

***Giraffokeryx* (Artiodactyla: Mammalia) Remains From the Lower Siwaliks of Pakistan**

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Abstract. – *Giraffokeryx* is represented in the middle Miocene vertebrate assemblage from the Chinji Formation by 13 remains. The material comprises predominantly isolated teeth, and a few fragments of maxilla and mandible. The well preserved upper and lower dentition allows recognizing the presence of *Giraffokeryx* cf. *punjabiensis* in the Chinji Formation of the Lower Siwaliks. A detailed description of the fossils and their taxonomic classification is being provided. The validity of the new species *Giraffokeryx chinjiensis* Sarwar, 1990 is discussed and the synonymy with *Giraffa priscilla* is proposed.

Keywords: Giraffidae, Palaeotraginae, vertebrates, Chinji Formation, middle Miocene.

INTRODUCTION

The fossil remains of *Giraffokeryx* Pilgrim, 1910 to be described in this paper have been recovered from the outcrops of the Dhok Bun Amir Khatoon (72° 55' 45.4 E, 32° 47' 26.4 N) and the Chinji (72° 22' E, 32° 41' N) villages of Chakwal district, northern Pakistan (Fig. 1). The outcrops belong to the Chinji Formation of Lower Siwaliks (Barry *et al.*, 2002; Khan *et al.*, 2008, 2009). These are dominantly composed of bright red and brown orange siltstones interbedded with soft ash grey sandstones. The sediments were probably deposited in a fluvial environment leaving behind the fine-grained and fossil-bearing flood plains (Barry *et al.*, 2002). Fluvial depositional environment is also represented by lithofacies and characteristic faunal composition. For a detailed description of the geological and biostratigraphical setting of the area see Behrensmeyer (1987, 1988), Willis (1993), Behrensmeyer *et al.* (1995) and Barry *et al.* (2002). The material provides additional evidence for the middle Miocene/earliest upper Miocene giraffid fauna of Pakistan. The basic aim of the paper is to

present poorly documented paleotragine giraffids from the Lower Siwaliks of Pakistan and discuss the synonymy of *Giraffokeryx chinjiensis* Sarwar, 1990 with *Giraffa priscilla* Pilgrim, 1911.

The Chinji Formation contains the fossils of a mixture of arboreal, burrowing, and terrestrial micro- and macromammals with the dominance of terrestrial herbivores (Badgley *et al.*, 2008). There is a little variation in the taxonomic composition of these mammals among different sites (Basu, 2004). The sites are highly fossiliferous bearing diversified vertebrate fauna. The fauna from the Chinji Formation includes at present the following species: *Sivapithecus sivalensis* (Lydekker 1879); *S. indicus* Szalay and Delson, 1979; *Ramapithecus punjabicus* Lewis, 1932; *Rhizomyoides punjabiensis* Colbert, 1933; *Hyanailouros bugtiensis* Pilgrim, 1912; *Dissopsalis carnifex* Pilgrim, 1910; *Chalicotherium salinum* Forster-Cooper, 1922; *Listriodon pentapotamiae* von Meyer, 1846; *Conohyus chinjiensis* Pilgrim, 1926; *Merycopotamus pusillus* Lydekker, 1885; *Palaeohypsodontus* sp. Khan *et al.*, 2008; *Dorcatherium majus* Lydekker, 1876; *D. minus* Lydekker, 1876; *Dorcabune anthracotherioides* Pilgrim, 1910; *Eotragus* sp. Pilgrim, 1939; *Miotragocerus gluten* (Pilgrim, 1937); *Kubanotragus sakolovi* Pilgrim, 1937; *Sivoreas eremite* Pilgrim, 1939; *Gazella* sp. Pilgrim, 1937; *Giraffokeryx punjabiensis* Pilgrim, 1910;

