



Tragoportax cf. *salmontanus* (Bovidae, Mammalia) from the Middle Miocene of Pakistan

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ABSTRACT

Tragoportax cf. *salmontanus* have been recovered from the Chinji Formation of the Lower Siwalik Subgroup, Pakistan. The remains comprise horn-cores, maxillary and mandibular fragments, and isolated teeth. Having compared with the previously described bovid remains from the Siwaliks, the new material has been allocated to *Tragoportax* cf. *salmontanus*. This species is well represented in the Middle Siwaliks but has not been previously reported from the Middle Miocene Chinji Formation of the Lower Siwalik Subgroup. The present evidence of *T. cf. salmontanus* in the Middle Miocene Chinji Formation of Pakistan extends the time range for the species from the Middle Miocene to the Late Miocene of Pakistan.

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Authors' Contribution

MAK, ZA and MA presented the concept and designed the study. MA, and SGA did acquisition of data. MA and MAB analysed and interpreted the data. MKN and KA drafted the manuscript.

Key words

Tragoportax, Siwaliks, Boselaphine, Palaeontology, Taxonomy.

INTRODUCTION

Boselaphines are one of the principal bovids found in the Late Miocene sites of the Subcontinent, Africa and Eurasia (Pilgrim, 1937, 1939; Gentry, 1970, 1971, 1994; Vrba and Schaller, 2000; Khan *et al.*, 2009, 2010). The Siwalik boselaphines include *Eotragus*, *Elachistoceras*, *Tragoportax* and *Miotragocerus* (Moya Solà, 1983; Gentry, 1999; Spassov and Geraads, 2004; Khan *et al.*, 2009). *Tragoportax* is a dominant Late Miocene genus in the Siwaliks and Eurasia (Spassov and Geraads, 2004; Khan *et al.*, 2013) and to far south of South Africa (Bibi *et al.*, 2009). It has also been recovered from the Late Miocene of Pikermi, Molayan and Samos (Solounias, 1981; Spassov and Geraads, 2004).

Tragoportax first appeared in the Siwaliks during the latest Middle Miocene (Thomas, 1984) and diversified during the Late Miocene, before going to extinct at the end of Pliocene (Gentry, 1999; Khan *et al.*, 2009, 2010). The genus is represented in the Siwalik by two valid species *Tragoportax salmontanus* and *T. punjabicus* (Pilgrim, 1937, 1939; Thomas, 1984; Akhtar, 1992; Spassov and Geraads, 2004; Khan *et al.*, 2010, 2013, 2014). There is a single report of this genus from the Middle Miocene

Chinji Formation (Khan *et al.*, 2013) however, all the other specimens are found in the Siwalik Late Miocene.

The infrequent collection of *Tragoportax* is explored from the outcrops of Dhok Bun Amir Khatoon, Parrhewala, Lawa, Bhilomar and Dhok Jand in district Chakwal, Punjab, Pakistan (Fig. 1). These five localities correspond to the Chinji Formation of the Lower Siwalik Subgroup. Among the studied localities, Bhilomar has been dated magnetostratigraphically (Johnson *et al.*, 1985, 1988); other four localities have been correlated lithologically by various researchers (Dehm, 1963; Khan *et al.*, 2008, 2011, 2013). The Chinji Formation comprises 70% predominant brightly red mud- and siltstone and 30% subsidiary ash gray fine to medium grained sandstone. The formation dates from 14 to 11.4 Ma (Barry *et al.*, 2013). The thickness of this formation differs from place to place. Though, its estimated thickness at type locality is 800 m while in Trans Indus range is 2000 m (Hussain *et al.*, 1979; Kafayat Ullah *et al.*, 2006).

The aim of the present work is to describe *Tragoportax* material from the Middle Miocene Chinji Formation of Pakistan.

Abbreviations

AMNH, American Museum of Natural History, America; GSI, the Geological Survey of India; PC-GCUF, the palaeontological collection of Government College University, Faisalabad, Pakistan.

