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Ruminant Fauna from the Tertiary Hills (Neogene) of the Siwaliks of Pakistan

Muhammad Akbar Khan, Abdul Ghaffar, Umar Farooq and Muhammad Akhtar
Department of Zoology, Punjab University, Lahore, (54590) Pakistan

Abstract: The Siwalik formations of northern Pakistan consist of (fluvial) deposits of ancient rivers that were formed from the early Miocene up to the late Pliocene. The tertiary continental deposits of the Siwaliks are highly fossiliferous with a diverse array of terrestrial and freshwater vertebrates in which ruminants are fairly abundant. The rich Siwalik fossil record presents a detailed history of the prehistoric mammals of the Indian Subcontinent. In this research it was analyzed individual well-sampled sites to study the past ruminant community. The Siwalik fossil record becomes increasingly informative for diverse research questions in paleobiology as a result of its growing and robust data set. The fossils from Pakistan may also document the first appearance and subsequent radiation of giraffes and bovids, two groups that dominate the late neogene (tertiary) as well as the modern herbivore faunas. Throughout the Siwalik formations, the ruminants are by far the most abundant mammal group. The number of ruminant species, as recorded in the tertiary hills of the Siwaliks is clearly greater than that observed in most ecosystems today, which probably indicates overall greater species richness than is typically present. Today, the ruminants constitute the largest group of ungulates, with more than 190 species and its distribution is widespread in all continents except Australia and Antarctica.

Key words: Ruminants, siwaliks, tertiary (Neogene)

INTRODUCTION

In the last decade, considerable work has been done on the mammalian fauna of the Siwalik deposits. The Neogene formations of Pakistan contain a diverse assemblage of fossil vertebrates that are the basis of mammalian evolution in southern Asia. Because of the continuous deposition of the Siwalik series rocks of the Potwar Plateau in Pakistan through almost all of the Neogene, Siwaliks (Potwar Plateau) are considered as a critical continent for understanding the origin and early evolutionary history of several higher-level mammalian taxa, including artiodactyls[1]. The artiodactyls have long been suspected to hold important clues for reconstructing early phases of their evolutionary history. Ruminant artiodactyls are the most geographically and ecologically successful living group of large mammals (Fig. 1). The suborder Ruminantia is traditionally defined as the artiodactyls that possess a cuboid fused with the navicular and incisiform lower canines. The former character is ambiguous because of its occurrence in the late Eocene ruminant-like genus *Amphimeryx* from Western Europe[2], whereas the second feature is rarely preserved in fossils of primitive ruminants.

Pecora (horned ruminants) and Tragulina-Pecora are today considered as the most diversified ruminants. Fossil remains are well known during the Neogene in Eurasia, North America and Africa. Globally, the phylogenetic relationships between early ruminants are misunderstood,

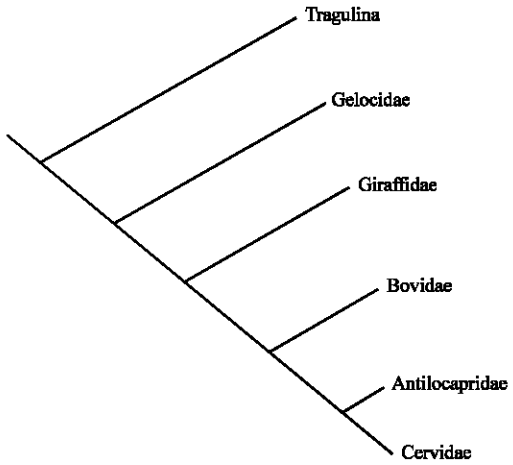

Fig. 1: Simplified Cladogram illustrating the interrelationships between different families of ruminants (modified from Janis and Scott[40]). The term Gelocidae designates a heterogeneous assemblage of extinct hornless pre-pecoran ruminants. Bovidae and Antilocapridae are described collectively in the text

Corresponding Author: M. Akbar Khan, Department of Zoology, University of the Punjab, Lahore, Pakistan

mainly because of the scarcity of remains of Eocene Asian ruminants. *Archaeomeryx*, the earliest known ruminant from Shara Murun (late-middle Eocene, Mongolia), is sometimes considered as the oldest of the Pecora group[3,4]. Early Miocene pecorans were not yet differentiated into the later families. At that period *Dremotherium* and various other genera were found in Europe and *Walangania* in Africa. Cervoids and giraffoids could have had predominantly vicariant origins within the Pecora, giraffoids within Africa, Arabia and/or India and cervoids further north in Eurasia. Undoubted cervids then appeared from among cervoids in the early Miocene of Europe and further east. Later again, cervids migrated to the Siwaliks and Northern Africa but this postdated the Miocene. Meanwhile, giraffids dispersed to Eurasia (beyond Siwaliks) in the middle Miocene. In the Indian Subcontinent there is virtually no Oligocene and earliest Miocene record. However, in Pakistan most of Bugti fauna extends from the Early Oligocene up to the Late/Latest Oligocene[5-8].

