Advances in Vertebrate Paleontology and Geochronology, edited by Y. Tomida, L. J. Flynn, and L. L. Jacobs, pp. 145–166. National Science Museum Monographs, No. 14, Tokyo, 1998

TAPHONOMY OF SMALL-MAMMAL FOSSIL ASSEMBLAGES FROM THE MIDDLE MIOCENE CHINJI FORMATION, SIWALIK GROUP, PAKISTAN

Catherine Badgley[1], Will Downs[2], and Lawrence J. Flynn[3]

[1]Museum of Paleontology, University of Michigan, Ann Arbor, MI 48109–1079, USA
[2]Bilby Research Center, Northern Arizona University, Flagstaff, AZ 86011, USA
[3]Peabody Museum, Harvard University, Cambridge, MA 02138, USA

Abstract This study focuses on taphonomy of small-mammal remains from the Lower Siwalik Chinji Formation in the stratotype area. From a stratigraphic interval about 20 m thick that extends laterally for 12 km, we prospected in all sedimentary facies for small-vertebrate concentrations. Thirteen sites were documented, most from facies representing abandoned floodplain channels. Screen-washed samples varied in richness, with sites yielding 0–256 identifiable small-mammal teeth. The sediment matrix ranged from fine conglomerate to silty clay. Based on sedimentological and taphonomic criteria, we propose that all concentrations were primary biological accumulations, in some instances with secondary fluvial reworking. Vertebrate predators were the probable agents of accumulation. The taxonomic composition of small-mammal assemblages varied little among sites; variation in lithology had no effect on the frequency of specimens at the family level. A mixture of arboreal, burrowing, and terrestrial small mammals was present; most species were terrestrial herbivores. Based on large and small mammals from the lower Chinji Formation, a seasonal woodland with riparian areas of forest was the likely vegetation.

Introduction

Species of small mammals (those less than ~1 kg in body weight) comprise at least half of the mammalian biodiversity of most modern terrestrial ecosystems, and rich mammalian fossil assemblages document this pattern throughout the history of mammals. In this study, we survey the depositional environments and taxonomic composition of small-mammal fossil assemblages from Neogene Siwalik fluvial sequences of Pakistan. The goals of the study are to characterize the taphonomy of small-mammal fossil assemblages, to evaluate variability in taxonomic composition of contemporaneous small-mammal assemblages from the paleoenvironments represented, and to infer ecological and taphonomic factors that created the patterns of preservation observed in this Siwalik sequence.

Sediments of the Siwalik Group (Fatmi, 1973; Shah, 1977; Willis and Behrensmeyer, 1995) form a thick Neogene molasse that accumulated on the southern margin of the

Himalayas and outcrop today in extensive but discontinuous exposures from Afghanistan to Burma (Myanmar). Locally, Siwalik sequences represent virtually uninterrupted deposition from the early Miocene to mid-Pleistocene. Siwalik vertebrate fossils have been documented since the nineteenth century. Siwalik sediments vary greatly in fossil productivity; the most fossiliferous areas studied to date are the Siwalik Hills, near Haritalyangar, India, and the Potwar Plateau of northern Pakistan (Pilbeam *et al.,* 1977). An outline of Siwalik mammalian biochronology was developed early in the twentieth century by Pilgrim (1910, 1913), Lewis (1937), and Colbert (1935a, b, c).

Since the mid-1970's, there has been renewed interest in Siwalik sediments as a record of fluvial response to Himalayan uplift and in Siwalik faunas as a South Asian theater of mammalian evolution. Siwalik sediments of the Potwar Plateau (Fig. 1) have been documented in terms of changes in sedimentary facies corresponding to Siwalik formations (Shah, 1977), lateral and vertical changes in the fluvial systems that produced the large-scale facies (Willis, 1983b), geochronology through paleomagnetic stratigraphy (e.g., N. M. Johnson *et al.,* 1982) and fission-track dating of ash layers (G. D. Johnson *et al.,* 1982), and stable-isotope geochemistry of paleosol carbonates and their paleoclimatic implications (Quade *et al.,* 1995). Siwalik faunas of the Potwar Plateau have been documented in terms of mammalian biochronology and evolution (e.g., Barry *et al.,* 1982; Flynn *et al.,* 1995), taphonomy and paleoecology of mammalian fossil assemblages (e.g., Badgley *et al.,* 1995), and faunal turnover in relation to paleoenvironmental change (Badgley and Behrensmeyer, 1995). Much of this work is still ongoing. Everett Lindsay was a major contributor to constructing paleomagnetic reference sections of the Potwar Plateau