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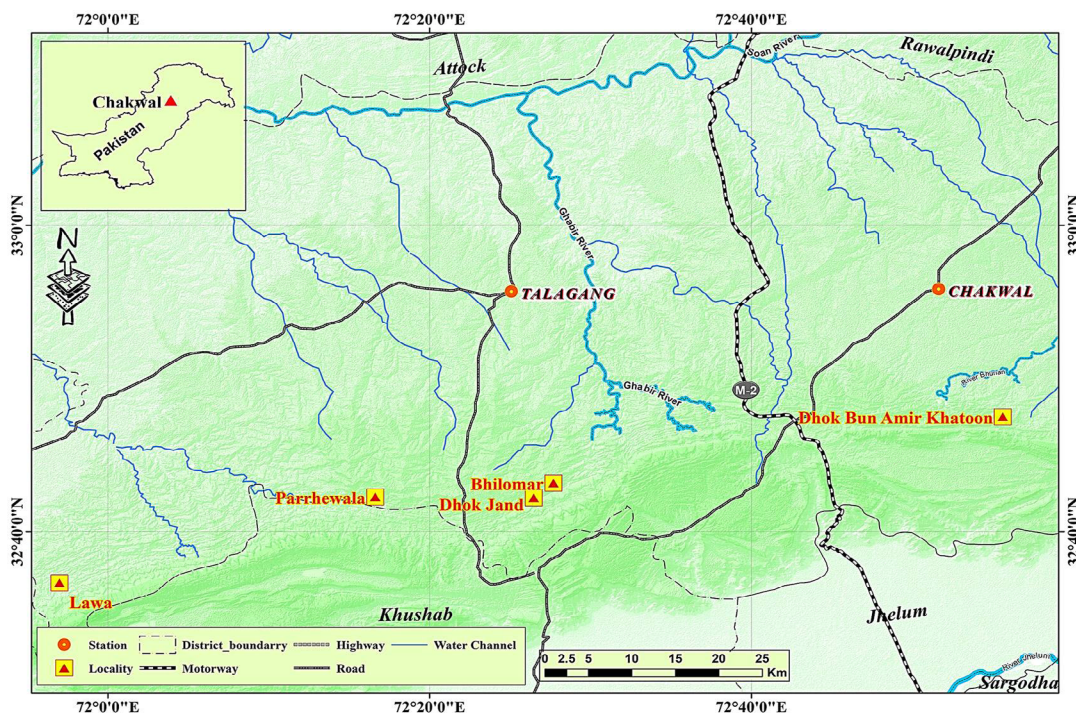


Fig. 1. Map showing the studied sites in Chakwal, Punjab, Pakistan.

MATERIALS AND METHODS

The completely exposed fossils were collected whereas the partially embedded were excavated carefully with the help of chisels and geological hammers from the localities (Fig. 1). The catalogue number of the specimens represents: PUPC (Punjab University Palaeontological Collection), the collection year (numerator) and a serial number (denominator) of that year (*e.g.* PUPC 16/45). The horn-core measurements were taken at the base. The anteroposterior diameter (DAP) was the large diameter of horn-core at the base and it might not be parallel to the sagittal plane. The mediolateral diameter (DT) was at right angles to the DAP. The length and width of teeth were measured occlusally. Measurements were taken with digital Vernier caliper in millimeters (mm). The measurements of horn-core and teeth follow Pilgrim (1937, 1939) and Gentry (1999).

Family Bovidae Gray, 1821

Genus *Tragoportax* Pilgrim, 1937

Tragoportax cf. salmontanus Pilgrim, 1937

Holotype: AMNH 19467, skull without hinder end of the occiput (Pilgrim, 1937).

Type locality: Dhok Pathan (Late Miocene), Punjab, Pakistan.

Diagnosis: As in Pilgrim (1937).

Stratigraphic range: Lower and Middle Siwaliks.

New material (localities are in parenthesis)

Horn-cores: PUPC 18/91, apical portion of right horn-core (Parrehwala); PUPC 18/36, basal portion of left horn-core (Bhilomar); PUPC 18/114, middle fragment of left horn-core (Dhok Jand). Upper dentition: PUPC 18/88, IP3 (Parrehwala). Lower dentition: PUPC 17/302, rp2 (Lawa); PUPC 15/420, rm1 (Dhok Bun Amir Khatoon); PUPC 14/214, rm1 (Dhok Bun Amir Khatoon); PUPC 15/435, rm1 (Dhok Bun Amir Khatoon); PUPC 14/210, rm2-m3 (Dhok Bun Amir Khatoon).

