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GIRAFFOKERYX (ARTIODACTYLA: RUMINANTIA: GIRAFFIDAE) FROM THE POTWAR PLATEAU MIDDLE MIOCENE, PAKISTAN

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ABSTRACT

Giraffokeryx remains are described from Chinji Formation of Lower Siwaliks. The material referred to this species comprises mandible fragments and isolated teeth. The studied specimens have been compared with the relevant specimens in the Geological Survey of India, American Museum of Natural History (AMNH) and Punjab University Paleontological Collection Stored in Zoology Department (Pakistan). The lower cheek teeth are quadrate with a very weak stylids, median ribs and ectosytlids. In most of the specimens, there is a trend towards the heightening of the crown from the lower Chinji to the upper Chinji Formation.

Key words: Giraffids, Giraffokerycinae, Chinji Formation, Lower Siwaliks.

INTRODUCTION

Fossils of giraffes are well-known in Asia, Europe and Africa (Colbert, 1935; Churcher, 1979; Geraads, 1985; West, 1981). The family Giraffidae consists of almost thirty species throughout the Neogene of Old World (Bohlin, 1926; Hamilton, 1978; Geraads, 1986; Janis and Scott, 1987; Gentry and Hooker, 1988). Now it includes only two living genera and species i.e. *Giraffa camelopardalis* and *Okapia johnstoni*. Both species are present in Ethiopian region (Beaufort, 1951; Solounias *et al*., 2000). *Giraffa camelopardalis* is found in Africa below the Sahara while *Okapia johnstoni* is confined to the thick forests of Africa.

Like many other mammalian groups, this family is also well represented in the Siwaliks of Pakistan. Fourteen giraffid species have been reported form the Siwaliks of Pakistan (Khan and Farooq, 2006). Giraffids or their likely ancestors had been present in the Early Miocene from Bugti in Pakistan (Barry *et al*., 2005). In the Lower Siwaliks of Pakistan, three genera of family Giraffidae were found i.e. *Progiraffa, Giraffokeryx* and *Giraffa*.

The First comprehensive study on "The Fossil Giraffidae of India" was made by Pilgrim (1911). He observed great diversity in the Siwalik giraffids. His work was later on reviewed by different workers such as Matthew (1929), Colbert (1935), Sarwar and Akhtar (1987), Sarwar (1990), Barry *et al*. (2005), Bhatti (2005) and Bhatti *et al.* (2007, 2012).

New remains of *Giraffokeryx punjabiensis* describe here have been recovered from five localities i.e. Dhulian, Ghungrila (lower Chinji), Dhok Bun Amir Khatoon, Lava (middle Chinji), and Bhelomar (upper Chinji) of the Lower Siwaliks of Pakistan (Fig. 1). These three levels (lower, middle and upper portion of the Chinji Formation) clearly show a tendency towards the heightening of the crown in most of the specimens.

Geography and geology: The Chinji Formation is exposed in the Potwar Plateau and the Kohat Plateau of Pakistan (Kafayat Ullah *et al*., 2006). The fossiliferous outcrops consist of 70% bright red clay and 30% subordinate ash grey fine to medium grained sandstones. The age of this Formation is from 14.2 to 11.2 Ma (Barry *et al*., 2002; Nanda, 2002, 2008). The Chinji thickness varies from place to place. However, it is estimated from 800 m thick at type locality (near Chinji village) to 2000 m thick in Trans Indus range (Hussain *et al*., 1979).

Dhulian: It is a small village (Late. 32° 39′ N; Long. 73° 43′ E) situated on Pindigheb road (Fig. 1). The fossiliferous beds extend from half km south of the village to the Soan River. The rocks are chiefly bright red clays containing some amount of gypsum. Clays are interbedded with thin layers of light brown sandstones (Khan *et al.*, 2005).

Ghungrilla: It is a railway station (Late. 33° 00′ N; Long. 73° 22′ E) situated on Lahore-Rawalpindi Railway track (Fig. 1). It is about 30 miles away from Jhelum city towards Rawalpindi. About a half km north of railway station, thick bedding of Lower Chinji sandstones with sub ordinate red clay may be seen. The fossils are found in the red clay only (Sarwar, 1990).

Dhok Bun Amir Khatoon: The Miocene fossil site of Dhok Bun Amir Khatoon (Lat. 32° 47' N, Long. 72° 55' E) is located about 16 km northeast of the Chinji stratotype, Chinji Formation (Fig. 1). The outcrops are composed of grey sandstones with red brown mudstones (Cheema, 2003; Khan *et al.*, 2008, 2011).

Lava: The Lava village (Late. 32° 36′ N; Long. 71° 56′ E) is connected with Rawalpindi Mianwali highway and the outcrops are about 11 Km southeast of the village (Fig. 1), comprises grey sandstones, siltstones and reddish shales (Barry *et al*., 2002).

Bhelomar: The outcrops of the Bhelomar area (Late. 32° 43′ N; Long. 72° 27′ E) are upper most Chinji in age (Fig. 1) comprises of bright red clays with subordinate light grey sandstone (Khan *et al*., 2012).

Abbreviations: GCUPC, Government College University Paleontological Collection, Lahore, Pakistan; GSI, Geological Survey of India; AMNH, American Museum of Natural History; PUPC, Punjab University Paleontological Collection, Lahore, Pakistan; l, left; r, Right; P, Premolar; M, Molar; W/L, Width/Length ratio; mm, Millimeters; Ma, Million years ago; s, series (more than one).

