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New Boselaphine Remains from the Dhok Pathan Formation of the Middle Siwaliks, Northern Pakistan

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Abstract.- Boselaphine bovids from the Dhok Pathan Formation of the Middle Siwaliks are identified, described and discussed in this paper. The new remains were recovered from the Tertiary continental deposits nearby Dhok Pathan and Hasnot villages, and three species namely *Selenoportax* cf. *vexillarius*, *Pachyportax* cf. *latidens* and cf. *Tragoportax browni* have been identified. The documentation of the new dental specimens is the objective of this paper. The Dhok Pathan Formation boselaphines suggest an age of the Late Miocene-Early Pliocene of the fosseliferous deposits.

Key words: Boselaphine bovids, Siwaliks, Late Miocene, Dhok Pathan Formation, fosseliferous deposits, *Selenoportax* sp.

INTRODUCTION

The studied specimens have been collected from the fossiliferous outcrops nearby Dhok Pathan village of the district Chakwal and Hasnot village of the district Jhelum, northern Pakistan (Fig. 1). The village Dhok Pathan (Lat. 33° 07′ N: Long. 72° 18′ E) is situated at 27 km from Talagong to Rawalpindi road in the district Chakwal, northern Pakistan and the sediments nearby the village is of the Late Miocene in age (Barry *et al*., 1980, 2002; Khan, 2008). The sediments is highly fossiliferous and is known for the presence of Tertiary fauna since the 19th Century. The Dhok Pathan Rest House section is particularly important because most of the Dhok Pathan fauna of Pilgrim, Brown and Lewis apparently came from the vicinity of the Dhok Pathan Rest House (Matthew, 1929; Colbert, 1935; Akhtar, 1992; Pilbeam *et al*., 1977; Barry *et al*., 2002; Khan *et al*., 2010).

The village Hasnot (Lat. 32° 49′ N: Long. 73° 18′ E) is located at about 70 km west of the Jhelum city in the Potwar Plateau of the northern Pakistan where extensive Neogene freshwater sedimentary rocks are exposed in the vicinity of the village (Khan *et al*., 2009a). The region of the Hasnot exposes the most complete sequence of the Siwalik group and yields a diversified assemblage of the Dhok Pathan Formation (Khan, 2007; Farooq *et al*., 2007a,b, 2008; Khan *et al*., 2006, 2007, 2008a, 2009a, 2010). The average thickness of the sequence around this area is about 180 m at an altitude of almost 326 m.

Besides the boselaphines and other bovids, the fossiliferous layers of the Dhok Pathan Formation have exposed a rich and diverse fauna. The fauna mainly consists of Artiodactyla (Cervidae, Tragulidae, Giraffidae, Suidae), Perissodactyla (Equidae, Rhinocerotidae), Proboscidea (*Trilophodon hasnotensis*, *Synconolophus dhokpathanensis*) and Primates (Cercopethicoids) (Ghaffar *et al*., 2009; Iqbal *et al*., 2009; Khan *et al*., 2008a-b, 2009a-b, 2010, 2011, 2012). Nevertheless, the bovids are considered more common components in the assemblages than the other taxa in the Dhok Pathan Formation (Khan *et al*., 2010). Among carnivores members of the families Canidae, Ursidae, Hyaenidae and Felidae are present. Rarely, crocodilian skates and isolated

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Abbreviations: PC-GCUF, Paleontological Collection of Government College University Faisalabad; PUPC, Punjab University Paleontological Collection; Ma, Million years; M, molar; I, incisor; P, premolar; L, Maximum length; W, Maximum width; l, left; r, right.