Horn-cores

The horn-core (PUPC 18/91) is slightly twisted (Fig. 2C). The anterior keel is well developed and acute. It is convex medially but flat laterally. The cross section is subtriangular. The DAP is 30.76 mm and DT is 17.91 mm.

PUPC 18/36 (Fig. 2B) is a basal fragment of left horn-core. A small portion of pedicel is also preserved. It is slightly twisted. The keel is partially preserved due to breakage and extreme weathering of the horn-core (Fig. 2B). The lateral side is flat and the medial is convex. A depression is present at the base of the keel due to weathering. The cross section is somewhat elliptical. The DAP is 28.54 mm and DT is 19.96 mm.



Fig. 2. *Tragoportax cf. salmontanus*: **A**, PUPC 18/114, left horn-core; **B**, PUPC 18/36, left horn-core; **C**, PUPC 18/91, right horn-core (views: a, anterior; b, medial). **D**, PUPC 18/88, IP3. **Ea**, PUPC 17/302, rp2; **F**, PUPC 15/420, rm1; **G**, PUPC 14/210, rm2-m3 (views: a, occlusal; b, lingual; c, labial). Scale bar for horn-cores 30 mm and for teeth 10 mm.

PUPC 18/114 (Fig. 2A) - portion of left horn-core. The horn-core is highly weathered, partially broken, belonging to the middle part as the basal part and the apical part is missing (Fig. 2A). The outer surface is flat and the inner surface is convex. It is slightly twisted. It is expanded medially. The cross section is subtriangular. The keel is blunt due to weathering. The DAP is 32.96 mm and DT is 22.79 mm.

Upper dentition

The parastyle and anterior rib are strong whereas the metastyle is slightly less developed in P3 (Fig. 2D). The third premolar is extremely worn resulting in loss of the posterior part of the median fossette. The median fossette is partially divided. The roots are also preserved especially the lingual one.

Lower dentition

PUPC 17/302 (Fig. 2E) is a right mandibular fragment with partial p2. The corpus is fragile. It is mostly preserved at the labial side and missing at the lingual side. The lingual conids are broken. The protoconid, anterior valley, protoconid and some portion of the metaconid are preserved. The tooth is moderately worn.

PUPC 15/420 is much worn right first molar (Fig. 2F). The apex of the hypoconid is partially broken. The transverse flange is small and thin. The fossettids are narrow. The ectostylid is small. The metastylid and entostylid are incipient whereas the mesostylid is thick. The apices of the lingual conids are round.

PUPC 14/214 and PUPC 15/435 are well preserved first right molars. The labial conids are higher and pointed. PUPC 15/435 is in middle wear whereas PUPC 14/214 is more worn. The goat fold is well developed in PUPC 15/435 and absent in PUPC 14/214. The stylids and median ribs are weakly developed. The fossettids are narrower in PUPC 14/214 than PUPC 15/435. The transverse valley is wider and contains small ectostylid at the base in PUPC 14/214 whereas the second one has narrow valley without ectostylid. The posthypocristid is moderately developed only in PUPC 15/435.

PUPC 14/ 210 includes right m2-3. The molar is less preserved and is in early wear (Fig. 2G). The ectostylid is absent in the median valley. The metastylid is comparatively more developed. The metaconid is broken at the top whereas other conids are well preserved. The postfossette is deeper than the prefossettid. The third molar is partially damaged and in early wear. The hypoconulid is broken completely. All the conids are well-preserved. The labial conids are somewhat lower than the lingual ones. The enamel is thin and slightly rugose. The entostylid is also broken whereas the meso- and metastylids are

conspicuous. The metaconid rib is comparatively more developed than the entoconid rib.

Table I.- The tooth measurements (in millimeters) of *Tragoportax* cf. *salmontanus*. The material for comparison is from Pilgrim (1937), Akhtar (1992), Khan *et al.* (2010) and Batool *et al.* (2014).

