Comments on 'Early Eocene land mammals from Vastan Lignite Mine, District Surat (Gujarat), western India' by Bajpai, S. *et al.* published in Journal of the Palaeontological Society of India 50, 1: 101-113, 2005

K. Kumar
Wadia Institute of Himalayan Geology,
33, General Mahadeo Singh Road,
Dehradun 248 001
India
kumark@wihg.res.in

ISSN 1567-2158

Abstract

Bajpai *et al.*'s recent paper (2005a) describing an important new Early Eocene mammal fauna from the Cambay Shale of Vastan Lignite Mine, Gujarat, India has a number of errors related to identification, naming, definition, characterisation and description of new taxa, and measurements of dentitions etc. that need to be recorded and addressed. This contribution discusses and clarifies some of the errors and will be useful for understanding the real impact of the Vastan fauna in relation to the India-Asia collision, the mammalian palaeobiogeography and origin of modern placental mammals.

Contents

Abbreviations

H-GSP Howard University-Geological Survey of Pakistan; IITR/SB/VLM, Indian Institute of Technology, Roorkee/ Sunil Bajpai/ Vastan Lignite Mine
WIF/A Wadia Institute of Himalayan Geology, Dehradun

1. Introduction

A rich collection of mandibles, jaws and isolated dental remains of a very important diverse new Early Eocene terrestrial mammal fauna has recently been described from the Cambay Shale of Vastan Lignite Mine in Gujarat, India (Bajpai *et al.,* 2005a). The material is remarkably diverse and well preserved. The discovery of pre-middle Eocene land mammals from India was expected for some time particularly after reports of Early Eocene mammals from the lignite beds of the Ghazij Formation in Quetta, Kach-Harnai and Gandhera areas of Baluchistan, Pakistan (Gingerich *et al.,* 1997, 1998, 2001; Ginsburg *et al*., 1999) and more recent reports of lower vertebrates and associated mammals including some bats (Bajpai & Kapur, 2004; Rana *et al*., 2004; Sahni *et al*., 2004) from the same lignite mine of Vastan. I have seen equally diverse, well preserved and very similar material recovered from the same *Nummulites burdigalensis* Zone of the Cambay Shale of Vastan Lignite Mine in collection of Dr R.S. Rana of HNB Garhwal University, Srinagar (India) and his collaborators. Papers on some of this material are already published (Rana *et al*., 2005) and others are in press. The overall diversity (also including rodents, bats, ?primates and marsupials mentioned in Rana *et al*. (2005) and Bajpai *et al*. (2005a, b) and richness of the Early Eocene mammalian fauna from Vastan is truly amazing and has surpassed our expectations. The lower vertebrates are also quite diverse (Bajpai & Kapur, 2004; Rana *et al*., 2004). Most recently an exceptionally diverse and well preserved amber-embedded biota has also been reported from the Vastan Mine (Alimohammadian *et al*., 2005). I am sure that the Vastan land mammal assemblage will change our perspective and thinking on the Eocene land mammals of the Indian subcontinent in the context of the India-Asia collision and the mammalian palaeobiogeography. However, for now the new assemblage seems to have raised some more interesting questions like endemic versus migrant component, 'out of India' versus 'into India' migration etc. than answering the prevailing ones, *e.g.* timing of first dispersal, bilateral migration and India-Asia collision.

I would like to congratulate Bajpai and his team for discovery of such a marvellous collection of important fossil material and for scientific content of their paper. However, the overall palaeontological treatment meted out to such significant fossil material is disappointing. There are quite a few lacunae in the section dealing with the systematic palaeontology. The quality of this otherwise very important paper has been compromised particularly in terms of clarity in definition and characterisation of new taxa, accuracy of descriptions, objective comparisons with closely similar taxa, nomenclature and to some extent in identification, measurements and illustrations (?coloured photos in plates I - II have been of no help) of fossils. Although I have not yet seen the material or its casts I feel confident enough to write this commentary and clarify some of the errors that needed to be addressed for better understanding of the Early Eocene mammalian paleobiogeography.

