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New *Giraffokeryx* and *Giraffa* (Ruminantia, Giraffidae) Dental Material from Lower Siwaliks of Northern Pakistan

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KA, MAK and ZA conceived and designed the study and analyzed and interpreted the data. KA, MAB and MA acquired the data. MAB, MKN and KA drafted the manuscript.

Key words
Palaeontology, Fossils, *Giraffokeryx*, *Giraffa*, Chinji.

ABSTRACT

Giraffokeryx punjabiensis and *Giraffa priscilla* have been discovered from the outcrops of district Chakwal, Punjab, Pakistan. The present description is about newly recovered specimens of small sized giraffids from Dhok Bun Amir Khatoon and Kund. These Middle Miocene localities are found within the Chinji Formation of the Lower Siwalik Subgroup in northern Pakistan. Our reports include isolated teeth, maxilla and mandible fragments of *Giraffokeryx punjabiensis* and *Giraffa priscilla*, which exhibit some primitive features for the Lower Siwalik giraffids. This paper also documents the first middle Miocene giraffid from the Kund locality of the Siwaliks. The lower sized giraffids preferred to inhabit the forested areas of the Siwalik.

INTRODUCTION

The Lower Siwalik Subgroup has generated significant fossil faunal assemblages of numerous mammals (Pilgrim, 1913; Khan *et al*., 2009, 2011, 2012, 2017; Khan and Akhtar, 2013; Patnaik and Prasad, 2016; Feroz *et al*., 2017). The Chinji Formation lies in the Lower Siwalik Pakistani Potwar Plateau and three extinct genera of Giraffidae *i.e. Progiraffa, Giraffokeryx* and *Giraffa* (Aftab *et al*., 2016) are represented in the respective fauna. The genus *Giraffokeryx* evolved from *Progiraffa* by gaining crown height in its cheek teeth, nevertheless, its metastylids were less prominent (Pilgrim, 1911; Gentry, 1990). *Giraffa priscilla,* an oldest representative of the subfamily Giraffinae, has been also recorded from the Lower Siwaliks (Matthew, 1929; Bhatti, 2005). The Indian locality Ram Nagar which belongs to the Chinji Formation as well (Sehgal and Patnaik, 2012), has also yielded fossil remains of *Giraffokeryx punjabiensis* and *Giraffa priscilla* (Patnaik, 2016).

Today Giraffidae are represented by two extant genera *Giraffa* (four species) and *Okapia* (one species) found only in Africa (Solounias *et al*., 2000; Groves and Grubb, 2011). During the Miocene, the family was more diverse, spreading throughout Eurasia and Africa (Rios *et al*., 2017). The earliest basal forms of the family come from the early and middle Miocene, whereas the advanced forms appeared in the late Miocene (Hamilton, 1978; Gentry, 1994). Overall, the late Miocene for the giraffids was a time of high diversification (Hamilton, 1978; Cantalapiedra *et al*., 2015).

The Siwalik Neogene in Pakistan is represented by fourteen species of giraffids (Bohlin, 1926; Hamilton, 1978; Gentry and Hooker, 1988; Bhatti, 2005; Khan and Farooq, 2006). Four subfamilies: Progiraffinae, Giraffokerycinae, Giraffinae and Sivatheriinae have been found in the Siwaliks (Bhatti, 2005; Solounias, 2007). The first giraffid was reported from the Kamlial Formation of the Siwaliks during the early Miocene (Solounias, 2007). The large sized Siwalik genera *Helladotherium, Bramatherium, Vishnutherium* and *Sivatherium* appeared in the late Miocene and survived up to the Pleistocene of the Siwaliks. The small Siwalik giraffids disappeared after the middle Miocene from the Siwalik Hills of Pakistan (ca. 14.2–13.2 Ma). New giraffid material is reported from two middle Miocene localities, Dhok Bun Amir Khatoon and Kund.

The faunal lists of Dhok Bun Amir Khatoon and Kund (Colbert, 1935; Pilgrim, 1937, 1939; Raza, 1983; Cheema, 2003; Khan *et al*., 2013) are provided in Supplementary Table I. Quantitatively, the artiodactyls are the most predominant in both localities. Proboscideans and perissodactyls are approximately equally common at these middle Miocene localities. Primates and carnivores

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seem to be uniformly rare. Nevertheless, faunas from these two localities are overall similar, reflecting a restricted biostratigraphic range. The faunal association of the two localities indicates strong similarities at the species level. Similar faunal assemblages are also present in the Chinji type locality. It seems more possible that this scarcity of small-sized giraffids in Kund could have been explained by local ecological factors. Nevertheless, we offer herein the first record of Giraffokerycinae and Giraffinae fossils from the Kund locality of the Pakistani Siwaliks.