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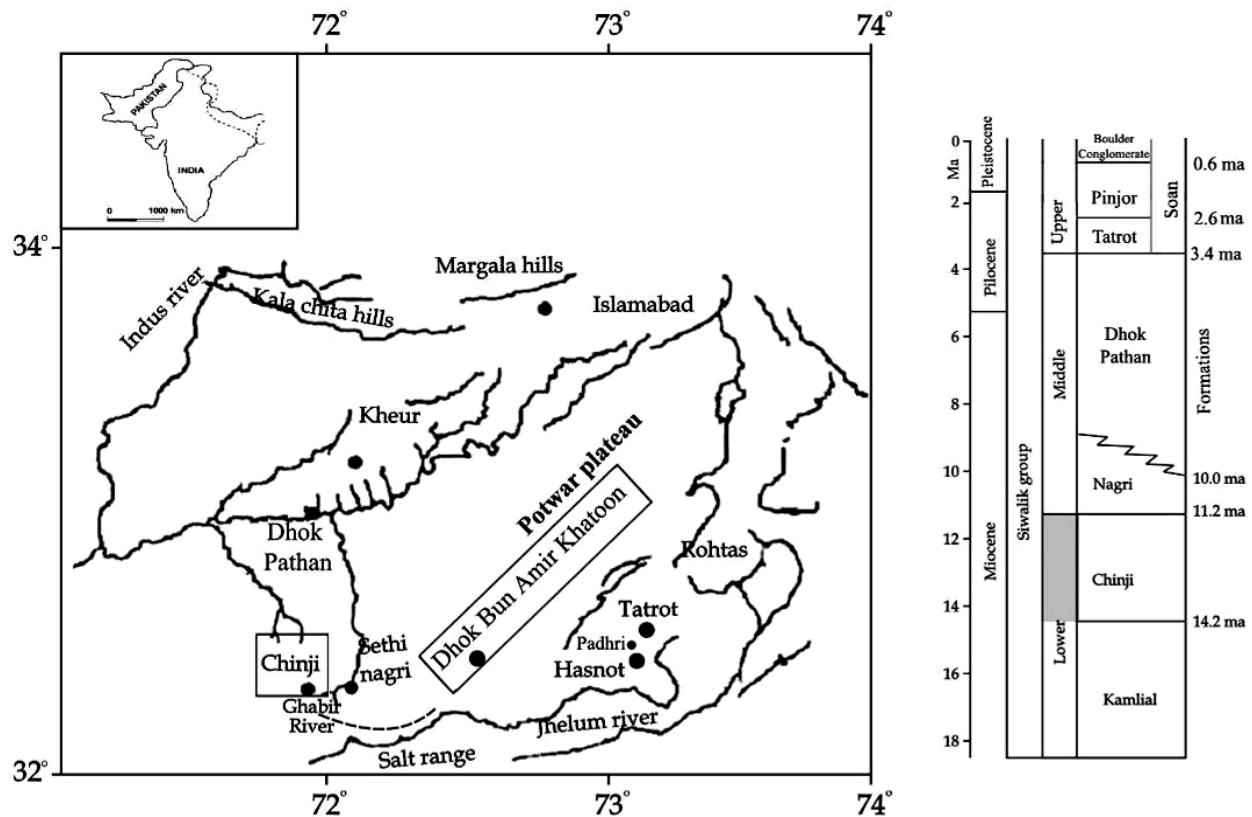


Fig. 1. The location of Chinji and Dhok Bun Amir Khatoon in northern Pakistan where the described material has been found. Boundary dates are from Barry *et al.* (2002) and Nanda (2002, 2008).

Giraffa priscilla Pilgrim, 1911 (Matthew, 1929; Colbert, 1933, 1935; Pilgrim, 1937, 1939; Raza, 1983; Akhtar 1992; Barry *et al.*, 2002; Badgley *et al.*, 2008; Khan *et al.*, 2008, 2009). This faunal association contains enough significant elements to allow comparison with some other middle Miocene faunas from Europe and Greco-Iranian Province (Savage and Long, 1986; Mitchell and Skinner, 2003). Barry *et al.* (2002) suggested 14.2-11.2 Ma age for the Chinji Formation. The Chinji Formation fauna is clearly of between middle Miocene and early upper Miocene age, being association with above mentioned taxa of the middle Miocene and the early upper Miocene.

