

## Report on Mammalian Fossils of Chinji Formation, Dhulian, Pakistan

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**Abstract:** Twenty mammalian fossil specimens of varying preservational state are described from the Chinji Formation of Dhulian, Pakistan. The remains described in this study are all teeth and represent the Proboscidea, Perissodactyla and Artiodactyla. All the dental specimens are new variants recorded here for the first time. *Pliotriplopus dhulianensis* is new to science having small size and absence of crista than *Pliotriplopus chinjiensis*. These findings extend the geographic distribution of this dentally highly derived Triplopinae, which was previously restricted to a single species, *Pliotriplopus chinjiensis*. Additional fossils of the three mammalian orders are necessary to shed new light on the phylogenetic relationships within the first representatives of the orders in Eurasia. A very important, deciduous tooth of the species *Stegolophodon cautleyi* hitherto unknown is described in this report.

**Key words:** Mammalian fossil, proboscidea, perissodactyla, artiodactyla, *Stegolophodon cautleyi*

### INTRODUCTION

The Siwalik rocks are fossiliferous throughout and thus contain an almost continuous record of mammalian evolution for the Indian sub-continent spanning 18 million years<sup>[1-4]</sup>. Miocene faunal turnover events introduced immigrants into South Asia mainly from Africa whereas the Pliocene events record mammalian faunas closely similar to contemporary ones in Northern and Western Eurasia<sup>[5]</sup>. The Chinji Formation strata in the area of Dhulian are comparatively richly fossiliferous. Material collected from these localities previously is currently stored in the collections of the American Museum of Natural History<sup>[6]</sup> as well as the Zoology department, Punjab University, Pakistan. Dhulian (Fig. 1) is one of the important Siwalik localities. It is located 3 km east of Pindigheb on Rawalpindi-Pindigheb highway. The area south of the town of Dhulian is covered by the vast Chinji strata. The low, flat-topped hills in the area where the Chinji beds occur consist of bright red clays with pseudo conglomerates of siliceous nature.

**Chinji formation:** Pilgrim<sup>[7]</sup> described this rock unit as Chinji zone, while Lewis<sup>[8]</sup> used the term Chinji Formation. At type locality the lower contact of Chinji Formation with Kamlial Formation is gradational, while the upper contact is conformable with the Nagri Formation. The Stratigraphic Committee recommended the name Chinji Formation with type section near Chinji.

**The siwalik sequence and stratigraphy of the locality:** Like the Indus River in Pakistan today, the paleo-Indus occupied a vast floodplain with local variation in relief and, presumably, habitats. Since at least early Miocene time<sup>[9]</sup>, it drained the rising hills of the highlands to the north, which would become the

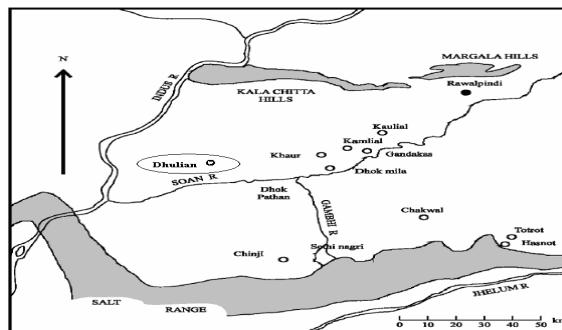


Fig. 1: Map of the Potwar Plateau showing main fossil localities. Inset encircled the study area

Hindu Kush and other mountain ranges on the fringe of the Tibetan Plateau. This vast drainage system deposited sediments in the floodplain, which are differentiated today as formations of the Chitarwata and Siwalik groups. In the Potwar Plateau of northern Pakistan, Siwalik Group sedimentation began with the Kamlial Formation. Its varied sands and reddish overbank deposits yield fossils somewhat grudgingly, but from the base of this unit before 18 ma. About four million years later, a change in sedimentary provenance is observed, dominated by red fine-grained units known collectively as the Chinji Formation, which is rich in fossils. The superposed Nagri Formation is time transgressive at its contacts and is characterized by dominance of thick, multistoried sands, usually blue-gray in hue. The base of the unit is >11 ma locally and its upper contact is usually <10 ma. The overlying Dhok Pathan Formation represents the end of the Miocene time and is characterized by fossiliferous overbank deposits and smaller sand units; most sands are buff in color, representing a different stream system

and there are local thin conglomerates (Table 1, Boundary dates are from Barry *et al.*<sup>[10]</sup>).

Table 1: Siwalik formations of the Potwar Plateau. \* In the southern Potwar, the Kamliyal and Murree Formations are not differentiated. In the north, the Murree is considerably older than 18 ma<sup>[10]</sup>

Formations	Age Range (ma)
Tatrot	3.5-3.3
Dhok Pathan	10.1-ca 3.5
Nagri	11.2-10.1
Chinji	14.2-11.2
Kamliyal/Murree*	18.3-14.2
Murree	?- 18.3

Detailed geological, palaeontological and geochronological studies, as well as magnetostratigraphic studies were recently carried out by a collaborative team from Harvard University (USA) and the Geological Survey of Pakistan. This study has generated significant insights concerning the Siwalik mammalian faunas, including their biostratigraphy, episodes of faunal turnover, species longevity, evolution and taphonomy. Also, they have demonstrated that in the backdrop of the mountain building activities of the Himalaya, the history of the sedimentation and the environments varied with time for the interval between 18 to 1 million years ago<sup>[1,2,5,10,11-17]</sup>.

