Pakistan J. Zool., vol. 41(6), pp. 429-435, 2009.

Chalicotheres in the Siwaliks of Pakistan

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Abstract.- Chalicothere fossils are rare and fragmentary finds in the Siwalik formations. Three specimens of chalicotheres are excavated including one upper premolar and one lower molar from the Nagri Formation, and a hemimandible with m1-3 from the Chinji Formation of the Siwaliks. The new material adds much to our knowledge for the Siwalik chalicotheres and provides new information about the upper and lower dentitions of the Siwalik Chalicotheriinae. We suggest that more than one species of Chalicatheres can be found throughout Miocene of the Siwaliks.

Key Words: Chalicotheres, *Chalicotherium salinum*, *Anisodon*, Siwaliks, Chinji, Nagri.

INTRODUCTION

The Chalicotherioidea Gill, 1872 are known from Middle Eocene to Pleistocene deposits of Africa, Eurasia and N. America (Schulz *et al*., 2007; Anquetin *et al*., 2007; Butler, 1965; Coombs, 1989; Falconer, 1868). Remains of the Chalicotheriidae are normally scarce in Eurasian late Miocene localities (Sarac and Sen, 2005) and also they constitute a very rare faunal element in the Siwaliks of Pakistan. A few scientists who have worked on the Siwalik chalicotheres are Forster-Cooper (1922), Pilgrim (1908, 1910, 1912), Matthew (1929), Colbert (1935a), Butler (1965), Pickford (1982), Sarwar and Akhtar (1990). Forster-Cooper (1922) was the first one to study the Siwalik chalicotheres. Later on Pickford (1982) listed all the Siwalik chalicothere material which was collected by the Yale-Pakistan expedition between 1973 and 1978 and by museum collection from the Geological Survey of India, Calcutta and from Geological Museum of Pakistan, Quetta. Pickford (1982) placed all the Chinji, Nagri, and Dhok Pathan chalicotheriine material in one species, *C. salinum* and after him no one described any material of the Siwalik chalicotheres in detail. Previously, *Anisodon* (*Nestoritherium*) *sivalense* was found throughout the old-world in lower Quaternary (Matthew, 1929; Colbert, 1935a, b) but in this study, *Chalicotherium* and *Anisodon* were recovered from the middle Miocene of the Siwaliks.

Nevertheless, the remains of *C. salinum* are rare finds and until now previous workers have only discovered a few specimens from the Siwaliks. Moreover, in the historical study of the Siwalik chalicotheres, compared to the other Siwalik perissodactyl groups like horses and rhinoceroses, we come across a rare chalicothere fauna. New findings from the areas near the Chinji and the Nagri type localities of the Siwaliks of middle Miocene age, suggest that more widespread taxa can be found in the vicinity of the Siwalik localities (Fig.1).

MATERIALS AND METHODS

PUPC 07/80 and PUPC 07/56 have been unearthed from the Nagri Formation outcropping between the villages Bhilomar and Kadirpur. Regionally the area is situated in the north of the Gabbir River, Jhelum, Pakistan (Fig. 1). The section from which the remains were excavated represents a typical sequence of fluvial sedimentation and consists of bluish grey, massive and coarse sandstone with purple and orange clay and thick brown sandstone. PUPC 02/154 was collected from the Chinji Formation of the village Kanati near the Dhok Kookraan Wali, Jhelum, Pakistan. The outcrop of Kanati is located about 12 km southwest of the Chinji type locality and is characterized by bright red clay, interbedded with grey, soft sandstone.

