

## Giraffokeryx Punjabiensis (Mammalia, Artiodactyla) New Remains from the Middle Miocene of Northern Pakistan

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### ABSTRACT

**Background:** New dental remains of the family Giraffidae from the Middle Miocene Siwaliks (Chinji Formation) are described and discussed in this paper. **Methods:** The discovery includes isolated upper and lower teeth belonging to *Giraffokeryx punjabiensis*. The identification is based on comparative morphometry to already published data. **Results:** Along with the systematic paleontological data the article also provides the comparative data between the Siwalik *Giraffokeryx* species and other species of this genus reported from other geological regions of the world. This data is important as not much comparative data is available for various species of *Giraffokeryx*. **Conclusion:** The present study improves the existing knowledge about the geography, stratigraphy and paleo environment of this extinct giraffid species and also identifies points of discussion and confusion related to the species of the genus *Giraffokeryx*.

**Keywords:** Chinji Formation; Dental remains; giraffids; Middle Miocene; Siwalik

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**AMK:** Supervision, Manuscript writing,  
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### INTRODUCTION

The Miocene was the time the giraffids first appeared in Africa (Romer, 1974; Gentry, 1994 and Harris et al., 2010) as it was the late Early Miocene of Africa, when extinct representative of the family Giraffidae first appeared in this region (Made and Morales, 2011). The next wave of change in giraffid diversity occurred in the Siwaliks of Indian Subcontinent and Kazakhstan during the Middle Miocene (Harris et al., 2010; Barry and Flynn, 1990; Vislobokova, 1997). According to Agustí and Antón (2002), the origin of the giraffids from the Alpine

belt led to the variety of giraffid genera in Asia, which later spread to Europe and Africa. Part of this dispersion led to the late Middle Miocene giraffid records in Turkey and Greece (De Bonis et al., 1997; Gentry, 1990). Although the Late Miocene was the time giraffes reached a wide distribution and increased in taxonomical variety, their diversity decreased at the end of the Late Miocene (Godina, 1979). Despite this reduced Late Miocene diversity in Eurasia several species persisted in Africa (Harris, 1991; Harris et al., 2010). Overall, the migration pattern of the Miocene giraffids built on

the reports of distribution (based on the data from Ramstein et al., 1997; De Bonis et al., 1997; Bhatti et al., 2012) is as follows.

Africa → Europe → Asia → Africa

The discovered material of *Giraffokeryx* (an extinct genus of the family Giraffidae) included in this study belongs to the Middle Miocene of the Siwaliks of Pakistan, part of the South Asian region. As per available data, the Siwalik giraffid genus *Giraffokeryx* made its first appearances in Pakistan during the Early Miocene (Raza, 1997) and remained in Pakistan even during the Middle Miocene. The family Giraffidae had a scattered distribution in the Siwaliks but was one of the prominent ruminants that reported in the region. The first report on Siwalik giraffes was submitted by Cautley (1835), who mentioned the occurrence of *Sivatherium giganteum* from the Upper Siwaliks of the Indian Subcontinent. This discovery included the third cervical vertebra, which was longer than usual (other than giraffes) mammalian cervical vertebrae in the Siwalik. This discovery was followed by discoveries with other excavations yielding other giraffid remains reported by Falconer and Cautley (1843).

The first fossil giraffids in the Siwaliks of the Indian Subcontinent, with identification and naming of the genus *Giraffokeryx* was made by Pilgrim (1910, 1911) in his published work entitled “The Fossil Giraffidae of India” and was based on isolated teeth and mandibles discovered in the Chinji deposits of the Potwar Plateau, Pakistan. According to Bhatti et al. (2012a) the genus *Giraffokeryx* is represented not only in the Siwalik localities of Pakistan, India and Nepal but also in the Belomechetskaia deposits of Russia.

