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Damaliscus niro horns from Wonderwerk Cave and other Pleistocene sites: morphological and chronological considerations

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Wonderwerk Cave, situated near Kuruman in the Northern Cape Province of South Africa, has yielded well-preserved horns of many antelope, including three horn fragments of *Damaliscus niro.* These specimens were discovered in the course of guano-mining operations in the 1940s. Remarkably, they retain a keratinous sheath. Dimensions of *Pleistocene* horn cores from Sterkfontein, Olduvai, Cornelia-Uitzoek, Florisbad and Maselspoort are used to assess the Wonderwerk specimens. Assuming that morphological variability can be used to assess relative chronology, we suggest that the Wonderwerk specimens date to the Middle Pleistocene, intermediate in age between specimens from Florisbad (between 400 000 and 100 000 years BP) and Cornelia-Uitzoek (*c.* 800 000 years BP). One of the Wonderwerk specimens has a radiocarbon date of close to the limit of the method. We interpret this to reflect an indefinite age of greater than 40 000 years ago. This is not in conflict with the suggested Middle Pleistocene age of the specimens. The horns are of further interest in that the keratin sheaths have carbon-nitrogen ratios that suggest the presence of protein suitable for ancient-DNA analysis.

Keywords: morphological variability, chronology, early Florisian.

INTRODUCTION

Wonderwerk Cave is a dolomitic solution cavity, extending almost 140 metres into a hill on the eastern side of the Kuruman hills, in the Ghaap Plateau Dolomite Formation in the Northern Cape Province (Fig. 1). Malan & Cooke (1941) gave a preliminary account of faunal remains, which had been discarded by guano-diggers at the site. Subsequently, Malan & Wells (1943) gave a more detailed report of these fossil collections. These assemblages have a Florisian character, comparable to those from the Florisbad springs (Brink 1978, 1988, in prep.)

Systematic excavations at Wonderwerk have been undertaken since the late 1970s (Beaumont 1979, 1990; Thackeray *et al.* 1981; Thackeray 1984a,b; Humphreys & Thackeray 1983), under the aegis of the McGregor Museum. The preservation of fauna is good in the cave where even keratinous sheaths of horn cores have been recovered (Malan & Wells 1943; Beaumont 1990). Two *Damaliscus niro* horns from the guano-digging operations (Figs 2 & 3) are here designated WH1 and WH2, respectively the larger and smaller of two fragments, which evidently belonged to one individual. A third horn fragment (WH3) from the same collections, representing the same species, has recently been recognized.

Although these horns are now assigned to the alcelaphine species *D. niro,* initially they had been identified as those of *Capra ibex.* Robert Broom had gone so far as to suggest that the horns had been carried in prehistory from Ethiopia, where ibex occur at present (Malan & Wells 1943). E.C.N. van Hoepen of the National Museum in Bloemfontein had examined the horns and had said 'to our astonishment it really is an ibex' (translation by J.F.T. from Afrikaans, Archaeological Survey manuscript, State Archives file B20/1/1, Pretoria; Thackeray 1987). The Abbe Breuil, who was familiar with ibex from Palaeolithic contexts in France, supported this view. Wells (1965) recognized WH1 and WH2 as horns of *D. niro* (Thackeray 1987, 1989, 1990), which are characterized by long, curved horns, similar to those of *Hippotragus equinus* (roan) and *Hippotragus niger* (sable). In fact, horns of *D. niro* were once regarded as *Hippotragus niro,* but Leakey (1965) recognized that '*Hippotragus niro*' was an alcelaphine rather than a hippotragine, a view supported by others (Gentry 1965; Gentry & Gentry 1978).

Damaliscus niro is represented in Early Pleistocene contexts at Sterkfontein (Member 5), Olduvai (Beds I and II) (Gentry & Gentry 1978; Vrba 1976) and in terminal Early Pleistocene faunal assemblages from Cornelia-Uitzoek. The fossil assemblages from Cornelia-Uitzoek

