NEW MURIDS AND GERBILLIDS (RODENTIA, MAMMALIA) FROM PLIOCENE SIWALIK SEDIMENTS OF INDIA

by

Rajeev PATNAIK*

CONTENTS

*Centre of Advanced Studies in Geology, Panjab University, Chandigarh-160014, India.

Mots-clés: Muridés, Gerbillidés, Pliocène, Siwalik, Evolution

Key-words: Murids, Gerbillids, Pliocene, Siwalik, Evolution

Palaeovertebrata, Montpellier, **26** (1-4): 129–165, 8 fig., 4 tabl., 3 pl.
(Reçu le 15 Avril 1995, accepté le 21 Juin 1995, publié le 15 Décembre 1997)

RESUME

Les muridés et gerbillidés (Rodentia, Mammalia) provenant de quatre localités du Siwalik supérieur, Moginand (env. 3,5-4,5 Ma), Kanthro (env. 2,5 Ma), Ghaggar (env. 2 Ma) et Nadah (env. 1,8-2 Ma), sont ici décrits. La comparaison de *Mus linnaeusi* nov. sp. montre qu'elle est étroitement apparentée à la souris actuelle *Mus musculus.* Contrairement à l'hypothèse que *Golunda* avait migré de l'Afrique vers le subcontinet indien au cours du Pliocène terminal, il est suggéré ici que *Golunda* (sous la forme de *Golunda tatroticus* nov. sp.) a évolué à partir de *Parapelomys robertsi* des dépôts du Miocene terminal du Siwalik. *Golunda tatroticus* nov. sp. montre une parenté progressive avec l'actuel rat indien des bush*Golunda ellioti* à travers *Golunda kelleri* et *Goulnda* sp. *Tatera pinjoricus* nov. sp. est considérée ici comme intermédiaire entre l'espèce fossile *Abudhabia kabulense*, et l'actuelle *Tatera indica.*

ABSTRACT

Murids and gerbillids (Rodentia, Mammalia) recovered from four Upper Siwalik localities; Moginand (around 3.5-4.5 m.y.), Kanthro (around 2.5 m.y.), Ghaggar (around 2 m.y.) and Nadah (around 1.8-2 m.y.) are described herein. A comparison of *Mus linnaeusi* sp. nov. reveals its close relationship towards the house mouse *Mus musculus.* In contradiction to earlier proposals that *Golunda* migrated to the Indian subcontinent from Africa sometime during Late Pliocene, it is suggested here that *Golunda* (in the form of *Golunda tatroticus* sp. nov.) evolved from *Parapelomys robertsi* of Late Miocene deposits of Siwaliks. *Golunda tatroticus* sp. nov. exhibits a progressive relationship to the extant Indian Bush Rat *Golunda ellioti* through *Golunda kelleri* and *Goulnda* sp. *Tatera pinjoricus* sp. nov. is considered here to be a link between the extinct *Abudhabia kabulense* and the extant *Tatera indica.*

INTRODUCTION

During the last one and a half decades a great wealth of murid rodents (rats and mice) have been unearthed from Miocene sediments of Siwaliks, which has contributed significantly towards the understanding of the origin and evolution of many murid taxa (see Jacobs, 1978;Jacobs *et al.*, 1990;Barry and Flynn, 1990). Untill recently (Patnaik in press) Pliocene murids and gerbillids from Siwaliks were almost unknown. This paper is the result of additional material collected from Kanthro and Moginand localities and new specimens recovered from recently discovered Ghaggar and Nadah localities (see fig. 1 and Table 1).

Tuffaceous mudstone layers occur in Ghaggar and Markanda river sections (Tandon and Kumar, 1984, Patnaik, 1991). The Ghaggar tuffaceous mudstone bed is dated to 2.14+0.51 m.y. (Mehta *et al.*, 1993) and that of Markanda river has been tentatively correlated to approx. 2.5 m.y. old tuffaceous mudstones occurring in Pakistan and Indian Upper Siwalik sequences (Opdyke *et al.*, 1979; Ranga Rao *et al.*, 1988; Patnaik, 1991). Palaeomagnetic studies have been carried out in Markanda and Nadah sections (Azzaroli and Napoleone,1979). Extrapolating from ages of tuffaceous mudstones, palaeomagnetic dates and sedimentation rates (see Visser and Johnson, 1978; Ranga Rao *et al.*, 1988) Kanthro, Ghaggar and Nadah localities havebeen considered here to be around 2.5, 2 and 1.8-2 m.y. old respectively.

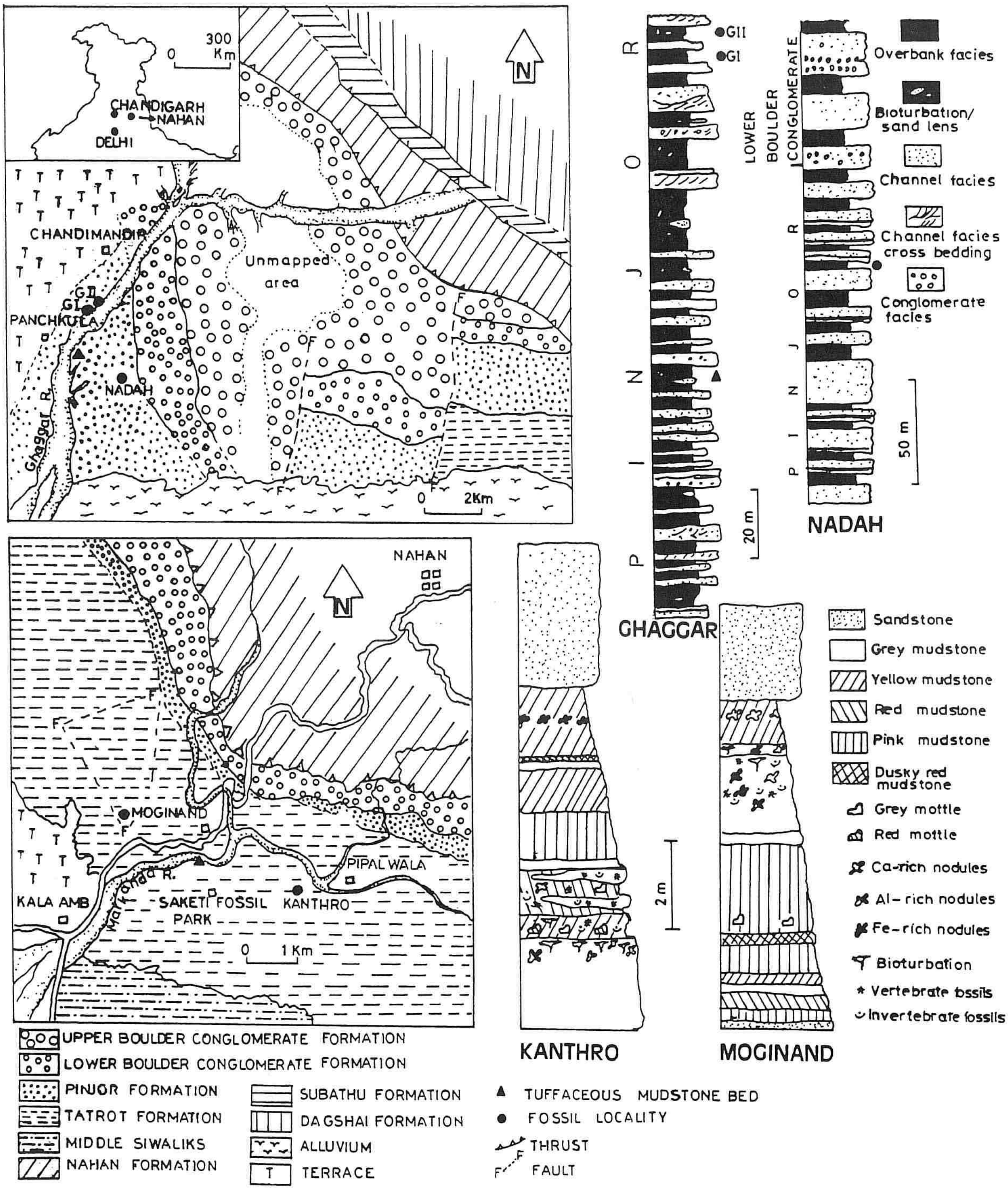


Figure1.— Geological maps and sections showing fossil localities east of Chandigarh and south-west of Nahan (Modified from Kumar and Tandon, 1985 and Patnaik in Press).

Based on faunal similarity with Ruscinian deposits of Afghanistan (Sen, 1983, Sen *et* *al.*, 1979) an Upper Ruscinian age is assigned to the Moginand locality.

The mudstone layers at GI and GII (Ghaggar section) have yielded evidence for pedogenic modifications under arid conditions. They lack organic matter, contain calcareous concretions and at places intercalated with carbonate rich bands. The sediments of Ghaggar river section have been compared with recent deposits of arid Central Australia on the bases of presence of high percentage of overbank deposits in individual cycles, lacking vegetal matter, organic poor palaeosol and abundance of syngenetic $CaCo_3$ (Kumar and Tandon, 1985). The microvertebrate yielding beds at Nadah have been placed in `Bluish grey mudstone facies ` of Kumar and Tandon (1985). These grey mudstones contain ferrugenous and calcareous nodules, molluscan shells, bioturbation products and are capped by around 15 cm thick nodular calcium carbonate band indicating presence of shallow seasonal pools of limited areal extent. Occurrence of tabular, variegated coloured units with wide areal extent, general absence of bedding, presence of microtopography at their contacts, Fe, Ca, Al, rich nodules, mottling and bioturbation products at Kanthro and Moginand localities has been interpreted as pedogenic modifications (Patnaik, 1995). Palaeoecological and taphonomical studies of Kanthro and Moginand sections indicates the presence of pond, pond-bank, bushland and grassland communities, and gradual accumulation of micro and megafossil remains in shallow seasonal ponds of broad flood plains, with concentration of some small mammal remains due to biogenic processes (Patnaik, 1995).

SYSTEMATICS

Additional material and critical reevaluation of murids and gerbillids described in an earlier paper (Patnaik in press) has allowed a revision. *Hadromys moginandensis* and Cf. *Cremnomys* are placed in *Dilatomys moginandensis* and *Cremnomys* sp. respectively. Cf. *Hadromys* and Cf. *Lemniscomys* have been transferred to Murinae indet. sp. Y. All the specimens of *Golunda* from Moginand locality have been included in a new species.

Family **MURIDAE** GRAY, 1821

Murid dental terminology proposed by Miller (1912) and Van de Weerd (1976) for upper and lower molars respectively, is followed here. The source of terminology of cranial features is from Musser and Newcomb (1983) and of cranial foramina is from Wahlert (1985). Skull and dental measurements used by Gerassimov *et al.*, (1990) and Musser and Heaney (1990) is followed here. Photographs used in the plates have been taken with the help of a Scanning Electron Microscope. All the specimens bear VPL/RP (Vertebrate Palaeontology Laboratory/Rajeev Patnaik) numbers.

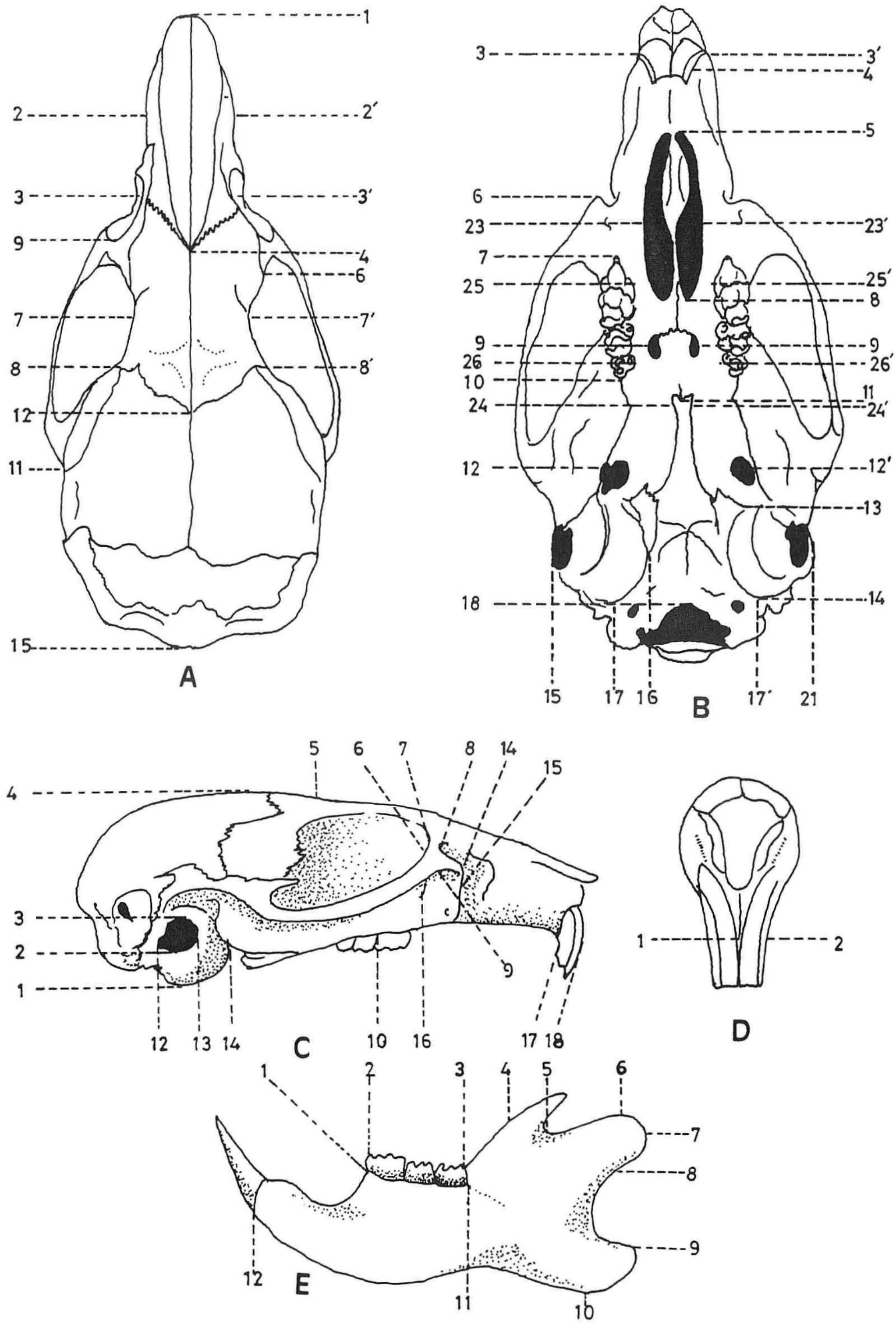


Figure 2.— Murid cranial measurements used in the present study (from Gerrasimov *et al.*, 1990 and Musser and Heaney, 1992). See table 2 for explanation.

