TWO UPPER SIWALIK (PINJAR 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 include P. bernissartensis, Crocuta crocuta, Panthera sp. P. ursana, a small canid, an ursid and a hominid. Locality 362 produced the first securely dated examples from the Upper Siwaliks of the large canid C. canina, 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 (Pinjar Stage), Locality 73, Locality 362, Pabbi Hills, Pakistan, Canis canina, Panthera sp., P. ursana

INTRODUCTION

In an earlier paper (Dennell et al. 2005), we described and discussed the fossil vertebrate remains recovered from locality 647 in the Pabbi Hills, northern Pakistan. This large locality, ca. 1.2 - 1.3 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 647, locality 73 was found in deposits cappned 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 Oldova 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), Denkmann et al. (1996) and Russell (2004).

LOCATION, SEDIMENTARY CONTEXT AND EXCAVATION OF LOCALITIES

Locality 73 was found a few hundred meters 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 *Himantotherium* carcass 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 substrate 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 647, as all the material was eroding from a small area of little more than 1.5 sq. m of Eight-Brown Silts. In general, large but fragmented bones were found on the top of the spur (zone C), with smaller material spilling down to the sides 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 to follow year.

Locality 362 was found in 1987 eroding from a small area ca. 1 m² 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. Locations 73 and 642 (shown by solid contour lines) were excavated between 1.2 and 1.4 Ma-old; locality 362 is ca. 1.7-1.9 Ma-old.](image-url)
collected, and the site was protected with wire mesh 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 then 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 Ankinton et al. (1989) and Dunning (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 (3Y 7/2) sandstone, with a "salt and pepper" appearance and white tanscent, slightly rounded Silt, clast, 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 greyish-orange (10YR 5/4) 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 seal horizon. Unit C (95 cm) had the same texture as Unit A, but lacked the "salt and pepper" appearance, and was light brown (7.5Y 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 26-30 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

![Diagram](image)

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

![Diagram](image)

Fig. 3. Schematic section of the local profile at locality 73. The section shown is in 2 cm (top high).

73A, 73Y

73, 73Y

73C, 73Z

ii. The sedimentary context of locality 362

The sedimentary sequence of the excavated deposits is shown in Fig. 4, and consists 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 mediumgrained 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 staining, and fresh roots protruded from the surface fractures of many of the bones. The fossil accumulations extended in a roughly rectangular

![Diagram](image)

Fig. 4. Section of locality 362. Based on field notes by Mark Beech and Edith Moholy.
strip from the centre of the northern part of the trench to its south-east corner, and was approximately 1.20 m. long, c. 75 cm. wide, with a uniform thickness of c. 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 in account of the excavations can be found in Beech and Awani (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 382 (based on field records by Beech, Ainsworth and E.A.R. Minto). Major specimens are shown shaded. These are the bivalve shell and bone (O2), a radius-socket of a hind (X 15, X 16), an articulated manus-socket of a Pachychoerus (X 2.3, X 2.3), and a bivalve banded and radula-valve (X 2.5, X 2.5).

Equis 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 usually abundant, as over half of all the Carnivora specimens found in the Pupu Hills were derived from this area locality.

The types represented are as follows:

One specimen (75G GB 12, the posterior fragment of I-left P4 with the parastryle and protocone missing) was identified as Pachychoerus brevirostris (Aymard, 1846), the giant hyaena; and another (77C GB 133, the worn root of a large canine which lacked the root bulge more typical of a felid canine) was assigned to Pachychoerus cf. P. brevirostris on the basis of its size rather than on any particular features.

Three specimens were identified as Crotalus crotalus (Erdelen, 1777). These were: 75G GB 56, the rear portion of a right horizontal mandibular rami with P4 and M1 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 Crotalus. 73X GB 57 was a left anterior mandible fragment with P2 in place and a portion of the P3; 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 in place and the P4/5 broken, was from an old animal, and although the wear on the teeth tempered identification, the metacone 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-Samarw, Mirpur, 30 km north of the Pupu Hills. They provide an extensive summary of the relevant literature, and conclude (1987, p. 366) that Ischyrocerus brevirostris, Crotalus, and possibly Crotalus crotalus. However, there is no basis for distinguishing Crotalus venaticus from Crotalus crotalus (Turner, 1990), and the locality 73 specimens of Crotalus are placed here in the latter species.

