Giraffokeryx punjabiensis (Artiodactyla, Ruminantia, Giraffidae) from Lower Siwaliks (Chinji Formation) of Dhok Bun Ameer Khatoon, Pakistan

Khizar Samiullah[1*], Muhammad Akhtar[2], Abdul Ghaffar[3], Muhammad Akbar Khan[4]

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Abstract

Fossil remains of *Giraffokeryx punjabiensis* (premolar and molar teeth belonging to the upper and lower jaws) have been collected and discussed from Chinji Formation of Dhok Bun Ameer Khatoon (32° 47' 26.4" N, 72° 55' 35.7" E). All these (twenty one) specimens are isolated teeth, which provide new data and give valuable information on the biostratigrphy and paleoecology of *Giraffokeryx punjabiensis* as well as the stratigraphy and paleoclimates of these Miocene rocks of the Chakwal district, Pakistan.

Keywords: *Giraffokeryx punjabiensis*, isolated teeth, Chinji Formation, biostratigraphy Miocene rocks, Chakwal district.

Introduction

Dhok Bun Ameer Khatoon (DBAK) is poorly known fossil site of the Siwaliks. Previous pioneer workers [1,2,3,4,5] did not visit this site nor mentioned it in their faunal list. During the last decade, this site had got attraction of researchers when few fossils were unearthed during the mechanical work for construction of dam for water storage purposes. Girafids, bovids, tragulids, suids, hominids, rhinos, chilothers anthracothers and carnivors are the common elements of the fauna (unbpublished data) and very similar to Chinji stratotype in the Chinji area situated 50km due west. Fossil remains of Eotragus sp. have been recently described by Khan[6]. *Giraffokeryx punjabiensis*, the type species of the genus *Giraffokeryx*, was erected by Pilgrim[2] on the basis of an isolated upper molar from the Chinji zone, of the Lower Siwaliks of Pakistan. The species is now known by several skulls, palatal fragments, mandibular ramii and a number of isolated teeth. Mathew[4] studied the material of this species at the Indian Museum, Kolkata (Calcutta), and recognized a larger and a smaller form. However, Colbert[5] suggested there was a continuous size gradation of the dental material of the species through the Chinji to the Nagri Formation and therefore that no such size division exists in the material of the genus *Giraffokeryx*. *Giraffokeryx* is similar to *Palaeotragus* but has an extra pair of horn cores on the frontals. *Giraffokeryx* followed a line of development that is different from other giraffids through the evolution of it's horn cores. In *Giraffokeryx*, the anterior horn arises from the frontal[5]. This Middle Miocene genus[7] shares several features with the Upper Miocene *Palaeotragus*, such as long, conical supra-orbital horns widely separated at the base, a much broader frontal compared to the occipital, with

[1,2] *Department of Zoology, Quaid-e-Azam campus, University of the Punjab, Lahore, Pakistan.*

[3] *Department of Meteorology, COMSATS Institute of Information Technology (CIIT), Islamabad*

[4] *Department of Zoology, GC, University, Faisalabad, Pakistan*

[*] Corresponding author: khizar502@yahoo.com

the skull being long and low[8]. *Giraffokeryx*, along with *Progiraffa* and *Giraffa*, are smaller forms of giraffid, of which *Giraffokeryx* was a mixed feeder. It disappeared during the deposition of the Nagri Formation, perhaps around 10 million years ago, whereas during the rest of Miocene, large giraffids remained present[9,10,11]. The Siwalik giraffes may be placed in three subfamilies: the Palaeotraginae, Sivatheriinae and Giraffinae. The Palaeotraginae comprises the genus *Giraffokeryx* only. The Sivatheriinae includes the genera *Sivatherium, Bramatherium, Hydaspitherium* and *Helladotherium* whereas the genus *Giraffa* is placed in the Giraffinae. All of these genera, except the genus *Giraffa*, were endemic to the Siwalik region.The palaeotragines were present in Asia and Europe during the Miocene Epoch[12,13] and it is probable that *Giraffokeryx* evolved from palaeotragines present in Asia. *Giraffokeryx* was a medium sized giraffid with four horns: two at the anterior extremities of the frontals and two on the fronto-parietal region. *Giraffokeryx chinjiensis* was described by Sarwar[14] from the Chinji type locality in Punjab, Pakistan and is based upon three different upper molars of different individuals. The difference between the two is in morphology of the teeth: the styles are strong and the median outer rib of the paracone is well developed in *Giraffokeryx chinjiensis.*

