

## TWO UPPER SIWALIK (PINJOR STAGE) FOSSIL ACCUMULATIONS FROM LOCALITIES 73 AND 362 IN THE PABBI HILLS, PAKISTAN

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### ABSTRACT

The small fossil accumulations from localities 73 and 362 in the Pabbi Hills, Pakistan, are ca. 1.2 – 1.4 and 1.7 – 1.9 Ma-old respectively, and are primarily interesting because of their carnivore remains. Those from locality 73 included *P. brevirostris*, *Crocota crocota*, *Panthera cf. P. uncia*, a small canid, an ursid and a herpestid. Locality 362 produced the first securely dated example from the Upper Siwaliks of the large canid *C. cautleyi*, of which a partial skeleton was preserved. Both localities raise general issues concerning the preservation of evidence of carnivores in the Upper Siwaliks, and the identification of the predator that killed the prey presented at these types of localities.

**Key words:** Upper Siwalik (Pinjor Stage), Locality 73, Locality 362, Pabbi Hills, Pakistan, *Canis cautleyi*, *Pachycrocuta brevirostris*, *Panthera cf. P. uncia*

### INTRODUCTION

In an earlier paper (Dennell *et al.* 2005), we described and discussed the fossil vertebrate remains recovered from locality 642 in the Pabbi Hills, northern Pakistan. This large locality, ca. 1.2 – 1.4 Ma-old, was interpreted as an accumulation of carcass segments that had been acquired by carnivores, most probably the giant hyaenid *Pachycrocuta brevirostris*. This paper discusses the results from two other fossil localities in the Pabbi Hills, numbers 73 and 362, which were also excavated. Like locality 642, locality 73 was found in deposits

capped by a sandstone unit known as Sandstone 12, and is thus 1.2 – 1.4 Ma-old. Locality 362 is older, as it was found in deposits assigned to the Olduvai Event by palaeomagnetic analysis, and is thus ca. 1.77 – 1.95 Ma-old. Their location is shown in Fig. 1; details of their dating and descriptions of the Pabbi Hills sequence are given in Dennell *et al.* (2004), Jenkinson *et al.* (1989) and Rendell (2004).

### LOCATION, SEDIMENTARY CONTEXT AND EXCAVATION OF LOCALITIES

Locality 73 was found a few hundred metres west of another rich fossil locality, no. 68, in a deeply dissected area of Sandstone 12, where the scarp face has been eroded into a series of gullies and spurs. When discovered, the two most obvious features were a concentration of bone fragments on top of and on both sides of a small spur, and a complete *Rhinoceros* scapula eroding from the spur's surface, and overlying a fragmented and fragile hyaenid skull. The site was divided into three main zones, A, B and C (see Fig. 2); the subsurface of each of these was also searched with some small-scale sieving as zones X, Y and Z respectively. Locality 73 was much smaller than locality 642, as all the material was eroding from a small area of little more than 1.5 sq. m. of light-brown silts. In general, large but fragmented bones were found on the top of the spur (zone C), with smaller material spilling down either side into zones A and B. A small excavation was conducted in 1986 to retrieve material that was visibly eroding from the sediments; the site was then protected with sand bags, and completely excavated the following year.

Locality 362 was found in 1987 eroding from a small area ca. 1 m<sup>2</sup> of orange-brown sandy silt near the top of a series of silts and sands that were capped by a sandstone. In 1987, all bones from this locality and immediately down slope were

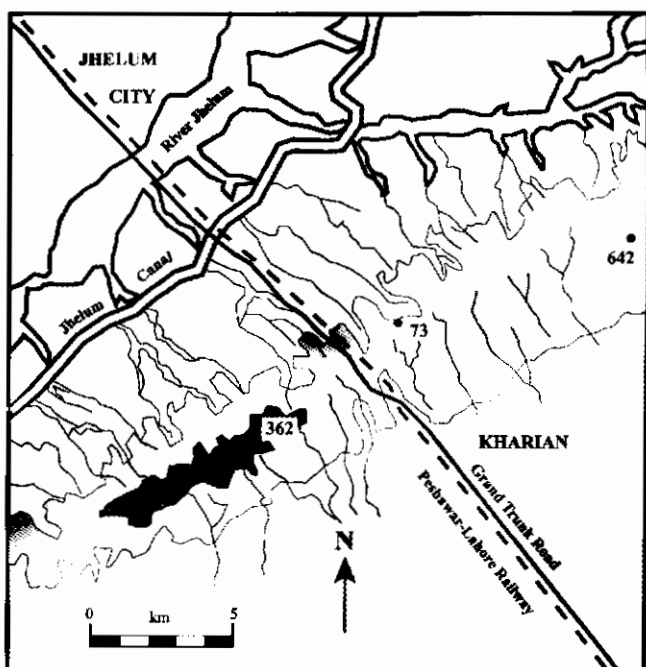


Fig. 1. Location of localities 73, 362 and 642. Localities 73 and 642 (shown by solid circles) are between 1.2 and 1.4 Ma-old; locality 362 is ca. 1.7-1.9 Ma-old.

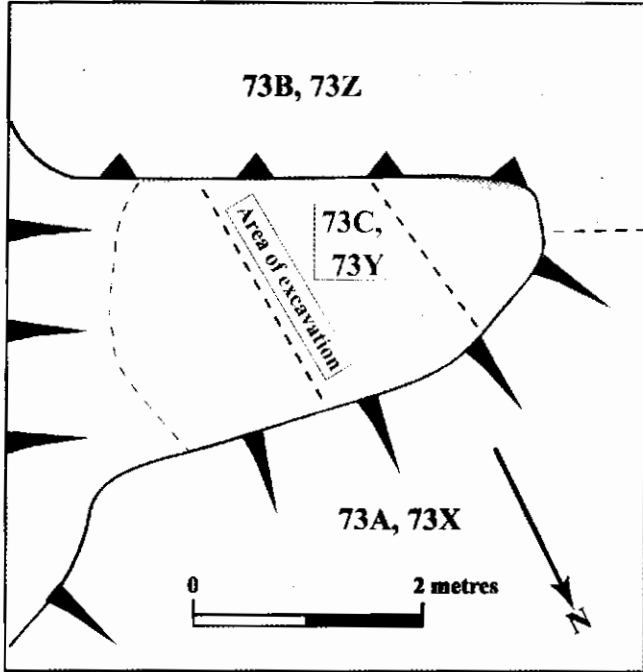


Fig. 2. Schematic map of locality 73. Based on field notes by Sheila Sutherland.

collected, and the site was protected with cloth and a layer of earth to retard further erosion. In 1989, it was apparent from the amount of material that had eroded in only two years that the site would not survive much longer, and it was thus decided to excavate it before it disappeared.