Dhok Bun Amir Khatoon (Lat. 32° 47' N, Long. 72° 55' E) is located approximately 50 km northeast of Chinji village, district Chakwal, Punjab, Pakistan (Fig. 1). The site is well known for the fossil remains of middle Miocene mammalian faunas (Khan *et al*., 2008, 2013). The outcrops consist of sandstones, siltstones and unique coloured shales (Behrensmeyer and Tauxe, 1982; Badgley, 1986).

Kund (Lat. 32° 68' N, Long. 72° 40' E) is such a fossiliferous site located about 3.5 km south east of the Chinji village, district Chakwal, Punjab, Pakistan (Fig. 1). The outcrops of the fossiliferous sediments contain bright red clays, ash gray sandstones and brownish to yellowish siltstones. The giraffids have been reported from this area for the first time.

MATERIALS AND METHODS

New giraffid fossils were recovered from Kund and Dhok Bun Amir Khatoon localities of Pakistan. A number of field trips were arranged to explore the giraffid fossils from these localities. As a result, fossils of *G. punjabiensis* and *G. priscilla* were collected. Overall 9 specimens have been recovered of which 4 specimens were collected from Dhok Bun Amir Khatoon and 5 from the locality of Kund. The material comprises maxillary and mandibular fragments, and isolated teeth. The embedded sedimentary matrix was carefully removed with the help of chisels, various types of needles and brushes. The material was carefully washed, cleaned and the broken parts carefully assembled by using various types of gums. The tightly encrusting sediments were removed by using hydrochloric acid, phosphoric acid and acetic acid. A hand lens was used to observe fine details of the studied material for morphological analysis and taxonomy.

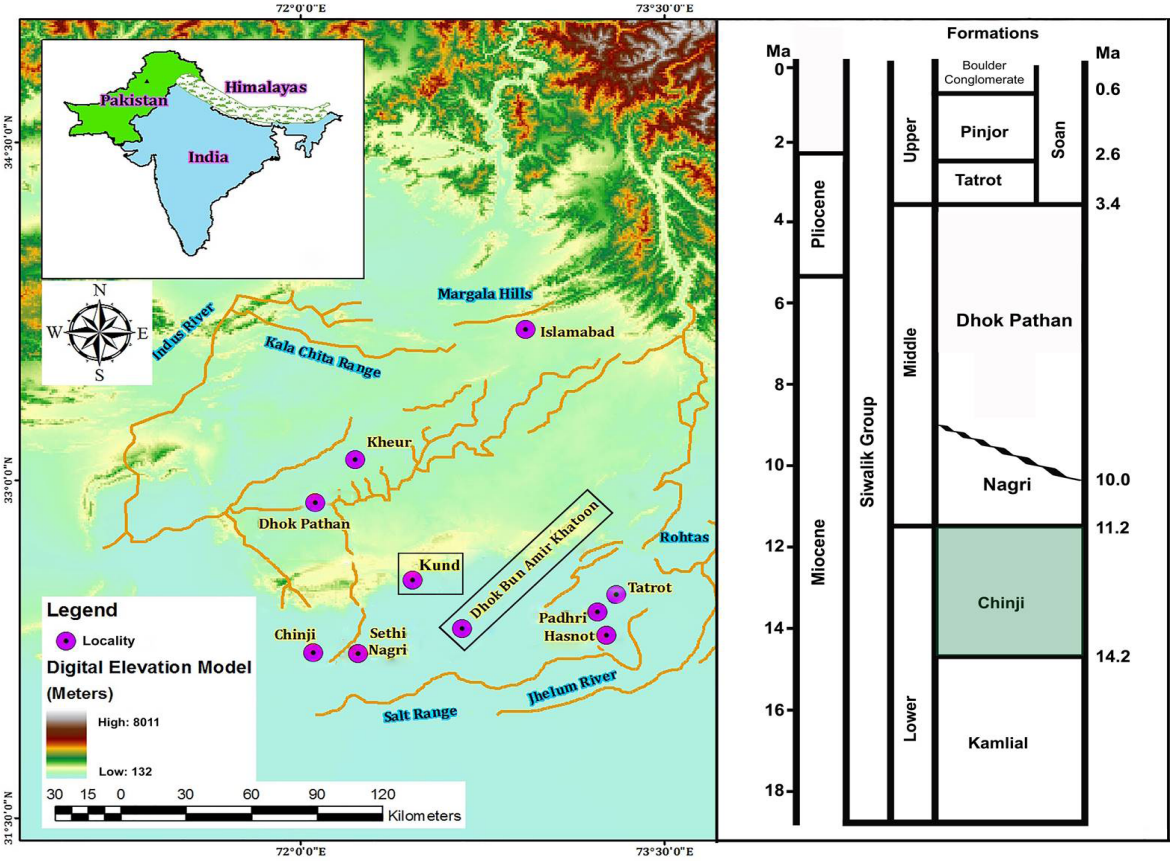

Fig. 1. The locations of Dhok Bun Amir Khatoon and Kund in northern Pakistan where the described material has been found.