Geology and stratigrphy

DBAK area contains an almost continuous geological record spanning approximately 18.5ma- 4.5BP[15]. The Siwalik group in this area is composed of five lithostratigraphic units which are kamlial, Chinji, Nagri, Dhok Pathan and Soan Formation. The overall lithological composition of these component formations are fairly identical with those described for their type sections but however are relatively less thicker and contain more mud stones. Chinji Formation has its good exposure in DBAK area and is in strike continuation with its stratotype in Chinji area (This paper). Chinji Formation dominantly consists of sandstones and shales. Detailed peterographic studies of Chinji sandstones contains abundant quartz with subordinate feldspars, variable proportions of lithic grains accessory amounts of micas and traces of a number of heavy minerals. The presence of appreciable amount of feldspars in all the sandstone samples favors the arctic climate. The Chinji sandstone shows equal contribution of medium high grade and low grade metamorphic rocks provenance. Similarly a consistent presence of mica, epidote and granet indicates that the Chinji Formation is composed of metamorphic rocks. Similarly the high amount of non-undulatory monocrystalline than the undulatory one suggests the presence of plutonic and volcanic rocks in Chinji area. Furthermore, the intersectional variation in composition and types of quartz grains in Chinji sandstones suggest a stony spatial control on their deposition[16]. In general the Chinji Formation is dominantly composed of bright red and brown orange siltstone interbeded with ash gray-sand stone (siltstone to sandstone ratio= 4:1) in the type section. The interbeded in-channel and over bank siltstone sequences are 10-50 meter thick that are complexly stacked both vertically and laterally[17]. Chinji Formation is described with reference to four units. The bottom unit consists of interbeded sandstone, silt clay and siltstone followed by a unit predominantly composed of sandstone containing subordinate beds of siltstones and silty clay and the topmost unit is mostly silty clay and claystone containing yellowish- gray medium to course-grained sandstone at the base[18]. Based on the magnetic stratigraphic studies in Potwar 14.3 Ma and 10.8Ma are interpreted tobe the ages of the lower and upper contacts of the Chinji Formation respectively[19]. On the basis of different fauna, the age of the formation is considered tobe late Miocene[20]. Lithofacies of the Chinji Formation are thought to represent deposits of either the Paleo-Indus River or a similar axial fluvial system[15]. The multistoried channel type sandstone-bodies of Chinji Formation suggest a consistent flow direction to the SSE[21]. There are broad similarities between channel geometrics, discharge and sedimentary characters of Siwalik rivers and modern Indus river system including emergence from mountain belt, generally parallel flow to the basin

axis, slopes range and bankfull discharge[22]. Inspite of adequate exposure of Chinji Formation in the DBAK, fossils are not easily found in this area as compare to Chinji stratotype. It is particularly because of steeper dips and some structural complication, thus reducing the area of exposure per bed and also an increase in mudstone indicates existence of floodplains, which relatively have less potential for fossilization.

Paleoecology and biostratigrphy

The primitive giraffid, *Georgiomeryx* appeared in MN5 (17Ma)[23], with unbranched and short horns. From MN6 (16Ma) to onward, the known giraffid hitherto in Europe are assigned to *Giraffokeryx* Pilgrim[3]. The features of *Giraffokeryx* that are advanced over *Georgiomeryx* are higher cheek teeth, upper molars with less of a basal pillar and lingual cingulum, labial wall of the metacone more upright on upper molars, lower molars with less prominent metastylids in earlier wear and small entostylids, frequent fusion of praemetacristid with postprotoconulidcristid on p4, deciduous p3 wider posteriorly and the front lobe of deciduous p4 more fully crescentic. There can be considerable plasticity of p4 morphology. The postprotocristid weakens but the praeentocristid mostly continues its old link with the labial side of the tooth[24]. The first giraffid appeared in Central Asia in Early Miocene from where they dispersed into Europe, most likely in the Middle Miocene[13,24]. Some Middle Miocene giraffids had an additional anterior pair of horns in front of the orbits[25]. In the Siwaliks, giraffids made their appearance in the lower Chinji strata but the sivatherine sized giraffids were not present in the Chinji Formation and definitely present in the Nagri Formation. In contrary, many species of sivatherine giraffes are known from the Dhok Pathan Formation and the Tatrot Formation (Upper Siwaliks) in Pakistan is still without any record of giraffids but the Pinjor, a part of Upper Siwaliks in India is characterized by the presence of large girafiids (*Sivatherium and Giraffa*). Giraffids have rich fossil history and approximately thirty species have been described so far throughout the Neogene of the Old World[26,27,28,29,30]. Today the family Giraffidae is only represented by two species *Okapia johnstoni* and *Giraffa camelopardalis*, both these are found in Africa. *Okapia johnstoni* is present in limited area of heavy forests in West Africa, whereas the *Giraffa camelopardalis* is found in the more open parts of Sub-Saharan Africa.

Paleoclimate and diet adaptation

The *Giraffokeryx* remains in this study document the vegetation of Chinji Formation as seasonal woodland with riparian areas of forest. The occurrence of *Giraffokeryx punjabiensis* from Chinji – Nagri Formation testifies a change in the composition of the Siwaliks from seasonal woodland – tree savannas. *Giraffokeryx Punjabiensis* was a mixed feeder and is well adapted to a life in savannas. They drink water when it is available but can go weeks without it. They rely on morning dew and water content of their food[31,29,32,33]. The diet of fossil Giraffidae was until recently thought to be similar to that of extant giraffes (committed browsers). In other words, all Giraffidae were described traditionally as browsers. Such notion changed when Solounias[34] showed that the extinct giraffid *Samotherium boissieri* Major, 1888 from the Miocene of Samos (Greece) was a mixed feeder-grazer. Tooth microwear analyses and premaxillary shape showed, that the diets of fossil Giraffidae are highly heterogeneous[34,32,33]. *Bramatherium megacephalum* Lydekker, 1878 and *Sivatherium giganteum* Falconer & Cautley, 1835 were probably grazers. Of the two Sivatheriinae; *Giraffokeryx punjabensis* Pilgrim, 1910, was a mixed feeder whereas “Palaeotragus” primaevus Churcher, 1970 was a browser. The Sivatheriinae, *Helladotherium duvemoyi* Gaudry, 1860, was also a browser. Among the Giraffinae and Palaeotraginae Pilgrim, 1911 there are also browsing, grazing and mixed feeding taxa. In addition, Solounias and Semprebon[35] found that the okapi (*Okapia johnstoni* (Sclater, 1901)), the second and rare extant species of Giraffidae, is not a browser but a fruit-dominated browser while the giraffe (*Giraffa camelopardalis* (Linnaeus, 1758)) can be redefined as a leaf-dominated

browser. Such dietary data suggest that Giraffidae grazing was taking place before the expansion of C4 grasslands. Some giraffids were mixed feeders around 6 to 8 Ma[36,37], and as such, they were feeding on C3 grasses, which are dominant in wooded environments (in open meadows and near the margins of water).

