

Early Miocene cricetid rodent (Mammalia) from the Murree Group of Kalakot, Rajauri District, Jammu and Kashmir, India

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Fossil dental remains of a small primitive cricetid rodent *Primus microps* (Hystricomorpha, Muroidea), are reported from the middle part of the lower Murree Group exposed near Kalakot (north-west Outer Himalaya) in the Rajauri District, Jammu and Kashmir, India. The new find clearly suggests an Early Miocene age for the fossiliferous bed and favours the view that the Subathu and Murree successions are separated by a considerable time gap.

THE Murree Group is generally poorly fossiliferous in comparison to the underlying Subathu and the younger Siwalik successions¹⁻³. Most published reports of fossil occurrences from the Murree succession in India mention fragmentary bones and teeth of large vertebrates and some invertebrates, which have been of little use in dating the fossiliferous beds⁴⁻⁶. Therefore, the occurrence of a rodent in the Murree Group is important from a biochronological viewpoint. The Murree sediments exposed in the vicinity of Sialsui, Kalakot and Mohgala in the Rajauri District, Tripathy in the Riasi District and Laren in the Udhampur District have been known to yield sporadic fossil remains, including vertebrates, but these are generally poorly documented. Here we describe an isolated upper second molar tooth of a generalized cricetid rodent, *Primus microps*, from the middle part of the lower Murree Group exposed at Sialsui village about 6 km (13.5 km by road) northwest of Sair Bridge at Kalakot (Figure 1a). Although *P. microps* is already known from the coeval beds in Pakistan, and the Indian material is meagre at this stage, its occurrence in India has four-fold significance: (i) it is the first micro-mammal from the Murree succession in India, which has been identified to the specific level and which is of definite chronologic value; (ii) it is the oldest cricetid rodent from India; (iii) it extends the geographic range of this taxon by about 350 km eastwards from Pakistani localities; and (iv) it provides a basis for correlation between the Miocene successions of India and Pakistan and increases the hope of recovering rodent assemblages from Murree and its coevals in India.

The Murree Group is a widespread succession of red and maroon shale, siltstone, sandstone and pseudoconglomerate exposed along the Himalayan foothills of Kohat–Potwar (Pakistan) and Jammu regions (India). In India, it overlies the Palaeocene-early Middle Eocene Subathu Group apparently conformably, as there is no field evidence to suggest a break between the two successions. However, most researchers, both in India and Pakistan, have traditionally suggested a gap as long as the whole Oligocene between the Subathu and Murree successions^{1,7}. The lower Murree sediments, which have yielded the present tooth are mainly argillaceous and consist of deep purple or chocolate coloured mudstone interbedded with mostly fine-grained micaceous, hard sandstone and purplish subordinate siltstone. Intrafor-

