

ON A NEW SUBSPECIES OF *EQUUS* FROM PINJOR FORMATION OF UPPER SIVALIKS—WITH REMARKS ON SIVALIK *EQUUS*.

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ABSTRACT

A new subspecies of *Equus*, viz. *Equus sivalensis minor*, is described from the Pinjor Formation of the Upper Sivaliks in the north of Chandigarh. It is smaller and more slender than *Equus sivalensis*. The stratigraphic significance of *Equus* in the Sivaliks is discussed.

INTRODUCTION

The molassic Sivalik deposits of the Indian Subcontinent are well-known for their rich fossils, especially mammals. The mammalian record from these deposits is well-documented through the efforts of a number of palaeontologists for over a century. Upper Sivalik constitutes the youngest Subgroup of the Sivalik Group and is further sub-divided into Tatrot, Pinjor, and Boulder Conglomerate Formations. These deposits are exposed in the northeast of Chandigarh in the form of deeply dissected low hills with deep gullies, cuestas, scarps, dipslopes, etc. Clay, silt, sandstone, and conglomerates of various textures and colours are met within the area. These deposits range in age from the Late Pliocene to the Middle Pleistocene (Sahni and Khan, 1964; Gaur, 1981; Gaur and Chopra, 1984). Preliminary magnetostratigraphy conducted by Azzaroli and Napoleone (1982) in this area reveals an age of between 3.7 to 0.73 myr. However, equivalent rocks in Pakistan have been assigned an age of 5.5 myr to 0.6 myr (Opdyke, *et al.*, 1979). Opdyke *et al.*, (1979), Azzaroli and Napoleone (1982), and Tandon *et al.*, (1984) place the Tatrot/Pinjor boundary at the Gause/Matuyama boundary, around 2.5 myr, on the basis of magnetostratigraphy. Khan (1962), Sahni and Khan (1964), Badam (1973), Nanda (1973), Gaur (1981), and Gaur and Chopra (1984) are among the recent workers who contributed to the palaeontology and geology of this area. The depositional environment and ecology of the Upper Sivaliks of the present area have been worked out by Gaur (1981), Gaur and Chopra (1983), and Gaur and Chopra (1984).

While carrying out palaeontological investigations in the Sivaliks, one of us (RG) recovered the remains

of a hitherto unrecorded small horse from Pinjor Formation of Upper Sivaliks exposed about 3 km. in the northeast of Mirzapur (Fig. 1), about 19.25 km. north of Chandigarh. One of the specimens, an isolated M¹, was collected *in situ* from the yellowish grey

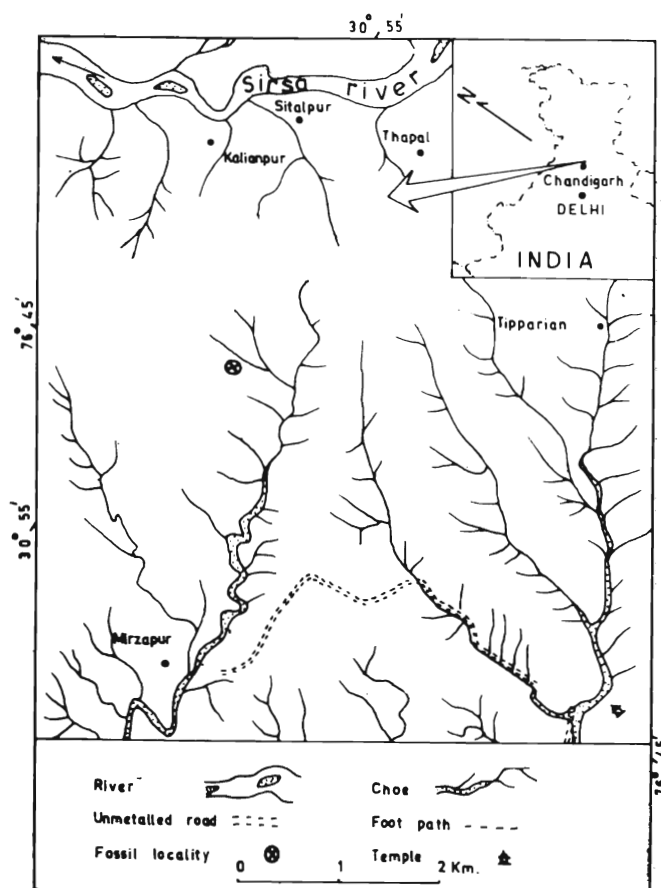


Fig. 1. Locality map of the area.