GEOLOGY CITED

The Siwalik Group is an arrange of southern Himalayan mountains extending for about 1689 km (1050 miles), from southwest Kashmir through India into southern Nepal. The hills are noted for their extensive fossil remains. The Siwalik sediments are found in widely separated areas all along the foothills of Himalayas (Fig. 2). The name Siwalik was introduced for the sub Himalayan rocks by Medlicott[9] and this term derived from the Siwalik Hills in Deharadun (India). It is commonly used for the molasse-type of Neogene sediments of the Himalayan foothill zone. The best record of the fossiliferous layers for the Siwalik can be found in Pakistan (Potwar Plateau).

The Potwar plateau of the Punjab Province (72°30′ E, 33°00′ N) is an elevated area of some 20,000 km bounded to the north by the Kala Chitta and Margala Hills, south by the Salt Range, east by the Jhelum River and west by the Indus River (Fig. 3).

The Siwalik formations have always been cryptic chronostratigraphic units and from a paleontological point of view recognition of the formations and their boundaries has been a crucial step in dating the fossils[10,13]. This practice has in the past produced much confusion and sterile debate, but it is now possible to assume that with the contribution of magnetostratigraphy as a means of dating the rocks this era of confusion is past. Boundary dates here are from Barry *et al.*[14]. (Table 1).

RUMINANTS FROM THE SIWALIK HILLS OF PAKISTAN

The following ruminants fauna is found in the Siwaliks of Pakistan.

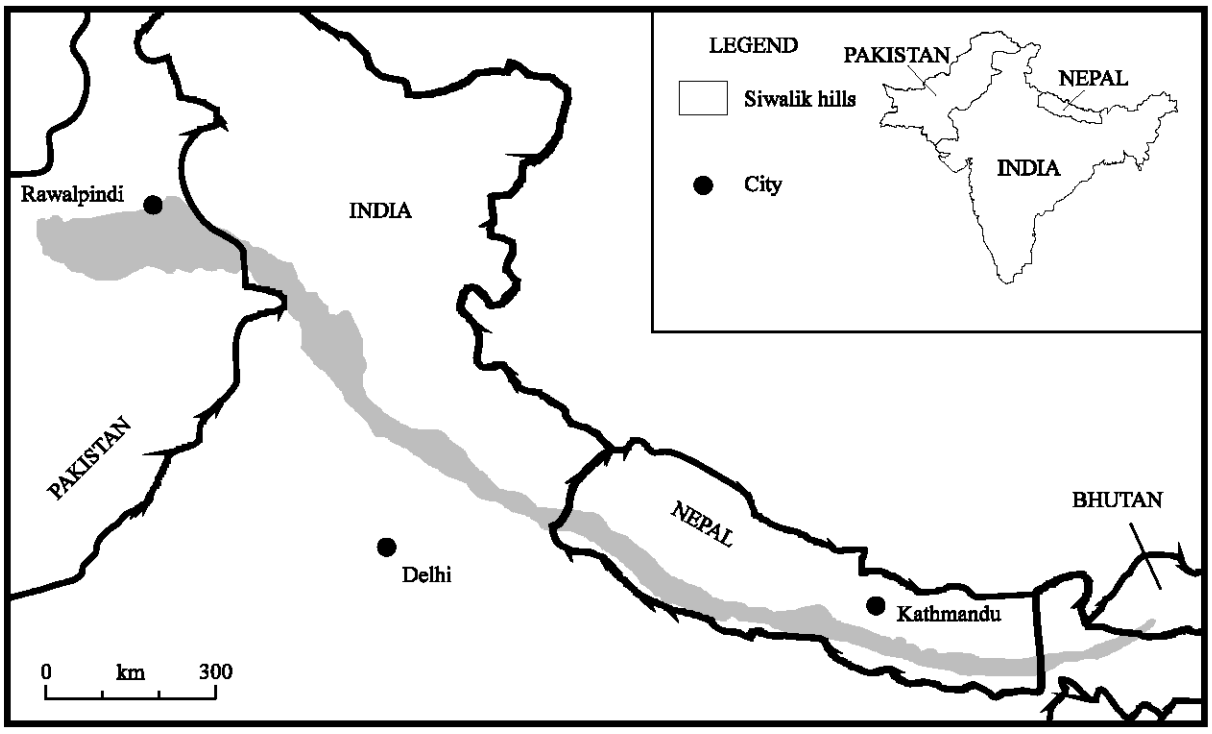

Fig. 2: Distribution of Siwalik sediments along the foothills of Himalayas

Table 1: Stratigraphic sections of siwalik group showing formations and zones

Potwar formations	The Siwali group	The Siwalik zone
Upper siwalik fms.	Upper siwalik subgroup	Boulder conglomerate zone
		Pinjor zone
		Tatrot zone
Dhok pathan	Middle siwalik subgroup	Dhok pathan zone
Nagri		Nagri zone
Chinji	Lower siwalik subgroup	Chinji zone
Kamlial		Kamlial zone