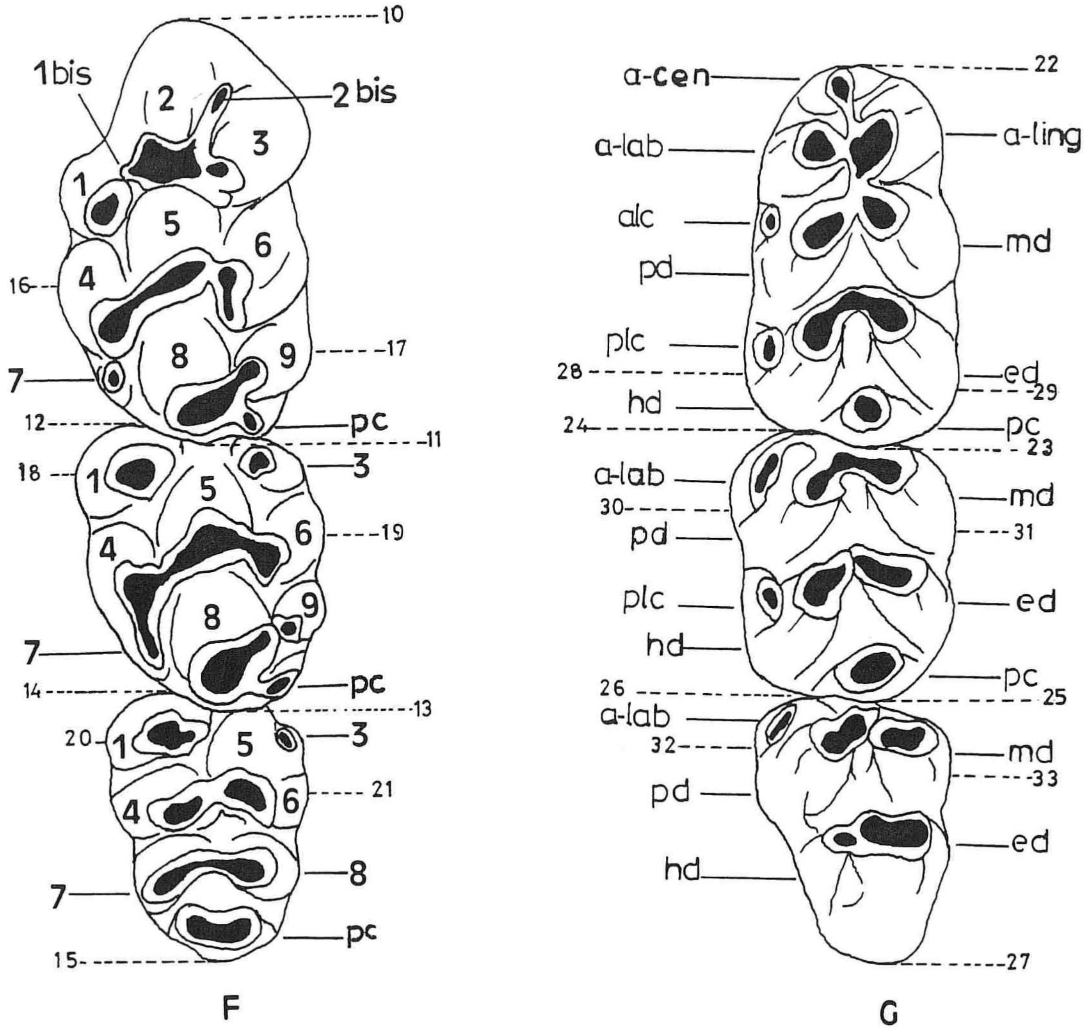


Figure 3.— Murid dental terminology and measurements (from Miller, 1912 and Van De Wreed, 1972). pc, posterior cingulum; a- cen, anterocentral cusp; a-lab, anterolabial cusp; a-ling, anterolingual cusp;alc, anterolingual cusplet; md, metaconid; pd, protocoind; plc, posterolabial cusplet; hd, hypoconid; ed, entoconid. Also see table 2 for explanation.

Mus LINNAEUS, 1758

Mus linnaeusi sp. nov.

(Plate 1 a-h)

Holotype : Skull (VPL/RP-GI 1)

Stratigraphic and Geographic range : Pinjor Formation, Panchkula (Haryana).

Age : Late Pliocene (around 2 m.y.).

Locality: Ghaggar river section.

Etymology: In honour of Carl Linnaeus.

Measurements: See table 2.

Diagnosis: Skull having a short incisive foramina; wide interpterygoid region; ? tightly attached auditory bullae and squamosal bone; greater distance between foramen infraorbitals, alveoli incisive lateralis, foramen ovale, and bullae osseae lateralis.

Description:

The cranium is moderately built. The braincase (partly broken) apparently seems to be wide and short, widest between squamosal roots of the zygomatic arches and decreases in width towards the occiput. The nasals are short and wide (anterior tipps of nasals are broken). Just anterior to the ends of nasals, broad and moderately deep zygomatic notches are situated. Interorbital area lacks ridges. Just anterior to the interorbital region and above the zygomatic plates platforms have been formed (Plate 1 d). The sides of braincase are almost vertical. The upper part of the zygomatic arch (broken) is apparently narrower than the anterior part of the mallax process.

In lateral view the dorsal margin of the cranium makes a gentle concave arc. The incisors leave the rostrum almost at a right angle (orthodont). The tips of the incisors are notched. Rostrum is deep and short. Zygomatic plates are broad. The anterior margin of the zygomatic plates are straight. The zygomatic plates bear small masseteric knobs. The anterior parts of zygomatic plates are extended so as to leave a moderately deep zygomatic notch. The length of the molar row is rather short relative to the size of the skull. The posterior root of the zygomatic arch is situated low on the brain case. Auditory bullae are moderately built relative to the cranium. The ventral margin of the auditory bullae is slightly ventral to the level of the toothrow. Squamosal bones are tightly attached to the auditory bullae. A strut (partly broken) of alesphenoid bone covers the lateral part of the alesphenoid canal and separates the foramen ovale accessorius from the masticatory - buccinator foramina (Plate 1b & c).

In ventral view the rostrum is wide, short and forms a prominent buldge to enclose a part of nasolacrimal capsules. The zygomatic plates slant dorso-laterally with a gentle angle. The incisive foramina are wide and short. The posterior margin of the incisive foramina (only from the left one) stops before the beginning of anterior root of the first upper molar. The palatal bridge is long, wide and has a smooth surface. The posterior edge of the palatal bridge slightly extends past the back surface of the third upper molars. The posterior palatine foramina is placed at the level of the second molar. At the posterior portion of the palatine bridge two foramina are present. The mesopterygoid fossa (interpterygoid region) is wide when compared to the extant species of *Mus* but relative to the size of the cranium it is moderately built. The pterygoid fossa is wide and short. Its floor is flat. The lateral margin of each pterygoid plate is outlined by a prominent ridge extending from the tip of the maxillary behind the molar row to the anterolateral margin of the auditory bullae. The foramen ovale is covered by a thin pterygoid bridge. The auditory bullae are moderately built with medium sized bony eustachian tubes.

The upper molars are highly worn indicating an older age for the individual. The M^1 is longer than wide.t2 shows a trace of an anterior cusplet. t1 is posteriorly placed relative to t2 and t3. t1 is laterally compressed. t4 is placed relatively posterior to t5 and t6. t8 is the posteriormost cusp on M^1 and is joined to a relatively large anteriorly placed t9. M^2 is as wide as M^1. M^3 is much reduced as compared to M^1 and M^2. Because of being highly worn, no trace of cusps are seen on M^2 and M^3.

Mandibles appear to be short and deep. The toothrow is short relative to the size of the mandible. Ends of coronoid, angular and condylar processes are broken. The capsule containing the end of the incisor forms a promonent projection on the labial side of the mandible. On the lingual side the shelf behind the molar row extends as a ridge for a short distance. The lower incisors are sharp and narrow. M_1 has anteriorly placed anterolingual cusp and relatively posteriorly placed anterolabial cusp. All the other cusps on M_2 and M_3 are highly worn and have lost their identity. M_2 is as wide as M_1 M_3 is a very reduced molar (Plate 1f).

Comparisons

The present skull is placed in the genus *Mus* owing to its small size (length range of *Mus* skull 17-30 mm); long M^1 (length exceeding 50% of the whole tooth row) and lack of t7(posterointernal cusp)) on the upper molars (see Marshall, 1972b). Characters like absence of supraorbital ridges and presence of narrow (less than 4mm) interorbital region places it in the subgenus *Mus* and distinguishes it from the recent species of the subgenera *Pyromys, Coelomys,* and *Nannomys.* But its comparatively shorter incisive foramina, relatively wider interpterygoid region and ? tightly attached auditory bullae and squamosal bones makes it probably the most primitive species of the subgenus *Mus* (see primitive cranial characters, Musser, 1981). A tight attachment between the squamosal bone and the auditory bulla in the present specimen might have formed due to the result of compaction of the enclosing sediments during diagenesis. But no direct evidence is shown by the specimen, like formation of oriented cracks, which could have easily formed on the delicate auditory bullae. Out of all the extant species of the subgenus *Mus* the present specimen resembles most closely to the house mouse *Mus musculus* group in having orthodont upper incisors; a short and deep rostrum (depth is approx. two third of the length); a zygomatic plate with a straight anterior margin and a narrower upper part of zygomatic arch compared to anterior part of the mallax process; a short mandible with a deep posterior portion.

Mus flynni PATNAIK (in press)

Mus* cf. *M. flynni

(fig. 4 a-c)

Referred material: N1(left M^2), N2(right M_1), N3(right M_2).

Stratigraphic and geographic range: Pinjor Formation, Nadah Village (Haryana).

Age: Late Pliocene (around 2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

M^2 is wider than long. A prominent t1 is present. t3 is very reduced. t4, t5 and t6 form the second cheveron. A large t8 is connected to anteriorly placed small t9.

M_1 has a 'X' pattern formed by the joining of anterolingual, anterolabial cusps, protoconid and metaconid. Labial cusps are posteriorly placed relative to the lingual cusps. Posterior cingulum is compressed anteroposteriorly and extends between hypoconid and entoconid. M_1 is two rooted.

M_2 comprises a small ridge-like anterolabial cusp joined to protoconid by an anterior connection. Metaconid and entoconid are anterior to protoconid and hypoconid. Posterior cingulum is anteroposteriorly compressed. M_2 has two roots.

Comparisons

M^2 and M_2 of *Mus* cf. *M. flynni* resemble strongly to those of *Mus flynni* reported from Kanthro (Patnaik, in press). The present M_1 also resembles very closely to that of *M. flynni,* except that the former has a slightly narrow anterior portion. M_1 of *M. jacobsi* (see Kotlia, 1992, Patnaik, in press) is comparatively smaller in size and bears anterior and posterior labial cusplets. The M_1 of *M. elegans* reported from Early Ruscinian sediments of Kabul, Afghanistan (Sen, 1983) differ from the present specimen in having a less anteriorly placed anterolingual cusp, lack of a 'X' pattern (anterolabial-anterolingual cusps joined labially to protoconid-metaconid lobe by a anterolabial cusp-protoconid connection), and presence of anterior and posterior labial cusplets.

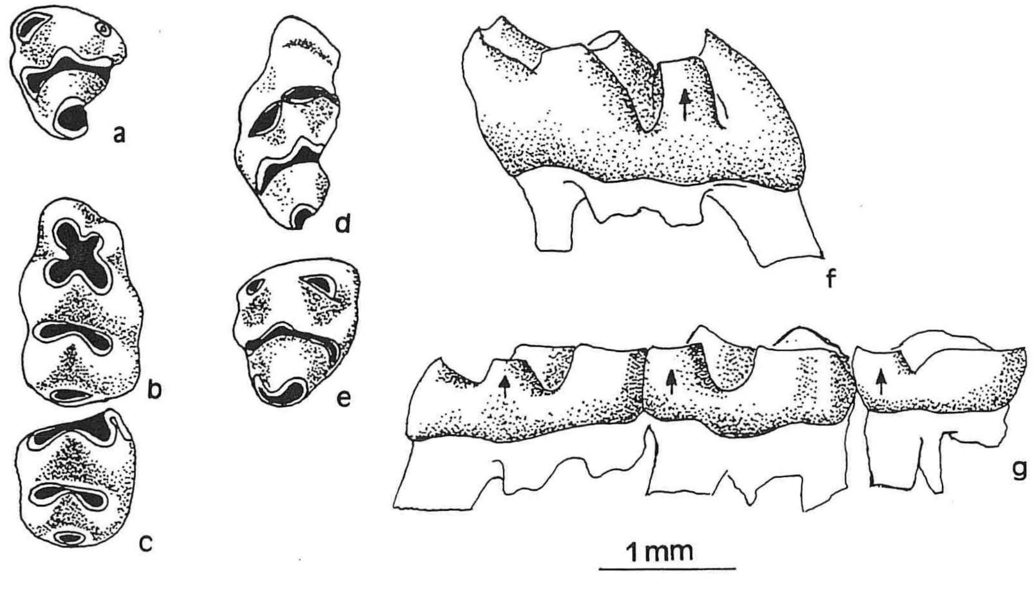


Figure 4.— *Mus* cf. *M. flynni*; a,b, & c, occlusal views of M^2 (N1), M_1 (N2) & M_2 (N3) respectively. *Mus* sp.; d & e, occlusal views of M^1 (MI7) and M^2 (MI8). Murinae indet. sp. Y; f, lingual view of M^1 (SM69). *Cremnomys* cf. *C. blanfordi*, g, lingual views of M^1, M^2 & M^3 (N8, N10 &N13 respectively).

