

# Miocene Giraffids (Giraffidae; Mammalia) from the Lower Siwalik of Pakistan

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## ABSTRACT

New dental material of Giraffidae is recorded from the Lower Siwalik, Punjab, Pakistan. The specimens are assigned to two genera, *Giraffokeryx* and *Giraffa*. The new material comprises isolated teeth, maxilla, and mandible fragments. The material was recovered from Lower Siwalik localities, Chabbar Sayadan and Phadial. These localities are assigned to a Middle Miocene age 14.2-11.2 Ma. *Giraffokeryx punjabiensis* and *Giraffa priscilla* disappeared before the Dhok Pathan Formation (ca 10.2 Ma). These lower-sized giraffids seem to prefer to inhabit the forested areas of the Siwalik region.

**Keywords:** Giraffids, Lower Siwalik, Mammalia, Miocene

## 1. INTRODUCTION

The deposits of mammalian fossil fauna in the Siwalik Hills of Pakistan are a primary way to understand the diversity and advancement of mammalian evolution. The Siwalik hills contain the deposits produced by the ancient river system in a mountain chain of the Himalayas. The Lower Siwalik comprises the deposits of vertebrate fauna and poses much importance in understanding the geological changes over time. The fossil deposition in this region is rich and still not highly explored, making it more suitable for investigating new evolutionary records [1, 2, 3].

Some new mammalian remains are discovered from the Lower Siwalik, which shows a diverse and versatile taxonomic approach. Lower Siwalik is further divided into Kamli and Chinji Formations. Lower Siwalik faunal elements represent primates, artiodactyls, perissodactyls and proboscideans [4, 5]. The bovids are in abundance in this age, representing many genera: *Miotragocerus*, *Tragoportax*, *Helicoportax*, *Elachistoceras*, *Tragoreas*, and *Gazella*. Anthracotheres include *Microbunodon silistrensis* and *Merycopotamus*

*nanus* [6]. The suid represents *Listriodon pentapotamiae* and *Conohyus sindiensis*. The giraffids comprise *Progiraffa sivalensis*, *Giraffokeryx punjabiensis*, and *Giraffa priscilla*. Other recorded species include *Gaindatherium browni* and *Hespanotherium matritense* [7, 8]

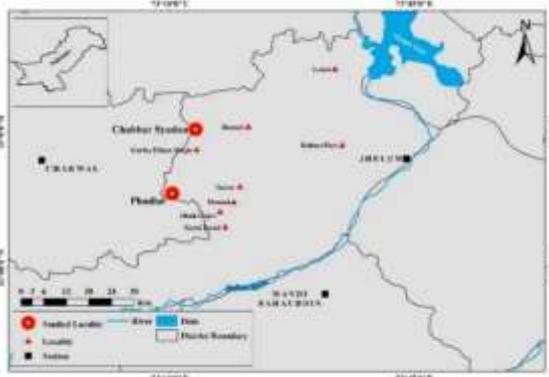
### 1.1. Geographic and geological context

The material was collected through several field trips to the localities Chabbar Sayadan (Late. 33° 00' N; Long. 73° 22' E), and Phadial (Late. 32° 83' N; Long. 73° 16' E), Lower Siwaliks, Punjab, Pakistan (Fig 1). The outcrops contain 70% red clay and 30% gray sandstones. The age of these localities is between 14.2 and 11.2 million years [9].

## 2. METHODS

Fieldwork consisted of recovering the fossils found on the upper surface of the soil as well as extracting the ones that are embedded in the rocks. The collected fossils were covered with cotton and packed in rigid plastic boxes to prevent any physical damage during their transport from the Lower Siwalik localities to the

Paleontology laboratory University of Gujrat, Gujrat. After bringing the specimens to the laboratory, they were prepared using needles and brushes. Phosphoric and hydrochloric acids in the diluted forms were used to deep clean the fossil material.



**Figure 1.** Chabbar Sayadan and Phadial Lower Siwaliks, Punjab, Pakistan, whence the described material was recovered

The broken specimens were glued using magic depoxi. The samples were then cataloged, each given a specific number indicating the serial number and the year. A magnifying glass was used to study the morphological characteristics of the specimen. After the identification and morphological study of the selected specimens, photographs were taken using a high-quality DSLR camera. Measurements of specimens were taken in millimeters using the digital Vernier caliper [10]; the systematics and terminology follow [11]. This material is compared with the specimens already present in the Department of Zoology, Government College University, Lahore (GCUPC), Geological Survey of India, Calcutta (GSI), American Museum of Natural History, New York (AMNH), Palaeontology Laboratory, Department of Zoology, University of Punjab, Pakistan (PUPC).