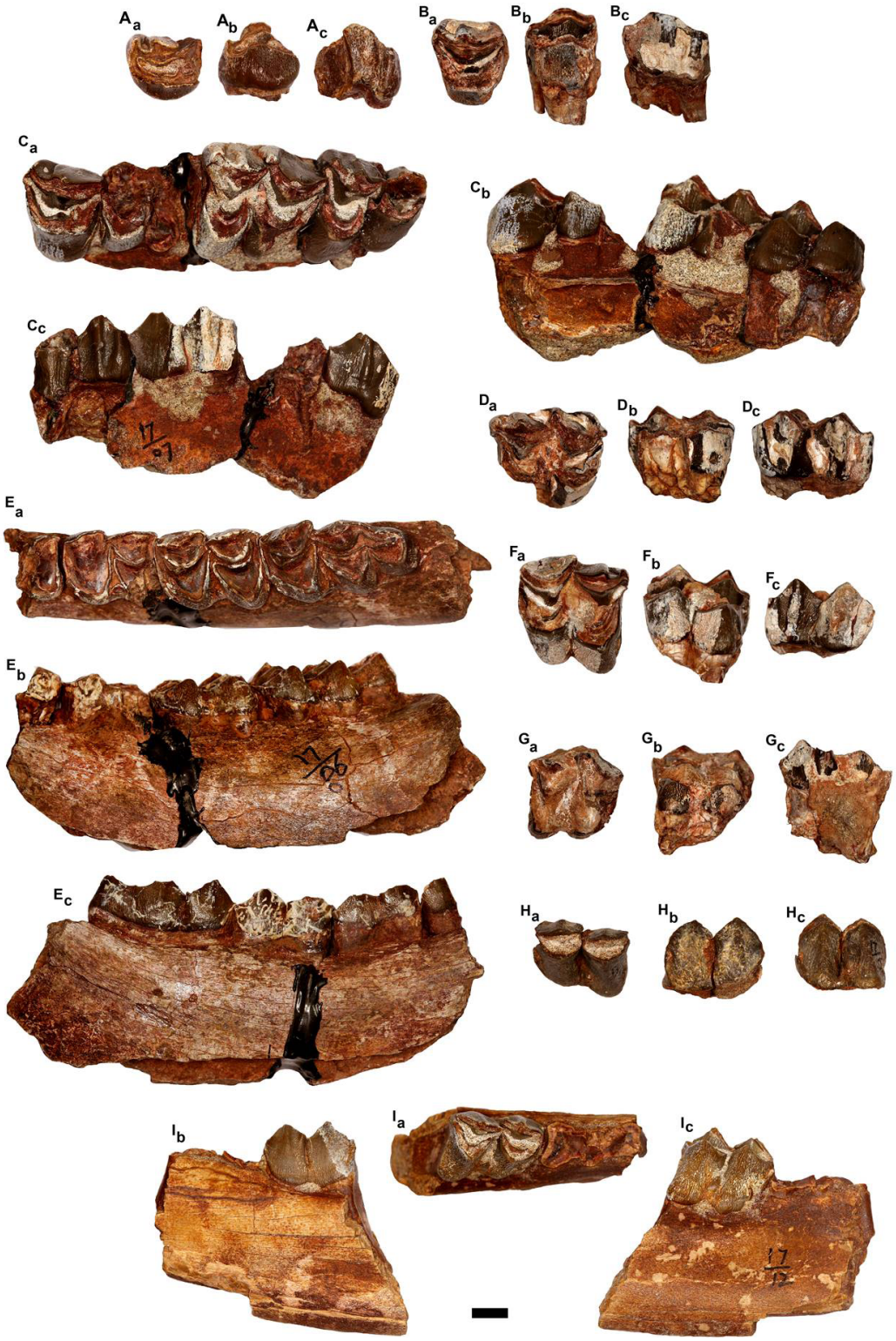

Fig. 2. *Giraffokeryx punjabiensis*: **A**, UOGPC 17/10, lP3; **B**, UOGPC 17/01, lP4; **C**, UOGPC 17/07, a left maxillary ramus with P4-M3; **D**, UOGPC 17/04, lM1; **E**, UOGPC 17/06, lp4–m3. *Giraffa priscilla*: **F**, UOGPC 17/02, lM1; **G**, UOGPC 17/03, lM1; **H**, UOGPC 17/05, rm1; **I**, UOGPC 17/12, lm1. a, occlusal view; b, lingual view; c, labial view. Scale bar = 10 mm.

The prepared remains are kept in the palaeontological collections of the Zoology Department, University of Gujrat, Punjab, Pakistan. The specimens are labelled with inventory numbers, *e.g.* UOGPC 17/05; the collection year is indicated by the numerator and the serial number of the respective year is indicated by the denominator (UOGPC-an institutional abbreviation-University of Gujrat Palaeontological Collection). The capital letter with number (M1) indicates upper dentition and small letter with number (m1) stands for lower dentition.