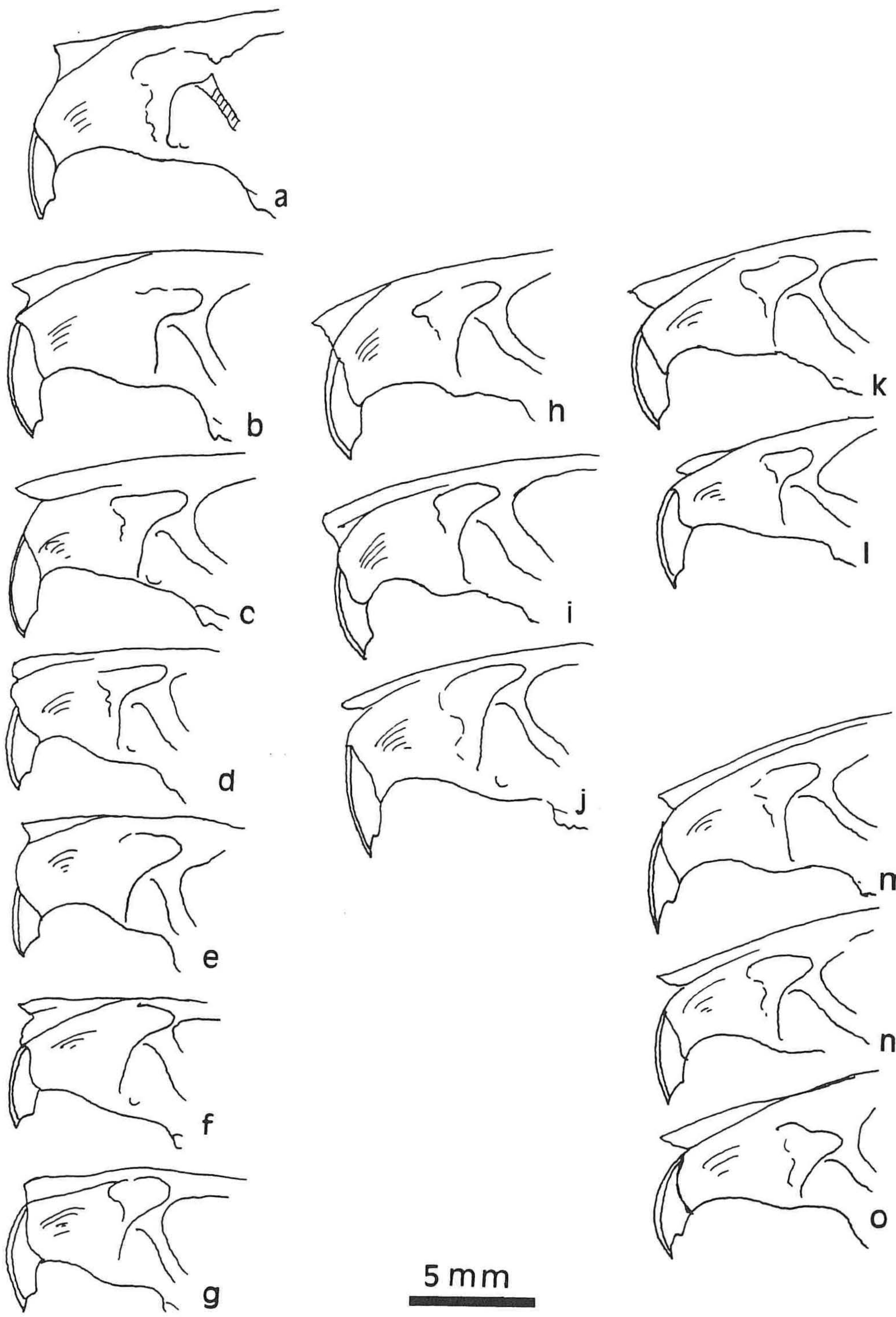


Figure 5.— Lateral view of the anterior part of skull of ; a, *Mus linnaeusi* sp. nov.; b, *M. m. casteneus*; c, *M. m. tytelri*; d, *M. m. bactrianus*; e, *M. m. molossinus*; f, *M. m. domesticus*; g, *M. m. musculus*; h, *M. spretus*; i, *M. macedonicus*; j, *M. spicilegus*; k, *M. booduga*; l, *M. dunni*; m, *M. caroli*; n, *M. cervicolor*; o, *M. cooki*.

Mus sp.

(fig. 4d & e)

Referred material: MI 7 (left M^1), MI 8 (right M^2).

Stratigraphic and geographic range: Tatrot Formation, Moginand Village (Himachal Pradesh).

Age: Early Pliocene (around 3.5-4.5 m.y.).

Locality: Moginand.

Mearurements: See table 3.

Description

The partly broken M^1 bears an anterior cingulum. t1 is laterally compressed and is isolated from t2. t1 and t4 are posteriorly placed to t2 and t5 respectively.

M^2 comprises t1, a small t3, t4-t5-t6 forming the second cheveron and a reduced t9 joined to a large t8.

Comparisons

The present M^1 resembles that of *M. elegans* and *M. flynni* in having an anterior cingulum. Relative to the size of M^1, M^2 is large and in this aspect it resembles *Mus auctor* described from Late Miocene Siwaliks of Pakistan (Jacobs, 1978).

GOLUNDA GRAY, 1837

Golunda tatroticus sp. nov.

(fig. 6a, plate 2a-d)

Holotype: MI1 (left M^1)

Referred material: M5 -A (left M^1), MI 2, 3 (right M^2 's), MI4 (left M^3) and MI 5 (left M_3).

Stratigraphic and geographic range:Tatrot Formation, Moginand Village (Himachal Pradesh).

Age: Early Pliocene (around 3.5-4.5 m.y.).

Locality: Moginand.

Etymology: For its occurrence in Tatrot Formation of Upper Siwaliks.

Measurements: See table 3.

Diagnosis: Large upper molars with multiple roots,t1 and t4 anteriorly placed relative to t3 and t6 on M^1, t1 on all the upper molars gently inclined and its occlusal surface oriented somewhat posterolabially.

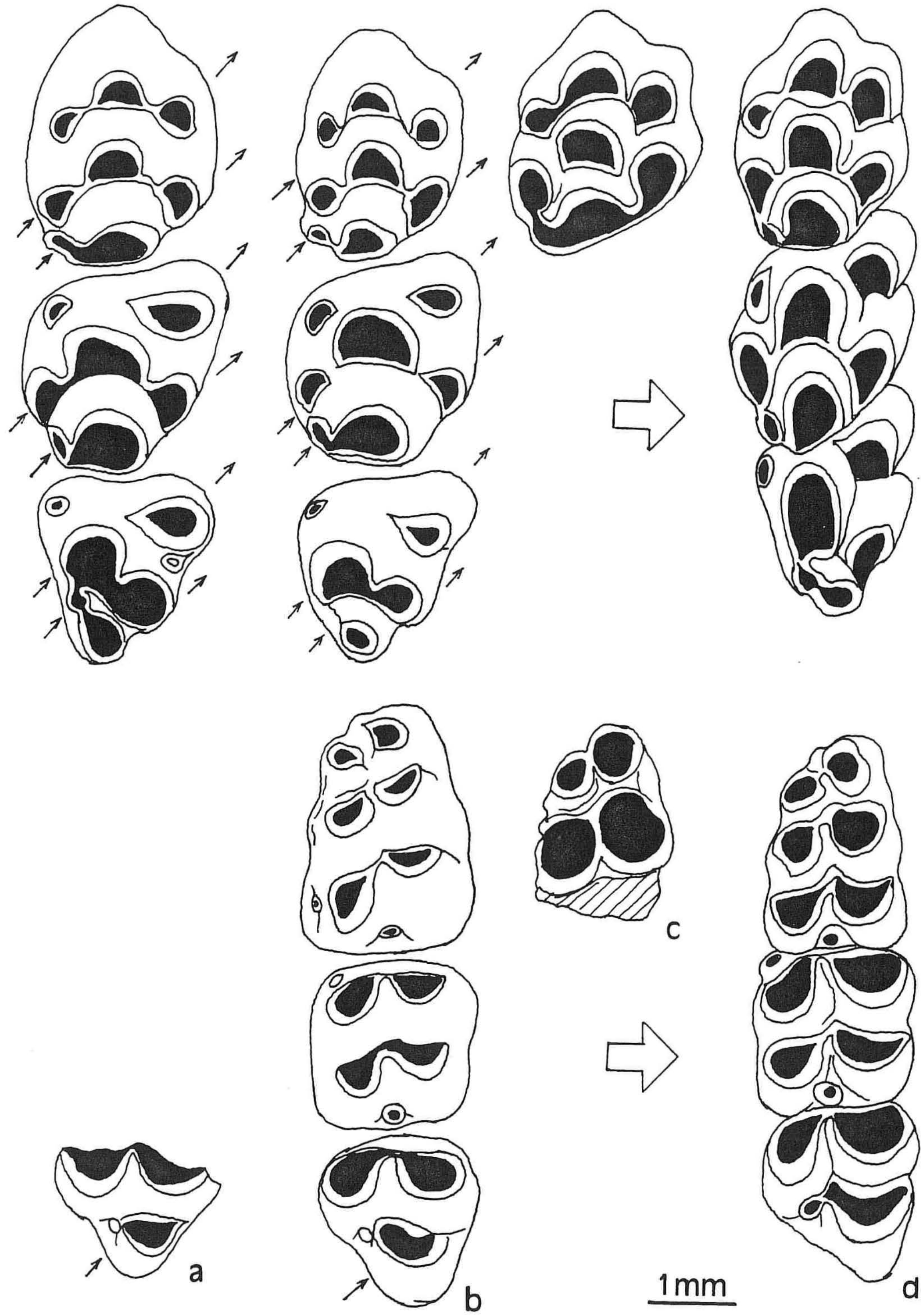


Figure 6.— a, *Golunda tatroticus* sp. nov., M^1 (MI1), M^2 (MI2), M^3 (MI4), M_3 (MI5) (images of M^1 and M^3 are inverted for convenience). b, *Golunda kelleri*, M^1 (SM50), M^2 (K4), M^3 (K6), M_1 (K7), M_2 (SM56), M_3, (K9). c, *Golunda* sp., M^1 (N4), M_1 (N7). d, Upper and lower molars of *Golunda ellioti* (extant taxon). Diagonal arrows indicate the probable region and direction of deformation.

Description

M^1 is somewhat round in occlusal outline with t1 and t4 are placed anteriorly relative to t3 and t6. t1 is gently inclined anteriorly (about 30°). t3 which is posteriorly situated to t1 and t2 is weakly attached to t2. A small t9 is attached to a very large t8. t9 is placed anterolabially relative to t8. An anterior cingulum is present. M^1 has five roots (one anterior, one posterior, two lingual and one labial).

M^2 comprises seven cusps. t1 is gently inclined and its occlucal surface is directed posterolabially. t3 is a very small cusp situated at the anterolabial border of the tooth. t4, t5 and t6 forms the second cheveron. A very small t9 is attached to t8. t9 is placed anteriorly relative to t8. M^2 has five roots.

M^3 is triangular in shape with wide anterior and narrow posterior portion. It has a gently inclined t1, a reduced t3, an almost vertical t4 attached to a gently inclined t5. t6 is absent. t9 is very small anteriorly placed to a large t8. A small cusplet is present below t1. M^3 is four rooted.

M_3 has protoconid, metaconid and a very small hypoconid attached to a large entoconid which is situated at the center of the molar. Roots are not preserved in the present specimen. No grooved upper incisors have been found associated with the molars.

Comparisons

Presence of strongly arcuate, posteriorly inclined (t1, t2, t3, t4, t5, and t6) and isolated (except for t8 and t9 and in extinct forms t4 and t5 on M^3) cusps on upper molars (degree of inclination varies from *Golunda tatroticus* sp. nov. to *Golunda ellioti*) distinguishes *Golunda* from *Mylomys, Pelomys, Parapelomys, Saidomys* and *Rhabdomys*. A detailed comparison of *Golunda tatroticus* sp. nov., *Golunda ellioti* (extant Indian bush rat), *Golunda kelleri* (Plio-Pleistocene Siwaliks, see Jacobs, 1978; Patnaik, in press, in the present work), *Golunda gurai* (from Pliocene of Ethiopia , see Sabatier, 1982 and Wesselman, 1984), *Parapelomys robertsi* (from Late Miocene to Late Pliocene Siwaliks, see Jacobs, 1978, Patnaik, in press), *Parapelomys charkhensis, Pelomys orientalis* and *Saidomys afghanensis* (Early Pliocene of Afghanistan, see Sen, 1983 and Sen *et al.*, 1979) are presented in Table 4.

Golunda kelleri JACOBS, 1978
Golunda kelleri
(fig. 6 b, Plate 2 e-j)

Referred material: K1 (right M^1), K2 (left M^1), K3 (right M^2), K4 (right M^2), K5, (right M^2), K6 (right M^3), K7 (left M_1), K8 (left M_1), K9 (left M_3), K10 (left M_3).

Stratigraphic and geographic range: Tatrot Formation to Pinjor Formation, Kanthro Village (Himachal Pradesh, India) to Potwar Plateu of Pakistan.

Age: Late Pliocene (around 2.5 m.y.).

Locality: Kanthro.

Measurements: See table 3.

Emended diagnosis: Upper molars with highly inclined cusps, small anterolabially placed t9 on M^1, M^1 with four roots and a narrow M^3 with a ridge-like t9.

Description

M^3 has a large t1 and a very minute t3. An almost vertical t4 is joined to posteriorly inclined t5. t8 forms the posteriormost cusp. t9 is ridge-like anteriorly placed between t8 and t5.

M_1 has a labial cingulum with a posterior labial cusplet. A small anterocentral cusp is fused to the anterolingual cusp. The labial and lingual cusps are highly alternate. M_1 has a small labial root besides one anterior and one posterior.

Two fragments of grooved upper incisors have been collected along with the molars.

For detailed description of upper and lower molars see Patnaik (in press) and Jacobs (1978) respectively.

Comparisons: See table 4.

Golunda sp.

(fig. 6c, plate 2k)

Referred material: N4 (right M^1), N5 (right M^1), N6 (right M_1), N7 (left M_1).