Abbreviations

PUPC, Punjab University Paleontological Collection; AMNH, American Museum of Natural History; Ma, million years; MN, European Neogene

Mammalian Zone; M, molar; P, premolar; L, largest length; W, width; l, left; r, right; mm, millimeters.

MATERIALS AND METHODS

The morphological and metrical characters of the specimens are described and their systematic determination is discussed. Measurements are given in millimeters (mm). Uppercase letters with superscript number stand for upper dentition (*e.g.*, M¹) and with subscript for lower dentition (*e.g.*, M₁). The catalogue number of the 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.*, 02/13). The terminology and measurement of the giraffid teeth follow Gentry (1994).

SYSTEMATIC PALAEONTOLOGY

Family Giraffidae Gray, 1821
 Subfamily Palaeotraginae Pilgrim, 1911
 Genus *GIRAFFOKERYX* Pilgrim, 1910

Type species

Giraffokeryx punjabiensis Pilgrim, 1910.

Generic diagnosis

Medium size giraffid with four horns, two at the anterior extremities of the frontal and two on the fronto-parietal region. Posterior horn overhanging the temporal fossae. Limbs and feet presumably of medium length. Teeth are brachydont with rugose enamel as in the other genera of Giraffidae. *Giraffokeryx* was a medium size member of Giraffidae distinguished by two pairs of horn cores (ossicones) (Pilgrim, 1910; Matthew, 1929; Colbert, 1933, 1935).

Known distribution

Indian subcontinent and Eurasia (Pilgrim, 1910; Colbert, 1935; Geraads, 1986; Janis and Scott, 1987; Gentry and Hooker, 1988; Bhatti, 2005; Bhatti *et al.*, 2007a,b; Khan *et al.*, 2010).

Giraffokeryx cf. punjabiensis Pilgrim, 1910

Lectotype

GSI B502, a third molar of the right maxilla.

Type locality

Chinji, Lower Siwaliks, Punjab, Pakistan (Fig. 1).

Stratigraphic range

Lower Siwaliks and the lower portion of the Middle Siwaliks (Pilgrim, 1910; Colbert, 1935; Bhatti, 2005).

Abbreviated diagnosis

Larger than the other species of the genus. Upper molars are comparatively large and subhypsodont. Parastyles and mesostyles are well pronounced. Accessory column present blocking the transverse valley. The anterior rib is more prominent

than posterior one which is normally missing (Pilgrim, 1910; Colbert, 1935).

Studied material (In parenthesis the inventory number and the locality name are given)

Upper dentition: IM^{1s} (PUPC 94/7, Dhok Bun Amir Khatoon; PUPC 02/157, Chinji), IM^{2s} (PUPC 69/137, Chinji; PUPC 94/1, PUPC 94/3, PUPC 02/100, Dhok Bun Amir Khatoon), rM^{2s} (PUPC 94/2, PUPC 02/13, Dhok Bun Amir Khatoon), a left maxillary fragment with M¹⁻³ (PUPC 66/95 Chinji). Lower dentition: a right mandible fragment with P₂₋₄ (PUPC 02/06, Chinji), rM_{3s} (PUPC 02/12, PUPC 02/19, Dhok Bun Amir Khatoon), IM₃ (PUPC 02/15, Dhok Bun Amir Khatoon).

DESCRIPTION*Upper dentition*

The upper dental remains include two first molars, six second molars and a maxilla fragment with a complete molar series (Fig. 2).