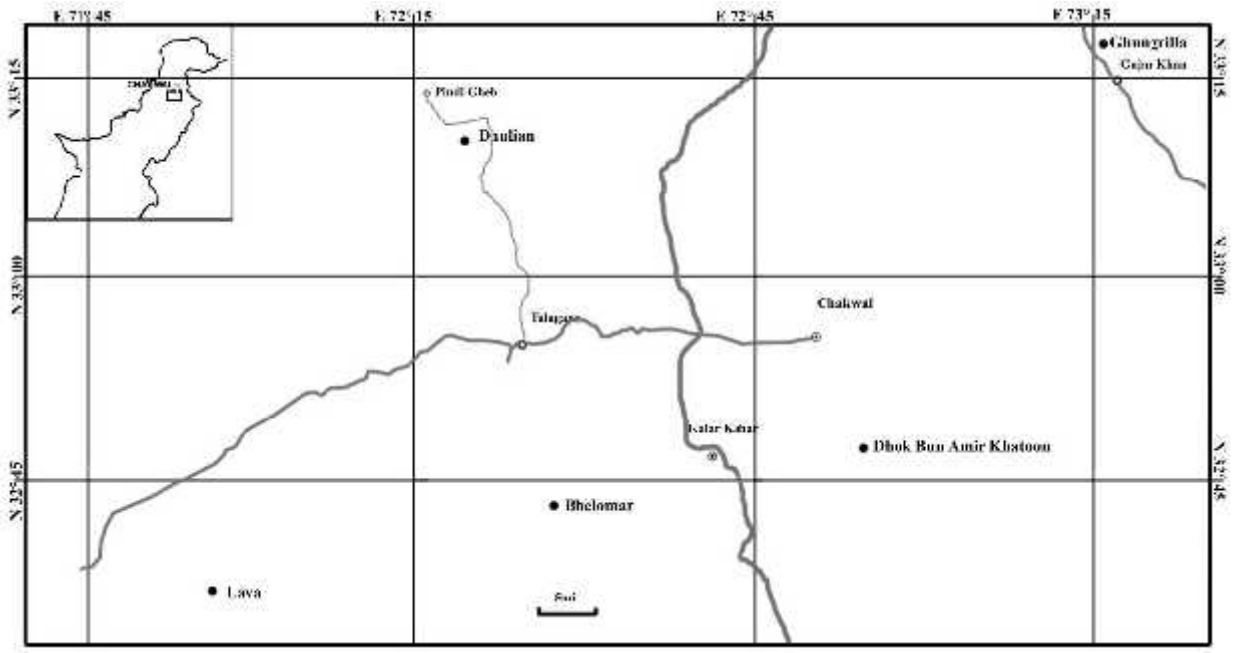

Fig. 1. The location of Dhulian, Ghungrila, Dhok Bun Amir Khatoon, Lava and Bhelomar in northern Pakistan where the described material has been found. Boundary dates are from Barry *et al.* (2002) and Nanda (2002, 2008).

MATERIAL AND METHODS

The material comprises mandible fragments and isolated lower teeth. The clay and siliceous material was removed with the help of chisels, needles, knives and brushes. The specimens were carefully washed. In order to remove the unwanted sediments, phosphoric acid, acetic acid and hydrochloric acid were used. The specimens were catalogued, showing serial number and the collection year e.g. GCUPC 1182/12, the upper figure denotes the serial number and lower one, the collection year.

Photographs were taken with digital camera. Length and width of the teeth were measured at occlusal level, height were measured on the protoconids of lower premolars and metastylids of lower molars. The terminology and identification follow Hamilton, (1973), Janis and Scott (1987) and Gentry (1994).

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

Type species. *Giraffokeryx punjabiensis* Pilgrim, 1910.

Generic diagnosis. Moderate-sized genus having brachyodont cheek teeth with rugose enamel sculpture. Length of limbs and feet is medium. Two pairs of ossicones are present, one projects from anterior extremities of the frontal bone and other pair is situated on the fronto-parietal region. The anterior horns are in front of the orbits, while posterior horns overhanging the

temporal fossa (Pilgrim, 1910; Matthew, 1929; Colbert, 1933, 1935; Solounias, 2007)

Geographic distribution. *Giraffokeryx* is best known from the Siwaliks (Pakistan, India), Dang Valley (Nepal), Belomechetskaia (Russian Federation), Fort Ternan (Kenya) and Turkey (Pilgrim, 1910; Colbert, 1935; Churcher, 1970; Geraads, 1986, Janis and Scott, 1987; Gentry and Hooker, 1988; Gentry, 1990; West *et al*., 1991; Pickford *et al.*, 2000; Geraads and Aslan, 2003; Bhatti, 2005; Bhatti *et al*., 2007, 2012; Khan *et al*., 2010). *Giraffokeryx* is recorded from Southern Asia, Africa and few Astaracian age localities of Europe (Gentry, 1990).

Included species. *Giraffokeryx primaevus* (Churcher, 1970); *Giraffokeryx anatoliensis* (Geraads and Aslan, 2003).

***Giraffokeryx punjabiensis* Pilgrim, 1910**

Lectotype. GSI B502, a third molar of the right maxilla.

Type locality. Chinji village (Lower Siwaliks), Chakwal district, the Punjab province, Pakistan (Colbert, 1935).