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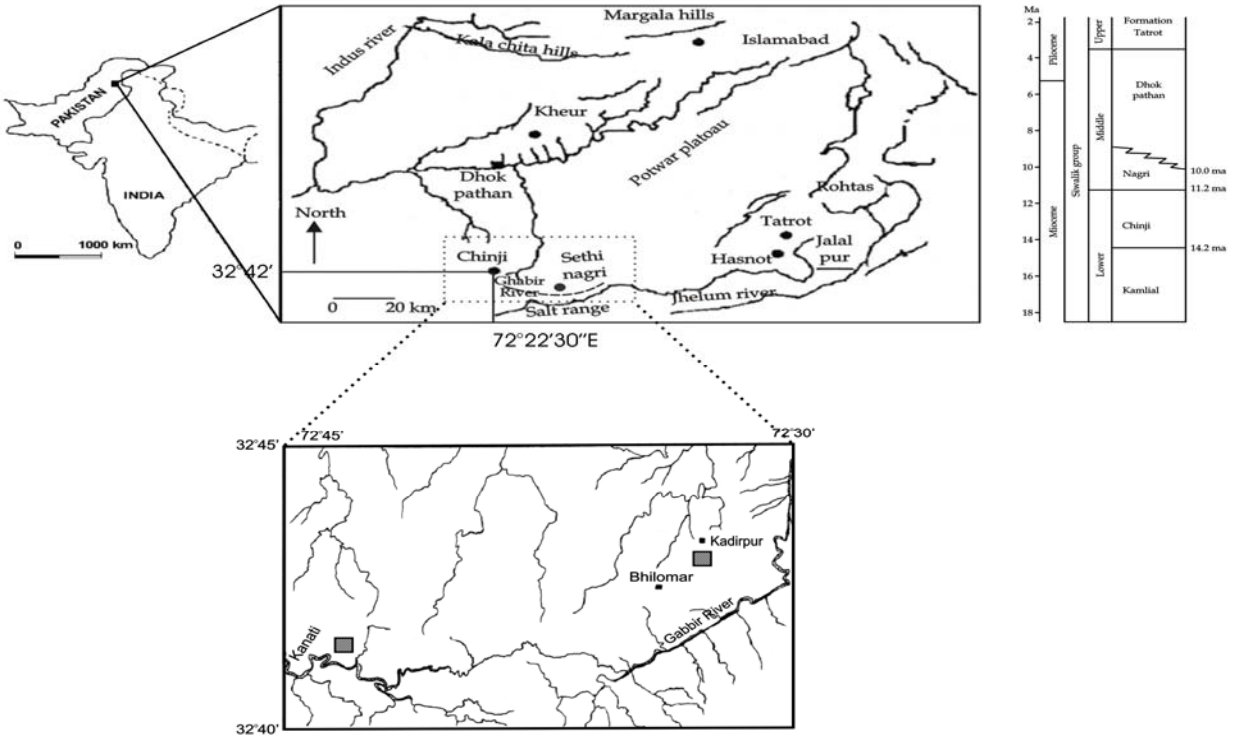

Fig. 1. Map of the Potwar Plateau in northern Pakistan, showing the study areas. Boxes indicate the collection sites (Boundary dates from Barry *et al*., 2002).

All measurements are given in mm, with an accuracy of one decimal digit. The dental length (l) was measured on the occlusal surface. The tooth width (w) is the maximum width. Upper case letters are for upper teeth and lower case letters for lower teeth. l, length; aw, anterior width; pw, posterior width.

The finding of the new remains allows to test the hypothesis that there were two species of chalicotheres in the Siwalik Miocene contrary to Pickford's findings (1982) who assigned all the Siwalik material to one species.

Institutional abbreviations: PUPC, Punjab University Palaeontological Collection; MNHN, Museum National d'Histoire Naturelle, Paris; AMNH, American Museum of Natural History. The catalogue number of the PUPC specimens consists of series, i.e. yearly catalogued number and serial catalogued number, so figures of the specimen represent the collection year (numerator) and serial number (denominator) of that year (*e.g*. 07/80).

SYSTEMATIC PALAEONTOLOGY

Order Perissodactyla Owen, 1848
Suborder Ancylopoda Cope, 1889
Superfamily Chalicotherioidea Gill, 1872
Family Chalicotheriidae Gill, 1872
Subfamily Chalicotheriinae Gill, 1872

CHALICOTHERIUM Kaup, 1833

Macrotherium Pictet, 1844

Chalicotherium salinum (Forster-Cooper, 1922)

Macrotherium salinum Forster – Cooper, 1922
Manis sindiensis Lydekker, 1876
Macrotherium salinum Forster-Cooper; Matthew, 1929
Macrotherium salinum (Forster-Cooper); Von Koenigswald, 1932
Macrotherium salinum Forster-Cooper; Colbert, 1935b
Macrotherium salinum (Forster-Cooper); Butler, 1965
(Fig. 2A-F)

