crowned tooth (Table 7). Enamel is moderately thick and very rugose. The rugosity is more prominent on the buccal side as compared to the lingual side. All the conids are well developed and well preserved except entoconid which is broken on the lingual side. Mesostylid is well developed. It is hypsodont tooth and has prominent styles (especially metastyle). Prominent anterior rib is present. The posterior central cavity is narrow and is formed between the hypoconid and entoconid. The transverse diameter of tooth is smaller as compared to the antero-posterior diameter. The inner cusps are slightly higher vertically as compared to the outer cusps. The protoconid is well developed and is present at the anterior buccal side. It is slightly higher but backward than the hypoconid and is connected with the metaconid through a thin enamel layer. Metaconid is present at the anterior lingual side of the tooth. It is pointed in the middle due to sloping ridges. On the lingual and posterior side of the tooth entoconid is present. Hypoconid is well developed and V shaped. The mesostylid is more developed as compared to metastylid. Metastylid is more developed as compared to other species. The median rib of metaconid and entoconid are moderately developed. The anterior central cavity is wider than posterior central cavity and both cavities are filled with shale and sand stone.

M_2

It is well preserved and inserted into left mandible. It is in an early stage of wear. It is hypsodont tooth with well prominent styles (especially metastyle). Its anterior rib is prominent. It is narrow crowned tooth (table 7). Its enamel is moderately thick and very rugose. Rugosity is more prominent on the buccal side as compared to the lingual side. The median basal pillar is entirely absent. The anterior half of the tooth is wider as compared to the posterior half. The transverse diameter of the tooth is smaller as compared to the antero-posterior diameter. The major conids are strongly developed. The inner conids are slightly higher vertically as compared to the outer conids. The protoconid is well developed. It is located at the anterior buccal side of the tooth and is slightly higher than the hypoconid and is connected with metaconid through a thin enamel layer. The length of the anterior limb of protoconid is greater as compared to the posterior limb. The metaconid is well developed and is pointed in the middle with antero-posterior sloping ridges. Mesostylid is well developed while metastylid is moderately developed. The upper portion of metaconid is broken. The posterior limb of the metaconid touches the anterior limb of entoconid. The entoconid is located on lingual side and at the posterior side of the metaconid and is pointed in the middle with sloping ridges. The hypoconid is well preserved and crescent shaped. The stylids are more prominent at the summit of crown and less distinct to the base of the tooth. Deep transverse valleys are present between cuspids.

PUPC 08/29 (Figure 4)

It is an isolated right second lower molar and is well preserved. It is in an early stage of wear. Major conids are well developed and well preserved with stylids more prominent at the summit of crown and less distinct to the base of the tooth and transverse valleys filled with sand stone, broad in the middle and narrow antero-posteriorly.

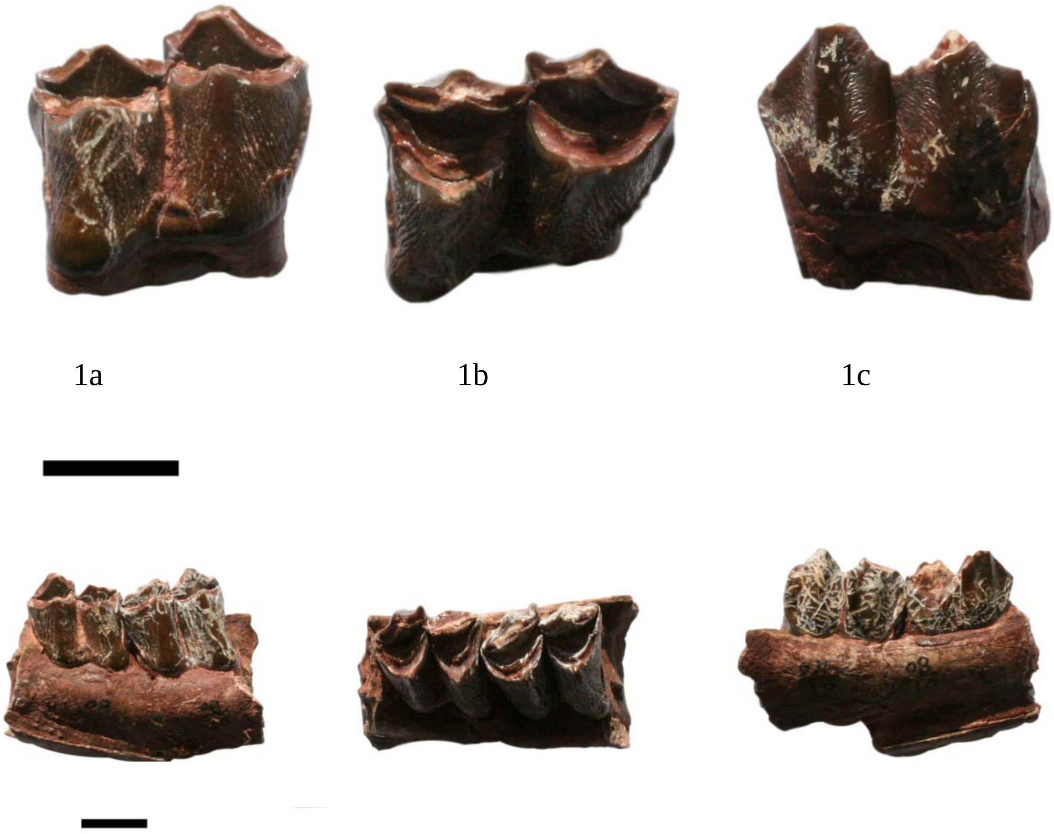
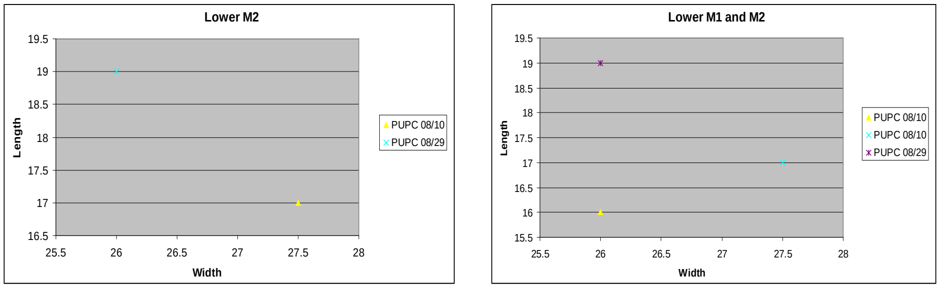


Fig. 4 *Giraffa priscilla* 1. PUPC 08/29 right second lower molar. 2. PUPC 08/10, left mandibular ramus having $M_{1-2.}$ a) - buccal view, b) occlusal view, c) lingual view. Scale bar 10 mm.

Table 3: Measurements (in mm) of molar teeth referred to *Giraffa priscilla* Mathew, 1929.

Number	Position	Length	Width	W/L
PUPC 08/10	M_1	26	16	0.61
PUPC 08/10	M_2	27.5	17	0.62
PUPC 08/29	M_2	26	19	0.73



Plot 5: Bivariate scatter graphs of cheek teeth of *G. priscilla* showing comparison of the studied specimens.