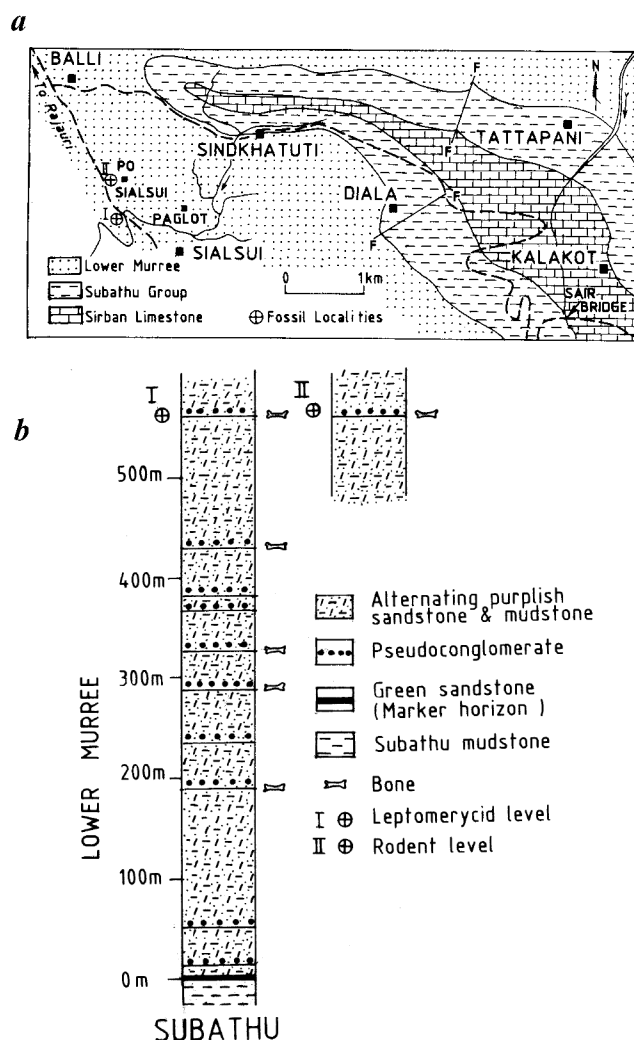


Figure 1. a, Location and geological map of the area around Sialsui and Kalakot (northwest Outer Himalaya), Rajauri District, Jammu and Kashmir showing the fossil locality; b, Composite stratigraphic section of the lower Murree sediments near Sialsui (Sialsui I), and a litholog of the rodent-yielding section (Sialsui II) showing the position of the fossiliferous bed in respect of the Subathu–Murree boundary.

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mational pseudoconglomerate beds consisting of pedogenic calcareous pebbles supported by sandy matrix are common. The thickness of the lower Murree beds around Kalakot is about 1000 m (ref. 1).

The cricetid tooth from Sialsui was recovered by disintegration and wet sieving of matrix from a localized purplish-red pseudoconglomerate bed, which is about 2 m thick and exposed in a small section (Sialsui-II) near a post office at Sialsui. As the basal part of this section is disturbed, stratigraphic position of the rodent-yielding bed in respect of the Subathu–Murree boundary is uncertain. However, extrapolation from a nearby section (Sialsui-I), which is more complete and richer in vertebrate remains suggests that the fossiliferous horizon is approximately 575 m above the Subathu–Murree boundary, i.e. somewhere in the middle part of the lower Murree Group (Figure 1 b). The Sialsui-I section situated near the main bridge at Sialsui had earlier produced a leptomyricid (*Artiodactyla*) tooth that was reported by Mehta and Jolly⁶ and a few rhinocerotoid and crocodilian teeth and fish remains, which are yet to be published.

Superfamily: Muroidea Miller and Gidley, 1918

Family: Cricetidae Rochebrune, 1883

Subfamily: Cricetodontinae Stehlin and Schaub, 1951

Genus *Primus* Bruijn *et al.*, 1981

Primus microps Bruijn *et al.*, 1981

(Figures 2 and 3)

Type species: *Primus microps* Bruijn *et al.*, 1981

Type locality: Howard University–Geological Survey of Pakistan (H–GSP) locality 116, Banda Daud Shah, Kohat, Pakistan.

Referred material: WIMF/A 1610, an isolated left upper second molar.

Horizon and locality: Red pseudoconglomerate of the lower Murree Group about 575 m above the Subathu–Murree boundary, Sialsui near Kalakot, Rajauri District, Jammu and Kashmir (northwest Outer Himalaya).

The specimen referred in this work is catalogued and stored in the Museum Repository of the Wadia Institute of Himalayan Geology, Dehradun.

M2/ is squarish (length, 1.02 mm; width, 0.95 mm), but slightly longer than broad. Its anterolabial and posterocentral margins are partially damaged. It has four main cusps that are sloping posteriorly and slightly compressed. The paracone and metacone are slender. The protocone is slightly smaller than the hypocone. The lingual cusps are slightly anteriorly shifted from the line of labial cusps. Thus, the protocone is followed posteriorly by paracone, hypocone and metacone, respectively (an incipient pattern of alternating cusps). This arrangement gives the tooth a lophodont appearance. The protoleph (=protolephule), metaloph