**i. The sedimentary context: of locality 73**

A detailed section of the entire sequence of deposits at locality 73 and other fossil localities along Sandstone 12 can be found in Jenkinson *et al.* (1989) and Dennell (2004: Fig. 5.2). Fig. 3 shows a schematic local section of the deposits at locality 73. From top to bottom, these are: Unit A (117 cm.): a fine-grained soft, homogeneous yellowish-grey (5Y7/2) sandstone, with a "salt and pepper" appearance and white translucent, slightly rounded SiO<sub>2</sub> clasts; Unit B (44 cm.) was a very fine-grained sand that was almost a siltstone, and was differentially eroded from both A above and C below. Its overall colour was grayish-orange (10YR7/4) with "veins" of moderate brown (5YR 4/4) iron colouring that may indicate bioturbations and burrowing by insects; this unit may have been a weak soil horizon. Unit C (93 cm.) had the same texture as Unit A, but lacked the "salt and pepper" appearance, and was light brown (5YR 5/6). This unit contained the fossil accumulation. The bone distribution was predominantly north to south, dipping slightly to north, with a very clear eastern limit and an almost continuous parallel western limit (see Figs. 2 and 5). Fossils were found in the top 20-30 cm. of the excavated area of this unit. Weak and slightly dipping bedding planes could be seen in this unit, and the fossils appeared to lie on top of one of them. Unit D (23 cm.) was a homogeneous, unbedded, slightly

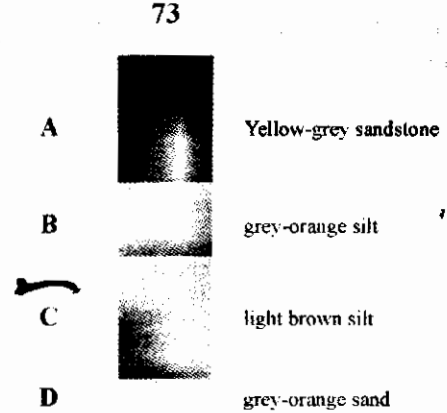


Fig. 3. Schematic section of the local profile at locality 73. The section shown in is ca. 3m high.

clayey, grayish orange (10YR 7/4) sand, and may denote another weak soil unit (Quade, pers. com.).

**ii. The sedimentary context of locality 362**

The sedimentary sequence of the excavated deposits is shown in Fig. 4, and consist of (from top to bottom): Unit 1, a grey, medium grained sandstone three metres thick (but only 10 cm. thick at the point of excavation); Unit two was a purple-pink, bioturbated, and moderately compacted mudstone ca. 40 cm. thick, that had sharp, uneven contacts with the overlying sandstone and underlying sandy silt unit; Unit three was an orange-brown, bioturbated, sandy silt ca. 50 cm. thick, with occasional concretions. This unit was compacted and had a few round-oval mudstone inclusions ca. 5 cm. in diameter. Unit four contained the fossil accumulation, and was an orange-brown sandy silt which graded downwards into a medium-grained sandstone. It had numerous concretions that increased in size with depth from ca. 5 mm. - 2 cm. in diameter. Mudstone inclusions were also present. Fossil roots in this unit were marked by mudstone and sandstone infilling, and fresh roots protruded from the surface fractures of many of the bones. The fossil accumulation extended in a roughly rectangular

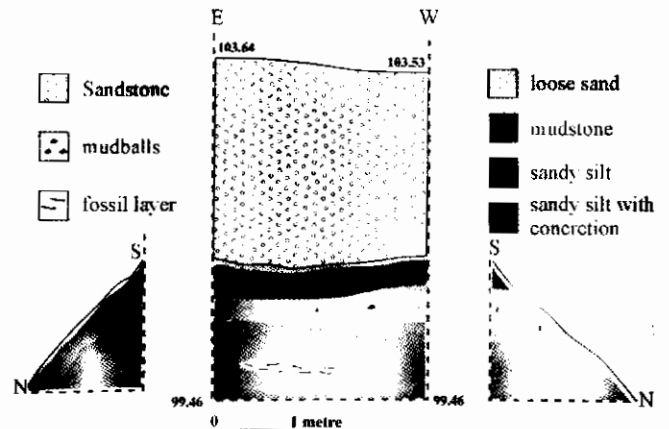


Fig. 4. Section of locality 362. (Based on field records by Mark Beech and Eddie Moth).