2. General comments

The fossil material treated in Bajpai *et al.* (2005a) has been described as representing 7 genera and 10 species, all new with 2 new families (Vastanidae and Cambaytheriidae). The diagnoses of several new taxa lack clarity and no differential diagnoses have been given for any of the new families or genera. Even characters mentioned under 'Diagnosis' are at times inadequate and inconsistent with description (*e.g*., *Vastania*) and poorly defined in a few cases (*e.g*., *Suratilestes*), and comparisons with the allied taxa are at best minimal. The systematic placement of one of the families (Cambaytheriidae) and of a few genera (*e.g*., *Frugivastodon*, *Cambaytherium* and *Cambaya*) is debatable. Besides this a few taxa (*e.g*., *Cambaytherium* sp. 'A' and *C. minor*) are founded on inadequate material.

Curiously, the illustrations of representative specimens of fossil taxa in the three plates incorporated in the article are not arranged in the order in which they have been described in the text. For example the first plate comprises photos of *Cambaytherium* even though this taxon is described in the end. Likewise *Anthraryctes*, described in the beginning has its photos in the last plate. In case of *Cambaytherium bidens* both upper and lower dentitions represented by dentaries and maxillary/premaxillary fragments have been listed under the 'Referred material' yet the authors have illustrated only the lower dentaries designating them as holotype. Upper dentition has not been included in the type material despite the fact that one of the named diagnostic familial/generic characters is based on the upper teeth. Synonymy has not been given for the new genus *Gujaratia* even though it has been proposed to include all material previously referred to *Diacodexis pakistanensis*. No measurements are given for the new taxon *Gujaratia indica* even though it has been differentiated from previously known dichobunids based only on size. All this is unconventional and somewhat confusing.

In naming new taxa, authors have derived names of some genera/species from incomplete name of a character, location or person. For example *Frugivastodon* named after Vastan where it was found should have been named as '*Frugivastanodon'* and the species *Cambaytherium thewissi* named after Dr J.G.M. Thewissen should have been named *C.* '*thewisseni'*. Similarly, *C. bidens* so named because it has two incisors in its lower jaw should have been named *C. 'bidenta'*, *C. 'bidentus'* or *C. 'bidentatus'*. Also it would have been very appropriate and logical to name *C. thewissi* with three incisors in its lower jaw as *C. 'tridenta'*, *C. 'tridentus'* or

C. 'tridentatus'. As per the systematic lexicon, the correct name for *Vastania sahnia* named after Dr A. Sahni would have been *V. 'sahnii'*. The suffix 'therium' used in naming *Cambaytherium* is not common only for the perissodactyls as stated by the authors. It is a Greek word meaning animal, wild animal or wild beast and is frequently used in naming all kinds of mammals including marsupials.

In systematic palaeontology, description of the designated 'Type species' of a genus should precede that of its other species if any. Accordingly, *C. thewissi* should have had been described in the text first followed by *C. bidens* and or others. Authors have used 'Mx'/ 'mx' at several places under 'Referred material' (*e.g.* on pages 109-110) and elsewhere (*e.g.* in table 1). I could follow that it means a molar of an uncertain position in the jaw, but more often than not it is easy to tell the last molar from the anterior ones and therefore, instead of Mx/mx why not write 'anterior molar' or better still make it explicit and write 'm1 or m2'.

In table 2, dimensions of P4/ of *Cambaytherium bidens* have been either mixed up – numbers shown against width probably represent length and vice versa or the tooth has been wrongly identified, and it could actually be a P3/. Right M/1 of *C. bidens* holotype has been measured as 120 percent as large as left M/1 of the same individual – somewhat unusual. In a few cases measurements of teeth given in their description disagree with illustrations. For example in *Suratilestes gingerichi* relative width of M/1-M/3 (0.60, 0.86 and 0.93 mm) given in its description do not seem to match with its figure (3) in plate III.