Stratigraphic range. Lower Siwaliks and the lower portion of the Middle Siwaliks (Chinji – basal Nagri, Daud Khel Fauna (Mianwali, Punjab), Manchar (Sind, Yale GSP locality 4 and 15) (Pilgrim, 1910; Matthew, 1929; Colbert, 1935; Hussain and West, 1979; Raza *et al*., 1984; Bhatti, 2005; Bhatti *et al*., 2007, 2012; Khan *et al*., 2010)

Geographic distribution. *Giraffokeryx punjabiensis* is recorded from south Asia (Pilgrim, 1910; Colbert, 1935 Bhatti, 2005; Bhatti *et al*., 2007, 2012; Khan *et al*., 2010). It is also known from Eurasia and Greco-Iranian province (Kostopoulos and Sarac, 2005).

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

Localities and age. The Chinji Formation is assigned a Middle Miocene age from 14.2-11.2 Ma (Barry *et al*., 2002; Nanda, 2002, 2008).

New material (in parenthesis the inventory number and the locality name are given). Right P_2–M_1 (GCUPC 1161/12, Dhok Bun Amir Khatoon), right $P_{2\text{-}3}$ (GCUPC 1140/12, Bhelomar), left P_{3s} (GCUPC 1190/12, GCUPC 1171/12, Dhok Bun Amir Khatoon), right P_4 (GCUPC 1150/09, Ghungrilla), right M_1 (GCUPC 1152/12, Dhulian), left M_2 (GCUPC 1156/12, Ghungrilla), right M_2 (GCUPC 720/05, Lava), left M_{3s} (GCUPC 959/08, Bhelomar; GCUPC 1182/12, Dhulian), right M_3 (GCUPC 1181/12, Lava).

DESCRIPTION

GCUPC 1161/12 is a right fragile mandible with P_2–M_1 (Fig. 2(1)). The length of the mandible is about 119 mm. The mandibular ramus is narrow anteriorly and broad posteriorly. It is excellently preserved but damaged lingu-labially.

P_2. The paraconid is present at anterior side of the tooth; it is vertically lower than meta and entoconids. These all cuspids are slightly worn out and are supported by the cingulum and cingular ridges anterolingually. The parastylid and entostylid are conspicuous in both specimens. The proto and hypoconids are almost same in vertical height. The dental morphology in both specimens is similar except the size of the crown. (Fig. 2(1-2))

P_3. The principal cuspids are well differentiated and conspicuous. The paraconid is supported by a thin parastylid anterolingually. The metaoconid and entoconid are closely oppressed forming a complex at the apex of crown surface. The entoconid is provided with pillar like entostylid which runs lingually forming transverse lamellae which are oval in shape and extensively worn out. The anterolabially protoconid is vertically higher than posterolingually hypoconid. It is extensively worn in GCUPC 1140/12 (Fig. 2(2)), but in GCUPC 1190/12 (Fig. 3(1)), it is unworn and covered by a thick layer of cement.

The enamel in the cuspids is thick, shiny and corrugated. The crown is supported by the thick layer of cingulum both labio-lingually. The transverse valley is deep and is open lingu-labially. All these specimens resemble each other except GCUPC 1171/12 (Fig. 3(2)) is worn out from the paraconid, entoconid and hypoconid forming sagittal valley, dentine is exposed on summit of the crown surface.

P_4. The specimens GCUPC 1161/12 and GCUPC 1150/09 (Fig. 3(3)) are inserted in a mandibular ramus. The teeth are quadrangular in shape, almost worn out from summit of the crown. The dentine is exposed forming dentinal valleys in all the cuspids. The protoconid and hypoconid are lower in vertical height than metaconid and entoconid. The crown is surrounded by a thick layer of cingulum and cingular ridges lingually and antero-posteriorly. The cingulum is weakly developed labially. The protoconid is oval in shape supported by robust protostylid which is seriated. The metaconid is inverted V-shape, mostly worn out lingually and labially, dentine is clearly visible.

The central cavity is oval in shape in between the protoconid and metaconid. The metaconid is supported by the metastylid which is incipiently produced. The hypoconid and entoconid are V-shape in structure, largely worn out and dentine is visible in both cuspids. The central cavity in between hypoconid and entoconid is spindle shape, quite shallow having thick enamel boarder. The hypoconid is supported by thin

hypostylid which is produced by the cingular ridges. The cingulum at the posterior end of the tooth is quite thick supported the tooth posteriorly. The dental morphology of both specimens is similar except the state of wearing and shifting of posterior half of the crown posteriorly. The fourth premolar is almost moralized; the four principal cuspids are similar in its outline to that of first molar.

M_1. The lower first molars are excellently preserved and rectangular in shape (Fig. 3(4)). A well-developed cingulum is present labially; it is incipiently lingually. The enamel is thick, shiny and corrugated. The protoconid is V-shaped antero-labially. It is half worn out and dentine is exposed. The cingulum is prominent at the base of protoconid. The preprotocristid and postprotocristid are almost equal in size. The hypoconid is present postero-labially. Its prehypocristid is shorter than posthypocristid. The protoconid and hypoconid are supported by the protostylid, and the crenulated cingular ridges found labially.

The metaconid is moderately worn out; dentine is exposed forming a very large dentinal islands. Its enamel border is thin and wrinkled as compared to the proto and hypoconids. The enamel lining of metaconid folded antero-backwardly to form a thin mesostylid. The preentocristid is much smaller and wavy than postentocristid. The postentocristid extend posteriorly to form a thin entostylid. The metastylid is not prominent. Anterior and posterior median ribs are thin. Both fossettes are V-shaped and narrow. The transverse valley is deep and shallow; open labio-lingually while longitudinal valley is sagittal.

M_2. The molars are excellently preserved and quadrangular in general contour. A pressure mark is present at the anterior and posterior side of the teeth, which suggests that these are second molars. A thick layer of cingulum is more prominent on posterior side of the crown which is multituberculated. The teeth are narrow crowned and moderately worn out exposing the dentine on the apices of crown surface (Fig. 3(5)) and (Fig. 4(1)).