### 3. RESULTS AND DISCUSSION

#### Systematic Palaeontology

- Order Artiodactyla Owen, 1848
- Suborder Ruminantia Scopoli, 1777
- Infraorder Pecora Linnaeus, 1758
- Superfamily Giraffoidea Gray, 1821
- Family Giraffidae Gray, 1821
- Subfamily Giraffokerycinae Solounias, 2007
- Genus *Giraffokeryx* Pilgrim, 1910

#### 3.1. *Giraffokeryx punjabiensis* Pilgrim, 1910

Material: (UOGPC 21/102), IP3; (UOGPC 20/107), rM2; (UOGPC 21/104), rp4–m3.

#### 3.1.1. Description



**Figure 2.** *Giraffokeryx punjabiensis*. 1. UOGPC 21/102, IP3. 2. UOGPC 20/107, rM2. 3. UOGPC 21/104, rp4–m3.; There is : a. an occlusal view; b. lingual view; c. labial view (Scale bar 10 mm).

Upper dentition: The specimens are well-preserved and squared in outline (Fig 2(1)). A thick and shiny enamel layer is present on the crown in the upper third premolar. The fossette is quite large and shallow. There is no distinction between the protocone and the metaconule. It is pretty difficult to differentiate between these two cusps.

The tooth UOGPC 20/107 is slightly worn out. All the cusps are finally preserved. The protocone is V-shaped. The paracone is present at the anterior labial side. Its enamel layer is pushed backwardly to form a strong parastyle. The prehypocrista and posthypocrista are equal in size; their enamel lining is shiny and wrinkled. The metacone is V-shaped, having a thin enamel border compared to other cusps. The metacone is slightly damaged at the anterior lingual side, and a median rib supports it. The prefossette and postfossette are crescentic and filled with sand particles.

Lower dentition: The specimen UOGPC 18/104 is a mandible ramus fragment with p4– m3. The mandible is slightly damaged on the posterior side, but all teeth are well preserved. In p4, metaconid is anterior labial cuspid. Due to wearing, dentinal islets are formed. Protoconid is slightly higher vertically than hypoconid. The protoconid of m1 is extensively worn out and forms a dentine island with metaconid and hypoconid. The hypoconid is supported by cingular ridges posteriorly. The etoconid is extensively worn out, contiguous with hypoconid posteriorly and metaconid anteriorly (Fig 2(3)). In m2, the postprotocristid is somewhat shorter than the preprotocristid. The pre and posthypocristid are

almost equal. The hypoconid of m3 is supported by cingulum, which is corrugated in appearance. An entostylid supports the entoconid. The median ribs are present at the lingual side of the metaconid and entoconid.

**Systematic Palaeontology**

- Order Artiodactyla Owen, 1848
- Suborder Ruminantia Scopoli, 1777
- Infraorder Pecora Linnaeus, 1758
- Superfamily Giraffoidea Gray, 1821
- Family Giraffidae Gray, 1821
- Subfamily Giraffinae Zittel, 1893
- Genus *Giraffa* Brisson, 1756

**3.2. *Giraffa priscilla* Matthew, 1929**

Material: (UOGPC 20/101), rM1; (UOGPC 20/116), rM2; (UOGPC 21/106), rM2; (UOGPC 20/113), rM2; (UOGPC 21/103), IM3

**3.2.1. Description**

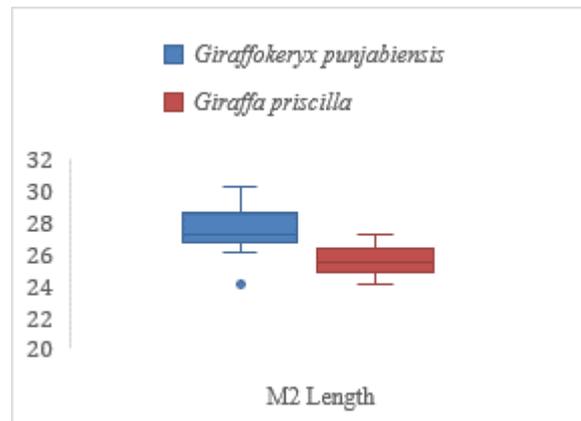


**Figure 3.** *Giraffa priscilla*. 4. UOGPC 20/101, rM1. 5. UOGPC 20/116, rM2. 6. UOGPC 21/106, rM2. 7. UOGPC 20/113, rM2. 8. UOGPC 21/103, IM3; a. occlusal view; b. lingual view; c. labial view (Scale bar 10 mm).