DISCUSSION

In genus *Giraffa* styles are strong, median ribs are well pronounced and crown is broader while in *Giraffokeryx* styles are weak, median ribs are absent and crown is narrow. In lower molars of genus *Giraffa* stylids are present and median ribs stronger while in *Giraffokeryx* stylids are absent (Pilgrim, 1910) and median ribs are weaker.

Giraffa punjabiensis is smaller than *G. sivalensis* and *G. camelopardalis*. Its upper premolars are relatively small and narrow while lower molars are long and lobes of molars set less obliquely to axis of jaw than in the recent giraffe. *G. sivalensis* is a larger species than modern giraffe. Its posterior half of last upper molar in the fossil form is reduced. *Camelopardalis affinis* is like *G. sivalensis* but larger in size to the modern giraffe. In *G. priscilla* broader and more brachyodont teeth, prominent styles (especially metastyle is prominent), prominent anterior rib. Parastyle is comparatively less developed as compared to the meso and metastyle that are well developed. Posterior median rib is also present.

In the light of above mentioned characteristics it is evident that the specimens under study belong to genus *Giraffa* and all the above mentioned characters of the specimen under discussion are comparable with type material GSI B 492 (described by Matthew, 1929) of the species *G. priscilla*. Therefore it is concluded that, on the basis of above mentioned characters, the overall contour of the teeth, size of the teeth, enamel constriction and development of the different crown structure, specimens are referred to species *G. priscilla*. Graphs showing width/length indexes of cheek teeth of *G. priscilla* and comparison of the studied specimens are also provided (Plot 5).

Family BOVIDAE Gray, 1821

Subfamily ANTILOPINAE Gray, 1821

Tribe ANTILOPINI Gray, 1821

Genus: *Gazella* Blainville, 1816

Type species

Gazella dorcas Linneus, 1758.

Included species

G. dorcas Linneus, 1758 ; *G. gazella* Pallas, 1758 ; *G. dama* Pallas, 1766 ; *G. subgutturosa* Guldenstacdt, 1780 ; *G. rufifrons* Gray, 1846; *G. deperdita* Gervais, 1847; *G. capricornis* Wagner, 1848; *G. atlantica* Bourguignat, 1870; *G.*

leptoceros Cuvier, 1882; *G. setifensis* Pomel, 1895; *G. thomasi* Pomel, 1895; *G. gaudryi* Schlosser, 1904; *G. longicornis* Andree, 1926; *G. mytilinii* Pilgrim, 1926; *G. rodleri* Pilgrim and Hopwood, 1928; *G. gaudryi* Bohlin, 1935; *G. pilgrimi* Bohlin, 1935; *G. dorcacoides* Bohlin, 1935; *G. lydekkeri* Pilgrim, 1937; *G. sinensis* Teilhard *et al*., 1930; *G. blacki* Teilhard and Trassaert, 1938; *G. arista* Bate, 1940; *G. decora* Bate, 1940; *G. praethomsoni* Arambourg, 1947; *G. wellsi* Cooke, 1949; *G. janenschi* Dietrich, 1950; *G. hennigi* Dietrich, 1950; *G. stehlini* Thenius, 1951; *G. gracilior* Cooke and Wells, 1956; *G. vanhoepeni* Cooke and Wells, 1956; *G. tingitana* Arambourg, 1957; *G. pregaudryi* Arambourg, 1959 and *G. padriensis* Akhtar, 1992.

Distribution

The genus Gazella is known from the Miocene and Pliocene of Eurasia and several Pleistocene localities in Africa (Gentry, 1966). It is abundantly found at the same time in Asia, Siwaliks and southern parts of Europe (Pilgrim, 1937, 1939; Akhtar, 1992; Khan, 2009a).

Diagnosis

Upper molars are hypsodont having prominent narrow styles, without basal pillars, central cavities are crescentic in shape, median ribs moderately strong in primitive forms while weak or absent in progressive forms, P2 longer as compared to P3 and P4. Lower molars with goat folds, small ectostylid, central cavities having fairly simple outline, ribs and stylids are moderately developed.

Gazella sp.

Locality

Dhok Pathan, Chakwal district, Punjab, Pakistan.

Stratigraphic range

Lower and Middle Siwaliks.

Diagnosis

Upper molars hypsodont, without entostyle and basal pillars while enamel is moderately thick and rugose, styles narrow and strong, anterior median rib stronger as compared to the posterior one, have narrow and deep central cavities, premolar series slightly long. Lower molars are extremely hypsodont with small basal pillars, well developed goat folds, central cavities fairly simple in their outline and moderately developed stylids and ribs.

Distribution

The species is known from the Dhok Pathan stage of the Middle Siwaliks (Pilgrim, 1937). It survived to the Late Pliocene and its most recent record is from the upper levels of the Dhok Pathan stage of the Middle Siwaliks (Akhtar, 1992) Chinji type locality, Lower Siwaliks (Khan, 2009a) and Dhok Bun Ameer Khatoon, Chakwal district, Punjab, Pakistan.

Material

PUPC 08/16, right mandibular ramus with M_{1-2} and PUPC 08/111, an isolated left second upper molar and PUPC 08/116, left mandibular ramus with M_{1-2}.

DESCRIPTION

Lower dentition

PUPC 08/16 and PUPC 08/116 (Fig. 5) are right and left mandibular ramii, and well preserved. Total length of M_{1-2} in left mandible is 51 mm while right one is 50 mm. The height of mandibular ramus below left M_1 is 19 mm and right M_1 is 18.5 mm and the width below left M_1 is 12 mm and right M_1 is 11 mm. The lower teeth are very well preserved, narrow crowned and in an early wear. A well developed goat fold is present anteriorly and it is somewhat heavy towards labially. A well developed median basal pillar is present in the transverse valley. The lingual conids are higher than those of labial ones. The protoconid is rounded in general appearance. The praeprotocristid is larger in antero-posterior length than the postprotocristid and continuous with the goat fold. In general appearance, the hypoconid looks to be V-shaped and less crescentic than the protoconid. It is forwardly directed. The metaconid is well developed and posterior to it, a pointed entoconid is present. The entoconid is high in the middle with praeentocristid and postentocristid sloping ridges. The metastylids and entostylids are well developed. The anterior median rib is more prominent than the posterior one.

Upper dentition

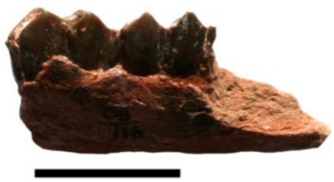
M^2

PUPC 08/111 (Fig. 5) is well preserved and in an early wear. It is hypsodont and narrow crowned tooth (Table 9). The enamel is moderately thick and rugose. The rugosity is more prominent on the lingual side as compared to the buccal side. The central cavities are wide and deep. The praeprotocrista is continuous with the paracone. The parastyle is well developed. The mesostyle is very strong, well developed and directed toward anterior side. The metastyle is damaged at the tip. The hypocone looks like crescentic in shape and is not uniform in thickness. The praehypocrista is comparatively thin than that of the posthypocrista. The paracone is almost equal to the metacone in antero-posterior length. The anterior rib is more prominent as compared to the posterior one which is only visible towards the crown top. Median basal pillar is absent.