Family bovidae: The family is highly diverse, with numerous extant species and has an extensive fossil record with species in Africa, Eurasia and North America. Bovids appear to have had three major adaptive radiations at 14, 7.5 and 2 ma[15-19] but few fossils are known from sediments older than 14 ma. Its geological range is enormous-from the Kamlial formation of the Lower Siwaliks to the later Pleistocene. The Kamlial fossils are all approximately 18.3 ma old[11], while those from the Vihowa Formation are most likely to be between 17.0 and 17.6 ma old[20-22]. The bovids present in these formations of Pakistan are considered as the oldest bovid[23]. Pilgrim[24] described 75 species of bovids from all over the Siwaliks (Appendix 1) but later on Akhtar[25] described 33 species of bovid, including the smallest bovids (*Elaschistoceras)* species from the Siwaliks of Pakistan. Solounias *et al.*[23] described the oldest bovid (*Eotragus*) from the Miocene of Pakistan (Kamlial and Vihowa formations, about 18 ma). The Siwalik Species of the family Bovidae are the following;

Species	Appearance in the siwalik hills of Pakistan
Miotragocerus dhokpathanensis Akhtar, 1992.	Middle Siwalik.
Tragocerus browni Pilgrim, 1937.	Middle Siwalik.
Tragocerus punjabicus Pilgrim, 1937.	Middle Siwalik.
Pachyportax latidens (Lydekker) Pilgrim, 1937.	Upper Siwalik (Tatrot Zone).
Pachyportax giganteus Akhtar, 1992.	Middle Siwalik.
Selenoportax vexillarious Pilgrim, 1937.	Lower & Middle Siwaliks.
Selenoportax lydekkeri Pilgrim, 1937.	Middle Siwalik.
Selenoportax dhokpathanensis Akhtar, 1992.	Middle Siwalik.
Selenoportax tatrotensis Akhtar, 1992.	Upper Siwalik (Tatrot Zone).
Helicoportax praecox Pilgrim, 1937.	Lower Siwalik (Chinji Zone).
Tragoportax salmontanus Pilgrim, 1937.	Middle Siwalik.
Tragoportax islami Pilgrim, 1939.	Middle Siwalik.
Ruticeros pugio Pilgrim, 1939.	Middle Siwalik.
Elachistoceras khauristanensis Thomas, 1977.	Middle Siwalik.
Proamphibos lachrymans Pilgrim, 1939.	Middle & Upper Siwaliks (Tatrot Zone).
Proamphibos kashmiricus Pilgrim, 1939.	Upper Siwalik (Tatrot Zone).
Proamphibos dhokawanensis Akhtar, 1992.	Middle Siwalik.
Hemibos triquetricornis Rutimeyer, 1866.	Middle & Upper siwaliks.
Bubalus bathygnathus Akhtar, 1992.	Upper Siwalik.
Bubalus jarikasensis Akhtar, 1992.	Upper Siwalik.
Bos Kashmiricus Akhtar, 1992.	Upper Siwalik.
Bison sivalensis (Falconer) Lydekker, 1878.	Upper Siwalik.
Bison crassicornis Richardson, 1854.	Upper Siwalik.
Hydaspicobus auritus Pilgrim, 1939.	Upper Siwalik (Tatrot Zone).
Vishnucobus patulicornis (Lydekker) Pilgrim, 1939.	Upper Siwalik.
Indoredunca gaalensis Akhtar, 1992.	Upper part of Middle Siwalik.
Sivadenota sepulta Pilgrim, 1939.	Upper Siwalik (Tatrot Zone).
Sivacobus palaeindicus (Lydekker) Pilgrim, 1939.	Upper Siwalik.
Antilope subtorta Pilgrim, 1937.	Upper Siwalik.
Antilope planicornis Pilgrim, 1939.	Middle Siwalik.
Antilope intermedius Akhtar, 1992.	Middle Siwalik.
Gazella lydekkeri Pilgrim, 1939.	Middle Siwalik.
Gazella padriensis Akhtar, 1992.	Middle Siwalik.
Eotragus noyei Solounias *et al.*, 1995.	Lower Siwalik (Kamlial Zone).