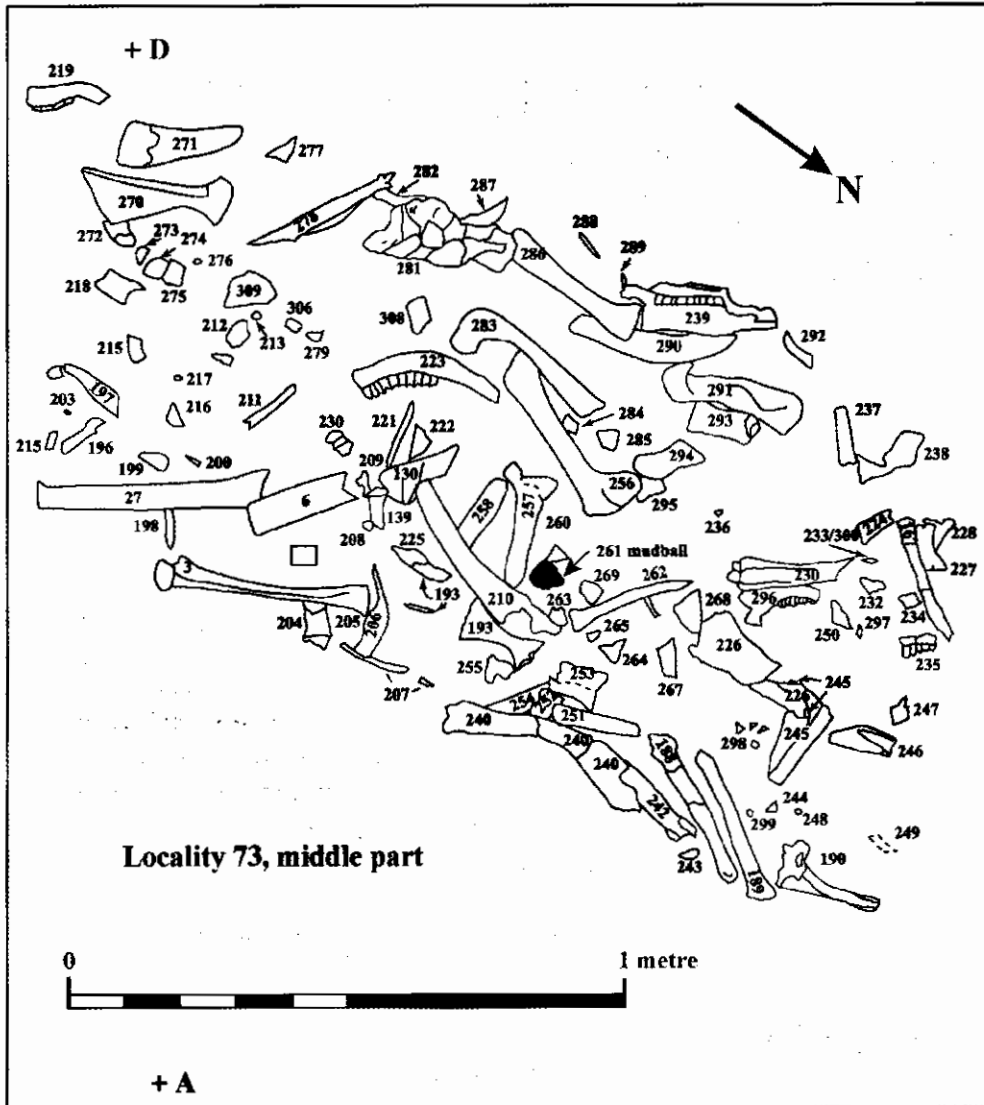


Fig. 5. Plan of excavation of middle part of locality 73 (based on plans by Eddie Moth and others).

strip from the centre of the northern part of the trench into its south-east corner, and was approximately 1.20 m. long, c. 75 cm. wide, with a uniform thickness of ca. 30 cm.

### iii. Excavation techniques

The methods used to investigate localities 73 and 362 were the same as at locality 642. All surface material was collected by zone. Fossils were then excavated by removing most sediment around them with small picks, chisels and hammers, and then the rest of the matrix with dental picks and small brushes. Dilute PVA (polyvinyl acetate) was used to consolidate fragile specimens. At locality 73, fossils were so densely packed together that it was rarely possible to remove large specimens individually. Most fossils had to be removed in plastered blocks containing up to 15 items; the 34 blocks removed in this way were later excavated in the laboratory. Locality 362 was much smaller, and most items were removed individually or in small groups. All specimens visible at the

time of excavation were recorded three-dimensionally, given unique numbers, and plotted on plans drawn at 1: 10 (see Figs. 5 and 6). Many smaller items from locality 73 were not visible when removed in a plastered block, and their location can be determined only approximately by reference to those items that were recorded when the block was removed. After excavation, further cleaning with dental picks and occasionally, dilute acetic acid took place to remove encrusted material. A complete catalogue of all material from both localities as well as an account of the excavations can be found in Beech and Anwar (2004) and Dennell (2004: 294 - 313).

## RESULTS: SITE 73

### i. Vertebrate taxa

As can be seen from Table 1, over 1600 specimens (including indeterminate ones) were collected from the surface, and a further 850 from the excavations. Bovids, cervids and

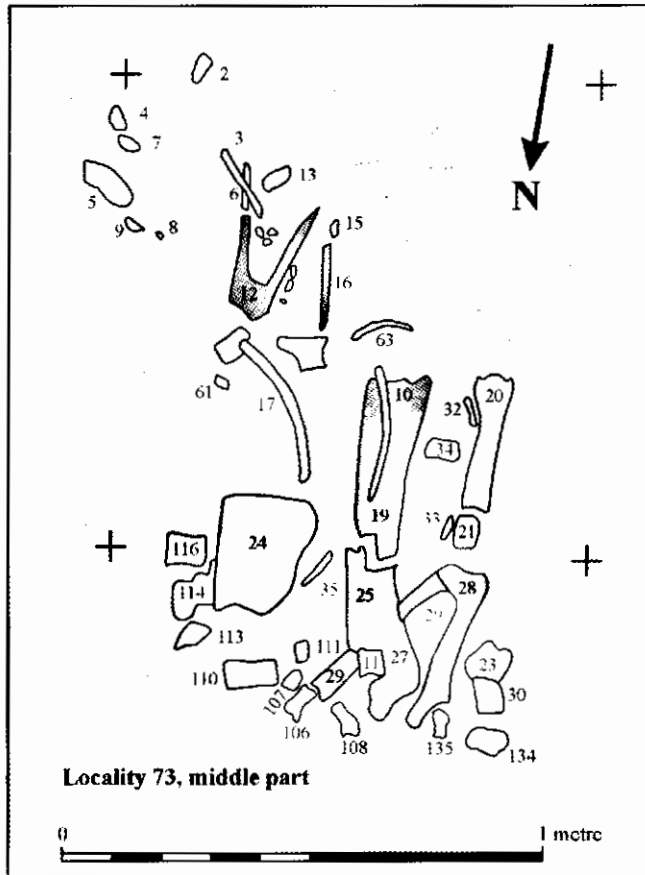


Fig. 6. Plan of the top part of locality 362 (based on field records by Beech, Anwar and Eddie Moth). Major specimens are shown shaded. These are the bovid skull and horns (X12), a radius-ulna of a bird (X 15, X 16), an articulated radius-ulna of a *Sivatherium* (X 19, X25, X27), and a bovid humerus and radius-ulna (X28, X29).