Five specimens were identified as Hyaenidae: partus and species indeterminate because they were either undistinguishable beyond the family level or undistinguishable with the comparative material at hand. These were: 73A GB 202, a left horizontal mandibular rami fragment with a broken P2, worn and broken P3 and a very worn and broken P4. The tooth enamel is black, smooth and almost polished in appearance. The P3 and P4 are ca. 20 and 22 mm long respectively. The specimen is too small to belong to P. brevirostris, and the size and general proportions of the enamel would be more appropriate to Crotalus. 73B GB 184, a right anterior mandibular rami fragment of a juvenile hyaena 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 Crotalus, 73B GB 520, the tip of a left upper canine; 73A GB 328, a left carnassial; this specimen is similar, but not identical, to the carnassial in Crotalus, 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, and therefore nearly a typical Crotalus, and 73B GB 520, the tip of a left upper canine; 73A GB 328, a left carnassial; this specimen is similar, but not identical, to the carnassial in Crotalus, 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, and therefore nearly a typical Crotalus, and 73B GB 520, the tip of a left upper canine; 73A GB 328, a left carnassial; this specimen is similar, but not identical, to the carnassial in Crotalus, with a total length of 60.8 mm; and 73BB GB 22, the proximal half of a first phalanx.
feld with an almost eroded M1 and an unworn canine in place and what appear to be broken roots of DM3/4 and DM4; 73X GB 51, a fragment of the crown of a left upper canine with the base and tip missing; 73B GB 503, 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 P1; 73C GB 430, an isolated lower U2; 73C GB 344, an isolated lower left E3; 73C GB 233, an isolated lower right E3; and 73C GB 382, a joined left I2/12.

The mandibular specimens 73 EX 238 and 73 EX 658 are clearly not of the mammalodont 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 M1 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 658, with its canine in place, is clearly of a pantherine cat. The morphology of the DM4's suggests allocation to Panthera rather than to Acinonyx, the chetah, since the teeth lack the posterior fourth cuspal 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 of 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 amongst 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 hom DM4; unnumbered, the broken metacone of a larger cat 73B GB 62, an indeterminate lower incisor, 73B GB 73, 73B GB 84, and 73B GB 86 three small fragments of phalanges.

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 (Faccio, 1979; Peeters and Howell, 1982; Turner, 1982, 1987) that the genera Megantereon, Homotherium, Acinonyx and Panthera were present in later Pliocene and earlier Pleistocene deposits in the Siwaliks. Gaar (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 smilus has

been identified in the new material discussed here, but the unidentifiable 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, M3214G, 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 zygoma, this specimen is clearly a species of Dipsosmilus and Wernert and Lewis (2003) have recently referred to it the species D. cristatus. 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 metapodals. A more precise identification was not possible. Gaar (1987) refers to two small canid species, the already known Smilodon curvifelis Falconer (1668), and a newly identified species, Canis pinjorensis Gaar 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 M1 and the alveolus for M2) 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 ards, somewhat larger than a small specimen of the extant European brown bear, Ursus arctos Linnaeus with a length of 19.2 mm and a breadth of 14.6 mm, was identified as an ards, genus and species indeterminate. Two other teeth (73B GB 519, 521) may also belong to this group.

Other taxa: The rhinoceros 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 Mangala-Samru, Pakistan, and ca. 2.5 Ma-old (Hosmin et al., 1992). The cervids are represented by antelopes, isolated teeth and limb segments, and could not be identified beyond family level. They were medium-sized, with teeth that were strongly hypodont and with a pronounced cingulum. The pig was small, and could not be identified to genus 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 (MNID) animals at this locality. The surface material was so fragmented that it was not possible to estimate
accurately the MNI of each taxon, and thus we have to rely upon the excavated assemblage. In this, at least some carnivores are represented. The ageing criteria of extant carnivors are not always easy to apply to extant forms, and age estimates here are based on eruption and wear rates, largely adapted from Springer (1973). The excavated sample includes four juveniles with deciduous dentition, four adults with permanent dentition (M3 erupted), and a single semi-adult with extremely worn adult dentition.