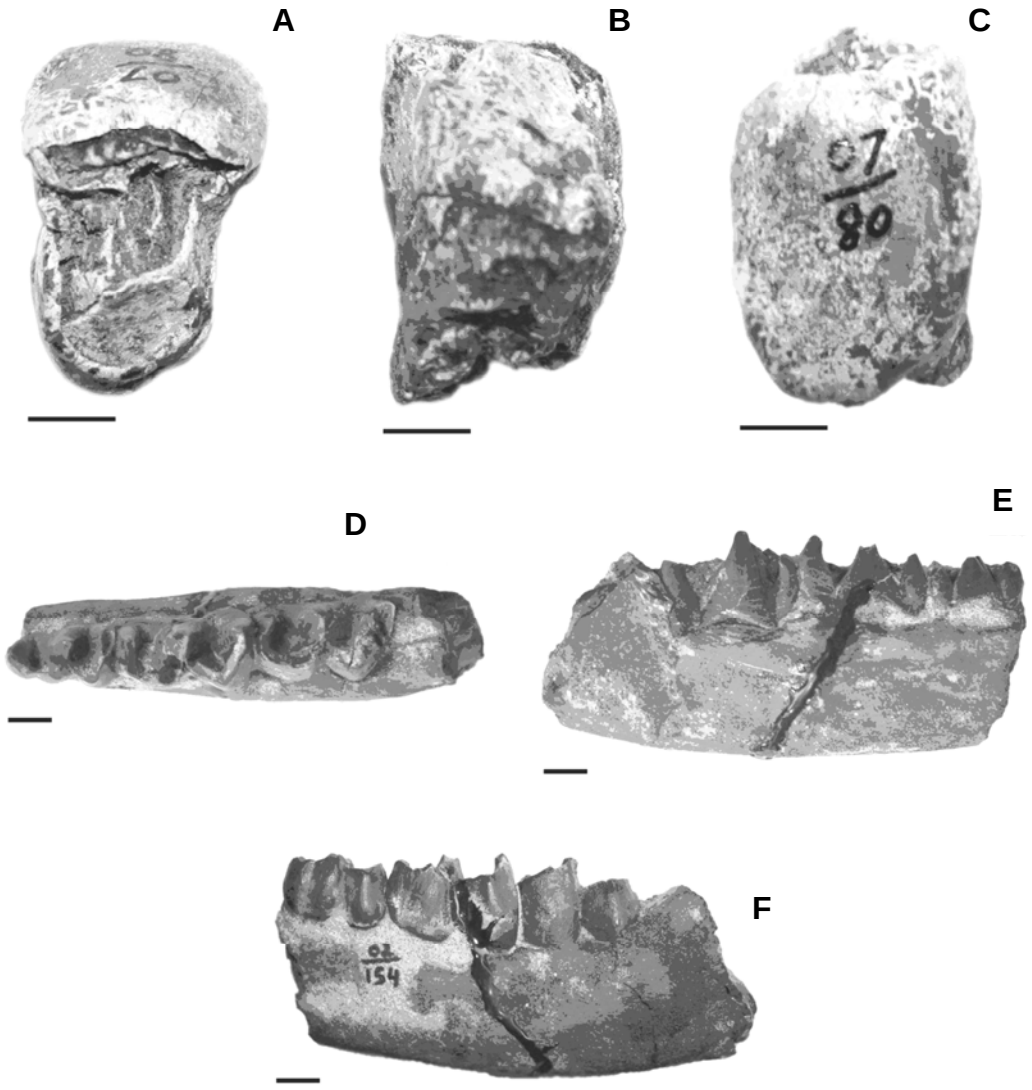

Fig. 2. *Chalicotherium salinum*; A-C, PUPC 07/80 left P4; B-F, PUPC 02/154 left dentary fragment with m1-3. A, D, occlusal view, B, E, lingual view; C, F, labial view. Scale bar 10 mm.

Material from the Bhilomar village near the Nagri type locality (Nagri Formation)

PUPC 07/80 left fourth upper premolar (length on the labial side = 29, length on the lingual side = 21.3, w = 41.6) (Fig. 2A-C).

Material from the Kanati village (Chinji Formation)

PUPC 02/154 left mandibular ramus with three molars (m1: l = 13.8, aw = 8.7, pw = 14; m2: l = 27, aw = 14.8, pw = 18; m3: l = 29.4, aw = 17, pw = 18.3) (Fig. 2D-F).

