New fossils of *Miotragocerus gluten* from the Lower Siwaliks, Pakistan

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Abstract

The five specimens of *Miotragocerus gluten* were collected from the Lower Siwalik outcrops nearby the villages Chabbar Sayadan and Phadial in Punjab, Pakistan. The newly discovered specimens include the two horn cores and isolated teeth. *Miotragocerus gluten* is the medium-sized bovids, having brachydont to the sub-hypsodont type of dentition. The cusps are elevated, and the crown is surrounded by a rugose enamel layer. The present study reveals the abundance of bovids in the middle Miocene deposits which indicates a grassland ecosystem in this area.

Keywords: Artiodactyla; Chinji; Mammalia; middle Miocene; Siwaliks.

1. Introduction

Siwalik Group is one of the important geological regions of Pakistan which imparts a great contribution to science especially in the field of paleontology. The fossil remains from Lower Siwalik of Pakistan give out much useful evidence and a better understanding of mammalian evolution and biogeography (Asim *et al*., 2020; Khan *et al*., 2017, 2021; Colbert, 1935; Pilgrim, 1913).

The geographical distribution and diversity of *Miotragocerus* have been studied from Indo-Pakistani Siwaliks (Khan *et al*., 2009), Sub-Saharan Africa (Bibi, 2011), China (Zhang, 2005), Asia minor (Kostopoulos, 2005; Kohler, 1987), and Europe (Hartung *et al*., 2020; Fuss *et al*., 2015; Gentry & Kaiser, 2009; Spassov & Geraads, 2004; Morales *et al*., 1999; Stromer, 1928,). Many well-known species are belonging to *Miotragocerus* including *M. cyrenaicus, M. monacensis, M. gluten, M. pannoniae, and M. valenciennesi.* From all these *M. pannoniae* and *M. monacensis* were closely related to each other but *Miotragocerus valenciennesi* is considered as the youngest species (Kirscher *et al*., 2016). This genus also has junior synonyms which include *Dystychoceras, Pikermicerus, Tragocerus, Sivaceros,* and *Graecoryx* (Kostopoulos, 2005).

Miotragocerus also has been recovered from Georgia, Moldova, Ukraine (Korotkevich, 1988; Pevzneret *et al*., 1987; Lungu, 1984), Spain (Moya-Sola, 1983), Iran and Turkey (Kohler, 1987), Germany (Fuss *et al*., 2015; Romaggi, 1987; Tobien, 1953), Austria (Vislobokova, 2007; Thenius, 1948), Bulgaria, Central and Western Europe (Spassov & Geraads, 2004), Pikemi and Samos (Greek), Platania and Nikiti (Greece, Drama Basin) (Vasileiadis *et al*., 2019 Gentry & Kaiser, 2009; Kostopoulos, 2005). *Miotragocerus* were found in the geological time scale of Astaracian and continued to the end of Vallesian and extended to the Turolian time (Gentry & Kaiser, 2009).

The remains of *Miotragocerus* are found in Chinji and Nagri Formations of Pakistani Siwaliks. They feed on shrubs, soft stems, or leaves which indicates that these animals adapt to a special kind of herbivory and are called browsers (Kostopoulos, 2016). The first appearance of *Miotragocerus* was in the middle Miocene and it extend to the late Miocene in Siwaliks. Some remains of *Miotragocerus* large sp. were recovered from the Dhok Pathan localities (Khan *et al*., 2010).

1.1 Geography and Geology

Chabbar Sayadan village (Late. 33° 00′ N; Long. 73° 22′ E) is in District Jhelum (Figure 1), Punjab Pakistan. The outcrops consist of 70% crimson red clay and 30% gray to brown sandstones. (Willis & Behrensmeyer, 1994). The sandstones are tough and cross-bedded. The stratigraphic range of the assemblage area is between 14.2 and 11.2 million years (Barry *et al.,* 2002). Most fossils are observed in claystone.

Phadial village (Late. 32° 83′ N; Long. 73° 16′ E) located in Jhelum valley (Figure 1). The outcrops are red with gray sandstones. It has yielded several mammalian groups such as early tragulids, giraffids, and suids (Sarwar, 1973).