M¹

The molars are in middle wear (Fig. 2A-B). The teeth are brachydont with moderately thick and rugose enamel. The rugosity is little bit more on the lingual side as compared to on the buccal one. The median basal pillar is missing in one molar but it is present in the second one. The cingulum is very poorly developed. The major cusps are fairly developed. The buccal cusps are slightly higher vertically than the lingual ones. The protocone is L-shaped. The praeprotocrista is narrow as compared to the postprotocrista, which is broad. The praeparacrasta is united with the parastyle whereas the postparacrasta is just touching the praemetacrasta. The metacone is pointed in the middle with the two sharply down running cristae. The parastyle is very well developed as compared to the meso- and metastyles. The parastyle is more prominent to the crown surface and less evident to the base of the tooth. The anterior median rib is prominent, while the posterior median rib is missing. It is more prominent towards the summit of the crown. The anterior central cavity is slightly narrow than the posterior one, which is broad.

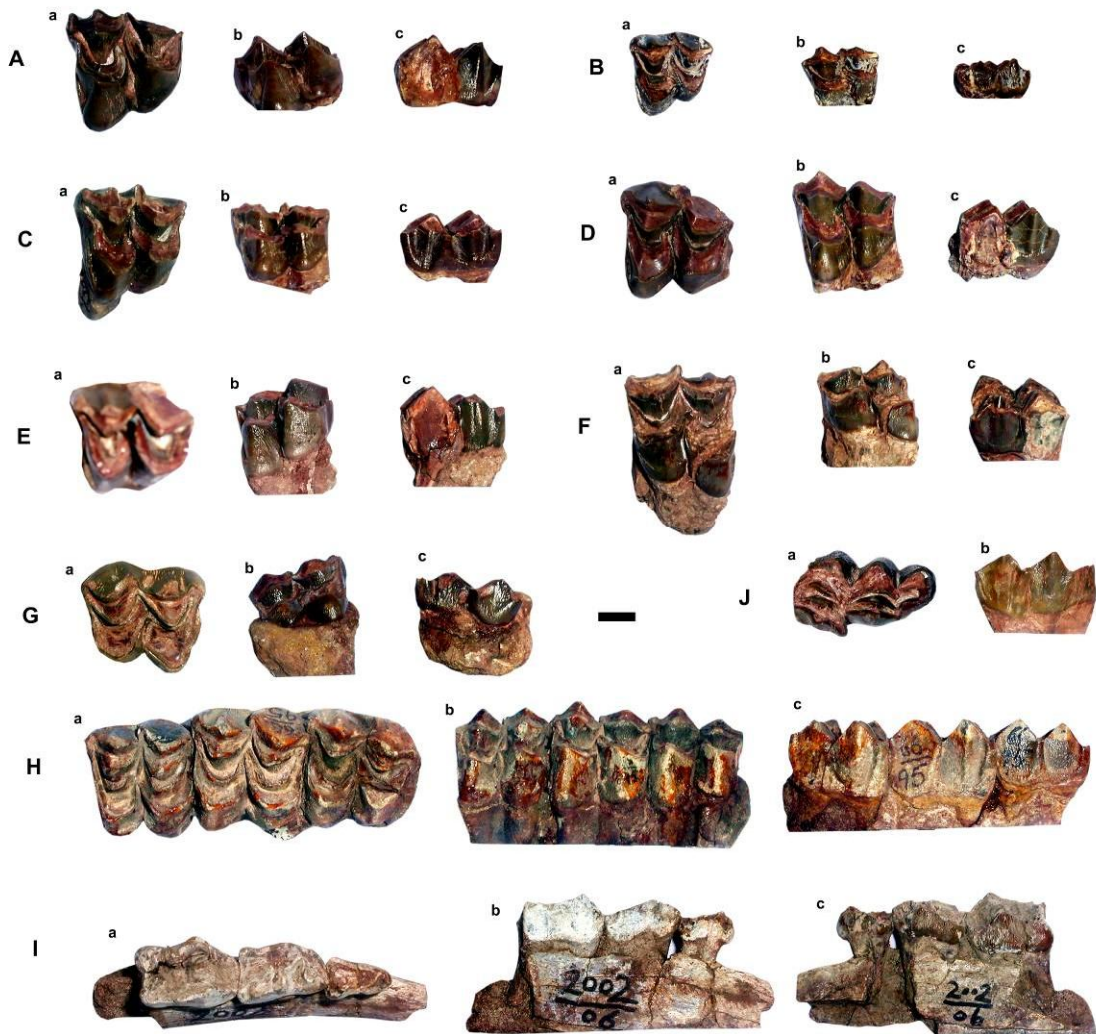


Fig. 2. *Giraffokeryx* cf. *punjabiensis*: A, PUPC 94/7 – IM^1 ; B, PUPC 02/157 – IM^1 ; C, PUPC 94/1 – IM^2 ; D, PUPC 94/3 – IM^2 ; E, PUPC 02/100 – IM^2 ; F, PUPC 94/2 – rM^2 ; G, PUPC 02/13 – rM^2 ; H, PUPC 66/95 – M^{1-3} ; I, PUPC 02/06 – P_{2-4} ; J, PUPC 02/12 – rM_3 (a, occlusal view; b, lingual view; c, labial view). Scale bar equals 10 mm total.

M^2

The second molars are represented by various states of wear as well as preservation (Fig. 2C-H). Some are excellently preserved and a few are partially damaged. The median basal pillar in the transverse valley between the protocone and the hypocone is poorly developed. The cingulum is poorly developed but it is slightly thick on the hypocone. The central cavities are very well developed. The anterior cavity is more developed and broader than the posterior one, which is narrow.

The cusp morphology is the same as in the M^1 . The development of the styles is variable in the second molars.

M^3

The third molar in the maxillary fragment represents an excellent state of preservation (Fig. 2H). The median basal pillar is poorly developed. The cingulum is missing. The protocone, paracone, metacone and hypocone are well developed. The posthypocrista is complete while the praehypocrista