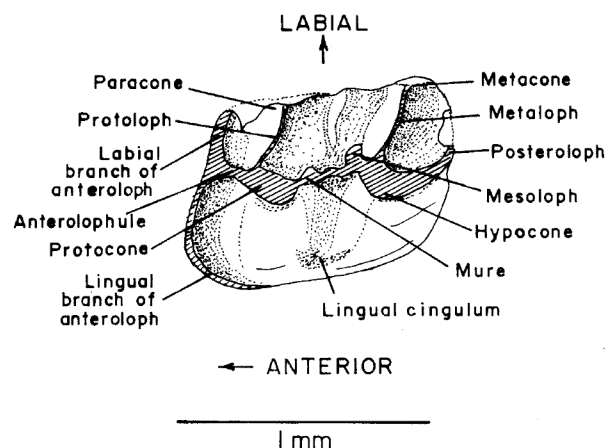


Figure 2. *Primus microps* WIMF/A 1610, line drawing of LM2/ in occlusal view showing terminology used in text.



Figure 3. *Primus microps* WIMF/A 1610, isolated LM2/ in (a) occlusal and (b) lingual view. Scale bar, 0.5 mm.

(=metalophule) and posteroloph are not transverse but oblique and anterolingually–posterolabially aligned. The protoleph terminates slightly anteriorly from the line of protocone. The posteroloph is quite strong and parallel to the metaloph. The anteroloph is not as strong as the posteroloph. Its two branches arise from the anterior mure or the anterolophule, which is connected to the protocone. The labial branch runs towards the anterolabial base of the paracone and is probably connected to it, while the lingual branch runs along the base of the protocone and joins the anterolingual base of the hypocone forming the lingual cingulum. Between the protocone and hypocone and nearer to the hypocone, a faint mesoloph (=mesolophule) originates from the mure (=ectoloph or longitudinal crest) and extends labially for a short distance. The lingual sinus or the transverse

valley between the protocone and hypocone is deep and narrow and not transverse but posteriorly directed. It is nearly parallel to the metaloph and protoloph. A strong ridge on the lingual edge of the sinus connects the anterolingual part of the hypocone to the posterolingual part of the protocone; it represents the lingual cingulum.

The fossil record of cricetid rodents from Asia is fairly rich right from the Late Eocene, but in the Indian subcontinent cricetids have so far been reported only from Miocene and younger sediments. The bulk of the cricetid fossil record from the subcontinent is from Pakistan. In India, prior to this report, cricetids were known from the Middle Siwalik Subgroup of Haritaly-angar area in Himachal Pradesh⁸ and from the Late Pliocene Karewa deposits of the Kashmir valley⁹.

Cricetidae is the most proliferate group of rodents, yet small forms with simple and primitive dental morphology like the present one from Sialsui are generally rare. However, isolated teeth of small generalized cricetids are relatively common in the Miocene of Pakistan. The taxa that are comparable with the Sialsui cricetodontine include *Primus* and *Spanocricetodon* from the Early and Early Middle Miocene of Pakistan^{10–12} and China^{13–15}, and *Democricetodon* and *Megacricetodon* from the Middle Miocene of China¹⁵, Europe¹⁶, and Pakistan^{11,12,17}. The latter genera are closely related to *Copemys* from the Miocene of North America¹⁸. Their teeth differ from the present tooth in over 20% larger size and in possessing a distinct mesoloph.