Stratigraphic and geographic range:Pinjor Formation (Upper Siwaliks), Nadah Village (Haryana).

Age: Late Pliocene (around 2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

M^1 is large and round. t1 and t4 posteriorly placed relative to t3 and t6. t1 and t4 streched anterolingually. t9 is very small and is posteriorly placed relative to a large t8. t9 is joined to t8 and is connected to t6 on the highly worn specimen. Because of the streching of t4 and possibly to accomodate a M^2 with highly sterched t1 and t4, the anterolingual margin of M^1 makes a steep angle with the antero-posterior axis of the upper molar row.

The two partly broken, highly worn M_1's show a small anterolabial cusp as compared to an anteriorly placed anterolingual cusp.

Three grooved upper incisor fragments have been found associated with the molars.

Comparisons

The present molars and incisors are strikingly similar to those of *Golunda ellioti* in all of their characters.

CREMNOMYS WROUGHTON, 1912

Cremnomys blanfordi WROUGHTON, 1912
Cremnomys cf *C. blanfordi*

(fig. 4g, pl. 3a)

Referred material: N8 (left M^1), N9 (right M^1), N10 (left M^2), N11 (left M^2), N12 (left M^2), N13 (left M^3), N14 (right M^3).

Stratigraphic and geographic range: Pinjor Formation, Nadah Village (Haryana).

Age: Late Pliocene (around 1.8-2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

M^1 with a t1 vertical, columnar (fig.4g) and round in occlusal outline, placed posteriorly relative to t2 and t3. t3 is a small cusp attached to t2 very strongly. t4 is placed posteriorly and oriented at a right angle to the lamina formed by t5 and t6. t9 is anterolabially placed and strongly joined to t8. M^1 has five roots.

M^2 is triangular in shape with a columnar and vertical t1. A small t3 is present. t4 is placed posterior and at a right angle to t5 and t6. A small t9 is extremely anteriorly placed to t8. M^2 has five roots.

M^3 is rather small relative to the size of M^1 and M^2. It has a large t1, t4-t5-t6 are strongly joined. t8 is strongly joined to t9 and weakly to t4. M^3 has three major roots and one thread-like root situated posterior to the anterior root.

Posterior roots of M^1 strongly overlap the level of anterior roots of M^2 and posterior roots of which in turn overlap the anterior roots of M^3.

Comparisons

Presence of overlapping root system on upper molars (Sabatier, 1982), round and anteriorly placed t1 on M^1 and less cuspidate upper molars differentiate *Cremnomys* from *Millardia.* Upper molars of *Cremnomys* cf. *C. blanfordi* resemble strongly to those of the extant taxon *Cramnomys blanfordi* in having a round and vertical t1, t3 very reduced and strongly connected to t2, which in turn has made the first cheveron significantly narrower than the second one, a small t9 anteriorly placed relative to t8 and a connection between t8 and t4.

Upper molars of *Cremnomys* cf. *C. cutchicus* reported from Kanthro locality (Patnaik, in press) show strong resemblance to upper molars of *Cremnomys* cf. *C. blanfordi* in having a significantly narrower anterior cheveron compared to the central one on M^1. The former differs from the latter in having a narrower M^2, a smaller t3 on M^1, t9 on M^3 and trace of posterior cingulum on M^1.

Upper molars of *Diomys crumphi* (extant taxon) also resembles closely to those of *Cremnomys* cf. *C. blanfordi* in most of the characters described above. The former differs from the latter in having a t1 laterally compressed and lacking a t3 on M^2.

Cf. ***Cremnomys*** PATNAIK, in press
Cremnomys sp.
(plate 3b-f)

Referred material: SM59 (right M^1), K11 (left M^2), K12 (right M^3), K13 (right M_1), K14 (left M_1), K15 (left M_3).

Stratigraphic and geographic range: Tatrot Formation, Kanthro Village (Himachal Pradesh).

Age: Late Pliocene (around 2.5 m.y.).

Locality: Kanthro.

Measurements: See table 3.

Description

M^1 has strongly connected cusps. t1 is round, vertical and is posteriorly placed relative to t2 and t3. t3 is small and is placed almost at the same level as that of t2 and is strongly joined to it. The anterior cheveron is significantly narrower than the central one. t4 is situated posterior and oriented at a right angle to t5-t6. t6 is slightly posterior to t5. t9 is small, placed labially and strongly joined to a large t8. M^1 has four roots (the two lingual roots are fused).

BANDICOTA GRAY, 1873
Bandicota sp.
(plate 3 g & h)

Referred material: N16 (left M^2), N17 (left M_3), N18 (right M_3).

Stratigraphic and geographic range: Pinjor Formation, Nadah Village (Haryana).

Age: Late Pliocene (around 1.8-2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

M^2 is hypsodont with a distinct t1 and a small t3. t4-t5-t6 are strongly joined to form a laminated cheveron. Posterior cheveron comprises ? t7, t8 and t9. M^2 has four roots.

M_3 is a hypsodont molar with highly laminated anterior (fused protoconid and metaconid) and posterior (fused hypoconid and entoconid) cheverons. M_3 has two roots.

Comparisons

Bandicota indica, Bandicota bengalensis and *Nesokia indica* are highly specialised extant taxa with laminated molars (Misonne, 1969). *Bandicota* differs from *Nesokia* by possessing a distinct t1 on M^2 and comparatively less laminated (cusps distinguishable on unworn teeth) upper molars (Misonne, 1969). *Bandicota* sp.

resembles *Bandicota sivalensis* reported from Kanthro locality (Patnaik, in press) in having a t1 and t3 on M^2 and differs perhaps in having a t7.

DILATOMYS SEN, 1983
Hadromys moginandensis PATNAIK, in press
Dilatomys moginandensis

Referred material: M7-B (left M^1).

Stratigraphic and geographic range: Tatrot Formation, Moginand Village (Himachal Pradesh).

Age: Early Pliocene (around 3.5-4.5 m.y.).

Locality: Moginand.

Measurements: See Patnaik in press.

Description: See Patnaik in press.

Comparisons

Dilatomys is characterised by having very large hypsodont molars with multiple roots. The present M^1 resembles that of *Dilatomys magnus* (SEN *et al.,* 1979) in having highly hypsodont cheverons, but retaining their cuspidate patterns, a prominent posterior cingulum and a reduced anteriorly placed t9 and differs in being slightly narrower, having more inclined cusps and fewer roots (five in the present specimen , whereas *D. magnus* has eight roots, Sen *et al.*, 1979).

Dilatomys sp.
(plate 2 1)

Referred material: N15 (left M^1).

Stratigraphic and geographic range: Pinjor Formation, Nadah Village (Haryana).

Age: Late Pliocene (around 1.8-2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

Highly hypsodont large cuspidate molar. t1 and t3 slightly posterior and weakly connected to t2, t4 and t5 slightly posterior and weakly connected to t5. t8 is large and joined to a small, labially placed t9. M^1 has six roots (one large anterior, two large lingual, two small posterior , one small labial and one central rootlet).

Comparisons

M^1 of *Dilatomys* sp. differs from those of *D. magnus* and *D. moginandensis* in being smaller in size, lacking a posterior cingulum, having a rather posteriorly placed t9 and six roots. *Dilatomys* molars resemble those of the recent Philippine murid *Tryphomys adustus* illustrated by Musser and Newcomb (1983, fig. 75, 76, 77 and 78). This does not necessarily imply any relationship and can only be judged on the availability of additional fossil material.

Murinae indet sp. X

(plate 3i & j)

Referred material: K17 (right M^1), MI 9 (right M^1).

Stratigraphic and geographic range: Tatrot Formation, Moginand and Kanthro Village (Himachal Pradesh).

Age: Early Pliocene (around 3.5-4.5) to Late Pliocene (around 2.5 m.y.).

Locality: Moginand and Kanthro.

Measurements: See table 3.

Description

M^1 with a laterally compressed t1 which is posteriorly placed relative to t2 and t3. t3 is small and is strongly joined to t2. Anterior cheveron is narrower than the central cheveron. t4 is placed posterior to t5 and t6. t6 is slightly posterior and strongly joined to t5. t9 is large, posteriorly placed and is situated labially relative to t8. Posterior cingulum is present in one of the specimens. Roots are not preserved.

Comparisons

In size and shape the present M^1 resembles those of *Millardia, Cremnomys* and *Praomys.* Presence of a less cuspidate pattern and a large t9 places it closer to *Praomys* and *Cremnomys.* Further, its anterolingually-posterolabially compressed and posteriorly inclined t1, a very large (comparable to the size of t8) and posteriorly situated t9 distinguishes it from *Cremnomys* and places it closer to the African genus *Praomys.* At the same time the M^1 of *Praomys* does not have a t1 as reduced as in the present specimen and it lacks a posterior cingulum. When compared the present M^1 represents somewhat an enlarged version of that of *Progonomys debruijni* described from Middle Miocene of Pakistan (Jacobs, 1978, fig. 15 a, b, c and d).

Cf. ***HADROMYS*** PATNAIK, in press
Cf. ***Lemniscomys*** PATNAIK, in press

Murinae indet sp. Y

(fig. 4f, plate 3k-m)

Referred material: SM69 (right M^1), K20 (left M^2), SM66 (left M_1).

Stratigraphic and geographic range: Tatrot Formation, Kanthro Village (Himachal Pradesh).

Age: Late Pliocene (around 2.5 m.y.).

Locality: Kanthro.

Measurements: See table 3.

Description

M^1 narrow, long and cuspidate. t1 almost vertical, columnar, isolated from t2 and is placed almost at the same level as that of t3. M^1 has a large anterior, a large posterior, a moderately built lingual and a small labial root. See Patnaik (in press) for detailed description of M^1 and M_1.

M^2 is large and tapers posteriorly. t1 is almost vertical. t3 is a very small cusp. t4, t5 and t6 have a triangular occlusal outline. t4 is weakly joined and posteriorly placed to t5. t6 is situated at the same level as that of t4. t9 is small, anteriorly placed and weakly joined to a large t8.

Comparisons

The shape and size of the present molars are rather rat-like. The shape, size and position of the cusps further support the above statement. However, in finer details they differ from any taxa included in the *Rattus* group or related groups like *Niviventar, subanus, beccari, Manipulus, Muelleri* (see Musser, 1981 and Musser and Newcomb, 1983) of Indo-Malayan region. The upper molars resemble those of *Rattus rattus* (the core taxa of the *Rattus* group) in having narrow and long upper molars with vertical t1 (fig. 4f) placed slightly posterior and anteriorly elongated t2; t4 and t6 placed almost at the same level and slightly posterior to t5; posteriorly elongated third cheveron with a large t8 and anteriorly placed small t9; a long M_1 with a narrow anterior lobe anterolingual and anterolabial cusps posteriorly joined, protoconid-metaconid and hypoconid-entoconid anteriorly joined and a prominent posterolabial cusplet. *Rattus rattus* differs from the present species in having rather strongly connected cusps, lacking t3 on M^2 and having multiple roots on M^1.

Family **GERBILLIDAE** ALSTON, 1876

Indian fossil gerbillids are known from Siwaliks (*Protatera* cf. *P. kabulense*, Patnaik in press) and Narmada Valley deposits (*Tatera* cf. *T. indica* and *Gerbillus* sp. Patnaik *et al.*, 1995). Barry and Flynn (1990) have mentioned the record of *Protatera* from Late Miocene Siwalik sediments of Pakistan, but its illustrations and descriptions are not available yet. Sen (1983) described *Protatera kabulense* from Early Pliocene of Afghanistan, which has been recently included in a new genus *Abudhabia* (BRUIJN and WHYBROW,1994). *Abudhabia bayununensis* comes from Late Miocene sediments of United Arab Emirates (Bruijn and Whybrow , 1994).

Gerbillids are widespread in Africa today and their fossil representatives are well documented from Pleistocene sediments of Tanzania (*Tatera* and *Gerbillus,* Denys 1987, 1989), Pliocene deposits of Ethiopia (*Tatera* sp., Sabatier, 1982, Wesselman, 1984).

Protatera cf. *P. kabulense* (Patnaik, in press) is included here in *Abudhabia* cf.

A. kabulense. Gerbillid dental terminology proposed by Tong (1986) is followed herein.

TATERA LATASTE, 1882
Tatera pinjoricus sp. nov.
(fig. 7c, plate 3 p & q)

Holotype: GII1 (left maxilla with M^{1-3}).

Referred material: GII2 (left maxilla with M^{1-3}), GII3 (right M^1), GII4 (left M^1), GII5 (left M^1), GII6 (right M^1), GII7 (left M^2), GII8 (left M^3), GII9 (left mandible with M_{1-2}), GII10 (right mandible with M_{2-3}).

Stratigraphic and geographic range: Pinjor Formation, Panchkula (Haryana).

Age: Late Pliocene (around 2 m.y.).

Locality: Ghaggar River Section.

Measurements: See table 3.

Etymology: For its occurrence in Pinjor Formation.

Diagnosis: M^1 with relatively narrow anterocone, joined longitudinally to protocone through an anterolophule; upper molars with alternately arranged labial and lingual cusps and prominent posterior cingulum on M^1, M^2.

Description

M^1 has an anterocone somewhat triangular in shape with fused labial and lingual cusps. Protocone and paracone joined transversely by a moderately strong connection in unworn teeth. Anterocone has a permanent longitudinal connection with the protocone but it becomes evident only after a little wear. Second lobe is significantly wider than the first. On the third lobe hypocone and metacone are joined together transversely. A distinct posterior cingulum (posterior sinus) is present. M^1 has four roots.

M^2 has two lobes. The anterior lobe comprises strongly joined protocone and paracone. Metacone and hypocone are weakly connected in unworn molars. A posterior cingulum is present. M^2 has three roots.

M^3 has a large anterior lobe and a small posterior lobe. They are longitudinally connected in highly worn molars. M^3 has two roots.

The present M_1 is a highly worn specimen and shows strong connection between labial and lingual cusps of prelobe, protoconid and metaconid, hypoconid and entoconid. It has got four roots.

M_2 also shows strongly joined protoconid and metaconid, hypoconid and entoconid. M_2 has two roots.

M_3 has only one lobe (partly broken) and one root.