Stratigraphic level

Middle Miocene.

Abbreviated diagnosis

Closely comparable to *Chalicotherium goldfussi*. The trigonid is V shaped and the talonid is U shaped. The talonid is longer than trigonid in lower molars. Upper molars quadrate and brachydont. The protoconule is more distinct than protocone.

Description

PUPC 07/80 (Fig. 2A-C) is much wider than long and premolariform. It has large ectoloph and a prominent conical lingual cusp (see measurements). The slightly worn P4 is a distinctly lophodont tooth. The ectoloph and deuterocone are joined anteriorly and posteriorly by strong cingula. The cingula are strong and present anteriorly, posteriorly as well as lingually. There is no mesostyle although there is a very faint ridge on the buccal wall of the centrocrista. The lophid crests arising from the protocone form the shape of a V, the mesial branch is composed of the protoloph, the distal branch is composed of the aligned postprotocrista and premetacrista (Fig. 2A-C). The protoloph just fails to meet the preparacrista. It has a faint swelling midway along its length, but this is not developed into a discrete structure that could be termed a paraconule. There is no metaconule on the lophid crest that joins the metacone right at its tip as the metaloph does on the molars (Fig. 2A-C).

PUPC 02/154 (Fig. 2D-F) is a left hemimandible of a young individual with three molars. The part anterior to m1 is missing but the rest of the hemimandible is preserved up to the ascending ramus. The hemimandible is broken posteriorly right at the start of the ascending ramus and an unworn molar within the crypt lies vertically along the distal broken end of the hemimandible. The molars within the hemimandible are low-crowned with an outline that narrows in a lingual direction. The hemimandible is elongated antero-posteriorly (Fig. 2D-F). The m1 has strong proximally protruding paraconid with papillate cingulum present anteriorly and tends to be doubly crescentic. The other molars consist of two crescents, one behind the other. As for the wear gradient on m1, wear is an earlier stage, on m2 it is moderate and on m3 it is slight. The talonid on the molars is longer than the trigonid. The trigonid is V shaped and the talonid is U shaped. The paraconid is low but well defined. The cingulum is missing. The metastylid is reduced in the molars. The hypolophid is well developed but does not reach the metaconid summit. The metacristid is strong and the ectolophid is W shaped. The vertical medial incisions are well developed on the distal walls of the metalophid and entolophid and on the mesial wall of the hypolophid.

Discussion

Pickford (1982) described four isolated P4s in the Siwaliks having variable sizes (e.g. GSP 4256: l = 18.8, w = 25.7; K16/469: l = 15.5, w = 21.8; K16/395: l = 18.4, w = ca. 25; K41/931: l = 17.9, w = 20.5) but the most interesting studied P4 (PUPC 07/80: l = 29, w = 41.6) is much larger than the previously known specimens of the *C. salinum*. The studied specimen differs from the already described specimens in 1) not having a sagittally deep valley and ectoloph groove which are the prominent characters of the Siwalik chalicotheres observed by Pickford (1982); 2) a very faint ridge on the buccal wall, sharing the characteristic with *Anisodon*; 3) the specimen is much larger than the previously known specimens of the Siwalik chalicotheres (Fig. 2D-F).

The previously described specimens from the Siwaliks are larger than *C. rusingense* from the lower Miocene of East Africa and *C. pilgrimi* from the Bugti fauna and smaller than *C. grande* and *C. goldfussi* (Pickford, 1982). The P4 is about the size of *Chemositia tugenensis* which is a large schizotheriine from the late Miocene of Mpesida, Kenya (Guerin and Pickford, 2005). The *Ancylotherium* has strong cingula on the anterior, lingual and posterior faces of P4 but the buccal surface of the premolar is flat, distinguishing it from that of *Chalicotherium* which has folded or depressed buccal surface (Zapfe, 1979). The depth of the mandibular ramus (PUPC 02/154) decreases from posterior to anterior as in the specimen of *Ancylotherium* (Geraads *et al*., 2006), and the ventral side of the ramus is slightly convex.