Abbreviations

P.U.P.C, Punjab University Palaeontological Collection; AMNH, American Museum of Natural History; P, premolar; M, molar; L, maximum preserved length; W, maximum preserved width; H, maximum preserved height; GSI, Geological Survey of India; W/Lx100, width length ratio.

Systematic palaeontology

Order: ARTIODACTYLA Owen, 1848

Suborder: RUMINANTIA Scopoli, 1777

Superfamily: GIRAFFOIDEA (Gray, 1821) Simpson, 1931

Family: GIRAFFIDAE Gray, 1821

Subfamily: GIRAFFINAE Zittel, 1893

Genus: *GIRAFFOKERYX* Pilgrim, 1910

Type Species

Giraffokeryx punjabiensis Pilgrim, 1910

Diagnosis

Giraffokeryx is a medium sized giraffid with four horns, two being at the anterior extremities of the fronto-parietal region. The posterior horn is overhanging the temporal fossa. Limbs and feet most probably have medium length. The teeth are brachydont with rugose enamel, as in other giraffids[2].

Giraffokeryx punjabiensis Pilgrim, 1910

Type specimen

Lectotype GSI 502, a third molar M^3 of the right maxilla

Locality

The Chinji zone and vicinity, Salt Range Punjab.

Stratigraphic range

Lower Siwaliks, Chinji Formation and the lower section of the Middle Siwaliks.

Diagnosis

Giraffokeryx punjabiensis is larger than *Giraffokeryx chinjiensis*. The upper molars are also comparatively larger and more hypsodont than those of *Giraffokeryx chinjiensis*. The para-, meso- and metastyle are not well pronounced. Median outer rib of paracone is present but weak. Teeth are brachyodont with rugose enamel. The median basal pillar is absent and the median ribs are moderately developed. The cingulum is slightly developed on the anterior side of the protocone.

Distribution

The species is known from the Kamlial and Chinji Formation (Lower Siwaliks) and the Nagri Formation of the Middle Siwaliks[2,5]. The Lower Siwalik localities are Kamlial and Chinji, Attock and Chakwal districts respectively, within the Punjab Province of Pakistan. The locality of the Nagri zone is in the Nathot, Jhelum district of Punjab, Pakistan.

Material

PUPC 08/35, an isolated left second upper premolar; PUPC 08/97, an isolated right second upper premolar; PUPC 08/33, an isolated right third upper premolar; PUPC 08/34, PUPC 08/43 and PUPC 08/98, isolated left third upper premolars; PUPC 08/26, an isolated left fourth upper premolar; PUPC 08/96, an isolated right fourth upper premolar; PUPC 08/31 and PUPC 08/105, isolated right first upper molars; PUPC 08/113, an isolated left first upper molar; PUPC 08/99, an isolated left second upper molar; PUPC 08/18 and PUPC 08/28, isolated right second upper molars; PUPC 08/117, an isolated right third upper molar; PUPC 08/38, an isolated right third lower premolar; PUPC 08/94 and PUPC 08/95, isolated left third lower premolars; PUPC 08/45, an isolated left first lower molar; PUPC 08/13, an isolated right lower second molar and PUPC 08/11, an isolated right third lower molar.

Locality

Dhok Bun Ameer Khatoon, Chakwal district, Punjab, Pakistan.

Description

Upper dentition

P^2

The specimens under study (PUPC 08/35 and PUPC 08/97) (Figure 2 and 3) are isolated upper left and right second premolars respectively. They display excellent preservation, and are in the middle stage of wear. Both are low and narrow crowned. The anterio-posterior length is more than the transverse width of the teeth. The enamel is moderately dense, with a thickness of 1.5 mm, and is rugose, with the rugosity being more prominent on the lingual side, when compared to the buccal side, of the tooth. A cingulum is not developed. The central cavity of the tooth is well developed and narrow; furthermore, it is deep and located more toward the anterior of the tooth. It is slightly taller in the centre of the tooth than at its anterior and posterior ends. The parastyle is well developed whilst the mesostyle is moderately developed on the buccal side. The metastyle is weakly developed. Between the parastyle and mesostyle, a faint layer of cement can be observed.

P^3

PUPC 08/33 is an isolated right and PUPC 08/34, PUPC 08/43 and PUPC 08/98 (Figure 4-7) are isolated left third premolars. The teeth are in an early stage of wear. They are well preserved except PUPC 08/34, which is broken anteriorly; the protocone and metacone are absent. PUPC 08/43 and PUPC 08/98 display more wear than PUPC 08/33 and PUPC 08/34. Tooth crowns are narrow. Anterio-posterior length is more than the transverse width. The enamel is rugose and equally evident around the entirety of the tooth. All major cusps are well preserved. Proto- and paracones are wider while meta- and hypocones are shorter. A cingulum is moderately developed on the anterior side of the right P^3 (PUPC 08/33), while it is faint and can only be observed on the lingual side of PUPC 08/34. There is no definite boundary between the major cones. The central cavity is formed by the union of major cusps, and is narrow and deep in the centre, while being shallow at the anterior and posterior ends. Para- and mesostyles are moderately developed and a groove is formed between them.