The collected giraffid material is compared with the respective Siwalik specimens housed in: (i) American Museum of Natural History, New York (AMNH), (ii) Indian Museum, Calcutta (GSI), (iii) Punjab University Palaeontological Collection, stored in the Zoology Department, University of the Punjab, Lahore, Pakistan and (iv) Palaeontology Laboratory of the Zoology Department, GC University, Lahore. The systematic taxonomy followed Solounias (2007) and the terminology used to describe the dental anatomy followed Hamilton (1973) and Gentry *et al*. (1999).

SYSTEMATIC PALAEONTOLOGY

Family Giraffidae Gray, 1821

Subfamily Giraffokerycinae Solounias, 2007

Genus Giraffokeryx Pilgrim, 1910

Type species

Giraffokeryx punjabiensis (Pilgrim, 1910).

New material

lP3 (UOGPC 17/10, Dhok Bun Amir Khatoon), lP4 (UOGPC 17/01, Kund), a left maxillary ramus with P4-M3 (UOGPC 17/07, Dhok Bun Amir Khatoon), lM1 (UOGPC 17/04, Kund), lp4–m3 (UOGPC 17/06, Dhok Bun Amir Khatoon).

Formation and age

The age of the Chinji Formation is considered to be Middle Miocene and more specifically from 14.2-11.2 Ma (Barry *et al*., 2002; Nanda, 2002, 2008).

Description

Upper dentition

P3. The only recovered third premolar is well preserved having a thin cingulum and a crenulated enamel layer (Fig. 2A; Table I). The protocone and the metaconule are oppressed to form a contiguous proto-metaconule complex. Paracone bears a quite low parastyle. An anterior cavity is crescent shaped and shallow, found between protocone and paracone. The tooth is slightly damaged at the posterior side, hence the metacone is not well differentiated. The premolar increases its labiolingual width transversely (Table I).

P4. The fourth premolars are finely preserved and moderately worn (Fig. 2B; Table I). The proto and paracones are similar to that of the above described third premolar. The metaconule is almost worn out forming a dentinal island. The metacone is united with a metaconule at the posterior end, through a narrow channel. The enamel lining of postparacrista extends posteriorly and of premetacrista anteriorly to form a mesostyle which is slightly higher than parastyle and metastyle. The longitudinal valleys are wavy. The premolar is extended lingually (Table I); anterolabially, the P4 forms fold all along the crown height.

M1. The first molars in UOGPC 17/07 and UOGPC 17/04 are half worn and the dentine is mostly exposed (Fig. 2C, D; Table I). The preprotocrista is higher than the postprotocrista. The enamel layer of metaconule is thin and crenulated. The paracone bears a parastyle which is thick proximally but thin distally. Premetacrista and postmetacrista are almost equal in size. The metastyle is produced by the folding of the metacone at its posterior end. Mesostyle is very strong and thicker than the metastyle. The para and metacones bear faint median ribs. The molar is anteroposteriorly elongated and labiolingually is almost cylindrical (Table I).

M2. In general contour, the preserved second molar is squared in outline indicating the presence of a second molar in molar series of specimen UOGPC 17/07 (Fig. 2C; Table I). Protocone is thick and rough perhaps due to weathering. The paracone is sloped posteriorly and directed backwardly to form a parastyle. Mesostyle and metastyle are thick and strong. The molar is almost equal in length and width (Table I).

M3. The third molar is a nicely preserved tooth, similar to the second molar in its general contour. The enamel is thick and wrinkled. The anterior fossette is quite shallow antero-posteriorly but deep in the middle. The posterior fossette is crescentic-shaped and filled by cement. The longitudinal valley is quite uneven, while the transverse valley is wavy and shallow (Fig. 2C; Table I). The molar is more rectangular, with similar length and width (Table I).

Lower dentition

UOGPC 17/06 is a left mandible ramus having p4–m3. It is nicely preserved but mostly worn out and the dentine is exposed on all the principal cuspids (Fig. 2E; Table I). The teeth are narrow crowned and rectangular in their general contour. The fourth premolar is slightly damaged on its anterior side. All cuspids are moderately conspicuous and are present in a straight line. At the antero-lingual side the metaconid is present having a thin and

wrinkled enamel border. Entoconid is present posteriorly to the metaconid. All stylids and median ribs are faint. A four cuspid third molar is moderately worn including its hypoconulid. Transverse valleys are linear and shallow, while longitudinal valleys are wavy. The lower teeth are narrow crowned, representing more length than width (Table I).

