Discovery of a micromammal-yielding Deccan intertrappean site near Kisalpuri, Dindori District, Madhya Pradesh

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An intertrappean section exposed along the right bank of Kharmer river near Kisalpuri village (Dindori District) in Madhya Pradesh has yielded a rich microvertebrate assemblage. This assemblage consists of fishes: *Igdabatis indicus*, *Lepisosteus* cf. *L. indicus*, Pycnodontiformes, Osteoglossiformes, Siluriformes; anurans: ?Leptodactylidae gen. et sp. indet.; squamates: indeterminate lizards, Serpentes indet., Bothremydidae group of chelonians, neosuchian crocodiles, sauropod, ornithoid, and theropod dinosaur egg-shell fragments and an eutherian mammal. This is one among the few mammal-yielding Late Cretaceous sites reported so far from India. Preliminary study of a single mammalian lower molar indicates a close affinity to the Laurasian boreosphenidan eutherians.

THE last one and half decades witnessed extensive and focused research on Deccan intertrappean biota of peninsular India, primarily aimed at understanding the response of the biosphere to the stressed environmental conditions at the end of the Cretaceous. As a result, many new microvertebrate-bearing infratrappean beds (Marepalli, Timsanpalli, Dongargaon, Pisdura, Nand, Jabalpur) and intertrappean beds (Upparhatti, Gurmatkal, Naskal, Rangapur, Duddukuru, Asifabad, Nagpur, Bombay, Anjar) have been reported and diverse vertebrate groups have been described from these beds[1,2] Despite such extensive work on these beds, only a few sections have yielded micromammals, which are poorly known from the Mesozoic deposits of the world. Prasad and Sahni[3] reported the first Late Cretaceous mammal (*Deccanolestes hislopi*) from the intertrappean beds of Naskal. This mammal has been assigned to the Laurasian group of palaeoryctoid mammals. Subsequent to this, another species of *Deccanolestes*, *D. robustus*, has been documented from the same site[4]. Das Sarma *et al.*[5] reported the occurrence of one eutherian molar from the intertrappean beds of Upparhatti and a couple of hypsodont sudamericid molars from the intertrappean beds of Naskal, but with little morphological description. Following this, Krause *et al.*[6] described a sudamericid mammal from the Naskal site and discussed in detail its palaeobiogeographic significance. More recently, Rana and Wilson[7] documented upper and lower molars of *Deccanolestes* and an upper molar of a new genus, *Sahnitherium* (family *incertae sedis*), from the intertrappean beds of Rangapur exposed close to the Naskal mammal site.

The present find of an intertrappean section yielding micromammalian remains from the right bank of Kharmer river near Kislapuri village, Dindori district, Madhya Pradesh (Figure 1), therefore, assumes significance as it is expected to improve the Late Cretaceous fossil record of mammals from India and their biogeographic relationships. This intertrappean section has been assigned Maastrichtian age based on the presence of typical Maastrichtian fish *Igdabatis indicus* Prasad & Cappetta, 1993 and ostracods *Paracypretta bhatiai* Khosla & Sahni, 2000 and *Paracandona jabalpurensis* Sahni & Khosla, 1994. It is thus considered as the northernmost Late Cretaceous mammal-bearing locality within the Deccan volcanic province. Wet screen-washing of about 500 kg of sediments from this intertrappean section resulted in the recovery of the following fauna, which includes one lower molar tooth of a new mammal.

Ostracods:
Paracypretta bhatiai Khosla & Sahni, 2000
Paracandona jabalpurensis Sahni & Khosla, 1994

Pisces
Selachians:
Myliobatidae
Igdabatis indicus Prasad & Cappetta, 1993 (Figure 2 *f*)

Holosteans:
Lepisosteidae
Lepisosteus cf. *L. indicus* Woodward, 1908 (Figure 2 *d*, *e*)

