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First Upper Pleistocene *Mus* (Muridae, Rodentia) from the Indian subcontinent

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Abstract. The taxonomic position and phylogenetic relationships of the first Upper Pleistocene *Mus* from the Indian subcontinent are presented. The fossil material has been recovered from fluvio-lacustrine sediments at Bhimtal-Bilaspur in the Kumaun Himalaya, north India. *Mus dhailai* KOTLIA, 1995, is the first record of an essentially modern representative of this genus in the subcontinent. I suggest that *Mus dhailai* may be related to *Mus shortridgei*, now living in the subcontinent. On the basis of the radiocarbon dating of the sequence yielding the fossils, the age of the fossil horizon is estimated to about 45-52 Ka.

Keywords: Upper Pleistocene, Muridae, Kumaun Himalaya, lake sediments.

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I. INTRODUCTION

An excellent monograph on the Muridae, including Indian murids, and particularly the Recent genera, was published by MISONNE (1969). As far as the fossil Muridae of the Indian subcontinent are concerned, earlier studies or citations of a few isolated molars from the Siwaliks include those of CAUTLEY (1835) and BLACK (1972). JACOBS (1978) made a significant contribution to the study of the Siwaliks of Pakistan by describing various murid taxa. Considerable work on the Muridae of Afghanistan has been carried out by BRANDY (1981), SEN (1983) and SEN et al. (1979), while further research on Siwalik murids was carried out by GAUR (1986), MUSSER (1987), RAGHAWAN (1988), PATNAIK (1991), and PATNAIK et al. (1993). A comprehensive study of the taxonomy and phylogeny of murids from the fluvio-lacustrine deposits of the Kashmir basin was published by KOTLIA (1992).

In this paper, I present the first detailed data on Upper Pleistocene *Mus* from south-central Kumaun Himalaya. Brief mention of *Mus dhailai* has been made earlier (KOTLIA 1995). Prior to this, the only known Pleistocene *Mus* from the Indian subcontinent is from the Lower Pleistocene strata of the Pakistan Siwaliks (JACOBS 1978). However, the genus is also known from the Miocene of Pakistan (*M. auctor*; JACOBS 1978), Pliocene of Afghanistan (*M. elegans*; SEN 1983), Pliocene of the Indian Siwaliks (*M. flynni*; PATNAIK 1991) and the Pliocene of Kashmir Karewas (*M. jacobsi*; KOTLIA 1992). The oldest occurrence of *Mus* is thus from the Miocene of Pakistan (JACOBS 1978) and is more than 5 Ma old. Elsewhere in Asia, *Mus* has been described from the Pleistocene of

Japan (KOWALSKI & HASEGAWA 1976) and Thailand (GINSBURG et al. 1982). At present, *Mus* is found worldwide due to the influence of man.

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II. GEOLOGICAL SETTING, QUATERNARY SEQUENCE AND FOSSIL HORIZON

The Bhimtal-Bilaspur area (Fig. 1) in the Kumaun Himalaya (Nainital District) lies between the Himalayan Range to the north and the Ganges Plain to the south. Geologically, the area is composed mainly of metabasites, quartzites and limestones. Major thrust and fault movements

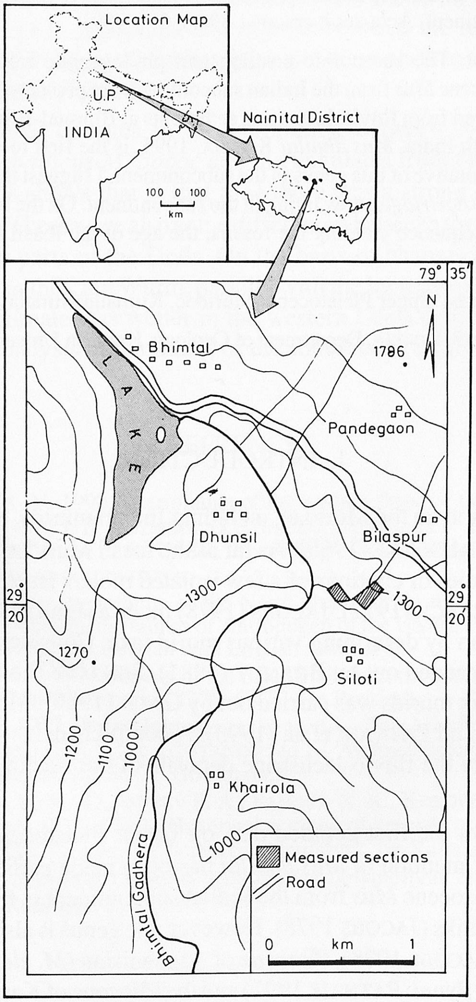

Fig. 1. Location of the study area.