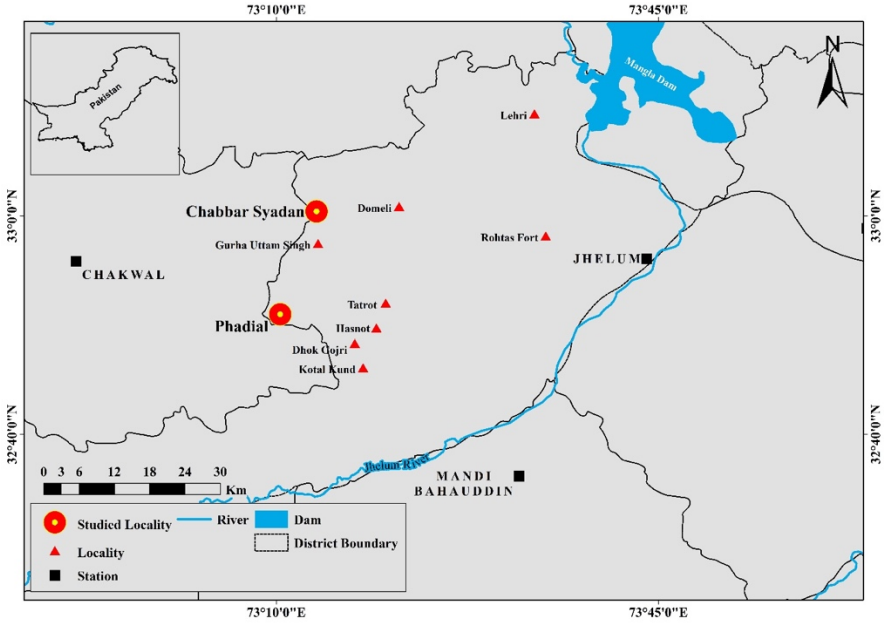

Fig. 1. Location of the middle Miocene sites of Chabbar Sayadan and Phadial in Lower Siwalik of Pakistan. Boundary dates are from Barry *et al.* (2002).

Abbreviations. Ma, million years ago; UOGPC, University of Gujrat Paleontological Collection, Gujrat Pakistan; PC-GCUF, Paleontological collection of Government College University, Faisalabad, Pakistan; AMNH, American Museum of Natural History, New York, USA; MTLA, Mytilini, Greece; PUPC, Punjab University Paleontological Collection, Lahore, Pakistan; M, upper molar; p, lower premolar; m, lower molar; W/L, Width/Length ratio; r, right; l, left; mm, millimeters.

2. Materials and methods

The collections were recovered from Chabbar Sayadan and Phadial outcrops of Lower Siwalik (Figure 1). The isolated upper and lower dentitions were collected in addition to the horn cores for study. Some samples were embedded in the rocks and were collected with the use of a chisel and hammer. Needles were used to remove the tough impurities like claystone and sandstone from the specimens before preparing them for further study.

Metric Vernier Caliper was used to measure the samples, and measurements were taken in millimeters. The numbering on the specimens represents the serial number (denominator) and collection year (numerator) e.g., UOGPC 19/71 in which 19 is the collection year and 71 is the serial number. The studied material was compared to the samples which have been placed in the Paleontological collection of Government College University, Faisalabad, Pakistan (PC-GCUF), American Museum of Natural History New York (AMNH), Mytilini Greece (MTLA), and Punjab University Paleontological Collection stored in Zoology Department, University of the Punjab, Lahore, Punjab, Pakistan (PUPC). The terminology follows Khan *et al*. (2021), Gentry & Hooker (1988).

3. Results

Systematic Palaeontology

Order**:** Cetartiodactyla Montgelard, Catzeflis and Douzery, 1997
Infraorder**:** Pecora Linnaeus, 1758 Sensu Webb, and Taylor, 1980
Family**:** Bovidae Gray, 1821
Subfamily**:** Bovinae Gray, 1821
Tribe**:** Boselaphini Knottnerus-Meyer, 1907
Genus**:** *Miotragocerus* Stromer, 1928

Miotragocerus gluten (Pilgrim, 1937)

New material (in parentheses, the inventory numbers are given). Right horn core (UOGPC 20/79, Chabbar Sayadan); basal fragment of right horn core (UOGPC 20/78, Phadial); rM3 (UOGPC 19/73, Phadial); lp3 (UOGPC 20/76, Chabbar Sayadan); rm3 (UOGPC 20/77, Chabbar Sayadan).

