

HIPPARION FROM THE DHOK PATHAN FORMATION OF THE MIDDLE SIWALIKS, PAKISTAN

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Abstract: New fossil material of *Hipparion antilopinum* has been described from the Dhok Pathan type locality, Chakwal district, Punjab Pakistan. This material consists of isolated lower premolars and molars. These specimens provide new data and contribute to recent work from the Middle Siwalik Hills of Pakistan.

Keywords: Mammals, *Hipparion antilopinum*, Dhok Pathan, Late Miocene, Siwaliks, Pakistan.

INTRODUCTION

Three-toed horses are very common elements in Miocene and Pliocene terrestrial mammalian faunas in New and Old Worlds. *Hipparion* is known since the middle of 19th century from the “craggs” of Suffolk, Southeastern England dating mainly to Pliocene. The Eurasian Late Miocene record is extensive and includes several multispecies super specific groups. They became extinct at the end of the Late Miocene (Bernor *et al.*, 1996). The fossil equids are very well known and abundant in the Siwaliks. They are represented by two genera, *Hipparion* and *Equus*. The genus *Equus* is restricted to the middle and upper parts of the Upper Siwaliks and *Hipparion* (three-toed horses) is abundant in the Middle Siwaliks. *Hipparion* remains are common in Late Miocene-Pliocene fossil sites. This is because the new climate conditions of the Eurasian ecosystems are more arid than in the Middle Miocene (Alberdi and Bonadonna 1990; Bernor *et al.*, 1990; Forstén, 1991; Calvo *et*

al., 1993; Alcalá *et al.*, 2000). Hussain (1971) recognized three species of *Hipparion* i.e., *H. nagriensis*, *H. antilopinum* and *H. theobaldi*. Hussain (1971) has created a new *H. nagriensis*, which according to him was the ancestor of *Hipparion antilopinum* and *Hipparion theobaldi*. *Hipparion* have been widely used for biostratigraphy purposes. This is very diverse equid group, having a wide stratigraphical distribution in Europe that spans from the beginning of the Upper Miocene to the beginning of the Upper Pliocene (Sen, 1990; Woodburne *et al.*, 1996; Gibbard *et al.*, 1998). *Hipparion* generally have relatively complicated enamel patterns, especially compared with New World *Pliohippus* of the *Equus* lineage from the same period. In *Hipparion* richly plicated teeth also tend to be relatively low-crowned (Forsten, 1981).

MATERIALS AND METHODS

The specimens were collected from the outcrops nearby the Dhok Pathan village (lat. 33° 07'N; long. 72° 14'E) and properly washed, cleaned and prepared for the study. Fine needles, hammer, chisel and camel hair brushes were used to remove the sediments. The broken parts were assembled by using various types of adhesive materials such as gums, Elphe, Peligon, Araldite and Epoxy Steel. In order to study the morphology more accurately the specimens were washed by using various acids such as sulphuric acid, hydrochloric acid, and acetic acid. These acids helped in removing the sediments and make the features or parts of specimens prominent for study. Photographs were taken with the help of digital camera. Various measurements of the specimens were made by the help of Metric Vernier Caliper and the tables were formulated. The specimen under study has been catalogued *e.g.*, PUPC 07/12. The upper figure denotes the year of collection and lower figure denotes the serial number of the respective year.

Systematic Palaeontology

Order	Perissodactyla Owen 1848
Suborder	Hippomorpha Wood, 1937
Family	Equidae Gray, 1821
Genus	<i>Hipparion</i> Christol, 1832

Type species: *Hipparion prostylum* Gervais.

Generic diagnosis

A group of hipparion horses with marked reduction of preorbital fossa in length, dorsoventral height, medial depth and posterior packing. Anterior most aspect of lacrimal placed posterior to the pre-orbital fossa. The cones and styles are named with suffix id in lower cheek teeth and the cones present on lingual side of upper cheek teeth are present on buccal side in lower cheek teeth. The entoconid is only present in lower cheek teeth. The hypoconulid is also a special character of lower cheek teeth. The metaconid and metastylid are distinct on all cheek teeth. In P2 isthmus usually connect the metaconid and mesostylid. The mesostylid is usually larger than the metaconid although the reverse generally occurs in M3. The upper and lower cheek teeth are moderately hypsodont.

