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Radiocarbon Dating Caribou Antler and Bone: Are They Different?

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ABSTRACT. Old archaeological radiocarbon dating lore has it that caribou antler and bone give different dating results, and that for some fundamental reason antler is unreliable as a dating material. We tested this idea by measuring radiocarbon concentrations in the bone and antler of two caribou (one recent, one ancient) for which the antler was still attached to the cranium. No significant differences were found. Thus, it seems that this old myth is groundless.

Key words: radiocarbon dating, caribou, antler

RÉSUMÉ. Selon de vieux dires, la radiodatation archéologique des bois et des os du renne donnerait des résultats différents et, pour une raison fondamentale, les bois ne représenteraient pas un matériau fiable pour la radiodatation. On a testé cette idée en mesurant les concentrations de radiocarbone dans les os et les bois de deux rennes (l'un mort récemment, l'autre il y a longtemps), où les bois étaient encore rattachés au crâne. On n'a pas trouvé de différence notable, ce qui semblerait signifier que l'ancien mythe est sans fondement.

Mots clés: radiodatation, renne, bois

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INTRODUCTION

Radiocarbon dating is a topic of continuing interest and controversy in Arctic archaeology. In a recent note, Nelson and McGhee (2002) re-examined a Thule arrowhead that had a radiocarbon age far too old for a Thule artefact and concluded that the point had been made on antler material that was already 2500 years old at the time of manufacture. During a casual discussion of this observation at the Greenland Research Centre of the National Museum of Denmark, another apparent problem with dating of caribou antler surfaced. It seems that during the early days of radiocarbon dating, archaeologists working in the Arctic noted that caribou antler could give anomalous radiocarbon results when compared to other terrestrial sample materials (cf. McGhee and Tuck, 1976). In contrast to caribou bone, antler came to be regarded as an unreliable dating material, an idea that remains a part of present-day Greenlandic research lore (M. Appelt and J. Meldgaard, pers. comm. 2002).

What could underlie this old concept? There is no fundamental reason to suspect that caribou antler should give a radiocarbon age significantly different from that given by bone from the same animal. Antler is a very rapidly growing tissue that is formed in a few weeks and then discarded a few months later, while bone tissue is formed over a period of a year or two and then very slowly remodeled over the lifetime of the animal. While antler might then reflect short-term atmospheric radiocarbon concentration fluctuations that would be absent from the longer-term average of the bone, this would not result in age differences of more than a decade or two at most (e.g., compare the annual and decadal radiocarbon calibration data in Stuiver et al., 1998) and thus seems unlikely to be the source of the problems noted in the past. Another technical explanation might be the very serious contamination problems encountered with both bone and antler in the early days of radiocarbon dating, when measurements were often taken on the material as a whole. Other possibilities are that the differences were archaeological in nature, if the associative interpretations of the human events and artefacts were erroneous, or if the differences reflected other instances of the reuse of old antler for tool manufacture. A test of caribou antler and bone seemed to be in order.

Modern methods for extracting bone collagen have greatly reduced the problems with dating bone, and it has become a material of choice for radiocarbon dating. A simple test would then be to date both bone and antler from the same animal, thus eliminating any possibility of associative misinterpretation or reuse of old material. Two such sets of Greenlandic samples were chosen for the study. The first was the remains of a recent animal, which was very well suited for detailed testing; the second, the cranium of an ancient animal from a Saqqaq midden—an example of a real archaeological application. As will be

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seen below, in neither case was a significant difference found between the radiocarbon ages of bone and antler.

SAMPLES AND METHODS

The samples from both animals were obtained from the osteological collections at the Zoological Museum, University of Copenhagen. The first animal comprised the complete skeletal remains of a dead caribou collected on 20 July 1979 by M. Meldgaard near Kangerlussuaq, West Greenland. It was an adult female with antlers still attached and, given the state of decay (there was still soft tissue present), it was estimated that at most a few years had elapsed since the animal's death. This animal may have succumbed to a severe winter. An estimate of its age could be made at the Zoological Museum by comparing its teeth with those in a collection of mandibles from caribou of known age. Tooth wear indicated that this animal was approximately nine years old at the time of its death.

Its death in the 1970s made this animal ideal for this experiment, as its tissue should reflect the large changes in atmospheric radiocarbon concentration that were then taking place as a consequence of atmospheric nuclear weapons testing. These concentration changes would be so large over the lifetime of this animal that radiocarbon measurement uncertainty is not an issue in interpretation, and one might expect the bone and antler concentrations to provide detailed information on the animal's life that could be compared to the zoological information. If there are fundamental differences between bone and antler, they should be clearly evident in this animal.

The ancient samples were taken from a cranium with an antler portion still attached that was excavated by A. Gotfredsen and T. Møbjerg from the Nipisat site near modern-day Sisimiut, West Greenland. This site was clearly of Saqqaq cultural affiliation, and the caribou was expected to yield a radiocarbon age of approximately 3000–3500 years. Unlike the modern specimen, this one was not well preserved; while it was likely an adult animal, it was not possible to determine its sex. This bone-antler pair provides a test of a real archaeological sample in which any dating problems with the antler should be evident.