Morphologically, the Sialsui cricetodontine tooth is nearly identical with the corresponding teeth of *P. microps* recorded from the basal part of the Murree Formation (about 2 m above the contact with the nummulitic limestones of the Kohat Formation) exposed at H-GSP locality 116, near Banda Daud Shah in the Kohat District, Pakistan (Bruijn *et al.*¹⁰, plate 2, figures 20 and 21). However, size-wise, it is intermediate between *P. microps* and *Spanocricetodon khani*, and more or less the same as *S. lii*. *S. khani* and *S. lii* are known from the same horizon and locality in Pakistan as *P. microps*. On an average, the Sialsui tooth is about 12% larger than the corresponding teeth of *P. microps* and about 10.5% smaller than teeth of *S. khani* from Pakistan and *S. ningensis* from China (Figure 4). In morphology, it is differentiated from M2/ of *S. khani* (Bruijn *et al.*¹⁰, plate 2, figure 5) by single protoloph (the anterior one), weaker mesoloph and a shorter and curved (U-shaped) mure. In *S. khani* M2/, the protoloph is often double – a complete and stronger anterior one and a short and weaker posterior one, and the mure is longer and semicircular. *S. ningensis* and *S. khani* are differentiated from each other on the basis of lower molars. Comparison of the present tooth with *S. lii* is not feasible, as its second upper molars are not recognized yet. Bruijn *et al.*¹⁰ attributed both *Primus* and *Spanocricetodon* to the subfamily Cricetodontinae, but

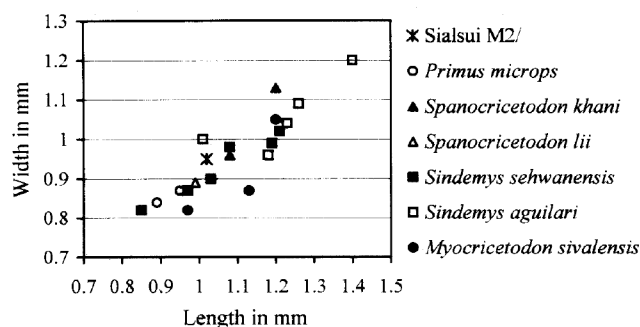


Figure 4. Scatter diagram showing dimensional parameters of the Sialsui M2/ in respect of other closely related cricetodontids.

Lindsay¹⁷ placed them with *Democricetodon* in the subfamily Democricetodontidae.

The myocricetodontid rodents, earlier classified under the family Cricetidae and recently upgraded to a family by Wessels¹⁹ also comprise a few small-generalized forms (*Myocricetodontinae*), which show considerable resemblance with the present tooth. These include *Sindemys*, *Punjabemys*, *Myocricetodon*, *Melalomy*, *Shamalina*, and *Dakkamys*. Of these, only *Sindemys* and *Myocricetodon* are in the size range of the present specimen, while the rest are over 25% larger (Figure 4). *Sindemys* is an endemic form recorded from the lower Manchar, Kamli and Chinji formations in Pakistan, whereas *Myocricetodon* is best known from northern Africa, and in Pakistan it has been reported from the lower Manchar and Kamli formations¹⁹.

Among the myocricetodontines, *Sindemys* has the strongest similarity with the Sialsui M2/. Two species, viz. *S. sehwanensis* and *S. aguilar* represent it. The present M2/ is nearly the same size as *S. sehwanensis* (Wessels¹⁹, plate 1, figures 8–10; plate 2, figures 11–13) but differs in lacking an enterostyle (=entostyle), anteriorly directed protoloph, stronger lingual branch of anteroloph, weak mesoloph, and narrower lingual sinus. In *S. sehwanensis*, lingual cusps are less sloping and more ‘pillar-like’ and the protoloph is either transverse or posteriorly directed. M2/ of *S. aguilar* is considerably larger than the M2/ from Sialsui. The two teeth also differ in their mure, which, in the former, is better developed posteriorly but has a weak or interrupted connection with the protocone. The Sialsui M2/ can be easily differentiated from *Myocricetodon* by the absence of enterostyle and labial cingulum and by the presence of a weak mesoloph.

Thus among the known small-generalized cricetodontids the present tooth is morphologically closest and dimensionally nearest to *P. microps*; hence here it is referred to this taxon. The difference in size with the type specimens of *P. microps* appears to be within the range of individual variation. This is corroborated by the size range of the corresponding teeth in the allied taxa like *S. khani*, *S. lii*, *S. sehwanensis* and *S. aguilar*.