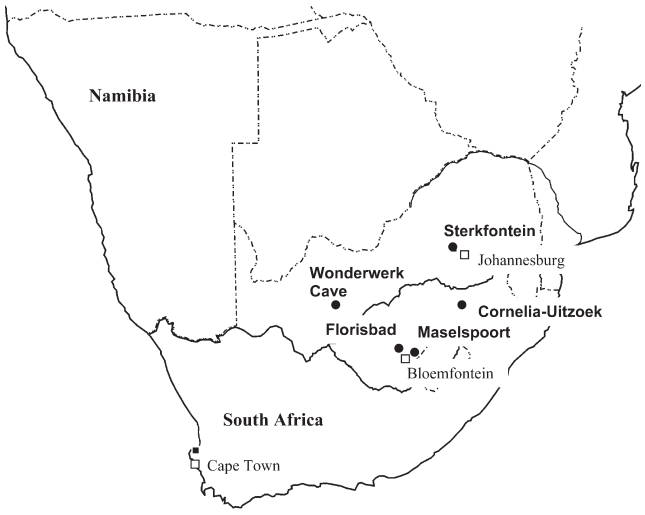


Figure 1. Map showing the localities of Wonderwerk, Florisbad, Maselspoort, Cornelia-Uitzoek and Sterkfontein, where horns of *Damaliscus niro* have been found.

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are the type materials of the Cornelian Land Mammal Age (LMA), estimated to date to *c.* 800 000 years BP (Brink & Rossouw 2000; Brink, in press). *D. niro* is also found in Middle and Late Pleistocene deposits at Florisbad and Maselspoort (Brink 1987, 1988; Fig. 1). The Florisbad spring assemblage is the type of the Florisian LMA and is dated by Electron Spin Resonance to between 400 000 and 100 000 years ago (Brink 1987, submitted; Grün *et al.* 1996). It was noted that the horn cores of *D. niro* become more rounded with decreasing geological age and that this is reflected by changes in the relationship between anterior–posterior length (APL) and mediolateral breadth (MLB) as measured at the nodes and internodes of the horn cores. Thackeray *et al.* (1996) quantified morphological variability in the shape of *D. niro* horn cores.

OBJECTIVES

The objectives of this analysis were firstly to try to obtain a radiocarbon date for the Wonderwerk horn specimen WH1, because it has no stratigraphic context, and to test the prospects of extracting ancient DNA from the specimens. Secondly, we compared dimensions of WH1 and WH3 with those of other specimens attributed to the same species, from Early, Middle and Late Pleistocene contexts, in order to assess the relative chronology of the *D. niro* horn cores from Wonderwerk. It has been demonstrated for the black wildebeest that morphological variability reflects geological age (Brink 1993, submitted). Therefore, it is assumed that horn core variability in *D. niro* may be used to indicate relative chronology, but not necessarily absolute chronology. The data presented in Thackeray *et al.* (1996) are used here as reference.

RESULTS

Radiocarbon and isotopic analyses

A small sample of keratin (<1 g) selected from a previously damaged portion of WH1 was submitted to the Radiocarbon Accelerator Unit at Oxford University. A date of 39 800 ± 1600 BP (OxA-2333) was obtained. Although this is an absolute date, just within the range of the radiocarbon dating technique, it is 'more realistic to regard the date as equal to or older than 40 000 B.P.' (R.E.M. Hedges, pers. comm to J.F.T.).

Keratin samples were analysed for stable carbon isotope ratios (^{13}C: ^{12}C), using facilities at Oxford University and at the University of Cape Town. Delta ^{13}C values of –7.2 per mil (<2 mg microsample UCT 3257, from WH1), and –9.3 per mil (from the same sample as that which provided a radiocarbon date, OxA-2333) indicate that *D. niro* was a grazer feeding on C_4 grassland (Thackeray 1990).

A carbon:nitrogen ratio of 3.6 obtained from microsample UCT 3257 (<2 mg) from WH1 is similar to the ratio which might be expected for modern keratin. This is remarkable for keratin from a horn core, which is older than 40 000 years, and suggests that it would be possible to extract ancient DNA from these specimens. The excellent preservation of the keratinous horn sheath of WH1 is attributable in part to dry conditions in the recesses of Wonderwerk Cave (Thackeray 1990).