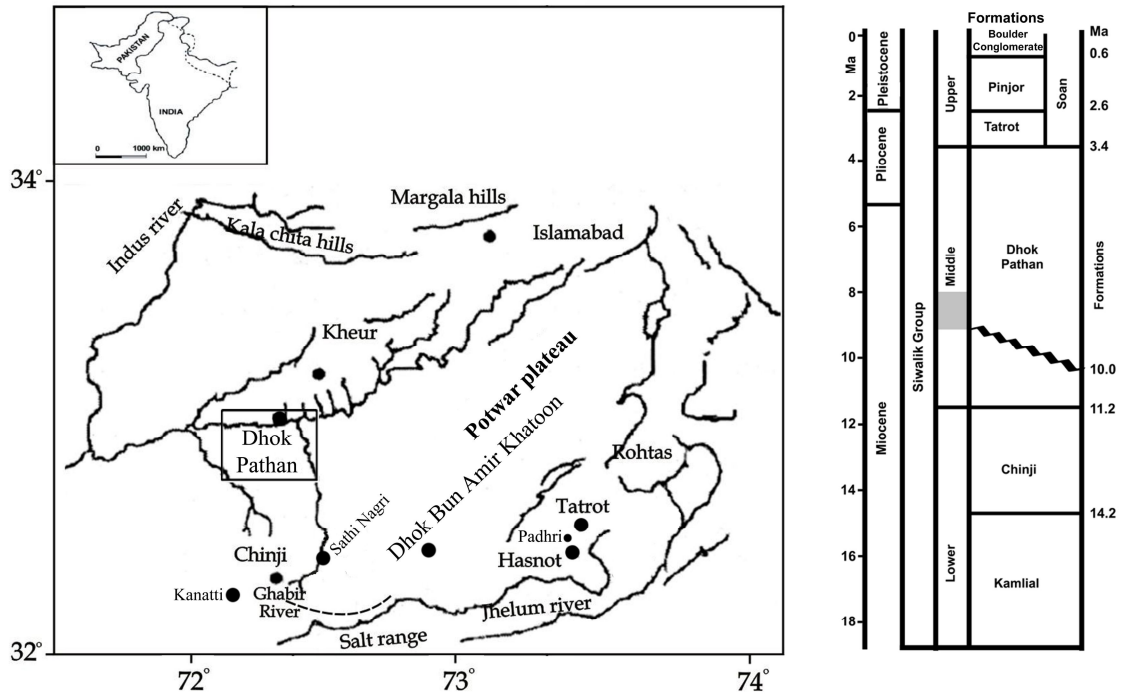

Fig. 1. Potwar Plateau of northern Pakistan indicating the studied areas and a generalized stratigraphic section of the main Siwalik formations (map is modified from Behrensmeyer and Barry, 2005 and the boundary dates are from Dennell *et al*., 2008; Nanda, 2008 and Cohen and Gibbard, 2008).

teeth are also observed (Colbert, 1935; Barry *et al*., 2002). The contribution of this paper is to document new boselaphine specimens from the Dhok Pathan Formation.

MATERIAL AND METHODS

Material

The material was collected from the fossiliferous outcrops of Hasnot and Dhok Pathan villages of the Potwar Plateau (Fig. 1). The sediments belong to the Dhok Pathan Formation (Late Miocene) of the Siwalik group (Barry *et al*., 2002). Some fossils were easily available for collection as they were exposed on the surface but some were partially embedded. For the excavation of the partially embedded fossils, piercing instruments such as chisels and geological hammers were employed and precaution measures were taken to prevent the fossils from disintegrating during excavation. To avoid the damage or shocks of transportation, each specimen was carefully wrapped with cotton. The specimens were successfully brought to the Palaeontology laboratory of Zoology Department, GC University, Faisalabad, Punjab, Pakistan.

Methodology

All specimens were carefully observed for the description of taxonomic and morphological characters along with a discussion of their systematic determination. Measurements were taken with calipers to the nearest 0.1 mm. The specimens have been catalogued with a yearly and a serially code number. So the numerator number written on the specimens represents the collection year and the denominator represents the serial number of that year. Upper case letter stands for upper teeth and lower case for lower teeth.

The terminology and measurement method follows Gentry *et al.* (1999).

Source of the comparative material

Pilgrim (1937, 1939) and Khan *et al.* (2009a,

2010). Identification of the dental assemblage up to the species level is somewhat difficult because of the lack of the horn cores and the associated skulls. Nevertheless, the morphometric characters of the dental material are pretty comparable to the species *Selenoportax vexillarius, Pachyportax latidens* and *Tragoportax browni* and allow us to assign the studied material to *Selenoportax* cf. *vexillarius Pachyportax* cf. *latidens* and *Tragoportax* cf. *browni*.