Upper dentition: Both the M1 and M2 and very similar; there is a transverse valley of moderate deepness between the labial and lingual cusps. Both fossettes are crescentic in shape and somewhat deep. The protocone is V-shaped. The enamel lining is thick

labially while it is thin lingually. A protostyle supports the protocone. The hypocone is supported by a thick cingulum labially. It is also supported by a pillar-like structure known as hypostyle. It is less worn than protocone, but the dentine is exposed. The enamel lining of the paracone is inclined posteriorly to form a parastyle covered by cement. Central ribs support the metacone, and proximally the metacone enamel is extended posteriorly to include mesostyle (Fig 3(4-8)).

The Giraffidae Family originated during the Early Miocene. The first Miocene fossils were discovered from Africa [10]. The members of the Giraffidae first appeared in the south Asian region during the Early Miocene. The fossils belonging to the family Giraffidae have been collected from Asian, African, and European regions [12, 13, 14, 15]. At least forty Giraffidae species have been collected to date in the Old World. Still, only two species belonging to two different genera have survived in Africa: *Giraffa camelopardalis* and *Okapia johnstoni* [11].



**Figure 4.** Boxplots of cheek teeth (M2) measurements of *Giraffokeryx punjabiensis* and *Giraffa priscilla* (measurements are taken from Table 1). The top and the bottom bars represent the broad range of the length. The vertical line in the center of each box represents the sample's median referred data are taken from [11, 17, 18, 21, 23, 24].

There are three Giraffidae subfamilies in the Lower Siwalik: Progiraffinae, Giraffokerycinae, and Giraffinae. These differ significantly in their dental morphological characteristics [16, 17, 18]. Progiraffinae is characterized by a bifurcated postmetaconule crista and well-developed cingulum on the preprotocrista [19, 9]. These features do not show resemblance with the specimens under study. The most significant differences between *Giraffokeryx* and *Giraffa* are enumerated as follows. The styles are absent in *Giraffokeryx* [20, 21], and the crown is narrow compared to *Giraffa* (Table 1, Fig. 4).

In *Giraffa*, the styles are solid and pillar-like, especially the metastyle, which is very strong. The hypoconulid is high and large [19, 11, 22, 23, 24].

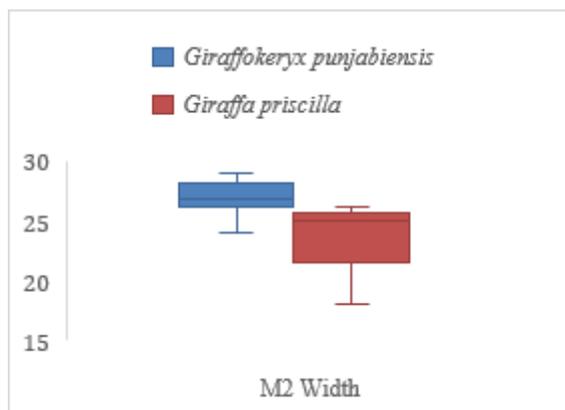
**Table 1.** Comparative dental measurements of the Giraffidae cheek teeth in mm (millimeters). Referred data are taken from [11, 17, 18, 21, 23, 24].

Taxa	Number	Nature	Length	Width	W/L
<i>Giraffokeryx punjabiensis</i>	UOGPC 17/102*	P3	22.5	21.4	0.94
	UOGPC 17/107*	M2	27.5	28.3	1.03
	UOGPC 18/104*	p4	22.3	14.1	0.63
		m1	24.1	17.3	0.72
		m2	25.5	18.1	0.71
		m3	36.1	17.8	0.49
	GCUPC 1170/12	P3	19.5	18.2	0.93
	GCUPC 1173/09	P3	22.7	21.4	0.94
	GCUPC 1072/09	P3	22.5	19.4	0.86
	GCUPC 1187/12	M2	28.4	26.3	0.93
	GCUPC 1188/12	M2	29.5	27.1	0.92
	GCUPC 1353/09	M2	26.1	26.7	1.02
	GCUPC 1144/09	M2	24.1	26.2	1.09
	GCUPC 1150/09	p4	24.0	15.0	0.63
	GCUPC 1175/13	p4	22.5	15.5	0.69
	GSI B510	P3	21.6	22.5	1.04
	AMNH 19930	P3	22.0	20.0	0.91
	AMNH 19311	P3	19.0	17.5	0.92
	PUPC 94/11	P3	23.0	22.0	0.96
	AMNH 19334	M2	27.0	27	1.00
	GSI B505	M2	30.2	28.2	0.93
	AMNH 19320	M2	29.0	28.5	0.98
	AMNH 19611	M2	27.0	26.0	0.96
	AMNH 19632	M2	28.0	24.0	0.86
	AMNH 19623	M2	27.0	29.0	1.07