3. Specific comments

Specific comments are given below genus wise. Familial and ordinal affinities of genera shown in parenthesis are *sensu* Bajpai *et al.* (2005a). References to plates and figures also pertain to plates and figures in Bajpai *et al.* (2005a).

Suratilestes (Cimolestidae, Proteutheria)

(Bajpai *et al*., 2005a: plate III, figures 1-3)

The genus is poorly defined; its diagnosis reads "Cimolestid with relatively long P/4 and anteriorly placed paraconid on M/1". The reader is left to guess (i) whether P/4 is longer in respect to adjacent teeth of *Suratilestes* or it is longer than P/4 of all other cimolestids or their molars, and (ii) actually how much longer it is. What is so special if the paraconid is placed anteriorly on M/1? A paraconid will always be anteriorly placed regardless of tooth position in a jaw, and it can well be seen anteriorly placed in all the three molars of *Suratilestes gingerichi* too (plate III, figure 3). The fact is that in M/1 of *S. gingerichi* it is particularly more anteriorly placed than the posterior molars and lies almost in the middle in front of protoconid and metaconid (plate III, figure 3).

Frugivastodon (Apatemyidae, Apatotheria)

(Bajpai *et al.,* 2005a: plate III, figures 7-9)

The basis of identification of the lone lower (?anterior) molar as an apatemyid is unclear and apparently ill-founded; there is no paraconid, which is present in all known apatemyids. This tooth has a strong resemblance with M/2 of an adapoid primate and lacks typical apatemyid characters. I think it may as well belong to an ?adapoid primate and therefore its comparison with Primates is absolutely necessary. In the past, apatemyids have been classified with primitive primates as well as insectivorans though presently they are included in their own order Apatotheria. There is no record of apatemyids outside Europe and North America (McKenna & Bell, 1997; Von Koenigswald *et al.,* 2005). The available evidence is clearly inadequate to announce the presence of Eocene apatemyids in India. Additional material will be necessary for its accurate taxonomic placement. "*P." cristatus* on page 104 is probably a typo for *F. cristatus*.

Vastania (Vastanidae, Insectivora)

(Bajpai *et al.,* 2005a: plate III, figures 4-6)

The familial diagnosis for Vastanidae based solely on P/4 morphology is inadequate and inconsistent with details given under 'Remarks'. It reads 'Erinaceomorphs with high protoconid on P/4 and straight and lingual cristid obliqua, lacking talonid basin'. *Vastania sahnia* is the only species under the family and authors' remarks on it read '[…] simple P/4 dominated by a single cusp, and with a talonid with a straight and labial cristid obliqua'. The genus has been diagnosed by similar-sized M/1 and M/2 with low cuspate paraconid. However, its

description giving size of lower molars as 1.11, 1.27 and 1.33 mm long and 0.66, 0.88 and 0.77 mm wide respectively contradicts this.

Cambaya (Nyctitheriidae, Insectivora)

(Bajpai *et al*., 2005a: plate III, figures 10-12)

This genus is based on and is known only by an isolated P/4, which shows typical chiropteran characters like a complete labial cingulum, a small metaconid and a very reduced talonid. I have seen Rana's collection of chiropteran dentitions from Vastan some of which is published (Rana *et al*., 2005) in the same issue of the journal as this paper of Bajpai *et al*. (2005a) and I think that the material referred to a new nyctithere *Cambaya* by Bajpai *et al.* (*ibidem*) may actually belong to a bat. Bajpai *et al.* (*ibidem*) have not compared their material with chiropterans although they have mentioned elsewhere in the text that their collection does contain bats.