P^4

PUPC 08/26 and PUPC 08/96 (Figure 8 and 9) are isolated left and right fourth upper premolars respectively. PUPC 08/26 is in an excellent state of preservation, whereas PUPC 08/96 is damaged. They are low and broad crowned. Anterio-posterior length is less than the transverse width of the teeth. Teeth are in the middle stages of wear. The enamel is rugose and moderately thick (2 mm). The rugosity is more prominent on the lingual side, compared to the buccal side in PUPC 08/26. In PUPC 08/96, the enamel is broken and dentine is visible on the posterior and lingual sides. A cingulum is not developed. The central cavity is shallow and extended more towards the anterior side and turns back towards the parastyle. A small amount of cement can be observed between the parastyle and mesostyle, which are both moderately developed, whilst the metastyle is well developed. The major cusps are moderately preserved. Crown height is greater at the buccal and lingual sides, compared to the smaller anterior and posterior sides. The outer cusps of the teeth are taller than the inner cusps. The anterio-posterior length of the buccal side is more than the lingual side of the tooth. The metacone and hypocone are slightly wider, whilst the protocone and paracone are narrow. Styles are weakly developed. Parastyle, mesostyle and metastyle are not prominent. The median outer rib of the paracone is weak. Median ribs are present but less pronounced.

M^1

PUPC 08/31 and PUPC 08/105 (Figure 10 and 11) are isolated first molars of the right maxilla. PUPC 08/113 is an isolated left first molar. Molars are in an excellent state of preservation and are in the middle stages of wear. The teeth being described are extremely brachyodont and narrow crowned. The enamel is moderately thick and is very rugose. The rugosity is more evident on the lingual side compared to the buccal side. Median basal pillar is absent. A weakly developed cingulum is present on the posterior

side of the teeth. The protocone is broken in PUPC 08/31 and PUPC 08/105 while the other major cusps are well preserved; in PUPC 08/113 (Figure 12) all the cones are well preserved. The outer cones are slightly taller than the inner ones. The paracone is present on the anterior side of the teeth. The middle of the paracone is well developed and slightly broader, having two sloping anterio-posteriorly running ridges. The anterior ridge of the paracone is united with the parastyle while the posterior ridge touches the anterior ridge of the metacone. Parastyle of PUPC 08/113 is broken. Metacone is well developed. The height of the metacone is equal to the paracone and points to the middle of the tooth with two sloping ridges. The hypocone is crescentic in shape and has anterior and posterior limbs. The anterior limb is relatively small compared to that of the posterior. The parastyle and mesostyle are well developed while the metastyle is not. The anterior median rib is well developed while the posterior median rib is less so. Anterior and posterior central cavities are present. The anterior central cavity is narrow and not as shallow as the central cavity of the posterior.

M^2

PUPC 08/18 and PUPC 08/28 (Figure 14 and 15) are isolated second molars of the right maxilla, whilst PUPC 08/99 (Figure 16) is an isolated left second molar. The teeth of the right maxilla are in an excellent state of preservation; however, the buccal side of PUPC 08/99 is damaged. PUPC 08/18 is in an early stage of wear while no wear is observed in PUPC 08/28. Teeth are brachyodont and narrow crowned. The enamel is very thick and rugose. The wrinkles are more prominent on the lingual side compared to the buccal side. The median basal pillar is absent. The cingulum is well developed on the anterior side of the teeth. It is prominent on the anterior side of protocone and is moderately developed around the hypocone. Comparatively, it is more developed on the anterior of the protocone compared with that of the posterior. The major cones are very well developed and the outer cones are slightly taller than the inner cones. A well developed protocone is present at the anterior lingual side of the teeth and is rounded in the middle. It has two limbs, one anterior and the other posterior, with the anterior limb being larger than the posterior. The paracone is pointed toward the middle of the tooth and is present at the anterio-buccal side of the teeth. From a posterior viewpoint, it is connected to the metacone, which is well developed. The metacone is slightly taller than the paracone. The mesostyle is well developed and the anterior median rib is more prominent than that of the posterior. The hypocone is present on the posterio-lingual side of both teeth and is well developed, having no connection between the hypocone and protocone. The parastyle is prominent. The paracone and metacone are joined to form an isolated pillar like structure known as the mesostyle. The parastyle, metastyle and mesostyle are absent in PUPC 08/99 because it's buccal side is deteriorated.

M^3

PUPC 08/117 (Figure 16) is an isolated third molar of the right maxilla. The tooth is in an excellent state of preservation, and is in the middle stages of wear. It is brachyodont and narrow crowned. The enamel is very thick and rugose. The wrinkles are more prominent on the lingual side compared to those of the buccal side. The median basal pillar is absent. The cingulum is well developed on the anterior side of the tooth. The major cones are very well developed and the outer cones are slightly taller than the inner cones. A well developed protocone is present on the anterio-lingual side of the tooth and is rounded in the middle. The anterior limb is larger than the posterior. The paracone is medially pointed and is present at the anterio-buccal side of the tooth. At the posterior side it is connected to the metacone which is well developed. The metacone is slightly taller than the paracone. The mesostyle is well developed and broken. The anterior median rib is more prominent than that of the posterior. The hypocone is present on the posterio-lingual side of the tooth and is well developed, having no connection with the protocone. The parastyle is prominent. The impression mark is

absent on the posterior side of the tooth which confirms that the specimen under study is the last molar.