The giraffids of the Siwalik area can be classified into three subfamilies: Palaeotraginae, Sivatheriinae and Giraffinae. The studied species *Giraffokeryx punjabiensis* belongs to the subfamily Giraffokerycinae and is reported from the Middle Miocene Siwalik outcrops of Pakistan. The other species included in the genus *Giraffokeryx* are the Turkish *G. anatoliensis* (Geraads and Aslan, 2003) and the African *G. primaevus* (Churcher, 1970). Hamilton (1978) and Gentry (1994) considered “*Paleomeryx*” *primaevus* close to or identical to *Giraffokeryx*. After the discovery from Fort Ternan, Kenya, *P. primaevus* was included in *G.*

*punjabiensis* by Gentry (1999). Both *G. punjabiensis* and *G. primaevus* are placed in Giraffokerycinae (Danowitz et al., 2015).

*Giraffokeryx punjabiensis* is included in the three reported Middle Miocene giraffid species of the Siwaliks of northern Pakistan (Barry et al., 2005; Matthew, 1929; Colbert, 1935; Khan et al., 2012). *Giraffokeryx punjabiensis* is considered as the earliest Middle Miocene species of giraffids and is reported from several localities of the Middle Miocene. The other two Middle Miocene species are *Giraffokeryx chinjiensis* and *Giraffa Priscilla* (Matthew, 1929; Colbert, 1935; Khan et al., 2012). The Middle Miocene Siwalik of Pakistan (Chinji Formation, Lat. 32° 41' N Long. 72° 22' E), type area is an area with a high number of fossil - rich localities and bright red colored deposits as its diagnostic feature. According to Barry et al. (2002) the chronological age of the Chinji Formation is 14.2-11.2 Ma. The detailed stratigraphy of the Chinji Formation of Pakistan and its geographic location are given in Khan et al. (2009) and Aftab (2015).

**Abbreviations:** DBAK, Dhok Bun Ameer Khatoon; PUPC, Punjab University Paleontological Collection, Lahore, Pakistan; AMNH, American Museum of Natural History; r, Right; l, left; P, Upper premolar; M, Upper molar; p, Lower premolar; m, Lower molar; mm, Millimeters; Ma, Million years ago.

## MATERIALS AND METHODS

The recently discovered material assigned to *Giraffokeryx punjabiensis* comprises isolated upper and lower dentition. The specimens were collected from the Chinji type locality and Dhok Bun Ameer Khatoon, Punjab, Pakistan (fig. 01), and were carefully cleaned off of any debris of clay and sandstone with the help of brushes, chisels and needles. An individual catalogue number was given to each specimen, starting with PUPC and included a serial number and the year of collection. The collected material has been housed in the Paleontology Laboratory of the Department of Zoology, University of the Punjab, Lahore, Pakistan. The material was photographed by digital camera and measurements were taken by Vernier calipers to make the morphometric comparison of the recovered material to the data found in the

available literature. The dental terminology used in the study follows Gentry (1994).

### **Systematic Paleontology**

Order Artiodactyla Owen, 1848

Suborder Ruminantia Scopoli, 1777

Infraorder Pecora Linnaeus, 1758

Superfamily: Giraffoidea (Gray, 1821) Simpson, 1931

Family Giraffidae Gray, 1821

Subfamily Giraffokerycinae Solounias, 2007

Genus *Giraffokeryx* Pilgrim, 1910

Type species *Giraffokeryx punjabiensis* Pilgrim, 1910

### **Species Diagnosis**

Major cusps in a straight line. Upper molars subhypodont and large with prominent parastyles and mesostyles, stylids weakly developed or absent. The entostyle/ectostylid is tiny or absent. The anterior rib is more prominent as compared to the posterior one (Pilgrim, 1910, 1911; Colbert, 1935; Bhatti, 2005).

### **Geographic Distribution**

South Asia and Greco-Iranian Province (Pilgrim, 1910; Colbert, 1935 Bhatti, 2005; Khan et al., 2010; Kostopoulos and Sarac, 2005).

### **Type Locality**

Lower Siwaliks and the lower portion of the Middle Siwaliks (Chinji – basal Nagri), District Chakwal, Province Punjab, Pakistan (fig. 01).