Gujaratia (Dichobunidae, Artiodactyla)

(Bajpai *et al.,* 2005a: plate II, figures 4-6)

Authors have excluded *Diacodexis pakistanensis* known from the Middle Eocene of India and Pakistan (Thewissen *et al*., 1983, 1987, 2001; Kumar & Jolly, 1986) from *Diacodexis* based on the absence of a character in its upper molars - lingual side slightly extended posteriorly in the form of a rudimentary hypocone, and renamed it as *Gujaratia pakistanensis* designating it as the type species for the genus. They have differentiated the new species *Gujaratia indica* from *G. pakistanensis* based only on its larger teeth. However, the size difference has not been quantified and measurements for *G. indica* teeth are not given in the paper. A comparison between metrics of P/4-M/3 in holotypes of *D. pakistanensis* (HGSP 300 5003, P/4-M/3 length ~ 17 mm) and *G. indica* (IITR/SB/VLM 511, P/4-M/3 length ~ 18.8 mm) indicates that teeth of the new species are only about 110-115 percent as large as those for *Diacodexis* species. For this comparison I have used measurements of *D. pakistanensis* given in Thewissen *et al.* (1983: figure 1b & table 2) and of *G. indica* from its scaled figures in Bajpai *et al.* (2005a: plate II, figures 4-6). I do not think that such a small difference in size of teeth can qualify to be an independent specific character; but actual dimensions of *G. indica* may indicate greater difference. Unless it is established that *G. indica* is indeed distinct from *D. pakistanensis* the renaming of *D. pakistanensis* as *G. pakistanensis* cannot be held valid especially because upper molars of *G. indica* are yet to be found; so the presumed absence of a rudimentary hypocone in the upper molars of the Vastan species *Gujaratia indica* (as implied by Bajpai *et al*.'s diagnosis for *Gujaratia*) cannot be established. The available evidence does not support renaming of *Diacodexis pakistanensis* and I think it should have had waited at least until the discovery of upper molars of *Gujaratia*. It may be mentioned here that out of the material from Kalakot originally referred to *Diacodexis pakistanensis* by Kumar & Jolly (1986) one RM2/ (WIF/A 1611) was subsequently referred to an adapiform primate but rest of the material is still with *D. pakistanensis*.

Cambaytherium (Cambaytheriidae, Perissodactyla)

(Bajpai *et al*., 2005a: plate I, figures 1-8; plate II, figures 1-3 & 7-10)

Authors have described *Cambaytherium* as a perissodactyl under its own new Family Cambaytheriidae. However, its teeth look extremely similar to those of anthracobunids, which are known by several forms (*e.g. Anthracobune, Jozaria, Nakusia*) in India and Pakistan and at least one (*Hsanotherium*) in Myanmar and are generally classified under Tethytheria or Proboscidea (West, 1984; McKenna & Bell, 1997; Ginsburg *et al*., 1999; Ducrocq *et al*., 2000). Although some anthracobunids (*e.g. Pilgrimella*) were referred to Perissodactyla in the past (Coombs & Coombs, 1979), later they were all clubbed in a separate Family Anthracobunidae under the Proboscidea (Wells & Gingerich, 1983; Kumar, 1991). Presently Anthracobunidae is referred to Tethytheria (ancestors for elephants and sea cows) and is unique to India-Pakistan-Myanmar region. While its ordinal affinity can still be debated, the dentition of *Cambaytherium* looks closest to anthracobunids and therefore its comparison with dentition of anthracobunids was absolutely necessary. Surprisingly, Bajpai *et al.* (2005a) have not compared their *Cambaytherium* material with anthracobunids at all. I wonder if they have any associated post-cranial material to authenticate its affinity with perissodactyls? They do list a proximal astragalus under referred material of *C. bidens* but fail to describe, illustrate or even mention it in the text. This is important because morphology of P/4 of *Cambaytherium* is quite unlike that of perissodactyls.

In the familial diagnosis of Cambaytheriidae (presently undistinguishable from generic diagnosis of *Cambaytherium*), authors write 'paraconule and metaconule prominent' even though they have not illustrated

any upper teeth for the genus. Since Cambaytheriidae is presently represented by the type and only genus *Cambaytherium* with four species and the upper molar dentition of only *C. bidens* has been recognised by the authors, it must have had been included in the type material (either holotype or paratype) of this species. Otherwise how do we establish the paraconule - metaconule prominence as a generic/familial character?