equids were the commonest remains, and there was no evidence of turtle, crocodile, or elephant. The carnivore remains were most interesting aspect of the assemblage. These were unusually abundant, as over half of all the carnivore specimens found in the Pabbi Hills were derived from this one locality. The types represented are as follows:

One specimen (73C GB 12, the posterior fragment of a left P4/ with the parastyle and protocone missing) was identified as *Pachycrocuta brevirostris* (Aymard, 1846), the giant hyaena; and another (73C GB 133, the worn root of a large canine which lacked the root bulge more typical of a felid canine) was assigned to *Pachycrocuta* cf. *P. brevirostris* on the basis of its size rather than on any particular features.

Three specimens were identified as *Crocuta crocuta* (Erxleben, 1777). These were: 73X GB 56, the rear portion of a right horizontal mandibular ramus with P/4 and M/1 in place; this specimen is from an old individual. Although the teeth are very worn, the shape and proportions of the carnassial (long and relatively narrow with a short talonid) are typical of *Crocuta*. 73X GB 57 was a left anterior mandible fragment with P/2 in place and a portion of the P/3; this specimen is not necessarily from the same individual as 73X GB 56, but the stage of wear is similar and the morphology of the tooth and

the general appearance suggest allocation to the same taxon. 73 EX 410, a right maxilla of an aged individual with the canine to P4/ in place and the P1/ broken, was from an old animal, and although the wear on the teeth hampered identification, the metastyle of the P4/ is relatively long, and allocation to this species therefore seems secure.

The most recent detailed discussion of Upper Siwalik hyaenas has been by de Vos *et al.* (1987) in the course of identifying new finds from Mangla-Samwal, Mirpur, 30 km. north of the Pabbi Hills. They provide an extensive summary of the relevant literature, and conclude (1987, p. 366) with a listing of the species likely to have been present that includes *Pachycrocuta brevirostris*, *Crocuta sivalensis* and possibly *Crocuta crocuta*. However, there is no basis for distinguishing *Crocuta sivalensis* from *Crocuta crocuta* (Turner, 1990), and the locality 73 specimens of *Crocuta* are placed here in the latter species.

Five specimens were identified as Hyaenidae, genus and species indeterminate because they were either unidentifiable beyond the family level or unidentifiable with the comparative material to hand. These were: 73A GB 202, a left horizontal mandibular ramus fragment with a broken P/2, worn and broken P/3 and a very worn and broken P/4. The tooth enamel is black, smooth and almost polished in appearance. The P/3 and P/4 are ca. 20 and 22 mm long respectively. The specimen is too small to belong to *P. brevirostris*, and the size and general smoothness of the enamel would be more appropriate to *Crocuta*; 73B GB 184, a right anterior mandibular ramus fragment of a juvenile hyaenid with the canine half erupted. Although the canine is partly obscured by the mandible, it is high crowned and somewhat slender, and therefore unlike a typical *Crocuta*; 73B GB 520, the tip of a left upper canine; 73A GB 328, a left calcaneum; this specimen is similar, but not identical, to the calcaneum in *Crocuta*, with a total length of 60.8 mm.; and 73BB GB 22, the proximal half of a first phalanx.

This indeterminate portion of the hyaenid sample comes mostly from smaller animals. In terms of the listing of taxa provided by de Vos *et al.* (1987, p. 366), the most likely candidate, based on size and inferred stratigraphic range, is what they refer to as *Hyaenictis bosei* (following Matthew, 1929), and what Werdelin and Solounias (1991) refer to as *Lycyaena boisei*, the holotype of which is the skull M37133 in the Natural History Museum, London.

A large felid was also present, and identified as *Panthera* cf. *P. uncia* (Schreber, 1775). The main specimens were: 73 EX 238, a right horizontal mandibular ramus of a medium-sized juvenile felid with the roots of DM/3, a moderately worn DM/4 and M/1 erupting and in initial stages of wear on both the protoconid and the paraconid; 73 EX 58, a fragment of right horizontal mandibular ramus with the anterior alveolus and rear root of the P/4 and a heavily damaged M/1; 73 EX 568, a left horizontal mandibular ramus of a medium-sized juvenile

felid with an almost erupted M1 and an unworn canine in place and what appear to be broken roots of DM/3 and DM/4; 73X GB 51, a fragment of the crown of a left upper canine with the base and tip missing; 73B GB 505, an isolated, unworn right P3/, broken, eroded and partially covered in matrix; 73C GB 203, an isolated left DM4, broken and moderately worn; 73C GB 300, an isolated I/1; 73C GB 420, an isolated lower I/2; 73C GB 344, an isolated lower left I/3; 73C GB 233, an isolated lower right I/3; and 73C GB 382, a joined left I2/ and I3/.

The mandibular specimens 73 EX 238 and 73 EX 568 are clearly not of the machairodont genus *Megantereon*, one specimen of which was found at fossil occurrence 674 in the Pabbi Hills, and probably 1.2 – 1.4 Ma-old. In the case of specimen 73 EX 238, the M/1 does not have a shortened paraconid, the angle between paraconid and protoconid of the tooth is not acute, and there is no sign of any flange developing at the antero-ventral border of the mandible. Specimen 73 EX 568, with its canine in place, is clearly of a pantherine cat. The morphology of the DM/4's suggests allocation to *Panthera* rather than to *Acinonyx*, the cheetah, since the teeth lack the posterior fourth cusp seen in deciduous molars of the latter genus. In so far as comparisons are possible, the heavily damaged mandibular specimen, 73 EX 58, is very similar to the two more complete mandibles. Specific allocation is difficult. All of the specimens are from cats the size of a leopard, *Panthera pardus* L, and one possibility to consider is the snow leopard, *Panthera uncia*. Among the collection of fossil felid remains from the Siwaliks held in the Natural History Museum in London is at least one mandible, 16537a, of similar size to the specimen and with the shortened diastema characteristic of the snow leopard among cats of the genus *Panthera*.