SYSTEMATIC PALAEONTOLOGY

Order Artiodactyla Owen, 1848
Suborder Ruminantia Scopoli, 1777
Family Bovidae Gray, 1821
Subfamily Bovinae Gray, 1821
Tribe Boselaphini Knottnerus-Meyer, 1907
Genus *SELENOPORTAX* Pilgrim, 1937

Selenoportax cf. *vexillarius* Pilgrim, 1937

New material

PUPC 96/05, lM1; PC-GCUF 01/03, right mandibular fragment with m2-3; PC-GCUF 10/02, rm3; PUPC 85/25, rm3.

Description

PUPC 96/05 is partially preserved, damaged lingually and presenting a middle degree of wear (Fig. 2(A)). It is almost quadrate and narrow at its base. The paracone and the metacone are well preserved while the protocone and the hypocone are missing. The enamel is much wrinkled all over the crown and its average thickness is about 1.1 mm. The entostyle is damaged. The tooth shows a dentinal islet due to middle wear. Transversely, the protocone is narrower than the hypocone. The paracone is relatively smaller in antero-posterior length than the metacone. The parastyle and mesostyle are well developed. The paraconus rib is more prominent than the metaconus rib.

PC-GCUF 01/03 comprises a left lower mandibular ramus with m2 and m3 (Fig. 2B). The length of the mandibular ramus is 69.3 mm. The second molar is well preserved except the metaconid which is broken. It is in late stage of wear. It is hypsodont and narrow crowned. The entostyle is moderately developed. The fossettes are narrow and have no indentation. The enamel is rugose lingually as well as labially. The protoconid is relatively wider than the hypoconid. The paraconid and the metaconid are approximately equal in their antero-posterior length. In the m3 the hypoconulid is partially broken distally. PC-GCUF 10/02 and PUPC 85/25 are lower third molars (Fig. 2C). The molars are in early stage of wear. The anterior transverse flange is present. The major conids are well preserved. The ectostylid is very pointed. The hypoconulid is missing in PUPC 85/25. The comparative measurements of the molars are provided in Table I.

Discussion

The studied specimens are characterized by large size, strong rugosity, the strong entostyle/ectostylid, the prominent ribs and the strong divergent styles. These characters are in agreement with the large-sized Siwalik boselaphines (Pilgrim, 1937, 1939; Khan *et al*., 2009a). Large-sized Siwalik boselaphines are represented by two genera *Pachyportax* and *Selenoportax*. *Pachyportax* molars are squarish equally labio-lingually. The studied sample (Fig. 2(A-C)) is clearly constricted basally labio-lingually that exclude the specimens from the genus *Pachyportax* and favor their inclusion in the genus *Selenoportax* (Khan *et al.*, 2007).

Selenoportax is represented by two species in the Siwaliks, *S. vexillarius* and *S. lydekkeri* (Pilgrim, 1937, 1939; Khan *et al*., 2009a). *S. lydekkeri* is a larger sized species than *S. vexillarius* (Pilgrim, 1937, 1939; Khan *et al.*, 2009a). The dimensions and the morphology of the studied material reveal all the features of the species *S. vexillarius*. The paraconid, parastylid, protoconid, entoconid, and the development of the stylids are fairly similar to the holotype specimens of *S. vexillarius* (Pilgrim, 1937). The sample shows the same basic features of the species such as the increased antero-posterior diameter near the summit of the crown and the strong development of styles/stylids and ribs (Khan *et al.*, 2007). Nevertheless, as the material is insufficient, it can be assigned to *S.* cf. *vexillarius*, based on the studied morpho-metric features (Table I).

Table I.- Comparative measurements of the cheek teeth of the studied boselaphines in mm (mm).