silt (Fig. 2). The other two specimens are surface finds and were found together within a radius of about thirty metres of the above M¹. All these specimens appear to have come from the middle part of Pinjor Formation. The specimens were found associated with *Sus* sp. nov., *Elephas hysudricus*, *Rhinoceros sivalensis*, *Rucervus simplicidens*, *Sus falconeri* etc., suggesting a Pleistocene age for the deposits. The new material is described here as a new subspecies of *Equus*, viz., *Equus sivalensis minor*.

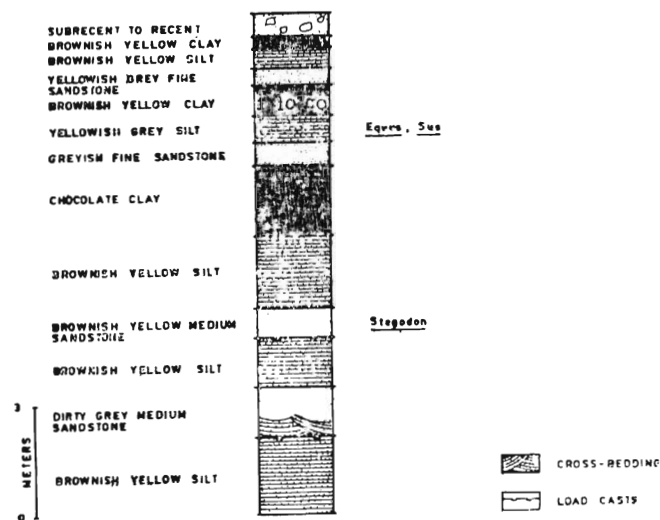


Fig. 2. Local section showing Pinjor deposits about 3 km. northeast of Mirzapur.

SYSTEMATIC DESCRIPTION

Family	Equidae	GRAY, 1821
Subfamily	Equidae	STEINMANN ET DODERLEIN, 1890
Genus	<i>Equus</i>	LINNAEUS, 1758
Species	<i>Equus sivalensis</i>	FALCONER AND CAUTLEY, 1849
Type species	<i>Equus caballus</i>	LINNAEUS, 1758

Diagnosis: Protocone of premolars small, never larger than in M². This distinguishes it from *E. caballus*; resembles *E. hemionus*, but larger in size and p¹ less reduced. A distinct trace of a preorbital fossa. Muzzle shorter than in *E. caballus*, jaw deeper, thereby approaching *E. hemionus*, limbs and feet also are relatively slender (Matthew, 1929; p. 530).

Subspecies *Equus sivalensis minor*, n. sub sp.
(Plate I—3)

Equus sivalensis Falconer and Cautley, S. I. and Khan, 1961, pp. 265-268, pls. 1-4.

Equus sivalensis (in parts) Falconer and Cautley, Badam 1979, Pleistocene Fauna of India.

- Holotype** : PUA 77/3, a right M¹.
Paratypes : PUA 78/23, a left M³; PUA 78/22, right metacarpal III.
Horizon : Pinjor Formation of Upper Sivaliks.
Locality : About 3.0 km. northeast of Mirzapur.
Etymology : The subspecies has been named due to its much smaller size and slender nature.