These characteristics have also been described on the remains collected from Sansan (France) and La Grive Saint-Alban (Anquetin *et al*., 2007). These characteristics correspond to that of *C. salinum* and the Siwalik hemimandible is assigned to *C. salinum*. Colbert (1935b) described a lower jaw with deciduous teeth (AMNH 19577) of a young individual under the name of *Macrotherium salinum* (see also Colbert, 1935b). As per observed metrical values of the studied animal in this paper, it is larger in size than the animal reported previously by Colbert (1935b).

Fig. 3. *Anisodon;* 3. PUPC 07/56 left m3. A, occlusal view; B, lingual view; C, labial view.

cf. *Anisodon* Lartet, 1851 (Non Pomel, 1848)
Nestoritherium Kaup, 1859
(Fig. 3)

Material from the Bhilomar village near the Nagri type locality (Nagri Formation)

PUPC 07/56 left lower third molar (l = 35, w = 18) (Fig. 3).

Stratigraphic level

Middle Miocene.

Description

The tooth is the first one ever known of the Siwalik Miocene (Fig. 3). The paraconid is low and the metaconid is stronger and higher than the other conids. The metastylid is observable and distinct from the metaconid. However, perissodactyls lost the metastylid early in their evolution; this pseudometastylid is the distal cusp of a twinned metaconid (Hooker, 1994). The metacristid is well developed. The talonid is more elongated than the trigonid and both are V shaped (Fig. 3). The distal cingular crest is pretty well developed at the base of the hypocone in this specimen and the cingulum is very weak elsewhere. The mesial wall of the hypolophid and the distal walls of the protolophid and entolophid show weak vertical medial incisions (Fig. 3).

Discussion

Morphologically PUPC 07/96 is similar to the lower third molar (m3) of the Paralectotype of *Anisodon grande* (MNHN Sa 9376), described by Anquetin *et al.* (2007, fig. 2a) and previously known as *Anoplotherium grande* de Blainville, 1849. Due to the lack of sufficient complete fossil material a definite determination is not yet possible. The morphology of the collected lower third molar probably most closely resembles *Anisodon grande* however, it can't be determined precisely. Therefore the most precise determination what can be given is cf. *Anisodon*.

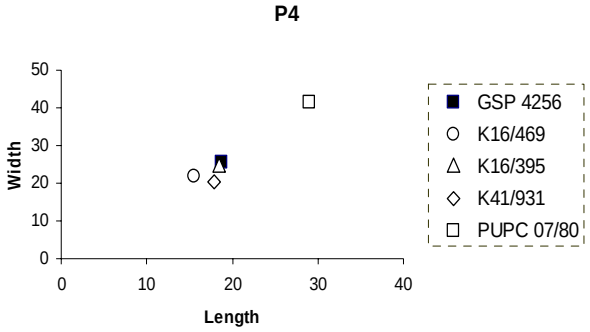

Fig. 4. Size variation of the upper fourth premolar of *C. salinum.*

CONCLUSIONS

The remains indicate that among Chalicotheriinae two distinct groups existed in the middle Miocene of the Siwaliks. It has become clear by the morphological and the palaeontological evidence that the two separate species of Chalicotheriinae in Siwalik deposits of the Chinji and Nagri formations were *Chalicotherium* and cf. *Anisodon*. The Siwalik Miocene fossil record reveals that the two lineages represented by *Chalicotherium* and cf. *Anisodon* were contemporary to the middle Miocene of Sansan,

France (Anquetin *et al.*, 2007). The coexistence of *Chalicotherium* and *Ancylotherium* from Pikerimi, and *Chalicotherium* and cf. *Anisodon* from the Nagri of the Siwaliks reinforces our suggestion of a similar habitat (Geraads *et al*., 2006). The Bhilomar upper fourth premolar material of *C. salinum* is one of the largest specimens ever found from the Siwaliks (Fig. 4). The present study is based on the dentition, so the inclusion of cranial and postcranial remains will be required to reach the stable conclusion.

ACKNOWLEDGMENTS

We are grateful to Mrs. Ghazala Roohi, Manager, Pakistan Natural History Museum, Islamabad, Pakistan for providing us with the required literature. Many thanks are due to Julia M. Fahlke of Institute of Palaeontology, University Bonn, Bonn, Germany for his useful comments and linguistic support on the manuscript. Special thanks are due to Nadeem, Fazal and Adeeb for their help in photography.

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(Received 3 March 2009, revised 4 June 2009)