M_3. These are four cuspid teeth with hypoconulid present posteriorly. The teeth are excellently preserved and moderately worn out so that dentals islets develop in all the principal cuspids including hypoconulids. These teeth are elongated and narrow crowned. The hypoconid is moderately worn out and the V-shape dentinal islet is quite conspicuous. It is supported by thick cingular ridges at the labial side of the crown. A small ectostylid is present at the base in between protoconid and hypoconid (Fig. 4(2-4)).

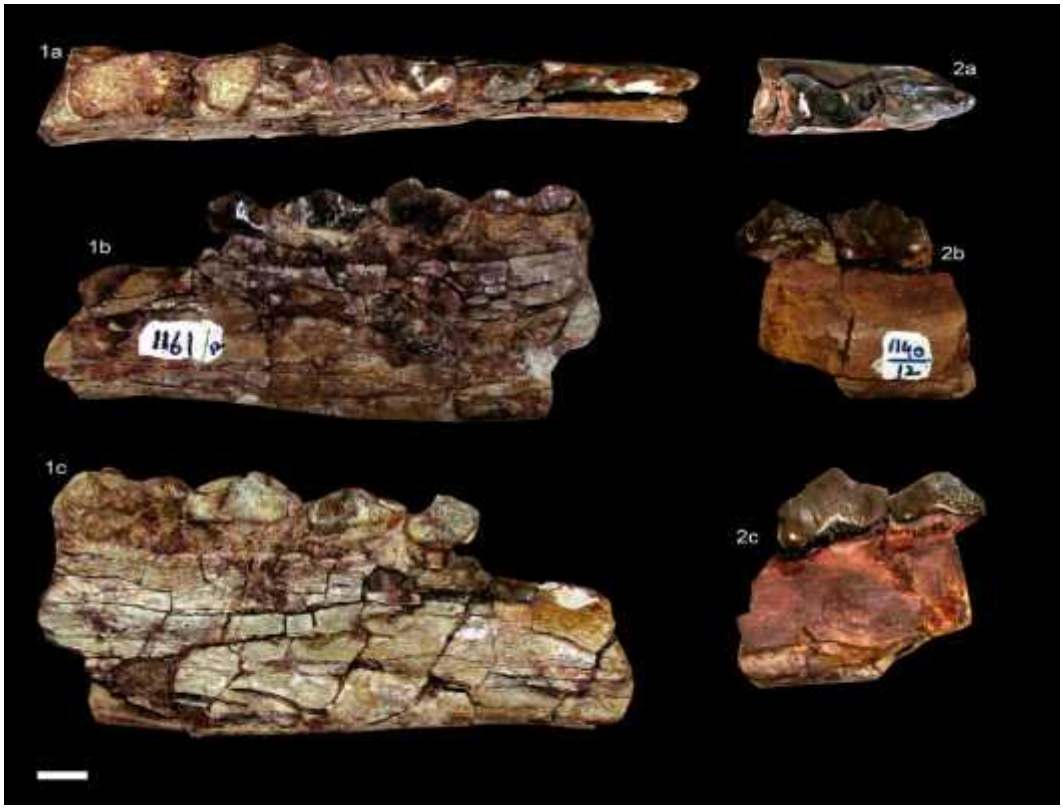

Fig. 2. *Giraffokeryx punjabiensis*: 1. GCUPC 1161/12, rP$_2$–M$_1$. 2. GCUPC 1140/12, rP$_{2-3}$ (a, occlusal view; b, lingual view; c, labial view). Scale bar equals 10 mm total.

Fig. 3. *Giraffokeryx punjabiensis*: 1. GCUPC 1190/12, lP$_3$. 2. GCUPC 1171/12, lP$_3$. 3. GCUPC 1150/09, rP$_4$. 4. GCUPC 1152/12, rM$_1$. 5. GCUPC 1156/12, lM$_2$ (a, occlusal view; b, lingual view; c, labial view). Scale bar equals 10 mm total.