is broken. The parastyle is strongly developed, whereas the meso- and metastyles are poorly developed. The parastyle is expanded to the base of the crown and united with the posterior side of the mesostyle. The anterior median rib is strongly developed whereas the posterior one is missing.

Lower dentition

The recovered lower dentition comprises a mandible fragment with premolar series (P_{2-4}) and three isolated last molars (Fig. 2I). The premolars are in early late wear and most of the crown terminology has been vanished. However, the P_3 shows occlusal morphological features of *Giraffokeryx punjabiensis*.

P_2

The paraconid is not distinct from the parastylid. The wear is more confined to the hypoconid than the paraconid which is slightly worn. The hypoconid is more prominent than the other conids. There are no postprotoconulid and metaconulid (Fig. 2I).

P_3

The paraconid is separated from the parastylid. The anterior valley is open in the P_3 . The metaconid extends forwards meeting the base of the paraconid. The crest joining the protoconid to the metaconid is oblique backwards (Fig. 2I).

P_4

The protoconid is connected to the hypoconid. The metaconid extend forwards meeting the base of the paraconid. The crest joins to the metaconid and incorporates the entoconid. The metaconid is expanded into the lingual valley, blocking the anterior valley. A well developed furrow separates the hypoconid from the strong protoconid on the buccal side (Fig. 2I).

M_3

The third molars are subhypsodont and narrow crowned (Fig. 2J). The median basal pillar is absent. The cingulum is developed anteriorly; it is weakly developed posteriorly and it is absent buccally and lingually. The major conids are crescentic in shape. The praeprotocristid is longer

than the postprotocristid. The anterior half of the protoconid is connected with the metaconid through a thin layer of enamel. The postmetacristid touches with the praentocristid. The postentocristid is joined with the hypoconulid. The hypoconulid is strong and well developed. It is crescentic in shape. The lingual side of the hypoconulid is higher than the buccal one. The stylids are moderately developed. The metastylid is weaker than the mesostylid. The stylids are more prominent at the summit of the crown and less distinct to the base of the tooth. The median inner rib of the metaconid is moderately developed. The comparative measurements are provided in Table I.