Taxa / Number	Nature and position	L	W	W/L
<i>T. cf. salmontanus</i>				
PUPC 18/88*	IP3	13.91	13.20	0.95
PUPC 17/302*	rp2	10.55	7.15	0.68
PUPC 15/420*	rm1	13.75	9.50	0.69
PUPC 14/214*	rm2	16.08	11.40	0.71
PUPC 15/435*	rm2	16.28	10.57	0.65
PUPC 14/210*	rm2	16.66	11.69	0.70
	rm3	15.26ca	8.35	0.55
PC-GCUF 12/11	lm1	12.5	9.7	0.76
<i>T. punjabicus</i>				
PUPC 87/327	IP3	13.0	12.0	0.92
GSI B486	P3	14.5	12.0	0.82
GSI B563	m2	21.0	13.0	0.62
	m3	30.0	13.5	0.45
GSI B564	m2	20.5	14.0	0.68
	m3	26.0	13.5	0.52
AMNH 29884	lm2	19.0	12.0	0.63
	lm3	25.5	12.0	0.47
PUPC 83/277	lm3	24.0	11.0	0.46
PUPC 97/11	lm3	26.0	11.0	0.42

*the specimens under study. ca- indicate the incomplete measurement of m3.

COMPARISON AND DISCUSSION

The Middle Miocene Siwalik bovids include *Miotragocerus*, *Sivaceros*, *Elachistoceras*, *Helicoportax*, *Sivoreas* and *Tragoportax* (Pilgrim, 1937, 1939; Solounias, 1981; Spassov and Geraads, 2004). The studied horn-cores differ from *Miotragocerus* in having well-developed posterolateral keel and clearly delineation (Solounias, 1981; Spassov and Geraads, 2004). *Sivaceros* has significantly stout horn-cores with elongated oval cross section (Khan *et al.*, 2011). The small size and elliptical or oval cross section of PUPC 18/36 owes to the juvenile individual as reported by Spassov and Geraads (2004). *Elachistoceras khauristanensis* differs in having small size, simple conical forms horn-cores with a straight axis (Thomas, 1977; Akhtar and Nayyer, 2001). *Helicoportax* have subtriangular cross section, much flattened medial surface and strongly convex lateral surface, and sharp antero-internal keel and rounded postero-internal keel

(Khan *et al.*, 2013). *Sivoreas* has horn-cores with elliptical cross section and show pronounced torsion (Made and Hussain, 1993).

The morphological features like slender horn-cores with well-marked keel, and archetypal triangular to subtriangular shape cross section with noticeable anterior keel associate them with the Middle Miocene Siwalik bovid *Tragoportax* (Pilgrim, 1937; Khan *et al.*, 2010). The horn-cores of *Tragoportax* differ from other Siwalik bovids with respect to the torsion. A slight torsion is found in *Tragoportax* whereas the small boselaphine *Eotragus* and *Sivaceros* and non-boselaphine genus *Gazella* have no torsion (Thomas, 1984; Made and Hussain, 1993). *Tragoportax* is represented by two species in the Siwaliks: *T. punjabicus* and *T. salmontanus* (Pilgrim, 1937, 1939). *Tragoportax punjabicus* is large species (Khan *et al.*, 2010) whereas *T. salmontanus* is comparatively small species (Pilgrim, 1937, 1939). The studied horn-cores are comparatively smaller than *T. punjabicus* (Table I). The horn-cores of *T. salmontanus* are short with less antero-posterior diameter (Pilgrim, 1937). The cross section and size of the studied horn-cores are similar to *T. salmontanus*, therefore, on the basis of the morphometric characters, the horn-cores can be reasonably assigned to *T. cf. salmontanus*.

The genus *Tragoportax* holds characters between *Miotragocerus* and *Selenoportax*. The horn-cores of *Tragoportax* are related to *Miotragocerus* in cross-section, with scalene triangle, having sharp postero-external keel whereas differentiated from the isosceles triangle of *Selenoportax*, having rounded postero-external keel. The horn-cores of European *Tragoportax* are little tending, less twisted and longer than those of the Lower Siwalik *Tragoportax* (Pilgrim, 1939; Kostopoulos, 2005, 2009; Khan *et al.*, 2010).