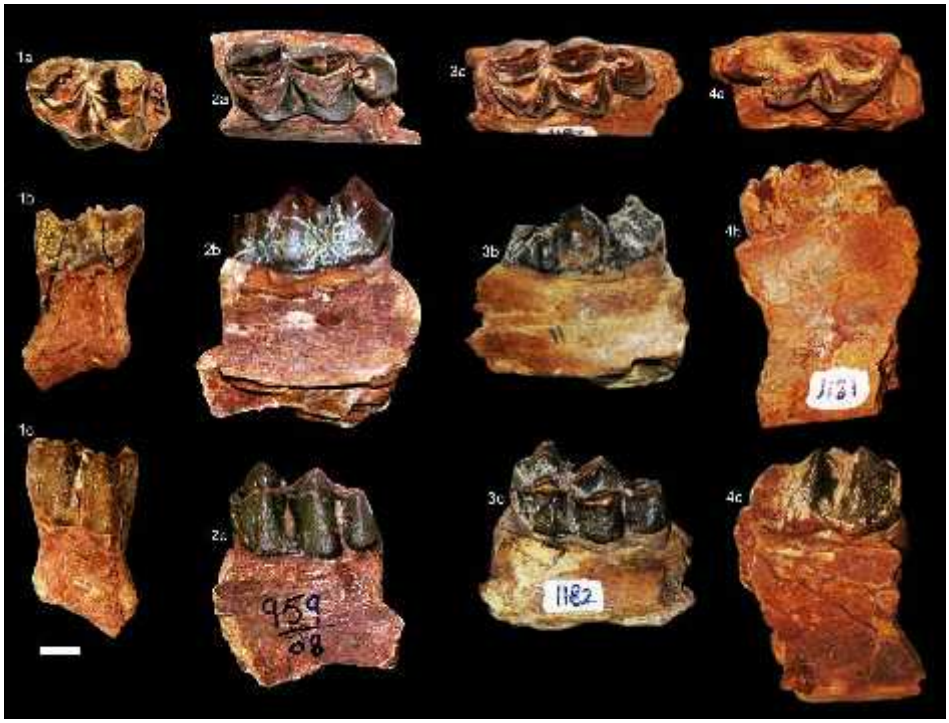

Fig. 4. *Giraffokeryx punjabiensis*: 1. GCUPC 720/05, rM$_2$. 2. GCUPC 959/08, lM$_3$. 3. GCUPC 1182/12, lM$_3$. 4. GCUPC 1181/12, rM$_3$ (a, occlusal view; b, lingual view; c, labial view). Scale bar equals 10 mm total.

Comparison and discussion: The teeth are selenodont and the enamel layer is fairly rugose, so they are referred to Giraffidae (Pilgrim, 1911). The premolars and molars are small in size, so they can be placed into subfamilies Progiraffinae, Giraffokerycinae and Giraffinae. In Progiraffinae (*Progiraffa*) and Giraffinae (*Giraffa priscilla*), stylids and median ribs are well developed. But in these specimens, stylids and median ribs are weak,

ectostylids are tiny or absent, the major conids are in a straight line and the crown is narrow. Lower second and third premolars of *G. punjabiensis* are more rectangular in shape as compared to other genera of family Giraffidae. In P_3, transversal crest are present in the specimens described by Pilgrim (1911) but Colbert (1935) noted that the internal border of P_3 may be closed or open.

In P_4, the anterior lobe is larger than posterior lobe. The lower fourth premolar of *Giraffokeryx* resembles that of *Palaeotragus tungurensis* (*P. primaevis*) (Hamilton, 1978). The P_4 of *Giraffokeryx anatoliensis* is different from *Giraffokeryx punjabiensis* in having bifurcated protoconid (Geraads and Aslan, 2003). The lower first and second molars represent less prominent stylids, median ribs and ectostylids (Figs. 3-4). These characters are present in lower molars of *G. punjabiensis* (Pilgrim, 1910; Colbert, 1935; Gentry, 1990; Bhatti *et al*., 2007, 2012). In M_3, ectostylid is tiny, hypoconid is less twisted and metastylid is less developed (De Bonis *et al*., 1997).

On the basis of these similarities, measurements and W/L index (Fig. 5; Table 1), all the premolar and molars refer to *G. punjabiensis* and can be compared with the specimens present in American Museum of Natural History New York, USA, Indian Museum, Kolkata, India and the Punjab University Paleontological Collection Stored in Zoology Department, University of the Punjab, Lahore, Pakistan (Pilgrim, 1910, 1911; Matthew, 1929; Colbert, 1935; Bhatti *et al*., 2012).

