

325 mm; altitude 286 m asl). These nests were observed daily for 2 h (4.00 pm to 6.00 pm) from the period of nest site-selection till the chicks fledged. Birds approaching the nests were caught using mist nets and marked with a non-toxic dye (Fevicryl fabric paint) of different colours. The number of marked helpers per nest was noted. The helpers involved in feeding the brooding female, nestling and fledgling were noted. Those which were defending the nests were also counted. Observations were made from close vicinity of the nests of the common babblers to record the clutch size, hatching and fledgling success per nest. The average number of eggs laid, hatched and young fledged was calculated. The number of nests built by the common babbler without helpers, with one helper and with two helpers was 18, 14 and 4, respectively in 10 km<sup>2</sup> of the field. In fourteen nests, one helper each was found to engage itself in feeding the brooding female, nestling and fledgling, and defending the nests. They were not found to help in nesting and incubation. Similarly, two helpers each in four nests were found to carry out activities like feeding of the brooding female, nestling and fledgling, and defending the nests. They also did not participate in nesting and incubation.

The total number of eggs in all the eighteen nests of the common babbler without helpers was 56. It was 46 and 14 in fourteen nests with one helper and four nests with two helpers, respectively. The average clutch size, number

of young hatched and young fledged were respectively  $3.1 \pm 0.1$ ,  $2.28 \pm 0.21$  and  $1.72 \pm 0.11$  in the nests of the common babbler without helpers, while it was  $3.32 \pm 0.2$ ,  $2.71 \pm 0.19$  and  $1.93 \pm 0.1$  in the nests with one helper. The average clutch size, number of young hatched and young fledged were comparatively higher, i.e.  $3.5 \pm 0.14$ ,  $3.0 \pm 0.1$  and  $2.5 \pm 0.1$ , respectively in the nests with two helpers. The differences are however not statistically significant ( $P > 0.05$ ). It was also noticed that in the nests with helpers, the nestling grew rapidly and all the chicks fledged earlier, compared to nests without helpers. None of the nests helped were predated.

The number of nests without helpers is higher compared to nests with one or two helpers in the arid-zone common babbler. This may be due to the omnivorous habit of the bird<sup>13</sup>. Our findings of helpers in the common babbler are similar to those of the jungle babbler, the Arabian babbler, the grey-crowned babbler and the white-headed babbler, except that in the Arabian babbler the helpers also play the role of obstructors<sup>8-12</sup>.

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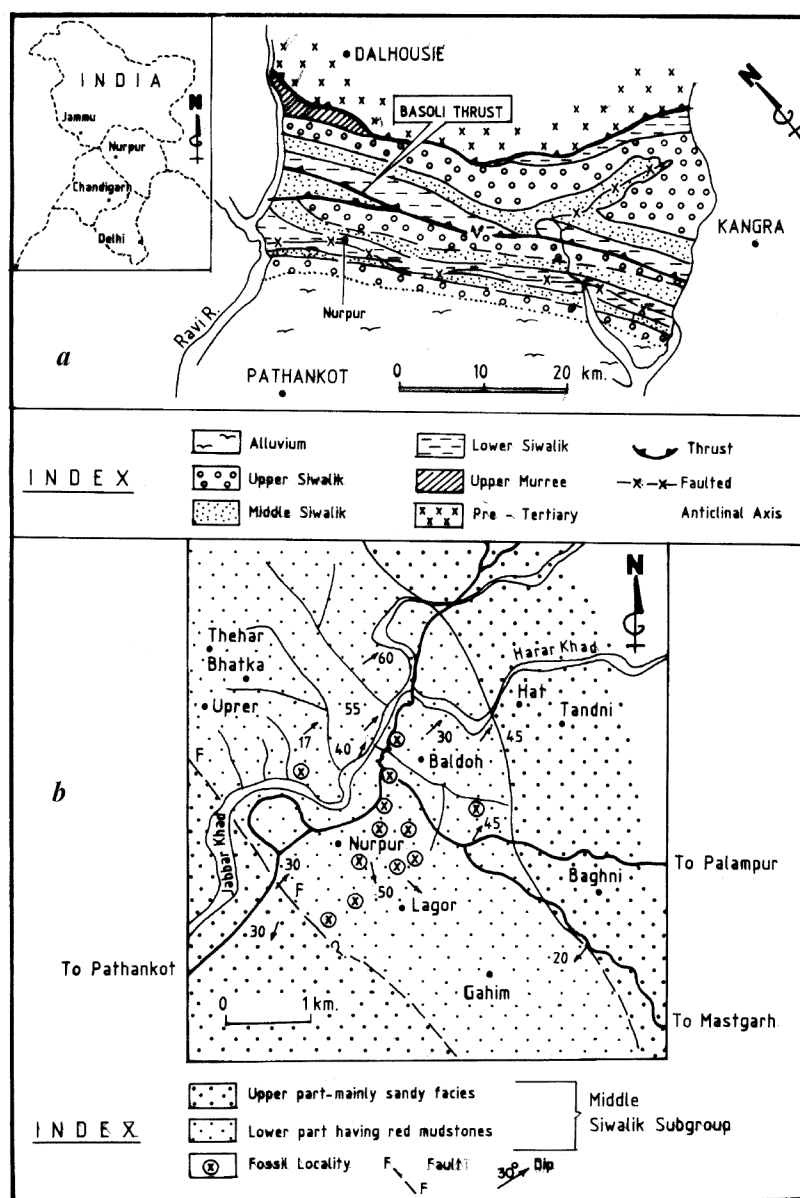
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## Age of the fossiliferous Siwalik sediments exposed in the vicinity of Nurpur, District Kangra, Himachal Pradesh