Two types of bone are represented by some cranial and post-cranial material, roughly 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, 1955). The second form is smaller and more slender, with lower measurable indices falling within a medium-size range. The absence of horn cores precluded more accurate identification.

At least three species are present. Based on the fusion of the surviving epiphyses, they are all at least 2.2-2.5 years of age and one 3.5 years of age (Silver, 1969). The formation of two of the mandibles shows the M3 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 larger and more slender than the third, which is shorter and more robust in the measurements of the long bones, peduncles and metapodials. All measurements were compared to Walker (1985) and indicate that these equids are larger than the extant zebras of Africa. All of the bones showing fusion would support an age estimate of around 2 years (Silver, 1969).

The two virtually complete mandibles (left and right) both show the M3 erupting which would indicate an individual around 2 years of age (quoted in Hillson, 1995). 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.

II. 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 more common than cranial pieces; unlike localities 362 and 642, there were no well-preserved cranial specimens from site 75, although there were several good dental and jaw specimens. The lack of cranial material, particularly of bovids, suggests identification of much of this material. The herbivores were represented overwhelmingly by limb segments, whereas the carnivores (see previous section) were primarily identified from mandibles, dental and some

Table 1: Number and % of Individual Specimens (NISP), and the minimum number of individual animals (MNI) from locality 75.

<table>
<thead>
<tr>
<th>Genera/Species</th>
<th>Excavation NISP</th>
<th>Excavation %</th>
<th>Surface collection NISP</th>
<th>Surface collection %</th>
<th>MNI, surface excavation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovid/Cervid</td>
<td>58</td>
<td>5.4</td>
<td>155</td>
<td>9.3</td>
<td>2</td>
</tr>
<tr>
<td>Bovid</td>
<td>44</td>
<td>4.1</td>
<td>55</td>
<td>3.2</td>
<td>2</td>
</tr>
<tr>
<td>Canid</td>
<td>47</td>
<td>4.6</td>
<td>133</td>
<td>7.9</td>
<td>9</td>
</tr>
<tr>
<td>Suid</td>
<td>22</td>
<td>2.0</td>
<td>5</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>Equus</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>Rhinoceros</td>
<td>60</td>
<td>5.5</td>
<td>71</td>
<td>4.4</td>
<td>7</td>
</tr>
<tr>
<td>Carnivorous indet.</td>
<td>15</td>
<td>1.5</td>
<td>39</td>
<td>2.3</td>
<td>3</td>
</tr>
<tr>
<td>Carnivorous</td>
<td>2</td>
<td>0.2</td>
<td>2</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>Hyrax</td>
<td>6</td>
<td>0.6</td>
<td>14</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>Rodent</td>
<td>8</td>
<td>0.7</td>
<td>9</td>
<td>0.5</td>
<td>3</td>
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<tr>
<td>Vertebrate</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>0.1</td>
<td>1</td>
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<tr>
<td>Hyolithocercus</td>
<td>914</td>
<td>75.3</td>
<td>1157</td>
<td>69.1</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>1079</td>
<td>100</td>
<td>1075</td>
<td>100</td>
<td>26</td>
</tr>
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</table>

Table 2: Number and % of Individual Specimens (NISP), and the minimum number of individual animals (MNI) from locality 36.