Table 1. Comparative measurements

Sr. No.	Measurement	<i>E. sivalensis minor</i>		<i>Equus sivalensis</i>				F. A. S. 1849, Pl. 81, Fig. 1.	Lydekker, 1882, Pl. 4, Fig. 2.
		Present specimen	Badam, 1979 A/639	PUA 77/59	PUA 77/60	PUA 77/92	PUA 127B		
1.	Max. mesio-distal dia. (L)	22.30	22.00	28.00	28.50	27.80	30.20	28.00	26.00
2.	Max. bucco-lingual dia. (B)	24.50	25.00	29.20	29.00	29.00	30.00	30.00	29.00
3.	Index (B/L)	1.09	1.13	1.04	1.02	1.04	0.97	1.07	1.11
4.	Length of protocone (I)	10.50	10.00*	11.70	11.00	11.20	11.50	—	—
5.	Breadth of protocone (b)	5.50	5.80*	4.30	4.00	4.30	4.20	—	—
6.	Protoconal shape index (b/1)	0.52	0.53	0.36	0.36	0.38	0.36	—	—
7.	Protoconal index (1/Lx100)	47.08	45.45	41.78	38.59	40.28	38.07	—	—

*Estimated from the figure.

Diagnosis : Smaller than *Equus sivalensis*. Upper molars small with comparatively thin enamel ; borders of fossettes relatively simple, protocone relatively broad. Lower molars small and narrow with comparatively thin enamel ; ectoflexid shallow with a prominent plicaballoid which is much more posteriorly directed than in other Sivalik species of *Equus*; lingual depression V-shaped and relatively shallow ; metastylid more rounded at the disto-lingual angle than in other Sivalik equids.

PUA 77/3 (Pl. I—a, b, c ; Fig. 3B)

Description : The molar is relatively small and roughly squarish in outline. On its buccal side, due to wear, the paracone and metacone have fused to form a continuous ectoloph which runs along the buccal margin of the molar. The mesostyle is the most prominent style and the metastyle is only slightly developed. The protocone occupies the medio-lingual portion of the molar and is pinched off from the rest of the tooth. The protocone in the present M¹ is broader than in other species of *Equus* (Table-1). The protoconal shape and protoconal indices are also more than Sivalik and Narbada *Equus*. The disto-lingual hypocone is slightly broken. The mesial half of the molar shows a pre-fossette between paracone and protoconule. In the distal half of the tooth a post-fossette is placed between metacone and hypocone. The fossettes are comparatively small. Their enamel borders are relatively simple and show less number of enamel plications than other Sivalik equids. The

tooth enamel is thinner than other species of Sivalik *Equus*. The molar is moderately worn.

PUA 78/23 (Pl. I—d, e, f ; Fig. 3A)

Present tooth is small, comparatively narrow, and roughly triangular in outline with its apex lying distally. The mesial border of the molar shows a narrow paralophid which travels buccally to join the protoconid. On the lingual side, the mesial part of the tooth displays an oval-shaped metaconid which is separated from a medially placed metastylid by a V-shaped and relatively broad and shallow lingual depression. Metastylid is relatively more rounded than in *E. sivalensis*. Entoconid is slightly damaged on the lingual side. Hypoconulid is slightly pinched off from the entoconid. The ectoflexid is shallow and shows a strong plicaballinid which is much more posteriorly directed than other fossil *Equus* species of India. The mesial half of the molar displays a cement-filled metaflexid which opens on the lingual side between paralophid and metaconid. Entoflexid is present in the distal half of the tooth and opens on the lingual side between metastylid and entoconid. The enamel borders of the cement-filled entoflexid are comparatively more crenulated than the metaflexid. The enamel of the molar is thinner than in other equids. It is much less worn than the M¹, indicating that these specimens came from two different individuals.

PUA 78/22 (Pl. I—g, h, i ; Fig. 3C) :

The present specimen is the distal end of the right

(in mm) of some species of *Equus*

<i>Equus sivalensis</i>						<i>Equus namadicus</i>			
Colbert,	1935	Khan,	1962	Badam,	Ind.	Fauna Antiqua Sivalensis, 1849			
Amer.	Amer.	A/587	A/598	1973	Mus.	Lydekker,	Pl. 81,	Pl. 81,	Pl. 82,
Mus. No.	Mus. No.			A/593	No. C 179	1882,	Fig. 7	Fig. 6	Fig. 7
19806	19827					Pl. 4			
						Figure. 2			
30.50	30.00	30.00	28.00	30.00	26.00	26.00	24.00	29.00	23.00
29.00	28.00	31.00	30.00	30.00	28.00	28.00	26.00	31.00	29.00
0.95	0.97	1.03	1.07	1.00	1.07	1.07	1.09	1.06	1.26
—	—	—	—	12.00	—	—	13.50*	—	—
—	—	—	—	4.50	—	—	4.30	—	—
—	—	—	—	0.37	—	—	0.31	—	—
—	—	—	—	40.00	—	—	56.25	—	—