Table 2: Previous mentioned taxa of the chinji formation

Primates Chalicotheriidae	
Sivapithecus sivalensis	Chalicotherium salinum
<i>S. indicus</i>	<b>Suidae:</b>
Ramapithecus punjabicus	Listriodon pentapotamiaie
<b>Rodentia:</b> <i>Conohyus chinjiensis</i>	
<i>Rhizomyoides punjabiensis</i>	<i>Lophochoerus</i> sp.
<i>Copemys</i> sp.	<b>Anthracotheriidae:</b>
<i>Megacricetodon</i> sp.	<i>Merycopotamus pusillus</i>
<i>Antemus chinjiensis</i>	<b>Tragulidae:</b>
<b>Carnivora:</b>	<i>Dorcatherium majus</i>
Hyanailouros bugtiensis	D. minus
Dissopsalis carnifex	<b>Bovidae:</b>
<b>Tubulidentata:</b>	<i>Protragocerus gluten</i>
<i>Orycteropus pilgrimi</i>	<i>Miotragocerus gradiens</i>
<b>Giraffidae:</b>	<i>Kubanotragus sakolovi</i>
<i>Giraffokeryx punjabiensis</i> , <i>Sivoreas eremita</i>	<i>Gazella</i> sp

### SYSTEMATIC ANALYSIS OF THE SPECIMENS

**Terminology:** For the description and comparison of the studied teeth, the following terminology has been used:

**Extremely brachyodont:** When H/W index is below 70.

**Brachyodont:** When H/W index is 70-80.

**Extremely narrow crowned:** When W/L index is below 70.

**Extremely broad crowned:** When W/L index is above 100.

**Abbreviations:** The following abbreviations have been used:

AMNH= American Museum of Natural History, New York, U.S.A.

P.U.P.C= Punjab University, Palaeontological Collection housed in Zoology Department, Punjab University, Lahore, Pakistan.

U.Z= University of the Punjab, Zoology Department, Lahore, Punjab, Pakistan.

Ind. Mus= Indian Museum.

G.S.I= Geological Survey of India, Kalkutta, India.

Ma= Million years ago

L= Crown length.

H= Crown Height.

W= Crown width.

H/W index= Height/Width × 100.

W/L index= Width/Length × 100.

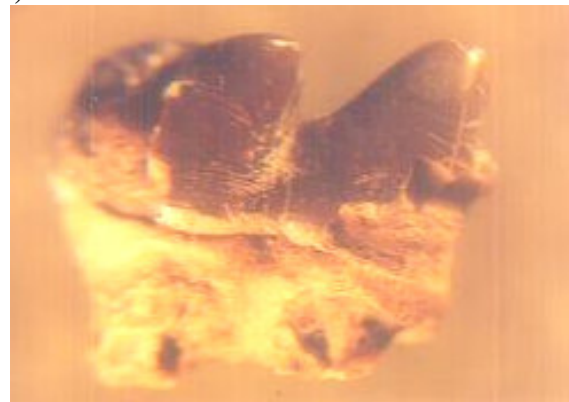
L= Left.

R= Right.

P= Preserved.



(a)



(b)

Fig. 2: *Stegolophodon cautleyi*, a rDP<sub>2</sub> (P.U.P.C. No. 99/16). a. crown view x 1.5, b. lateral view x 1.5

### Systematic palaeontology

Order PROBOSCIDEA

Suborder ELEPHANTOIDEA

Family ELEPHANTIDAE

Genus *STEGOLOPHODON* Schlesinger

*Stegolophodon cautleyi* Lydekker

**Type specimen:** (Lectotype): 1. M<sup>3</sup>, Brit. Mus. M. 2705.

**Type locality:** Perim Island, India.

**Stratigraphic range:** Middle Siwalik.

**Diagnosis:** Median cleft more or less prominent. Conules of the anterior ridge plates somewhat dislocated. Each ridge plate is surmounted by 4 to 5 conules in M<sup>3</sup> and by 5 to 6 in intermediate molars. Small conules or accessory tubercles present in the transverse valleys. M<sub>3</sub> 4 crested.

**Distribution:** The species is known only from the Siwaliks of Pakistan and India where it appeared for the first time at the base of lower Chinji<sup>[18]</sup>. The species survived to the late Pliocene and its latest record is from the upper levels of the Dhok Pathan zone of the Middle Siwalik.

**Material:** P.U.P.C. No. 99/16 is an isolated right lower deciduous second premolar.

**Description:** The preservation of the studied tooth (Fig. 2) is excellent. It is elongated and the crown is divided into two halves; an anterior broad half and a narrower posterior half. Enamel is fairly thick, almost smooth, simple and shiny with an average thickness of about 3mm. The crown is basically tetratuberculated. The cusps are arranged in two definite transverse plates, a protoloph and a metaloph. In between the two transverse lophs there is a wide transverse valley with an almost perpendicular anterior side and a gently sloping posterior surface. A very small and very low median accessory tubercle is located labially close to the mid longitudinal line of the crown. Pretrite is almost triangular with anteroposterioly extended median part, which is actually made by three tubercles, arranged in a linear fashion. The protoconid is almost round and very well defined and the posttrite is composed of two tubercles. The metaconid has a smaller inner tubercle. At the anterior of the protoloph a very small anteroposteriorly thin foretalon is present. In front of the median cleft, a large rounded tubercle can be seen. The deep wear of the tooth has produced a large transversely elongated dentinal islet on the grinding surface of the pretrite. The first posttrite is comparatively less worn and its dentinal islet are still isolated. The 2<sup>nd</sup> pretrite is divisible into two tubercles – a major labial and a minor median one. The second posttrite is likewise divisible into two. The hind talon is fairly high but very thin.