Comparison

The samples exhibits selenodonty and these may be referred to tylopods or ruminants. Since the specimens under study have very rugose enamel and this fine rugosity is not seen in tylopods so they can be referred to ruminants. In ruminants, such a heavy rugosity is found in Giraffidae (Pilgrim, 1911; Matthew, 1929; Colbert, 1935). The Siwalik giraffids are divided into two forms comprising large forms and small forms (Sarwar and Akhtar, 1987). The small forms include the genera *Giraffokeryx* Pilgrim, 1910 and *Giraffa* Pilgrim, 1911 while the large ones include the genera *Bramatherium* Falconer 1845, *Hydasphitherium* Lydekker 1877, *Sivatherium* Falconer and Cautley, 1835 and *Vishnutherium* Lydekker, 1876 (Colbert, 1935).

The studied teeth are small in size and can be referred to *Giraffokeryx* and *Giraffa* (Matthew, 1929; Colbert, 1935). *Giraffokeryx punjabiensis* is very close to *Giraffa priscilla* in size (Colbert, 1935). The styles are very weak in *Giraffokeryx* whereas these are strong in *Giraffa*. Median ribs are absent or very weak in *Giraffokeryx* and these are well pronounced in *Giraffa* (Matthew, 1929; Colbert, 1935). Furthermore, the crown is narrow in *Giraffokeryx* and it is broad in *Giraffa*. The specimens are much more similar to *Giraffokeryx punjabiensis* and the teeth show the typical morphology of the species (Figs. 2-3, Table I). The overall pattern of the described teeth is clearly different from that of the "*Giraffa priscilla*" and much more similar to the pattern observed in the