Family cervidae: The family Cervidae contains nearly all-living Cervoidea. They exhibit a wide variety in ruminant body size and shape from the little South American Padu to the giant Alaskan moose. The most outstanding and typifying character among cervids, except *Hydropotes*, is the possession of antlers in males[26]. Formerly used definitive cervid characters like the doubled lacrimal aperture, the lacrimal pit and the antorbital vacuity are sometimes also present in Moschidae and Palaeomerycidae. During the evolution of cervids their cranial appendages changed immensely not only in size, structure and morphology, but also in proportions, cranial position and orientation of pedicles. Early to Middle Miocene primitive cervids that appeared in Europe show great dental and skeletal similarities to their moschid ancestors. Late Miocene genera known from Europe are more obviously advanced towards later antlered deer. The tooth morphology and crown height in these Miocene species was less advanced than in Pliocene deer. Cervids entered the Siwaliks during the Plio-Pleistocene and they showed the similarity with the Pliocene fossil record of deer in Europe.

Several species of cervids have been described mainly from the Upper Siwalik rocks of the Western Sub Himalayas including the Siwalik Hills and adjoining ranges in India and the Southern Kashmir, Potwar and the trans Indus Hill ranges of Pakistan. The earlier identification was based on a few fragmentary specimens and their holotype designations including maxillary fragments and rarely skulls.

Arif and Shah[27] and Ghaffar[28] have been critically reviewed the Siwalik cervids and the following species are considered valid.