Taxa	Number	Nature/Position	Length	Width	W/L
S. cf. *vexillarius*	PUPC 96/05*	lM1	23.4	--	--
	PC-GCUF 10/03*	rm2	26.0	16.4	0.63
		rm3	34.0	16.4	0.43
	PC-GCUF 10/02	rm3	31.5	13.5	0.43
	PUPC 85/25	rm3	--	13.0	--
S. vexillarius	PUPC 87/19	rM1	24.2	21.5	0.88
	PUPC 04/1	lm2	27.9	16.1	0.57
		lm3	31.4	16.0	0.50
	PUPC 98/78	lm2	25.0	16.0	0.64
		lm3	36.0	15.0	0.41
	PUPC 04/12	lm2	20.0	12.5	0.62
	PUPC 87/90	lm3	38.0	16.5	0.43
	AMNH 10514	lm3	33.0	15.0	0.45
	AMNH 19844	lm2	25.9	16.5	0.63
	AMNH 19514	lm2	22.0	15.5	0.70
	AMNH 29917	lm2	21.0	15.0	0.71
	AMNH 19514	lm3	33.0	21.5	0.65
P. cf. *latidens*	PC-GCUF 09/12*	lM3	28.5	28.5	1.00
	PUPC 96/04*	rM3	37.3	30.5	0.82
	PUPC 96/38*	rM3	30.0	26.5	0.88
	PC-GCUF 09/14*	rp4	22.0	12.0	0.55
	PUPC 68/171*	lm1	28.0	19.0	0.68
P. latidens	PUPC 96/42	lM3	33.2	22.5	0.74
	PUPC 01/24	lM3	28.4	25.0	0.88
	PUPC 96/38	lM3	34.4	29.0	0.84
	GSI B219	lM3	34.5	28	0.81
	AMNH 29914	lM3	36.0	34.0	0.94
	AMNH 29913	lM3	31.0	29.0	0.93
	AMNH 19730	lM3	29.5	27.0	0.91
	GSI B268	m1	24.0	10.0	0.41
cf. *T. browni*	PC-GCUF 10/13*	li1	16.0	14.0	0.87
	PC-GCUF 10/12*	rP4	14.0	15.5	1.09
		rM1	20.0	20.0	1.00
		rM2	22.0	22.0	1.00
T. browni	AMNH 19662	P4	12.5	17.0	1.36
		M1	18.0	18.0	1.00
		M2	20.0	20.0	1.00
	PC-GCUF 09/43	rP4	12.0	13.0	1.08
	PUPC 83/689	lM1	18.0	18.0	1.00
	PUPC 86/151	lM1	19.0	18.0	0.94
	PUPC 86/29	lM1	18.0	16.0	0.88
	PUPC 83/861	lM1	16.0	16.0	1.00
	PUPC 86/151	lM2	21.0	17.5	0.83
	PUPC 86/29	lM2	20.5	18.0	0.87
	PUPC 97/80	lM2	21.0	19.0	0.90
	PUPC 83/662	rM2	20.0	18.0	0.90
	PUPC 87/324	rM2	18.0	15.0	0.83

*The studied specimens. Referred data are taken from Pilgrim (1937, 1939), Akhtar (1992) and Khan *et al.* (2009a, 2010).

Genus *PACHYPORTAX* Pilgrim, 1937
Pachyportax cf. *latidens* Pilgrim, 1937

New material

PC-GCUF 09/12, lM3; PUPC 96/04, rM3; PUPC 96/38, rM3; PC-GCUF 09/14, rp4; PUPC 68/171, lm1.

Description

PC-GCUF 09/12, PUPC 96/04 and PUPC 96/38 are three isolated last molars of the upper molar series. The molars show excellent state of preservation (Figs. 2D-F). The crown is almost quadrate. The metastyle is bulky. The enamel is thick especially around the protocone and the hypocone. A very well developed entostyle is present in the median valley extending transversally, forming two prominent enamel islets. The labial cones are relatively higher vertically than the lingual ones. Transversely, the protocone is relatively narrower than the hypocone. The prae-protocrista is longer than the post-protocrista. The mesial half of the protocone projects distally more inwardly than that of the hypocone. The parastyle is well developed. The mesostyle is strongly developed having greater height than the parastyle. The paracone rib is strongly developed while the metacone rib is weak. The former is visible at the base of the crown while the later becomes wider as it approaches the base of the tooth. The pre-hypocrista is thicker than that of the post-hypocrista.