followed by tectonic phenomena have led to the formation of many lakes around the Bhimtal area (VALDIYA 1988). The occurrence of lake sediments in the depressions around Bhimtal indicates that there existed a huge lake during the Quaternary Period in which fluvio-lacustrine sedimentation continued until it was drained in the uppermost Pleistocene. An uninterrupted sequence of about 52m of fluvio-lacustrine deposits is exposed at Gazar (Fig. 1), some 0.75 km southwest of Bilaspur village (Lat. 29°20' N; Long. 79°34'40" E). The sequence comprises gravels, mudstones, silty claystones and unconsolidated sandstones (Fig. 2).

A few radiocarbon dates are available in the sequence (Fig. 2). A mudstone layer within the sandstone, stratigraphically 10.4-10.5m above the base of the section, is dated to >40 000 yr (C2). A charcoal rich mudstone sample 18.0-18.1m above the base is dated to 25 600 ± 780 yr (C5). In the upper part of the section another charcoal rich mudstone sample, 40.1-40.2m above the base, is dated to 3650 ± 120 yr. On the basis of the ages of samples C5 and C8 (disregarding the deposition of colluvial gravels), the approximate sedimentation rate may be calculated as 70mm/1000 yr and the age of the basal lacustrine sediments is thus estimated at about 45-52 000 years. Palaeoclimatic data from this sequence are reported by KOTLIA et al. (in press).

The fossils are well preserved. The drawings of the specimens were made using a stereomicroscope (M-5A, Wild). The dental terminology is taken from JACOBS (1978) and KOTLIA (1992). BMM stands for Bhimtal Muridae.

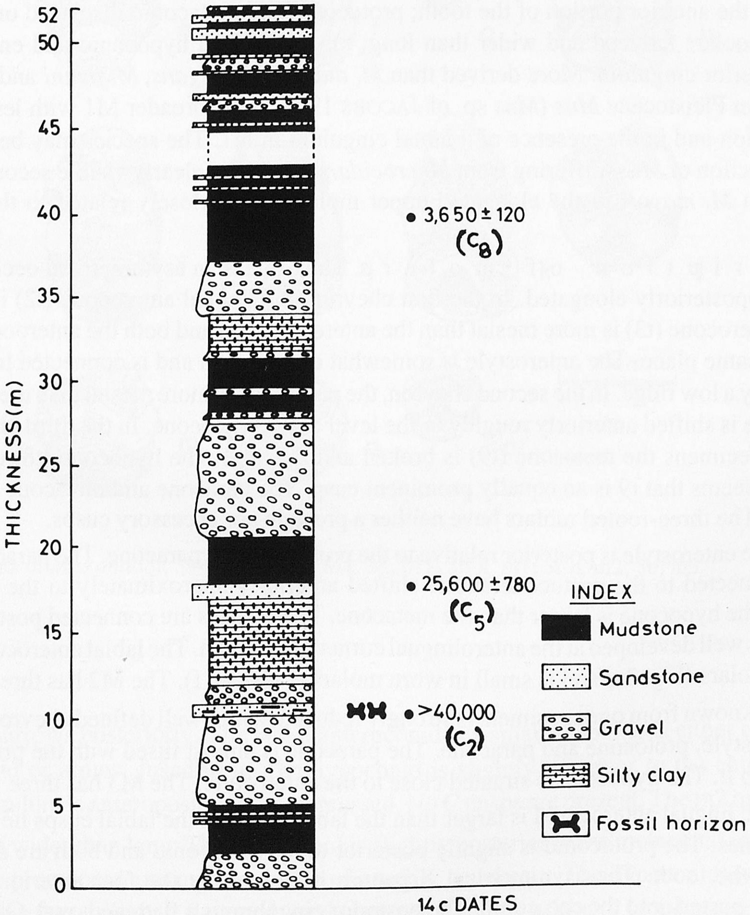

Fig. 2. Quaternary section showing the fossil horizon and the radiocarbon dates.