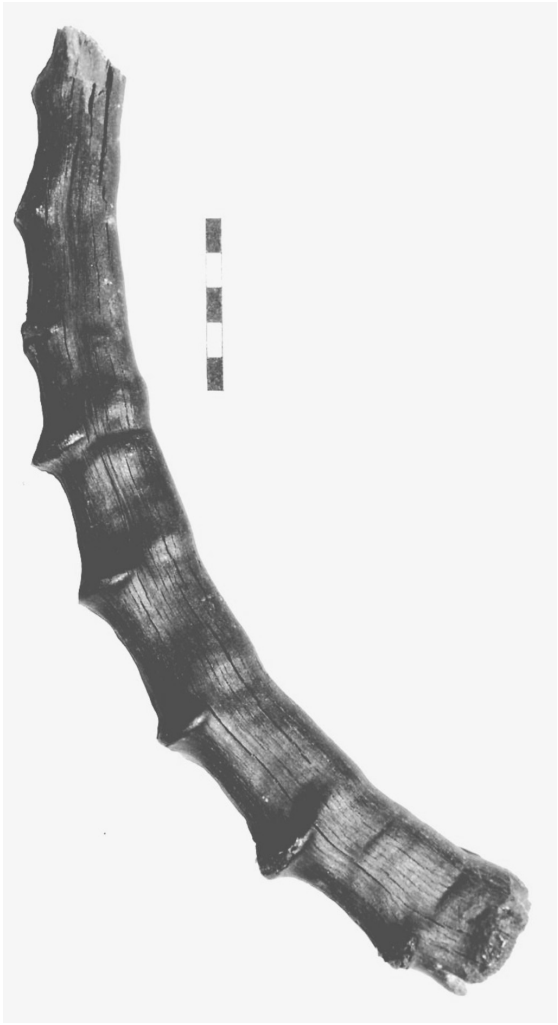


Figure. 2. Photograph of the horn of *Damaliscus niro* (WH1) recovered by guano miners at Wonderwerk Cave *circa* 1940. The horn retains a keratinous sheath. Scale in centimetres.



Figure 3. Photograph of Wonderwerk horn WH2 (left) and X-ray image (right).

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Morphological analysis

Anterior–posterior length (APL) and mediolateral breadth (MLB) dimensions of the horn core of WH1 have been determined from CT scans, taken at intervals along the length of the horn. CT sections were taken non-destructively at nodes and internodes. Conventional X-ray images were obtained from WH3, a fragment which lacks the bony core but which has a well-preserved keratinous sheath, the inner margins of which reflect APL and MLD dimensions of the missing core.

By means of least-squares linear regression analysis, relationships between log-transformed APL values (x-axis) and log-transformed MLB values (y-axis) can be determined, using the general form of the regression equation $y = mx + c$, where the m-coefficient refers to the slope of a regression line, based on measurements of APL and MLB in millimetre units.

The following equation was obtained from log-transformed APL and MLB values of Wonderwerk horns WH1 and WH3:

$y = 1.440x - 0.915$ ($r = 0.984$, $n = 11$ measurements) (1)
(standard error of m-coefficient: 0.162)

Regression analyses were undertaken in the same way on horn cores from Early, Middle and Late Pleistocene contexts (Thackeray *et al.* 1996). The following results were obtained:

Early Pleistocene horn cores
(Olduvai Beds I and II; Sterkfontein Member 5)

$y = 1.047x - 0.202$ ($r = 0.98$, $n = 47$ measurements) (2)
(standard error of m-coefficient: 0.027)

Terminal Early Pleistocene horn cores
(Cornelia-Uitzoek)

$y = 1.195x - 0.517$ ($r = 0.97$, $n = 22$ measurements) (3)
(standard error of m-coefficient: 0.070)

Middle & Late Pleistocene horn cores
(Florisbad and Maselspoort)

$y = 2.105x - 1.935$ ($r = 0.87$, $n = 50$ measurements) (4)
(standard error of m-coefficient: 0.171)

The curvature of WH1 and that of a horn core of *D. niro* from Cornelia-Uitzoek (C770.1) are both associated with a radius of *c.* 230 mm. Fig. 4 serves to reconstruct a mid-Pleistocene horn of *D. niro,* from the juxtaposition of specimen C770.1 (including the base of a large horn) and Wonderwerk specimen WH1 (closer to the tip of a horn).