The Siwalik Group, forming the southernmost foothills of the Himalaya, is represented by fluviatile sediments. This 7-km thick succession is divided into three subgroups: Lower, Middle and Upper. The Lower Siwalik Subgroup contains dominantly red mudstones that alternate with fine-to-medium, grey and compact sandstones. The presence of red mudstones exposed in the basal part of the Siwalik Group is

generally taken as characteristic for the Lower Siwalik Subgroup. A thick succession of fossiliferous red mudstones is exposed in the vicinity of Nurpur (Kangra, Himachal Pradesh). The Siwalik Group here forms an anticline, the axis of which is faulted and passes near the Nurpur Fort<sup>1,2</sup>. The red-bed succession is exposed in the core and the base of the succession is not exposed. The exposed red-bed succession is about

1100 m thick. In general, the succession is dipping towards NE to ENE with dip amounts of 4–5° in the basal part and increasing to 65° upwards in the succession. In the uppermost part of the section, the beds are erected vertically or are even overturned. A fresh *in situ* collection has been made from these red beds, to interpret the age of these beds. For better resolution, faunas described by earlier workers are also undertaken.



**Figure 1.** *a*, Regional geological map of Nurpur area. The township of Nurpur lies on the Lower Siwalik Subgroup (after Karunakaran and Ranga Rao<sup>1</sup>); *b*, Detailed geological map of Nurpur area showing extension of red-bed succession (= Dhok Pathan Formation) and important fossil localities.

The vertebrate fossils are known from Nurpur since 1913, when *Hipparion* and *Amphicyon* were reported from the red-bed succession. At that time these sediments were correlated with the Chinji Formation of the Lower Siwalik Subgroup<sup>3</sup>. Scientists at ONGC<sup>1,2</sup> also mapped these sediments as belonging to the Lower Siwalik Subgroup. Later workers<sup>4-6</sup>, on the basis of fossils, considered the Nurpur beds as transitional between the Chinji and Nagri formations, i.e. between the Lower and Middle Siwalik. However, we<sup>7</sup> have referred

this fossiliferous Siwalik succession to the Middle Siwalik Subgroup and opined that the Lower Siwalik sediments are absent in Nurpur. But no definite age was given at that time (Figure 1).

The fossil hipparionine (includes species of *Hipparion* and *Cormohipparion*) has been reported by almost all the workers from the Siwalik succession of Nurpur. The presence of hipparionine itself indicates a Middle Siwalik age, as it is now well established that the hipparionine made their

first appearance in the Middle Siwalik<sup>7-10</sup>. Recently, the lower limit of hipparionine in the Indian subcontinent is marked at 10.4 Ma<sup>11</sup>. In addition to hipparionines, we have collected *Dicoryphochoerus vinayaki* and *Hydaspitherium megacephalum*, from Nurpur (Figure 2). Both the species are restricted to the Dhok Pathan Formation (upper part of the Middle Siwalik Subgroup) of the type area in Pakistan<sup>12</sup>. Earlier workers<sup>4-6</sup> reported *Propotamochoerus hysudricus*, *Merycopotamus dissimilis*, *Tetralophodon* sp. and