The following specimens were referred to Felidae, genus and species indeterminate: 73B GB 407/181, a right fourth metacarpal, formerly broken into two. Morphologically, the specimen could be from a species of *Panthera*, although it is large for a leopard; 73B GB, six miscellaneous fragments; 73B GB 61, the anterior portion of a felid DM4/; unnumbered, the broken metastyle of a larger cat P4/; 73B GB 62, an indeterminate lower incisor; 73B GB 73, 73B GB 84, and 73B GB 86 three small phalanx/metapodial fragments.

So far as the Felidae are concerned, it is hard to add to the remarks already made. It is clear from the collections at the Natural History Museum, London (Turner, unpublished data), as well as from wider considerations of other samples (Ficcarelli, 1979; Petter and Howell, 1982; Turner, 1984, 1987) that the genera *Megantereon*, *Homotherium*, *Acinonyx* and *Panthera* were present in later Pliocene and earlier Pleistocene deposits in the Siwaliks. Gaur (1987) also suggested that the genus *Machairodus* was present, but this is unlikely in Upper Siwalik deposits and the material to which he refers is more probably of the genus *Homotherium*. Only *Panthera* cf *P. uncia* has

been identified in the new material discussed here, but the unidentified portion of the sample clearly contains at least one other larger taxon although, as discussed, this does not appear to be *Homotherium*. One further intriguing possibility for allocation of these specimens is raised by the presence in the Natural History Museum collection of several fragmentary specimens, plus a complete felid skull, M32148, collected near Pinjor (but otherwise unprovenanced) and presented to the museum in 1977. With its flattened canines, shortened and wide muzzle, domed skull and short, wide zygomata, this specimen is clearly a species of *Dinofelis*, and Werdelin and Lewis (2001) have recently referred it to the species *D. cristata*.

A small canid was represented by 73X GB 36 and 73X GB 20, distal metapodial fragments; 73X GB 59 a right calcaneum; and 73C GB 61-63, three associated broken metapodia. A more precise identification was not possible. Gaur (1987) refers to two small canid species, the already known *Sivacyon curviplatus* Falconer (1868), and a newly identified species, *Canis pinjorensis* Gaur (1987), but the fragmentary material available here cannot be referred with any confidence to either.

One specimen (73A GB 52, a right posterior mandible fragment retaining most of a broken M/1 and the alveolus for M/2) was identified as a herpestid. The broken molar exhibits the trenchant cusps typical of this type. Barry (1983) discussed the presence of the common mongoose genus *Herpestes* (mongooses were then referred to the Viverridae as a subfamily, Herpestinae) in the Siwaliks but based on material from Miocene-age deposits. This material could perhaps be referred to that genus, but without certainty.

73B GB 515, an isolated right M1/ of an ursid, somewhat larger than a small specimen of the extant European brown bear, *Ursus arctos* Linnaeus with a length of 19.0 mm and a breadth of 14.6 mm. was identified as an ursid, genus and species indeterminate. Two other teeth (73B GB 519, 521) may also belong to this group.

*Other taxa:* The rhinoceros was identified as *R. sivalensis*, and shows stronger affinities to the present-day black rather than the white rhino of Africa. The horse remains were identified as *E. sivalensis*: they were small, like those from locality 642 (Dennell *et al.*, 2005), and smaller than those Mangla-Samwal, Pakistan, and ca. 2.5 Ma-old (Hussain *et al.*, 1992). The cervids are represented by dentitions, isolated teeth and limb segments, and could not be identified beyond family level. They were medium-sized, with teeth that were strongly hypsodont and with a pronounced cingulum. The pig was small, and could not be identified to generic level with the comparative material available.

## ii. Age profiles and minimum numbers of individuals

*Site 73:* Table 1 lists the probable minimum number of individual (MNI) animals at this locality. The surface material was so fragmented that it was not possible to estimate

**Table 1: Number and % of Individual Specimens (NISP), and the minimum number of individual animals (MNI) from locality 73.**

Genus/Species	Excavation		Surface collection		MNI, excavation
	NISP	%	NISP	%	
Bovid/Cervid	58	5.4	155	9.3	-
Bovid	44	4.1	55	3.3	2
Cervid	47	4.4	133	7.9	9
Suid	22	2.0	5	0.3	1
<i>Equus</i>	60	5.5	73	4.4	3
<i>Rhinoceros</i>	5	0.5	6	0.4	1
Carnivora indet.	15	1.5	39	2.3	-
Canid	3	0.3	14	0.8	1
Hyaenid	3	0.3	23	1.4	4
Felid	8	0.7	9	0.5	3
Ursid	0	0.0	3	0.2	1
Herpestid	0	0.0	1	0.1	1
Indeterminate	814	75.3	1157	69.1	-
<b>Total</b>	<b>1079</b>	<b>100</b>	<b>1673</b>	<b>100</b>	<b>26</b>

accurately the MNI of each taxon, and thus we have to rely upon the excavated assemblage. In this, at least nine cervids are represented. The ageing criteria of extant cervids are not always easy to apply to extinct forms, and age estimates here are based on eruption and wear rates, largely adapted from Spinage (1973). The excavated sample includes four juveniles with deciduous dentition, four adults with permanent dentition ( $M_3$  erupted), and a single senile adult with extremely worn adult dentition.

Two types of bovid are represented by some cranial and post-cranial material, mainly limb bones. One type is very large, with all measurable indices in excess of the largest extant African bovids such as the buffalo and giant eland (Walker, 1985). The second form is smaller and more slender, with few measurable indices but falling within a medium size range. The absence of horn cores precluded more accurate identifications.