PC-GCUF 09/14 is a fourth lower premolar in an early stage of wear (Fig. 3(A)). The paraconid of the premolar is well projected. It is clearly separated from the parastylid. A furrow is present between the paraconid and the parastylid. The protoconid rib on the labial side is less projected. A rib- like structure is present on the lingual side downward from the protoconid. The metaconid and entoconid are separated by a deep longitudinal depression. The hypoconid is well projected. The protoconid is the highest conid. PUPC 68/171 is an isolated first lower molar of the left side (Fig. 3B). The crown of the tooth is almost rectangular. A very well developed ectostylid is present which is relatively wide at the base of the tooth. All the conids are well developed. The pre-protocristid is longer than the post-protocristid. The comparative measurements are provided in Table I.

Discussion

The teeth show all the basic features of the genus *Pachyportax*: Large-sized, with quadrate upper molars and strong entostyle extended transversely; the crown is not extended at the apex, relatively strong styles and ribs, enamel moderately

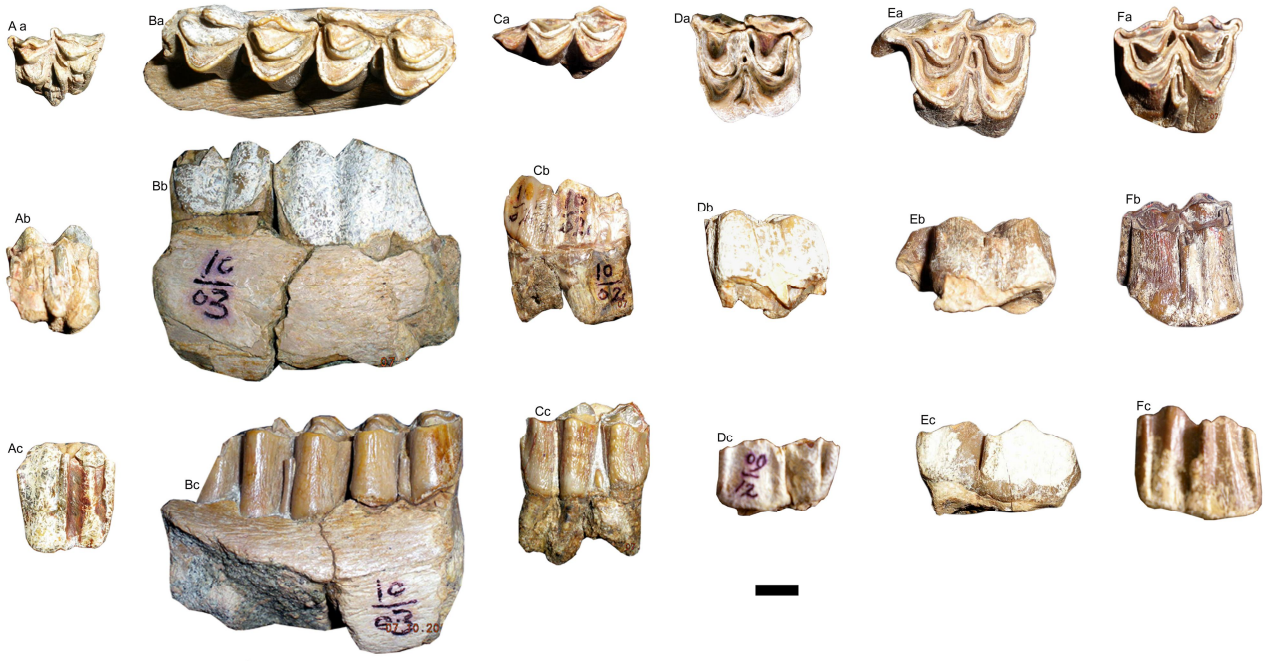

Fig. 2. *Selenoportax* cf. *vexillarius*: A. PUPC 96/05 – lM1. B. PC-GCUF 01/03 – a right mandible fragment with m2-m3; C, PC-GCUF 10/02 – rm3. *Pachyportax* cf. *latidens*; D, PC-GCUF 09/12 – lM3. E. PUPC 96/04 – rM3. F. PUPC 96/38 – rM3. a, occlusal view; b, lingual view; c, labial view. Scale bar equals 10 mm.

thick and rugose with traces of cement (Pilgrim, 1937, 1939; Khan *et al.*, 2007, 2009a). In *Selenoportax* the crown is narrow at the base and broad at the apex whereas in *Pachyportax* the crown is not extended occlusally at the apex. *Pachyportax* has a strong entostyle extending transversely, while in *Selenoportax* it is not considerably extended (Khan *et al.*, 2007).