	AMNH 19327	M2	24.0	26.0	1.08
	AMNH 19587	p4	24.0	15.0	0.63
		m1	24.0	16.0	0.67
		m2	25.0	17.0	0.68
		m3	37.0	17.0	0.46
	AMNH 19849	p4	19.0	11.5	0.61
		m1	22.0	14.5	0.66
		m2	22.0	16.0	0.73
		m3	35.0	15.5	0.44
	PUPC 2002/06	p4	23.0	14.5	0.63
	AMNH 19323	p4	22.0	14.5	0.66
		m1	22.5	16.0	0.71
		m2	25.0	18.0	0.72
		m3	33.0	17.0	0.52
	GSI B 495	p4	23.7	14.0	0.59
	AMNH 19329	p4	23.0	15.0	0.65
	AMNH 19324	p4	22.0	15.5	0.70
		m1	25.5	17.5	0.69
		m2	27.0	19.0	0.70
		m3	38.0	17.0	0.45
	AMNH 19419	m2	29.0	19.0	0.66
	AMNH 19593	m1	24.0	16.0	0.67
	AMNH 19320	m1	27.0	16.0	0.59
		m2	27.0	15.0	0.56
	AMNH 19332	m1	25.0	16.0	0.62
		m2	26.0	18.0	0.69
	GSI B 493	m2	25.0	17.6	0.70
		m3	36.0	16.6	0.46

	AMNH 19317	m3	37.0	18.0	0.49
	AMNH 19335	m3	39.0	20.0	0.51
	PUPC 02/12	m3	34	18	0.53
	PUPC 02/15	m3	23.5	17.5	0.74
	PUPC 02/19	m3	27.1	19.0	0.70
	AMNH 19318	m1	27.0	22.0	0.81
<i>Giraffa priscilla</i>	UOGPC 17/101*	M1	25.6	26.1	1.01
	UOGPC 17/116*	M2	25.5	18.1	0.71
	UOGPC 17/106*	M2	27.2	25.1	0.92
	UOGPC 18/113*	M2	24.1	26.2	1.09
	UOGPC 18/103*	M3	27.3	27.9	1.02
	GCUPC 1174/09	M1	24.0	24.0	1.00
	PUPC 07/131	M1	25.0	25.0	1.00
	PUPC 07/89	M1	27.0	27.0	1.00

This W/L index of the studied material was compared to specimens curated in different Museums and Scientific Institutions (Table 1, Fig. 5). The lower cheek teeth of *Giraffokeryx punjabiensis* are quadrate with very weak stylids, median ribs, and ectostylids. *Giraffa priscilla* has strong stylids, median ribs, and a broad crown compared to *Giraffokeryx* (Table 1).



**Figure 5.** Boxplots of cheek teeth (M2) measurements of *Giraffokeryx punjabiensis* and *Giraffa priscilla* (measurements are taken from Table 1). The top and the bottom bars represent the broad range of the width. The vertical line in the center of each box represents the sample's median referred data are taken from [11, 17, 18, 21, 23, 24].

This species is endemic to the Lower Siwalik, wet and moist with high rainfall. The Lower Siwalik fauna resembles Eurasian and African Middle Miocene faunal elements. *Palaeotragus* and *Injanatherium* have been discovered from different localities of Eurasia and Africa, which are pretty similar to *Giraffokeryx* in size.

#### AUTHORS' CONTRIBUTIONS

Kiran Aftab and Muhammad Akbar Khan designed the study and interpreted the data. Sumera Afsheen, Mubashar Hussain, and Areej Arif acquired the data and helped prepare the manuscript.

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