Comparisons

Tatera indica (extant Indian gerbillid), the only species to have been included in the subgenus *Tatera* (Pavilove, 1990), exhibits a permanent longitudinal connection between anterocone and the second lobe on M^1. *Tatera pinjoricus* sp. nov. resembles most closely to *Tatera indica* in having a permanent longitudinal connection between the anterocone and the second lobe; that between protocone and metacone on unworn M^1's, and multiple roots on upper and lower molars (four each on $M^1$and M_1, three on M^2, two each on M^3 and M_2 and one on M_3). The former differ from the latter in having a narrower anterocone and the anterocone- second lobe connection is lingual with the protocone and not at the centre of the second lobe. As compared to *T. pinjoricus* sp. nov. all the fossil forms of *Tatera* reported from Africa show well laminated lobes on upper molars and lack longitudinal connection between the lobes, they are norrower and have more gap between various inclined lobes and have anterocones on M^1 showing tendency towards division into two cusps. The African *Tatera* shows great variation in form and size of the molars and it is hard to distinguish them solely on the basis of molar morphology (Denys, 1989).

Tatera pinjoricus sp. nov. resemble *Taterillus* (extant taxa widespread in Africa see Genest and Petter, 1973) in having highly alternate labial and lingual cusps on upper molars and posterior cingulum on M^1 and M^2. However, *Taterillus* molars are slightly smaller in size and have a narrower anterocone on M^1. A rather small sized taxa *Gerbillus* also resembles *T.pinjoricus* sp. nov. in morphological characters mentioned above for *Taterillus* and *T. pinjoricus* sp. nov.

T. pinjoricus sp. nov. shares many characters with the extinct form *Abudhabia kabulense,* like presence of an anterocone-protocone connection, alternate lingual and labial cusps, a connection (slightly lingual) between second and third lobe and a prominent posterior cingulum on M^1. The latter differs from the former in having weakly connected cusps on unworn molars; M^1 with a narrower anterocone; labial cusp on prelobe is reduced and weakly joined anteriorly to the lingual cusp and a prominent (isolated in unworn tooth) posterior cingulum on M_1; M_2 with a faint labial cusp on the prelobe and a trace of posterior cingulum; three roots on M^1 and two on M_1.

Cf. ***Tatera***

Referred material: N19 (left M^2).

Stratigraphic and geographic range: Pinjor Formation, Nadah Village (Haryana).

Age: Late Pliocene (around 1.8-2 m.y.).

Locality: Nadah.

Measurements: See table 3.

Description

The present M^2 has a strongly joined protocone and paracone. Metacone and hypocone are also strongly joined. A faint posterior cingulum is present. M^2 has three roots.

Comparisons

In all its characters the present specimen strongly resembles that of *Tatera pinjoricus* sp. nov.

ABUDHABIA BRUIJN and WHYBROW, 1994

Protatera kabulense SEN, 1983
Abudhabia kabulense BRUIJN and WHYBROW, 1994
Protatera cf. ***P. kabulense*** PATNAIK, in press
Abudhabia cf. ***A. kabulense***
(Plate 3 n & o)

Referred material: MI10 (left M^2), K21 (right M_2).

Stratigraphic and geographic range: Tatrot Formation, Moginand and Kanthro Villages (Himachal Pradesh).

Age: Early to Late Pliocene (around 3.5-4.5 m.y. to 2.5 m.y.).

Locality: Moginand and Kanthro.

Measurements: See table 3.

Description

M^2 has transversely joined alternate lingual and labial cusps and a prominent posterior cingulum. M^2 has two roots.

M_2 has alternate labial and lingual cusps, a small labial cusp of prelobe attachad to the protoconid at its base, a small round posterior cingulum and two roots.

Comparisons: In all their characters the present M^2 and M_2 resemble most closely to those of *Abudhabia kabulense* (see Sen, 1983).

DISCUSSION AND CONCLUSIONS

A preliminary analysis based on morphological similarities to deduce relationships among Pliocene Siwalik murids and gerbillids, and to some extent, to closely resembling Miocene, Pleistocene and extant forms of Indian subcontinent and Africa is presented here. Only well represented (both taxonomically and numerically) taxa have been considered. Primitive and derived dental characters of murids proposed by Misonne (1969), Jacobs (1978) and Musser (1981) are followed.

Apart from cf. *Mus* (Patnaik, in press) all the other Pliocene and Pleistocene *Mus* of Indian subcontinent are attributable to the *Mus booduga* group of Misonne (1969). See Patnaik *et al.* (1993) for details. M^1 of cf. *Mus* is moderately elongated and bears a relatively less posteriorly placed, anterolingually and posterolabially compressed t1.

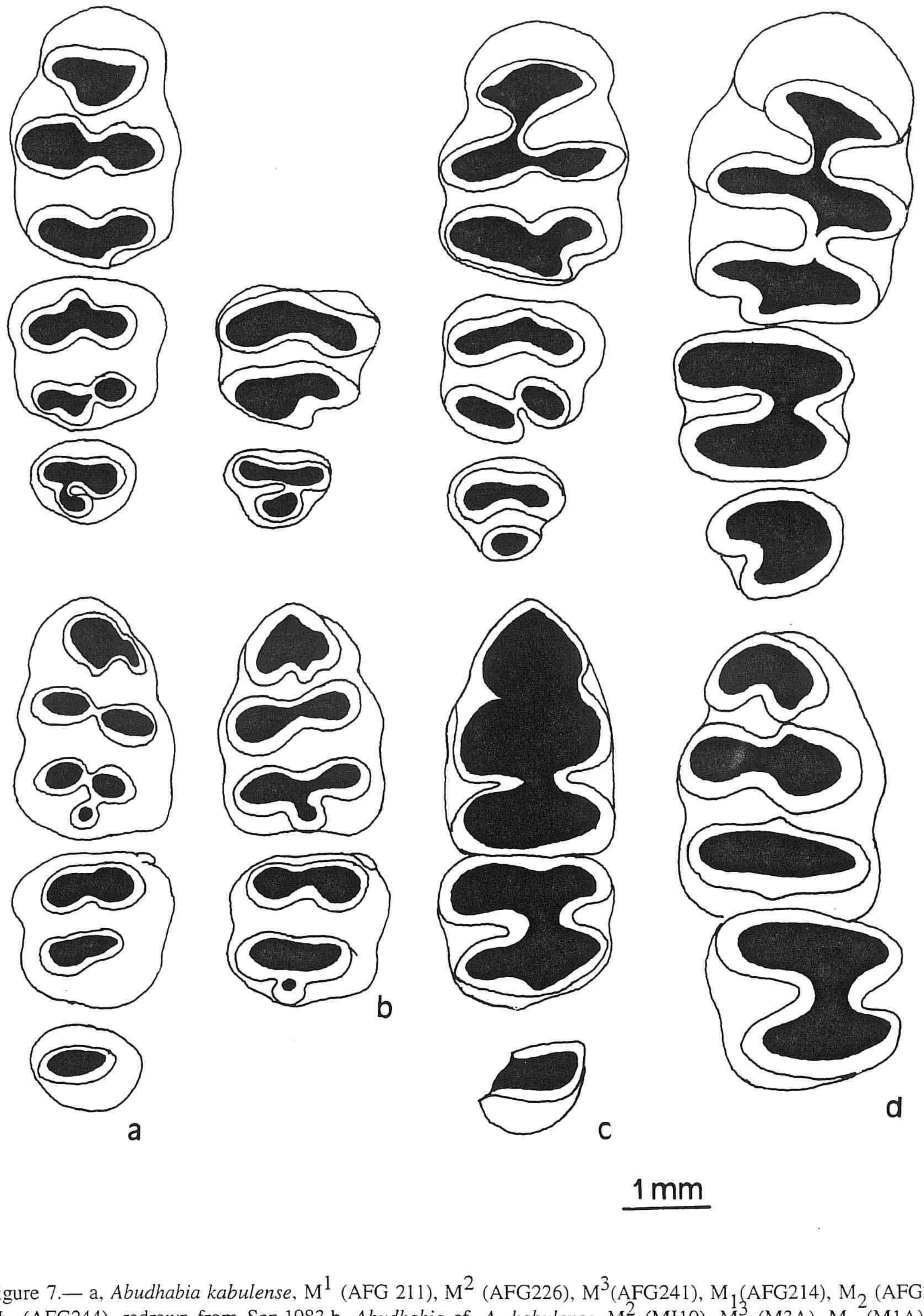


Figure 7.— a, *Abudhabia kabulense*, M^1 (AFG 211), M^2 (AFG226), M^3(AFG241), M_1(AFG214), M_2 (AFG236), M_3 (AFG244), redrawn from Sen,1983.b, *Abudhabia* cf. *A. kabulense*, M^2 (MI10), M^3 (M3A), M_1 (M1A), M_2 (K21). *Tatera pinjoricus* sp. nov., M^1 (GII5), M^2 (GII2), M^3 (GII8), M_1 M_2 (GII9), M_3 (GII10). d, Upper and lower molars of *Tatera indica* (extant taxon).

These characters places cf. *Mus* close to *Mus pahari* group (Misonne, 1969). It has been shown (Patnaik in press) that presence of an anteriorly placed, non compressed t1 makes cf. *Mus* closer to a *Karnimata* lineage rather than to a *Progonomys-Mus* auctor lineage of Jacobs (1978). *Mus* sp. described herein has a very weakly connected t1 and t2 on M^1 and at the moment cannot be linked to any fossil form of *Mus*. Though *Mus linnaeusi* sp. nov. resembles *Mus musculus*, it also shares several of its features with other species of the subgenus *Mus*. Since features like moderately deep and short rostrum, orthodont upper incisors, and moderately high zygomatic plates with straight anterior margins occur both in *Mus linnaeusi* and in most of the species and subspecies of the subgenus *Mus*, they may be considered as being generalised ones. On the other hand a shallow and long rostrum, proodont or highly opisthodont upper incisors and modification of zygomatic plate may be taken as derivations. Keeping this in mind species of the subgenus *Mus* have been arranged tentatively into four groups according to their closeness to *Mus linnaeusi* (fig. 5). However, as mentioned before, a rather short incisive foramina, wide interpterygoid region and ? tightly attached squamosal bone and auditory bullae makes *Mus linnaeusi* sp. nov. primitive to the extant species of the subgenus *Mus*.

It was first proposed by Sabatier (1982) that *Golunda* migrated to the Indian subcontinent from Africa sometime in Late Pliocene. An idea Jacobs (1978) advocated. This view was supported by Wesselman (1984), who described *G. gurai* from Pliocene sediments of Omo, Ethiopia. Patnaik (in press) also supported the above view. Brandy *et al.*, (1980) were of the opinion that *Parapelomys charkhensis* is ? ancestor to *G. kelleri* (an interpretation solely based on the lower molars). In a comprehensive account Musser (1987) demonstrated that *gurai* is significantly different from *Golunda ellioti* and this led him to propose that *Golunda* is endemic to the Indian subcontinent and suggested that *gurai* should be removed from the genus *Golunda*.

Among *Golunda tatroticus* sp. nov., *G. kelleri*, *G.* sp. and *G. ellioti*, *G. tatroticus* sp. nov. having a M^1 with t1 and t4 placed anteriorly relative to t4 and t6, t1 less inclined posteriorly and wider M^3 with less inclined cusps, seems to be the most primitive form. These characters also makes it closest to *Parapelomys robertsi*. *G. tatroticus* sp. nov. may have evolved from *P. robertsi* probably through an intermediate form lacking posterior cingula on M^1 and M^2, t6 on M^3 and retaining a large t9 on M^1 and M^3, large labial anteroconid on M_1 and M_2. *Golunda kelleri* having a ridge-like t9 on M^3 appears to be more derived than *G. tatroticus* sp. nov. Jacobs (1978) diagnosed *G. kelleri* as having a M_3 with a hypoconid (entoconid in the present work) slightly labial relative to metaconid and he considered this as a derivation. Here it is considered as a generalisation since it occurs in *G. tatroticus*, *G. gurai*, *Parapelomys charkhensis* and *Saidomys afghanensis*.

High stretching of upper molars along an anterolingual direction and a placement of entoconid on M_3 on the lingual side is diagnostic of *G. ellioti*. If it is assumed that the deformation took place in an anterolingual (or both in anterior and lingual directions) direction on the molars of *G. tatroticus* sp. nov. (fig. 7) effecting both the lingual and labial cusps, highly specialised molars of *G. ellioti* are derivable through *G. kelleri* and *G.* sp.