1a

1b

1c



2a

2b

2c

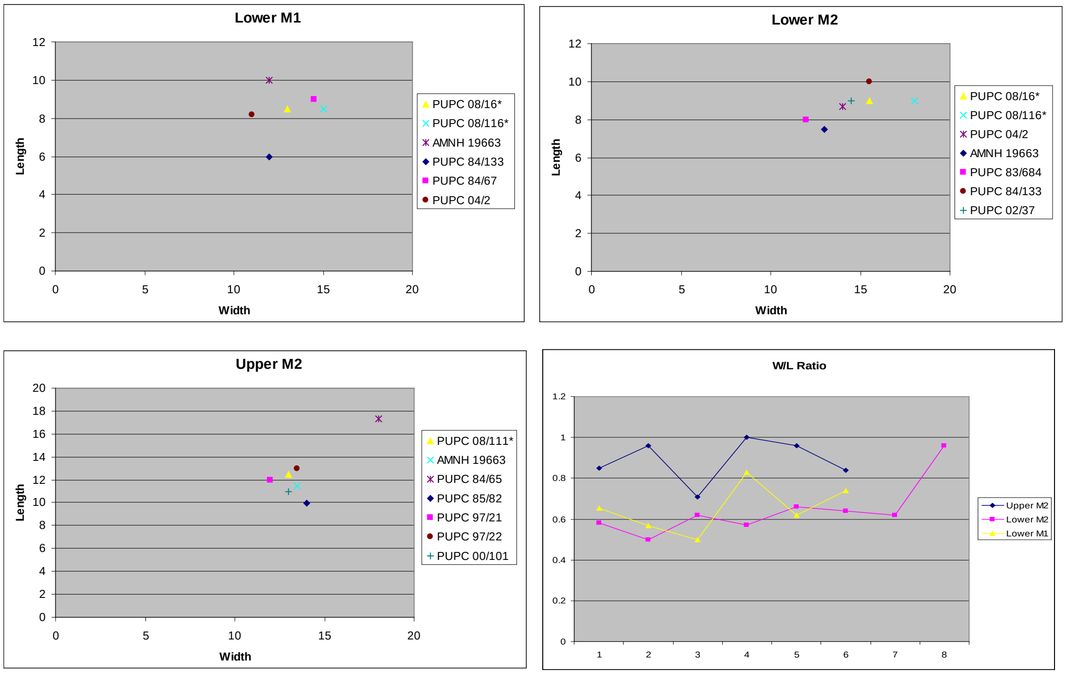
3a 3b 3c

Fig. 5 *Gazella* sp., 1. PUPC 08/16 a right mandibular ramus having $M_{1-2.}$ 2. PUPC 08/116 a left mandibular ramus having $M_{1-2.}$ 3. PUPC 08/111 a left second upper molar. a) buccal view, b) occlusal view, c) lingual view. Scale bar 10 mm.

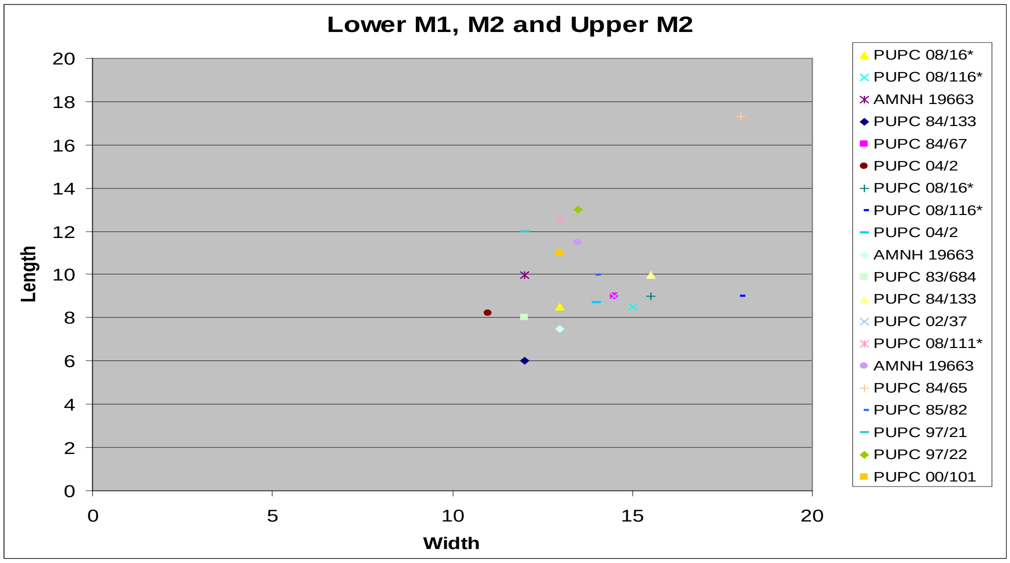
Table 4: Comparative measurements of the cheek teeth of *Gazella* sp. in mm (millimeters). *The studied specimens. (AMNH taken from Colbert,1935).

Number	Position	Length	Width	W/L
PUPC 08/16*	M_1	13	8.5	65.4
	M_2	15.5	9	0.58
PUPC 08/116*	M_1	15	8.5	56.6
	M_2	18	9	0.5
AMNH 19663	M_1	12.0	10	0.83
PUPC 84/133	M_1	12.0	6.0	0.5
PUPC 84/67	M_1	14.5	9.0	0.62
PUPC 04/2	M_1	11.0	8.2	0.74
	M_2	14.0	8.7	0.62
AMNH 19663	M_2	13.0	7.5	0.57
PUPC 83/684	M_2	12.0	8.0	0.66
PUPC 84/133	M_2	15.5	10.0	0.64
PUPC 02/37	M_2	14.5	9.0	0.62
PUPC 08/111*	M^2	13	12.5	0.96
AMNH 19663	M^2	13.5	11.5	0.85
PUPC 84/65	M^2	18.0	17.3	0.96
PUPC 85/82	M^2	14.0	10.0	0.71
PUPC 97/21	M^2	12.0	12.0	1.0
PUPC 97/22	M^2	13.5	13.0	0.96

PUPC 00/101	M^2	13.0	11.0	0.84



Plot 6: Bivariates showing comparison of *Gazella* sp. of the studied specimens with the type specimens.



Plot 7: Plot shows the size variation in the dentition of *Gazella* sp.

DISCUSSION

The specimens under study are square and tetratuberculate; these can be referred to some herbivorous mammals. Since the cusps are crescentic in outline, so it can be included in sub-order ruminantia of the order artiodactyla. The molars being smaller in size and enamel layer is finely rugose, can be referred to family Bovidae. The teeth are not so large that they can be included in the large Siwalik bovids. The general contour of the studied specimens, upper molar hypsodonty, without entostyle and basal pillars while enamel is moderately thick and rugose, styles narrow and strong, anterior median rib stronger as compared to the posterior one, have narrow and deep central cavities, premolar series slightly long. Lower molars are extremely hypsodont with small basal pillars, well developed goat folds, central cavities fairly simple in their outline, moderately developed stylids and ribs evidently prove the specimens inclusion in subfamily Antilopinae. This subfamily is characterized by many genera including the genus *Gazella*. A very distinct and common feature of the specimens under study and the type is the presence of a single deep furrow on the posterior side, generic features of the genus *Gazella* cited by Pilgrim (1939). The dimensions (Table 4) and the morphology of the studied material reveal all the features of the species *Gazella* sp. cited by Pilgrim in 1937.