Table 3: Measurements (in mm) of right lower deciduous second premolar (P.U.P.C No. 99/16), *Stegolophodon cautleyi*

Preserved antero-posterior crowned length	41
Preserved transverse crowned width	31.5
Preserved crowned height	22.5
H/W index	71
W/L index	76
Enamel thickness	3

**Discussion:** The enamel layer compared to the tooth size is very thick, a feature typical of the proboscidean

deciduous dentition. According to Sarwar<sup>[19]</sup>, the crown is brachyodont in proboscidea except the later forms such as *Elephas*, *Mammuthus* and *Loxodonta*. Since the crown of PUPC No. 99/16 is low, it cannot be referred to any of these. In PUPC. No. 99/16, the conules are arranged in transverse plates. Such type of arrangement is displayed by the teeth of *Tetralophodon*, *Stegolophodon*, *Stegodon* and *Stegotetabelodon*. In *Tetralophodon* the conules are much compressed as compared to those of the other three genera<sup>[20]</sup>. Moreover, the median sulcus is almost indistinct in the molar teeth of the genus *Tetralophodon*. The ridge plates are widely spaced in the molar teeth of the genera *Stegolophodon* and *Stegotetabelodon*<sup>[21,22]</sup> whereas these are closely oppressed in those of the genus *Stegodon*<sup>[19]</sup>. Thus the specimen under study can either be referred to the genus *Stegolophodon* or to the genus *Stegotetabelodon*. The genus *Stegolophodon*, being chronologically older than the genus *Stegotetabelodon*, has more deep and prominent median sulcus<sup>[20]</sup>. The presence of strong median sulcus and the transverse arrangement of the conules of the plates very safely warrant the inclusion of the studied specimen in the genus *Stegolophodon*. The oblique nature of the protoloph, the deep median cleft and the presence of anterior and median accessory conules are primitive proboscidean characters<sup>[23]</sup> shared with the specimen under study. Both dental features and the stratigraphic level, indicate that it belongs to the most primitive species of the genus, *Stegolophodon cautleyi*. The description of PUPC No. 99/16 is very important, as the deciduous teeth of the species *Stegolophodon cautleyi* were hitherto unknown.

Order PERISSODACTYLA  
 Suborder CERATOMORPHA  
 Super family RHINOCEROTOIDEA  
 Family HYRACODONTIDAE  
 Subfamily TRIPLOPINAЕ  
 Genus *PLIOTRIPLOPUS* Sarwar

*Pliotriplopus dhulianensis* n.sp.

**Type specimen:** P.U.P.C. No. 99/17, right upper last molar.

**Type locality:** Dhulian, district Attock, Punjab, Pakistan.

**Diagnosis:** A smaller form of *Pliotriplopus*, distinguished from the genotype in the presence of a crochet.

**Description:** P.U.P.C. No. 99/17. Molar tooth (Fig. 3).

The tooth (P.U.P.C. No. 99/17) is extremely broad and hypsodont (Table 4). The protocone and hypocone are fused (Fig. 3). Enamel is simple towards the outer side but becomes rugose to the lingual side where it is raised and has taken the shape of a mini loph. Anteriorly, the enamel is much stronger and it is well raised towards the paracone. The anterior face shows a very strong pressure mark caused by the anterior tooth. A similar pressure mark may also be seen at the posterior face of the tooth.

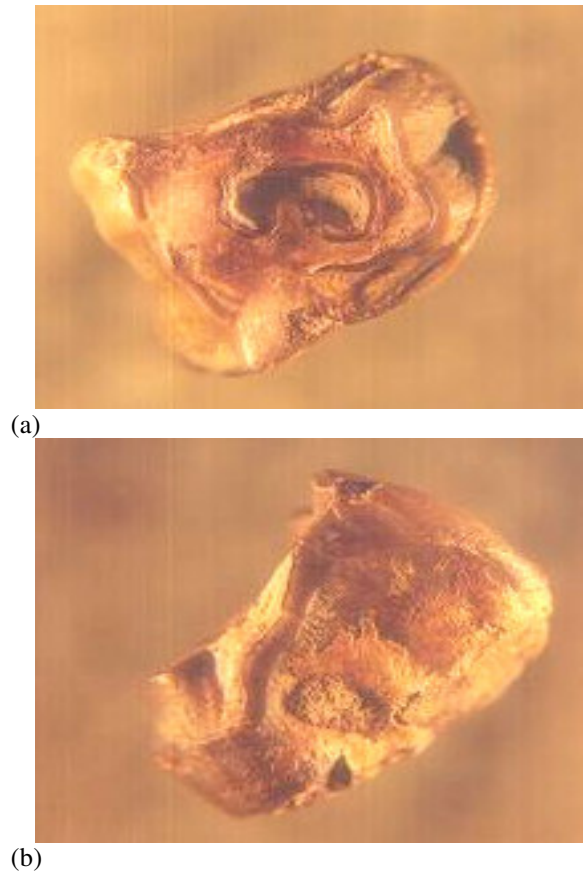


Fig. 3: *Pliotriplopus dhulianensis* n.sp., Type P<sup>4</sup> (P.U.P.C. No. 99/17)  
a. crown view x 1.5, b. anterior view x 1.5

At the labial side of the tooth, the paracone has a very strong outer vertical folding, a parastyle. A similar but comparatively much weaker folding, a metastyle, is present at the metacone. At the labial side and parallel to the parastyle there is a median rib, which is equally strong. A very weak vertical folding is present almost at the center of the ectoloph. The protoloph is obliquely placed to the transverse line of the tooth where the outer side forwardly projected. The protocone is a strong lingual anterior pillar, well separated from the hypocone pillar due to the presence of a deep vertical median lingual cleft.

Table 4: Measurements (in mm) of rP<sup>4</sup> (P.U.P.C. No. 99/17) of *Pliotriplopus dhulianensis* n.sp. and *Pliotriplopus chinjiensis*

	<i>P. dhulianensis</i> n.sp.	<i>P. chinjiensis</i>
Antero-posterior crowned length	32	40
Transverse crowned width	4055	
W/L index	125	138
Preserved crowned height	26	-
H/W index	65	-
Enamel thickness	1.5	-

The protoloph is invaginated anteriorly close to the protocone pillar. The fusion of two lingual cusps i.e.,

protocone and hypocone indicate that the tooth is the last of the premolar series. The metaloph like the protoloph is also obliquely placed and it bears a very strong crochet, which is rounded and blunt, with a loop like structure projecting in the median fossette. Posteriorly, due to the presence of a cingulum, an open cavity is produced which may be labeled as posterior fossette. The grinding surface in antero-posterior view is strongly concave with the outer and inner margin of the crown raised, while the ectoloph shows a central or median depression.