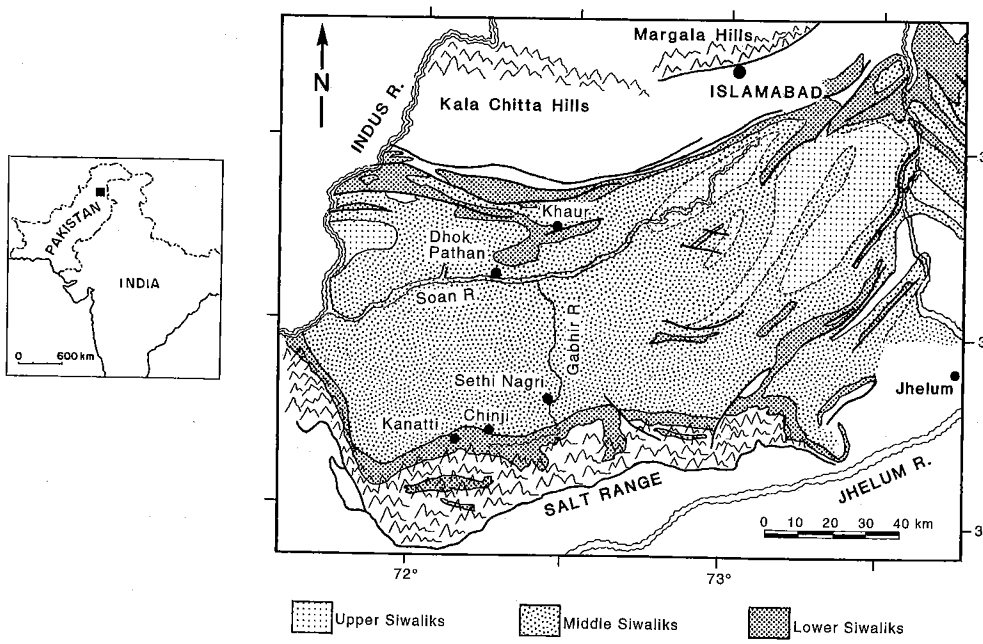

Fig. 1. Map of the Potwar Plateau with the distribution of Siwalik Group sediments. The study interval is southeast of Chinji village in the Lower Siwalik Chinji Formation.

(e.g., N. M. Johnson *et al.*, 1982) and establishing the taxonomy and biostratigraphy of Siwalik small mammals (e.g., Lindsay *et al.*, 1980; Barry *et al.*, 1982; Lindsay, 1988).

The earliest Siwalik biochronologies were based primarily upon large mammals (e.g., Pilgrim, 1913; Colbert, 1935b), because surface-collecting focused on them. Only when Lindsay and several of his students conducted intensive screen-washing campaigns did small primates, tree shrews, rodents, and insectivores emerge in large numbers from Siwalik fossil localities. A detailed picture of small-mammal systematics and biochronology followed (e.g., Jacobs, 1978; Flynn, 1982; Jacobs *et al.*, 1989; Lindsay, 1988; see also Flynn *et al.* (this volume)). Now, mammalian biochronology and faunal turnover from the Potwar Plateau are based equally on records of large and small mammals (Barry *et al.*, 1982, 1995).

Siwalik taphonomy has focused primarily on large-mammal remains (Badgley and Behrensmeyer, 1980; Raza, 1983; Badgley, 1986; Badgley *et al.*, 1995). This study is the first

Table 1. Small mammals known from the Chinji Formation, Potwar Plateau, Pakistan. All taxa listed have been recovered by us and our colleagues over the last 20 years, with the exception of *Sivacanthion*, reported by Colbert (1935c).

- Insectivora
  - Erinaceidae
    - *Galerix rutlandae*
    - cf. *Echinosorex* sp.
    - *Amphechinus kreuzae*
  - Soricidae
    - Large, gen. et sp. indet.
    - Crocidurinae, gen. & sp. indet. A
    - Crocidurinae, gen. & sp. indet. B
- Chiroptera
  - Small gen. & sp. indet.
- Scandentia
  - Tupaiidae
    - Gen. & sp. indet. A
    - Gen. & sp. indet. B
- Primates
  - Adapidae
    - *Sivaladapis* sp.
  - Lorisidae
    - Gen. & sp. indet.
- Rodentia
  - Sciuridae
    - Large Sciurinae, gen. & sp. indet.
    - *Eutamias urialis*
    - *Ratufa* sp.
    - *Heteroxerus* sp.
    - Petauristinae, gen. & sp. indet.
    - cf. *Hylopetes* sp.
  - Gliridae
    - cf. *Myomimus* sp.
  - Ctenodacytlidae
    - *Sayimys sivalensis*
    - *Sayimys chinjiensis*
    - *Sayimys* sp. B[1]
  - Thryonomyidae
    - *Kochalia geespei*
    - *Paraulacodus indicus*
  - Rhizomyidae
    - *Prokanisamys* cf. *P. benjavuni*
    - *Kanisamys indicus*
    - *Kanisamys nagrii*
    - *Kanisamys potwarensis*
  - Muridae
    - *Antemus chinjiensis*
    - *Progonomys* sp.
  - Cricetidae
    - *Dakkamys barryi*
    - *Dakkamys asiaticus*
    - *Paradakkamys chinjiensis*
    - *Dakkamyoides lavocati*
    - *Dakkamyoides perplexus*
    - *Punjabemys mikros*
    - *Punjabemys downsi*
    - *Megacricetodon aguilari*
    - *Megacricetodon sivalensis*
    - *Megacricetodon mythikos*
    - *Megacricetodon daamsi*
    - *Myocricetodon* sp.
    - *Democricetodon* A[2]
    - *Democricetodon* B-C
    - *Democricetodon kohatensis*
    - *Democricetodon* E
    - *Democricetodon* F
    - *Democricetodon* G
    - *Democricetodon* H
  - Hystricidae
    - *Sivacanthion complicatus*