### **Referred Material**

PUPC 17/332 (P3), PUPC 13/107 (P4), PUPC 13/327(M2), PUPC 94/75 (p3), PUPC 17/333 (p4)

### **Localities**

The fossils have been excavated from Chinji type locality (PUPC 17/332, PUPC 13/327, PUPC 94/75 and PUPC 17/333) and DBAK (PUPC 13/107)

### **DESCRIPTION**

**PUPC 17/332 (P3)** (fig. 2) is an isolated right upper premolar in the middle stage of wear. Trapezoidal-shaped in occlusal view. Prominent buccal ribs present. Protocone and hypocone separated with a very weak lingual groove. Parastyle and mesostyle moderately developed. Lingual valley closed.

**PUPC 13/107 (P4)** (fig. 2) is a broken fragment of the right upper fourth premolar with only protocone and hypocone preserved. The presence of a deep lingual valley and a very weak and slight anterior

cingulum are the morphological features that can be clearly observed in this specimen.

**PUPC 13/327(M2)** (fig. 2) is an isolated upper molar from the left side of maxilla. It is in the very early stage of wear and well preserved but with the enamel broken on the metacone. Brachyodont tooth. Enamel thick and rugose. Median basal pillar absent. A prominent and high cingulum present on the antero-lingual side. Buccal cones are more in height than lingual ones. Parastyle and parastyle ribs moderately developed.

**PUPC 94/75 (p3)** (fig. 2) is a well-preserved lower premolar in middle wear. Lingual valleys open with narrow crowns. The paraconid is distinct and separated from the parastylid. The metaconid is higher than the paraconid which expands posteriorly. The entostylid is weakly developed. The hypoconid is projected with a deep valley in front of it.

**PUPC 17/333 (p4)** (fig. 2) is the left isolated lower premolar with a distinct conid pattern. The lingual valleys are closed. Buccal fold more pronounced on posterior side but not very deep. Long anterior lobe of protoconid is incompletely formed and reaches to hypoconid with a gap. A spur like structure present in anterior valley (valley closed due to strong lingual wall). Metaconid and hypoconid joined by strong bridge. Stylids and cingulids absent. Entoconid and hypoconid fused in a hook like fashion.

### **COMPARISON**

The studied specimens included in this article show the typical morphological features that were reported in the holotype of the genus *Giraffokeryx* reported by Pilgrim (1910, 1911). These features are: brachyodont dentition, weakly developed styles and stylids and less developed median ribs. The measurements of the studied samples have similarities to the measurements reported for the dental remains of *Giraffokeryx punjabiensis* (Table 1).

There are strong morphological resemblances but slight variations in the length and width of studied Siwalik specimens as compared to the already described specimens (from Samiullah et al., 2011) of the genus from the Siwaliks. The most concerning point here is the comparison of p4 to the specimens discovered from the Middle Miocene of central Turkey, published by Geraads et al. (1995). They assigned the specimens to *Giraffokeryx* sp. or

cf. *G. punjabiensis*. The morphology of both Siwaliks and Turkish p4 specimens of the genus are nearly identical, as both have pronounced buccal fold, the presence of a gap in protoconid and hypoconid, joined metaconid and hypoconid with a bridge and a hook-like appearance of entoconid and hypoconid. However, the p4 from the Siwalik outcrops is slightly longer than the Turkish specimen. The above discussion shows that the newly discovered specimens that are included in this study (fig. 02) closely resemble the reported dental features of *Giraffokeryx punjabiensis*. Although, there are slight variations in morphology in some reported specimens of the species but the measurements of the referred specimens are in line with those described by Colbert (1933) in AMNH 19587.

As the genus *Giraffokeryx* has three included species: *Giraffokeryx punjabiensis* (Pilgrim, 1910), "*Palaeotragus*" *primaevus* (Churcher, 1970); and *Giraffokeryx anatoliensis* (Geraads and Aslan, 2003), we can compare the referred material of *G. punjabiensis* with the other two species to give data on the interspecific dental variations within the *Giraffokeryx* (Table 2). There was a need for comparison because there was a lot of confusion previously in the identification of the included species e.g *Giraffokeryx* was identified initially in Turkey, by Pilgrim (1910), as *G. punjabiensis*. Later established giraffe species by Geraads and Aslan (2003) was *G. anatoliensis*. According to Geraads and Aslan (2003), the Siwalik specimens have many morphological variations which make the authors unable to place them in any single species. The same is indicated by the statement of Colbert (1935) that "the internal border of the third premolar may be closed or open" while all p3 have transverse crest (as described by Pilgrim, 1911). The other examples are: p4 large anterior lobe (Pilgrim, 1911) closed on the lingual side, while Colbert's specimens have no anterior lobes like Turkish specimens.