The Middle Siwaliks is represented by two species of *Pachyportax*, the large-sized *P. latidens* and small-sized *P. nagrii* (Pilgrim, 1937, 1939; Khan *et al.*, 2009a). Metrically, the studied samples are comparable to *P. latidens* (Figs. 2-3; Table I). Nevertheless, as the recovered material is insufficient, it can be assigned to *P.* cf. *latidens*. The described specimens give additional information about the upper and lower dentitions of the species.

Genus *TRAGOPORTAX* Pilgrim, 1937
cf. *Tragoportax browni* (Pilgrim, 1937)

New material

PC-GCUF 10/13, li1; PC-GCUF 10/12, right maxillar fragment with P4-M2.

Description

The right lower incisor is in early wear and has a simple out-line (Fig. 3C). The incisor has a wide cutting edge with the outer angle pulled out-words. In mesial view the crown is slightly inclined upwards. PC-GCUF 10/12 is a partially damaged maxillar fragment (Fig. 3(D)) and most of the occlusal characters are vanished. It comprises one premolar and two molars. The P4 is relatively long, slender and horse shoe-shaped (Fig. 3(D)). The parastyle is strong and divergent. The mesostyle is weak and its posterior end is connected with the base of the parastyle. The M1 is in a late stage of wear and damaged. Most of the occlusal morphology is worn. Nevertheless, the entostyle is present. The M2 is partially broken and the morphological characters are invisible. The cones are poorly preserved. The damaged entostyle is present. The measurements are provided in Table I.

Discussion

The teeth are small sized and selenodont. The teeth may be distinguished at a glance from teeth of *Pachyportax* and *Selenoportax* by their smaller size