3.1 Description

Horn cores: At the base of the right horn core, a small portion of the frontal and right orbit is preserved (Figures 2a-2d). A prominent infra-orbital foramen is present in the orbit. The pedicel is complete. The horn core is recovered in two pieces with a broken apex. The anterior keel is prominent, and a small step is present at its base. It is slightly compressed laterally at the base, while towards the apex, both sides become rounded. The cross-section at the base is semi-oval but oval at the apex. The total preserved length is 80.19 mm, DAP is 26.20 mm and DT is 14.33 mm.

The basil fragment of the right horn core (Figures 2e-2h) is partially broken at the base anteriorly resulting in the partial loss of the anterior keel. The pedicel is well preserved. At the base of the pedicel, the cross-section is triangular while at the pressurized apex of the horn core, the cross-section is oval. The total preserved length is 35.21 mm, DAP is 25.47 mm and DT is 20.09 mm.

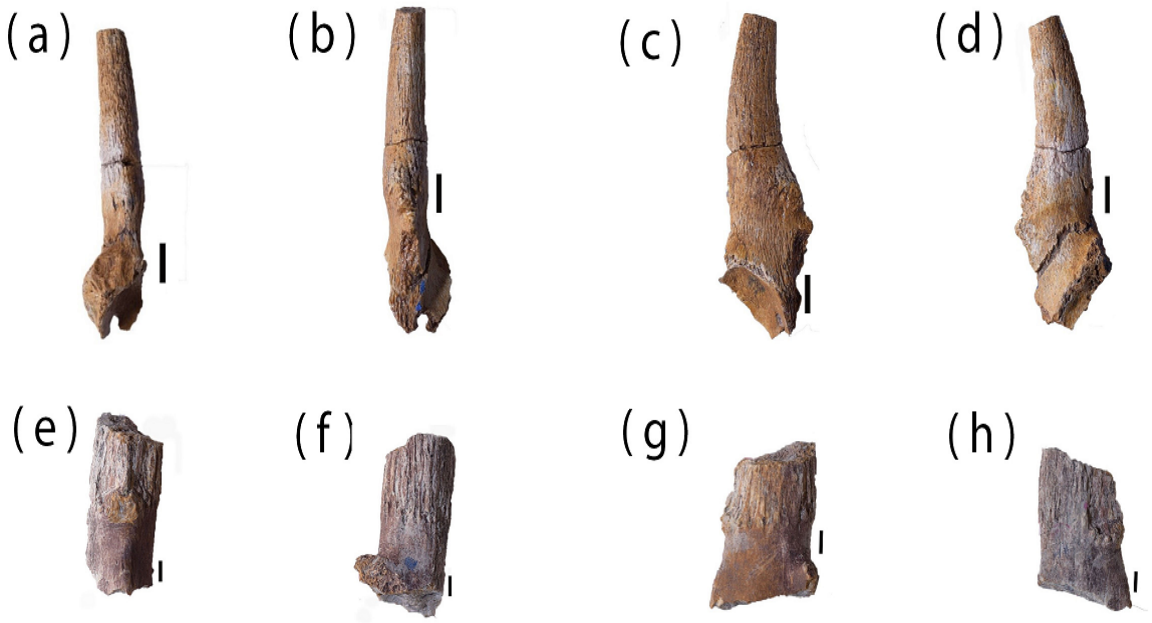

Fig. 2. ***Miotragocerus gluten.*** UOGPC 20/79, Right horn core (a–d); UOGPC 20/78, basal fragment of right horn core (e-h). Views, anterior (a, e); posterior (b, f); medial (c, g) lateral (d, h). Scale bar 30 mm.

Upper dentition: The specimen UOGPC No. 19/73 is an isolated upper third molar of the right side. It is finally preserved, largely worn and the dentine is mostly exposed. A thick cingulum is present at the anterior and lingual side of the crown while it is quite thin at the labial side. The enamel layer is thick shiny and corrugated (Figures 3i-3k). The protocone and paracone are well preserved, but the tooth is partially broken from the posterior side resulting in loss of the apex of the metacone. Both the anterior and posterior fossettes are preserved but

the posterior fossette is narrow anteriorly and broader posteriorly. All the styles are well developed and strong. A thick and strong entostyle covers the medium valleys completely. A weak but prominent cingulum is present at the base of preprotocrista. The paracone rib is well developed and strong. Longitudinal valleys are wavy and deep while transverse valleys are linear and open labially.