About the upper molars Pilgrim (1937) stated that the antero-posterior length is decidedly greater than the transverse diameter in the case of the last two molars, but M^I is slightly quadrate. All the teeth under study show typical features of this species as stated by Pilgrim (1937), "on the outer side of the molars the anterior and median folds are of about equal strength and rather prominent while the posterior fold is weak. The median rib of the anterior lobe is strongly developed, where as the posterior lobe is weaker, but both are visible to the base of the crown. Median basal pillars are not visible". No basal pillar could be detected in the upper studied tooth. In case of lower molars Pilgrim (1937) stated that At the anterior end, both on the inner as well as on the outer side, each molar has a strong fold, called goat fold. It is more prominent on the outer than on the inner side. At the posterior end there is only a weak fold on the inner side and none at all on the outer side.

PUPC 08/16, PUPC 08/111 and PUPC 08/116 present the same morphological features of the type specimen AMNH 19663 (Pilgrim, 1937) and specimens studied by Khan, 2008. The type specimen and the specimens under study all are narrow crowned. In case of PUPC 08/111 antero-posterior length of specimen is smaller and transverse width is more than the type specimen while all other teeth are, however, slightly larger than the type specimen but this, in all probability, is within the range of individual variation. Plots (6 and 7) are bivariates showing comparison of the studied specimens with the type specimens, width/length indexes and the size variation in the dentition of *Gazella* sp.

The studied material is referred to genus *Gazella* but more material is required to identify it up to species level and due to scarcity of material, *Gazella* sp. is attributed for the material under study.

Genus: *Eotragus* Pilgrim, 1939

Type Species

Eotragus sansaniensis (Lartet, 1851).

Generic Diagnosis

Small sized bovid with the buccal walls of the upper molars inclined, and obliquely situated teeth so that the buccal walls do not line up. The triangular shaped horn core, when examined laterally (in profile) is not symmetrical longitudinally, but rather has more bone mass at the base of the anterior region than the base of its posterior region. This results in a characteristically wide horn core base. In lateral view, the posterior edge is usually convex while the anterior one is concave. These characteristics make the horn core axis curve to project slightly forward. The cross section of the *Eotragus* horn core is slightly oval, often resulting in a weak anterior keel. The horn core is situated above the orbits on a medium-sized pedicle. The orbital rims appear to protrude in relation to the position of the horn core pedicles. The horn cores are inclined posteriorly about 40° in lateral view (Solounias *et al.*, 1995).

Included Species

E. sansaniensis Lartet, 1851; *E. cristatus* Biedermann, 1873; *E. haplodon* Thenius, 1952; *E. artenensis* Ginsburg and Heintz, 1968; *E. halamagaiensis* Ye, 1989 and *E. noyei* Solounias *et al.*, 1995.

Distribution

Spain, Central Europe, Libya, Kenya, Israel, China and Pakistan.

Stratigraphic range

Lower and Middle Siwaliks.

***Eotragus* sp.**

Material

PUPC 08/100, a right mandibular ramus having P_3-$M_{3.}$ PUPC 08/101, left mandibular ramus having M_{1-3} and PUPC 08/114, an isolated right first lower molar.

DESCRIPTION

PUPC 08/100 (Figure 6) is right mandibular ramus having well preserved P_3- M_3. The length of the preserved mandibular ramus is 71mm while the depth below the M_2 is 16 mm and the M_3 is 17 mm. The thickness of ramus below M_2 is 9 mm and M_3 is 10 mm. The teeth present a middle stage of wear. Specimen PUPC 08/101 (Figure 6) is a left mandible fragment having M $_{1-3}$. It is in an early stage of wear and seems to belong to a young individual. PUPC 08/114 (Figure 6) is an isolated right first lower molar. The tooth is very well preserved and is in an early stage of wear.

The P_3 is well preserved with thick and shinny enamel. The tooth is narrow crowned and a layer of cement is prominent at the base of the crown. The median basal pillar is absent. All the conids of the tooth are well preserved.

P_4 is narrow crowned with a conical structure and part of the right mandible. It is damaged on the lingual side while all other portions are well preserved. Its buccal side is also more rugose as compared to the lingual side which has quite thick and shinny enamel. Layer of cement is also prominent at the base of the crown.

In the molar series of PUPC 08/100 and PUPC 08/101, the principal conids are well preserved and prominent. The lingual conids are very similar to each other in their general appearance and same is the case with the buccal ones. The lingal conids are broad, vertically higher and the buccal conids are roughly V-shaped. The lingual conids are broad in the middle while narrow antero-posteriorly. All the crown features are preserved and the teeth show the confluence of the metacristid, the protocristid and the postmetacristid. The median ribs and the mesostylid are weakly developed, whereas the metastylid are well developed. The anterior median rib is more prominent and strong than that of posterior one. A small goat fold connected with the prastylid forms a transverse flange. A median basal pillar is present in the transverse valleys on the buccal sides of molars. The enamel is rugose and this rugosity is more prominent on the buccal side of the teeth while the cingulum is absent.

Well preserved M_{1-3} teeth are the part of both right and left mandibular ramii. The hypoconid is forwardly directed as compared to the protoconid. A thick layer of cement is present at the base of the right M_{1-3}. Central cavities are well preserved and these are narrow in the middle while broad antero-posteriorly. The first molar in PUPC 101 can be firmly determine as an M_1, because of the typical rounded shape of the anterior contact facet for the premolar and the wider anterior part of the tooth comparatively to the posterior part of the tooth (Rossner, 1995) and trace of anterior cingulum is present in it. The second molars are larger than the first molars with anterolingual and anterolabial folds present, the basal pillar is weaker, and metastylid is conspicuous. In right third molar median basal pillar is hardly visible because of the thick layer of cement. It is broad at the base while narrow towards the crown. The central cavities are well preserved and these are narrow in the middle while broad antero-posteriorly. The crown of M_2 is higher than that of M_3. In M_3, a well-developed talonid is present and its height is comparatively lower than the other major conids. It is opened anteriorly and roughly circular posteriorly.