Comparison

Three giraffid subfamilies Progiraffinae, Giraffokerycinae and Giraffinae have been reported from the Lower Siwaliks (Colbert, 1935; Solounias, 2007; Aftab *et al*., 2015). Progiraffinae present the following characteristics: bifurcated postmetaconule cristae, well-developed cingula on preprotocristae, postprotocristae and premetaconule cristae are united by an enamel complex (Pilgrim, 1911; Barry *et al*., 2005). The newly collected material (Fig. 2; Table I) is characterized by a relatively higher degree of hypsodonty compared to Progiraffinae. The P3 has a crescentic fossette and it is longer than the P4. In the upper molars, the parastyles, mesostyles, metastyles and median ribs are well developed. Resultantly, the specimens can be referred to the genera *Giraffokeryx* or *Giraffa* (Bhatti, 2005; Khan *et al*., 2010).

Table I.- Comparative dental measurements (millimetres*) of the cheek teeth of the Siwalik Giraffids of the studied specimens.

Taxa	Number	Nature	Length	Width	W/L
Giraffokeryx punjabiensis	UOGPC 17/10*	P3	21.1	20.3	0.96
	UOGPC 17/01*	P4	18.5	22.3	1.21
	UOGPC 17/07*	P4	18.7	22.8	1.22
		M1	22	23	1.04
		M2	26.8	25.7	0.95
		M3	27.2	27.9	1.02
	UOGPC 17/04*	M1	23.7	24.6	1.03
	UOGPC 17/08*	p4	21	14.4	0.68
		m1	22.9	16.3	0.71
		m2	26.1	18.9	0.72
		m3	36.1	18.4	0.51
	GCUPC 1141/09	P3	22.5	21.7	0.96
	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 707/05	P4	19.3	23.5	1.05
	GCUPC 1162/13	P4	19.5	20.5	1.22
	GCUPC 706/05	P4	19.3	23.2	1.20
		M1	26.2	27.1	1.03
	GCUPC 1185/12	M1	27.5	28.0	1.02
	GCUPC 1172/09	M2	27.5	28.3	1.03
	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 1183/12	M2	27.3	25.7	0.94
	GCUPC 1184/12	M2	29.4	28.1	0.96
	GCUPC 1167/12	M2	27.2	25.1	0.92
	GCUPC 1144/09	M2	24.1	26.2	1.09
	GCUPC 1135/09	M2	26.7	25.3	0.95
		M3	25.0	25.5	1.02
	GCUPC 1148/12	M3	27.3	27.9	1.02
	GCUPC 1161/12	p4	22.3	14.1	0.63
		m1	23	16.8	0.73
	GCUPC 1165/13	p4	23.2	15.1	0.65
		m1	24.1	17.3	0.72

Taxa	Number	Nature	Length	Width	W/L
Giraffokeryx punjabiensis	GCUPC 1165/13	m2	25.5	18.1	0.71
		m3	36.1	17.8	0.49
	GCUPC 1150/09	p4	24.0	15.0	0.63
	GCUPC 1175/13	p4	22.5	15.5	0.69
	GCUPC 1152/12	m1	27.3	17.4	0.64
	GCUPC 1156/12	m2	29.0	20.0	0.69
	GCUPC 1146/12	m2	29.5	20.3	0.69
	GCUPC 1143/09	m2	29.5	18.2	0.62
	GCUPC 720/5	m2	25.0	17.5	0.70
	GCUPC 959/08	m3	37.6	17.3	0.46
	GCUPC 1182/12	m3	37.8	17.1	0.45
	GCUPC 1181/12	m3	35.4	16	0.45
	GCUPC 419/01	m3	35.0	16.0	0.46
	GSI B510	P3	21.6	22.5	1.04
	AMNH 19475	P3	20.5	20.0	0.98
		P4	17.5	21.0	1.20
		M1	22.0	24.0	1.09
		M2	25.0	27.0	1.08
		M3	24.5	26.0	1.06
	AMNH 19930	P3	22.0	20.0	0.91
		P4	19.5	23.5	1.21
		M1	26.5	28.0	1.06
	AMNH 19311	P3	19.0	17.5	0.92
		P4	15.0	18.0	1.20
		M1	23.0	22.0	0.95
	PUPC 94/11	P3	23.0	22.0	0.96
	GSI B509	P4	20.6	24.7	1.20
	AMNH 19325	P4	18.0	24.0	1.33
		M2	29.5	27.0	0.92
		M3	27.5	28.0	1.02
	AMNH 19330	P4	17.0	23.0	1.35
	PUPC 94/12	P4	20.0	24.0	1.20
	GSI B504	M1	24.2	25.7	1.06
	AMNH 19593	M1	24.0	24.0	1.00
	AMNH 19334	M1	25.5	25	0.98
		M2	27.0	27	1.00
	PUPC 66/95	M1	26.0	28.0	1.08
	PUPC 94/07	M1	25.0	17.0	0.68
	PUPC 02/157	M1	20.0	21.0	1.05
	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 19632	M3	23	23.5	1.02
	AMNH 19472	M2	27.0	25.5	0.94
		M3	25.0	25.0	1.00
	PUPC 69/37	M2	29.0	29.0	1.00
	PUPC 94/1	M2	27.0	25.0	0.93