Bruijn *et al.*¹⁰ compared *P. microps* with the most primitive known species of *Antemus*, *A. primitivus* (Murinae) known from the Chinji Formation in Pakistan and suggested that *P. microps* may be in or close to the ancestry of *Antemus* and therefore of the true mice or Muridae. This was doubted by Wessels *et al.*²⁰. We also do not find the suggestion tenable as the dental features of *A. primitivus* and *P. microps* are quite different. While the former clearly shows incipient murid features, viz. conical pillar-like and opposing cusps, lack of longitudinal lophs, etc., the latter still has more generalized dental pattern. The present tooth shows an incipient stage of alternating arrangement of cusps, which are inclined posteriorly and a fairly strong longitudinal crest. In these respects, *P. microps* looks much closer to myocricetodontines like *Sindemys* than to murine *Antemus* and it may well be in the ancestry of the family Myocricetodontidae.

P. microps is the only rodent species identified thus far in the Murree Group in India. Being an endemic species, *P. microps* alone is not of much value in dating the fossiliferous beds. However, its association in Pakistan with an assemblage of 8 genera and 9 species belonging to at least 4 families makes it significant for age interpretation. The rodents that occur associated with *P. microps* in Pakistan include primitive cricetodontines *S. khani* and *S. lii*, a rhizomyid *Prokanisamys arifi*, which is a probable ancestor of *Kanisamys*, a ctenodactylid *Sayimys minor* and some indeterminate taxa representing Chapattimyidae, Cricetidae, Thryonomyidae, Sciuridae and Rodentia indet. This assemblage has a few taxa, which are clearly part of the lineage whose ancestral species occurred in the Murree and descendant in the younger Chinji Formation (Lower Siwalik Subgroup). The best examples of this are *S. minor*–*S. sivalensis* and *P. arifi*–*K. indicus*. On the basis of this rodent assemblage and its relationship with similar species in Europe, China and North America, Bruijn *et al.*¹⁰ assigned an Early to Middle Miocene age to the Murree rodent fauna from Banda Daud Shah (Pakistan). The Chinji rodent fauna from Pakistan was considered Early Astarcan or Middle Miocene by Wessels *et al.*²⁰.

The common presence of a small-generalized rodent *P. microps* in the Murree sediments of India and Pakistan obviously indicates a similar age for the fossiliferous beds of the two areas. Moreover, an unnamed species of *Primus* has also been recognized in the Early Middle Miocene of China¹¹ and *Spanocricetodon* is already known from Early and Early Middle Miocene of China^{11,13}. Therefore, the age of rodent-bearing horizon at Sialsui is also considered as Early Miocene. This is well supported by a majority of the associated mammalian fossils, except the artiodactyl *Leptomeryx*, which was earlier recorded on the basis of an upper molar from almost the same stratigraphic level as the present rodent⁶. Mehta and Jolly⁶ compared the leptomerycid

molar with *L. evansi* and *L. mamifer*, both of which are typically Oligocene species^{21,22}. *Leptomeryx* ranges in age from Lower Oligocene to Lower Miocene. Sialsui leptomerycid probably represents a new species, but it is difficult to define on the basis of a single molar tooth; therefore, its precise age is uncertain.

On the basis of occurrence of *Leptomeryx* remains in the Murree Group, Mehta and Jolly⁶ stated that the lower limit of the Murree Group extends in Oligocene and it may go even lower without any break at the boundary. The present evidence does not rule out the possibility of the Murree Group extending into Oligocene, because 575 m thick sediments between the rodent-yielding middle part of the lower Murree and the Subathu–Murree boundary are also to be accounted. However, there is no firm basis yet to support the view that Subathu and Murree are continuous sequences. Even if the age of the leptomerycid and rodent-yielding lower Murree beds is taken as Middle Oligocene–Lower Miocene, there is no account of Late Middle Eocene, Late Eocene and Early Oligocene. After the deposition of Subathu Formation, which completed in the Early Middle Eocene time (Early Lutetian), there is absolutely no fossil evidence to account for this gap. This implies that the Subathu and Murree groups are separated by a considerable time gap, although the same is not corroborated by field evidence. In several sections of Pakistan, the gap between the Eocene and Murree successions has been clearly established on the basis of faunal evidence. For example, in Potwar Plateau the basal Murree beds (=Fatehjang Beds) have produced vertebrate fauna of Late Oligocene (?) and Early Miocene age²³. Similarly, basal Murree from Banda Daud Shah near Kohat has yielded an assemblage of Early Miocene rodents¹⁰. These data fully support the view that there is a gap between the Eocene and Murree successions, although its extent may vary from area to area because the top of Eocene (pre-Murree) sediments and the base of Murree are dichronous in India and Pakistan.