DISCUSSION

The m-coefficients associated with equations 2, 3 and 4 reflect temporal changes in breadth relative to anterior–posterior length at the nodes of Pleistocene *D. niro* horn cores. The slope for the end-Early Pleistocene horn cores from Cornelia-Uitzoek is 1.195, associated with a standard error of only 0.070. The coefficient obtained from analysis of the Early Pleistocene cores (1.047) is significantly lower ($P = 0.05$) than that associated with the Cornelia-Uitzoek specimens. By contrast, the coefficient of 2.105 obtained from Middle and Late Pleistocene specimens from Florisbad and Maselspoort is significantly higher ($P = 0.05$) than that obtained from analysis of the Cornelia-Uitzoek specimens. The coefficient for the Wonderwerk specimen (WH1) is 1.440, intermediate between values obtained from analyses of Cornelia-Uitzoek and Florisbad specimens, but closest to the value obtained from end-Early-Pleistocene horn cores of Cornelian age.

Table 1. Anterior–posterior length (APL) and mediolateral breadth (MLB) dimensions (mm) of the bony core of Wonderwerk horn core fragment WH1, determined from non-destructive CT scans through nodes and inter-nodes of the horn sheath; CT scans taken at approximately 90° to the tangent of the curvature of this horn. Dimensions obtained from WH3 were taken from X-ray analyses of the well-preserved keratinous sheath, the inner margins of which can be used to infer APL and MLB dimensions of the bony core (missing from this specimen). If WH1 and WH3 represent one individual, WH1 would be part of the horn near the tip, whereas WH3 would be closer to the base of the horn.

	APL	MLB
WH1 (adjacent internode)	8.2	2.8
WH1 (adjacent node)	8.8	2.7
WH1 (adjacent node)	11.0	3.6
WH1 (adjacent node)	15.0	5.
WH3 (adjacent internode)	35.0	20.0
WH3 (adjacent node)	36.5	21.0
WH3 (adjacent internode)	37.0	21.0
WH3 (adjacent internode)	37.5	22.0
WH3 (adjacent internode)	37.0	22.5
WH3 (adjacent node)	38	23
WH3 (adjacent internode)	39	26.5

The approximate date for the Cornelia-Uitzoek samples (associated with a m-coefficient value of 1.195) is *c.* 800 000 BP, or somewhat older (Brink & Rossouw 2000; Brink, submitted), while the age for the Florisbad samples (associated with a m-coefficient of 2.105) is *c.* 400 000 to 100 000 B.P. (Grün *et al.* 1996). Given the infinite radiocarbon age of the Wonderwerk horn core specimen, we would place the Wonderwerk horns (associated with an intermediate m-coefficient of 1.44) in an intermediate period within the Middle Pleistocene.

It should be noted that the degree of intraspecific variation and sexual dimorphism of the horn cores in the various temporal assemblages of *D. niro* appear not to be different from that of the living blesbok/bontebok (*Damaliscus pygargus*), which is a close relative of *D. niro.* Furthermore, the relationship between mediolateral and antero–posterior diameter of the nodes and internodes of the *D. niro* horn core appears not to be affected by intra-population variability as seen in the fossil assemblages (Thackeray *et al.* 1996). There is at present no evidence for geographic variability in the horn cores of *D. niro.*

CONCLUSIONS

We conclude that Wonderwerk horns WH1, WH2 and WH3 are outside the range of the conventional radiocarbon dating technique. By comparison with specimens of Early, Middle and Late Pleistocene age we suggest that the Wonderwerk specimens are closest in age to the terminal-Early Pleistocene samples from Cornelia-Uitzoek. This suggests an early Florisian faunal age, which in absolute terms may approach 800 000 years ago, which is the

assumed upper limit of the Florisian LMA (Brink, submitted). The remarkable preservation of the Wonderwerk specimens, and the associated C:N ratio of 3.6 for a keratinous horn sheath, indicate the potential opportunity for DNA analysis. Preliminary analyses undertaken on part of the horn drilled by T.J. Robinson (University of Pretoria) and Williamson (1996) were inconclusive, but indicated the presence of DNA in a degraded form. This discovery is remarkable in that it possibly represents the oldest ancient DNA known thus far.