Relationship of *G. gurai* (Sabatier, 1982) with Siwalik *G. tatroticus, G. kelleri.*

G. sp. and extant Indian bush rat *G. ellioti* is enigmatic. Presence of a large labially situated t9 on M^1 and M^3 makes it primitive to the asiatic species, at the same time larger size difference between the upper molars, a narrow M^3, longer incisive foramina and a palatal bridge posteriorly placed in relation to M^3 makes it more derived even to *G. ellioti*. Observations made here (see table 4) suggest that the Early Pliocene Siwalik

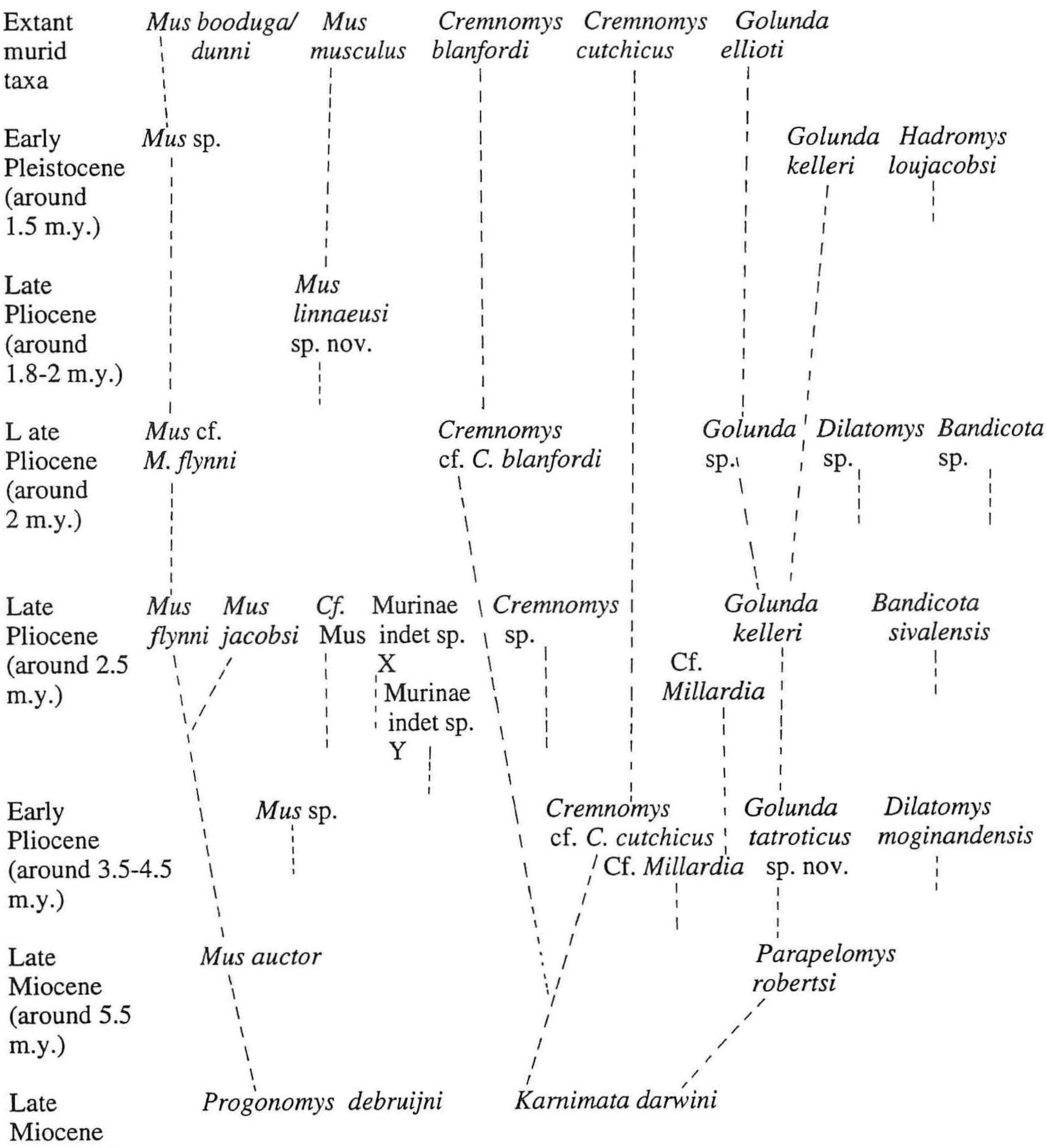


Figure 8.— Tentative placement of the present murids among the related Late Miocene to Early Pleistocene Siwalik and extant murids of the Indian subcontinent.

form *G. tatroticus* sp. nov. and *G. gurai* share many characters and differ in few. The major difference observed is in size and position of t9 on M^1 and M^3 and an overall shape of M^3. At the present moment the author is not sure that whether the differences are diagnostic enough to place *gurai* in a separate genus or not. Furthermore, *gurai* also shows affinity towards *Parapelomys charkhensis* reported from Early Pliocene of Afghanistan (Sen, 1983). The characters they share are a large labially placed t9 on M^1 and M^3. Additional material particularly from Early Pliocene of Ethiopia, Afghanistan and Indo-Pakistan may provide a better picture.

Cremnomys cf. *C. cutchicus* (Patnaik, in press), *C.* cf. *C. blanfordi* and *Cremnomys* sp. show affinity towards a *Karnimata* lineage of Jacobs (1978). *Cremnomys* cf. *C. cutchicus* resembles closely to the Miocene Siwalik form *Karnimata darwini* (JACOBS, 1978) in general shape of molars; in having a M^1 with a small anteriorly placed t3, t1 round and moderately posterior in position relative to t2 and a posterior cingulum; M^2 with a t3, broadly joined t4, t5 and t6; M^3 with the last cheveron joined to t6 of the central cheveron. However, *Karnimata darwini* shows some obvious primitive characters, like presence of a more cuspidate M^1 with t4 rather anteriorly placed, a prominent posterior cingulum, a large t9 and three roots; M^3 with a t3 in addition to other cusps.

An attempt has been made here (fig. 8) to place the present murids in a generalised phylogeny of the Pliocene Siwalik muridae (modified from Patnaik, in press). All the species of *Mus* are grouped together except for cf. *Mus* and *Mus* sp. (Early Pliocene) and they show affinity towards the Miocene *Mus auctor-Progonomys* lineage. *Golunda* has been linked to the *Parapelomys* lineage. *Cremnomys* cf. *C. cutchicus, C.* cf. *C. blanfordi, Cremnomys* sp., cf. *Millardia*, murinae indet. sp. X and Y have been grouped together which in turn shows affinity towards the *Karnimata* lineage. *Dilatomys moginandensis, D.* sp., *Hadromys loujacobsi* (from Musser, 1987), *Bandicota sivalensis* and *B.* sp. are placed in one category owing to their large, hypsodont molars. This group shows affinity towards a *Parapelomys-Saidomys* group in having similar cusp patterns, but no direct relationship can be demonstrated at the moment.

Recently, Bruijn and Whybrow (1994) have shown that *Abudhabia baynunensis* exhibits dental characters intermediate between Myocricetodontinae and the Gerbillinae. They have also suggested an ancestor-descendant relationship between *A. baynunensis* and *A. kabulense. A. baynunensis* is primitive to *A. kabulense* in having a distinct posterior cingulum (posterocentral cusp) on M^1 and M_1, a well developed labial cusp of anterocone and prelobe on M^2 and M_2 respectively (see Bruijn and Whybrow, 1994). The author is of the opinion that *A. baynunensis* differs considerably from *A. kabulense* in lacking a longitudinal connection between the transverse lobes of upper molars, in having a small posterior lobe on M_3 (formed by the fusion of hypoconid and entoconid) in one of the specimens. An ancestor to *A. kabulense* should possess an anterocone-protocone connection with alternately arranged labial and lingual cusps. However, a phylogenetic origin of *A. kabulense* would be clearer once the detail description of the so called *Protatera* from Late Miocene Siwaliks is available.

A comparison of *A. kabulense*, *A.* cf. *A. kabulense*, *Tatera pinjoricus* sp. nov. and *T. indica* reveals close relationship among them. As we move from *A. kabulense* to

T. pinjoricus sp. nov. through *A.* cf. *A. kabulense* a tendency towards increase in transeverse width of anterocone and posterior lobe on M^1, a reduction of cusps of anterocone on M^2 and prelobe on M_2, loss of posterior cingulum on M_2, significant reduction of posterior cingulum on M_1 and an increase in number of roots on M^1, M^2 and M_1 can be observed. A change in overall size of molars, increase in size of anterocone, shift in the position of the longitudinal connection between anterocone and the second lobe and alignment of labial and lingual cusps to form more laminated lobes can be seen when we move from *T. pinjoricus* sp. nov. to *T. indica* (fig. 7).

ACKNOWLEDGEMENTS

I would like to extend my gratitude to Prof. J.-J. JAEGER for providing all the necessary laboratory facilities at the Institute des Sciences de l' Evolution, guidance and useful suggestions on the manuscript. I am grateful to Prof. A. SAHNI for his constant encouragement and help for the present work at the CAS in Geology, Chandigarh. Dr. S. SEN kindly shared his pertinent literature, knowledge and comparative material for the present study. Prof. T. SHARMA, M. BAHADUR, Dr. J-C. AUFFRAY and the Paris Museum of Natural History provided recent mouse skulls. I thank Drs. H. CAPPETTA, J. MICHAUX, J. SUDRE, F. CATZEFLIS, B. MARANDAT, B. MOULOUD and N. ABDELMAJID for their help in various ways. Dr. L. DATAS and M. PONS helped in SEM microphotography.

Financial support by DST (New Delhi) and CIES (Paris) is thankfully acknowledged.

REFERENCES

AZZAROLI, A. & NAPOLEONE, G., 1982.— Magnetostratigraphic investigations of the Upper Siwaliks near Pinjor, India. *Riv. Ital. Paleont.*, 87 (4): 739-762.

BARRY, J.C. & FLYNN, L.J. 1990.— Key biostratigraphic events in the Siwalik sequence, in LINDSAY, E.H., FAHLBUSCH, V. & MEIN, P. eds. European Neogene Mammal Biochronology, Plenum Press. New York.

BRANDY, L-D., SABATIER, M. & JAEGER, J.J., 1980.— Implications phylogenetiques et biogeographiques des derniéres découvertes de Muridae en Afghanistan, au Pakistan et en Ethiopie. *Geobios*, 13 (4): 639-643.

BRUIJN, H.D. & WHYBROW, P.J., 1994.— A Late Miocene rodent fauna from the Baynunah Formation, Emirates of Abu Dhabi, United Arab Emirates. *Proc. Kon. Ned. Akad. v. Wetensch.*, 97 (4): 407-422.

DENYS, C., 1989.— Two new Gerbillids (Rodentia, Mammalia) from Olduvai Bed I (Pleistocene, Tanzania). *N. Jb. Geol. Palaont. Abh.*, 178 (2): 243-265.

DENYS, C., 1987.— Rodentia and Lagomorpha. 6.1: Fossil rodents (other than Pedetidae) from Laetoli. (In: M.D. LEAKEY & HARRIS, J.M. (eds.): Laetoli a Pliocene site in Tanzania. Oxford Univ. Press, London. 118-170.

GERASSIMOV, S.N.H., MIHAILOVA, V., AUFFRAY, J.C. & BONHOMME, F., 1990.— Morphometric stepwise discriminant analysis of the five genetically determined European taxa of the genus *Mus. Biol. J. Linn. Soc.*, 41 (1-3): 47-64.

GENEST, H. & PETTER, F., 1973.— Les *Taterillus* de République Centrafricaine (Rongeurs, Gerbillidés). *Mammalia*, 37: 66-75.

JACOBS, L.L. 1978.— Fossil rodents (Rhizomyidae and Muridae) from Neogene Siwalik deposits, Pakistan. *Mus. Nor. Ariz. Press Flag. Bull.*, Ser. 52: 1-103.

JACOBS, .L.L., FLYNN, L.J., DOWNS, W.R. & BARRY, J.C., 1990.— Quo Vadis *Antemus* ? The Siwalik murid record. in LINDSAY, E.H., FAHLBUSCH,V. & MEIN, P., eds., European Neogene Mammal Biochronology, New York Plenum Press, New York.

KOTLIA, B.S. 1992.— Pliocene murids (Rodentia, Mammalia) from Kashmir Basin, northwestern India. *N. JB. Geol. Palaeont.*, 184 (34): 339-357.

KUMAR, R. & TANDON, S.K., 1985.— Sedimentology of Plio-Pleistocene late orogenic deposits associated with interplate subduction- The Upper Siwalik Subgroup of a part of Panjab sub-Himalaya, India. *Sedimentary Geology*, 42: 105-158.

MARSHALL, J.T. Jr. 1977.— A Synopsis of Asian species of Mus (Rodentia, Muridae). *Bull. Am. Mus. Nat. Hist.*, 158 (3): 173-220.

MEHTA, Y.P., THAKUR, A.K., LAL, N., SHUKLA, B. & TANDON, S.K., 1993.— Fisson track age of zircon separates of tuffaceous mudstones of the Upper Siwalik subgroup of Jammu-Chandigarh section of the Panjab Himalaya. *Curr. Sci.*, 64 (7): 519-521.

MILLER, G.S., 1912.— Catalogue of the mammals of Western Europe (Europe exclusive of Russia) in the collection of the British Museum London. British Museum Natural History.

MISONNE, X., 1969.— African and Indo-Australian Muridae. Evolutionary trends. *Mus. Roy. d' Afrique Cent.*, Tervuren, Zool., 172: 1-219.

MUSSER, G.G., 1981.— Results of the Archbold Expedition No. 105. Notes on systematics of Indo-Malayan murid rodents and descriptions of new genera and species from Ceylon, Sulawesi, and the Philipines. *Bull. Am. Mus. Nat. Hist.*, 168 (3): 225-334.

MUSSER, G.G. & NEWCOMB, B.C., 1983.— Malaysian Murids and the giant rat of Sumatra. *Bull. Am. Mus. Nat. Hist.*, 174 (4): 327-598.

MUSSER, G.G., 1987.— The occurrence of Hadromys (Rodentia: Muridae) in Early Pleistocene Siwalik strata in Northern Pakistan and its bearing on biogeographic affinities between India and northeastern African murine faunas. *Amer. Mus. Nov.* 2883: 1-36.

MUSSER, G.G. & HEANEY, L.R. 1992.— Philippine Rodents: Definitions of Tarsomys and Limnomys plus a preliminary assesment of phylogenetic patterns among native philippine murines (Murinae, Muridae). *Amer. Mus. Nat. Hist.*, 211: 1-138.

OPDYKE, N.D., LINDSAY, E.H., JOHNSON, G.D., TAHIRKHELI, R.A.K. & MIRZA, M.A. 1979.— Magnetic polarity stratigraphy and vertebrate palaeontology of the Upper Siwalik subgroup of northern Pakistan. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 27: 1-34.

PATNAIK, R., 1991.— Micropalaeontology, biostratigraphy and palaeoenvironmental analysis of the Siwalik sequences in the Saketi-Nahan area (Himachal Pradesh). Unpub. Ph.D thesis. Panjab University, Chandigarh, p. 1-158.

PATNAIK, R.— Late Pliocene micromammals from Tatrot Formation (Upper Siwaliks) exposed near Village Saketi, Himachal Pradesh, India. *Palaeontographica* (in press).

PATNAIK, R., 1995.— Micromammal-based palaeoenvironment of Upper Siwaliks exposed near Village Saketi, H.P. *Jour. Geol. Soc. India*, 46: 429-437.

PATNAIK, R., BAHADUR, M., SHARMA, T. & SAHNI, A., 1993.— A comparative analysis of Mus booduga, Mus dunni and fossil Mus of Indian subcontinent: phylogenetic and palaeobiogeographic implications. *Curr. Sci.*, 65 (10): 782-786.

PATNAIK, R., BADAM, G.L. & SATHE, V., 1995.— Discovery of microvertebrates from Pleistocene deposits of the Central Narmada Valley India. *Curr. Sci.*, 68 (8): 828-830.