Lower dentition

P_3

PUPC 08/38 is an isolated right third lower premolar, and PUPC 08/94 and PUPC 08/95 (Figure 17-19) are isolated left third lower premolars. PUPC 08/95 is a well preserved tooth, whilst PUPC 08/38 and PUPC 08/94 are broken anteriorly. The teeth are in the middle stages of wear. Dentine can be seen on all conids. They are hypsodont and narrow crowned. The enamel is thick and rugose; the rugosity is more prominent on the outer side. The paraconid is fairly distinct and separated from the parastylid by a wide furrow. The paraconid and the metaconid are not fused and a deep valley is present between them. The metaconid is higher than the paraconid which is growing backward, enclosing an elongated and transverse valley together with the entoconid. The entostylid is weakly developed. The hypoconid is projected latterly with a deep valley in front of it.

M_1

PUPC 08/45 (Figure 20) is a lower left isolated first molar and is in the early stages of wear. It is hypsodont and narrow crowned. The enamel is moderately thick and very rugose. The rugosity is more prominent on the buccal side, compared to that of the lingual side. All conids are well developed. The entoconid is slightly higher than the hypoconid. The mesostylid is well developed. The posterior central cavity is narrow and is formed between the hypoconid and entoconid. The transverse diameter of the tooth is smaller than the anterio-posterior diameter. The inner cusps are slightly taller than the outer cusps. The protoconid is well developed and present on the anterio-buccal side. It is slightly higher than the hypoconid and is connected with the metaconid through a thin enamel layer. The metaconid is present at the anterio-lingual side of the tooth. The entoconid is present on the lingual and posterior side of the tooth. The entoconid is pointed in the middle due to sloping ridges. The hypoconid is well developed and V-shaped. The mesostylid is more developed than the metastylid. The median ribs of the metaconid and entoconid are moderately developed. The anterior central cavity is wider than the central cavity of the posterior.

M_2

PUPC 08/13 (Figure 21) is a lower right isolated second molar and is in the early stages of wear. It is hypsodont and narrow crowned. The enamel is moderately thick and very rugose. The rugosity is more prominent on the buccal side compared to that of the lingual side. All conids are well developed. The entoconid is slightly taller than the hypoconid. The mesostylid is well developed. The posterior central cavity is narrow and is formed between the hypoconid and entoconid. The transverse diameter of the tooth is smaller compared to the anterio-posterior diameter. The inner cusps are slightly taller compared to the outer cusps. The protoconid is well developed and is present at the anterio-buccal side. It is slightly higher than the hypoconid and is connected with the metaconid through a thin enamel layer. The metaconid is present on the anterio-lingual side of the tooth. The entoconid is present on the lingual and posterior side of the tooth and is pointed in the middle due to sloping ridges. The hypoconid is well developed and V shaped. The mesostylid is more developed compared to the metastylid. The median ribs of the metaconid and entoconid are moderately developed. The anterior central cavity is wider than the central cavity of the posterior.

M_3

PUPC 08/11 (Figure 22) is an isolated third molar of the right mandible and the tooth is embedded in the jawbone. It is well preserved and is in the early stage of wear. It is extremely narrow crowned. Its enamel is moderately thick and very rugose. The rugosity is prominent around the entirety of the tooth. The median basal pillar is entirely absent. The cingulum is weakly developed on the anterior side of the protoconid. The anterior half of the tooth is wider than the posterior half. The transverse diameter of the tooth is smaller compared to the anterio-posterior diameter. The major

conids are strongly developed. The inner conids are slightly taller than the outer ones. The protoconid is well developed. It is located at the anterio-buccal side of the tooth and is slightly higher than the hypoconid and is connected with the metaconid through a thin layer of enamel. The length of the anterior limb of the protoconid is greater compared to the posterior limb. The metaconid is well developed and is pointed in the middle with anterio-posterior sloping ridges. The mesostylid is well developed, whilst the metastylid is weaker. The posterior limb of the metaconid touches the anterior limb of the entoconid. The entoconid is located on the lingual side and at the posterior side of the metaconid and is pointed in the middle with sloping ridges. A strong and well developed talonid is present on the posterior side of the tooth. The posterior end of the entoconid is joined with the talonid. The hypoconid is well preserved and crescent shaped. The stylids are more prominent at the summit of the crown and less distinct at the base of the tooth. Deep transverse valleys are present between the cuspids.