Taxa	Number	Nature	Length	Width	W/L
Giraffokeryx punjabiensis	PUPC 94/02	M2	26.0	26.4	1.02
	PUPC 02/13	M2	27.1	27	1.00
	PUPC 94/3	M2	27.5	26.1	0.95
	PUPC 66/95	M2	28.0	28.0	1.00
		M3	27.0	28.0	1.04
	GSI B502	M3	30.3	36.3	1.20
	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
	GSI	M1	28.2	30.8	1.09
	GSI K 13/349	M1	30.0	24.0	0.80
	PUPC 95/23	M1	31.0	27.0	0.87
	PUPC 86/84	M1	21.0	28.0	1.33
	AMNH 19318	m1	27.0	22.0	0.81
G.aff. punjabiensis	E 369	P4	21.4	15.0	0.70
		m1	23.0	17.8	0.77
		m2	24.8	17.7	0.71
		m3	35.2	16.3	0.46
Progiraffa exigua	H 312	P3	18.5	15.1	0.82
		M1	22.3	21.7	0.97
		M2	24.0	25.9	1.08
	H 312	M3	24.3	23.7	0.98
	H 664	M3	26.7	29.1	1.09
	Y 41662	m2	21.2	14.4	0.68

Taxa	Number	Nature	Length	Width	W/L
Progiraffa exigua	H 208	m3	32.1	14.5	0.45
	GSI B 491	m2	21.3	13.8	0.65
		m3	27.2	12.9	0.47
Progiraffa sivalensis	GSI B 492	m3	36.1	17.3	0.48
Giraffa priscilla	UOGPC 17/02*	M1	25.6	26.1	1.01
	UOGPC 17/03*	M1	26.7	26.9	1.00
	UOGPC 17/12*	m1	24.4	16.8	0.69
	UOGPC 17/05*	m1	25.5	15.6	0.61
	GCUPC 1174/09	M1	24.0	24.0	1.00
	GCUPC 1157/12	M1	26.0	26.0	1.00
	PUPC 02/99	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

Referred data are taken from Pilgrim (1911), Matthew (1929), Colbert (1935), Gentry (1990), Barry *et al*. (2005), Bhatti (2005), Bhatti *et al*. (2012a) and Aftab *et al*. (2014, 2015).

In the Middle Miocene Lower Siwaliks of Pakistan, aged 14.2 to 11.2 Ma, *Giraffokeryx* has been recognized by the species *G. punjabiensis,* and *Giraffa* is represented by *G. priscilla* (Basu, 2004; Mahmood *et al*., 2015). Dental morphological features that characterise *G. punjabiensis* are: (i) major cusps and conids in a straight line (Pilgrim, 1911; Bhatti, 2005); (ii) narrow crowned teeth (Bhatti *et al*., 2012a); (iii) spur present in prefossette (Bhatti, 2005); (iv) styles and stylids weakly developed or absent (Pilgrim, 1910; Aftab *et al*., 2014) and (v) the presence of faint median ribs (Colbert, 1935). Based on morphometric features (Table I; Fig. 3), the studied specimens can be assigned to *Giraffokeryx punjabiensis* and can be compared (Table I) with the specimens discussed by Bhatti *et al*. (2012a) and Aftab *et al*. (2015). The structure of the studied P3 and P4 resemble with the type specimen GSI B510 (Pilgrim, 1911) in its antero-posterior length and transverse width. Specimens UOGPC 17/07, UOGPC 17/04, UOGPC 17/06 resemble with the specimens AMNH 19475, AMNH 19930, AMNH 19311, AMNH 19849 AMNH 19323 as discussed by Pilgrim (1911) (Table I). The studied specimens resemble in size (Table I) the holotype of *G. punjabiensis*, therefore, they are attributed to this species. Compared with the already studied specimens of *G. punjabiensis,* the teeth are almost same size with minor variations (Table I).

Subfamily Giraffinae Zittel, 1893
Genus *Giraffa* Brisson, 1762
Giraffa priscilla Pilgrim, 1911

Type species

Giraffa Giraffe Brisson, 1762.

New material

lM1 (UOGPC 17/02, Kund), lM1 (UOGPC 17/03, Kund), rm1 (UOGPC 17/05, Kund), lm1 (UOGPC 17/12, Dhok Bun Amir Khatoon).