The compressed outer cusps/conids and the divergent styles/stylids of the studied molars favor their addition in the Middle Miocene boselaphines of the Siwalik Group. In the Lower Siwaliks, *Eotragus*, *Helicopotax* and *Elachistoceras* are small sized boselaphines (Pilgrim, 1937, 1939; Akhtar, 1992; Khan *et al.*, 2009), and *Tragoportax* and *Miotragocerus* are medium sized boselaphines (Khan *et al.*, 2009). The described specimens distinguish from *Miotragocerus* due to lack of the highly accentuated molar array (Spasov and Geraads, 2004). The material is alike *T. salmontanus* (Pilgrim, 1937; fig. 61, p. 834) and can be positively assigned to *T. cf. salmontanus* (Fig. 2; Table I).

Tragoportax was erected by Pilgrim (1937), on the basis of *T. salmontanus* that is a renowned species of the Siwaliks. Bibi *et al.* (2009) named this group as *Tragoportacini*. It was prevalent during the Turolian in Europe and south Asia (Bibi and Gulec, 2008).

Tragoportax is a common genus in the Siwaliks during the Late Miocene (Pilgrim, 1939; Akhtar, 1992; Khan *et al.*, 2010, 2013; Babar, 2017). *Tragoportax punjabicus* is restricted to the Late Miocene of the Siwalik Group (Nagri and Dhok Pathan formations) (Pilgrim, 1939; Akhtar, 1992; Khan *et al.*, 2010), whereas *T. salmontanus* is known to appear in the Middle Miocene of the Siwalik Group (Chinji Formation). With the description of these specimens, the stratigraphic range of *T. salmontanus* is extended to the Middle Miocene Chinji Formation. The presence of *T. salmontanus* in the Middle Miocene of the Potwar plateau, Pakistan represents the oldest record in the Siwalik Group and extends its geochronological range from the Middle Miocene to Late Miocene of the subcontinent. Nevertheless, the Chinji *T. salmontanus* begs further study in the light of more samples to confirm the first appearance of the species in the Siwalik Middle Miocene.

CONCLUSIONS

The record of *T. cf. salmontanus* in the Middle Miocene represents the oldest record of the species in the subcontinent. *Tragoportax cf. salmontanus* is being reported for the first time from the Middle Miocene Chinji Formation of Pakistan. Earlier, this species has been documented from the Late Miocene of the Siwaliks. The findings confirm that *T. cf. salmontanus* appears in the Middle Miocene of the Siwalik Group, which extends the stratigraphic range of this species from the Late Miocene to Middle Miocene of the Siwalik Group.

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Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

- Akhtar, M., 1992. *Taxonomy and distribution of the Siwalik bovids*. Ph. D. thesis, University of the Punjab, Lahore, Pakistan, pp. 371.
- Akhtar, M. and Nayyer, A.Q., 2001. Presence of very small bovid in the Dhok Pathan Formation of Hasnot, Jhelum district, the Punjab province, Pakistan. *Punjab Univ. J. Zool.*, **16**: 55-59.
- Babar, M.A., 2017. *Taxonomic studies of Late Miocene artiodactyls (Mammalia) from Northern Pakistan*. Ph. D. thesis, University of the Punjab, Lahore,