Lower dentition: An isolated left p3 (UOGPC 20/76) is well preserved and moderately worn. All the cusps are well developed and prominent (Figure 3l-3m). The protoconid is extensively worn out and form dentinal Island with metaconid and hypoconid. The hypoconid is supported by cingulum and cingular ridges posteriorly. The entoconid is extensively worn out and is contiguous with the metaconid anteriorly. The anterior valley is open and broad while the posterior valleys are closed by a large metastylid that joins the entoconid at the posterior border of the premolar.

The specimen UOGPC 20/77 is an isolated lower third molar of the right side. It is in the late stage of wear. All four types of conids are well preserved. The enamel layer is thick, shiny, smooth, and corrugated. In general contour, it is quadrangular in outline. The anterior fossette is well preserved and C-shaped while the posterior fossette is narrow. The postprotocristid is contiguous with prehypocristid. The mesostylid is well preserved and it is divergent posteriorly. The entoconid is supported by a strong entostylid posteriorly. At its posterior end, a fold is produced in m3 known as hypoconulid (Figures 3n-3p).

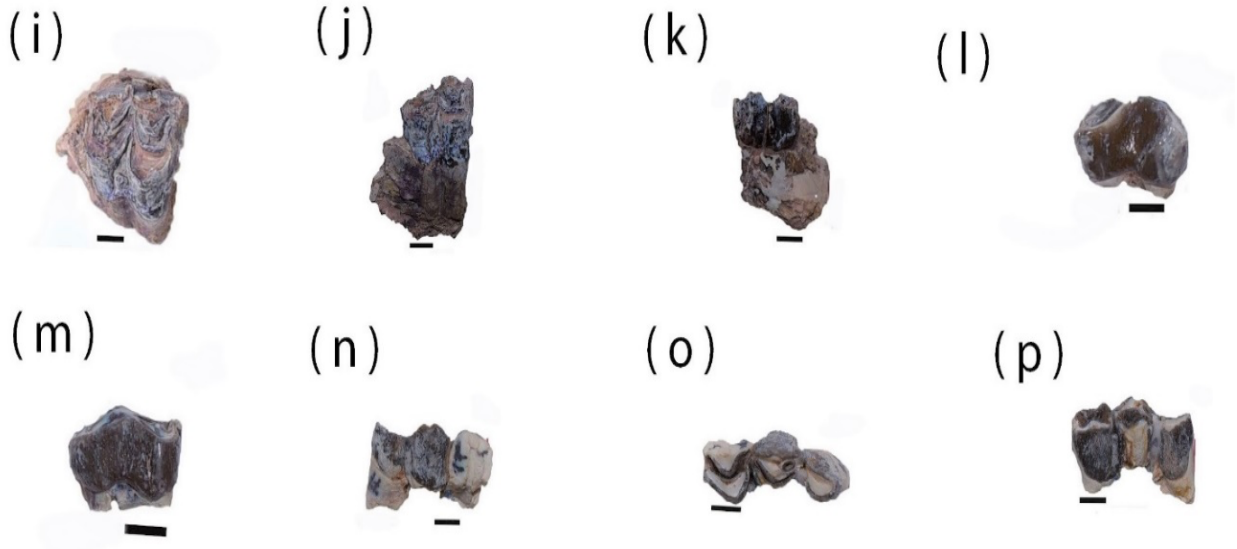

Fig. 3. ***Miotragocerus gluten.*** UOGPC 19/73, rM3(i-k); UOGPC 20/76, lp3(l-m); UOGPC 20/77, rm3 (n-p). views, occlusal (i,o), lingual (j,l,n); labial (k,m,p);. Scale bar 10 mm.

Table 1. Comparative measurements (in mm) of the teeth of ***Miotragocerus gluten*****.** *The studied specimens. Referred data are taken from Iqbal, (2010), Khan *et al*. (2010, 2012, and 2013).