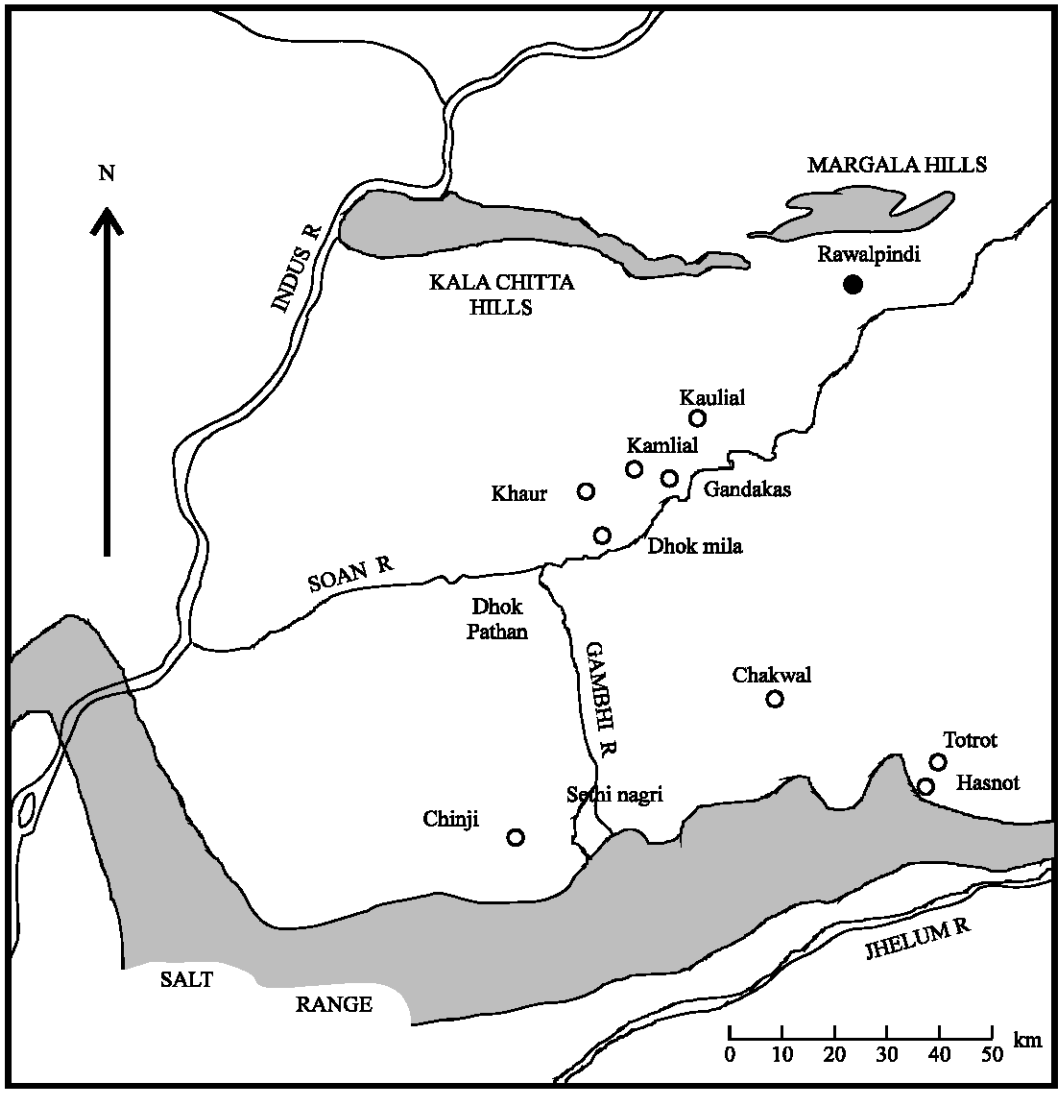

Fig. 3: Map of Potwar Plateau showing main fossil localities

Species	Appearance in the siwalik hills of Pakistan
Cervus punjabiensis Brown, 1926.	Upper part of Middle Siwalik-Upper Siwalik.
Cervus rewati Arif and Shah, 1991.	Upper part of Middle Siwalik-Upper Siwalik.
Cervus sivalensis Lydekker, 1884.	Upper part of Lower Siwalik-Upper Siwalik.
Cervus simplicidens Lydekker, 1876.	Upper part of Middle Siwalik-Upper Siwalik.
Cervus triplidense Lydekker, 1876.	Upper part of Middle Siwalik-Upper Siwalik.

Family giraffidae: The family Giraffidae represents only two living species, the Okapi (*Okapia johnstoni*) and the Giraffe (*Giraffa cameloparadalis*)[29]. Both species today are present in Africa (Ethiopian region). However, the Giraffidae have a rich fossil history consisting of approximately thirty species throughout the Neogene of the Old World[30-33]. The giraffids started their history in the early Miocene. They appeared in the early Miocene sediments Africa of central Asia from where they dispersed to Europe most probably in the Middle Miocene. The giraffids record in South Asia begins from the early Miocene times, from where they later dispersed to Southeast Asia.

Several species of the family giraffidae have been described from the Upper, Middle and Lower Siwaliks. The Siwalik species can be distinguished on the basis of their dentition and skull patterns. These species are as follows;

Species	Appearance in the Siwalik Hills of Pakistan
Bramatherium perimense Falconer, 1845.	Middle Siwalik
Giraffokeryx chinjiensis Sarwar, 1990.	Lower Siwalik
*Giraffokeryx punjabien*sis Pilgrim, 1910.	Lower Siwalik
Giraffa sivalensis Falconer and Cautley, 1843.	Upper Siwalik (Pinjor Zone)
Giraffa punjabiensis Pilgrim, 1910.	Middle Siwalik
Giraffa priscilla Matthew, 1929.	Lower Siwalik
Helladotherium grande Gaudry, 1860.	Middle Siwalik
Hydaspitherium birmanicum Pilgrim, 1910.	Middle Siwalik
Hydaspitherium grande Lydekker, 1878.	Middle Siwalik
Hydaspitherium megacephalum Lydekker, 1876.	Middle Siwalik
Hydaspitherium magnum Pilgrim, 1910.	Middle Siwalik
Bramatherium geraadsi Falconer, 1845.	Upper Siwalik (Pinjor Zone)
Sivatherium giganteum Falconer and Cautley, 1836.	Upper Siwalik (Pinjor Zone)
Vishnutherium iravaticum Lydekker, 1876.	Middle Siwalik

Table 2: The siwalik ruminant families, represented by number of species (recently collected data)

Families	No. of species
Bovidae	34
Giraffidae	14
Cervidae	5
Tragulidae	4

Family tragulidae: Tragulina are believed to be of primitive grade among ruminants[26]. This group includes both North American and Eurasian forms and can be considered as a paraphyletic group of primitive non-pecoran ruminants[34], although no consensus is established concerning the first unambiguous Pecora. During the late Palaeogene, tragulines was diversified and comprised by Eocene North American traguloids and some ambiguous Eurasian forms. Among North American Palaeogene traguloids, hypertragulids are the most primitive forms. This distinction is mainly based on their cranial and postcranial characters. Recently, however, Vislobokova[35] pointed out the presence of a new hypertragulid ruminant from the late Eocene of Khoer-Dzan (Mongolia), extending the geographical range of hypertragulids to Asia during the Palaeogene. Leptomerycids are mainly known from the late Eocene of North America onwards, but some unclear and poorly documented Asian forms are related to leptomerycids[36]. Tragulids are traditionally considered as the most primitive living ruminants[37] and they still survive as tropical relicts: the water chevrotains *(Hyemoschus)* of Africa and the mouse deer or Asiatic chevrotain *(Tragulus)* of Southeast Asia. They are characterized by their skeletal and dental features, which are primitive within ruminants and their general shape, digestive system and ethology, which are reminiscent to those of pigs[38]. The family Tragulidae is the only surviving family from the assumed paraphyletic Tragulina[37].