The major confusion that is identified in this comparative discussion is that *G. anatoliensis* was one of the species of *Giraffokeryx* that is identified based on *G. punjabiensis* as a type species but it differs from *G. punjabiensis*- in the size of its horns, its occipital bone and p3 oblique epicristid.

*G. primaevus* is the third species of the genus *Giraffokeryx*. Churcher (1970) identified that the species *G. primaevus* is morphologically close to *G. punjabiensis*. However, Harris et al. (2010) specified some more differences between these two species (in addition to the comparison mentioned in table II). These additional differences are: choanae posterior in position than M3, separated lingual cuspid in p4, longer P2 and P3. The other major difference is the body size; it is large in *G. primaevus* which also closely resembles the genus *Giraffa* in respect to both the height of the body and of the limbs.

## DISCUSSION

For the construction of phylogeny, after Pilgrim's (1911) initial work, Matthew (1929), Colbert (1933, 1935) made a reconstruction of this genus. According to the observation of the size and shape of the skull Colbert (1935a) postulated, that *Giraffokeryx* was a small - sized giraffe with an elongated neck. Later, another reconstruction was made by Savage and Long (1986) which indicated this extinct genus was more like representative of the living giraffid genus, *Okapia* but with long necks and according to Mitchel et al. (2003), they occupied the forested niche and used it as a refuge against the food and shelter threats from the other species.

The three species included in the genus *Giraffokeryx* are compared above (Table 2) and many points of discussion exist due to variations in the samples recovered from the same area. For example, the *Giraffokeryx* material recovered from the Chinji Formation has many variations in tooth morphology. Similar is the case with the Pasalar (Turkish) specimens which were named as *Giraffokeryx* aff. *punjabiensis* by Gentry (1990), but later, another giraffe remains were unearthed and were identified as *Giraffokeryx anatoliensis* (Geraads and Aslan 2003). This species is known well from the Middle Miocene locality of Çandır (Turkey) in the form of cranial and postcranial remains which are not hard to identify (Geraads and Aslan, 2003). The characteristic features of this species, as mentioned by Geraads and Aslan (2003), are: supraoccipital horns unfused with frontal bone in young animal; occipital shelf protruding; horns have inward curving with rounded tips; anterior lobe

in DP3 longer than *Palaeotragus*; premolars without entostyles almost without cingulum; moderate ribs and styles; molars with weak or absent ectostylid; complete loop of third lobe on m3 and the limb bones are not much helpful in creating distinction and hence phylogeny.

According to Hamilton (1978) and Gentry (1994) "*Palaeotragus*" *primaevus* is close to or identical to *G. punjabiensis*. They proposed that the palaeotragines were the first of the giraffe clade, to have migrated from North Africa to eastern Eurasia, including Turkey Greece and then to Iraq, Western Europe and India.

The confusion in dental morphology that existed particularly between "*Palaeotragus*" *primaevus* and *G. punjabiensis* indicates that they faced nearly the same environmental pressure in some specific time period. However, it may be that the said species were not present at the same time. The assumption made by Churcher (1970) is that "*P*". *primaevus* originated from Paleotragine stock which reached Africa by lowering of eustatic level across the Suez isthmus. This assumption creates the view that one of the species became extinct or might have migrated towards Africa to fill the niche of available resources. Also, Lönnig (2011) discussed the temporal range of the genus *Giraffokeryx* and the long range of "*Palaeotragus*", which overlaps with that of *Giraffokeryx* supporting the view that there are similarities in both species. This could be due to the similar environmental pressures where both genera overlapped. The existence of long limbs in "*Palaeotragus*" might become supportive for the genus to escape from the harsh conditions or perhaps reduction of predatory pressure due to more escaping power as compared to *G. punjabiensis*.