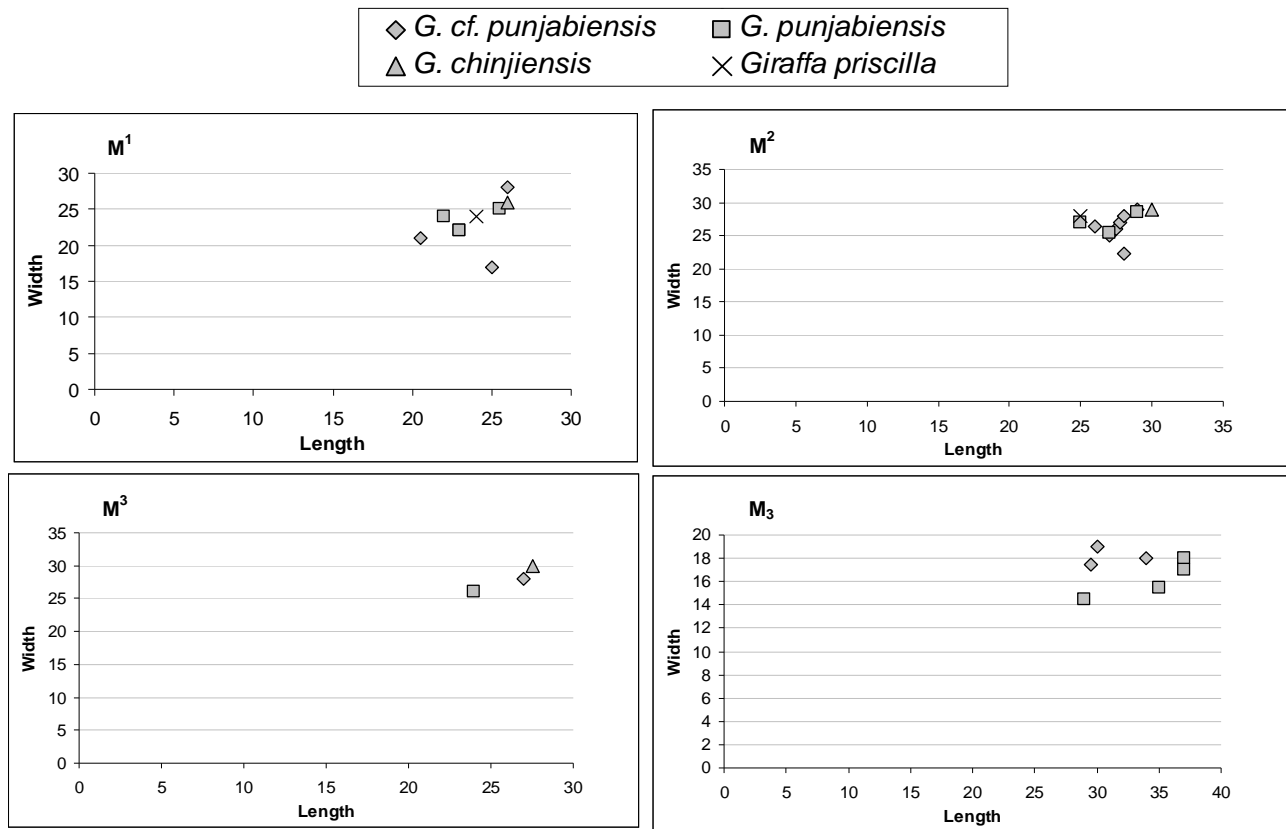


Fig. 3. Scatter diagram showing dental proportions of the Siwalik *Giraffokeryx* species and *Giraffa priscilla*. Referred data are taken from Matthew (1929) and Colbert (1935).

“*Giraffokeryx punjabiensis*”. The teeth stylids and less pronounced median ribs are features that match those of the *Giraffokeryx punjabiensis* holotype (Colbert, 1933, 1935). Morphometrically, the specimens resemble to the already described samples of *Giraffokeryx punjabiensis* (Fig. 3) and should be assigned to *Giraffokeryx cf. punjabiensis*.

DISCUSSION

Giraffokeryx punjabiensis has been recorded from the Siwaliks (Matthew, 1929; Colbert, 1933, 1935; Bhatti *et al.*, 2007a) and Greco-Irano-Afganian province (Geraads *et al.*, 1995). The genus *Giraffokeryx* was founded by Pilgrim (1910) on the genotype *Giraffokeryx punjabiensis*. Pilgrim (1910) based *Giraffokeryx* upon a collection from various Lower Siwalik localities of Pakistan and India. The

collection consisted of a skull, cranial fragments, mandibular fragments and many isolated teeth from the Nagri Formation of the Middle Siwaliks and the Chinji Formation of the Lower Siwaliks, which are described and figured by Pilgrim (1910, 1911) and Colbert (1933, 1935).

Synonymy

Sarwar (1990) added one new species *Giraffokeryx chinjiensis*, based on the type, second upper molar PUPC 121 and the hypodigm, the first upper molar PUPC 67/177 and third upper molar PUPC 67/187: styles that are strong, prominent median ribs and posterior half of the metaconule not bifurcated. The characters such as strong styles and prominent median ribs with broad crown are recorded in *Giraffa priscilla* (Matthew, 1929; Colbert, 1935; Bhatti *et al.*, 2007b). Sarwar (1990,

p. 383) confirmed the same size as *Giraffokeryx punjabiensis* (Table I) but he mentioned the type (PUPC 121) was quite distinct morphologically.

Table I.- Comparative dental measurements of the cheek teeth of the Lower Siwalik *Giraffokeryx* in mm. * The studied specimens. Referred data are taken from Matthew (1929) and Colbert (1935).