It is curious to see that authors preferred IIT/SB/VLM 503 containing only the lower dentition (RC-RM/3 and LP/1-LM/3) as holotype for *Cambaytherium bidens* over IIT/SB/VLM 502, which contains lower as well as partial upper dentition (LP/1-LP/3, LM/1-LM/3, RP/3-RM/3 as well as RC/-RP1/, RP2/-RP/4, LC/). It has probably been favoured for the better preservation and less wear, but surely IIT/SB/VLM 502 qualifies to be designated as a paratype simply because it also contains the upper dentition, which partly forms the basis for diagnosis of the new family. *Cambaytherium bidens* is better known species of the genus represented by a large number of specimens with upper as well as lower teeth, therefore it should have been named as the type species instead of *C. thewissi,* which is founded only on the lower dentition though with less worn teeth. In diagnosis of *C. bidens* the authors mention presence of two lower incisors, but none of the type or referred specimens has been shown to possess I/1-I/2 or their alveoli. Incisors cannot be made out from illustrations probably because the specimens are all black, and they do not find a mention in description either. It is absolutely necessary that all characters included in the diagnosis of a species must show up either in the holotype or paratype. Likewise diagnosis of *C. thewissi* mentions that the species has three lower incisors but again details of specimens given under 'Holotype' do not indicate their presence or of their alveoli. Although in this case description does mention that the holotype has three alveoli for incisors, the same cannot be seen in the figure. The description of *C. bidens* mentions that there is a decrease in tooth size from P/2 to P/4 (table 2); actually it is not the tooth size but only the tooth length that decreases from P/2 to P/4.

The size difference between *C. thewissi* and *C. bidens* seems inadequate for separating them (*C. thewissi* has teeth 82-88 percent as large as those of *C. bidens*) and there is little or no difference in occlusal morphology of their teeth. However, presence of a diastema between P/1 and P/2 and two lower incisors in *C. bidens* against three in *C. thewissi* do support splitting. I wonder if by any chance *C. thewissi* dentaries could be of a juvenile, or the sexual dimorphism discussed by the authors based on canines has anything to do with this. I may well be wrong but I think it should be looked into because *C. thewissi* is based on more or less unworn dentaries of a single individual.

The third species, *C. minor* represented by two isolated heavily worn partially broken anterior lower molars has been diagnosed as smaller than other *Cambaytherium* and approximately 75 percent as large as *C. thewissi*. The length of its holotype molar (10.5 mm) is very close to those for M/1s in holotypes of *C. thewissi* (11.0-11.3 mm) and *C. bidens* (10.8-13.0 mm) but the width is much less (only 5.3 mm against 8.0 mm in *C. thewissi* and 9.1 mm in *C. bidens*). So if *C. minor* has to be separated from other species it can be, but based on its much narrower tooth (only 66 and 58 percent as wide as M/1s of *C. thewissi* and *C. bidens* respectively) rather than smaller tooth. Its heavily worn and low crown (pl. II, figures 9-10) raises the question if the tooth could be a deciduous? I think the authors should have waited for additional material before designating it a new species.

The identification of fourth species (unnamed), *Cambaytherium* sp. 'A' is based only on an isolated presumed P2/ (IITR/SB/VLM 549). It has been diagnosed as 130 percent as large as *C. bidens*. A comparison of its dimensions with those for P2/ of *C. bidens* given in Bajpai *et al*.'s (2005a) table 2 indicates that it is 121 percent as long and 102 percent as wide as *C. bidens*. Therefore, the tooth is more elongated than P2/ of *C. bidens* rather than larger. I wonder if this presumed P2/ could actually be a P3/ of *C. bidens* because often the main difference between these two teeth is of size. In the absence of a morphological description no further comments can be made.