III. SYSTEMATIC PALAEONTOLOGY

Family: Muridae

Genus: *Mus* LINNAEUS, 1758

D i a g n o s i s. As in MISONNE (1969), JACOBS (1978) and KOTLIA (1992).

Mus dhailai KOTLIA, 1995

(Figs. 3a-3o)

T y p e l o c a l i t y. Gazar, 2 km southeast of Bhimtal bus stop and about 0.75 km southwest of Bilaspur village (Fig. 1).

H o r i z o n. Medium grained, greyish and unconsolidated sandstone, stratigraphically about 10.5m above the base of the section, Upper Pleistocene (Fig. 2).

H o l o t y p e. Isolated lower right first molar (BMM/6), Fig. 3h.

R e f e r r e d m a t e r i a l. 2 left M1; 3 left and 1 right M2; 1 left M3; 3 right and 1 left m1; 2 right and 1 left m2; 1 left m3.

D i a g n o s i s. Derived *Mus*; M1 showing weak distortion; labial anterocone of M3 and labial anteroconid of m3 absent; labial anterocone of M2 very small; m1 forming an asymmetrical X-pattern in the anterior portion of the tooth; protoconid and metaconid displaced on toward the sides; third molars reduced and wider than long; m3 with fused hypoconid and entoconid and without posterior cingulum. More derived than *M. auctor*, *M. elegans*, *M. flynni* and *M. jacobsi*; differing from Pleistocene *Mus* (*Mus* sp. of JACOBS 1978) in its broader M1 with less elongated anterior portion and in the presence of a labial cingulum in m1. The species may be included in the *pahari* section of *Mus* (differing from *M. crociduroides* in the clearly visible second lamina of m3 and from *M. mayori* in the elongated upper molars). It is closely related to the extant *M. shortridgei*.

D e s c r i p t i o n o f m o l a r s. The M1 has an asymmetrical occlusal outline and is anteroposteriorly elongated. In the first chevron, the lingual anterocone (t2) is elongated, the labial anterocone (t3) is more mesial than the anterostyle (t1) and both the anterocones occupy roughly the same plane. The anterostyle is somewhat compressed and is connected to the lingual anterocone by a low ridge. In the second chevron, the protocone is more mesial than the enterostyle. The paracone is shifted anteriorly roughly to the level of the protocone. In the third chevron of all recovered specimens the metacone (t9) is broken and thus only the hypocone (t8) can be seen. However, it seems that t9 is an equally prominent cusp. The paracone and metacone are separate throughout. The three-rooted molars have neither a prestyle nor accessory cusps.

In M2, the enterostyle is posterior relative to the protocone and paracone. The paracone is more strongly connected to the protocone and is shifted anteriorly approximately to the level of the protocone. The hypocone is larger than the metacone. These cusps are connected posteriorly. The anterostyle is well developed at the anterolingual corner of the tooth. The labial anterocone is absent in unworn molars (Fig. 3c) and is small in worn molars (Figs. 3e, f). The M2 has three roots.

The M3, known from one specimen, is strongly reduced, with a well defined chevron consisting of the enterostyle, protocone and paracone. The paracone is almost fused with the protocone and is posterior to it. The hypocone is situated close to the enterostyle. The M3 has three roots.

In m1, the lingual anteroconid is larger than the labial one. All the labial cusps lie posterior to the lingual ones. The protoconid is slightly posterior to the metaconid and both are displaced on the sides of the tooth. The asymmetrical X-pattern is formed by the four anterior cusps. The hypoconid is posterior to the entoconid. The posterior cingulum is a flattened oval. One specimen (Fig. 3j) has a C1 cusp and another (Fig. 3i) has C1 and C3 cusps. This tooth has two roots.