RANGA RAO, A., AGARWAL, R.P., SHARMA, U.N., BHALLA, M.S. & NANDA, A.C., 1988.— Magnetic polarity stratigraphy and vertebrate palaeontology of the Upper Siwalik subgroup of Jammu Hills, India. *Jour. Geol. Soc. India*, 31 (4): 361-385.

SABATIER, M., 1982.— Les Rongeurs et du site Pliocene a Homonides de Hadar (Ethiopia). *Palaeovertebrata*, 12 (1): 1-56.

SEN, S., 1983.— Rongeurs et Lagomorphs du gisement Pliocene de Pul-e Charkhi, bassin de Kabul, Afghanistan. *Bull. Mus. nat. Hist. nat. Paris*, 5e Ser., 1: 33-74.

SEN, S., BRUNET, M. & HEINTZ, E., 1979.— Découverte de Rongeurs africans dans le Pliocène d' Afghanistan (bassin de Sarobi). Implications paléobiogéographiques et stratigraphique. *Bull. Mus. Nat. Hist. nat. Paris*, 4 e Sér., 1, sect. c, (1): 65-75.

TANDON, S.K. & KUMAR, R., 1984.— Discovery of tuffeceous mudstones in the Pinjor Formation of Panjab sub-Himalaya, India. *Curr. Sci.*, 53 (18): 982-984.

TONG, H., 1986.— Origine et evolution des gerbillidae (Mammalia, rodentia) en Afrique du Nord. These Doc. Univ. Paris, VI,

VISSER, C.F. & JOHNSON, G.D., 1978.— Tectonic control of the Late Pliocene Molasse sedimentation in a portion of the Jhelum re-entrant, Pakistan. *Geol. Rund.*, 67: 15-37.

WEERD, A. V. D., 1976.— Rodent faunas of the Mio-Pliocene continental sediments of the Teruel-Alhambra, region. Spain. Utrecht Micropalaeo. *Bull. sp. Publ.*, 2: 1-218.

WAHLERT, J.H., 1985.— Cranial foramina of rodents. In W.P. LUCKETT & J.L. HARTENBERGER (eds.) Evolutionary relationships among rodents, a multidisciplinary analysis. New York and London Plenum Press, p. 311-332.

WESSELMAN, H.B., 1984.— The Omo micromammals. Sytematics and palaeoecology of Early Man sites from Ethiopia. *Cont. Vert. Evol.*, 7: 1-219.

EXPLANATIONS OF PLATES

PLATE 1

Mus linnaeusi sp. nov. (VPL/RP-GI1).a, b & d, dorsal, ventral and lateral views of the cranium;c, occlusal view of the left upper molars; e,g & h, occlusal, lingual and labial views of the right lower mandible; f, occlusal view of the lower molars. 1 mm bar if for figures c & f.

PLATE 2

Golunda tatroticus sp. nov. a, left M^1 (MI1); b, right M^2 (MI2); c, left M^3 (MI4); d, left M_3 (MI3). *Golunda kelleri*, e, right M^1 (SM50);f, right M^2 (K3); g, right M^3 (K6); h, left M_1 (K7); i, left M_2 (SM 56); j, left M_3 (K9). *Golunda* sp., k, right M^1 (N4). *Dilatomys* sp., l, left M^1 (N15).

PLATE 3

Cremnomys cf. *C. blanfordi*, a, right M^{1-3} (N8, N10, N13); *Cremnomys* sp., b, left M^1 (SM6); c, right M^2 (SM59); d, left M^3 (K11); e, right M_1 (K12); f, left M_3 (K14). *Bandicota* sp. g, right M^2 (N16); h, left M_3 (N17). Murinae indet sp. X, i, left M^1 (MI 9); j, left M^1 (K13). Murinae indet sp. Y, k, left M_1 (SM 69); l, right M^2 (K20); m, left M_1 (SM 66). *Abudhabia* cf. *A. kabulense*, n, left M^2 (MI10); o, left M_2 (K21). *Tatera pinjoricus* sp. nov., p, left M^{1-3} (GII 1); q, left M_{1-2} (GII 6).

Taxa	Localités			
	Moginand	Kanthro	Nadah	Ghaggar
RODENTIA				
Muridae				
1. *Mus linnaeusi* sp. nov.	-	-	-	+
2. *Mus flynni*	-	+	-	-
3. *Mus jacobsi*	-	+	-	-
4. *Mus* cf. *M. flynni*	-	-	+	-
5. *Mus* sp.	+	-	-	-
6. Cf. *Mus*	-	+	-	-
7. *Golunda tatroticus* nov.	+	-	-	-
8. *Golunda kelleri*	-	+	-	-
9. *Golunda* sp.	-	-	+	-
10. *Parapelomys robertsi*	-	+	-	-
11. *Cremnomys* cf. *C.cutchicus*	+	-	-	-
12. *Cremnomys* cf. *C. blanfordi*	-	-	+	-
13. *Cremnomys* sp.	-	+	-	-
14. Cf. *Millardia*	+	+	-	-
15. *Dilatomys moginandensis*	+	-	-	-
16. *Dilatomys* sp.	-	-	+	-
17. *Bandicota sivalensis*	-	+	-	-
18. *Bandicota* sp.	-	-	+	-
19. Murinae indet sp. A.	-	+	-	-
20. Murinae indet sp. B.	-	+	-	-
21. Murinae indet sp. X.	+	+	-	-
22. Murinae indet sp. Y.	+	+	-	-
Gerbillidae				
23. *Tatera pinjoricus* sp. nov.	-	-	-	+
24. Cf. *Tatera*	-	-	+	-
25. *Abudhabia* cf. *A. kabulense*	+	+	-	-
Rhizomydae				
26. *Rhizomyides* sp.	-	+	-	-
27. Cf. *Brachyrhizomys*	-	+	-	-
INSECTIVORA				
Soricidae				
26. *Crocidura* sp.	+	+	+	-
27. *Suncus* cf. *S. murinus*	-	+	-	-
28. Soricidae indet.	-	+	-	-
LAGOMORPHA				
Leporidae				
29. *Pliosiwalagus whitei*	+	+	-	-

Table 1.— List of micromammals from Siwalik sequences exposed near Chandigarh and Nahan.

Points of measurements	Cranial elements measured	measurements in mm
A (1-15)	Total skull length	approx. 21.502
B (2-19)	Condylobasal length	20.119
B (2-18)	Basl length	18.392
A (1-4)	Length of os nasale	6.705
B (6-19)	distance between foramen infraorbitale and condylus occipitale	16.480
B (4-7)	Diastema	4.841
B (7-10)	Length of maxillar teeth row (alveolare)	3.520
A (1-9)	Length of rostrum	approx. 5.734
A (2-2')	Breadth of rostrum	5.240
A (3-3')	Distance between foramen infraorbitales	4.676
A (7-7')	Postorbital breadth	3.962
B (17-17')	Mastoid breadth	9.915
B (15-16)	Bullae osseae breadth	3.682
B (13-14)	Bullae osseae length	3.659
B (22-22')	Palatine durum breadth	3.606
C (1-4)	Height of the skull through bullae osseae	7.443
C (4-13)	Height of the skull between bullae osseae	7.02
C (5-10)	Height of the face part of the skull	6.817
F (10-11)	M^1 length	1.918
F (16-17)	M^1 breadth	1.050
F (12-13)	M^2 length	.928
F (18-19)	M^2 breadth	1.028
F (14-15)	M^3 length	.705
F (20-21)	M^3 breadth	.626
F (10-15)	Length of maxillar teeth row (coronare)	3.483
C (11-12)	Meatus auditorius externus length	2.047
C (2-3)	Meatus auditorius externus breadth	1.872
B (5-8)	Anterior palatine foramen length	4.608
B (3-3')	Distance between alveoli incisivi lateralis	2.776
B (9-9')	Distance between posterior palatal fissures	1.580
B (12-12')	Distance between foramen ovale	3.976

Table 2.— Cranial measurements of *Mus linnaeusi* sp. nov.

Points of measurements	Cranial elements measured	measurements in mm
B (15-21)	Distance between bullae osseae lateralis	10.460
B (23-23')	Breadth of incisive foramina	2.220
B (24-24')	Breadth of pterygoid fossa	1.134
B (25-25')	Breadth of bony plate at first molar	2.512
B (26-26')	Breadth of bony plate at third molar	3.408
B (27-27')	Length of bony plate	4.309
B (4-11)	Palatine durum length	10.313
B (11-18)	Distance between palatine durum posterior and foramen occipitalis	7.946
C (7-8)	Width of zygomatic arch (upper part)	approx. .437
C (6-9)	Width of mallax process (anterior part)	.862
C (17-18)	Incisor depth	1.872
C (8-14)	Zygomatic notch depth	1.360
C (15-16)	Width of zygomatic plate	2.248
D (1-2)	Breadth of incisor	.671
A (6-9)	Anterior-posterior diameter of foramen postorbitale	5.720
A (4-11)	Sutura frontalis length	5.202
A (8-8')	Distance between suture coronare lateralis	approx. 4.842
E (7-11)	Total mandible length	approx. 13.011
E (1-11)	Mandible alveoli teeth row length	3.630
E (6-10)	Mandible height I	4.763
E (5-10)	Mandible height II	approx. 4.784
E (4-8)	Distance between proc. coronoideus and proc. condyloideus	approx. 3.026
G (22-23)	M_1 length	1.556
G (28-29)	M_1 breadth	.886
G (24-25)	M_2 length	1.023
G (30-31)	M_2 breadth	.830
G (26-27)	M_3 length	.347
G (32-33)	M_3 breadth	.441
E (2-3)	Mandibular teeth-row length (M_1- M_3, coronare)	3.040

Table 2.— Cranial measurements of *Mus linnaeusi* sp. nov., continued.

Taxa	Specimen numbers	Element	Length	Width
Mus cf. *M. flynni*	N1	left M^2	.951	.853
	N2	right M_1	1.574	.962
	N3	right M_2	1.034	.893
Mus sp.	MI7	left M^1	1.622	-
	MI8	right M^2	1.27	.986
Golunda tatroticus sp. nov.	MI1	left M^1	2.901	2.165
	M5-A	left M^1	2.874	2.211
	MI2	right M^2	2.532	2.289
	MI3	right M^2	2.221	2.089
	MI4	left M^3	1.988	1.930
	MI5	left M_3	-	1.778
Golunda kelleri	K1	right M^1	2.726	1.845
	K2	left M^1	-	2.054
	K3	right M^2	2.581	2.322
	K4	right M^2	2.163	2.345
	K5	right M^2	2.264	2.451
	K6	right M^3	2.105	1.889
	K7	left M_1	2.760	1.914
	K8	left M_1	2.635	1.922
	K9	left M_3	1.874	1.864
	K10	left M_3	1.858	1.824
Golunda sp.	N4	right M^1	2.800	2.144
	N5	right M^1	-	2.193
	N6	right M_1	-	1.680
	N7	left M_1	-	1.588
Cremnomys cf. *C. blanfordi*	N8	left M^1	-	.532
	N9	right M^1	2.018	1.744
	N10	left M^2	1.688	1.536
	N11	left M^2	1.718	1.470
	N12	left M^2	-	1.501
	N13	left M^3	1.214	1.253
	N14	right M^3	1.230	1.230
Cremnomys sp.	SM59	right M^1	2.172	1.427
	K11	left M^2	1.425	1.461
	K12	right M^3	1.125	1.310

Table 3.— Dental measurements of the present murids and gerbillids.

Taxa	Specimen numbers	Element	Length	Width
Cremnomys sp.	K13	right M_1	2.074	1.220
	K14	left M_1	2.203	1.340
	K15	left M_3	.982	.991
Dilatomys sp.	N15	left M^1	2.830	2.429
Bandicota sp.	N16	left M^2	2.007	2.270
	N17	left M_3	1.283	1.831
	N18	right M_3	1.498	1.980
Murinae indet. sp. X	K17	right M^1	2.205	1.369
	MI9	right M^1	2.284	1.370
Murinae indet. sp. Y	SM69	right M^1	2.593	1.695
	K20	left M^2	1.895	1.694
	SM66	left M^1	2.515	1.505
Tatera pinjoricus sp. nov.	GII1	left M^1	2.87	2.053
		left M^2	1.538	-
		left M^3	1.117	1.251
	GII2	left M^1	2.866	2.201
		left M^2	1.565	1.867
		left M^3	.938	1.231
	GII3	right M^1	2.818	2.243
	GII4	left M^1	2.649	2.198
	GII5	left M^1	2.877	2.203
	GII6	right M^1	2.538	2.532
	GII7	left M^2	1.511	2.051
	GII8	left M^3	1.007	1.258
	GII9	left M_1	2.711	1.928
		left M_2	1.623	1.933
	GII10	right M_2	1.555	1.935
		right M_3	.827	-
Cf. *Tatera*	N19	left M^2	1.445	1.950
Abudhabia cf. *A. kabulense*	SMI10	left M^2	1.650	1.730
	K21	right M^2	1.530	1.886

Table 3.— Dental measurements of the present murids and gerbillids, continued.

Golunda tatroticus sp. nov.	*Golunda elliotti*	*Golunda kelleri*	*Golunda gurai*	*Parapelomys robertsi*	*Parapelomys charkhensis*	*Pelomys orientalis*	*Saidomys afghanensis*
M^1							
Wide relative to its length	wide	long	long	wide	long	long	wide
t1 less inclined	more	more	less	less	less	less	less
t1 & t4 less stretched antero-lingually	more	less	less	less	less	less	less
t1 & t4 anteriorly placed relative to t3 & t6	posteriorly	posteriorly	posteriorly	anteriorly	posteriorly	posteriorly	posteriorly
t1, t2 not connected	not	not	not	connected	connected	connected	weakly connected
t2, t3 weakly connected	not	not	not	connected	connected	connected	weakly connected
t4, t5 not connected	not	not	not	connected	connected	connected	connected
t5, t6 not connected	not	not	not	connected	connected	connected	connected
t9 small antero-labially placed relative to t8	very small posteriorly	small antero-labially	large antero-labially	large antero-labially	large antero-labially	large antero-labially	large antero-labially
posterior cingulum absent	absent	absent	absent	present	present	present	present
5 roots	5	4	4-5	3-4	4	-	4-5
M^2							
wide relative to its length	wide	wide	wide	wide	long	-	wide
t1 less inclined	more	more	more	less	less	less	less
t1, t4 not stretched	stretched	not	not	not	not	not	not
posterior cingulum absent	absent	absent	absent	present	absent	-	present
5 roots	4	-	5	4	4	-	4
M^3							
wide relative to its length	wide	wide	narrow & long	long	long	-	long
t1 less inclined	more	more	less	less	less	less	less
t4 less inclined	more	less	less	not	not	not	not

Table 4.— Comparison of *Golunda tatroticus* sp. nov. with *Golunda ellioti*, *Golunda kelleri*, *Golunda gurai* (from Sabatier, 1982), *Parapelomys robertsi* (from Jacobs, 1978), *P. charkhensis*, *P. orientalis* and *Saidomys afghanensis* (from Sen, 1983).

