Scientific Notes

A case of carnivore-inflicted damage to a fossil femur from Swartkrans, comparable to that on a hominid femur representing *Orrorin tugenensis,* BAR 1003'00 (Kenya)

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Since the discovery in 1948 of the Swartkrans site in the Sterkfontein Valley in the Cradle of Humankind World Heritage Site (Brain, 1981, 1993*a*; Brain and Watson, 1992; Broom, 1950; Broom and Robinson, 1952), several fossilized bones with signs of carnivore activity have been found (Brain, 1970, 1993*b*; Brain and Watson, 1992; Newman, 1993; Pickering *et al.,* 2004). A famous example is a cranium of a young hominid (SK 54) with two holes punctured by a carnivore, probably a leopard (Brain, 1970, 1981). Marks caused by carnivore activity on fossil hominids are not rare. Such is probably the case for BAR 1003'00 (Fig. 1), a proximal left femur attributed to *Orrorin tugenensis* (Senut *et al.,* 2001; Pickford *et al.,* 2002), dated between 6 and 5.7 million years (Sawada *et al.,* 2002) which presents such marks, but the agent is uncertain. It was possibly a large felid (Pickford and Senut, 2001), rather than a crocodile, which is a common reptile in the Lukeino Formation, but which causes a different kind of damage to bones (Njau and Blumenschine, 2006). The possibility that the agent was a felid is assessed in the context of a femur from Swartkrans (SK 1884) (Fig. 2).

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BAR 1003'00

This left femur (Fig. 1) was discovered at the site of Kapsomin in the Lukeino Formation, Kenya (Pickford and Senut, 2001). The proximal part with a substantial portion of the shaft is preserved (length = 149.6 mm; maximum width = 43.6 mm; antero-posterior thickness of the shaft = 19.7 mm; medio-lateral thickness of the shaft = 26.2 mm). The femoral head is missing, as is the greater trochanter. Two additional femora attributed to *Orrorin tugenensis* come from the sites of Kapsomin (BAR 1002'00) and Aragai (BAR 1215'00), in the same geological formation. They also lack the greater trochanters, a type of damage probably being related to the activity of a carnivore (Fig. 3).

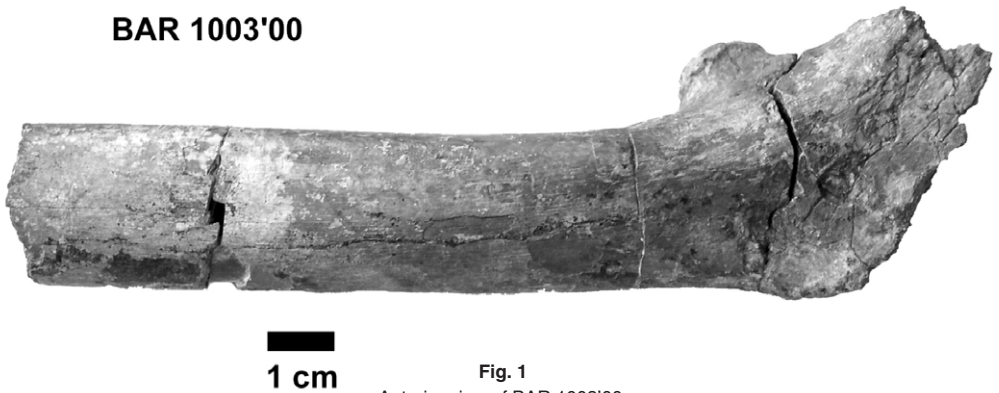

Fig. 1
Anterior view of BAR 1003'00.

Fig. 2
Anterior view of SK 1884.

The greater trochanter is the place of insertion or origin of several muscles and tendons; in hominids this part of the body is thus fleshy. In order to detach the leg from the hip, a carnivore would have chewed this part preferentially. This hypothesis is confirmed by the presence of three puncture marks on the anterior side of the femur BAR 1003'00 which correspond to tooth marks (Fig. 3), probably those of canines (Pickford and Senut, 2001).

SK 1884

This is a left femur of medium size (length = 151.9 mm; maximum width = 55.3 mm; antero-posterior thickness of the shaft = 18.9 mm; medio-lateral thickness of the shaft = 19.9 mm) (Fig. 2), from Swartkrans (Member 2), curated at the Transvaal Museum in Pretoria. This fossil was found in a box with the following indications: 'Box 16, Swartkrans Member 2, non-bovid postcranial'. For better observation, F. Sénégas cleaned the fossil by acid preparation in order to remove the adhering breccia. The fossil consists of the proximal end lacking the head and greater trochanter, and much of the shaft lacking the lesser trochanter (Fig. 4). Breccia inside the bone indicates that the greater trochanter was missing prior to fossilization. The

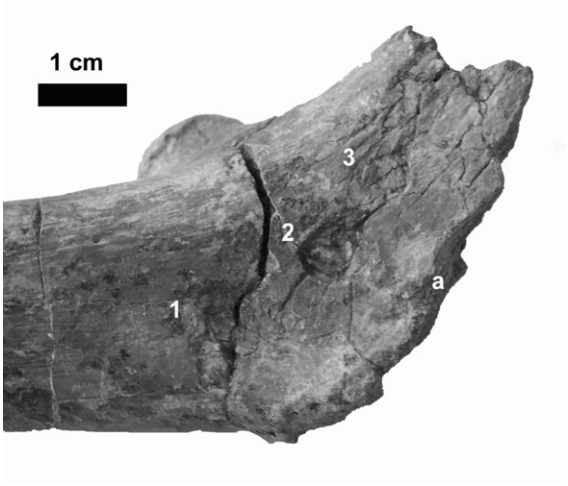

Fig. 3
Anterior view of BAR 1003'00 proximal part: (1) the lateral puncture mark, (2) the central puncture mark, (3) the median puncture mark, (a) the chewed greater trochanter.