**Discussion:** In rhinoceroses, the upper molar crown is characteristically  $\pi$ -shaped<sup>[24]</sup> and is much larger than that of tapirs. Moreover, the molar crown of tapirs is very simple and lacking any accessory structure<sup>[25]</sup>. The specimen under study having a  $\pi$ -shaped lophodont crown may thus be undoubtedly referred to the rhinoceroses. Siwalik rhinoceroses have been attributed to the genera, *Rhinoceros*, *Coelodonta*, *Gaindatherium*, *Aceratherium*, *Pliotriplopus* and *Chilotherium*. The genera *Rhinoceros* and *Coelodonta* appear for the first time in the Pleistocene<sup>[26]</sup>. These genera have stronger crista and crochet which give complicated crown pattern to the tooth. Ectoloph is much elongated in the genera *Aceratherium* and *Chilotherium* but shorter in the genus *Gaindatherium*<sup>[6]</sup>. Generally, the dental morphology is simpler in the genus *Gaindatherium* than in other Siwalik genera<sup>[6]</sup>. This simplicity of the crown and the shortening of the ectoloph are also shared by the tooth under study. However, it shows a very clear distinction from the genus *Gaindatherium* in having the entoloph – a new structure identified in the molars of rhinoceroses by Sarwar<sup>[27]</sup>. The fusion of lingual cusps occurs in the genus *Pliotriplopus*<sup>[27]</sup> and in the premolar teeth of *Protapirus*<sup>[28]</sup>.

The presences of a crochet, however, negate the second possibility and warrant its inclusion in the genus *Pliotriplopus*. The genus includes a single species i.e., *Pliotriplopus chinjiensis*. The type specimen (U.Z. 126) of *Pliotriplopus chinjiensis* bears a very strong crista, whereas the studied specimen essentially lacks this structure. Although, crista is known to highly variable, as well as 20-28% size variation (W-L) but in the studied specimen it is completely absent. Moreover, it is much smaller tooth (Table 4). It is, therefore, advisable to erect a new species to include the specimen understudy. The name *Pliotriplopus dhulianensis* is proposed for this new hyracodont rhinoceros. The argument is reinforced because of the definitive time of the localities of the type specimen and the studied specimen.

Order                   ARTIODACTYALA  
Suborder               SUIFORMES  
Infraorder             SUINA  
Family                 SUIDAE  
Subfamily             LISTRIODONTINAE  
Genus                 *LISTRIDON* Meyer  
*Listriodon pentapotamiae* Falconer

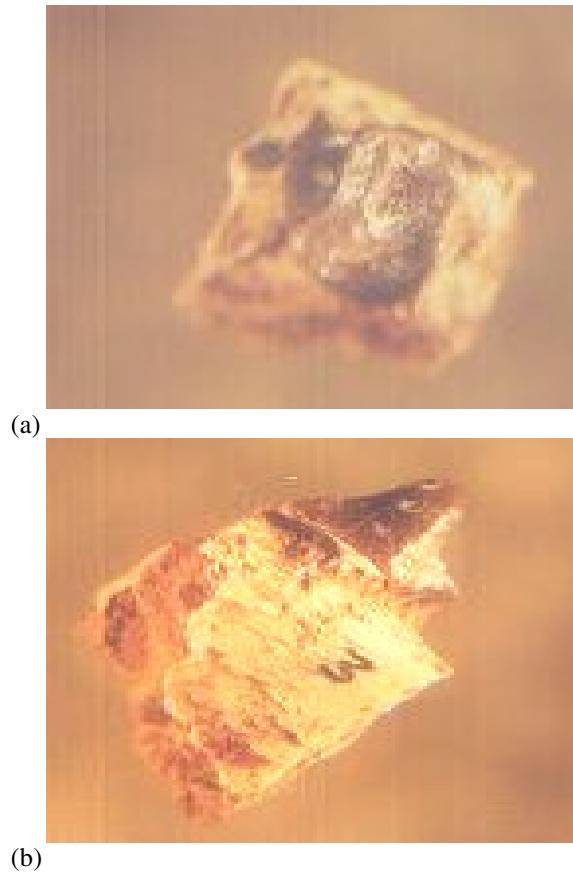


Fig. 4: *Listriodon pentapotamiae*, rM<sub>2</sub> (P.U.P.C. No. 99/18). a. crown view x 2.3, b. lateral view x 1.6

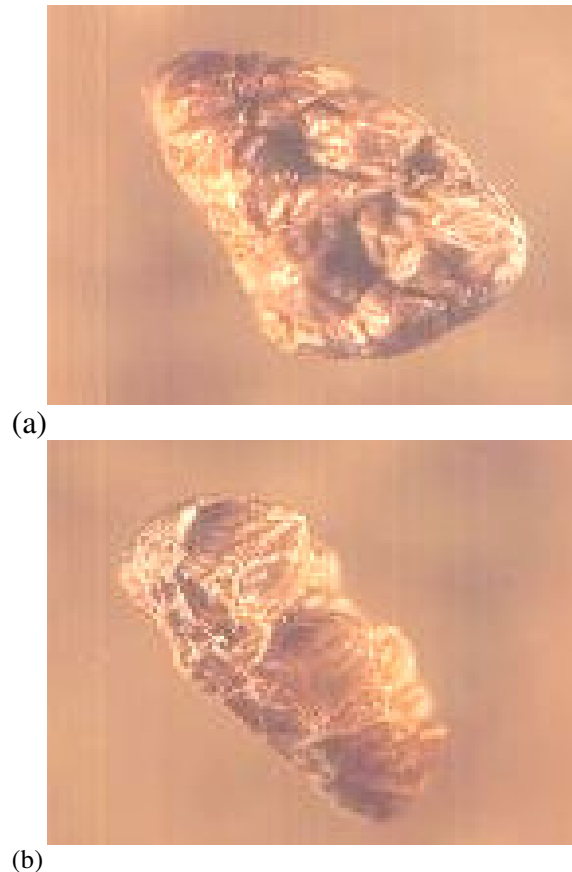


Fig. 5: *Conohyus sindiensis*, a rM<sup>3</sup> (P.U.P.C. No. 99/19). a. crown view x 1.5, b. lateral view x 1.5

**Type specimen:** G.S.I. No. B 107, a complete right M<sup>2</sup>, a fragment of a right M<sup>3</sup> and right and left P<sup>4</sup>.