Appendix 1: Bovid species described by pilgrim (1939) from the siwaliks:

Incertae sedis	
Vishnumeryx daviesi (Lydekker)	
Gazellinae	
Gazella lydekkeri Pilgrim	*Gazella* sp. cf. lydekkeri
Gazella (?) *superba* Pilgrim	*Gazella* sp. cf. *superba*
Gen. indet. (aff. *Helicotragus*)-*vinayaki* Pilgrim	
Antilope cervicapra (Linn.)	
Gazella sp.	Gen. indet. sp. indet.
Antilope subtorta Pilgrim	*Antilope* (?) *planicornis* Pilgrim
Dorcadoxa porrecticornis (Lydekker)	
Caprinae	
Sivacapra sivalensis (Lydekker)	*Sivacapra* (?) *crassicornis* Pilgrim
Gen. indet. (aff. *Capricornis)roylei*-Pilgrim	*Pantholops hundesiensis* Lydekker
Alcelaphinae	
Damalops palaeindicus *(Falconer)*	
Hippotraginae	
Sivoryx cautleyi Pilgrim	*Sivoryx sivalensis* (Lydekker)
Sivatragus bohlini Pilgrim	*Sivatragus* (?) *brevicornis* Pilgrim
Gen. indet. (cf. *Tragoreas)*-*potwaricus* Pilgrim	Gen. indet. sp. indet.
Reduncinae	
Kobikeryx atavus Pilgrim	*Cambayella watsoni* Pilgrim
Hydaspicobus auritus Pilgrim	Gen. indet. cf. *Hydaspicobus auritus*
Vishnucobus patulicornis (Lydekker)	*Indoreduncа sterilis* Pilgrim
Gen. indet. (cf. *Indoreduncа)*-*theobaldi* Pilgrim	*Gangicobus asinalis* Pilgrim
Sevadenota biforis Pilgrim	Gen. indet. (cf. *Sivadenota)*-*sepulta* Pilgrim
Sivacobus palaeindicus (Lydekker)	
Tragelaphinae	
Sivoreas eremita Pilgrim	
Boselaphinae	
Sivaceros gradiens Pilgrim	*Sivaceros vedicus* Pilgrim
Sivaceros sp.	*Tragocerus punjabicus* Pilgrim
Tragocerus browni Pilgrim	*Tragocerus perimensis* (Lydekker)
Tragoportax salmontanus Pilgrim	*Tragoportax aiyengari* Pilgrim
Tragoportax islami Pilgrim	*Tragoportax* sp. cf. *islami*
Ruticeros pugio Pilgrim	*Strepsiportax gluten* Pilgrim
Strepsiportax chinjiensis Pilgrim	*Pachyportax latidens* (Lydekker) type
Pachyportax latidens var.-*dhokpathanensis* Pilgrim	*Pachyportax nagrii* Pilgrim
Sivaportax dolabella Pilgrim	*Boselaphus namadicus* Rutimeyer
Helicoportax praecox Pilgrim	*Helicoportax tragelaphoides* Pilgrim
Selenoportax vexillarius Pilgrim	*Selenoportax lydekkeri* (Pilgrim)
Perimia falconeri (Lydekker)	
Bovinae	
Proamphibos lachrymans Pilgrim	*Proamphibos kashmiricus* Pilgrim
Proamphibos sp. cf. *lachrymans.*	*Proamphibos* (?) *hasticornis* Pilgrim
Hemibos triquetricornis Rutimeyer	*Hemibos acuticornis* (Fale. et Caut.)
Hemibos antelopinus Rutimeyer	*Bubalus platyceros* Lydekker
Bubalus bubalis (Linn) var.-*palaeindicus* (Falconer)	*Bucapra daviesii* Rutimeyer
Proleptobos birmanicus Pilgrim	*Leptobos falconeri* Rutimeyer
Platybos aceros (Rutimeyer)	Gen. indet. (cf. *Platybos*) *platyrhinus* (Lydekker)
Bison sivalensis Lydekker	*Bos acutifrons* Lydekker
Bos namadicus Falconer	

The Siwalik species of family Tragulidae are as follows[39];

Species	Appearance in the Siwalik Hills of Pakistan
Dorcatherium majus Lydekker, 1876.	Siwaliks (Lower, Middle, Upper).
Dorcatherium minus Lydekker, 1876.	Siwaliks (Lower, Middle, Upper).
Dorcabune anthracotheriides Pilgrim, 1910.	Lower Siwalik (Chinji Zone).
Dorcabune nagrii Pilgrim, 1915.	Middle Siwalik

Choice of species: we have mentioned the species of the ruminants, which have yielded significant fossil record. Geographically, widespread species of Siwaliks are also considered thoroughly. This study avoids mentioning those species having an insignificant fossil record and those that have fossil record, fragmentary in nature. In this study most emphasis is given to those species, which are collected from Pakistani Siwaliks for the last two decades by the various workers.