**Table 1.** Faunal assemblage from Nurpur with its stratigraphic range (after refs 4–7, 13)

Order family/species	Lower Siwalik Chinji	Middle Siwalik	
		Nagri	Dhok Pathan
REPTILIA			
Crocodylidae			
<i>Crocodylus</i> sp.	+	+	+
Chelonidae			
<i>Trionyx</i> sp.	+	+	+
CARNIVORA			
<i>*Dissopsalis carnifex</i>	+	+	—
<i>Amphicyon palaeindicus</i>	+	+	+
PROBOSCIDEA			
<i>Deinotherium</i> sp.	+	+	+
<i>Tetralophodon</i> sp.	—	—	+
PERISSODACTYLA			
Rhinocerotidae			
<i>*Aceratherium perimense</i>	+	+	+
<i>Gaindatherium browni</i>	+	+	+
Equidae			
<i>Cormohipparion theobaldi</i>	—	+	+
<i>Hipparion antelopinum</i>	—	+	+
ARTIODACTYLA			
Suidae			
<i>Listriodon pentapotamiae</i>	+	+	+
<i>Propotamochoerus hysudricus</i>	+	+	+
<i>*Dicoryphochorus vinayaki</i>	—	—	+
<i>?Tetraconodon minor</i>	—	+	—
Anthracotheridae			
<i>Merycopotamus dissimilis</i>	—	—	+
Tragulidae			
<i>Dorcabune</i> sp.	+	+	+
<i>Dorcatherium majus</i>	+	+	+
<i>*D. minus</i>	+	+	+
<i>D. nagrii</i>	+	+	+
Giraffidae			
<i>Giraffokeryx punjabiensis</i>	+	+	—
<i>Bramatherium megacephalum minus</i>	—	—	+
<i>*Hydasphitherium megacephalum</i>	—	—	+
Bovidae			
<i>?Protragocerus gluten</i>	+	+	+

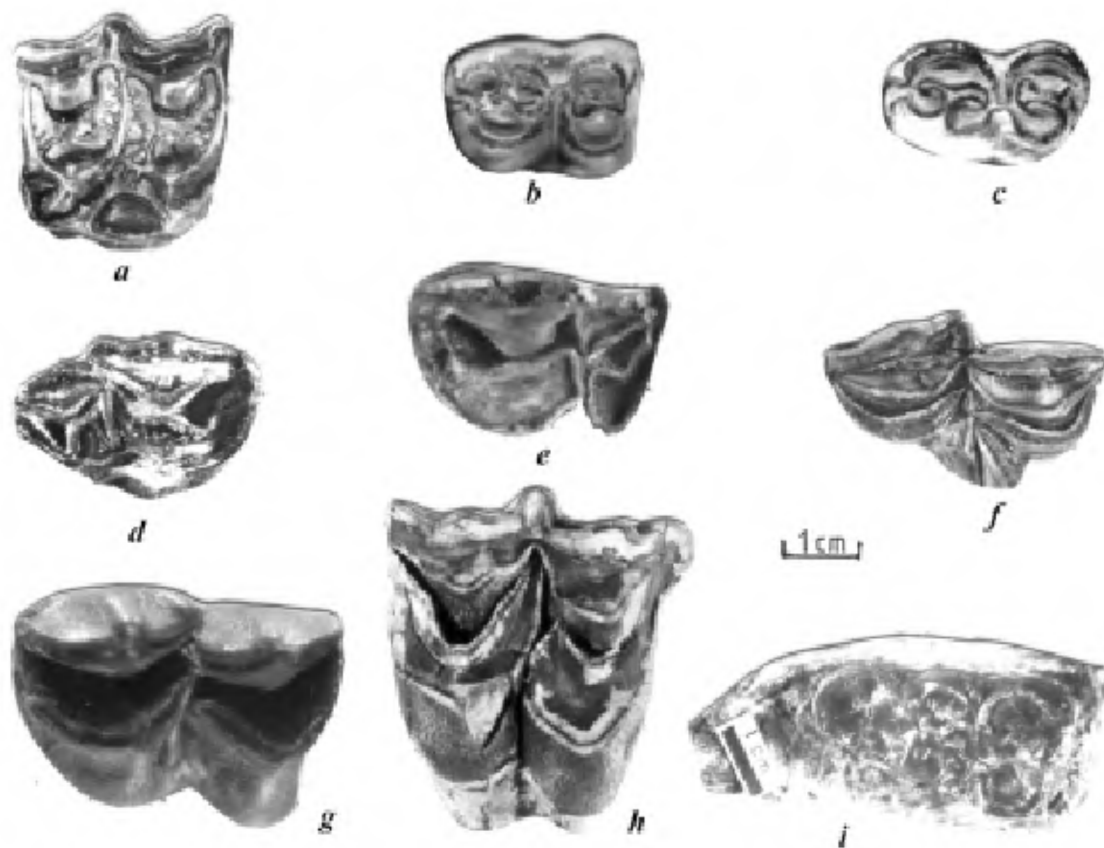
\*Reported by the authors.