Taxa	Inventory No.	Position	Length	Width	W/L
Miotragocerus gluten	UOGPC 19/73*	rM3	15.07	15.21	1.00
	UOGPC 20/76*	rp3	11.51	8.07	0.70
	UOGPC 20/77*	rm3	26.78	10.06	0.37
	PC-GCUF 11/57	lM3	16.00	16.50	1.03
	PC-GCUF 10/12	p3	12.00	6.20	0.52
	PC-GCUF 11/14	rp3	9.00	5.00	0.55
		rm3	17.00	8.50	0.50
	PC-GCUF 11/13	rm3	17.00	8.00	0.47
	AMNH 29862	M3	16.00	16.0	1.00
Miotragocerus valenciennesi	MTLB 161	M3	19.6	19.0	0.97
	MTLA 190	M3	17.20	15.00	0.87
	MTLA 492	M3	7.40	16.80	0.97
	MTLA 324	M3	19.0	18.50	0.97
	MTLC 25	p3	16.1	8.60	0.53
		m3	24.5	11.8	0.48
	MTLA 299	p3	14.0	8.00	0.57
		m3	21.7	11.8	0.54
	MTLA 284	m3	21.5	11.4	0.53
	MTLA 184	m3	21.1	10.0	0.47
***Miotragocerus* large sp.**	PUPC 83/708	rp3	15.2	6.30	0.41
	PUPC 83/709	lp3	14.0	8.00	0.57
	PUPC 09/86	lm3	25.4	11.4	0.44
***Miotragocerus* sp.**	PUPC 08/20	M3	21.01	9.20	0.43

4. Discussion and comparison

The bovids were in abundance in the Lower Siwalik of Pakistan. The discovered specimen depicts the characters of a medium-sized Bovidae and exhibit the morphology of Miocene boselaphines. *Miotragocerus* and *Tragoportax* are medium-sized boselaphines but *Eotragus, Helicoportax* and *Elachistoceras* are comparatively small size boselaphines (Pilgrim, 1937; Khan *et al*., 2009).

These boselaphines from the Chinji Formation vary in certain characteristics (Khan *et al*., 2009; Thomas, 1984; Pilgrim, 1939, 1937). *Miotragocerus* teeth have a divergent style which is the reason for their inclusion in boselaphine. The upper molars are sub-hypsodont and quadrate in *Miotragocerus gluten* (Table1, Figure 4). In M3 entostyle are smaller than *Tragoportax* (Solounias, 1981). The parastyle and endostyle are very well developed in M3. In the lower premolar, the metaconid is weak and the cavity between the paraconid and metaconid is open and shallow. In the lower 3rd molar, the hypoconulid is compressed transversely. There are certain features of *Miotragocerus* lower molar which include taloned, an anterior flange which is transverse in shape, shiny enamel, convex shape, and a strong mesostylid. The morphological studies and measurements (Table1, Figure 4) show that these newly discovered specimens are similar to the already described remains of *Miotragocerus gluten* (Khan *et al*., 2010; Spassov & Geraads, 2004).

Tangential compression of horn cores is a distinctive feature of *Miotragocerus*. Distinguishing by tangentially constricting horn cores, weak posterolateral keel, little size, clear delineation, and clockwise rotation present the individual characters of *Miotragocerus* (Kostopoulos & Koufos, 1996). It has been found that the horn core of *Miotrgocerus gluten* recovered from central Europe is denser and has a more vertical shape as compared to the *Miotragocerus* (Stromer, 1928). The horn core of *Miotrgocerus gluten* is larger from *Miotrgocerus* cf. *pannoniae* (Kostopoulos & Koufos, 1996). The medial and lateral surfaces of the horn core are flattened, and it is mediolaterally compressed. The anterior keel is sharp, but the posterior keel is absent or poorly developed. A divergent tip and a convergent basal portion are found due to the little torsion at the base of the horn core, in the front view. (Abbas *et al,* 2021). The characteristic features of recovered horn cores are similar to the already described *Miotragocerus gluten*.

The Artiodactyls are in abundance in Lower Siwalik of Pakistan during the middle Miocene age. *Miotragocerus* are medium-sized bovids that prefer wood mean forested areas (Spassov & Geraads, 2004). The bovids together with tragulid indicate a wet and forested landscape. Chinji Formation exbibit half-closed and half-opened woodland ecosystem (Barry *et al*., 2002: Ameen *et al*., 2020).