4. Concluding remarks

This critique is the result of a keen and careful study of Bajpai *et al*.'s (2005a) paper. I was prompted to pen it owing to my deep interest in the Early Tertiary mammalian faunas of India as I myself have been working on the same though mostly from Himalaya and secondly because I think it is necessary for understanding the real importance of the Vastan mammal fauna in relation to the India-Asia collision, the mammalian palaeobiogeography and origin of modern placental mammals. By raising the concern I do not mean to undermine the scientific value of the paper. My only intention is to highlight the problems so that these could be redressed in the next communication on Vastan material. I fully understand palaeontologists' (including me) keenness in publishing the new material quickly but I am against casual documentation particularly of occurrences of new taxa just to speed up the publication of an article. With description of as many as 10 new species the paper in question will be taken as a key contribution on Vastan mammalian fauna so it ought to have contained maximum and correct information on all the named taxa. Else the authors could have put up a small note announcing the discovery and then following up with detailed taxonomic treatment of the material.

It is curious that out of a total of 14 new mammalian species representing 9 new genera recorded from Vastan (Bajpai *et al.,* 2005a, b), 12 are based on lower dentition, and the upper dentition has not been recognised for any of them except *C. bidens.* The two remaining species, *viz. Anthraryctes vastanensis* and *Cambaytherium* sp. A are known only by solitary isolated M3/ and P2/ respectively. So skulls and maxillae of 14 or more species are waiting to be discovered. As most of the open mines are non-static, enough samples should be taken as soon as possible. I am sure both Rana's and Bajpai's teams will be aware of this and will do all that is required. I thank the PalArch Foundation in advance for considering publication of my views on an important research paper.

5. Cited literature

Alimohammadian, H., A. Sahni, R. Patnaik, R.S. Rana & H. Singh. 2005. First record of an exceptionally diverse and well preserved amber-embedded biota from Lower Eocene (~ 52 Ma) lignites, Vastan, Gujarat.- Current Science 89, 8: 1328-1330.

Bajpai, S. & V.V. Kapur. 2004. Oldest known gobiids from Vastan Lignite Mine (early Eocene), District Surat, Gujarat. - Current Science 87, 4: 433-435.

Bajpai, S., V.V. Kapur, D.P. Das, B.N. Tiwari, N. Sarvanan & R. Sharma. 2005a. Early Eocene land mammals from Vastan Lignite Mine, District Surat (Gujarat), western India. - Journal Palaeontological Society of India 50, 1: 101-113.

Bajpai, S., V.V. Kapur, J.G.M. Thewissen, B.N. Tiwari & D.P. Das. 2005b. First fossil marsupials from India: Early Eocene *Indodelphis* n. gen. and *Jaegeria* n. gen. from Vastan lignite mine, District Surat, Gujarat. - Journal of the Palaeontological Society of India 50, 1: 147-151.

Coombs, W.P. & M.C. Coombs. 1979. *Pilgrimella*, a primitive Asiatic perissodactyl. - Zoological Journal of Linnean Society 65: 165-192.

Ducrocq, S., A.N. Soe, B. Bo, M. Benammi, Y. Chaimanee, T. Tun, T. Thein & J.J. Jaeger. 2000. First record of an Anthracobunidae (Mammalia, ?Tethytheria) from the Eocene of Pondaung Formation, Myanmar. - Comptes Rendus de l'Acadèmie des Sciences de Paris, Earth and Planetary Sciences 330: 725-730.

Gingerich, P.D., S.G. Abbas & M. Arif. 1997. Early Eocene *Quettacyon parachai* (Condylarthra) from the Ghazij Formation of Baluchistan (Pakistan): oldest Cenozoic land mammal from South Asia. - Journal of Vertebrate Paleontology 17, 4: 629-637.

Gingerich, P.D., M. Arif, I.H. Khan & S.G. Abbas. 1998. First Early Eocene land mammals from the Upper Ghazij Formation of the Sor Range, Baluchistan. In: **Ghaznavi, M.I., S.M. Raza & M.T. Hasan. Eds. 1998.** Siwaliks of South Asia. - Proceedings 3rd GEOSAS Workshop, Islamabad, Geological Survey of Pakistan: 1-17.

Gingerich, P.D., M. Arif, I.H. Khan, M.-U. Haq, J.I. Bloch, W.C. Clyde & G.F. Gunnell. 2001. Gandhera quarry, a unique mammalian fossil assemblage from the Early Eocene of Baluchistan (Pakistan). In: **Gunnell, G.F. Ed. 2001.** Eocene vertebrates: unusual occurrences and rarely sampled habitats. - New York, Plenum Press: 251-262.