Discussion

The specimens described (Figure II and III), are of typical giraffid type, which show basic features, such as the depth of enamel folds and the rugose sculpture of the enamel, and they are here referred to *Giraffokeryx punjabiensis*. Specimen PUPC 08/35 is a second upper left premolar and PUPC 08/97 is an isolated right P^2. When they are compared with AMNH 19475 (identified as *Giraffokeryx punjabiensis* by Colbert[5], it is evident that the anterio-posterior length and crown width are identical in the case of PUPC 08/35 and compare favorably with PUPC 08/97. They are narrow crowned while AMNH 19475 is also narrow crowned. All the major cusps are well preserved with a grooved lingual side in the middle while the buccal side is spindle shaped. The anterio-posterior length of the teeth is greater than the transverse width (Table-1). Median ribs are missing while the styles are weakly preserved which indicate that specimens under study belong to *Giraffokeryx punjabiensis*. The specimens PUPC 08/33, PUPC 08/34, PUPC 08/43 and PUPC 08/98 are also smaller in size. On the basis of tooth size, contour and enamel constriction and structure of crown, they resemble, based on information given by Colbert[5], the species *Giraffokeryx punjabiensis*. The P^3 measurements described here strongly resemble those given for AMNH 19475. They are all narrow crowned and their W/L ratio also resembles the type specimen. In *Giraffa punjabiensis* the external folds are comparatively more developed in the premolars, and in the specimens under study the styles and median ribs are less pronounced which is a feature of *Giraffokeryx punjabiensis*. The specimens PUPC 08/26, PUPC 08/96 are fourth upper left and right premolars respectively, and when compared with AMNH 19475 and AMNH 19330, they resemble the known material of *Giraffokeryx punjabiensis*. All of the teeth are broad crowned and show the typical morphology of this species. Additionally, crown width is greater than the anterio-posterior length. Moreover, the anterio-posterior length, transverse width and W/L ratio also resemble the P^4 of AMNH 19475 and AMNH 19330. In specimens PUPC 08/31, PUPC 08/105 and PUPC 08/113 the median ribs and styles are less pronounced and the measurements and tooth morphology resemble AMNH 19334 and AMNH 19311. The specimens presently under study, together with the M^1 in the AMNH collections, are narrow crowned. PUPC 08/18 and PUPC 08/28 are right upper second molars while PUPC 08/99 is a left molar and is comparable to AMNH 19320, AMNH 19472 and AMNH 19611 (Table-5). PUPC 08/117 is a right upper third molar and is comparable to AMNH 19325, AMNH 19327, AMNH 19472 and AMNH 19475. They have similar anterio-posterior lengths, crown widths and are narrow crowned. In the specimens under study, the parastyle is more developed compared to the mesostyle and metastyle, while the posterior median rib is also missing[5]. PUPC 08/38, PUPC 08/94 and PUPC 08/95 are lower third premolars. Measurements exhibit a close relationship with the type specimens AMNH 19587 and AMNH 19849. These lower third premolars resemble,

in terms of the structure of the cusps, cingula, rugosity of enamel, anterio-posterior length and development of styles, the type specimen. Their W/L index lies close to specimen AMNH 19849. The teeth are narrow crowned. The specimens under study show all the morphological features of the cheek teeth cited by Colbert[5]. In *Giraffokeryx* the styles are weak, median ribs are absent and the crown is narrow. Stylids are absent in the lower molars. The lower first molar, on the basis of cusp structure, rugosity of enamel, anterio-posterior length, and W/L index, compares favorably with the type specimen and other specimens present in the AMNH, i.e. AMNH 19849, AMNH 19587 and AMNH 19593. Specimen PUPC 08/13 is a lower right second molar. When it is compared with AMNH 19849, AMNH 19587 and AMNH 19324, it is evident that all teeth are narrow crowned and their anterio-posterior length and crown width resemble each other. It is also observed that the anterio-posterior length is greater than the crown width. Stylids are weakly developed in the specimen under study, which is a major character of the genus *Giraffokeryx*. The specimen PUPC 08/11 is a right lower third molar embedded in a piece of jaw bone, and it resembles AMNH 19324, AMNH 19587 and AMNH 19849 (identified as *Giraffokeryx punjabiensis* by Colbert, 1935) in terms of anterio-posterior length and crown width (Table-1). The tooth under study also resembles the typical morphology of *Giraffokeryx punjabiensis*. Slight differences in the measurements obtained are due to intraspecific variation. The stylids and median ribs are less pronounced in the specimen under study which is a character of *Giraffokeryx punjabiensis*. Therefore, all the specimens under study are being referred to *Giraffokeryx punjabiensis* (Table-I).

Conclusion

The Siwalik giraffids may be divided into two groups: one comprising a larger form, the other, a smaller form. The larger forms are represented by five genera: *Sivatherium, Bramatherium, Hydaspitherium, Helladotherium and Vishnutherium*, while smaller forms of fossil giraffids consist of two genera, *Giraffokeryx* and *Giraffa*. *Giraffokeryx punjabiensis* was disappearing when the Nagri Formation was deposited, perhaps around 10 Ma. Large giraffids are observed during the remainder of the Miocene[9]. *Giraffokeryx* was a mixed feeder and had an extra pair of horn cores on the frontals. They had long, conical supra orbital horns widely separated at the base while the anterior horn arose from the frontal; the skull was long and low. The occurrence of fossil remains of *Giraffokeryx punjabiensis* from Chinji Formation of DBAK also testifies its widespread distribution in the Lower Siwaliks.