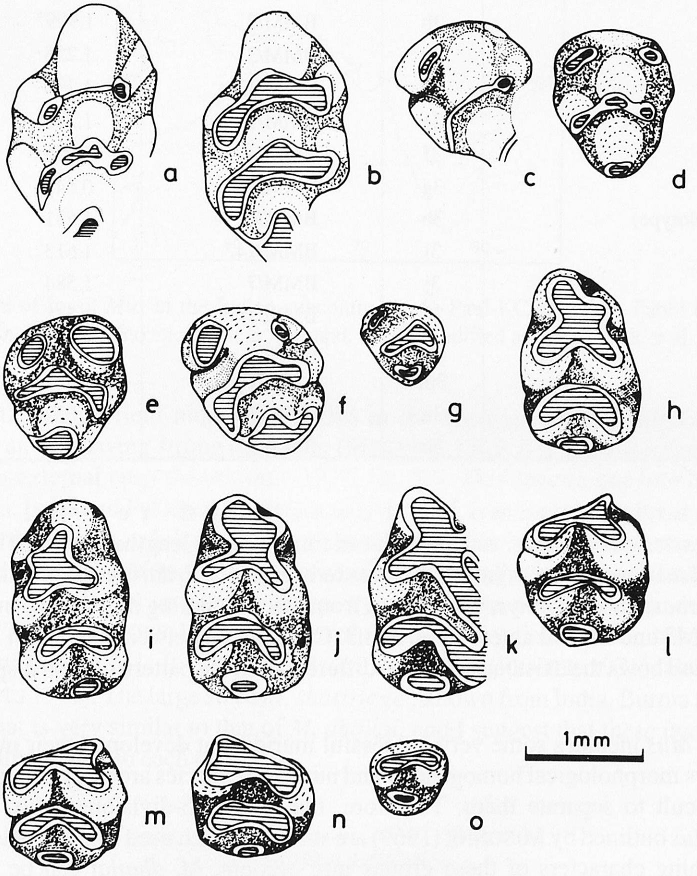

Fig. 3. Elements of *Mus dhailai*; 3a-b, M1; 3c-f, M2; 3g, M3; 3h-k, m1; 3l-n, m2; 3o, m3.

The m2 narrows posteriorly. The labial anteroconid is a small cusp that is either connected to the protoconid or almost fused to it. The hypoconid is slightly posterior to the entoconid. The posterior cingulum is anteroposteriorly compressed. No C cusps are present. The m2 has two roots.

The m3 is wider than long. The protoconid is slightly posterior to the metaconid in the anterior chevron. The protoconid and metaconid are of roughly equal size. The hypoconid and entoconid are merged together to form a flattened, oval chevron. There is neither a labial anteroconid nor a posterior cingulum. The tooth is extremely reduced and has two roots.

Table I

Measurements (in mm) of molars of *Mus dhailai* from the Upper Pleistocene of Bhimtal-Bilaspur

Tooth type	Figure	Specimen numbers	Length	Width
Left M1	3a	BMM/1	1.968+	1.258
Left M1	3b	BMM/2	1.999+	1.226
Left M2	3c	BMM/3	1.258	1.032
Left M2	3d	BMM/12	1.290	1.032
Right M2	3e	BMM/13	1.226	1.032
Left M2	3f	BMM/4	1.258	1.065
Left M3	3g	BMM/5	0.645	0.677
Right m1 (Holotype)	3h	BMM/6	1.581	1.000
Left m1	3i	BMM/14	1.613	0.936
Right m1	3j	BMM/7	1.584	0.968
Right m1	3k	BMM/8	1.548	0.968+
Right m2	3l	BMM/9	1.161	1.032
Right m2	3m	BMM/10	1.065	1.000
Left m2	3n	BMM/15	1.032	1.000
Left m3	3o	BMM/11	0.613	0.645

Comparisons with fossil and recent species. The main characteristic features, such as reduced third molars, lengthening of M1 with t1 usually set distally and m1 forming an asymmetric X-pattern, allow us to attribute this taxon to *Mus*. Some *Mus*-like genera, such as *Acomys*, are distinct from *Mus*, including *M. dhailai*, in having a labial anterocone in M3 and a labial anteroconid in m3. Comparison between the South African *Acomys mabele* and *Mus* shows the existence of many differences in the pattern of cusp disposition (DENYS 1990).