Distribution

Eurasia (Nanda, 1978); Afghanistan (Sen *et al.*, 1997) and China (Chow, 1957).

***Hipparion antilopinum* Falconer and Cautley, 1849**

Type (Lectotype) BMNH M2647, a right maxilla with P²-M³(1935).

Horizon Middle Siwaliks, typically from Dhok Pathan zone.

Locality Salt Range, Punjab, Pakistan.

Material PUPU 07/164, rP₂; PUPC 07/165, IP₂; PUPC 04/12, rM₂; PUPC 04/16, rM₂; PUPC 04/10, IM₁; PUPC 04/11, IM₂; PUPC 07/163, IM₃; PUPC 04/13, IM₃.

Locality Dhok Pathan for the described specimens.

Stratigraphic Range Middle Siwaliks.

Diagnosis *Hipparion antilopinum* is an average sized *Hipparion* and is characterized by small and very hypsodont teeth, oval protocone, and complicated enamel placcations of the upper molars. Well-developed pre-orbital fossa of skull, short snout and slender metapodials of the feet (Hussain, 1971).

DESCRIPTION

PUPC 07/164, rP₂

The specimen under study is well preserved and is in the middle stage of wear. The enamel is thick and rugose while dentine is also visible in the specimen under study. It is extremely narrow crowned and hypsodont. It is covered by cement, which is more evident on the buccal side. The major cuspids are well preserved. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The hypoconid and entoconid along with mesostylid are vertically higher than protoconid and metaconid. The hypoconid is greater in its diameter antero-posterior diameter than protoconid. The parastylid is clear and present on the anterior side. The protostylid and ectostylid are on the buccal side while hypoconulid, entostylid and mesostylid are on the lingual side. Mesostylid is circular in its general appearance. It is similar in structure to metaconid but they are opposite in direction. The metaflexid and entoflexid are clearly visible. The metaflexid is narrow from middle and broad antero-posteriorly. It has complicated enamel folding. The entoflexid is narrower than metaflexid and greater in antero-posterior length than metaflexid.

PUPC 07/165, lP₂

The specimen under study is poorly preserved and is broken from lower side. It is in an early stage of wear. The enamel is thick and rugose while dentine is visible in the tooth. It is extremely narrow crowned and hypsodont. It is broad at upper side than lower side. The major cuspids are well preserved. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The diameter of posterior conids is greater as compared to the anterior ones. The protoconid is circular in diameter and smaller than hypoconid. The cement is present between protoconid and hypoconid. The stylids are present. The protostylid and ectostylid are on the buccal side while mesostylid is well preserved and is present on the lingual side. The hypoconulid is posterior to the hypoconid. The mesostylid and metaconid are similar in structure but opposite in direction. The metaflexid and entoflexid are well preserved. The antero-posterior part of metaflexid is broad and narrow from middle.

The entoflexid is very narrow than metaflexid. Its length is great than metaflexid. The plihypoconid is depression on the lingual side.

PUPC 04/10, IM₁

The specimen is well preserved and is in an early stage of wear. The specimen is rectangular in shape. The enamel is thick and rugose and dentine is also visible in the tooth under study. It is narrow crowned and extremely hypsodont. It is covered by cement which is more evident on lingual side than on buccal side. The hypoconid is forwardly directed and protoconid is backwardly directed. The major cuspids are well preserved. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The posterior side of tooth is slightly higher than anterior side. The metaconid and entoconid are vertically higher than protoconid and hypoconid. The lingual conids are greater in their anteroposterior diameter than buccal conids. The protoconid is circular and smaller than hypoconid. The parastylid is not well preserved. The ectostylid and protostylid is on the buccal side while hypoconulid and entostylid is on lingual side. The metaflexid is well preserved, narrow from middle and broad from anteroposterior. The entoflexid is on the posterior side of hypoconid and is narrow anteroposteriorly. The hypoconulid is touching the enamel of hypoconid. The mesostylid is located between metaconid and entoconid. The mesostylid is similar in structure to metaconid but opposite in direction. The mesostylid is very close to entoconid and are touching each other. The metaconid is higher among all conids and more higher crowned. The dentine is visible. The plihypoconid is on the lingual side.