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Arsenic contamination in groundwater affecting major parts of southern West Bengal and parts of western Chhattisgarh: Source and mobilization process

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Arsenic contamination problem in West Bengal and in Chhattisgarh is a natural phenomenon. The main sources of arsenic in the latter area are in weathered acid magmatic rocks of the Dongargarh rift belt and not from locally present sulphides. In West Bengal, arsenic-sorbed in Fe-oxyhydroxide was preferentially captured in argillaceous, organic-rich, mid-Holocene deltaic sediments. Arsenic concentrations are neither high nor very different between adjacently located polluted or unpolluted aquifers. Arsenic is released to groundwater in both cases by bio-mediated reductive dissolution of Fe-oxyhydroxide. In West Bengal, continued and increased recharging of shallow aquifer because of extensive pumping triggered the reduction process, by inducing and enhancing movement of groundwater having highly reducing degraded organic products.

ARSENIC contamination in groundwater and related diseases affect major parts of Ganga delta down stream of Rajmahal hills in West Bengal, India and other low-lying areas in Bangladesh^{1–5} (Figure 1). Alluvial areas from USA, Hungary, China, Taiwan and Vietnam are also similarly affected^{6–8}. The problem has also been reported recently from Kaurikasa area, Chhattisgarh^{9–13} (Figure 2). Some fear that the manifestation may contaminate Seonath river and groundwater, endangering well-populated townships like Drug, Rajnandgaon and

Raipur^{10,11}. Arsenic-affected areas in Bengal Basin and Chhattisgarh virtually do not have industrial, mining or thermal water activities as many other affected areas^{6–8,14–16}. Results of our studies on this problem in West Bengal and Chhattisgarh are presented here.

There are two contending schools on arsenic contamination in the Bengal Basin: (1) It is caused by oxidation of pyrite and arsenopyrite that are present in aquifer sediments, by atmospheric oxygen which enters the groundwater due to lowering of the water table caused by excessive groundwater abstraction^{1–3,17}. (2) It is caused (in Bengal and other alluvial aquifers) by reductive dissolution of ferric-oxyhydroxide that contains sorbed arsenic^{4,18–23}.

Enormity of arsenic problem in the Bengal Basin has prompted reversion to surface water-based supply in many affected areas. Such a policy shift will involve enormous financial outlay and would nullify the investment of around Rs 10,000 crores already made in West Bengal alone over the last 30 years. It is necessary that such major policy shift should not be ad hoc, but a science-driven decision^{24,25}.

A strong correlation exists between the distribution of arsenic-affected area in Bengal Basin and palaeogeomorphology and Quaternary stratigraphy^{22,24}. The arsenic-prone low-lying alluvial basin of the Ganga river system, downstream of Rajmahal hills, was entrenched and incised over the Pleistocene uplands during low-stand setting of latest Pleistocene age. The Pleistocene terraces and uplands flanking the western side of the delta and those to the north, northwest and central part of the Bengal basin (Barind and Madhupur tracts) exposing older oxidized and the overlying early Holocene sediments are free from arsenic contamination. The basal sandy fills of entrenched channels are also generally free from such contamination. Dominantly argillaceous and organic-rich fluvio-deltaic sediments that were deposited during the high-stand setting of mid Holocene age (10,000–7500 yr BP)^{22–24} are arsenic-prone. The period beginning with 10,000 yr BP, initial

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