Description

Upper dentition

M1. The teeth are excellently preserved, squared in shape, and cusps are not found in a straight line (Fig. 2F, G; Table I). Due to extensive wear, the dentinal valleys of inner and outer cusps have become more exposed. However, they are still separated from each other. Protocone is crescentic and extensively worn out. Metaconule is extensively worn out and dentinal islet is quite large, while its enamel border is corrugated. Premetaconule crista is shorter than postmetaconule crista. Preparacrista and postparacrista are nearly equal in size. Paracone has a thin labial rib and a strong parastyle. Metacone is robust and corrugated and is directed backwardly to form a very strong pillar like a metastyle. Mesostyle and a median rib are well established. The anterior fossettes between protocone and paracone are V-shaped and filled with matrix, while posterior fossettes between hypocone and metacone are shallow. The molars are not significantly larger, have better developed styles and ribs (Table I).

Lower dentition

M1. These are well preserved teeth and their major conids are found not in a straight line (Fig. 2H, I; Table I). Protoconid is extensively worn. The prehypocristid is smaller than the posthypocristid. Meta and entoconids show an inverted V-shape structure. Premetacristids and postmetacristids are nearly equal in size. The entoconids are contiguous with hypoconids posteriorly and metaconids anteriorly. Their maximum height is in the centre with gentle slopes on either side of the crown. Entoconids are supported lingually by prominent central ribs, and distally the entoconid enamel is extended posteriorly to form entostylids, which are lower in height than the mesostylids.

A small basal pillar is present between the labial cuspids. The longitudinal valleys are shallow and open at both ends. The transverse valleys are open labially but some of them are closed lingually.