PUPC 04/12, rM₂

The specimen under study is poorly preserved and is in the late stage of wear. The enamel is moderately thick and rugose while dentine is visible. A thick layer of cement is present which is more evident on buccal side. The major cuspids are well preserved. The specimen is narrow crowned on the basis of width and length ratio. It is extremely hypsodont on the basis of height and length ratio. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The outer conids are greater in their antero-posterior diameter. The antero-posterior diameter of hypoconid is greater than protoconid. The posterior or lingual conids are vertically higher than anterior conids. The metaconid is circular in outline and smaller than the entoconid. Among all the conids the

hypoconid is the greatest one and metaconid is the smallest one. The stylids are also present. The parastylid is present on the anterior side. The protostylid and ectostylid are present on the buccal side while entostylid and mesostylid is on the lingual side. The parastylid is not clear because it is in more weared form. Metaflexid and entoflexid are two invaginations on the lingual side. The metaflexid is formed by the anterior wall of protoconid and posterior wall of parastylid and metaconid. The metaflexid has complicated enamel foldings. It is narrow from middle and broad anteroposteriorly. The entoflexid is formed by the union of anterior wall of hypoconid and posterior wall of mesostylid and entoconid. It is greater in length than metaflexid. The plihypoconid is a depression on lingual side.

PUPC 04/16, rM₂

The specimen is well preserved and is in the middle stage of wear. The enamel is moderately thick and rugose while dentine is also visible. The specimen is covered by hard cement. It is narrow crowned and extremely hypsodont. Major cusps are well preserved. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The protoconid is circular and smaller than hypoconid. The formers are greater in their anteroposterior diameter. The metaconid and entoconid are vertically higher than protoconid and hypoconid. The parastylid is on the anterior side and is L-shaped. The protostylid and ectostylid are on the buccal side while mesostylid, entostylid are present on the lingual side. The mesostylid and metaconid are similar in their outline and structure but their direction is opposite. The metaflexid and entoflexid are two invaginations on the lingual side. The metaflexid is narrow from middle and it is broad from anterior and posterior side. The hypoconulid is present on the lingual side posteriorly. The metaflexid has complicated enamel folding. The entoflexid is formed by the union of the anterior wall of hypoconid and posterior wall of mesostylid and entoconid. It is elongated curved anteriorly. The plihypoconid is depression on the lingual side.

PUPC 04/11, lM₂

The specimen is well preserved and is in an early stage of wear. The enamel is thick and rugose. The dentine is visible. It is narrow crowned and extremely hypsodont. It is covered by cement that is more evident on the buccal side than on the lingual side. The major cuspids are well preserved. The protoconid and hypoconid are on the buccal side while the metaconid

and entoconid are on the lingual side. The protoconid and hypoconid are greater in their anteroposterior diameter than metaconid and entoconid. The anteroposterior diameter of hypoconid is greater than protoconid. The protoconid is circular in outline than hypoconid and also smaller than hypoconid. The posterior end of tooth is slightly higher than anterior one. The metaconid is circular and smaller than protoconid. The stylids are present. The parastylid is on the anterior side and it is L-shaped. It is an anterior extension of protoconid. On the buccal side the protostylid and ectostylid while on the lingual side mesostylid, entostylid and hypoconulid are present. The hypoconid is posterior extension. The parastylid, mesostylid and hypoconid are well developed. The mesostylid and metaconid are similar in their structure but opposite in direction. The metaflexid is present on anterior side while entoflexid is on the posterior side. It is narrow from middle and broad anteroposteriorly. The metaflexid has butterfly like enamel foldings. The anterior side of metaflexid has more complicated enamel folding than posterior. The entoflexid is broad than metaflexid. It is greater in length anteroposteriorly than metaflexid.