At least three equids are present. Based on the fusion of the surviving epiphyses, they are all at least 2-2.5 years of age and one 3.5 years of age (Silver, 1969). The dentition of two of the mandibles shows the  $M_2$  erupting and as they are from a left and a right mandible, they are probably from the same individual. This would be consistent with the estimated age range from the bone fusion of around 2-2.5 years of age. Two of the equids are taller and more slender than the third, which is shorter and more robust in the measurements of the long

bones, podials and metapodials. All measurements were compared to Walker (1985) and indicate that these equids are larger than the extant zebra of Africa. All of the bones showing fusion would support an age estimate of around 2 years (Silver, 1969).

The two virtually complete suid mandibles (left and right) both show the  $M_3$  erupting, which would indicate an individual around 2 years of age (quoted in Hillson, 1986). This is consistent with the age estimates based on the fusion of the long bones, using estimates derived from Silver (1969). The rhinoceros was adult.

### iii. Skeletal part representation

At least nine groups of bone were either articulated or anatomically adjacent to each other. Of these, only one consisted of vertebrae (three lumbar vertebrae and sacrum), and all of the rest were lower limb bone combinations. Limb-bones were much commoner than cranial pieces: unlike localities 362 and 642, there were no well-preserved cranial specimens from site 73, although there were several good dental and jaw specimens. The lack of cranial material, particularly of bovids, impeded identification of much of this material. The herbivores were represented overwhelmingly by limb segments, whereas the carnivores (see previous section) were primarily identified from mandibular, dental and some

**Table 2: Number and % of Individual Specimens (NISP), and the minimum number of individual animals (MNI) from locality 362.**

Genus/Species	Excavation		Surface collection		MNI, surface and excavation
	NISP	%	NISP	%	
<i>Canis cautleyi</i>	67	55	0	0	1
<i>Sivatherium</i>	6	7	10	16	1
<i>Rhinoceros</i>	2	2	12	20	1
Large bovid	34	28	20	33	3
Medium Bovid	2	2	12	20	1
Aves	3	2	0	0	1
Proboscidean	0	0	6	10	1
<b>Total</b>	<b>121</b>	<b>100</b>	<b>60</b>	<b>100</b>	<b>9</b>

foot specimens. *Rhinoceros* was represented by a partial left forelimb (scapula and humerus) and part of a left foot (cuneiform, astragalus and metapodial) from a minimum of one individual. *Equus* was overwhelmingly represented by limb fragments. These were mainly from the upper and lower forelimb, lower hind-limb, and hooves; the only trunk and head elements were an atlas and axis, and a mandible and maxilla. Similarly, a medium-sized bovid was represented by an upper and lower fore- and hind-limb, but the only axial element was an atlas, and a large bovid was represented only by part of a lower fore- and hind-limb. Cervids were also largely represented by the upper and lower fore-limb, lower hind-limb, hooves, and dentitions. The remains of a single suid comprised a forelimb, hind-limb and both mandibles. Ribs and vertebrae were rare, and only 47 rib fragments and 24 vertebra fragments, including one find of a sacrum and three articulated vertebrae, were recovered from the excavation.

## RESULTS: SITE 362

### i. Vertebrate taxa

Table 2 lists the number of specimens and individuals of each taxon from the surface and excavation. Overall, six taxa were identified, each represented by an individual animal, apart from a large bovid, of which there were three individuals. The largest animals, with estimated body weights of over 820 kg, are *Sivatherium*, *Rhinoceros* and a Proboscidean. At least two types of bovid are represented. One has a small dentition (e.g. maxillary specimen 362 EX46) comparable to that of *Damalops palaeindicus*, which is well represented at locality 642 (see Dennell *et al.*, 2005). The second type was larger, and had horns that were less twisted than *Damalops*. Its affiliation is unknown, but superficially it resembles one of the Tragelaphines, or bush-buck/kudu tribe. The teeth are as large as, and similar to, those of *Hemibos triquetricornis*, (e.g. mandibular specimen 362 GB65, a left mandible with a moderately worn M<sub>3</sub>, 38mm long and 12mm wide, and 362E GB2, a right mandible with the dm3 (34.8mm x 10mm) and M1 erupting, and may have been associated with a pair of horns, 362EX6 and 362EX12. These were 4 cm apart at the base, and more or less circular in cross-section, without a keel and only slightly twisted. The tape-length from tine to skull was 25cm., but 24cm., if measured directly, and thus the twisting ratio was 1.04. The identification of this type remains unclear.

The most significant evidence from locality 362 is the partial skeleton of a large canid, with much of the lower dentition preserved. The remains of the canid were found at the base of the fossil accumulation, and comprised two jaw fragments (X119/X124), three canines (X88/X104/X126), an atlas (X92), humerus (X38), radius (X55), ulna (X41), os penis (X75), both tibiae (X56/125), calcaneum (X105), astragalus (X100), four metapodials (X84/X93/154/X158), four carpals

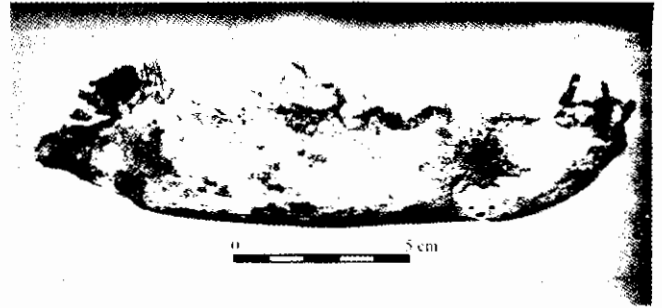


Fig. 7. Mandible of *Canis cautleyi* from locality 362.