Table 2. Comparative measurements of M_3 (in mm) of some species of *Equus*

Sr. No.	Measurement	<i>E. sivalensis minor</i>			<i>E. sivalensis</i>			<i>E. namadicus</i>	
		Present specimen PUA 78/23	Khan, 1961 A/602 Pl. 4	Badam, 1979 A/601	PUA 77/65	PUA 135B	PUA 136B	Colbert, 1935. Amer. Mus. No. 19884	Badam, 1979 B/40
1.	Max. mesio-distal dia.	27.90	28.00*	28.00	37.00	33.00	33.00	35.00	35.00
2.	Max. bucco-lingual dia.	11.70	13.00*	12.00	18.00	17.50	16.00	15.00	16.00
3.	Index	0.42	0.46	42.85	0.49	0.53	0.48	0.43	0.46
4.	Thickness of enamel	1.05	1.16*	1.15*	1.35	1.45	1.55	1.50*	1.75*

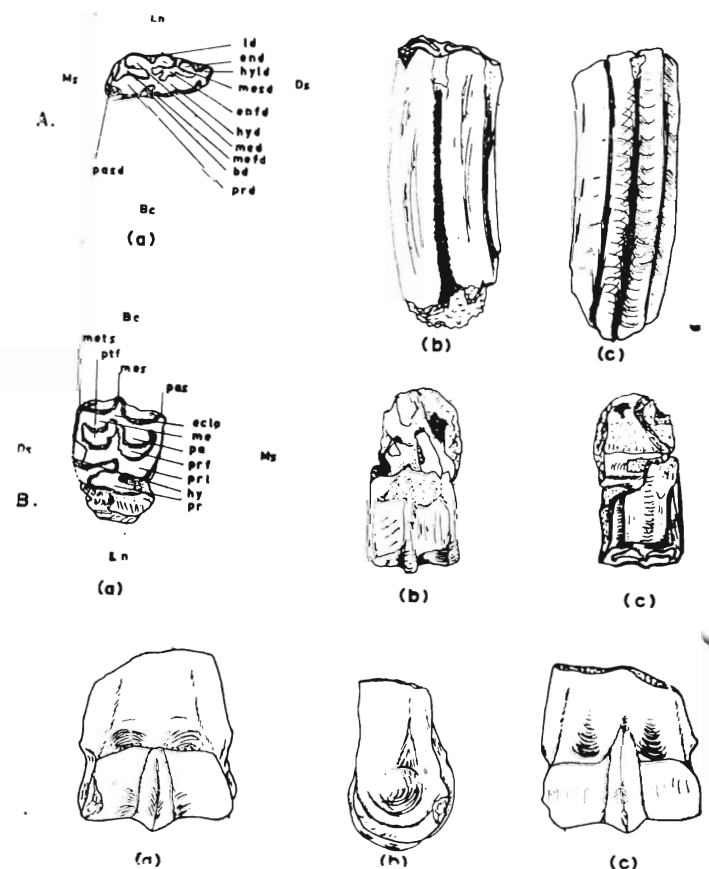
*Estimated from the figure.

third metacarpal. It is smaller in size than that of *Equus sivalensis* (Table 3). The specimen is broken about 2.5 cm., above the condyles. It lacks concavities posterior to the tuberosities and has relatively circular condyles. The specimen came from an adult individual, as the distal epiphysis is completely fused with the diaphysis.