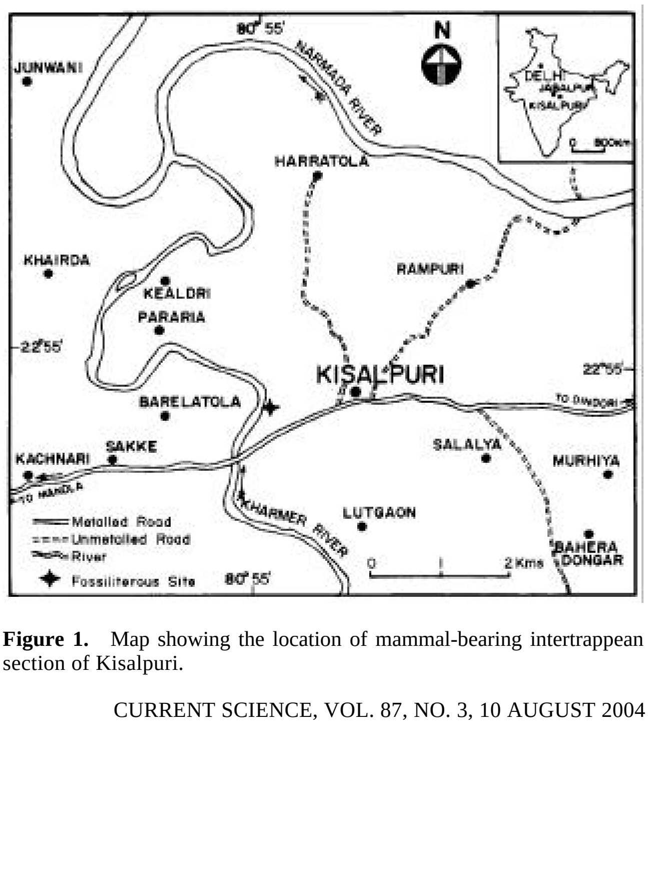

Figure 1. Map showing the location of mammal-bearing intertrappean section of Kisalpuri.

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Pycnodontiformes:
  Pycnodontidae gen. et sp. indet. (Figure 2 *a*)

Teleosteans:
  Osteoglossiformes:
  Osteoglossidae gen. et sp. indet. (Figure 2 *b*, *c*)
  Siluriformes incertae sedis (Figure 3 *c*)

Amphibians
  ? Leptodactylidae gen. et sp. indet. (Figures 2 *g* and 3 *d*)

Reptiles
  Squamates:
    Lacertilia indet. (Figure 2 *j*)

Chelonians:
  Bothremydidae
  Taphrosphys group
  cf. *Carteremys*

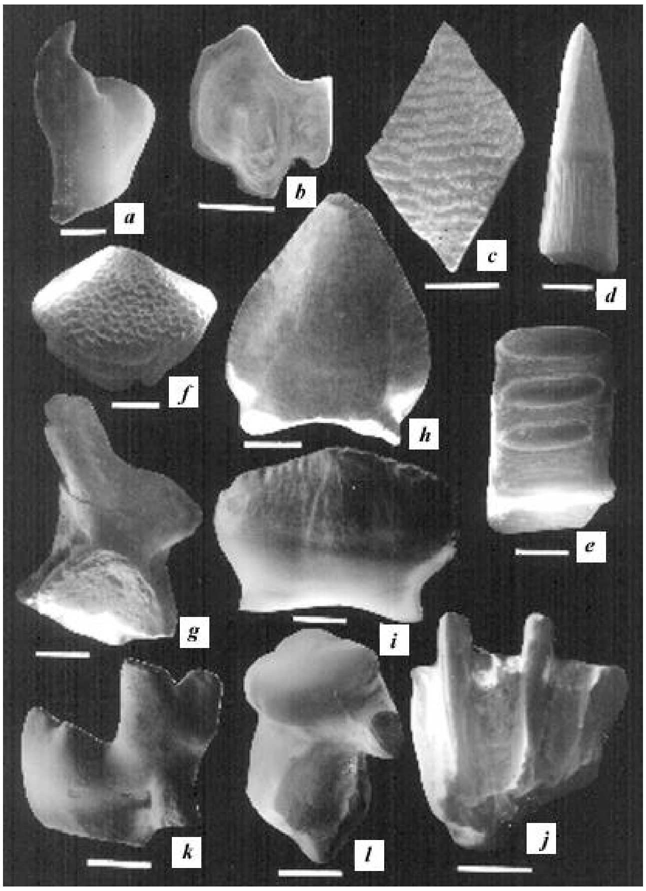

Figure 2. ***a***, Pycnodontidae gen. et sp. indet., lateral view of branchial tooth; ***b*** and ***c***, Osteoglossidae gen. et sp. indet, internal view of squamule (***b***), and external view of squamule (***c***); ***d*** and ***e***, *Lepisosteus* cf. *L. indicus* Woodward, 1908, lateral view of tooth (***d***) and scale from the caudal segment in external view (***e***); ***f***, *Igdabatis indicus* Prasad & Cappetta, 1993, lateral tooth in occlusal view; ***g***, ?Leptodactylidae gen. et sp. indet., lateral view of left ilium; ***h*** and ***i***, Crocodylia indet, tooth of intermediate series in lingual view (***h***) and tooth of posterior series in lingual view (***i***); ***j***, Premaxilla of indeterminate lizard in lingual view; ***k*** and ***l***, ?Otlestidae gen. et sp. indet. lingual view (***k***) and occlusal view (***l***). Bar equals 500 μm.