PUPC 04/13, IM₃

The specimen under study is poorly preserved. It is in an early stage of wear. It is rectangular in shape. The enamel is thick and rugose. The dentine is visible. This specimen is also narrow crowned and extremely hypsodont. Cement is present between protoconid and hypoconid and also on the lateral side. The major cuspids are well preserved except protoconid which is broken from its anterior surface. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The formers are greater in their anteroposterior diameter than laterals. The posterior side of tooth is slightly higher than anterior side. The parastylid is not clear and ectostylid is present on the buccal side. The hypoconid, entostylid and mesostylid are on the lingual side of tooth. Mesostylid is circular in outline and some narrow. The metaflexid is well preserved and clear. It is narrow from middle and broad from anteroposteriorly. The entoflexid is more in length than metaflexid. The plihypoconid is depression on the lingual side.

PUPC 07/163, IM₃

The specimen under study is well preserved. It is in an early stage of wear. The enamel is thick and rugose while the dentine is visible. It is covered by cement; only spotty portions are free from cement. It is

extremely narrow crowned and hypsodont. The surface of tooth is rough. The major cuspids are well preserved. The protoconid and hypoconid are on the buccal side while metaconid and entoconid are on the lingual side. The hypoconid is greater in anteroposterior diameter than protoconid. It is broad than protoconid. The back of tooth is slightly higher than front side. The parastylid is on the anterior side and is L-shaped. The protostylid and ectostylid is on the buccal side. The hypoconid, entostylid and mesostylid are on the lingual side. Mesostylid is narrow and circular. It is narrow from middle and broad from anteroposteriorly, some extending anteriorly. The hypoconid is well developed and is extending on the posterior side.

COMPARISON AND DISCUSSION

The specimens under study are narrow crowned, hypsodont and tetracuspids teeth. Hypsodonty and brachydonty are related directly to species environment. The hypsodont species could eat coarse grasses, so lived in open habitat where environmental condition is intermediate (Lacombat, 2005). Four cuspids teeth are the unique feature of class Mammalia. Since the crown of the specimens is narrow with the mesostylid and metaconid joined by a narrow isthmus, and forming the double knot that shows that these are lower cheek teeth and may be referred to the order Perissodactyla, suborder Hippomorpha and especially to family Equidae. In these family lower cheek teeth comprise major four cusps that is protoconid and hypoconid towards buccal side and metaconid and entoconid towards the lingual side. These features are also observed in the specimens under study. The family Equidae comprises a variety of horses and including two wide spread extinct three-toed horses (i) *H. antelopinum* (Falconer and Cautley) and (ii) *H. theobaldi* (Lydekker) in upper Pliocene. These two species are distinguished by the structure of the cheek-teeth. There is no appreciable difference in the molar patterns. *H. antelopinum* (Falconer and Cautley, 1849) is an average sized *Hipparion* characterized by small and very hypsodont teeth, oval protocone, and complicated enamel plications in the upper molars. They have well-developed pre-orbital fossa, short snout and slender metapodials (Hussain, 1971).

The second premolars are lengthwise larger than type specimen (AMNH 19855). The length of studied specimen is 32 mm while that of type specimen is 27 mm. The studied specimen width and that of type

specimen is almost similar with little variation. There is variation in the indices of W/L ratio from type specimen. The specimen PUPC 04/10 is first molar with measurements both in length and width and also indices of W/L ratio is almost closely related to AMNH 19855 (Colbert, 1935). The measurements of specimen PUPC 04/11, PUPC 04/12, PUPC 04/16, second molar are almost similar to the type specimen AMNH 19855 (Colbert, 1935). The indices of W/L ratio are similar to type specimen with insignificant differences. The indices show that specimens are narrowing crowned and hypsodont like that of Colbert studied specimens.