Table 3. Measurements (in mm) of the third metacarpal of *Equus*

Sr. No.	Measurement	<i>E. sivalensis minor</i>	<i>Equus sivalensis</i>	
		PUA 78/22	PUA 79/11	PUA 79/83
1.	Max. antero-posterior dia. of the distal end.	26.00	35.50	32.80
2.	Max. transverse dia. of the distal end.	38.00	50.00	49.30

Remarks : Although there is a lot of controversy about the species of *Equus* in the Sivalik and younger deposits of India, two species names stand out in literature, viz., *Equus sivalensis* and *Equus namadicus*. The present specimens differ from *E. namadicus* by their smaller size (Tables 1-3) and the short and broad nature of the protocone. In their basic morphology, the specimens under description come closer to *E. sivalensis*. However, they clearly differ from the latter by their much smaller size. Apart from size, the present M^1 (PUA 77/3) can be distinguished from *E. sivalensis* by its comparatively thin enamel, relatively short and broad protocone, and rather simple borders of the fossettes. The third lower molar (PUA 78/23) in the present collection differs from *E. sivalensis* by its small size, less bucco-lingual diameter, and relatively thin enamel. It further differs from *E. sivalensis* and *E. namadicus*

Fig. 3. *Equus sivalensis minor* subsp. nov.

- A. M_3 (a, occlusal view; b, buccal view; c, lingual view).
B. M^1 (a, occlusal view; b, buccal view; c, lingual view).
C. Third metacarpal (a, anterior view; b, lateral view; c, posterior view.).

bd-buccal depression, ecto-ectoloph end-entocoinid, enfd-entoflexid, hy-hypocone, hyd-hypoconid, hyd-hypoconulid, ld-lingual depression, me-metacone, med-metacoid, mefd-metaflexid, mes-mesostyle, mesd-metastylid, mets: metastyle, pa-paracone, pas-parastyle, pasd-parastylid, pr-protocone, prd-protocoid, prf-prefossette, prl-protocorule, ptf-postfossette Bc-buccal, Ds-distal, Ln-lingual, Ms-mesial.

All figures approx. $\times 0.6$.

by the rounded distolingual angle of the metastylid. The disto-lingual angle of metastylid in *E. namadicus* and *E. sivalensis* is rather pointed. Another feature which sets the present M_3 , apart from *E. sivalensis* is the presence of a much more posteriorly directed plicaballinid in the ectoflexid. It differs from the M_3 of *Hipparion* by the absence of a tripartite third lobe and by the presence of a V-shaped lingual depression. In *Hipparion*, the third lobe of M_3 is tripartite (Gromova, 1968 ; p. 411) and the lingual depression is U-shaped. The third metacarpal under description (PUA 78/22) is smaller than that of *E. sivalensis*. It differs from the same of *Hipparion* by the absence of concavities posterior to the tuberosities and by the presence of more circular condyles.

Figure 4a shows the scatter diagram of the mesio-distal and bucco-lingual diameters of M^1 of *Equus sivalensis*, *Equus namadicus* and the present M^1 . The present specimen is placed much away from the cluster of *Equus sivalensis* and *Equus namadicus*, pointing towards its metrical differences from them. The plot of the length and breadth of the protocones of M^1 of *E. sivalensis*, *E. namadicus* and the present M^1 (Figure 4b) displays a pattern similar to the previous plot, thereby

establishing distinctness between the present M^1 , and *E. sivalensis* and *E. namadicus*.

From the foregoing it is clear that the present specimens belong to a form somewhat different from *E. sivalensis* and *E. namadicus*. These differences would warrant the emplacement of the present material in a new species. But since the differences are less of morphological and more of metrical nature, and the material being isolated, the present specimens are assigned to a new subspecies of *E. sivalensis*, viz., *E. sivalensis minor*. A skull (A/639) and two ramii (A/601, A/602) figured by Sahni and Khan (1961, pls. 1-4) are reassigned here to *Equus sivalensis minor*. This subspecies shows a slightly broad and a V-shaped lingual depression on the lower molars, thereby pointing towards its zeberine affinities.