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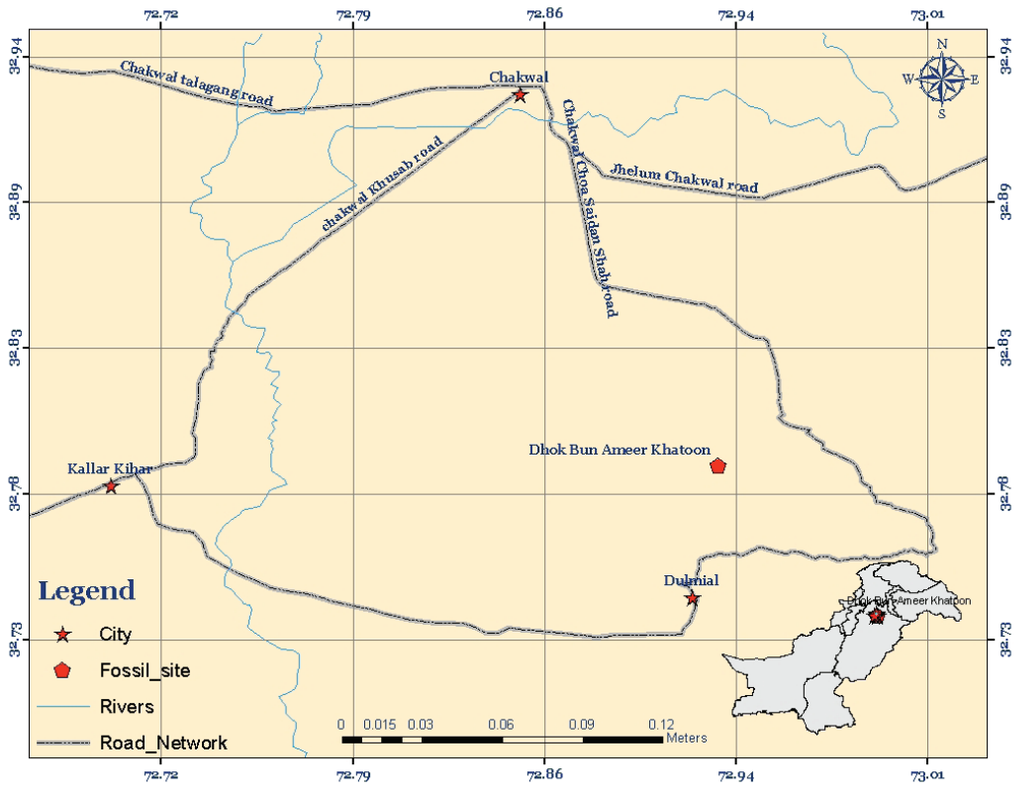
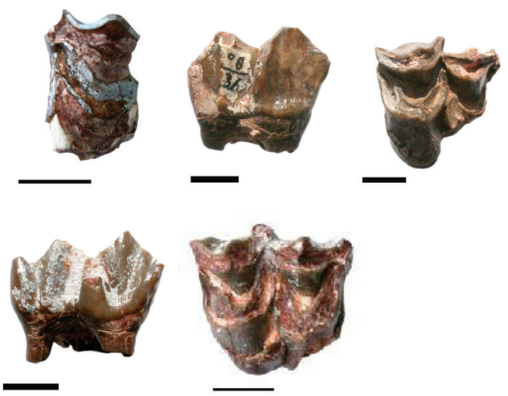


Figure 1 Map of site (Dhok Bun Ameer Khatoon) from where the fossils were collected.

2A 2B 2C 3B 4A 4B



9B 10A 10B 11A 11B

5B 6B 7B 8A 8B 8C

12A 12B 12C 13B 14A 14B 14C

15B 16A 16B 16C 17B

18A 18B 18C 19B 20B

21B 22A 22B 22C

Figure 2 *Giraffokeryx punjabiensis*, PUPC 08/35, isolated left second upper premolar (2A-C), PUPC 08/97, isolated right second upper premolar (3), PUPC 08/33, isolated right third upper premolar (4 A-B), PUPC 08/34, isolated left third upper premolar (5), PUPC 08/43, isolated left third upper premolar (6), PUPC 08/98, isolated left third upper premolar (7), PUPC 08/26, isolated left fourth upper premolar (8 A-C), PUPC 08/96, isolated right fourth upper premolar (9), PUPC 08/31, isolated right first upper molar (10 A-B), PUPC 08/105, isolated right first upper molar (11 A-B), PUPC 08/113, isolated left first upper molar (12 A-C), PUPC 08/99, isolated left second upper molar (13), PUPC 08/18, isolated right second upper molar (14 A-C), PUPC 08/28, isolated right second upper molar (15), PUPC 08/117, isolated right third upper molar (16 A-C), PUPC 08/38, isolated right third lower premolar (17), PUPC 08/94, isolated left third lower premolar (18 A-C), PUPC 08/95, isolated left third lower premolar (19), PUPC 08/45, isolated left first lower molar (20), PUPC 08/13, isolated right second lower molar (21), PUPC 08/11, isolated right third lower molar (22 A-C). A- buccal view, B- occlusal view, C- lingual view. (Scale bar 10 mm)