CONCLUSIONS

Bovids were numerous in the Neogene of the Siwaliks. Pilgrim[24] described 75 species of bovids in which indet. species were 17 and 28 were new to science. Pilgrim described some species just on a single specimen. Later on Akhtar[25] described bovid faunas from the Siwaliks and determined 33 species. Solounias *et al.*[23] described a new species of what they considered as the oldest bovid. Four species of Tragulidae are considered as valid in Pakistani Siwaliks. *Dorcatherium nagrii* has been rejected already owing to descriptions on the basis of single isolated tooth. *Dorcabune hyaemoschiodus* and *Dorcabune latidens* were also rejected found synonym to *Dorcabune anthracothecioides* and *D. onigrii*, respectively[10]. The family Cervidae is represented by a single genus, *Cervus*, having five species. Fourteen species of giraffids have been reported from the Siwaliks, which are mostly confined to the Dhokpathan Formation and until now only one species has been reported from the Soan Formation (Table 2).

REFERENCES

1. Pilgrim, G.E., 1940. The dispersal of the Artiodactyla. Biological Rev., 16: 155-158.
2. Sudre, J., 1977. Les Artiodactyles de l'Eocène Moyen et Supérieur d'Europe Occidentale; Systématique et Évolution. Montpellier: Université des Sciences et Techniques du Languedoc.
3. Matthew, W.D. and W. Granger, 1925. New ungulates from the ardyn obo formation of Mongolia. American Museum Novitates, 195: 1-12.
4. Colbert, E.H., 1941. The osteology and relationships of *Archaeomeryx*, an ancestral ruminant. American Museum Novitates, 1135: 1-24.
5. Marivaux, L., M. Vianey-liaud and J.L. Welcomme, 1999. Premiere decouverte de Cricetidae (Rodentia Mammalia) oligocenes dans le synclinal Sud de Gandoi (Bugti Hills, Balouchistan, Pakistan). Comptes Rendus de l'Academie des Sciences, Sciences de la Terre et des Planetes, 329: 839-844.
6. Marivaux, L. and J.L. Welcomme, 2003. Diatomyid and baluchimyine rodents from the oligocene of Pakistan (Bugti Hills Balochistan): Biochronologic and paleobiogeographic implications. J. Vertebrate Paleontol., 23: 420-434.
7. Marivaux, L., J.L. Welcomme, P.O. Antoine, G. Metais, M. Benammi, I. Baloch, Y. Chaimanee, S. Ducrocq and J.J. Jaeger, 2001. A fossil lemur from the oligocene of Pakistan. Sci., 294: 587-591.
8. Antoine, P.O., S.M.I. Shah, I.U. Cheema, J.Y. Crochet, D. De Franceschi, L. Marivaux, G. Metais and J.L. Welcomme, 2004. New remains of the baluchithere *Paraceratherium bugtiense* (Pilgrim, 1910) from the late/latest oligocene of the bugti hills, Balochistan, Pakistan. J. Asian Earth Sci., 24: 71-77.
9. Medlicott, H.B., 1864. On the geological structure and relations of the Southern portion of the Himalayan range between the rivers Ganges and Ravee. Geol. Surv. India, Mem. III.
10. Colbert, E.H., 1935. Siwalik mammals in the American Museum of Natural History. Trans. Am. Phil. Soc., n.s., 26: 1-401.
11. Johnson, N.M., J. Stix, L. Tauxe, P.F. Cerveny and R.A.K. Tahirkheli, 1985. Paleomagnetic chronology, fluvial processes and tectonic implications of the siwalik deposits near Chinji Village, Pakistan. J. Geol., 93: 27-40.
12. Tauxe, L. and C. Badgley, 1988. Stratigraphy and remanence acquisition of a paleomagnetic reversal in alluvial Siwalik rocks of Pakistan. Sedimentology, 35: 697-715.
13. Tauxe, L. and N.D. Opdyke, 1982. A time framework based on magnetostratigraphy for the siwalik sediments of the khaur area, northern Pakistan. Palaeogeography, Palaeoclimatol. Palaeoecol., 37: 43-61.
14. Barry, J., M. Morgan, L. Flynn, D. Pilbeam, A.K. Behrensmeyer, S. Raza, I. Khan, C. Badgely, J. Hicks and J. Kelley, 2002. Faunal and environmental change in the late miocene siwaliks of northern Pakistan. Paleobiology, 28: 1-72.