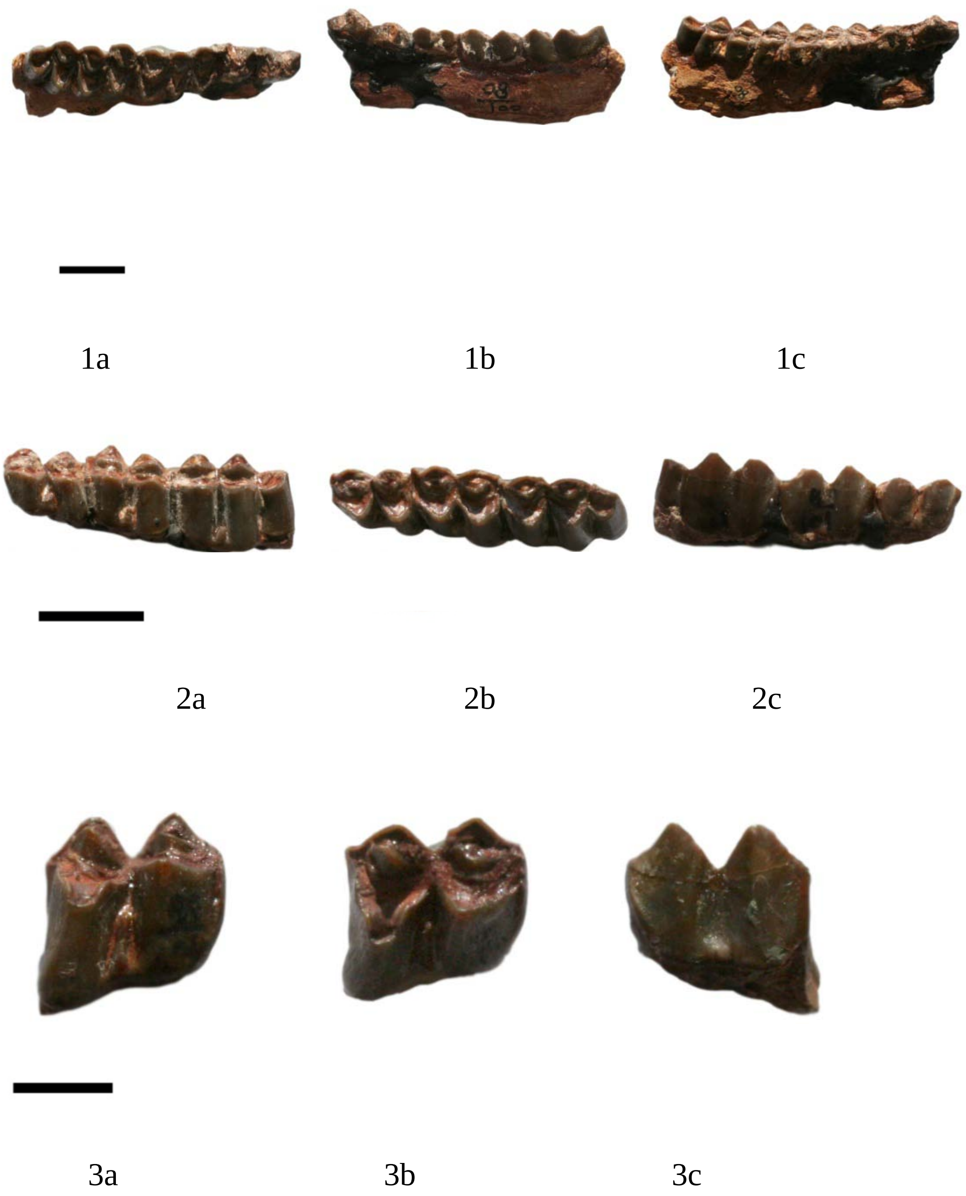


Fig. 6: *Eotragus* sp., 1. PUPC 08/100, right mandibular ramus having P_3-M_3. 2. PUPC 08/101, left mandibular fragment with M_{1-3}. 3. PUPC 08/114, a right first lower molar. a) buccal view, b) occlusal view, c) lingual view. Scale bar 10 mm.

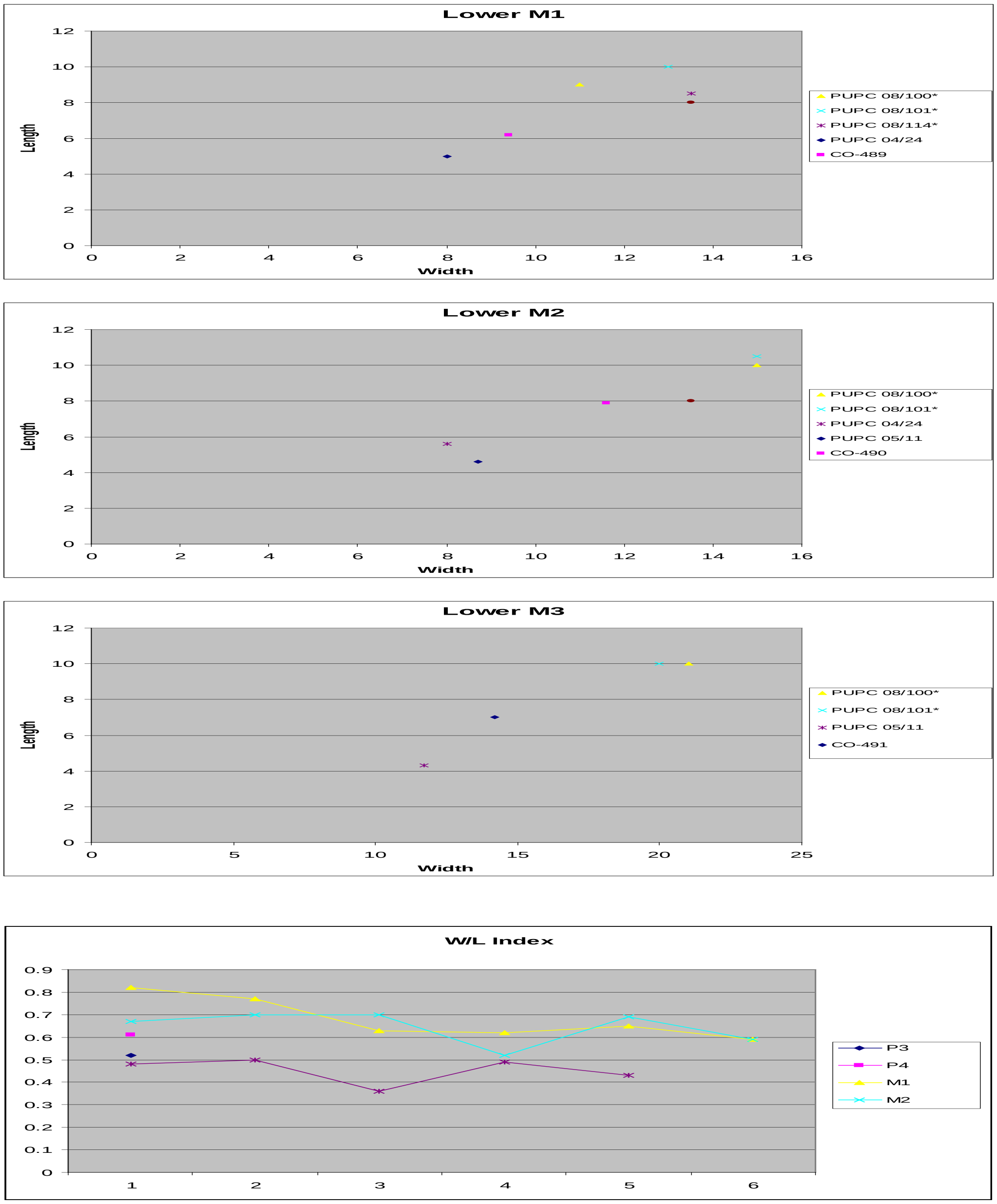
Table 5: Comparative measurements (in mm) of the cheek teeth of *Eotragus* sp. (data taken from Alfarez *et al.*, 1980; Solounias *et al.*, 1995; Khan *et al.*, 2008a, 2009). *The studied specimens. ** *Eotragus* sp. (large size) Khan *et al.*, 2008a.