Archosaurs:
    Crocodylia indet. (neosuchians) (Figure 2 *h*, *i*)
  Sauropod egg-shell fragments
    Megaloolithus baghensis Khosla & Sahni, 1995
  Ornithoid egg-shell fragments
    Subtiliolithus kachchhensis Khosla & Sahni, 1995
  Theropod egg-shell fragments

Mammals:
  Family ?Otlestidae
  Gen. et sp. indet.
  (Figures 2 *k*, *l* and 3 *a*, *b*)

One incompletely preserved ultimate left lower molar (VPL/JU/IM/31) has been recovered from this site. In the reduced height difference of trigonid and talonid, the arrangement of trigonid cusps in an acute-angled triangle, relatively large paraconid connate at its base with the metaconid and placed at an anterolingual margin of the crown, hypoconulid closer to the entoconid than to the hypoconid and presence of deep hypoflexid and development of roots, it is comparable to *Otlestes meiman*[8] known from the Lower Cenomanian of Uzbekistan. However, it appears to be more derived than *Otlestes* in having inflated cusps, relatively shorter (anteroposteriorly) talonid with respect to trigonid and the absence of entoconulid. In its inflated cusps, VPL/JU/IM/31 is more derived than *Deccanolestes*[3]. A detailed description of this will be presented elsewhere. In light of its close morphological resemblance to *Otlestes*, the specimen is

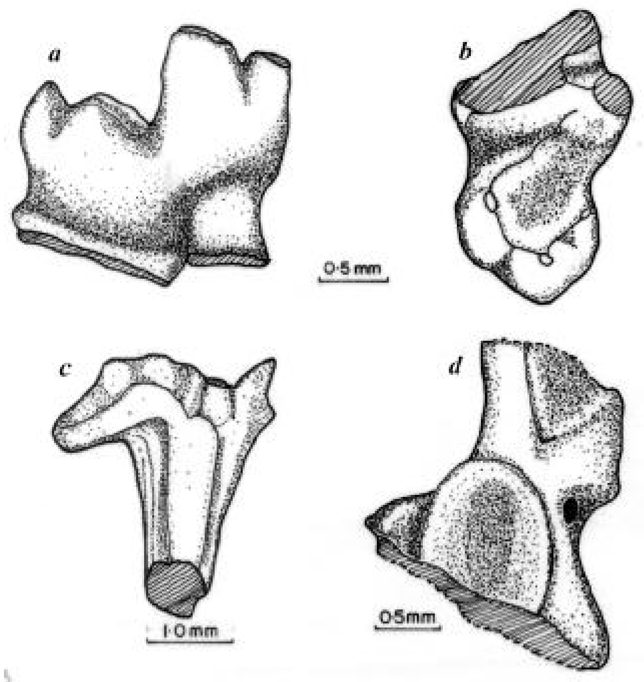

Figure 3. ***a–b***, ?Otlestidae gen. et sp. indet. lingual view (***a***) and occlusal view (***b***). ***c***, Siluriformes indet., anterior view of pectoral spine ***d***, ?Leptodactylidae gen. et sp. indet., lateral view of left ilium.

tentatively referred to the family Otlestidae, representing a boreosphenidan mammalian group, pending the recovery of well-preserved specimens.

The microvertebrate assemblage recovered from the site is broadly similar to that of other known intertrappean beds of peninsular India. However, the presence of micromammal in this site is of paramount importance, as Mesozoic mammals are relatively rare in the fossil record of former Gondwanaland and any new find from these continents is bound to augment our knowledge on their diversity and biogeographic relationships. For long, it was widely accepted that tribosphenic mammals (mammals with dentition capable of both shearing and grinding) had originated and diversified in Laurasian continents and were excluded from the southern continents until latest Cretaceous or early Palaeocene[9,10]. The fossil record of Mesozoic mammals documented up to 1999 supported this. Until this period, the earliest tribosphenic mammals (both placentals and metatherians), such as *Prokennalestes* from ?Aptian or Albian Khoboor beds, Gobi Desert, Mongolia[11], *Montanalestes* from Aptian–Albian Cloverly Formation, Montana, USA[12], *Deltatheridium*[13] and *Kokopellia*[14] came from North America and Asia only. The latest discoveries of tribosphenic mammals from much older (Middle Jurassic) deposits of Madagascar (*Ambondro*)[15], and from the Early Cretaceous of Australia (*Ausktribosphenos*)[16] and Early Cretaceous (? Berriasian) of Morocco (*Tribotherium*)[17] countered the traditional view of Laurasian origin for tribosphenic mammals. On the other hand, Luo *et al*.[18] argued for independent evolution of tribosphenic mammals on both Gondwanan and Laurasian continents. They named the Gondwanan clade as Australosphenida and here they included *Ausktribosphenos*, *Ambondro*, *Stereopodon* and living monotremes. Their Laurasian clade named as Boreosphenida includes living placentals, marsupials and their fossil relatives.