**Type locality:** Khushalghar, Attock, Punjab, Pakistan.

**Stratigraphic range:** Lower Siwalik and lower portion of Middle Siwalik.

**Diagnosis:** Similar to *Listriodon splendens* of Europe, but with a larger talon on the third molar, a strong cingulum in the fourth premolar, a shorter and more slender symphysis.

**Distribution:** Nathot, Phadial, district Jhelum; Chinji, district Chakwal; Khushalghar, district Attock, Punjab, Pakistan and Ramnagar, India<sup>[6]</sup>, Paridarweza, district Jhelum<sup>[29]</sup>. Dhulian, district Attock, Punjab, Pakistan (P.U.P.C. No. 99/18).

**Material:** P.U.P.C. No 99/18 is a right mandibular portion bearing posterior half of a 2nd molar.

**Description:** This mandibular fragment, which bears the posterior half of M<sub>2</sub> (Fig. 4). This determination is indicated by the outward deflection of the dentary posterior to the molar tooth. At the posterior face of the jawbone, the roots of a M<sub>3</sub> can be observed. A close observation of the molar crown of M<sub>2</sub> indicates that the tooth was bilophodont. It is a narrow crowned subhypodont tooth (Table 5). Its numerical seriation is indicated by the elongation of the crown as well as by the development of the post talon, which is well raised and tuberculated. The posterior loph is worn and

dentine has just become exposed at the lateral extremities of the principal cusp. From the hypoconid a well-marked oblique ridge slopes down obliquely in the transverse valley. A similar ridge can be seen at the posterior side of the hypoconid which is a new variation not seen in the known material. This is also worn showing a narrow dentinal channel. The worn surface of the metalophid is quite sharp, with a chisel shaped cutting edge. Enamel is smooth, single and shiny all around the crown.

Table 5: Measurements (in mm) of rM<sub>2</sub> (P.U.P.C. No. 99/18) of *Listriodon pentapotamiae*

Preserved antero-posterior crowned length	13
Crowned width	13.5
Preserved crowned height	10.5
W/L index	103
H/W index	77
Enamel thickness	0.9

**Discussion:** The sharp chisel shaped crest is a feature seen in the molar teeth of Deinotheriid proboscideans, lophodonts pigs and some metatheres. The tooth under discussion is too small to be referred to any of the proboscideans. In lophodont metatheres the crest is imperfect. In lophodont pigs i.e. listriodonts, the tooth crests are perfect with very sharp cutting edges<sup>[24]</sup>. All lophodont pigs are placed in a single genus, *Listriodon*

that consists of three species<sup>[1]</sup>. Of these, the species *Listriodon pentapotamiae* is the smallest and is known from the Chinji Formation. Structurally, it is the most primitive. The small size of the tooth, the simple crown and the stratigraphic position favour its tentative inclusion in the species *Listriodon pentapotamiae*.

Subfamily TETRACONODONTINAE

Genus *CONOHYUS* Pilgrim

*Conohyus sindiensis* Lydekker

**Type specimen:** G.S.I. No. B. 102, fragment of a maxilla, with left M<sup>2-3</sup>.

**Type locality:** The type came from the Lakhi hills, Sind, Pakistan. Referred specimens are from the Punjab, Pakistan.

**Stratigraphic range:** Lower Siwalik. Also lower Middle Siwalik.

**Diagnosis:** An upper Tertiary suid of rather primitive form. It is closely related to *Hyotherium* and may be considered as a direct derivative of *Palaeochoerus*.

**Distribution:** The species is known from a number of localities in Pakistan and one or two localities in India. From Pakistan, it has been found in the following localities:

1. Rhadak and Bhagothoro, Sind<sup>[30]</sup>.
2. Gaj River, Bhagothoro, Sind<sup>[30]</sup>.
3. Lakhi Hills, Sind<sup>[31]</sup>.
4. Chinji, district Chakwal, Punjab<sup>[6,30]</sup>.
5. Kunatti, district Chakwal, Punjab<sup>[32]</sup>.
6. Chharat, district Attock, Punjab<sup>[32]</sup>.
7. Phadial, district Jhelum, Punjab<sup>[6,30]</sup>.
8. Hasnot, district Jhelum, Punjab<sup>[6]</sup>.
9. Sadrial, district Jhelum, Punjab<sup>[32]</sup>.
10. Bhelomar, Bharat, Kadirpur, Mundi, district Chakwal, Punjab<sup>[32]</sup>.
11. Vasnal, Chinji and Bhilomar, district Chakwal<sup>[29]</sup>.
12. Chabbar Sayadan Diyal and Tarakki, district Jhelum<sup>[29]</sup>.
13. Rattarian and Dhulian, district Attock<sup>[29]</sup>.