15. Gentry, A.W., 1970. The Bovidae (Mammalia) of the Fort Ternan fossil fauna; in Leakey, L.S.B. and R.J.G. Savage (Eds.), Fossil Vertebrates of Africa, Academic Press, London, 2: 243-323.
16. Gentry, A.W., 1978. Bovidae: In Maglio, V.J. and H.B.S. Cooke (Eds.). Evolution of African Mammals. Harvard University Press, Cambridge, Massachusetts, pp: 540-572.
17. Solounias, N., 1982. Evolutionary patterns of the Bovidae (Mammalia). Proc. North American Paleontol., Convention III, 2: 495-499.
18. Thomas, H., 1984. Un nouveau bovide dans les couches a Hominoidea du Nagri (Siwaliks moyens, Miocene superieur), Plateau du Potwar, Pakistan: Elachistoceras khauristanensis, gen. nov. sp. nov. (Bovidae, Artiodactyla, Mammalia) Bulletin de la Societe Geologique de France, 19: 375-383.
19. Ye, J., 1989. Middle Miocene artiodactyls from the northern Junggar Basin. Vertebrata PalAsiatica, 27: 37-52.
20. Barry, J.C. and L.J. Flynn, 1989. Key biostratigraphic events in the Siwalik sequence. In European Neogene Mammal Chronology. Ed. Lindsay, E.H., V. Fahlbusch and P. Mein, New York, Plenum, pp: 55-71.
21. Downing, K.F., E.H. Lindsay, W.R. Downs and S.E. Speyer, 1993. Lithostratigraphy and vertebrate biostratigraphy of the early Miocene Himalayan Foreland, Zinda Pir Dome, Pakistan., Sedimentary Geol., 87: 25-37.
22. Friedman, R., J. Gee, L. Tauxe, K. Downing and E. Lindsay, 1992. The magnetostratigraphy of the Chitarwata and lower Vihowa formations of the Dera Ghazi Khan area, Pakistan. Sedimentary Geol., 81: 253-268.
23. Solounias, N., J.C. Barry, R.L. Bernor, E.H. Lindsay and S.M. Raza, 1995. The Oldest Bovid from the Siwaliks, Pakistan. J. Vertebrate Paleontol., 15: 806-814.
24. Pilgrim, G.E., 1937. The fossil Bovidae of India. Pal. Ind. (n.s.), 26: 1-356.
25. Akhtar, M., 1992. Taxonomy and Distribution of the Siwalik Bovid. Ph. D. Thesis, University of the Punjab, Pakistan.
26. Janis, C.M. and K.M. Scott, 1987. The inter-relationship of Higher Ruminant families with special emphasis on the members of the Cervoidea. Am. Mus. Novitates, 10024: 1-85.
27. Arif, M. and S.M.I. Shah, 1991. *Cervus rewati* sp. nov. (Mammalia, Cervidae) from the Upper Siwaliks of Pakistan. Pak. Geol. Surv. Mem., 17: 11.
28. Ghaffar, A., 2005. Studies on Equids, Cervids and Carnivora from the Siwalik Hills of Pakistan. Ph. D. Thesis, University of the Punjab, Pakistan.
29. Solounias, N., W.S. McGraw, L.A. Hayek and L. Werdelin, 2000. The paleodiet of the Giraffidae, chapter 6, Antelopes, Deer and Relatives, Edited by Elisabeth S. Vrba and George B. Schaller, Yale University Press, New Haven and London.
30. Bohlin, B., 1926. Die familie Giraffidae. Palaeotologia Sinica Pekin, C4, 1: 1-78.
31. Hamilton, W.R., 1978. Fossil giraffes from the Miocene of Africa and a revision of the Giraffoiea. Phylosophical Trans. Royal Soc., London, 283: 165-229.
32. Geraads, D., 1986. Remarques sur la systrematique *et al.* phylogenie des Giraffidae (Artiodactyla, Mammalia). Geobios, 19: 465-477.
33. Gentry, A.W. and J.J. Hooker, 1988. The Phylogeny of Artiodactyla. In: The Phylogeny and Classification of the Tetrapods, (Ed. M.J. Benton), Systematics Association Special Volume No. 35B Clarendon, Oxford, 2: 235-272.
34. Scott, K.M. and C.M. Janis, 1993. Relationships of the Ruminantia (Artiodactyla) and an analysis of the characters used in Ruminant taxonomy. In: Szalay, F.S., M.J. Novacek and M.C. McKenna (Eds.) Mammal Phylogeny, Placentals. New York: Springer-Verlag, pp: 282-302.
35. Vislobokova, I., 1998. A new representative of the Hypertraguloidea (Tragulina, Ruminantia) from the Khoer-Dzan locality in Mongolia, with remarks on the relationship of the Hypertragulidae. Am. Museum Novitates, 3225: 1-24.
36. Mckenna, M.C. and S.K. Bell, 1997. Classification of Mammals Above the Species Level. New York: Columbia University Press.
37. Janis, C.M., 1984. Tragulids as Living Fossils. In: Eldredge, N. and S.M. Stanley (Eds) Living Fossils. New York, Berlin, Heidelberg, Tokyo: Casebooks in Earth Sciences, pp: 87-94.
38. Dubost, G., 1965. Quelques traits remarquables du comportement de Hyaemoschus aquaticus. Biologia Gabonica, 1: 282-287.
39. Farooq, U., 2005. Studies of evolutionary trends in dentition of the siwalik tragulids. Ph. D. Thesis, University of the Punjab, Pakistan.
40. 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. Vertebrate Paleontol., 7: 200-216.