Notes: [1]terminology of Baskin (1996); [2]*Democricetodon* species from Lindsay (1996).

to focus on small-mammal taphonomy. We examined a narrow stratigraphic interval from the Lower Siwalik Chinji Formation for both empirical and logistical reasons. First, small-mammals from the Chinji Formation have been collected from numerous stratigraphic levels, and the taxonomy of small-mammals is well established for most groups (Table 1). From the study interval, several rich fossil localities were known to have yielded large samples of both large- and small-mammal fossils before our study began. Second, paleomagnetic reversal boundaries and marker sandstones have been traced laterally for over 10 km within this part of the Chinji Formation (Sheikh, 1984; Johnson *et al.*, 1988). Also, a detailed lateral facies study focused on the distribution of paleosols in relation to channels and floodplains (Behrensmeyer, 1987; Behrensmeyer *et al.*, 1995).

The study interval lies in the lower third of the type section of the Chinji Formation (Fig. 2). Magnetic reversal boundaries, documented in multiple short stratigraphic sections, are tied into the Siwalik paleomagnetic reference section (Fig. 3; Johnson *et al.*, 1988). Correlation to the geomagnetic polarity timescale of Cande and Kent (1995) results in an age estimate of 13.7–13.4 Ma for the study interval.

Four sets of research questions guided this study. (1) In which facies are small-mammal assemblages found? How do the environments of fossil preservation compare to the range of originally habitable environments represented? (2) What agent(s) of accumulation created the small-mammal fossil assemblages? What kinds of preservation bias were introduced by these agents? (3) Is variability in the taxonomic composition and

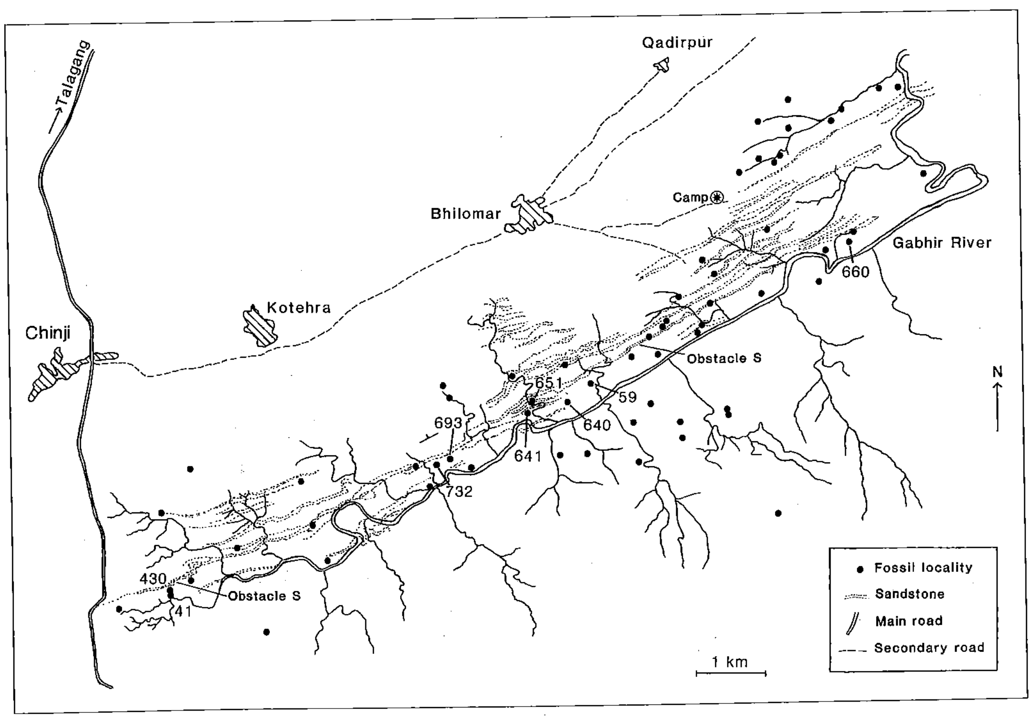

Fig. 2. Stratotype area for the Chinji Formation. The study interval extends from Locality 430 in the southwest to Locality 660 in the northeast. Only those localities sampled for this study are numbered.