The Indian localities, which have yielded the material of *Conohyus sindiensis*, are the following:

1. Perim Island<sup>[33]</sup>.
2. Ramnagar and Haritalyengar<sup>[34]</sup>.

**Material:** P.U.P.C. No. 99/19, an isolated upper right third molar.

**Description:** The specimen is an unworn molar (Fig. 5). The length-width proportion indicates that it is a 3<sup>rd</sup> molar. The tooth is extremely crowned and extremely brachyodont. The labial side is strongly convex, whereas the lingual side is strongly concave. The anterior side is convex and does not bear any distinct pressure mark caused by the preceding tooth. However some shiny surface of very small extent may be seen. All this indicates that the tooth was still unerupted. The enamel is fairly folded producing a strong cingulum at the anterior and antero-labial side. The anterior cingulum extends from the median anterior accessory tubercle both lingually as well as labially. This anterior cingulum is divided by a longitudinal cleft. The

principal anterior cusps are rounded and low. Their surface is strongly uneven due to the presence of vertical grooves. Three major grooves can be observed; an anterior, a posterior and a median. Apart from the main grooves, the whole surface of the cusps is grooved. The transverse valley between the anterior and posterior pair of cusps is obliterated by a low, blunt and transversely expanded posterior median accessory tubercle. A small, low, triangular singular tubercle blocks the labial entrance of the first transverse valley. Metacone and hypocone are lower in height than the anterior pair of cusps. The structure of these cones is simpler. The metacone clearly shows the three typical suid grooves. The talonid is comparatively much lower in vertical height. It is V-shaped having a relatively longer labial wing. The labial wing is produced into four minor tubercles whereas the lingual wing is monotuberculated. This single tubercle is transversely expanded and antero-posteriorly compressed.

**Measurements:** Anteroposterior crown length, 25 mm; Transverse crown width, 16 mm, Crown height, 11 mm; W/L index, 64; H/W index, 69.

**Discussion:** The vertical grooves and ridges have a definite arrangement- a character of the primitive bunodont pigs<sup>[29]</sup>. The structure of the conules of the studied tooth resembles the bunodont genera *Conohyus*, *Propotamochoerus* and *Hippopotamodon*. The first two genera have the same chronological occurrence, whereas the last one does not appear before the Dhok Pathan Formation. Moreover, the genus *Hippopotamodon* was a very gigantic form<sup>[31]</sup> much different from the primitive Chinji bunodont pigs. The major distinction between the genera *Conohyus* and *Propotamochoerus* lies in the size of the P<sup>4</sup>, which is abnormally large in the former and normal in the later. However, some difference does occur in the M<sup>3-5</sup>. In the genus *Conohyus*, the suid grooves and cingula are less conspicuous than in the genus *Propotamochoerus*<sup>[29]</sup>. Moreover, the latter is a comparatively much larger form. Thus, the studied material can be referred to the genus *Conohyus*. It consists of two species, *Conohyus sindiensis* and *Conohyus indicus*. The former is much smaller than the later. Keeping in view the small size of P.U.P.C. No. 99/19, it can be referred to the species *Conohyus sindiensis*. Regarding dimensions, the tooth under discussion is well within the variation limits of the species given by Ahmad<sup>[29]</sup>.

Infraorder ANCODONTA  
 Superfamily ANTHRACOTHERIOIDEA  
 Family ANTHRACOTHERIIDAE  
 Genus *HEMIMERYX* Lydekker

*Hemimeryx pusillus* Lydekker

**Type specimen:** G.S.I. No. B 324, a right maxillary fragment with the third molar.

**Type locality:** From the Siwaliks of Khushalghar, Punjab, Pakistan.

**Stratigraphic range:** Lower Siwaliks. Also Lower Middle Siwaliks.

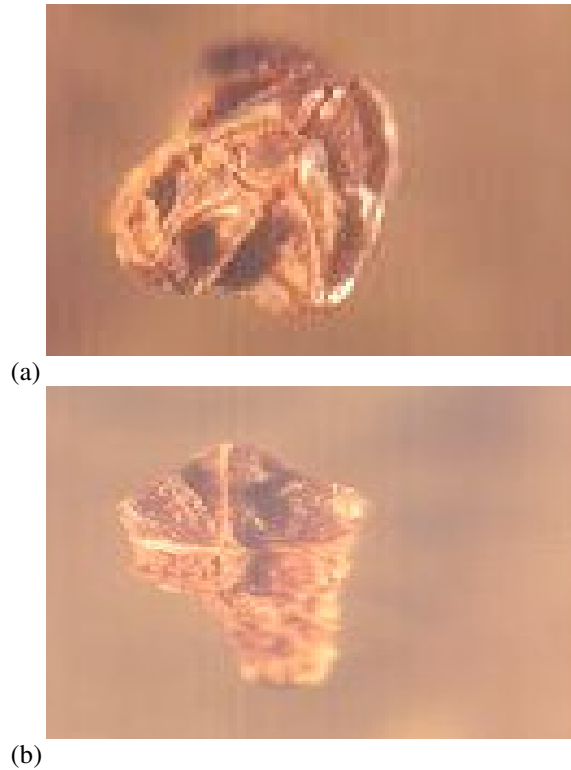


Fig. 6: *Hemimeryx pusillus*, a rP<sup>4</sup> (P.U.P.C. No. 99/20)  
a. crown view x 1.6, b. outer view x 1.4

**Diagnosis:** Considerably smaller than *H. blandfordi*, with a cingulum completely encircling the tooth. Molars with four crescentic cusps.

**Distribution:** Chinji, district Chakwal; Hasnot, district Jhelum<sup>[6]</sup> and Dhulian, district Attock (P.U.P.C. No. 99/20), Punjab, Pakistan.

**Specimen under study:** P.U.P.C. No. 99/20 is an isolated upper 4<sup>th</sup> premolar.

**Description:** P.U.P.C. No. 99/20 is a well-preserved (4<sup>th</sup>) premolar tooth of some anthracotheriid (Fig. 7). The tooth is extremely broad and brachyodont. Its crown structure is quite characteristic of the group with a strong lingual pinching outer surface. The upper surface is strongly directed. Two well-marked cones can be seen on the crown surface but looking at the undersurface of the tooth, three very distinct roots can be also observed. Of these, the outer roots are damaged, whereas a lingual one is fully preserved and much longer. The outer part of the crown actually consists of two cusps, which are fused together forming a single median cusp. These are the paracone and the metacone. The enamel is strongly rugose all around the crown, which is characteristic of the group. The protocone is strongly V-shaped with well-raised median tubercle. The cingulum is located away from the base of the cusp both anteriorly and posteriorly producing an open, elongated shallow cavity, which is also characteristic of the group. Cingulum covers the whole anteroposterior face of the crown and partially the outer surface of the

paracone and the metacone. However, the cingulum is not found at the median outer side. The paracone-metacone complex is quite V-shaped similar to the protocone. Its posterior and anterior limbs are quite parallel to the respective flanges of the protocone. The central peak of paracone-metacone complex is quite thick as compared to the protocone. A vertical ridge of the mesostyle can be seen at the outer side of para-meta complex. The cavity between the outer and inner cusps is very shallow and V-shaped.