The genus *Mus* includes some very successful murids that developed their own evolutionary trends. It shows morphological homogeneity and numerous species are morphologically so similar that it is difficult to separate them. Therefore, the three sub-divisions (*Mus*, *Nannomys* and *Celomys*) of *Mus* outlined by MISONNE (1969) are still very much used by palaeontologists. Taking the distinguishing characters of these groups into account, *M. dhailai* can be included in the *Celomys* section. The characteristic features of this section are: large size, less elongated M1, t9 large in M1 and M2, t3 usually small or absent in M2 and reduction of m3 (MISONNE 1969). *M. auctor* is primitive compared to *M. dhailai* in the labial anterocone of M3 and the labial anteroconid of m3. The anterior cingulum in the M1 of *M. auctor* is very strong while it is absent in *M. dhailai*. In *M. elegans*, the M1 has an anterior cingulum, M2 has a labial anterocone even in unworn molars and the lingual anteroconid is never connected to the metaconid in m1. It may be mentioned that *M. flynni* and *M. dhailai* share a few derived characters, such as M3 without a labial anterocone and m3 without a labial anteroconid. However, *M. flynni* differs from *M. dhailai* in having a prestyle in M1 and M3 and a distinct labial anterocone in M2. *Mus* sp., described from the Pleistocene of Pakistan (JACOBS 1978), can be separated from *M. dhailai* by its narrower M1 and labial cingulum in m1. The distribution of fossil *Mus* in the subcontinent is shown in Fig. 4.

M. dhailai can also be compared with living species of the genus. In India, *Mus* is represented by three subgenera; *Mus* with *M. booduga* and *M. dunni*; *Pyromys* with *M. saxicola*, *M. shortridgei* and *M. platythrix*; and *Coelomys* with *M. mayori*, *M. pahari* and *M. crociduroides* (MARSHALL 1977).

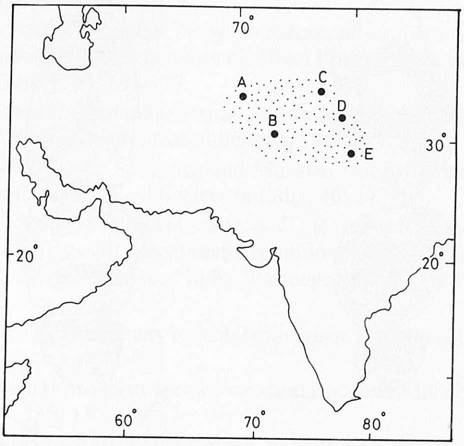

Fig. 4. Distribution of fossil *Mus* in the Indian subcontinent. A: Paul-I-Charkhi; B: Pabbi Hills, Pakistan; C: Kashmir basin, India; D: Saketi, India; E: Bhimtal, India (modified after PATNAIK et al. 1993).

M. booduga (little Indian field mouse), included in the *booduga* section (MISONNE 1969) is characterised by an M1 having strong distortion (MISONNE 1969, p. 149) and a broad M1 with a prominent antero-external cusp (MARSHALL 1977, fig. 37). This species consists of forms from Burma, Sri Lanka, India and Pakistan. *M. dunni*, similar to *M. booduga* and probably belonging to same section, also has a long and slender M1 with an inconspicuous anterocentral cusp (MARSHALL 1977, fig. 41) and therefore differs from *M. dhailai*. Known from Pakistan, the Himalayan foothills and Kumaun, *M. saxicola* has an anterior accessory cusp on the medially expanded part of M1 (MARSHALL 1977: 182; JACOBS 1978). *M. platythrix*, the spiny field mouse, has an extremely elongated anterior part of M1. It is reported from Kathiawar (PRATER 1971), Baluchistan and Pakistan (ROBERTS 1977). The large sized *M. shortridgei*, known from India, Burma and Thailand, has a dentition that is very similar to that of *M. dhailai*, and I suggest that these two species may be phylogenetically related to each other.