After the evolution of 20-30 species, there are two modern species of giraffids exist as: *Okapia johnstoni*, living in Democratic Republic of the Congo and *Giraffa camelopardalis* which is an inhabitant of Africa that makes discoveries of giraffids remains very much important.

According to Tariq and Jahan (2014), the comparison of dental measowear in *Giraffa camelopardalis* and *G. punjabiensis* indicates that *G. punjabiensis* is browser and seasonal mixed feeder. Few of the associated fauna of *G. punjabiensis* in the Middle Miocene (*Conohyus sindiensis*, *Deinotherium pentapotamie*, *Sivapithecus sp.*, *Gaindatherium browni* and *Brachypotherium perimense*) is the characteristic identification of zone of the Chinji Formation (Sarwar, 1977 and Barry et al., 2002). The paleo environment of ungulates can be reconstructed based on the information of their diet. So, the restricted grazing and mixed feeding habit of *G. punjabiensis* and the variety of its key contemporaneous fauna indicates that the Middle Miocene of Potwar Plateau had a forested environment as well as woodland and wooded paleo environment as also indicated by Damuth and Janis (2011).

## CONCLUSION

The morphometric analysis has indicated that referred newly discovered remains belong to *Giraffokeryx punjabiensis* and its study supports the already available literature on this species. In this paper, the morphological comparison between three reported *Giraffokeryx* species indicates similarities and differences among these species belonging to the same genus. This comparison indicates that further discoveries of the genus are required to make this comparison more comprehensive.

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## Statement of conflict of interest

None to declare.

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**Table 1: Comparison of measurements in *G. punjabiensis* dental remains from the Siwaliks**

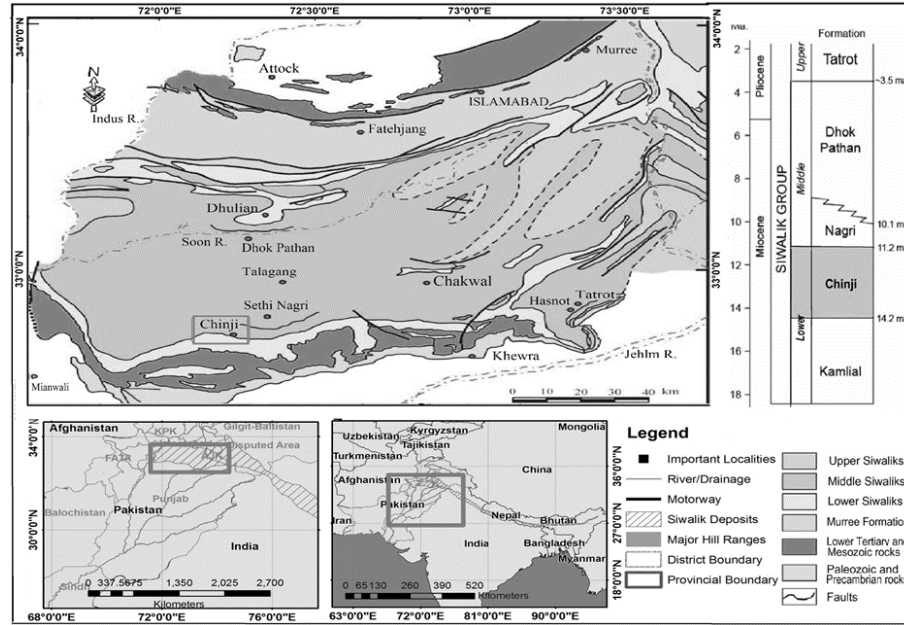
Sr. No.	Specimen No.	Type	Length	Width
1	PUPC 17/332	P3	23.5	20.0
2	AMNH 19475*	P3	20.5	20
3	PUPC 08/33**	P3	23	21.5
4	PUPC 13/107	P4	----	----
5	PUPC 17/327	M2	31.5	28.35
6	AMNH 19320*	M2	29	28.5
7	PUPC 08/28**	M2	30	29
8	PUPC 17/333	p4	24.7	15.35
9	PUPC 09/117**	p4	21.7	13.2
10	PUPC 94/75	p3	22.5	11.90
11	AMNH 19587*	p3	20.5	12
12	PUPC 08/95**	p3	22	13

\*Pilgrim (1910) Specimens are stored in collections of the American Museum of Natural History New York, USA, the Indian Museum, Kolkata, India; \*\*Samiullah *et al.* (2011).