**Measurements:** Anteroposterior crown length, 14 mm; Transverse crown width, 15 mm; Crown height, 12 mm; W/L index, 107; H/W index, 80.

**Discussion:** P.U.P.C. No. 99/20 is an upper 4<sup>th</sup> premolar in which the labial cusps are fused to form a single cusp. Pseudoselenodonty is accompanied by strongly inward deflection of the paracone-metacone, which is a complex is the notable feature of the tooth under discussion. Anthacotherioids are the only mammals showing this unique modification<sup>[35]</sup>. The degree of selenodonty varies greatly among the anthracotheriid genera. It is almost absent in the genus *Anthracotherium*<sup>[36]</sup>, it is present in the infancy stage of the genus *Hyoboops*<sup>[37]</sup>, it is weakly developed in the genus *Choeromeryx*<sup>[38]</sup> and finally it is moderately developed in the genera *Hemimeryx*<sup>[39]</sup> and *Merycopotamus*<sup>[10]</sup>. *Merycopotamus* is known only from the upper Siwalik strata. The other previously mentioned genera are known from the Chinji and Dhok Pathan Formations. Keeping in mind, the degree of selenodonty, the cingulum, the protocone crescent and the chronologic occurrence, the studied tooth can be referred to the species *Hemimeryx pusillus* described by Lydekker in 1885. The specimen under study is quite different from the known P<sup>4-s</sup> of the species in having distinct anterior and posterior cingular shelves of the protocone.

Suborder	RUMINANTIA	
Family	TRAGULIDAE	Milne-Edwards, 1864
Genus	DORCATHERIUM Kaup, 1833	

**Generic diagnosis:** The cheek teeth are prominently hypsodont. The upper molars bear strongly developed styles and basal cingulum. The lower molars are characterized, either by well-developed median basal pillar or by a vestigial median basal pillar.

**Included species:** *Dorcatherium majus* Lydekker, 1876; *Dorcatherium minus* Lydekker, 1876; *Dorcatherium minimus* West, 1980; *Dorcatherium nagrii* Guar et al., 1983.

**Distribution:** The genus *Dorcatherium* is known from the Lower Miocene of Europe, East Africa and the Siwaliks.

Species *Dorcatherium minus* Lydekker

**Type:** G.S.I. No. B 195, two upper molars namely right M<sup>1-2</sup>.

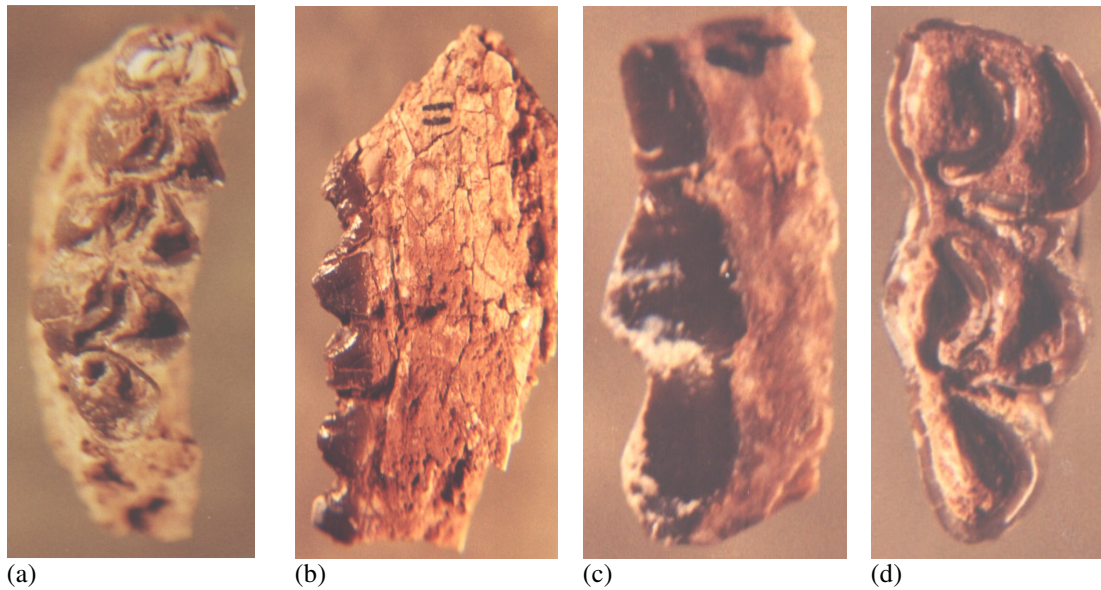


Fig. 7: *Dorcatherium minus*. P.U.P.C. No. 99/11  
a. crown view x 1.5, b. lateral view x1.5 P.U.P.C. No. 99/4. c. outer view x 1.7. d. crown view x 1.7

**Locality:** Near Hasnot, district Jhelum, Punjab, Pakistan.

**Stratigraphic range:** The Siwaliks (Probably the Middle Siwalik). Lower and Middle Siwaliks for the referred specimens.

**Diagnosis:** The species is characterized by its small size, extremely hypsodont cheek-teeth and the strong development of the cingulum in the upper molars.

**Distribution:** Chinji, district Chakwal; Nathot and Phadial, district Jhelum, Punjab, Pakistan; Dhulian (P.U.P.C. No. 99/11, P.U.P.C. No. 99/4), district Attock, Punjab, Pakistan.