The new tooth from Central India lacked a continuous, mesial cingulid wrapping around and extending onto the lingual side of the crown. Absence of this cingulid is characteristic of boreosphenidan mammals. Therefore, VPL/JU/IM/31 is referred to the Boreosphenida clade. The presence of a boreosphenidan mammal in the Late Cretaceous of India assumes great palaeobiogeographic significance, because the Indian plate was drifting northwards as an island at this point of time and was separated from Asia by a wide (about 1000 km) Tethys sea[19]. Previous works have demonstrated the presence of Laurasiatic vertebrate fauna in the Late Cretaceous of India[3,20–22]. However, Thewissin and McKenna[23] and McKenna[24] questioned the referral of *Deccanolestes*[3] to the North American family Palaeoryctidae on the grounds that the similarities with palaeoryctids are only in plesiomorphic characters and the fossil material is inadequate. The boreosphenidan affinity of the mammalian find from Central India, particularly with Otlestidae, confirms the presence of mammals with non-Gondwanan affinities in the Cretaceous of India.

The presence of Laurasian taxa in the northward-drifting Indian plate has been explained either by an early India/Asia contact[25,26] or by dispersals across intermittent islands between India and Asia[2,27,28]. More recent molecular studies favoured an 'out of India dispersal' for ratite birds[29], acrodont lizards[30], and ranoid frogs[31]. Molecular phylogeny has also favoured a long history for placental mammals on the Gondwanan continents[32]. As the current Mesozoic fossil record of the Gondwanan continents is too sketchy, more work remains to be done before a synoptic biogeographic model can be developed.

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ACKNOWLEDGEMENTS. We thank the anonymous referee for his valuable suggestions on the manuscript. This work was supported by grants from the Department of Science and Technology and University Grants Commission to A.K. and G.V.R.P. respectively. O.V. thanks the Geological Society of India for L. Rama Rao Research Grant.

Received 5 December 2003; revised accepted 3 March 2004

Developmental and hormonal regulation of actin and tubulin in the central nervous system of silkworm, *Bombyx mori* during postembryonic development[†]

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We investigated changes in the synthesis and content of the cytoskeletal proteins to understand their role in ganglionic fusion and nerve-cord shortening during metamorphosis in insects. SDS–PAGE and [^{35}S]-methionine incorporation studies revealed high protein synthesis in the central nervous system (CNS) of *Bombyx mori*, during the late-last instar larval and late-pupal stages of development, and actin and tubulin were the two major proteins synthesized. Western analysis revealed high *b*-tubulin in CNS during the larval stages. It declined at the pupal stage, which might be due to the resorption of the interganglionic connectives. A specific *b*-tubulin protein band was expressed during the pupal stages, when endogenous 20-hydroxyecdysone (20E) titre was reported to be high. Based on the similarity to an earlier report on the developmental expression of tubulin in *Drosophila*, we speculate this as a *b*3 isoform of *b*-tubulin. The increased accumulation of actin in the CNS during pupal stages suggests an active role for microfilaments in nerve-cord shortening. Synthesis of actin as well as tubulin was stimulated by 20E.

HOLOMETABOLOUS insect metamorphosis is accompanied with neurogenesis, programmed cell death and reorganization of larval neurons to perform new functions in the adult central nervous system (CNS). During the transformation of larval CNS to that of adult, drastic reduction occurs in the length of the nerve cord and in the number of ganglia[1,2]. Active participation of the cytoskeletal components in cellular movements, extension of neurites, coiling or looping of axons, and resorption of axonic material in the CNS has been reported[3,4]. However, there is hardly any information on the role of cytoskeletal elements in the ganglionic fusion and nerve-cord shortening process during metamorphosis.

The mechanical explanation for changes in cell shape and motility during metamorphosis in insects lies in the assembly and movement of the cytoskeleton component.

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[†]A. S., A. A. and A. D. G. dedicate the paper to Ch. R. K. M., who passed away recently.