Table I: Comparative dental measurements (mm) of second premolars referred to *H. antilopinum* (* Ghaffar, 2005, ** Colbert, 1935).

Number	Nature	Position	Length	Width	(CI)
			(L)	(W)	
PUPC 07/164	Premolar	P ²	32.0	13.0	40.62
PUPC 07/165	Premolar	P ²	31.0	12.5	40.32
PUPC 00/99 *	Premolar	P ²	33.0	17.5	53.30
AMNH 19855 **	Premolar	P ²	27.0	15.5	57.40
PUPC 04/10	Molar	M ₁	24.0	14.0	58.34
PUPC 00/99 *	Molar	M ₁	22.0	14.5	65.90
AMNH 19855 **	Molar	M ₁	24.5	15.0	61.22
PUPC 04/11	Molar	M ₂	26.0	15.0	57.69
PUPC 04/12	Molar	M ₂	24.0	12.0	50.00
PUPC 04/16	Molar	M ₂	24.0	14.0	58.33
PUPC 2000/99 *	Molar	M ₂	22.0	15.0	68.18
AMNH 19855 **	Molar	M ₂	25.0	14.0	56.00
PUPC 04/13	Molar	M ₃	28.0	15.0	53.57
PUPC 07/163	Molar	M ₃	31.0	15.0	48.38
PUPC 2000/99 *	Molar	M ₃	28.5	14.0	49.12
AMNH 19855 **	Molar	M ₃	28.0	14.0	50.00



1A



1B



1C



2A



2B



2C



3A



3B



3C



4A



4B



4C



5A



5B



5C



6A



6B



6C



7A



7B



7C



Fig. 1 *Hipparion antilopinum*, PUPC 07/164, an isolated right second premolar (1A-C); PUPC 07/165, an isolated left second premolar (2A-C); PUPC 04/10, an isolated left first molar (3A-C); PUPC 04/12, an isolated right second molar (4A-C); PUPC 04/16, an isolated right second molar (5A-C); PUPC 04/11, an isolated left second molar (6A-C); PUPC 04/13, an isolated left second molar (7A-C); PUPC 07/163, an isolated left second molar (8A-C). A = buccal view, B = occlusal view, C = lingual view. Scale bar 10 mm.

The specimens PUPC 04/13, PUPC 07/163 exhibit a close relationship with the type specimen AMNH 19855 (Colbert, 1935) and can be referred to the species *H. antilopinum*. This is a medium sized species of slender build especially by metapodials while *H. theobaldi* is typically a large, robust species with heavy metapodials. But the differences between these two species are mainly the size and in any large series of teeth an almost perfect gradation may be found between them.

Lydekker separated *H. theobaldi* from *H. antelopinum* on the basis of the following distinctions: greater size of molars, and their more oblong and less square shape in *H. theobaldi*, protocone is compressed, as compared to a round-oval protocone in *H. antelopinum*, hypocone extending back to the posterior border of the molar crown in *H. theobaldi*, hypocone is united to posterior crescent in DP2 of *H. theobaldi* and enamel borders of fossettes relatively simple in *H. theobaldi*, complicated in *H. antelopinum*.

The genus *Hipparion* is represented by two upper cheek teeth and a lower cheek tooth series, both are much worn (the crown heights are between 15 and 19 mm), a fragment of mandibular symphysis, a complete metatarsal, a distal metatarsal of third another individual, and a few other bones. The complete metatarsal is very slender. Slenderness is good indicator of dry environments (Gromova, 1949). The depth of the bone at mid-diaphysis, at the proximal and at the distal end, the development of the facet for the cuboid, the effacement of the supra-articular tuberosities and

the constriction near the keel are characters indicating strong cursorial adaptations and a tendency toward functional monodactyly (Eisenmann *et al.*, 1988).

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