Taxa	Number	Nature/ position	Length	Width
<i>G. cf. punjabiensis</i>	PUPC 94/7*	IM ¹	25.0	17.0
	PUPC 02/157*	IM ¹	20.5	21.0
	PUPC 69/137*	IM ²	29.0	29.0
	PUPC 94/1*	IM ²	27.0	25.0
	PUPC 94/3*	IM ²	27.5	26.0
	PUPC 02/100*	IM ²	28.0	22.3
	PUPC 94/2*	rM ²	26.0	26.4
	PUPC 02/13*	rM ²	27.8	27.0
	PUPC 66/95*	IM ¹	26.0	28.0
		IM ²	28.0	28.0
		IM ³	27.0	28.0
	PUPC 02/06*	rP ₂	16.0	9.00
		rP ₃	21.0	12.5
		rP ₄	23.0	14.5
		rM ₃	34.0	18.0
PUPC 02/12*	rM ₃	34.0	18.0	
PUPC 02/19*	rM ₃	30.0	19.0	
PUPC 02/15*	IM ₃	29.5	17.5	
<i>G. punjabiensis</i>	AMNH 19475	M ¹	22.0	24.0
		M ²	25.0	27.0
		M ³	24.0	26.0
	AMNH 19334	M ¹	25.5	25.0
	AMNH 19311	M ¹	23.0	22.0
	AMNH 19593	M ¹	23.0	22.0
	AMNH 19472	M ²	27.0	25.5
	AMNH 19320	M ²	29.0	28.5
	AMNH 19611	M ²	27.0	26.0
	AMNH 19587	P ₂	18.0	9.00
		P ₃	20.5	12.0
		P ₄	24.0	15.0
		M ₃	37.0	17.0
	AMNH 19317	M ₃	37.0	18.0
AMNH 19623	M ₃	29.0	14.5	
AMNH 19849	M ₃	35.0	15.5	
<i>G. chinjiensis</i>	PUPC 67/177	M ¹	26.0	26.0
	PUPC 121	M ²	30.0	29.0
	PUPC 67/187	M ³	27.5	30.0
<i>Giraffa priscilla</i>	PUPC 02/99	M ¹	24.0	24.0
		M ²	25.0	28.0

Sarwar (1990) compared the *Giraffokeryx chinjiensis* type (PUPC 121) with *Giraffokeryx punjabiensis* but not with *Giraffa priscilla* and considered that its distinct morphologically clearly made it different from *Giraffokeryx punjabiensis*.

Giraffokeryx chinjiensis has the same characteristics as *Giraffa priscilla* in having almost the same size with pronounced styles, ribs and brachydonty teeth (Matthew, 1929; Colbert, 1935; Sarwar, 1990; Bhatti *et al.*, 2007b). Moreover, these characters are highly variable even within a single individual of ruminants (Bibi, 2007) and all these variations can be observed in *Giraffa priscilla* (Matthew, 1929; Colbert, 1935; Bhatti *et al.*, 2007b). Metrically, the *Giraffokeryx chinjiensis* specimens fall within the range of this species, which evidently supports its inclusion within *Giraffa priscilla* (Table I, Fig. 3) and it is confirmed invalid species of the Siwalik *Giraffokeryx*. Therefore, we consider that the genus *Giraffokeryx* consists of only one valid species *Giraffokeryx punjabiensis* in the Siwaliks.

CONCLUSIONS

During the middle Miocene, the Lower Siwaliks were mainly characterized by the presence of two species of small-sized giraffids: *Giraffokeryx punjabiensis* and *Giraffa priscilla*. *Giraffokeryx punjabiensis* in the Siwaliks was identified as a single valid species of the genus *Giraffokeryx*, recorded from the middle Miocene – the early late Miocene of the Siwaliks. The presence of *Giraffokeryx* in the middle Miocene of the Siwaliks and the Greco-Irano-Afganian province implies at this time, the Himalayan Mountains did not act as a barrier in the dispersal of the fauna out of southern Asia. The range contraction of this species suggests that it occupied a wide territory from the Subcontinent to the Greco-Irano-Afganian in Middle Miocene of the Siwaliks.

ACKNOWLEDGEMENTS

Thanks to Anaar Khan, Saeed Qazi and Sajjad Shah for their fieldwork assistance and the hospitality. Maskeen Ali provided efficient helps during the fieldwork, and Adeeb Babar and Abdul Rehman prepared the figures.

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(Received 23 February 2011, revised 16 April 2012)