**Referred specimens:** P.U.P.C. No. 99/11, a posterior mandibular fragment of the right side bearing last two molars; P.U.P.C. No. 99/4, an isolated lower right last molar with half worn crown.

**Locality:** Dhulian, Attock district, Punjab, Pakistan.

**Stratigraphic range:** Lower and Middle Siwaliks.

**Description:** Mandible (DN11) (Fig. 7a, b)

P.U.P.C. No. 99/11 is a posterior mandibular fragment of the right side bearing last two molars. The mandible is thin below both the  $M_2$  and  $M_3$  becoming gradually thinner to the ventral and posterior side. Posteriorly it is damaged at the base of the ascending ramus. However, it is fairly deep.

**$M_2$ :** It is extremely hypsodont but moderately broad crowned half worn tooth. The tooth measurements in millimeters are: Antero-posterior crown length 11, crown width 9.5, crown height 8 and enamel thickness 0.7. The anterior pair of cusps is much worn resulting in the formation of common enamel loop. Only the anterior half of median fossette may be seen which is very shallow. In spite of the deep wear, the two anterior cusps still have their identity. Protoconid has a definite

“V” shaped labial enamel loop and transverse median loop, which is partially preserved. The metalophid has almost rounded lingual enamel loop. The posterior vertical groove characteristic of the group is almost indistinct. Posterior pair of cusps is comparatively less worn having their own enamel loop. The median fossette between the two cusps is narrower, opening to the lingual side. The hypolophid shows “V” shaped labial contour with finely rugose enamel. The median contour of the hypolophid is almost concave extending to the posterior lingual side. Entoconid is a spindle shaped tubercle placed somewhat oblique to the longitudinal axis of the crown. The grinding surface of the tooth, in general, slopes to the labial side.

**$M_3$ :** It is comparatively much less worn than  $M_2$ . It measures in millimeters are: Antero-posterior crown length 20, crown width 10, crown height 7.5 and enamel thickness 0.7. The principal cusps resemble much those of the preceding tooth except the differences related to the degree of wear. The tooth is extremely narrow crowned and hypsodont. Talonid resembles the labial cusps but its limbs are comparatively compressed and are directed anteriorly. It is much elongated posteriorly and comparatively low in vertical height (P.U.P.C. No. 99/4 (Fig. 7c, d).

P.U.P.C. No. 99/4 is a lower last molar of the right side. It is extremely narrow crowned and extremely hypsodont tooth. The tooth measurements in millimeters are: Antero-posterior crown length 21, crown width 9.8, crown height 7 and enamel thickness 0.8. It is selenodont molar tooth with half worn crown. The presence of loop like posteriorly extended talonid indicates that the tooth is last of the molar series.



All the cusps have so much worn that their dentinal loops have become contiguous with one another producing two much compressed V-shaped anterior and posterior median fossettes. These fossettes are so much compressed that outer and inner enamel loops are in contact with one another. Enamel is relatively simple to the lingual side and much rugose at the labial side. The lingual cusps are almost similar except the differences related to degree of wear.

In between the two lingual cusps a well-raised but smaller singular pillar may be observed. The outer cusps are also singular with blunt but well marked lingual median ribs. The lingual margin of the tooth is much raised than the labial one. The talonid is strongly developed single, large postero-labially directed loop. Looking at the under side, five roots may be observed.

### DISCUSSION

P.U.P.C. No. 99/11 is a posterior mandibular fragment bearing  $M_2$  and  $M_3$ . In the molars all principal cusps are in wear. Although worn still the selenodont crown pattern is very much clear. Pseudoselenodonty may be found in many mammalian groups but complete or true selenodonty is the characteristic feature of the suborder ruminantia of order artiodactyla<sup>[26]</sup>. Ruminants include chevrotains, cervids, bovids and giraffids. Among these the smaller forms occur only in chevrotains and bovids. In bovids, the styles/stylids are quite prominent. Apart from these structures, the basal pillars also frequently occur. The styles/stylids and median ribs are the vertically straight enamel foldings in bovids.

Median ribs in chevrotains are directed backwardly. Enamel layer is usually simpler and smooth in bovids but rugose in the dentition of the tragulids. The Siwalik chevrotains are grouped in two genera, *Dorcabune* and *Dorcatherium*. The former is much primitive with primitive selenodonty. In *Dorcatherium* there are included two species, a smaller known from Chinji formation and a larger one known from the rocks above the level of Nagri. The smaller form i.e., *Dorcatherium minus* founded by Lydekker in 1876 is characterized by its extreme hypsodonty which may be seen in all the specimens under study. The teeth under study are quite comparable with the relevant dentition contained in the American Museum of Natural History figured by Colbert<sup>[6]</sup>. Regarding measurements it also falls within the known variation limits of  $M_3$ .s. P.U.P.C. No. 99/4 resembles much the specimen P.U.P.C. No. 99/11 except those differences, which are related with the wear.

### BIOSTRATIGRAPHIC SIGNIFICANCE AND CONCLUSION

The Dhulian locality is important because it represents heretofore-sampled strata correlative to

either the upper part of the Chinji Formation or the lower part of the Nagri Formation. Its mammal fauna is diverse with 20 numbered specimens representing atleast 3 Orders. Almost all of the material consists of isolated teeth, but few postcranial elements were also retrieved. Taxa identified from the locality are *Stegolophodon cautleyi*, *Pliotriplopus dhulianensis* n.sp., *Listriodon pentapotamiae*, *Conohyus sindiensis*, *Hemimeryx pusillus*. The composition of this mammalian fauna supports the superposed position of the Dhulian locality above the Chinji Formation and within the Nagri Formation. Thus this locality enhances the faunal correlation of this region to better studied areas on the Potwar Plateau. All the mentioned taxa have also appearance through the Dhok Pathan Formation, which corresponds to the uppermost part of the Chinji Formation in its type area.

### ACKNOWLEDGMENTS

We wish to thank a Dr. George Iliopoulos, Natural History Museum, Crete, Greece, for his advice and for the critical review of the manuscript.

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