or tarsals (X103/X105/X112/X160) and three phalanges (X83/X175/X178). Several of the smaller ribs from the excavation may also have belonged to this animal. The dentition of this specimen (see Fig. 7) shows a *Canis*-like morphology in the structure of the lower carnassial, with a marked entoconid in addition to the main hypoconid of the talonid. The metaconid is also strongly developed. This morphology is very similar to that of the Upper Pleistocene and extant Holarctic *Canis lupus*, and in marked contrast to that seen in Natural History Museum specimens of the large European hunting dog, *Canis (Xenocyon) lycaonoides* (Kretzoi, 1938), from the British Middle Pleistocene site of Westbury-sub-Mendip (Turner, 1999). Although it is somewhat larger, the new specimen bears a considerable resemblance to material previously collected from the Siwaliks during the earlier part of last century and now held in the Natural History Museum in London. Two mandibles, referred to *Canis cautleyi* (Bose, 1880), are of particular relevance, and their measurements are given for comparison in Table 3. The stratigraphic locations of these two specimens were not clearly indicated by Bose, other than that they were found in Siwaliks deposits, with a possible mid-Pliocene date, although he did acknowledge the possibility of them being more recent. The relationship of *Canis cautleyi* to other canids is currently unclear. European canids referred to the genus *Canis* are generally much smaller until the Upper Pleistocene (Turner, 1999), and the presence of such a large species in the Siwaliks at this time is clearly a matter for further investigation. As there is no evidence of *C. cautleyi* from any of the material from Sandstone 12 (which comprised half the total found in the Pabbi Hills, and included also the material from localities 73 and 642), it is possible that it had become extinct by 1.4 Ma.

The *Sivatherium* is of interest as it is rare type of giant Pleistocene giraffe. The Sivatheriinae, a sub-family of the Giraffidae, contains a variety of fossil forms, all of which are now extinct. They are widely, although not abundantly, represented in Early Pleistocene deposits across Asia and are also present at some South African cave sites of a similar date (Brain, 1981). All the material at Locality 362 is post-cranial and most probably from *Sivatherium giganteum*,

**Table 3: Measurements of lower dentitions of *Canis cautleyi*.**

C		P/3		P/4		M/1			M2		P/1-M/3	
L	B	L	B	L	B	L	B	Lt	L	B		
<i>Canis cf. C. cautleyi</i>												
Locality 362: X124												
14.0	9.7	15.0	7.3	17.5	9.0	31.5	12.7	8.5	-	-		102
<i>Canis cautleyi</i>												
Natural History Museum specimens												
-	-	-	-	-	-	27	10.7	7.2	11.1	7.6	-	M40182
-	-	-	-	-	-	25.2	10.0	6.3	10.6	7.6	-	M40181

**Falconer and Courtley, 1835.** Although the cranial material for this species is more extensively described than the post-cranial (Lydekker, 1878; Arif and de Vos, 1989), the post-cranial specimens at Locality 362 fit the general description of a large, heavy *Sivatherium* (Colbert, 1935), not elongated in the limb.

Finally, and somewhat remarkably, a complete ulna (X15/16) and almost complete carpometacarpus (X66) of a large bird were also found.

### ii. Age profiles

The epiphysial fusion of the long bones and/or the presence of permanent dentition indicate that all the animals (including the canid) were fully adult at the time of death except the large bovid, of which a femur and the distal metatarsals were unfused. Precise age estimates were not possible because so little dentition was present.

### iii. Skeletal part representation

The assemblage mainly consists of post-cranial remains and specifically limbs bones. Three groups were articulated: a bovid humerus-radius-ulna, a *Sivatherium* humerus-radius-ulna (see Fig. 6), and the already-mentioned canid partial skeleton. Preservation was excellent. Many of the smaller rib fragments from the excavation may also have belonged to this particular animal, as no other species of small body size were present. There was no duplication of any anatomical element, and the size and fusion of the bones indicates that only one individual is present. Much of the other material consisted of either anatomically adjacent bones or fully articulated remains. The articulation is predominantly in the lower limbs, with the feet varying in degrees of articulation from a whole foot (tarsals, metatarsals and first, second and even third phalanges) to two carpal bones (scaphoid and lunar). Other material was anatomically adjacent, such as

the humerus, ulna and radius.

## INTERPRETATION OF THE FOSSIL ACCUMULATIONS

### i. Carnivore damage

At locality 73, many epiphyses of long bones had been gnawed, and often the gnawing extended into the shaft of the bone. Spiral fractures were also very common. There were also many tooth marks, and these included evidence of chewing, striations, puncture marks and even whole tooth row outlines. These marks were mainly on mandibles but also on long bones and long bone fragments. The damage was not restricted to any particular taxon but was particularly evident on the suid and cervid remains.

The carnivore damage indicates that at least two sizes of carnivore were active at the site. The first was a large bone-crunching individual that had the ability to inflict a considerable amount of damage to the bones of different sized animals and different skeletal parts. This damage could have been caused by the hyaenids *Pachycrocuta* and *Crocuta*. The second carnivore was much smaller, and inflicted less destructive damage in the form of striations and small pitting marks. The bones of both sizes of carnivores were recorded at the site, but it is possible that some of the damage was inflicted by juveniles of the larger type.

At locality 362, ca. 10% of the bones from both the excavation and the surface collection showed evidence of damage by a large carnivore, such as single and multiple puncture marks, striations, gnaw marks, spiral fractures, depressed fractures, and gnawed epiphyses. *Canis cautleyi* could have caused most of this damage, but interestingly, even the skeleton of this carnivore was heavily carnivore-damaged. The ends of some of the limb bones were missing as a result of chewing and there are puncture and gnaw marks



on the bones. There is also evidence, in the form of finer and smaller striations, of a second and much smaller modifier of bones. The canid mandible had several groups of fine striations on it. The striations were concentrated below the lower canine and range from 4 mm - 20 mm long. These irregular striations have more similarity to a small carnivore gnawing the bones than the more uniform and parallel striations of a rodent (Brain, 1981). A smaller carnivore, either a juvenile of the canid species already at the site or a different species not preserved at the site, is more likely to have produced these marks.

## ii. Site formation processes

The absence of stone artefacts, bones with cut marks and hominin remains at either locality means that hominins can be safely excluded from further consideration. The main agents of accumulation are thus likely to have been carnivores or fluvial activity. The evidence points overwhelmingly to the former as the primary cause for both fossil concentrations.