- Pakistan, pp. 263.
- Barry, J.C., Morgan, M.E., Flynn, L.J., Pilbeam, D., Behrensmeyer, A.K., Raza, S.M., Khan, I., Badgely, C., Hicks, J. and Kelley, J., 2002. Faunal and environmental change in the Late Miocene Siwaliks of Northern Pakistan. *Paleobiology*, **28**: 1-72. [https://doi.org/10.1666/0094-8373\(2002\)28\[1:FAECIT\]2.0.CO;2](https://doi.org/10.1666/0094-8373(2002)28[1:FAECIT]2.0.CO;2)
- Barry, J.C., Behrensmeyer, A.K., Badgely, C.E., Flynn, L.J., Peltonen, H., Cheema, I.U. and Morgan, M.E., 2013. *The Neogene Siwaliks of the Potwar Plateau, Pakistan. Fossil Mammals of Asia: Neogene Biostratigraphy and Chronology*. Columbia University Press, New York, pp. 373-399. <https://doi.org/10.7312/columbia/9780231150125.003.0015>
- Batool, A., Khan, M.A., Akhtar, M. and Qureshi, N.A., 2014. New remains of Tragulids (Mammalia, Tragulidae) from the Dhok Pathan Formation of Hasnot (Late Miocene), Pakistan. *Pakistan J. Zool.*, **46**: 1323-1336.
- Bibi, F. and Güleş, E.S., 2008. Bovidae (Mammalia: Artiodactyla) from the Late Miocene of Sivas, Turkey. *J. Verteb. Paleontol.*, **28**: 501-519. [https://doi.org/10.1671/0272-4634\(2008\)28\[501:BMAFTL\]2.0.CO;2](https://doi.org/10.1671/0272-4634(2008)28[501:BMAFTL]2.0.CO;2)
- Bibi, F., Bukhsianidze, M., Gentry, A.W., Geraads, D., Kostopoulos, D.S. and Vrba, E.S., 2009. The fossil record and evolution of Bovidae: State of the field. *Palaeontol. Electron.*, **12**: 1-11.
- Dehm, R., 1963. Palaontologische und geologische untersuchungen im Tertiär von Pakistan. 3. *Dinotherium* in der Chinji-Stufe der Unteren Siwalik-Schichten. *Bayer. Akad. Wiss. Math. Natur. Kl. N.F.*, **114**: 1-34.
- Gentry, A.W., 1970. The Bovidae (Mammalia) of the Fort Ternan fossil fauna. In: *Fossil vertebrates of Africa* (eds. L.S.B. Leakey and R.J.G. Savage). Academic Press, London, pp. 243-323.
- Gentry, A.W., 1971. The earliest goats and other antelopes from the Samos *Hipparion* fauna. *Bull. Br. Mus. Nat. Hist. Geol. Ser.*, **20**: 229-296.
- Gentry, A.W., 1994. The Miocene differentiation of Old World Pecora (Mammalia). *Histor. Biol.*, **7**: 115-158. <https://doi.org/10.1080/10292389409380449>
- Gentry, A.W., 1999. Fossil pecorans from the Baynunah Formation, Emirate of Abu Dhabi, United Arab Emirates. In: *Fossil vertebrates of Arabia* (eds. P.J. Whybrow and A. Hill). Yale University Press, New Haven, pp. 290-316.
- Hussain, S.T., Mounthe, J., Shah, S.M., West, R.M. and Lukacs, J.R., 1979. Neogene stratigraphy and fossil vertebrates of the Daud Khel area, Mianwali district, Pakistan. *Mem. Geol. Surv. Pak.*, pp. 1-13.
- Johnson, N.M., Stix, J., Tauxe, L., Cervený, P.F. and Tahirkheli, R.A.K., 1985. Paleomagnetic chronology, fluvial processes and tectonic implications of the Siwalik deposits near Chinji Village, Pakistan. *J. Geol.*, **93**: 27-40. <https://doi.org/10.1086/628917>
- Johnson, N.M., Sheikh, K.A., Dawson-Saunders, E. and McRae, L.E. 1988. The use of magnetic-reversal time lines in stratigraphic analysis: A case study in measuring variability in sedimentation rates. In: *New perspectives in basin analysis* (eds. K.L. Kleinspehn and C. Paola). Springer, New York, pp. 189-200. https://doi.org/10.1007/978-1-4612-3788-4_9
- Kafayat Ullah, Arif, M. and Shah, M.T., 2006. Petrography of sandstones from the Kamlial and Chinji formations, southwestern Kohat Plateau, NW Pakistan: Implications for source lithology and paleoclimate. *J. Hemal. Earth Sci.*, **39**: 2-28.
- Khan, M.A., Akhtar, M., Ghaffar, A., Iqbal, M., Khan, A.M. and Farooq, U., 2008. Early Ruminants from Dhok Bin Mir Khatoon (Chakwal, Punjab, Pakistan): Systematics, biostratigraphy and paleoecology. *Pakistan J. Zool.*, **40**: 457-463.
- Khan, M.A., Iliopoulos, G. and Akhtar, M., 2009. Boselaphines (Artiodactyla, Ruminantia, Bovidae) from the Middle Siwaliks of Hasnot, Pakistan. *Geobios*, **42**: 739-753. <https://doi.org/10.1016/j.geobios.2009.04.003>
- Khan, M.A., Akhtar, M. and Iqbal, M., 2010. The Late Miocene artiodactyls in the Dhok Pathan type locality of the Dhok Pathan formation, the Middle Siwaliks, Pakistan. *Pakistan J. Zool., Suppl. Ser.*, **10**: 1-90.
- Khan, M.A., Akhtar, M., Khan, A.M., Iqbal, M., Samiullah, K. and Ghaffar, A., 2011. New fossil locality in the Middle Miocene of lava from the Chinji Formation of the lower Siwaliks, Pakistan. *Pakistan J. Zool.*, **43**: 61-72.
- Khan, M.A., Akhtar, M., Babar, M.A., Abbas, G., Siddiq, M.K., Nawaz, M.K., Yaqoob, H. and Zahra, N., 2013. Some new remains of Middle Miocene Mammals from the Chinji Formation, northern Pakistan. *Pakistan J. Zool., Suppl. Ser.*, **13**: 1-55.
- Khan, M.A., Akhtar, M. and Irum, A., 2014. Bramatherium (Artiodactyla, Ruminantia, Giraffidae) from the Middle Siwaliks of Hasnot, Pakistan: Biostratigraphy and Palaeoecology. *Turkish J. Earth Sci.*, **23**: 308-320. <https://doi.org/10.3906/yer-1112-11>
- Kostopoulos, D.S., 2005. The Bovidae (Mammalia,