<table>
<thead>
<tr>
<th>Genera/Species</th>
<th>Excavation NISP</th>
<th>Excavation %</th>
<th>Surface collection NISP</th>
<th>Surface collection %</th>
<th>MNI, surface excavation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canid</td>
<td>67</td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Suid</td>
<td>6</td>
<td>7</td>
<td>10</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Equus</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Large bovid</td>
<td>34</td>
<td>28</td>
<td>20</td>
<td>33</td>
<td>3</td>
</tr>
<tr>
<td>Medium bovid</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Aves</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidean</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>100</td>
<td>60</td>
<td>100</td>
<td>9</td>
</tr>
</tbody>
</table>
foot specimens. *Rhinoceros* was represented by a partial left forelimb (scapula and humerus) and part of a left foot (calcaneum, astragalus and metapodial) from a minimum of one individual. *Equus* was overwhelmingly represented by limb fractures. The right upper and lower forelimb, lower hindlimb, and hooves; the only trunk and head elements were an atlas and axis, and a mandible and maxilla. Similarly, a moderately-sized bovid was represented by an upper and lower forelimb, lower hindlimb, hooves, and dentitions. The remains of a single said comprised a forelimb, hindlimb and both mandibles, ribs and vertebral base were rare, and only 47 rib fragments and 24 vertebrae 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. In 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 weight of over 820 kg, are *Statherium*, *Rhinoceros* and a Proboscidea. At least two types of bovid are represented. One has a small dentition (e.g. *maximum* specimen 362X146), comparable to that of *Danailopala* palaichadus, 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 *Danailopala*. Its affiliation is unknown, but superficially it resembles one of the Tragelaphines, or bushbuck/kudu tribe. The teeth are as large as, and similar to, those of *jembus* triquercornis, (e.g. mandibular specimens 362G06, a left maxilla with a moderately worn M3, 38mm long and 12mm wide, and 362G82, a right maxilla with the dm3 (34.8mm long) and M1 erupting, and may have been associated with a part of horns, 362GEX and 362E12. There 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 the time to skull was 25 cm, but 24 cm, 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 in the base of the fossil accumulation, and comprised two jaw fragments (1109X124), three canines (XX9X104/X126), an atlas (X92), humerus (X38), radius (X35), ulna (X41), epiphysis (X75), both tibias (X56/125), calcaneum (X105), astragalus (X100), four metapodia (X184/X93/154/X159), four carpalis or tarsals (X103/X105/X112/X160) and three phalanges (XX3X/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 ectodontid in addition to the main hypocodion of the talus. The metacast 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 thirteen in Natural History Museum specimens of the large European hunting dog, *Canis* (*Vulpes*) *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 caudalis* (Bone, 1881), 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 Bone, other than that they were found in Siwaliks deposits, with a possible mid-Pleistocene date, although he did acknowledge the possibility of them being more recent. The relationship of *Canis caudalis* to either 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. caudalis* from any of the material from Sandstone 12 (which comprised half the total found in the Pakli Hills), and included also the material from localities 73 and 642), it is possible that it has become extinct by 1.4 Ma.

The *Statherium* is of interest as it is rare type of giant Pleistocene giraffe. The *Statherium*, 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 in some South African cave sites of a similar date (Brain, 1981). As the material at Locality 362 is post-craneal and most probably from *Statherium giganteum*,
Table 3: Measurements of lower dentitions of *Canis canadiensis*.

<table>
<thead>
<tr>
<th>C</th>
<th>P3</th>
<th>P4</th>
<th>M1</th>
<th>M2</th>
<th>P1-M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>B</td>
<td>L</td>
<td>B</td>
<td>L</td>
<td>B</td>
</tr>
</tbody>
</table>

*Canis canadiensis*

**Locality 362: X124**

| 14.0 | 9.7 | 15.6 | 7.3 | 17.5 | 9.0 | 31.5 | 12.7 | 8.5 |

Natural History Museum specimens

| -   | -   | -   | -   | -   | s27 | 10.7 | 7.2 | 11.1 | 7.6 | -   | M40182 |
| -   | -   | -   | -   | 25.2 | 10.0 | 6.3 | 19.6 | 7.3 | -   | M40181 |

*Palaeon and Courtenay, 1835.* Although the cranial material for this species is more extensively described that the postcranial (Gould, 1878; Asf and de Vos, 1980), the postcranial specimens at Locality 362 fit the general description of a large, heavy *Staurotherium* (Colbert, 1935), not elongated in the limbs.

Finally, and somewhat remarkably, a complete ulna (X15/16) and almost complete carpometacarpus (X166) of a large bird were also found.