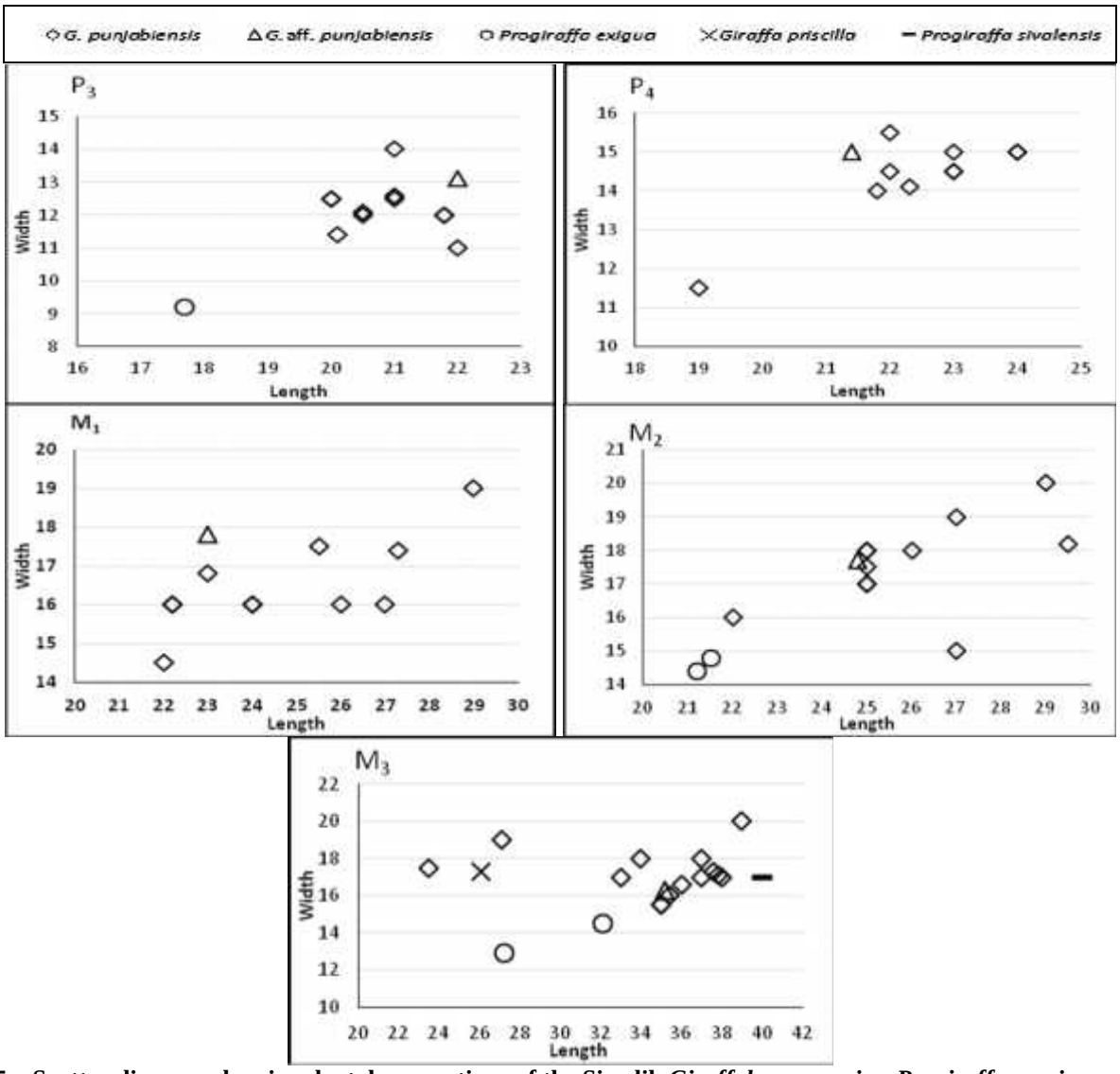

Fig. 5. Scatter diagram showing dental proportions of the Siwalik *Giraffokeryx* species, *Progiraffa* species and *Giraffa priscilla*. Referred data are taken from Pilgrim (1911), Colbert (1935), Gentry (1990), Barry *et al.* (2005), Bhatti (2005), and Bhatti *et al.* (2012).

Table I. Comparative dental measurements of the cheek teeth of the Lower Siwalik *Giraffokeryx* in mm. *the studied specimens. Referred data are taken from Pilgrim (1911), Colbert (1935), Gentry (1990), Barry *et al.* (2005), Bhatti (2005), and Bhatti *et al.* (2012).

Taxa	Number	Nature / Position	Length	Width	W/L
G. punjabiensis	GCUPC 1161/12*	P_2	16.1	9.1	0.57
		P_3	21.0	12.6	0.60
		P_4	22.3	14.1	0.63
		M_1	23.0	16.8	0.73
	GCUPC 1140/12*	P_2	18.0	10.0	0.56
		P_3	20.0	12.5	0.63
	GCUPC 1190/12*	P_3	20.1	11.4	0.57
	GCUPC 1171/12*	P_3	20.5	12.1	0.59
	GCUPC 1150/09*	P_4	24.0	15.0	0.63
	GCUPC 1152/12*	M_1	27.3	17.4	0.64
	GCUPC 1156/12*	M_2	29.0	20.0	0.69
	GCUPC 720/5*	M_2	25.0	17.5	0.70
	GCUPC 959/08*	M_3	37.6	17.3	0.46
	GCUPC 1182/12*	M_3	37.8	17.1	0.45
	GCUPC 1181/12*	M_3	35.4	16.0	0.45
	AMNH 19587	P_2	18.0	9.0	0.50
		P_3	20.5	12.0	0.59
		P_4	24.0	15.0	0.63
		M_1	24.0	16.0	0.67
		M_2	25.0	17.0	0.68
		M_3	37.0	17.0	0.46
	AMNH 19849	P_2	16.0	9.0	0.56
		P_3	22.0	11.0	0.50
		P_4	19.0	11.5	0.61
		M_1	22.0	14.5	0.66
		M_2	22.0	16.0	0.73
		M_3	35.0	15.5	0.44
	PUPC 2002/06	P_2	16.0	9.0	0.56
		P_3	21.0	12.5	0.60
		P_4	23.0	14.5	0.63
	GSI B 496	P_3	21.8	14.0	0.64
	AMNH 19323	P_3	20.0	12.0	0.60
		P_4	22.0	14.5	0.66
		M_1	22.2	16.0	0.72
		M_2	25.0	18.0	0.72
		M_3	33.0	17.0	0.52
	GSI B. 495	P_4	21.8	14.0	0.64
	AMNH 19329	P_4	23.0	15.0	0.65
	AMNH 19324	P_4	22.0	15.5	0.70
		M_1	25.5	17.5	0.69
		M_2	27.0	19.0	0.70
		M_3	38.0	17.0	0.45
	AMNH 19419	M_1	29.0	19.0	0.66
	AMNH 19593	M_1	24.0	16.0	0.67
	AMNH 19320	M_1	27.0	16.0	0.59
		M_2	27.0	15.0	0.56
	AMNH 19332	M_1	26.0	16.0	0.62
		M_2	26.0	18.0	0.69
	GSI B. 493	M_2	25.0	17.0	0.68
		M_3	36.0	16.6	0.46

	AMNH 19317	M_3	37.0	18.0	0.49
	AMNH 19335	M_3	39.0	20.0	0.51
	PUPC 02/12	M_3	34.0	18.0	0.53
	PUPC 02/15	M_3	23.5	17.5	0.74
	PUPC 02/19	M_3	27.1	19.0	0.70
*G.*aff. *punjabiensis*	E 369	P_3	22.0	13.1	0.60
		P_4	21.4	15.0	0.70
		M_1	23.0	17.8	0.77
		M_2	24.8	17.7	0.71
		M_3	35.2	16.3	0.46
Progiraffa exigua	S 412	P_3	17.7	9.2	0.52
	Y 41662	M_2	21.2	14.4	0.68
	H 208	M_3	32.1	14.5	0.45
	GSI B. 491	M_2	21.3	13.8	0.65
		M_3	27.2	12.9	0.47
Progiraffa sivalensis	GSI B. 492	M_3	36.1	17.3	0.48
Giraffa Priscilla	PUPC 02/9	M_3	40.0	17.0	0.43

Conclusions: *Giraffokeryx punjabiensis* is known from the Chinji to Nagri formations of the Siwaliks. It can be differentiated from other Lower Siwalik giraffid genera by tiny ectostylid, less prominent median ribs and weak metastylid. *Giraffokeryx punjabiensis* became extinct during the early part of the Nagri Formation in the Siwaliks.