–, Stratigraphic ranges after refs 12, 16–18.

*Bramatherium megacephalum minus* from Nurpur area. *P. hysudricus* and *M. dissimilis* make their first appearance in the Dhok Pathan Formation and are not known from the older Nagri Formation<sup>12</sup>. *B. megacephalum minus* and *Tetralophodon* sp. are restricted only to the Dhok Pathan Formation in the type area. Moreover, there is not even a single typical Chinji taxon in the present collection or in the collection made by earlier workers (Table 1). Most of the other species (*Amphicyon palaeindicus*, *Listriodon pentapotamiae*, *Dorcabune* sp., *Dorcatherium* spp., *Giraffokeryx punjabiensis* and *Protragocerus gluten*) range from the Chinji to Dhok Pathan Formation and are recorded from the Nurpur beds.

The magnetostratigraphic studies are very scanty; only one study has been carried out and that shows the Siwalik succession of Nurpur spans a time interval between 8.14 and 2.5 Ma (the succession also includes the Upper Siwalik Subgroup)<sup>13</sup>. The base of the Dhok Pathan Formation is dated 7.9 Ma in the type section in Potwar Plateau<sup>14</sup>. It implies that the oldest Siwalik sediments in Nurpur are approximately equivalent to the Dhok Pathan Formation. Four biostratigraphic interval-zones are proposed in Potwar Plateau, Pakistan in which the biostratigraphic studies are clubbed with magnetostratigraphic ages<sup>15</sup>. These zones are *Hipparion* sl. Interval-Zone; *Selenoportax lydekkeri* Interval-Zone; *Hexaprotodon sivalensis* Interval-Zone

and *Elephas planifrons* Interval-Zone. It is noticed that the Nurpur assemblage is comparable to *S. lydekkeri* Interval-Zone (7.4 to 5.3 Ma). *Propotamochoerus hysudricus*, *Dorcatherium majus* and large giraffe such as *Hydasphitherium megacephalum*, and *Bramatherium megacephalum* are present both in Nurpur beds and *S. lydekkeri* Interval-Zone of Barry *et al.*<sup>15</sup>. Moreover *Deinotherium* sp. and *Dorcatherium nagrii* became extinct in *S. lydekkeri* Interval-Zone and are present in Nurpur beds. These taxa are not known in the succession younger to the Dhok Pathan Formation. *S. lydekkeri* Interval-Zone is referred as roughly corresponding to the Dhok Pathan faunal zone of Pilgrim in faunal content as well as in time span<sup>15</sup>.



**Figure 2.** Characteristic Middle Siwalik fossils (= Dhok Pathan Formation) from Nurpur (all figures in natural size). **a**, *Cormohipparion theobaldi* (WIF/A 1415) – RM<sup>1</sup>; **b**, *C. theobaldi* (WIF/A 1418) – RM<sub>2</sub>; **c**, *C. theobaldi* (WIF/A 1419) – LM<sub>2</sub>; **d**, *Hydasphitherium megacephalum* (WIF/A 1510) – RP<sub>4</sub>; **e**, *H. megacephalum* (WIF/A 1511) – LP<sub>4</sub>; **f**, *H. megacephalum* (WIF/A 1512) – LM<sub>1</sub>; **g**, *H. megacephalum* (WIF/A 1513) – LM<sub>2</sub>; **h**, *H. megacephalum* (WIF/A 1509) – RM<sub>3</sub>; and **i**, *Dicoryphochoerus vinayaki* (WIF/A 1439) – RM<sub>3</sub>.

The affinity of the Nurpur mammalian assemblage represented by *P. hysudricus*, *D. vinayaki*, *H. megacephalum*, *Tetralophodon* sp. and *Bramatherium megacephalum minus* with the Dhok Pathan Formation, supports our view that the Nurpur beds are equivalent to the Dhok Pathan Formation. No mammalian taxa having affinity with the Lower Siwalik Subgroup is present in Nurpur. The red mudstones, which are taken as characteristic for the Lower Siwalik Subgroup are time-transgressive, as elsewhere in Potwar Plateau, Ramnagar (J&K) and Dang Valley, Nepal these beds have yielded the Chinji fauna belonging to the Lower Siwalik Subgroup.

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