- Artiodactyla) from the Late Miocene of Akkasdagı, Turkey. *Geodiversitas*, **27**: 747-791.
- Kostopoulos, D.S., 2009. The Late Miocene mammal faunas of the Mytilinii basin, Samos Island, Greece: New collection. 14. Bovidae. *Beiträge Paläontol.*, **31**: 339-383.
- Made, van der J. and Hussain, S.T., 1993. Horn-cores of *Sivoreas* (Bovidae) from the Miocene of Pakistan and utility of their torsion as a taxonomic tool. *Geobios*, **27**: 103-111. [https://doi.org/10.1016/S0016-6995\(06\)80218-4](https://doi.org/10.1016/S0016-6995(06)80218-4)
- Moya-Sola, S., 1983. *Les Boselaphini (Bovidae, Mammalia) del Neogeno de la Peninsula Iberica*. Dissertation, Universidad Autonoma de Barcelona, Publicaciones de Geologia, pp. 1-236.
- Pilgrim, G.E., 1937. Siwalik antelopes and oxen in the American Museum of Natural History. *Bull. Am. Mus. Nat. Hist.*, **72**: 729-874.
- Pilgrim, G.E., 1939. The fossil bovidae of India. Memoir of the Geological Survey of India. *Palaeontol. Indic.*, **26**: 1-356.
- Solounias, N., 1981. The Turolian fauna from the Island of Samos, Greece. *Contrib. Verteb. Evol.*, **6**: 99-232.
- Spassov, N. and Geraads, D., 2004. *Tragoportax* Pilgrim, 1937 and *Miotragocerus* Stromer, 1928 (Mammalia, Bovidae) from the Turolian of Hadjidimovo, Bulgaria, and a revision of the Late Miocene Mediterranean Boselaphini. *Geodiversitas*, **26**: 339-370.
- Thomas, H., 1977. Un nouveau Bovide dans les couches a Hominoidea du Nagri (Siwaliks moyens, Miocene superieur), Plateau du Potwar, Pakistan: *Elachistoceras khauristanensis* gen. et sp. nov. (Bovidae, Artiodactyla, Mammalia). *Bull. Soc. Géol. Fr.*, **19**: 375-383. <https://doi.org/10.2113/gssgfbull.S7-XIX.2.375>
- Thomas, H., 1984. Les bovides ante-hipparions des Siwaliks inferieurs (Plateau du Potwar), Pakistan. *Mém. Soc. Géol. Fr.*, **145**: 1-68.
- Vrba, E.S. and Schaller, G., 2000. Phylogeny of Bovidae based on behavior, glands, skulls and postcrania. In: *Antelopes, deer and relatives* (eds. E.S. Vrba and G. Schaller). Yale University Press, New Haven, pp. 203-222.