Number	**Position**	**Length**	**Width**	**W/L**
PUPC 08/100*	P_3	11.5	6	0.52
	P_4	11.5	7	0.61
	M_1	11	9	0.82
	M_2	15	10	0.67
	M_3	21	10	0.48
PUPC 08/101*	M_1	13	10	0.77
	M_2	15	10.5	0.7
	M_3	20	10	0.5
PUPC 08/114*	M_1	13.5	8.5	0.63
PUPC 04/24	M_1	8.0	5.0	0.62
	M_2	8.0	5.6	0.7
PUPC 05/11	M_2	8.7	4.6	0.52
	M_3	11.7	4.3	0.36
CO-489	M_1	9.4	6.2	0.65
CO-490	M_2	11.6	7.9	0.69
CO-491	M_3	14.2	7.0	0.49
PC-GCUF 08/01	M_3	11.0	4.84	0.43

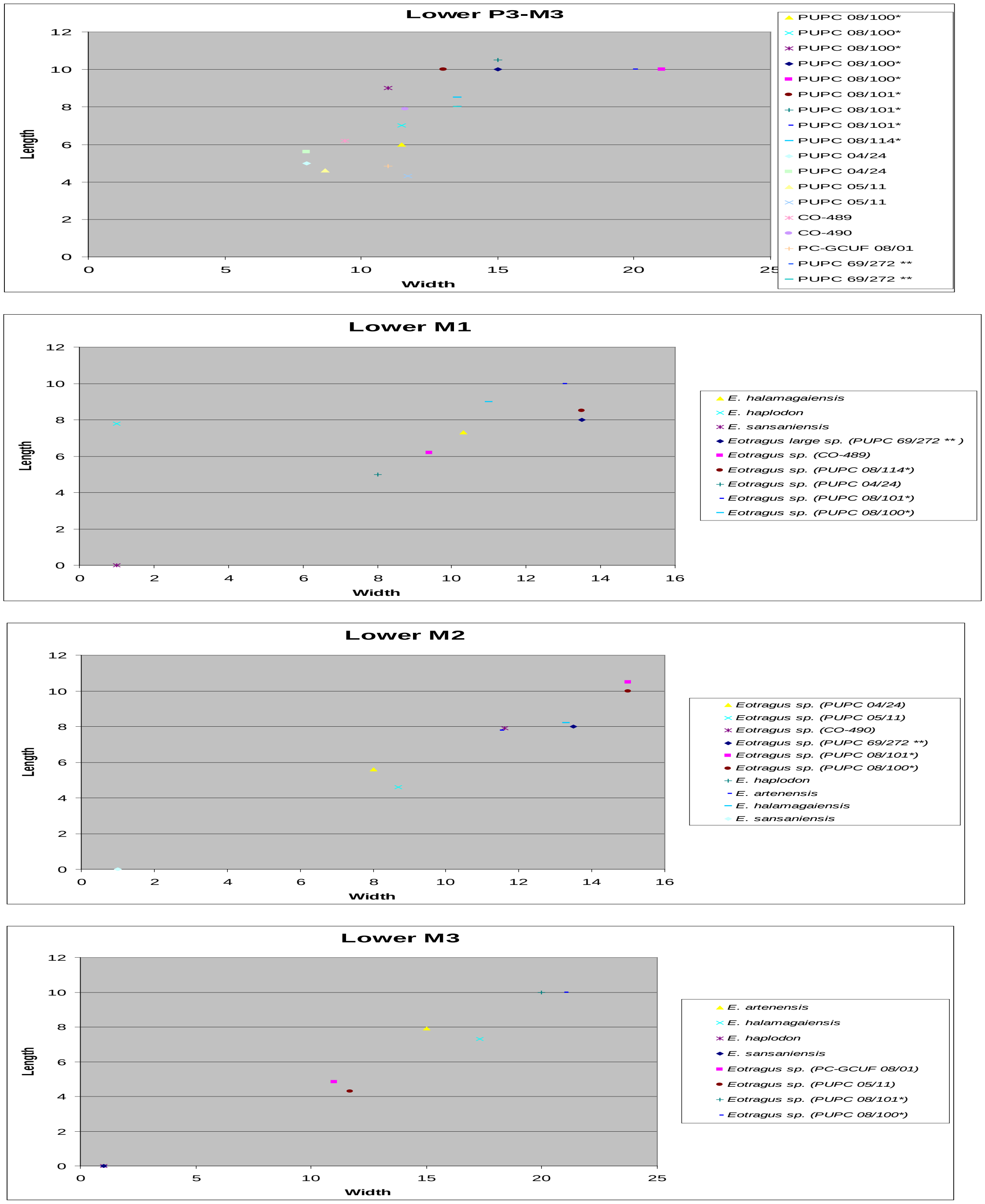
PUPC 69/272 **	M_1	13.5	8.0	0.59
	M_2	13.5	8.0	0.59

Table 6: Dental measurements of different species of the genus *Eotragus* (in mm) taken from Ye, 1989.

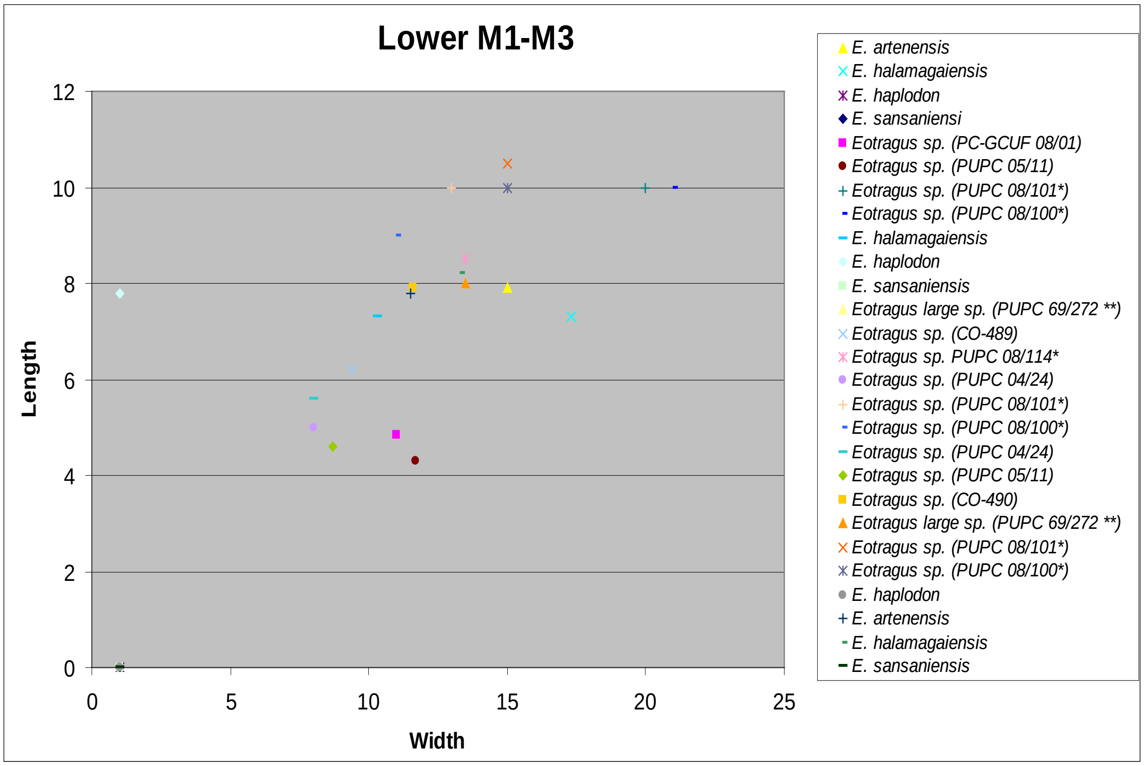
Species	**Position**	**Length**	**Width**	**W/L**
E. halamagaiensis	M_1	10.3	7.3	0.71
	M_2	13.3	8.2	0.62
	M_3	17.3	7.3	0.42
E. artenensis	M_2	11.5	7.8	0.69
(From Ginsburg, 1968)	M_3	15	7.9	53
E. haplodon	M_1	10.5-11.4	7.8	-
(From Thenius, 1952)	M_2	12.0-12.8	8.9-9.4	-
	M_3	15.0-16.4	8.8-9.1	-
E. sansaniensis	M_1	10.3-10.4	7.0-7.3	-
(From Thenius, 1952)	M_2	11.1-11.3	8.2-8.4	-
	M_3	15.0-17.6	7.5-8.8	-