Golunda tatroticus sp. nov.	*Golunda elliotí*	*Golunda kelleri*	*Golunda gurai*	*Parapelomys robertsi*	*Parapelomys charkhensis*	*Pelomys orientalis*	*Saidomys afghanensis*
t1, t4 not stretched	stretched	not	not	not	not	not	not
t4, t5 connected	not	connected	connected	connected	connected	connected	connected
t6 absent	absent	absent	absent	present	present	present	present
t3 present	present	present	present	-	present	absent	present
t5 less inclined	more	less	less	not	not	not	not
t9 small, anteriorly placed relative to t8	very small anteriorly	ridgelike anteriorly	large labially	large labially	large labially	large labially	large labially
4 roots	4	-	4	-	3-4	-	3
M_1							
-	small antero-central cusp	small	small	absent	small	absent	large
-	small antero-labial cusp	small	large	large	large	large	large
-	anterior mure absent	absent	absent	absent	present	absent	absent
	4 roots	4	4	2	4	4	4
M_2							
-	small antero-labial cusp	small	large	large	small	large	large
-	postero-labial cusplet absent	absent	present	present	present	present	present
-	posterior cingulum small & round	small round	small round	large elliptical	large elliptical	large elliptical	large elliptical
-	4 roots	4	4	4	4	3	4
M_3							
-	antero-labial cusp present	absent	present	present	present	absent	present
hypoconid present	present	present	present in most of the specimens	present	present	absent	present
small entoconid at the center of the molar	small on the lingual side	small at the center	small at the center	large at the center	small at the center	large at the center	large at the center
-	3 roots	3	3	3	3	3	3

Table 4.— Comparison of *Golunda tatroticus* sp. nov. with *Golunda elliotí*, *Golunda kelleri*, *Golunda gurai* (from Sabatier, 1982), *Parapelomys robertsi* (from Jacobs, 1978), *P. charkhensis*, *P. orientalis* and *Saidomys afghanensis* (from Sen, 1983), continued.

PLATE 1

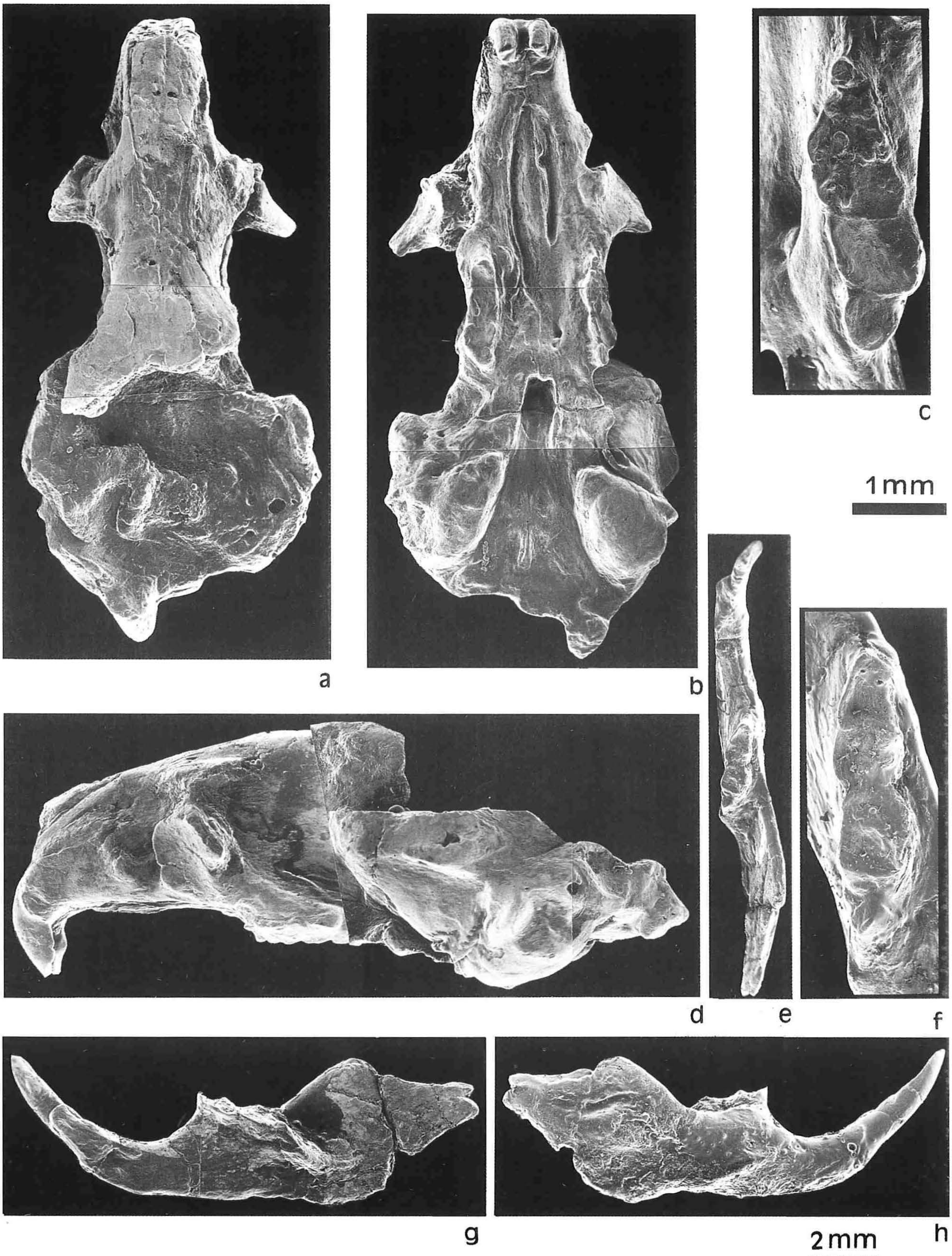
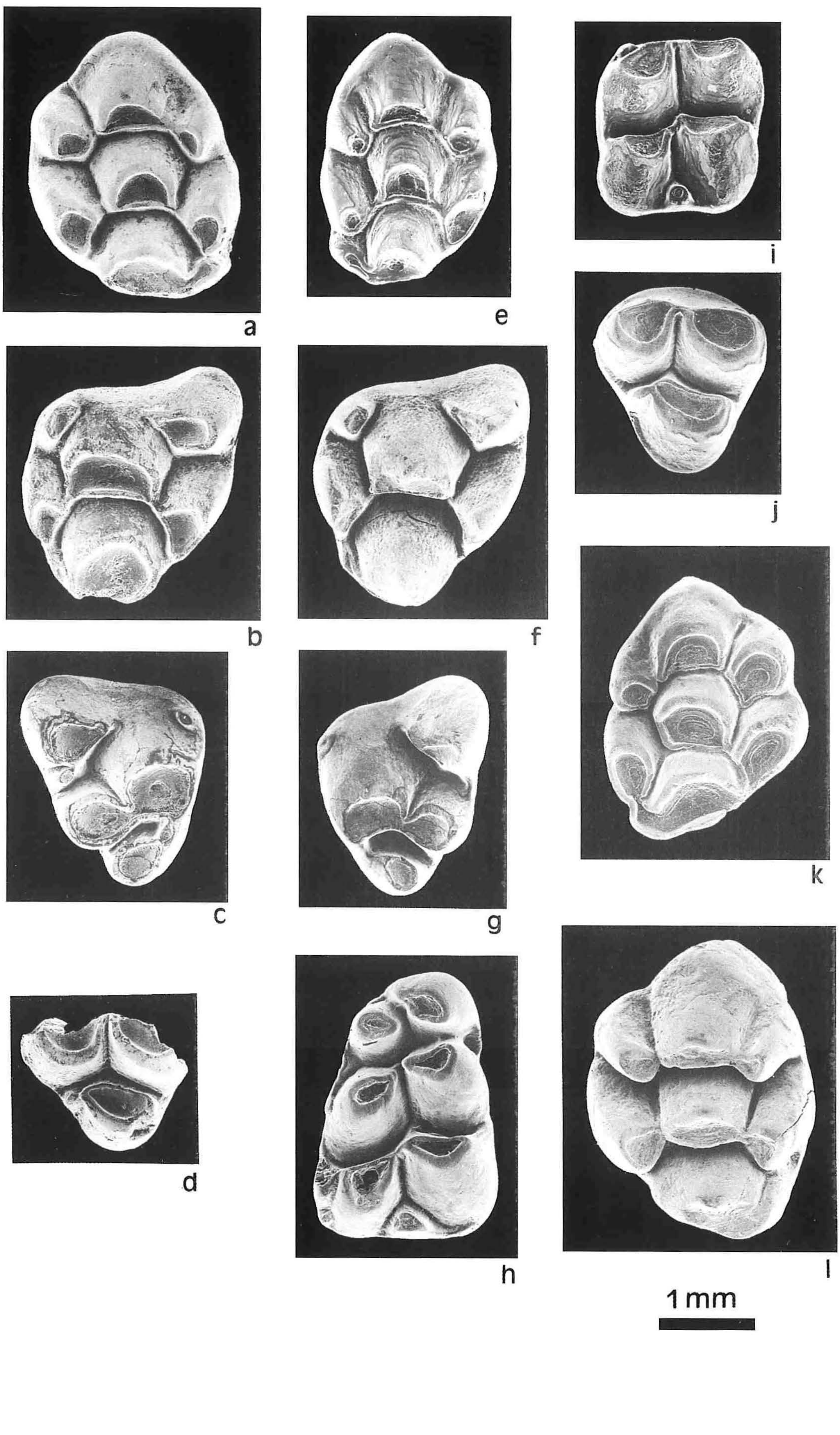
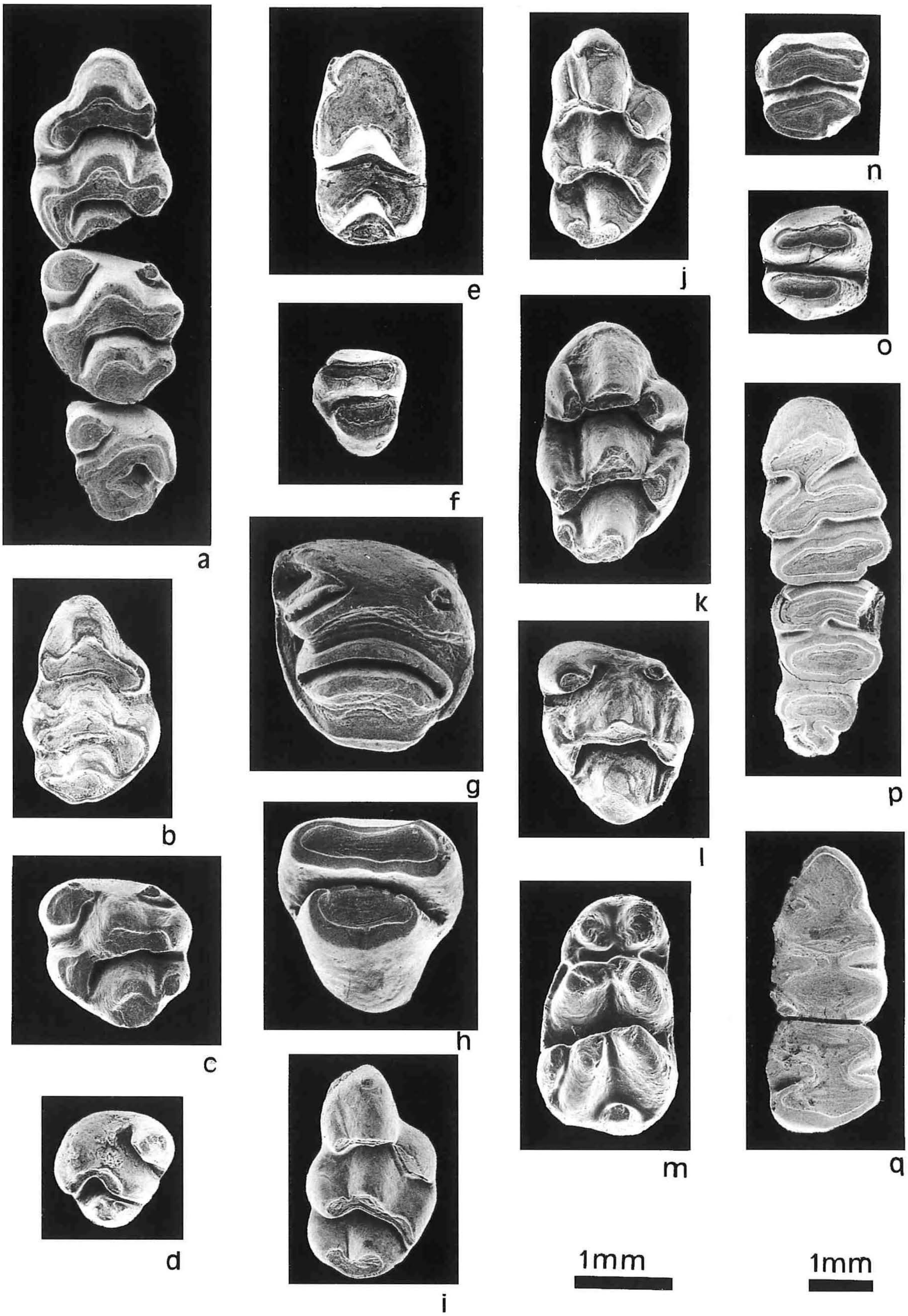


PLATE 2




a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
1mm
1mm