Table 1
Measurements of marks of BAR 1003'00 and SK 1884.

Puncture marks	BAR 1003'00 median	BAR 1003'00	BAR 1003'00 central	SK 1884 lateral
Dimension antero-superior (mm)	4.4	5.5	5.7	6.2
Dimension medio-lateral (mm)	4.4	5.9	5.3	4.8

anterior side carries at least two puncture marks resembling tooth marks (Fig. 4). It represents a subadult individual of a hyaena such as *Crocuta crocuta* (the femoral neck has signs that the epiphysis was not completely fused at the time of death). The comparison was made with extant material from the Archaeozoology Collection of the Transvaal Museum.

Carnivore marks

The two above femora have similar types of marks caused by carnivore activity. In both cases, the greater trochanter has been chewed, and the anterior side of the proximal end of the femur bears puncture marks. There are three punctures marks on BAR 1003'00 (median, central, and lateral) (Fig. 3). One large mark is found on SK 1884 (Fig. 4), and there is a very small puncture mark near the femoral neck (2.1 × 2.1 mm). In addition, the edge near the base of the greater trochanter of SK 1884 is curved in a way that could correspond to a tooth mark. Measurements are given in Table 1.

We measured the internal dimensions in the deepest parts of the puncture marks. Crushing of the bone by the teeth has affected more of the bone, especially in BAR 1003'00.

DISCUSSION

BAR 1003'00 was found in lake margin deposits at Kapsomin. This lake was inhabited by crocodiles such as *Crocodylus lloydi* and *Crocodylus* sp. (Pickford and Senut, 2001), although these were probably not responsible for the tooth marks on the hominid femora. The shape of some of the crocodile tooth marks on extant and fossil bones (Njau *et al.,* 2006) is comparable to those made by carnivores. The absence of the greater trochanter in all three femora attributed to *Orrorin* indicates that this part was gnawed, something that crocodiles cannot do (Njau *et al.,* 2006). Medium-sized to large carnivores are present in the fauna from the Lukeino Formation, including Hyaenidae, Canidae and Felidae (Pickford *et al.,* 2001). The first of these predators usually crush bones. Felids chew bones and gnaw the fleshy parts. Canidae are unable to crush big bones, but they can gnaw and chew them. The puncture marks on BAR 1003'00 are large and do not correspond to the tooth marks made by Canidae. The same is true for SK 1884, which also has large marks.

The Swartkrans collection contains the remains of some medium-sized to large mammalian predators such as Hyaenidae, Canidae and Felidae, but no crocodiles have ever been found there (Brain, 1981; De Ruiter, 2003; Turner, 1993; Watson, 1993). The greater trochanter of SK 1884 is gnawed and this predation resembles damage caused by a felid. Newman (1993) questioned whether some tooth marks on bones from Swartkrans could have been produced by the activity of hyaenas. Study of bones

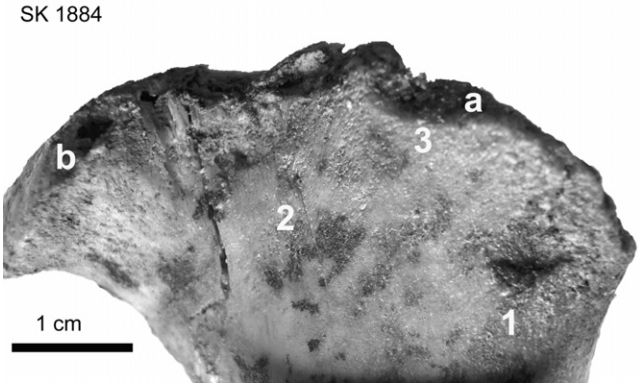

Fig. 4
Anterior view of SK 1884, proximal part: (1) the lateral puncture mark, (2) the median puncture mark, (3) the curvature which could correspond to a tooth mark: a, the chewed greater trochanter; b, the non-fusion of the femoral head.

eaten by the extant spotted hyaena (Blumenschine, 1988) revealed that 15% of long bone fragments showed distinctive tooth marks. However, a hyaena would not have gnawed only the greater trochanter of SK 1884 or BAR 1003'00 but would have destroyed the entire proximal part of a femur. This is confirmed by studies of the effects of striped hyaena activity on human (Horowitz and Smith, 1988) or animal remains (Brain, 1981). The spongy epiphyses of proximal femora are gnawed preferentially, leaving the shaft which is composed of compact bone.

The Kapsomin mammalian assemblage is dominated by small to medium-sized ruminants and colobus monkeys. The main carnivore agent of accumulation could have been a leopard-like cat (Pickford and Senut, 2001). More recent research at Kapsomin led to the discovery of the remains of large mammals, including rhinoceros and hippopotamus, the carcasses of which would attract occasional scavengers such as hyaenas.

CONCLUSION

The study of SK 1884 is relevant to the analysis of the femora of *Orrorin tugenensis.* The predators involved in the damage to these bones were not crocodiles, but could have been carnivores endowed with relatively weak jaws, and which could chew and gnaw bone, without crushing it completely. A felid such as a leopard may have been the agent but the possibility that a hyaena was responsible for the marks cannot be excluded.

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