Plot 8: Bivariate scatter graphs and Width/length indexes of the cheek teeth of *Eotragus* sp. showing comparison of the studied specimens with the type specimens



Plot 9: Plot showing the size variation in the lower dentition of *Eotragus* sp. And Variation in the dentition of various species of genus *Eotragus*.



Plot 10: *Comparison of the studied specimens with different species of genus* Eotragus.

DISCUSSION

Eotragus is known from the Late Early Miocene of Europe (15 Ma, MN6; Mein, 1989; Steininger *et al.*, 1989; Gentry *et al.*, 1999), Pakistan (18–5 Ma; Solounias *et al.*, 1995; Khan *et al.*, 2008a; Khan, 2009) and from the Middle Miocene of China (16 Ma; Ye, 1989). *E. noyei* was erected by Solounias *et al.* (1995) on the basis of a cranial specimen, a horn core (type specimen) and five postcranial specimens recovered from the Lower Siwaliks, with an estimated age between 18.0 and 18.3 Ma (Barry and Flynn, 1989). To date, it is considered as the oldest and smallest species of the genus (Solounias *et al.*, 1995). The oldest representative of the genus is *E. artenensis* from the middle Burdigalian of Artenay, France, which is a slightly smaller species than others in the genus (Ginsburg and Heintz, 1968). *E. haplodon* from the Middle Miocene (MN6) locality of Göriach, in the Steirmark Basin of Austria, is relatively larger, has an oval horncore cross-section, horncore abruptly attenuates from base to apex, lower premolars are relatively elongated, and molars are slightly brachydont with a basal pillar. *E. sansaniensis* from the MN6-MN7 localities in the Sansan Basin of France in addition to Leoben in the Steirmark basin of Austria, is a rather derived species with a size that approaches *E. haplodon,* horncores are more laterally compressed and gradually attenuate dorsally, dentition is more hypsodont than the former two species, basal pillar is absent, and lower molars are more narrow (Ye, 1989) (Table 5).

E. artenesis from Artenay, France, is similar to *E. noyei* and approximately of the same age (Solounias *et al*., 1995). *E. cristatus* from Velheim is approximately 15.5 Ma old. *E. haplodon*, which is probably conspecific with *E. sansaniensis* is known from the Austrian locality of Goriach (15 Ma, MN6, Mein, 1989; Steininger *et al*., 1989). Hamilton (1973) described *Eotragus* sp. from Gebel Zelten, Libya, which was reported to have an age of 16.5 Ma (Mein, 1989). Tchernov *et al.* (1987) reported the occurrence of *E. cf. sansaniensis* in the Negev of Israel. *E. halamagaiensis*, is known from China. Its age is reported as middle Miocene by Ye (1989). Moya-Sola (1983:pl. 1, figs. 1-2) reported *Eotragus* sp., from Can Canals and Bunyol (Valencia), and *E.* cf *artenensis,* from Corcoles, Spain.

The dentitions of *E. artenensis, E. sansaniensis,* and from Bunyol have less inclined buccal walls, larger lingual cingula, larger entostyles, and larger molar metaconules than *E.* sp. The buccal walls are not as aligned as in *E. sansaniensis,* whereas in *E. artenensis* they are aligned, forming a straight line (Solounias *et al*., 1995). Several morphological features, such as the crests of the cusps join up earlier in wear; styles, stylids and ribs are less bulky; obliquely situated hypoconulid, weaker cingula and the confluence of the metaristid, protocristid and postmetacristid are characters corresponding to the genus *Eotragus* (Gentry, 1999; Rössner, 2006). However, the teeth are too large (Table 10) for *E. noyei* described from the Kamlial Formation (Solounias *et al*., 1995), Hasnot, Dhok Pathan formation (Khan, 2007; Khan *et al*., 2009) and *Eotragus* sp. (Large size) Dhok Bun Ameer Khatoon (Khan *et al*., 2008a).

The specimens under study are square and tetratuberculate; these can be referred to some herbivorous mammals. Since the cusps are crescentic in outline, so it can be included in sub-order ruminantia of the order artiodactyla. Morphological and metrical features of the specimen clearly indicate a small sized Miocene bovid. Enamel layer is finely rugose, can be referred to family bovidae. The studied cheek teeth differ from cervids in being higher; the crests of the cusps join up earlier in wear; styles, stylids, and ribs are less bulky and cingula are weaker (Gentry, 1999).

The studied specimens (PUPC 08/100, PUPC 08/101, and PUPC 08/114) are clearly comparable with specimens recovered by Solounias *et al.* (1995), and Khan *et al.* (2008a) from the Lower Siwaliks. PUPC 08/114 compare positively with first molar of PUPC 69/272 large sp. (Table 5). The size variation is observed among different species of the genus *Eotragus* (Table 5 & 6, Plots 8 and 9). Plot 10 provides comparison of the studied specimens with different species of genus *Eotragus*.

Therefore, the material is referred to *Eotragus* sp. but more material is needed for precise species identification.

AGE AND CORRELATION OF FOSSIL LOCALITY DHOKE BUN AMEER KHATOON

The fossilmammals identified from the Dhoke Bun Ameer Khatoon on the basis of the published and unpublished work by Cheema, 2003, Khan *et al.*, 2008a Samiullah *et al.*, 2010, Samiullah, 2011 and the present article is as follows:

Family Suidae	*Listriodon pentapotamiae*
	Conohyus sindiensis
Family rhinocerotidae	*Gaindatherium browni*
	Brachypotherium perimense
	Chilotherium intermedium
Family Chalicotheriidae	*Chalicotherium intermedium*

Family Bovidae	
Tribe Boselaphini	*Sivaceros gradiens*
	Eotragus noyei
	Eotragus sp.
	Elachistocerus sp.
Tribe Antilopini	*Gazella* sp.
	Gazella lydekkeri
Family Tragulidae	*Dorcatherium majus*
	Dorcatherium minus
Family Giraffidae	*Giraffa priscilla*
	Giraffokeryx punjabiensis

The age of the fossilmammals identified from the Dhoke Bun Ameer Khatoon is clearly later than the early Miocene, and also they appear to be earlier than the Pliocene, because boselaphines are part of the fossilfauna, likely to be the end representatives of the late Miocene. Fossilmammals found in the Dhoke Bun Ameer Khatoon belong to the families Bovidae, Tragulidae, Suidae, Rhinocerotidae and Giraffidae. Thus, this makes the recovered fossilmammals fauna from DBAK respectable enough to provide an indication for the age. Whereas, giraffids, which are present very common in Village DBAK. The suid (10.2-6.5 Ma) and the antilopini (8.6-7.4 Ma) suggest an age of 7-5 Ma for DBAK. In the present work, all the collected specimens come from the lower Siwaliks.