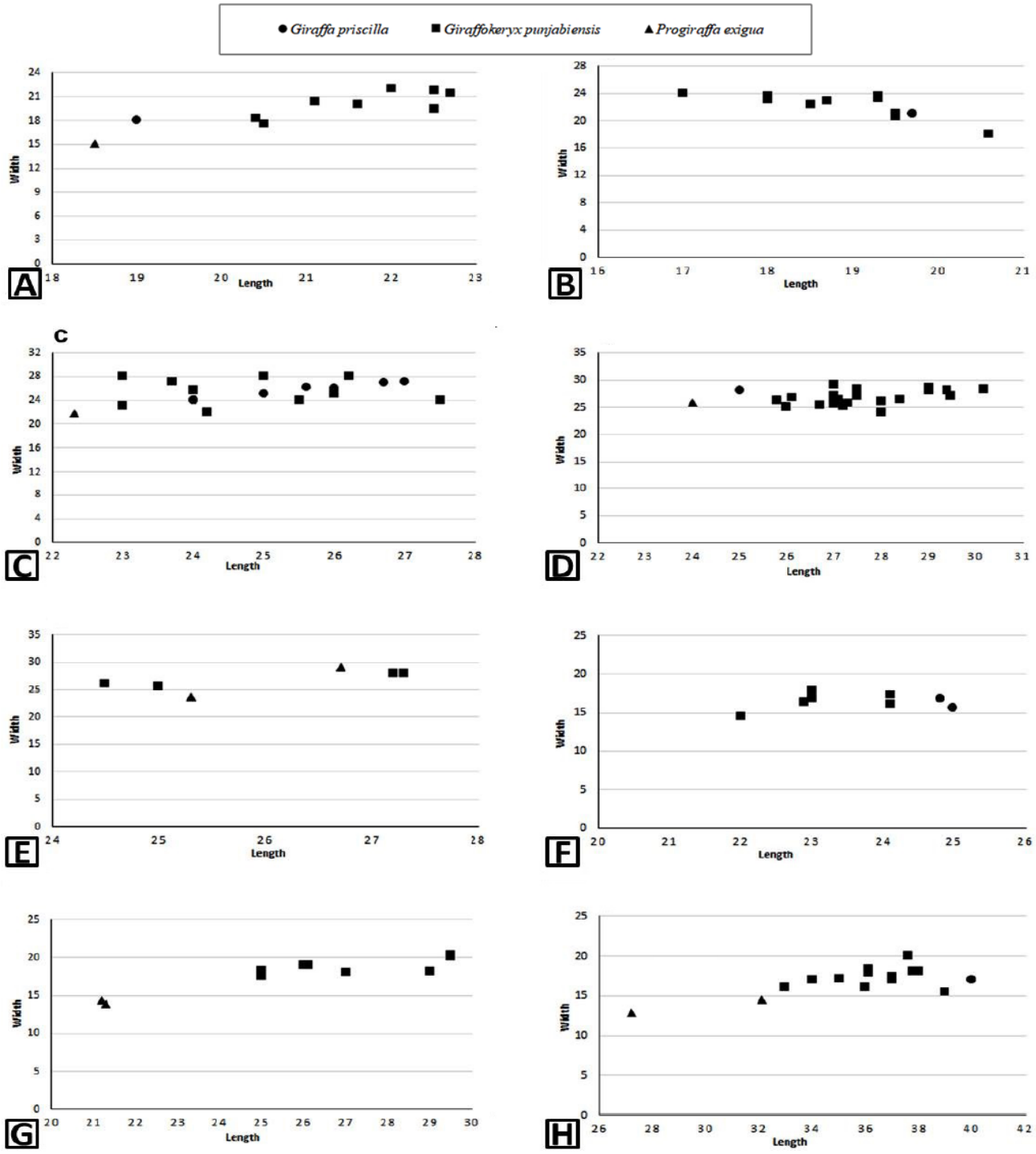

Fig. 3. Scatter diagrams showing dental proportions of the Lower Siwalik giraffids: **A**, P3; **B**, P4; **C,** M1; **D**, M2; **E**, M3: **F**, m1; **G**, m2; **H**, m3. Referred data are taken from Pilgrim (1911), Matthew (1929), Colbert (1935), Gentry (1990), Barry *et al*. (2005), Bhatti (2005), Bhatti *et al*. (2012a, b), Khan *et al*. (2012) and Aftab *et al*. (2013, 2014, 2015, 2016).

Comparison

Morphometrically, the molars (Fig. 2F-I; Table I) resemble the previously collected specimens of the species *G. priscilla,* housed in: (i) AMNH, New York, USA, (ii) Indian Museum, Kolkata, India, (iii) Punjab University Paleontological Collection, stored in Zoology Department, University of the Punjab, Lahore, Pakistan and (iv) the Palaeontology Laboratory of Zoology Department of GC University, Lahore (Table I; Fig. 3) (Matthew, 1929; Bhatti *et al*., 2012b; Aftab *et al*., 2016). *Giraffa priscilla* is recognized by the following characters: (i) major cusps and conids are not in a straight line (Pilgrim, 1911); (ii) crown is relatively broad (Bhatti *et al*., 2012b); (iii) spur is absent in prefossette (Bhatti, 2005); (iv) strong styles, especially metastyle, very strong; stylids are clearly observed; hypoconulid is high and large (Pilgrim, 1910; Colbert, 1935; Aftab *et al*., 2013) and (v) prominent median ribs (Matthew, 1929). Metrically, UOGPC 17/02, UOGPC 17/03, UOGPC 17/05 and UOGPC 17/12 compare well with the referred specimens present in PUPC (Table I) and described by Bhatti (2005) and Bhatti *et al*. (2012a). They resemble in all structural and dimensional details with the earlier specimens of *G. priscilla* (Figs. 2, 3; Table I). The studied specimens show similar metric values (Table I) with the holotype of the small giraffid species of the Siwaliks *G. priscilla* and thus they can be assigned to it.

DISCUSSION

Giraffokeryx punjabiensis and *Giraffa priscilla* have been recovered from the middle Miocene of Dhok Bun Amir Khatoon and Kund. These localities have also produced medium sized bovids and tragulids especially *Dorcatherium* (Dhem, 1963; Thomas, 1984; Khan *et al*., 2008, 2013). The medium sized gazelle community is related to widespread open or bushy landmass at no great distance (Solounias, 2007). A comparison of the dental size of *G. punjabiensis* and *G. priscilla* shows that the Lower Siwalik giraffids are similar in size (Table I; Fig. 3). The dental size of *Progiraffa sivalensis* is also similar to *G. punjabiensis* and *G. priscilla* (Fig. 3; Table I). The presence of the forest inhabitants (*Progiraffa*, *Giraffokeryx*, *Giraffa*, *Hispanotherium*, *Deinotherium*, *Gaindatherium*, *Brachypotherium*, *Listriodon*) as well as *Dorcatherium,* reflects rather a humid climate with woodland to savannah environment at or near the studied localities during the middle Miocene of the Siwalik Group (Khan *et al*., 2008, 2013; Mahmood *et al*., 2015).

It can be assumed that the wooded mean forested areas were the most common habitat for *Giraffokeryx* and *Giraffa*. This is also indicated by the taxonomic composition of the localities (Khan *et al*., 2008, 2013). The taxa show brachydont dentition indicating that the palaeoecosystems were probably favourable for browsers, feeding in woodlands. Moreover, the small sized giraffids seem to have spread to areas where woodland and forest environment predominated. From a palaeogeographical point of view, *Giraffokeryx* and *Giraffa* indicate the existence of a wide land that connected it with the mainland. This land would allow terrestrial mammals without good swimming abilities to spread. *Giraffokeryx* and *Giraffa* were found in the Middle Miocene sequence of the Potwar Plateau and this is likely synchronous with the Eurasian early giraffids between 14 and 11 Ma.

CONCLUSIONS

G. punjabiensis and *G. priscilla* are reported from the middle Miocene localities of the Lower Siwalik Subgroup. The giraffid specimens have been recorded for the first time from the Kund locality of the Chinji Formation. The small sized giraffids were the most successful giraffids in the middle Miocene localities of the Siwalik Group, inhabiting forests and woodlands.

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Supplementary material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.pjz/2019.51.1.177.188

Statement of conflict of interest

Authors have declared no conflict of interest.

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