DISCUSSION

As has already been pointed out, there is considerable controversy regarding the number of species of *Equus* in Sivaliks. Falconer and Cautley (1849, pls. 81, 82, 84, 85) recognised three species of fossil *Equus* in the Indian subcontinent, viz. *E. sivalensis*, *E. namadicus*, and *E. palaeonius*, the former from the Lower Pleistocene of Sivaliks and the latter two from the Upper Pleistocene of Narmada Valley. Lydekker (1883) felt that *E. palaeonius* was not a separate species but a younger specimen of *E. namadicus*. Matthew (1929, p. 531) and Colbert (1934, p. 162) considered *E. palaeonius* as a junior synonym of *E. namadicus*. Lydekker (1882) differentiated *E. namadicus* from *E. sivalensis* by the greater length of the protocone of cheek teeth and an elongated skull. Matthew (1929, p. 531) and Colbert (1935, p. 162) considered *E. namadicus* synonymous with *E. sivalensis*. Hooijer (1949, p. 2) also considered *E. namadicus* as a synonym of *E. sivalensis*, and the characters on which Lydekker (1882) distinguished *E. namadicus* from *E. sivalensis* were taken as invalid in view of high interspecific variability. Badam (1979, p. 53), Badam and Tewari (1974, p. 10), and Gaur (1981, pp.117-118) also consider *E. namadicus* as a synonym of *E. sivalensis*. Azzaroli (1966) placed *E. sivalensis* and *E. namadicus* in the subgenus *Hippotigris* which includes the mountain zebra *E. zebra*, Burchell's zebra *E. burchelli* and the quagga, *E. quagga*. Azzaroli (1966) differentiated the species *E. namadicus* from *E. sivalensis* on the basis of large and broad skulls, and the greater length of protocone of cheek teeth. These characters were attributed to variations within a species by Badam (1979, p. 53). Azzaroli (1982, p. 81) considers *E. namadicus* and *E. sivalensis* distinct species but recognises the similarity of their skull features except the large size and longer snout of the former. Gromova (1949) in her study

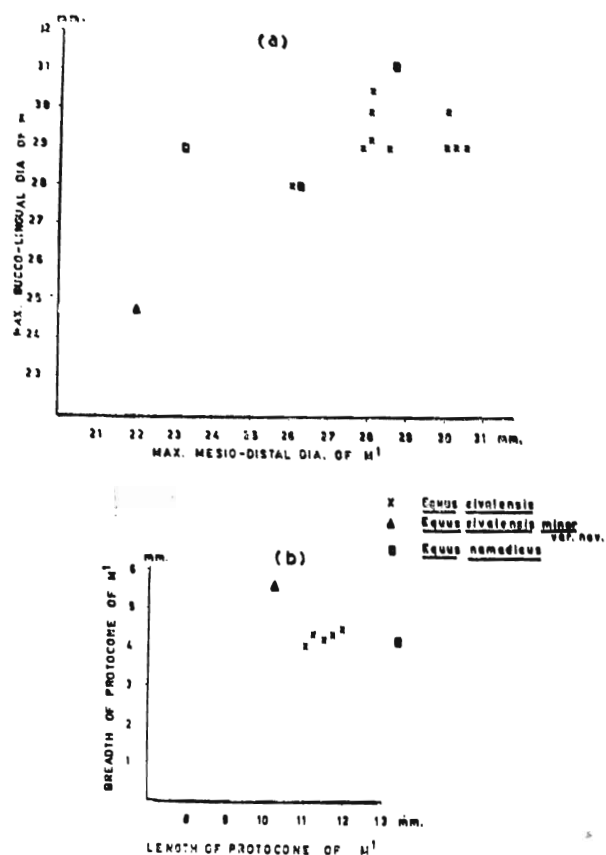


Fig. 4. Scatter diagrams of *Equus sivalensis*, *Equus namadicus*, and *Equus sivalensis minor* subsp. nov.

of Old World Equids pointed out that *E. sivalensis* is ancestral to *E. hemionus* through *E. namadicus*. According to Azzaroli (1982, p. 91), *E. namadicus* is a species of large size with an elongated snout, and *E. sivalensis* has a smaller snout and is of smaller size.

Another species of *Equus*, *E. cautleyi*, was created by Hopwood (1937, p. 907) on the basis of the larger size of the mandibular ramii. Sahni and Khan (1961 p. 267) also endorsed Hopwood's viewpoint. According to Hopwood (1937) *E. cautleyi* was the only zeb-rine horse while the others were caballine. Subsequent authors, such as Hooijer (1949, p. 2), Badam and Tewari (1974, p. 10), Nanda (1978, p. 168), Badam (1979) and Gaur (1981, p. 126) did not consider *E. cautleyi* as a valid species and synonymised it with *E. sivalensis*, which was shown to have zeb-rine affinities by Khan (1961), Azzaroli (1966), Badam and Tewari (1974), Badam (1979), and Gaur (1981).