REFERENCES

Barry, J.C., M.E. Morgan, L.J. Flynn, D. Pilbeam, A.K. Behrensmeyer, S.R. Mahmood, I.A. Khan, C. Badgley, J. Hicks and J. Kelley (2002). Faunal and environmental change in the late Miocene Siwaliks of northern Pakistan. Paleob. 28 (2): 1-71.

Barry, J.C., S. Cote, L. Maclatchy, E.H. Lindsay, R. Kityo, and A.R. Rajpar (2005). Oligocene and Early Miocene Ruminants (Mammalia, Artiodactyla) from Pakistan and Uganda, Palaeont. Electr. 8 (1): 1-29.

Beaufort, L.F.de. (1951). Zoogeography of the land and inland waters. Sidgwick and Jackson, Limited, London. 208 p.

Bhatti, Z.H. (2005). Taxonomy, evolutionary history and biogeography of the Siwalik giraffids. Ph.D. thesis (unpublished). University of the Punjab. Pakistan.

Bhatti, Z.H., M.A. Khan, M. Akhtar, A.M. Khan A. Ghaffar, M. Iqbal and T. Ikram (2012). *Giraffokeryx* (Artiodactyla: Mammalia) remains from the Lower Siwaliks of Pakistan. Pakistan J. Zool. 44(6): 1623-1631.

Bhatti, Z.H., M.A. Qureshi, M.A. Khan, M. Akhtar, A. Ghaffar and M. Ejaz (2007). Individual variations in some premolars of species *Giraffokeryx punjabiensis* (Mammalia, Giraffidae) from Lower Siwalik (Chinji Formation) of Pakistan. Contribution to Geology of Pakistan; Proc. Pak. Geol. Cong. 2004, 5: 261-272.

Bohlin, B. (1926). Die familie Giraffidae. Palaeot. Sin. Pekin. C4 (I): 1-78.

Cheema, I. (2003). Phylogeny and evolution of Neogene murine rodents from the Potwar Plateau of Pakistan and Azad Kashmir with special emphasis on zoogeographic diversification and stratigraphic implications. Ph.D. Thesis (unpublished).University of the Punjab, Lahore, Pakistan.

Churcher, C.S. (1970). Two new upper Miocene Giraffids from Fort Ternan, Kenya, East Africa. Fossil Vertebrates of Africa 2: 1–105.

Churcher, C.S. (1979). The large palaeotragine giraffid. *Palaeotragus germaini*, from Late Miocene deposits of Lothagam Hill, Kenya. Breviora. 453: 1-8.

Colbert, E.H. (1933). A skull and mandible of *Giraffokeryx punjabiensis* (Pilgrim). Am. Mus. Novit. 632: 1–14.

Colbert, E.H. (1935). Siwalik mammals in the American Museum of Natural History. Trans. Am. Phil. Soc. N. S. 26: 1-401.

De Bonis, L., G.D. Koufos, and S. Sen (1997). A Giraffid from the middle Miocene of the island of Chios, Greece. Palaeont. 40(1): 121–133.

Gentry, A.W. (1990). Ruminants artiodactyls of Paşalar. J. Hum. Evol. 19: 529-550.

Gentry, A.W. (1994). The Miocene differentiation of Old World Pecora (Mammalia). Hist. Biol. 7: 115-158.

Gentry, A.W and J.J. Hooker (1988). The phylogeny of Artiodactyla. In: The Phylogeny and Classification of the Tetrapods. 2:

Mammals, pp. 235-272 (ed. M. J. Benton), Systematics Association Special 35B Clarendon, Oxford.

Geraads, D. (1985). *Sivatherium naurusium* (Pomel) (Giraffidae, Mammalia) de Pleistocene de la Republique de Djibouri. Palaont. Z. Stuttgart. 59(3-4): 311-321.

Geraads, D. (1986). Remarques sur la systrematique et la phylogenic des Girffidae (Artiodactyla. Mammalia). Geob. 19: 465-477.

Geraads, D and F. Aslan (2003). Giraffidae from the Middle Miocene hominoid locality of Candir (Turkey). Cour. Forch.-Inst. Senckenberg, Frankfurt. 240**:** 201-209.

Hamilton, W.R. (1973). The lower Miocene ruminants of Gebel Zelten, Libya. *Bull. Br. Mus. (Nat. Hist.) Lond. Geol.* 21(3): 73–150.

Hamilton, W.R. (1978). Fossil giraffes from the Miocene of Africa and a revision of the Giraffoidea. Philos. Trans. Royl. Soc. (Lond). 283**:** 165-229.

Hussain S.T., J. Munthe, S.M.I. Shah, R.M. West and J.R. Lukacs (1979). Neogene stratigraphy and fossil vertebrates of the Daud Khel Area, Mianwali District, Pakistan Mem. Geol. Surv. Pak. 13: 1-27.