IV. CONCLUSIONS

Mus dhailai is characterised by an M1 with lingual and labial anterocones occupying roughly the same plane and a paracone placed at the level of the protocone, M3 and m3 lacking the labial anterocone and labial anteroconid respectively and an M2 with an extremely small labial anterocone. It may belong to the *Celomys* group, which includes geographically widely separated species. The forms of the *Celomys* section have more rounded and less elongated M1 than forms in the *booduga* and *minutoides* sections (MISONNE 1969). The *Celomys* section includes Asiatic species such as *M. mayori*, *M. pahari*, *M. crociduroides* and *M. shortridgei* (MISONNE 1969). Among these, *M. crociduroides* has a weak second chevron in m3, in contrast to the other forms, and *M. dhailai*, in which it is prominent. The upper molars are broad and squarish in *M. mayori* (MARSHALL 1977) and narrow in our fossil form. *M. dhailai* shows greater morphological affinity with the living *M. shortridgei* (Fig. 5) than with any other murid reported from the Indian subcontinent (see also MISONNE 1969, plate XXI). It is likely that *M. shortridgei* (total length of upper molars 4.820.18 mm; MARSHALL 1977) evolved from something like *M. dhailai* (total length of upper molars 3.838^{+}mm).

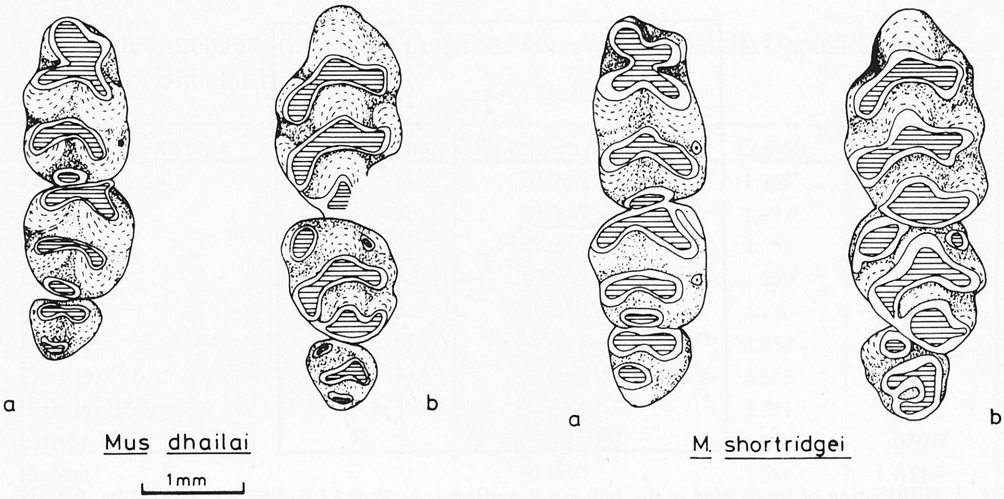

Fig. 5. Dentition of *Mus dhailai* and *M. shortridgei* (a: lower dentition; b: upper dentition).

M. auctor has been considered a very primitive relative of other species of *Mus* and a representative of the basal stock of the genus (JACOBS 1978). The dental morphology of *M. auctor* is similar to that of the extant *M. booduga* and *M. dunni* (JACOBS et al. 1989). The arrangement of the cusps in *M. booduga* is very similar to that in the Karewa *Mus*, *M. jacobsi* (KOTLIA 1992). It has also been shown that *M. jacobsi* probably evolved from *M. auctor* (KOTLIA 1992). Thus, *M. auctor* (Miocene), *M. jacobsi* (Pliocene) and *M. booduga* (Recent) show close affinities with each other. The ratio of the lengths of M1, M2 and M3 (length of M2 set to 100%) in these species is as follows; *M. auctor* (162:100:60), *M. jacobsi* (200:100) and *M. booduga* (199:100:60). This may be one line of murid evolution. On the basis of this study, I can not rule out the possibility of another line of evolutionary trend from *M. dhailai* (Upper Pleistocene) to *M. shortridgei* (Recent) with the ratio of the length of the upper molars 158^{+}:100:51 in the former and 170:100:65 in the latter. However, more fossil material of Upper Pleistocene *Mus* is certainly needed for understanding of its precise phylogenetic and zoogeographical relationships.

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