From the foregoing it is evident that despite the large number of studies conducted over the years, there still exists some confusion about the number of *Equus* species in the Indian Pleistocene. Moreover the range of variation of this horse has never been properly worked out. A detailed review of the Indian *Equus* material is suggested to sort out the above problems.

THE OCCURRENCE OF EQUUS AND THE PLIO-PLEISTOCENE BOUNDARY IN THE SIVALIKS

As suggested by Tobien (1970), the combination of *Equus-Leptobos-Elephas* has been the traditional Pleistocene marker in Europe. Most early workers used the first appearance of *Equus* along with *Elephas*, *Camelus* and *Leptobos* to identify Pleistocene deposits in Sivaliks. More recently, the association of *Equus*, *Elephas* and *Cervus* with antlers has been accepted in India to indicate the beginning of Pleistocene (Ranga Rao *et al.*, 1979). Until recently, no absolute ages were available for the Upper Sivaliks of India. Sahni and Khan (1964) on a faunal basis assigned an Upper Pliocene and Lower Pleistocene age to Tatrot and Pinjor Formations, respectively, and placed the Plio-Pleistocene boundary at the base of Pinjor.

In recent years some magneto-stratigraphic studies have been conducted on the Upper Sivaliks. According to the magnetic polarity time scale the Pleistocene Epoch commences at the Olduvai event which has been dated to 1.8 myr. Keller *et al.* (1977) initially based Sivalik palaeomagnetic data on the oldest occurrence of *Equus*, which is 3.5 m.y. in North America (Evernden, *et al.*, 1964) and 2.5 m.y. in the Old World (Boit, 1970), and showed the earliest occurrence of *Equus* at the base of Olduvai event in the Pabbi Hills, Pakistan. Subsequently, Opdyke *et al.* (1979)

reported the oldest record of *Equus* at 2.48 m.y. (in the Matuyama magnetic epoch) in the Mangla-Samwal section of northern Pakistan. Very recently, Azzaroli and Napoleone (1982) recorded *Equus* from Matuyama magnetic epoch in the Nadah section of Pinjor Formation of Indian Sivaliks. In the present area, *Equus* is restricted to the Pinjor Formation which falls in the Matuyama magnetic epoch extending back to 2.48 m.y. The Tatrot/Pinjor boundary corresponds with the Gauss/Matuyama boundary which has been dated to 2.48 m.y. (Opdyke *et al.*, 1979; Azzaroli and Napoleone, 1981; Tandon *et al.*, 1984).

From the foregoing it is clear that there is a definite conflict between the vertebrate palaeontology and magnetostratigraphy as far as the Plio-Pleistocene boundary in Sivaliks is concerned. The mammalian biochronology relies upon the first appearance of *Equus*, *Elephas* and *Cervus* with antlers to mark the beginning of Pleistocene which extends upto the base of Pinjors (2.48 m.y.). The palaeomagnetic studies consider the Olduvai event (1.8 m.y.) as the starting point for Pleistocene. Thus, there is a time lag of 0.68 m.y. between these two approaches. Going by magnetostratigraphy a part of Pinjors would fall in the Upper Pliocene and the traditional Pleistocene markers, such as *Equus*, *Elephas* and *Cervus* too appear somewhere in the Upper Pliocene.