Ginsburg, L., K.H. Durrani, A.M. Kassi & J.-L. Welcomme. 1999. A new anthracobunid mammal from the Kach-Harnai lignites of Baluchistan. - Comptes Rendus de l'Acadèmie des Sciences de Paris, Earth and Planetary Sciences, Series II 328: 23-31.

Koenigswald, Von, W., K. Rose, L. Grande & R. Martin. 2005. Die Lebensweise eozäner Säugetiere (Pantolestidae und Apatemyidae) aus Messel (Europa) im Vergleich zu neuen Skelettfunden aus dem Fossil Butte Member von Wyoming (Nordamerika).- Geologisches Jahrbuch Hessen 132: 43-54.

Kumar, K. 1991. *Anthracobune aijiensis* sp. nov. (Mammalia: Proboscidea) from the Subathu Formation, Eocene north-western Himalaya, India. - Geobios 24, 2: 221-239.

Kumar, K., M.W. Hamrick & J.G.M. Thewissen. 2002. Middle Eocene prosimian primate from the Subathu Group of Kalakot, northwestern Himalaya, India.- Current Science 83, 10: 1255-1259.

Kumar, K. & A. Jolly. 1986. Earliest artiodactyl (*Diacodexis*, Dichobunidae: Mammalia) from the Eocene of Kalakot, north-western Himalaya, India. - Bulletin of the Indian Society of Geoscientists 2: 20-30.

McKenna, M.C. & S.K. Bell. 1997. Classification of mammals above the species level. – New York, Columbia University Press.

Rana, R.S., K. Kumar & H. Singh. 2004. Vertebrate fauna from the subsurface Cambay Shale (Lower Eocene) Vastan Lignite Mine, Gujarat, India.- Current Science 87, 12: 1726-1733.

Rana, R.S., H. Singh, A. Sahni, K.D. Rose & P.K. Saraswati. 2005. Early Eocene Chiropterans from a new mammalian assemblage (Vastan Lignite Mine, Gujarat, western peninsular margin): oldest known bats from Asia.- Journal of the Palaeontological Society of India 50, 1: 93-100.

Sahni, A., R.S. Rana, R.S. Loyal, P.K. Saraswati, S.K. Mathur, K.D. Rose, S.K.M. Tripathi & R. Garg. 2004. Western margin Palaeocene-Lower Eocene lignites: biostratigraphic and palaeoecological constraints.- 2nd Conference & Exhibition, Association of Petroleum Geologists: 1-18.

Thewissen, J.G.M., P.D. Gingerich & D.E. Russell. 1987. Artiodactyla and Perissodactyla (Mammalia) from the Early-Middle Eocene Kuldana Formation of Kohat (Pakistan). – Contributions from the Museum of Paleontology, University of Michigan 27, 10: 247-274.

Thewissen, J.G.M., D.E. Russell, P.D. Gingerich & S.T. Hussain. 1983. A new dichobunid artiodactyl (Mammalia) from the Eocene of North-west Pakistan. – Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Ser B 86, 2: 153-180.

Thewissen, J.G.M., E.M. Williams & S.T. Hussain. 2001. Eocene mammal faunas from northwestern Indo-Pakistan. - Journal of Vertebrate Paleontology 21, 2: 347-366.

Wells, N.A. & P.D. Gingerich. 1983. Review of Eocene Anthracobunidae (Mammalia, Proboscidea) with a new genus and species, *Jozaria palustris*, from the Kuldana Formation of Kohat (Pakistan). – Contributions from Museum of Paleontology, University of Michigan 26, 7: 117-139.

West, R.M. 1984. A review of the South Asian Middle Eocene Moeritheriidae (Mammalia: Tethytheria). – Mémoires de la Société Géologique de France, N.S. 147: 183-190.

Submitted: 3 October 2005
Published: 1 January 2006