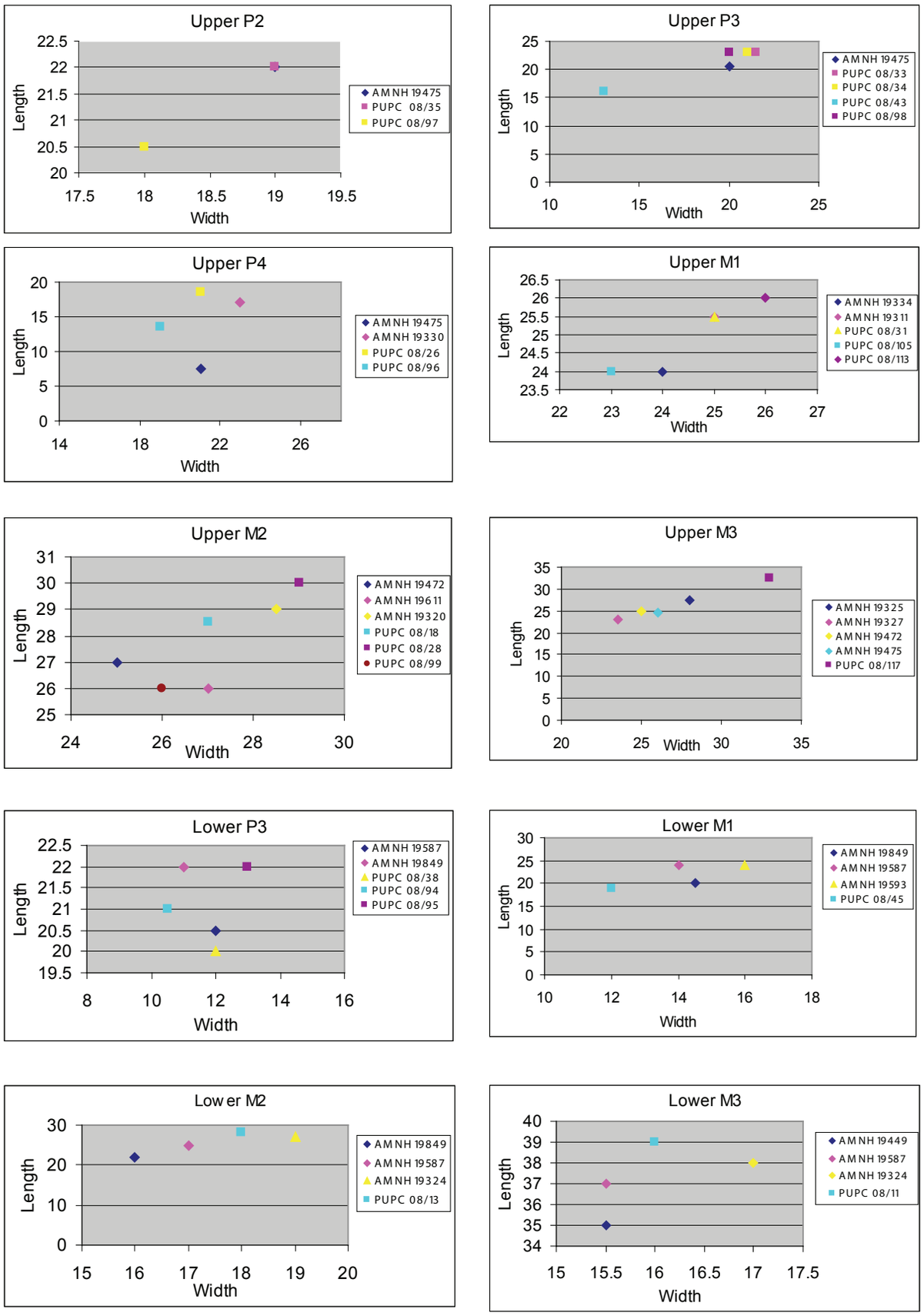


Figure 3 Bivariate scatter diagram showing comparison of the studied specimens with the type specimens.

Table 1 Comparative measurements (mm) of the cheek teeth referred to *Giraffokeryx punjabiensis* Pilgrim[2].

Number	Nature	Position	Length (L)	Width (W)	W/L index
AMNH 19475	premolar	P^2	22	19	86.36
PUPC 08/35	premolar	P^2	22	19	86.36
PUPC 08/97	premolar	P^2	20.5	18	87.7
AMNH 19475	premolar	P^3	20.5	20	97.5
PUPC 08/33	premolar	P^3	23	21.5	93.4
PUPC 08/34	premolar	P^3	23	21	91.3
PUPC 08/43	premolar	P^3	16	13	81.2
PUPC 08/98	premolar	P^3	23	20	86.9
AMNH 19475	premolar	P^4	7.5	21	120
AMNH 19330	premolar	P^4	17	23	135.5
PUPC 08/26	premolar	P^4	18.5	21	113.5
PUPC 08/96	premolar	P^4	13.5	19	140.7
AMNH 19334	molar	M^1	24	24	100
AMNH 19311	molar	M^1	25.5	25	98
PUPC 08/31	molar	M^1	25.5	25	98
PUPC 08/105	molar	M^1	24	23	95.8
PUPC 08/113	molar	M^1	26	26	100
AMNH 19472	molar	M^2	27	25	92.5
AMNH 19611	molar	M^2	26	27	96.2
AMNH 19320	molar	M^2	29	28.5	98.2
PUPC 08/18	molar	M^2	28.5	27	94.7
PUPC 08/28	molar	M^2	30	29	96.6
PUPC 08/99	molar	M^2	26	26	100
AMNH 19325	molar	M^3	27.5	28	101.8
AMNH 19327	molar	M^3	23	23.5	102.1
AMNH 19472	molar	M^3	25	25	100
AMNH 19475	molar	M^3	24.5	26	106
PUPC 08/117	molar	M^3	32.5	33	101.5
AMNH 19587	premolar	P_3	20.5	12	85.5
AMNH 19849	premolar	P_3	22	11	50
PUPC 08/38	premolar	P_3	20	12	60
PUPC 08/94	premolar	P_3	21	10.5	50
PUPC 08/95	premolar	P_3	22	13	59
AMNH 19849	molar	M_1	20	14.5	72.5
AMNH 19587	molar	M_1	24	14	58.3
AMNH 19593	molar	M_1	24	16	66.6
PUPC 08/45	molar	M_1	19	12	63.2
AMNH 19849	molar	M_2	22	16	72.2
AMNH 19587	molar	M_2	25	17	68

Number	Nature	Position	Length (L)	Width (W)	W/L index
AMNH 19324	molar	M_2	27	19	70.3
PUPC 08/13	molar	M_2	28	18	64.2
AMNH 19449	molar	M_3	35	15.5	44.2
AMNH 19587	molar	M_3	37	17	45.9
AMNH 19324	molar	M_3	38	17	44.7
PUPC 08/11	molar	M_3	39	16	41