The following points suggest that carnivores were the main accumulating agency at locality 73: 1) number and diversity of carnivores species present; 2) the presence of young hyaena and coprolites 3) the presence of gnaw marks; and 4) the presence of several articulated segments of carcasses; and 5) the fresh, unrolled state of the bones; and 6) the tightly localized concentration of carcass remains. However, there is some evidence that fluvial agents were also involved: 1) the mixture of sediments (including grey silt-sand and red clay) amongst bones 2) the alignment of some long-bones (see Fig. 5), although this could be due to carnivores or the configuration of a burrow; and 3) the presence of a mud-ball (specimen 73C EX 260, see Fig. 5). A possible scenario might thus have been a depression or gully that was used by hyaenas as a den, and later infilled by hillwash (causing some orientation of bones). Alternatively, the locality might have been a burrow (with bones lined against the edge), which flooded and then collapsed, resulting in a mixture of deposits, an influx of stream deposits, and some re-orientation of long bones.

There is no evidence that the fossils at locality 362 were accumulated by stream action. Factors suggesting that the assemblage was not accumulated by water include the compact spatial distribution of the bones, the presence of articulated or anatomically adjacent bones, their lack of orientation, and the complete absence of turtle, crocodilian remains. Instead, it

is probable that carnivores accumulated the assemblage. The skeletal part representation is consistent with a carnivore-accumulated deposit. Limb bones or head parts represent most of the animals at locality 362, and this pattern is in keeping with that of large carnivores and possibly scavengers. The schlepp effect or the preferential transport by a carnivore of limb bones or a head, would explain this patterning (Perkins and Daly, 1968; Marean *et al.*, 1992). There is no evidence that locality 362 was a den - there is no evidence of coprolites, or juvenile carnivores, apart from the fine striations on the large canid mandible, but this could equally be attributed to other agents, such as other small carnivores. The high representation of limbs bones and the spatial confinement of the bones would suggest a location where the bones were brought from elsewhere. The presence of the bird wing at locality 362 is unusual and could represent an unfortunate individual who got in the way during a frenzied feeding session. Intense competition over food resources is certainly well documented in modern environments and is evident in other palaeo-faunal assemblages (Brain, 1981; Kruuk, 1972; Potts, 1988).

## iii. Weathering

Table 4 summarizes the degree of surface weathering of fossil specimens from both the surface collections and excavated material from localities 73 and 362, based on the scheme proposed by Behrensmeyer (1978) for modern carcass remains. The data from the excavated assemblages provides a clear indication of how much weathering occurred before burial. Generally, the state of preservation of all taxa in the excavated assemblages from localities 73 and 362 was excellent (typically stage 2), implying that most bone was not exposed to weathering for more than a few months between death and burial. However, the more heavily weathered bone may give a more realistic assessment of exposure (Lyman and Fox, 1989). 21 bones from locality 362 were recorded in the higher categories of weathering stages evident at the site, that is fossils in Behrensmeyer's stage 2 or 3. This may indicate an exposure of nearer three years or so. It is difficult to assess if all or just a few bones were exposed for this length of time as a few bones may have been exposed longer than others or were exposed to more extreme weathering agents. The condition of specimens found on the surface was very similar, which is consistent with the fact that these bone pockets were clearly being actively eroded from their matrix at the time of discovery.

Table 4: Bone surface weathering at localities 73 and 362. The weathering stages are based on Behrensmeyer (1978).

Weathering stage	1	2	2a	2b	3	4	5	Total
Locality 362 surface	80	16			3			99
Locality 362 excavation	66	9	8	2	2			87
Locality 73 surface	27		46	29	19	6	4	131
Locality 73, excavation	12		140	59	43	8	2	264

## CONCLUSIONS

The evidence from these two localities raises two related general issues concerning the fossil record of the Upper Siwaliks. The first is the evidence for carnivores. These are rare in the Upper Siwaliks, and the only ones reported from the Pinjor Formation in India are *Canis pinjorensis*, *Crocuta felina*, *C. colvini*, *Panthera* cf *P. cristata* and *Mellivora sivalensis* (Nanda, 2002, p. 46, 48, 2002). This list is likely to be incomplete. As *Pachycrocuta* has now been found in deposits of the same age in Pakistan at localities 73 and 642 (and also at localities 68 (1.2 – 1.4 Ma) and 214 (1.7 – 1.9 Ma) and at another small occurrence 291 (Turner, 2004: 404), as well as at Longuppo in southern China (Wanpo *et al.*, 1995), it is not clear whether the absence from the Upper Siwaliks of India of *Pachycrocuta* is genuine, or is likely of to result from insufficient sampling of rare taxa. The same is likely to be true of *Panthera* cf *P. uncia*, *Canis cautleyi*, *Megantereon*, and ursids, all of which are recorded in the Pabbi Hills. However, the Upper Siwalik record of the Pabbi Hills and other Upper Siwalik exposures in Pakistan is also likely to be incomplete: *Homotherium*, for example, is recorded at Dmanisi (Gabunia *et al.*, 2000a) to the west and Longuppo (Wanpo *et al.*, 1995) to the east, and is thus likely to have also been present in the Indian subcontinent at this time. It may be significant that the only indication of *C. cautleyi* and *P. uncia* came from deposits that were excavated, and the only specimen of *Megantereon* came from a thorough survey. This makes the point that taxa such as carnivores will be under-represented in surface collections, particularly those obtained without intensive and systematic searching of exposures.

The second and related issue is the identification of the carnivore(s) responsible for accumulating the remains of prey at fossil concentrations such as localities 73 and 362. Although it is likely that hyaenids accumulated the prey, it does not necessarily follow that they killed the prey themselves. Scavenging is especially advantageous to a predator if it can capture carcasses from other predators before they have had a chance to eat them. Whilst it is parsimonious to assume that a fresh kill was consumed by the predator that made the kill, predators frequently scavenge off each other, and other types of scavenger. We need therefore to recognize that evidence that a predator consumed carcasses in prime condition is not necessarily an indicator that it hunted those animals. More specifically, even if *Pachycrocuta* ate carcasses in prime condition, it might have hunted the animals it ate, or stolen their carcasses from other predators. If we bear in mind that some predators such as *Homotherium* and *Megantereon* (and hominins) are very poorly represented in the fossil record, we cannot eliminate the possibility that these may have killed many of the prey consumed by *Pachycrocuta*.

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