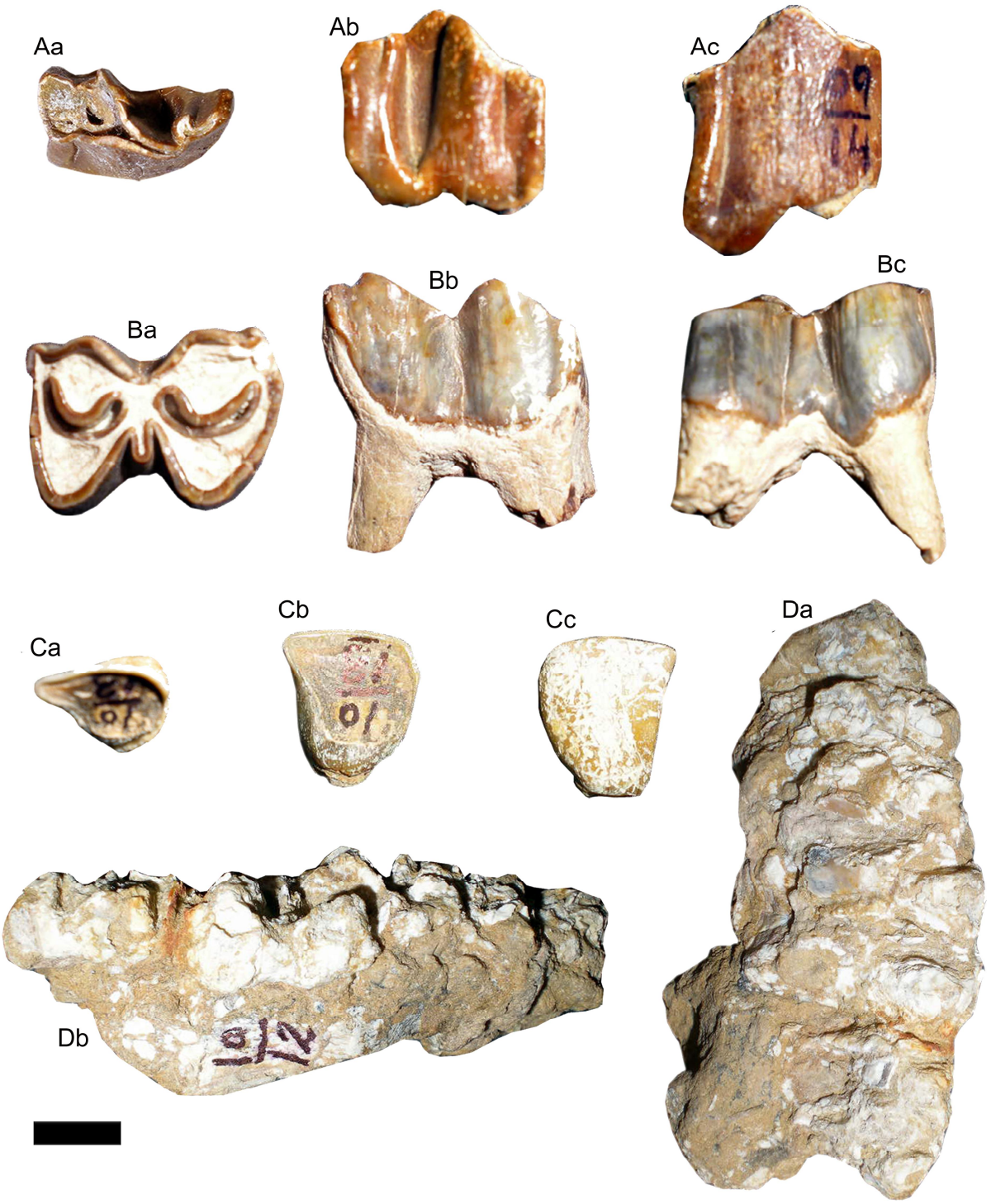

Fig. 3. *Pachyportax* cf. *latidens*: A, PC-GCUF 09/14 – rp4. B. PUPC 68/171 – lm1. cf. *Tragoportax browni*: C, PC-GCUF 10/13 – li1. D, PC-GCUF 10/12 – a right maxillary fragment with P4-M2. a, occlusal view, b, lingual view, c, labial view. Scale bar equals 10 mm.