Several descriptive phases exist for the late Miocene (Vallesian and mainly Turolian) faunas that are known from Greece, through Turkey to Iran, known as the Graeco-Iranian province (Iliopoulos, 2003). Knowledge of these faunas originated from the discovery and study of the major localities of Pikermi (Greece), Samos (Greece), and Maragheh (Iran), known since the 19th century (Gentry, 1999; Solounias, 1982a). *Gazella* are considered as typical late Miocene taxa. Hence, a date around 7.0 Ma or during the latest Miocene (Barry *et al.*, 1991 for dating of the Siwalik deposits) would be considered as a possible date for a fauna containing. Based on the fossil record, it seems that Sivatheres do not appear before the late Miocene, unless one adopts the doubtful proposition that the four horns of the middle Miocene *Giraffokeryx* indicate a sivatheriine affinity (Gentry, 1999). *G. punjabiensis* comes from the Dhok Pathan (Colbert, 1935) in the time span between 7.1-5.0 Ma (Barry *et al.*, 1991). *G. punjabiensis* is abundant in the DBAK localities, having a size similar to that of *Palaetragus coelophrys* from Maragheh (Iran). The tragulids (*Dorcatherium*) that appear in the Siwalik sequences are dated as 18-6.4 Ma (Barry and Flynn, 1989).

The genus *Dorcatherium* is close to the genus *Saimotragulus*, found in the Middle Miocene of Thailand and the genus *Yunnanotherium*, reported from the late Miocene of China (Vislobokova, 2001). Therefore, the fossilmammals of DBAK support a late Miocene perhaps equivalent to MN 13 (late Turolian to late Vellasian) in terms of European Mammal Neogene zone scale and around 7.0-5.0 Ma in terms of dating.

The DBAK localities can be compared with those late Miocene faunas in adjacent continental regions. Making comparisons at regional level, rather than with particular localities, increases the deficiency of temporal regions. Below tribal level the DBAK fossilmammals show little resemblance to the rich Turolian assemblage. *Gazella lydekkeri*, the much greater abundance of spiral-horned Antilopini is also noteworthy in the Graeco-Iranian Turolian province.

Bovini, Boselaphini and Antilopini are present in the Turolian of the Graeco-Iranian province as well as in the DBAK. There are rare records of Tragulidae in the Graeco-Iranian Turolian.

Most of the species show primitive characters and are thereby differentiated from later species of East and South Africa. Only *Giraffa* sp. and *Gazella* sp. has a resemblance to a species from the DBAK and this is likely to reflect that both species fit in late Miocene.

Tragulidae are absent in the Baynunah Formation, however some Bovidae and Giraffidae species are common with the localities of the DBAK.

This assemblage has some resemblance to Langebaanweg (South Africa), but Cephalophini, Hippotragini, and *Aepyceros* are additional African constituents. The only resemblance to the DBAK fossilmammals seems to be the presence of a giraffids (*Giraffa* sp.) and bovids (*Gazella* sp.) at a comparable stage of evolutionary development. There are no Boselaphini or spiral horned Antilopini, although boselaphines were present earlier in the East African Miocene at Lothagam 1 (Kenya). Also, Nakaya *et al.* (1984: 109) recorded a possible spiral horned antilopini (as *Palaeoreas* sp.) in the earlier Namurungule Formation, and Smart (1976) listed *Antilope* sp. for Lothagam 1 (Kenya).

The African tribes are very close to the DBAK fossil mammals with a conspecific spiral-horned antilopini and giraffids, but they differ in the presence of several exclusively African tribes. It needs to be remembered that several stratigraphic levels are represented at these localities, probably ranging up into the Pliocene (Geraads, 1989) and some of the African tribes of antelopes may be present only in the higher levels.

The DBAK fossilmammals are different from those of the Graeco-Iranean Turolian province. Where genera are common, the species are different, and the DBAK ones look earlier. They also differ from East and South African faunas in that the giraffid sp. indet. is not a *Giraffa*, and in the absence of African tribes of antelopes. The DBAK fauna shows some affinity with the Baynunah Formation (Abu Dhabi) and the North African faunas. While deer are common in late Miocene faunas north of the present Black Sea, they are rare in Greece, Turkey, Iran, and the Late Miocene of the Siwaliks, and until now they are absent from Abu Dhabi, and North Africa. The presence of giraffines, boselaphines, antilopines, and a gazelle at Abu Dhabi, North Africa and the Siwaliks could indicate a rather parkland-like landscape. The presence of a southern or hot climate is plausible, however, without any substantial development of aridity. The gazelle might have had a life style more like that of the present day West African *Gazella rufifrons* than the lifestyle of the desert gazelles of North Africa and Arabia. The presence of the tragulids in the Late Miocene of the Siwaliks and their absence from North Africa and Abu Dhabi suggests that the range contraction of this family had proceeded further, and that suitable habitats were unavailable in the Arabian Peninsula.

The presence of *Chilotherium*, *Dorcatherium* sp., *Eotragus* sp., *Eotragus* large size sp. and a listriodont suid in the lower stratum suggest and Early Miocene age (Welcomme *et al.*, 2001, Antoine and Welcome, 2000). *Eotragus* is known from the late early Miocene of Europe (Gentry *et al.*, 1999), Pakistan (Solounis *et al.*, 1995) and from the middle Miocene of China (Ye, 1989) but the presence of this taxon in the DBAK site considerable extends its geographical distribution.

For the comparison of various faunal assemblages and quantity similarities and differences, Simpson (1945, 1960) method is considered best among all others to compare various faunal assemblages. The mammalian fossil fauna of North Africa resembles with East Africa as compare to southern Europe, whereas there is not any resemblance of any genera between Spanish and Siwalik assemblages. While the Siwaliks assemblage shares more taxa with East African sites. African assemblages in general, show more similarities with the Spanish assemblage than that of the Siwalik assemblages (Hail-Sellassie *et al.*, 2003). The Siwalik fauna can be clearly separated from other localities under comparison and this is more likely to be a consequence of either geographic remoteness of presence of different barriers for possible faunal interchange during these times. In general, the quantitative results indicate a higher faunal interchange within Africa during the Late Miocene than between Africa and either Europe or Asia. However, it should also be noted that the presence of taxa shared exclusively between these regions. However, immigration is one of the most powerful processes that affect diversity of a given faunal assemblage. Miocene genera are common in Europe, Africa and India. During much of the Tertiary Africa and India were isolated. Major difficulties are more likely to be assigned to a new species, than to be subsumed with a conspecific species geographically farther away (Colbert, 1935, Beck and Burbank, 1990, Barry and Flynn, 1990, Hail-Selassie *et al.*, 2003). From above review it is clear that much more work is required to correct such biases.

CONCLUSION

All the described specimens are collected from the Chinji Formation because the Chinji Formation is well exposed in the study area, although the Nagri and Dhok Pathan Formation are also exposed but author could not collect any specimen during the particular field work from these Formations. The base of Dhok Pathan Formation is only exposed in the study area and perhaps the structural complication is one of the basic reason that the fossils are very rare in the study area.

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