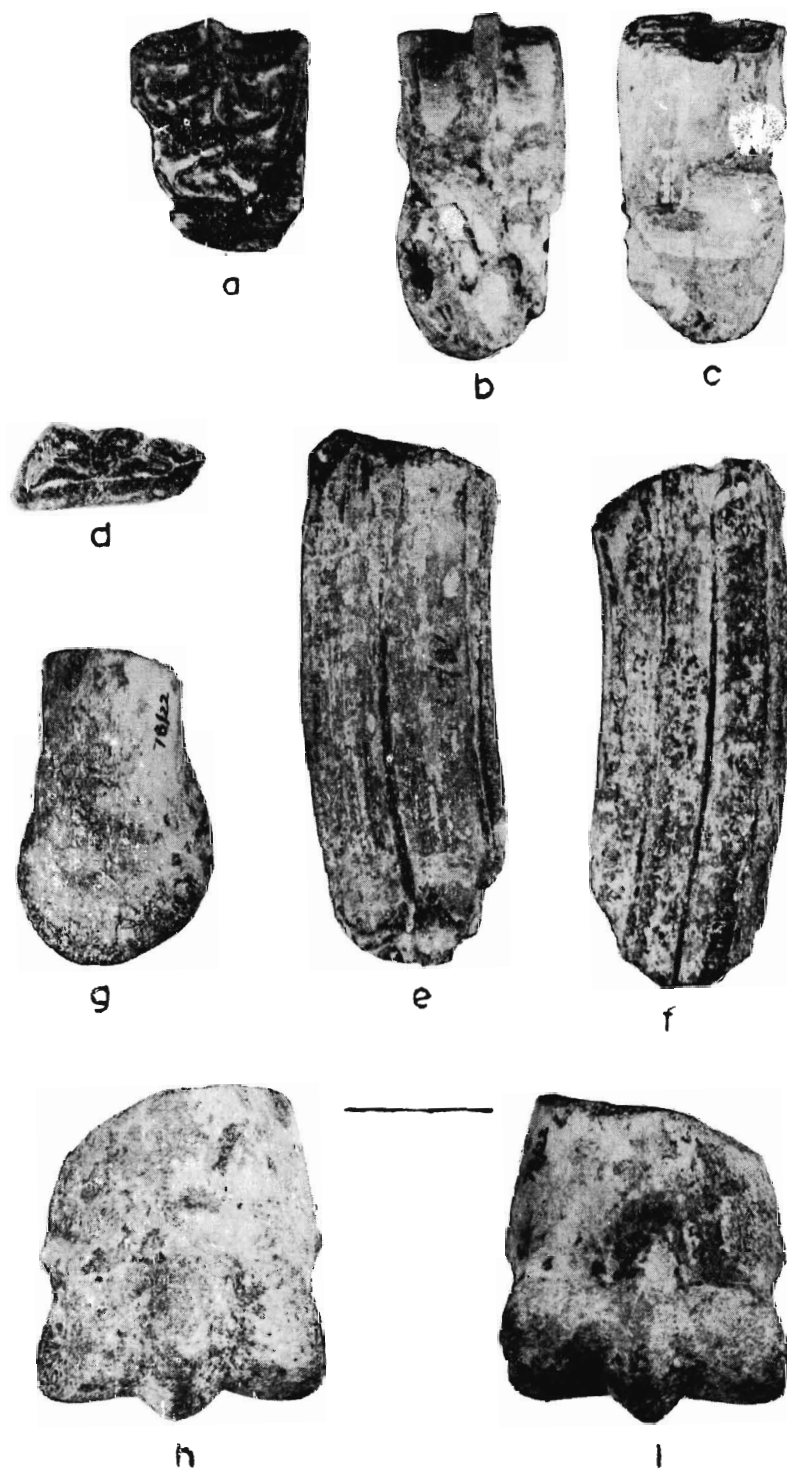
In other words *Equus*, *Elephas* and *Cervus* lose their significance as indicators of Pleistocene, and the beginning of Pleistocene becomes unmarked by a major faunal event. We think the best way to resolve this conflict is to work out in detail the faunal associations in the Upper Sivaliks spanning between 1.8 m.y. and 2.48 m.y. Besides this, concerted efforts should be made to locate volcanic ash beds in the Pinjor Formation of Upper Sivaliks so as to work out the absolute radiometric dates for various faunal events in the type sections. Pending these investigations, the traditional faunal associations may also be used to distinguish Pliocene and Pleistocene in the Sivaliks.

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EXPLANATION OF PLATE

PLATE I

Equus sivalensis minor n. subsp. from Upper Sivaliks. a-c, right M^1 (a, occlusal view, b. buccal view, c. lingual view); d-f, left M^1 (d. occlusal view, e. buccal view, f. lingual view); g-i, third metacarpal (g. lateral view, h. anterior view, i. posterior view). Bar represents 2 cm.