Hussain, S.T and R.M. West (1979). Daud Khel local fauna: a preliminary report on a Neogene vertebrate assemblage from the Trans-Indus Siwaliks, Pakistan. Milw. Public Mus. Contrib. Biol. Geol. 16: 1-17.

Janis, C.M and K.M. Scott (1987). Grades and clades in hornless ruminant evolution: the reality of Gelocidae and the systematic position of *Lophiomeryx* and *Bachitherium.* J. Vertebr. Paleontol. 7: 200-216.

Kafayat Ullah, M. Arif and M.T. Shah (2006). Petrography of Sandstones from the Kamlial and Chinji Formations, Southwestern Kohat Plateau, NW Pakistan: Implications for Source Lithology and Paleoclimate. Jour. Hemal. Earth Sci. 39: 2-28.

Khan, M. A., A. Ghafar, Z. Ali, U. Farooq, Z.B. Hameed and M. Akhtar (2005). Report on Mammalian Fossils of Chinji Formation, Dhulian, Pakistan. Am. J. Appl. Sci. 2(12): 1619-1628.

Khan, M.A., M. Akhtar, A. Ghafar, M. Iqbal, A.M. Khan and U. Farooq (2008). Early ruminants from Dhok Bin Mir Khatoon (Chakwal, Punjab, Pakistan): Systematics, Biostratigraphy and Paleoecology. Pak. J. Zool., 40: 457-463.

Khan, M.A., M. Akhtar, G. Rohi, M. Iqbal and K. Samiullah (2011). *Sivaceros gradiens* Pilgrim 1937 (Mammalia, Bovidae, Boselaphini) from the Lower Siwaliks of Dhok Bun Amir Khatoon, Chakwal, Pakistan: Systematics and Biostratigraphy. Turk. J. Zool. 35(2): 281-286.

Khan, M.A., M. Akhtar and T. Ikram (2012). True ungulates from the Nagri type locality (Late Miocene), northern Pakistan. The J. Anim. Plant Sci. Suppl. Ser. 1: 1-59.

Khan, M.A and M.U. Farooq (2006). Paleobiogeography of the Siwalik Ruminants. Int. J. Zool. Res. 2(2): 100-10.

Khan, M.A., S.S. Butt, A.M. Khan and M. Akhtar (2010). A New Collection of *Giraffokeryx punjabiensis* (Giraffidae, Ruminantia, Artiodactyla) from the Lehri Outcrops, Jhelum, Northern Pakistan. Pak. J. Sci. 62(2): 120-123.

Kostopoulos, D.S and G. Sarac (2005). Giraffidae (Mammalia, Artiodactyla) from the late Miocene of Akkasdagi, Turkey. In: Geology, mammals and environments at Akkasdagi, Late Miocene of Central Anatolia (ed.S.Sen). Geodivers. 27: 735-745.

Matthew, W.D. (1929). Critical observations upon Siwalik mammals (exclusive of Proboscidea). Am. Mus. Nat. Hist. Bull. 56: 437-560.

Nanda, A.C. (2002). Upper Siwalik mammalian faunas of India and associated events. J. Asian Ear. Sc. 21: 47-58.

Nanda, A.C. (2008). Comments on the Pinjor Mammalian Fauna of the Siwalik Group in relation to the Post-Siwalik Faunas of Peninsular India and Indo-Gangetic Plain. Quater. Int. 192: 6-13.

Pickford, M., L. Gabunia, P. Mein, J. Morales and B. Azanza (2000). The middle Miocene mammalian site of Belometchetskaya, North Caucasus: an important biostratigraphic link between Europe and China. Geobios. 33: 257-267.

Pilgrim, G.E. (1910). Notices of new Mammalian genera and species from the Tertieries of India-Calcutta. Rec. Geol. Sur. Ind. 40: 63-71.

Pilgrim, G.E. (1911). The fossil Giraffidae of India. Mem. Geol. Sur. Ind. Palaeont. Indic. N. S., 4 (I): 1-29.

Raza, S.M., J.C. Barry, G.E. Meyer and L. Martin (1984). Preliminary report on the geology and vertebrate fauna of the Miocene Manchar Formation, Sind, Pakistan. J. Vertebr. Paleont. 4: 584-599.

Sarwar, M. (1990). A new species of the genus *Giraffokeryx* from Potwar Plateau, Pakistan. Pak. J. Zool. 22(4): 379-385.

Sarwar, M and M. Akhtar (1987). A new *Sivatherium giganteum* from Pabbi Hills of Potwar, Pakistan. Kashmir. J. Geol. 5: 95-99.

Solounias, N. (2007). Family Giraffidae. In: Prothero, D.R.,Foss, S.E. (Eds.), The Evolution of Artiodactyls. The Johns Hopkins University Press, Baltimore, pp. 257–277.

Solounias, N., W.S. McGraw, L. Hayek and L. Werdelin (2000). The Paleodiet of Giraffidae; in Antelopes, deer and relatives. Fossil record, behavioural ecology, systematics and conservation (eds) E S Vrba and G B Schaller (New York: Yale University) chapter 6, pp 84–95.

West, R.M. (1981). Plio-Pleistocene fossil vertebrates and biostratigraphy, Bhittanni and Marwat ranges, north-west Pakistan. In proceedings of the Field Conference on Neogene-Quaternary Boundary, India. 1979, pp. 211-215.

West, R.M., J.H. Hutchison and J. Munthe (1991). Miocene vertebrates from the Siwalik Group, Western Nepal. J. Vertebr. Paleontol. 11: 108-129.