**II. Age profiles**

The epiphysial fusion of the long bones and/or the presence of permanent dentition indicates that all the animals (including the canid) were fully adult at the time of death except the large bovid, of which a murid 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 *Staurotherium* 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 spines 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 elements. The articulation is predominantly in the lower limbs, with the foot varying in degree of articulation from a whole foot (tarsals, metatarsals and first, second, and even third phalanges) to two carpals (scaphoid and lunar). Other material was anatomically adjacent, such as the humerus, ulna and radius.

**INTERPRETATION OF THE FOSSIL ACCUMULATION**

**I. Carnivore damage**

At locality 73, many epiphyseal of long bones had been broken, and often the growing 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 malleable but also on long bones and long bone fragments. The damage was not restricted to any particular taxon but was particularly evident on the ulna and tabid remains.

The carnivore damage indicates that at least two types of carnivore were active at this 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 to break into soft skeletal parts. The damage could have been caused by the hyperaids *Pachycentrus* and *Crocisio*. The second carnivore was much smaller, and inflicted less destructive damage in the form of incisions 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, grain marks, spiral fractures, depressed fractures, and gnawed epiphyseal. *Canis canadiensis* 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 lath 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 caudal 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 (Bain, 1981). A smaller carnivore, either a juvenile or the same species already at the site as a different species not preserved at the site, is more likely to have produced these marks.

ii. Site formation processes

The absence of stone artifacts, 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 aepycynites 3) the presence of gnaw marks; and 4) the presence of several articulated segments of carcasses; and 5) the fresh, unrotted 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 sil-turb 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 mudball (specimen 73C EX 260, see Fig. 5). A possible scenario might thus have been a depression or gully that was used by hyaena 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 possible 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 kleptoparas 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 either is a site of.epigravins, or juvenile carnivores, apart from the fine striations on the large caudal mandible, but this could equally be attributed to other agents, such as other small carnivores. The high representation of limb 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 it is evident in other palaeo-faunal assemblages (Bain, 1981; Kronk, 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 clearer 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. 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 the 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).

<table>
<thead>
<tr>
<th>Weathering stage</th>
<th>1</th>
<th>2</th>
<th>2a</th>
<th>2b</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locality 362 surface</td>
<td>86</td>
<td>16</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Locality 362 excavation</td>
<td>66</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>19</td>
<td>6</td>
<td>4</td>
<td>133</td>
</tr>
<tr>
<td>Locality 73 surface</td>
<td>27</td>
<td>44</td>
<td>25</td>
<td>19</td>
<td>6</td>
<td>4</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>Locality 73, excavation</td>
<td>12</td>
<td>140</td>
<td>59</td>
<td>43</td>
<td>8</td>
<td>2</td>
<td>264</td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSIONS

The evidence from these two localities raises two related general issues concerning the fossil record of the Upper Swatik. The first is the evidence for carnivores. There are rare in the Upper Swatik, and the only ones reported from the Pinjor Formation in India are Caris spinosusmus, Crouco felinus, and Utirmanus in the fossil record (Nanda, 1992, p. 46, 48, 202). 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 215) (Tutur, 2004, 485), it is highly possible that there are records in southern China (Wang, et al., 1995). It is not certain whether the absence from the Upper Swatik of India of Pachycrocuta is genuine, or is likely to result from insufficient sampling of rare taxa. This is the likely to be true of Pterocerus of P. secus, Caris canis, Megacerotherium, and others, all of which are recorded in the Pabbi Hills. However, the Upper Swatik record of the Pabbi Hills and other Upper Swatik exposures in Pakistan is also likely to be incomplete: Homoalotherium, for example, is recorded at Durrani (Gahunia et al., 2000a) to the west and Langopu (Wang, 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 Homoalotherium has come from deposits that were excavated, and the only specimen of Megacerotherium came from a through 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 in fossil concentrations such as localities 73 and 362. Although it is likely that hyaenids accumulated the prey remains only to subsequently scavenged and, at the same time, scavenged on 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 base in mind that some predators such as Homoalotherium and Megacerotherium (and hominoids) 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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