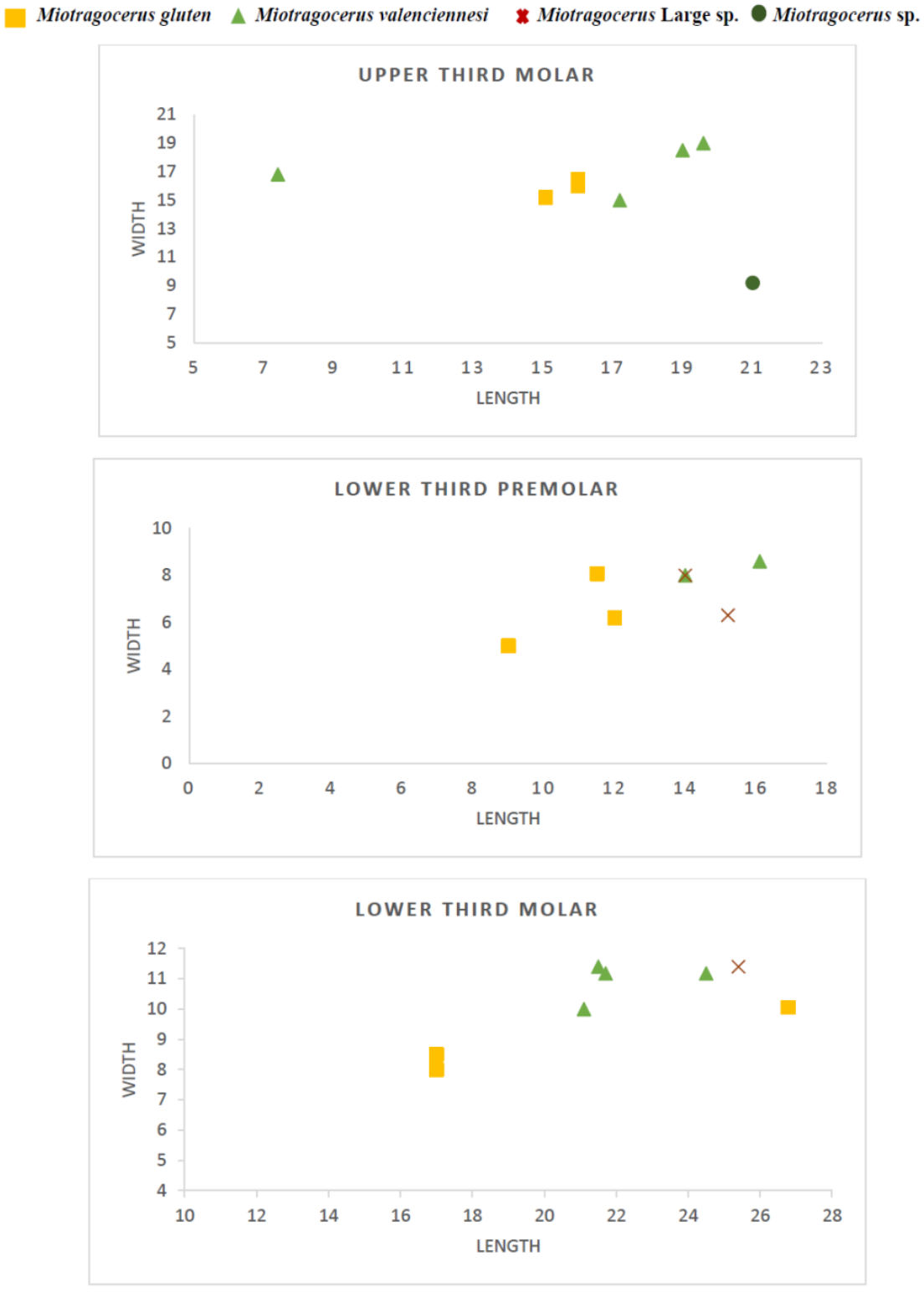

Fig. 4. Scatter diagram showing dental proportions of the *Miotragocerus gluten*. Referred data are taken from Iqbal (2010), Khan *et al*. (2010, 2012, and 2013).

5. Conclusions

Miotragocerus gluten have been recorded from the Chinji Formation of Lower Siwaliks (Pakistan), which is dated to 14.2–11.2 Ma. The cheek teeth are sub-hypsodont with moderately thick and rugose enamel. The middle Miocene boselaphine represents a mixture of habitats, ranging from wetlands with densely forested pockets to woodlands. The early Siwalik bovids with giraffids and tragulids indicate humid, forested habitats.

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