We thank R.E.M. Hedges for assistance with radiocarbon dating of a small sample (<1 mg) of keratin obtained from WH1; F.W. Zonneveld for assisting with CT scanning of specimen WH1; A. Morris and E. Vrba for assistance in relocating WH1 which was temporarily lost in the Anatomy Department of the Medical School of the University of Cape Town, where it had been studied by the late L.H. Wells; R. Liversidge of the McGregor Museum, and staff of the Kimberley hospital, for assistance with X-ray analysis of WH2 when the specimen was in Kimberley, before being returned to the University of the Witwatersrand where collections formerly associated with the Archaeological Research Unit were curated (unfortunately WH2 is now missing); T. Huffman of the University of the Witwatersrand for efforts to retrace WH2; P. Beaumont for access to WH3, and staff of the Jacaranda Clinic in Pretoria for X-ray analysis of WH3. The carbon-isotope analysis of a microsample of WH1 was approved by permit Per/4/187 granted through J. Deacon by the National Monuments Council. Specimens WH1 and WH3 are now curated by the McGregor Museum, Kimberley. This project was supported by the National Research Foundation (GUN 2065329) South Africa.

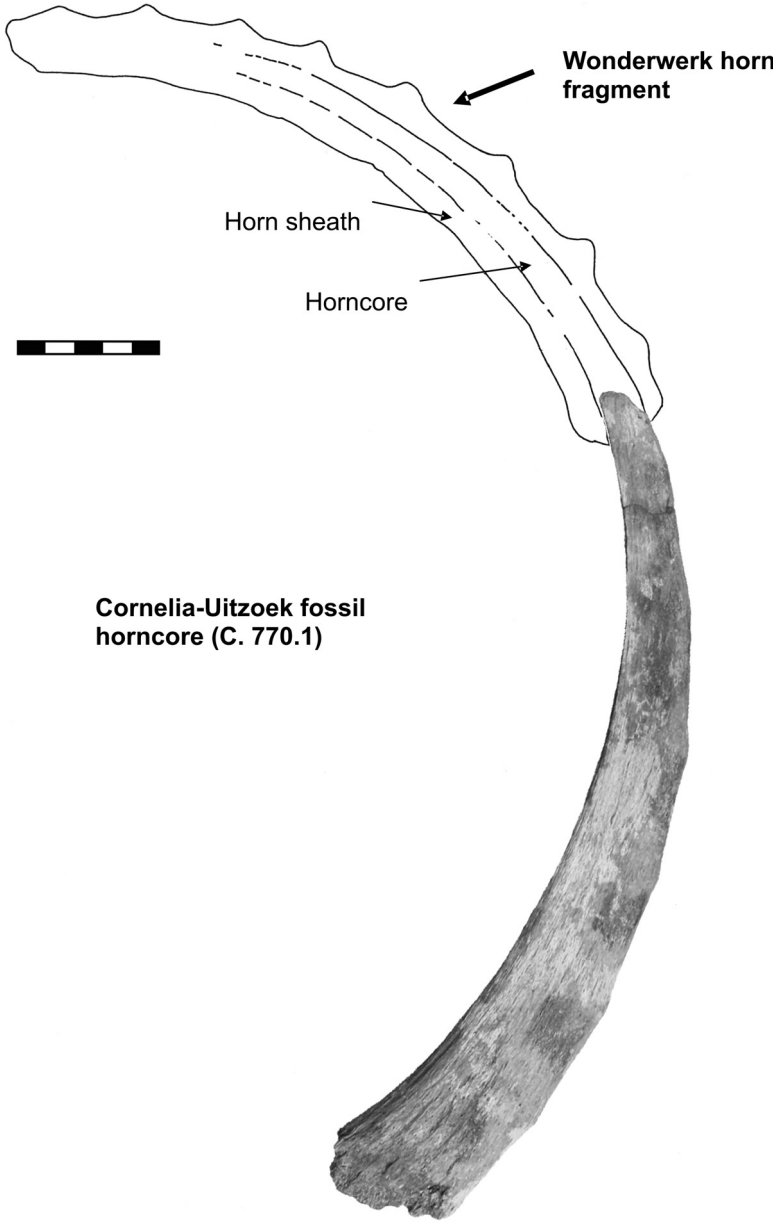


Figure. 4. Reconstruction of a mid-Pleistocene horn of *Damaliscus niro,* based partly on Cornelia horn core C770.1 (near the base of a large specimen), and partly on Wonderwerk horn WH1 (with keratinous sheath, nearer the tip of the horn). Both horn fragments are associated with curvatures with a radius of *c.* 230 mm.

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