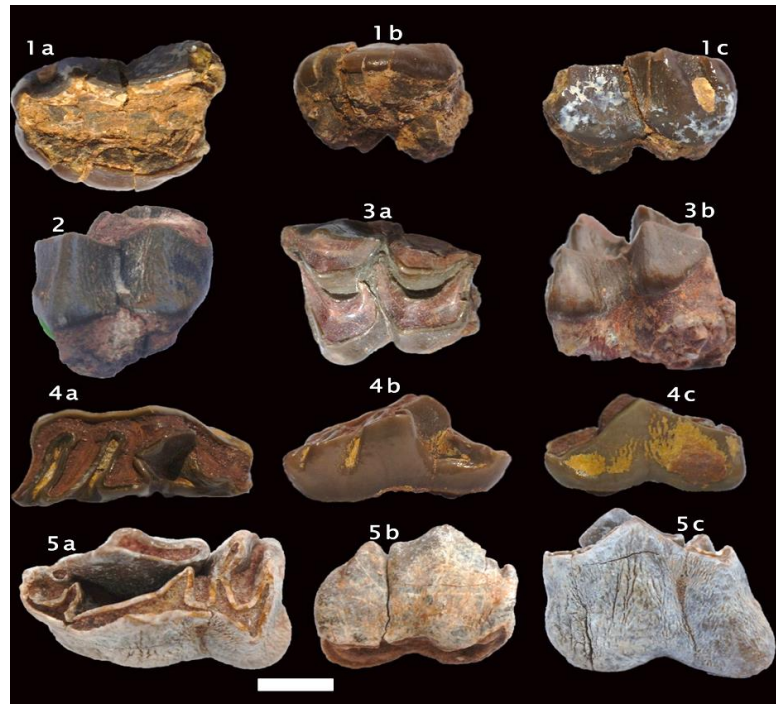
**Table 2: The comparison of characters in the three included species of the genus *Giraffokeryx***

Character	<i>G. punjabiensis</i>	<i>G. anatoliensis</i>	" <i>Palaeotragus</i> " <i>primaevus</i>
<b>Horns</b>			
Number	Two pairs	Two pairs	Two pairs
Length	Longer	Less longer	Longer than <i>G. punjabiensis</i>
Orientation	More inclined	Less inclined	-----
<b>Skull</b>			
Breadth	Less broad	Less broad	More broad
Occipital crest	less salient	more pronounced	-----
<b>Dentition</b>			
Type	Brachyodont	Brachyodont	Brachyodont
Styles/Stylids	Styles/stylids weak/absent	Ectostylids weak/absent	-----
Ribs	Anterior rib prominent	Weak ribs/absent	-----
<b>Neck and limbs</b>			
Elongation	Elongated	-----	More elongated
<b>Dental formula</b>	I?/? C?/? P3/ 3 M3/ 3 = ??.	I 0/ 3 C0/2 P3/ 3 M3/ 3 = 33.	I 0/ 3 C0/ 1 P3/ 3 M3/ 3 = 32.





**Figure 1:** Map of Potwar Plateau (Northern Pakistan), the study section labelled grey in the stratigraphic column at right hand (taken and modified from Barry et al., 2002) showing the chronostratigraphy of major formations of Siwaliks.



**Figure 2:** The newly discovered studied samples of *Giraffokeryx punjabiensis*; 1. PUPC 17/332 (P3), 2. PUPC 13/107 (P4), 3. PUPC 13/327(M2), 4. PUPC 94/75 (p3), 5. PUPC 17/333 (p4), a=occlusal view, b=lingual view, c= labial view. Scale bar is equal to 10 mm.