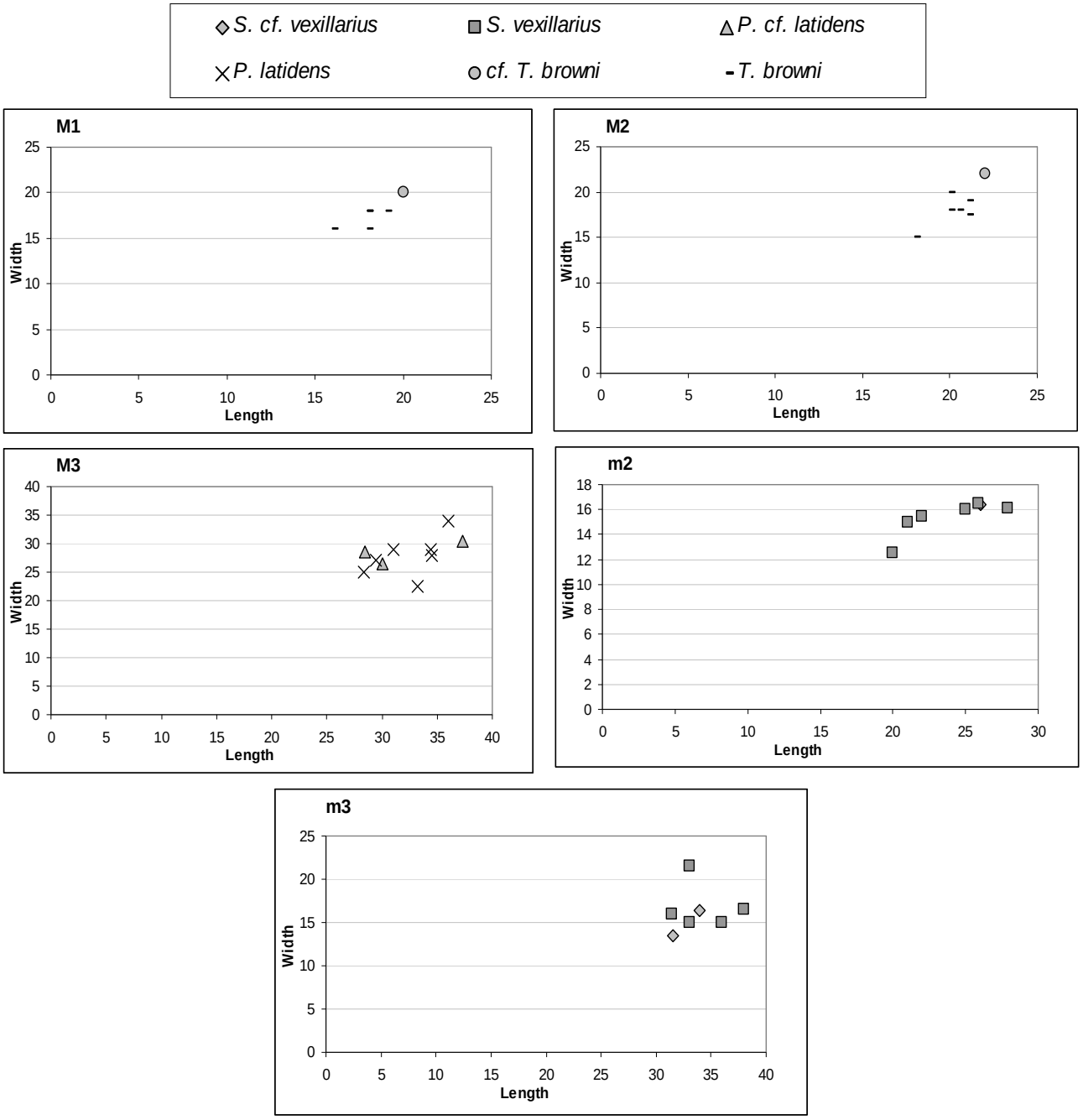

Fig. 4. Scatter diagram showing dental proportions of the studied boselaphines. Referred data are taken from Pilgrim (1937, 1939), Akhtar (1992) and Khan *et al.* (2009a, 2010).

and the weaker entostyles (Gaudry, 1865; Arambourg and Piveteau, 1929; Pilgrim, 1937). The studied P4 indicates an inflated hypocone which is the feature of the genus *Tragoportax*. The described character somewhat corresponds to numerous medium-sized boselaphine *Tragoportax* from the Siwaliks to which this specimen could be attributed. The teeth are much similar, metrically, to the

holotype of *T. browni* (Table I) (Pilgrim, 1937). The material is imperfect and is ascribed to cf. *T. browni*.

DISCUSSION AND CONCLUSIONS

Boselaphine remains were abundant in the Late Miocene of the Dhok Pathan Formation, and *Selenoportax*, *Pachyportax* and *Tragoportax* are considered the dominant Late Miocene Siwalik boselaphines (Fig. 4). The Dhok Pathan Formation boselaphines suggest a much higher diversity during the Late Miocene of the Siwaliks. It is concluded that during the Late Miocene and the Early Pliocene, the areas that the Dhok Pathan Formation extended were considerably better vegetated than it is today (Barry *et al.*, 2002; Khan *et al.*, 2009a, 2010). These genera are characteristic for the Late Miocene (10.0 Ma – 3.4 Ma) across Eurasia from China to Spain, and from the Siwaliks to the far south of South Africa (Pilgrim, 1939; Moya-Sola, 1983; Thomas, 1984; Bibi, 2007; Bibi *et al.*, 2009).

The fossil boselaphines from the Late Miocene of the Dhok Pathan Formation suggest an overlapping of the North African, Greco-Iranian (=Sub-Paratethyan), and Oriental (south Asian) provinces (Bibi *et al.*, 2009; Khan *et al.*, 2009a). Late Miocene links between sub-Saharan Africa and southern Asia are also apparent in the shared presence of bovid taxa such as *Tragoportax* (Gentry, 1999; Janis *et al.*, 2002; Spassov and Geraads, 2004; literature therein). The abundance of boselaphines indicates a mixture of woodland and grassland biomes for the Dhok Pathan Formation and a mosaic palaeoenvironment is inferred for the deposits.

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