Both bone and antler were sampled by boring with a slow-speed drill. The area to be sampled was selected by appearance, and the surface was removed using a spherical milling bit. A drill bit 2 mm in diameter was then used to bore into the cleaned area, yielding about 60 mg of drillings from each sample. For the recent animal, the antler and a femur were sampled. For the ancient animal, a sample of antler was taken from a portion that remained connected to the cranium, and the bone sample was taken from the cranium itself.

Collagen was extracted using the usual method employed at the Simon Fraser University (SFU) Archaeometry Laboratory (details are given in Takahashi and Nelson, 2002). In short, the method isolates from the sample only those remaining collagen fragments with a molecular weight greater than about 30 kDaltons. During this sampling and extraction procedure, there are numerous tests of the quality of the material under study.

A portion of each extract was burned to yield CO_2, which was then sent to the Center for Accelerator Mass Spectrometry (CAMS) Group at the Lawrence Livermore National Laboratory for radiocarbon determination by accelerator mass spectrometry. A second aliquot was sent to the Earth and Ocean Sciences Department of the University of British Columbia for measurement of carbon and nitrogen concentrations and stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) values.

RESULTS

The material thus extracted from the recent samples has the characteristics (carbon and nitrogen concentrations and C/N ratio) expected for well-preserved bone and antler, as shown in Table 1. Those from the ancient animal were not well preserved, but nevertheless gave extracts that satisfy the requirements for isotopic measurement, as may be seen by comparison to those from the recent animal. The stable isotope results give a further test of the quality of the extract. For both animals, these values are very similar to those of numerous other Greenlandic caribou samples measured at the SFU laboratory. (To compare the recent and the ancient animals directly, one must add 1.5‰ (Friedli et al., 1986) to the recent $\delta^{13}C$ values to correct for the impact on atmospheric CO_2 of fossil fuel burning.) There is thus every indication that the radiocarbon determinations are reliable.

Since the basic concern here is the possible difference in radiocarbon concentration between bone and antler, the data are presented in Table 1 as $\Delta^{14}C$ values, which are the measured ^{14}C concentrations in the samples as compared (in parts per thousand) to that of the International radiocarbon standard (Stuiver and Polach, 1977). This allows direct comparison of the recent animal with the so-called 'bomb curve' data for the Northern Hemisphere, which gives the atmospheric radiocarbon concentrations since A.D. 1950 (Levin et al., 1985).

The data for the bone and antler of the recent caribou (Table 1) differ by 5.4‰. In statistical terms, this difference corresponds to 0.9 standard deviations (e.g., $5.4 / \sqrt{(4.4^2 + 4.4^2)}$), so these are results that could be expected for repeat measurements on the same sample. In Figure 1, these determinations are placed on the plot for atmospheric radiocarbon concentrations for the bomb-test period (Levin et al., 1985). The antler measurement provides a very precise time for the death of this animal, since caribou form and cast their antlers annually, and females keep theirs throughout the winter. The attachment of the antler to the cranium thus indicates that the death of this female occurred during late fall or winter. Given the measured concentration, there are two possible years in

TABLE 1. AMS and stable isotope results for the recent and ancient caribou.

SFU#	CAMS#	Sample	C conc. (%)	N conc. (%)	C/N ratio	$\delta^{13}C$ (‰ vPDB)	$\delta^{15}N$ (‰ vAIR)	$\Delta^{14}C$ (‰)
Recent:								
Rens–25	82922	antler	45.1	16.4	2.7	-21.1	2.4	498.2 ± 4.4
Rens–26	82923	femur	44.9	16.1	2.8	-19.7	2.1	503.6 ± 4.4
Ancient:								
Rens–27	82924	antler	45.3	15.6	2.8	-18.0	2.6	-309.0 ± 2.2
Rens–28	82925	cranium	44.7	15.6	2.9	-17.9	2.9	-314.6 ± 3.6

which this death could have occurred, either 1963 or 1971. The former is inconsistent with the collector's observations on the state of the carcass, and so we may conclude that the animal died in very early or very late 1971, as shown in Figure 1.

The femur result also indicates (Fig. 1) that the animal formed its bone collagen in either 1963 or 1971. The latter possibility is very unlikely, as the animal was an adult. If its femur radiocarbon concentration reflected that of the 1971 atmosphere, it must have been remodeling its bone collagen as rapidly as it formed antler. That is not reasonable, and so the most probable date for the animal's birth and growth period is 1962–63, indicating that the animal was about eight or nine years old at the time of its death in 1971. This age corresponds extremely well with the nine-year age estimate made on the basis of tooth wear. The data provided by the antler and bone radiocarbon measurements can thus be combined with zoological observation to provide detailed information on this animal's birth and death. This would not be the result if there were some systematic problem with antler determinations, and we conclude that there is no fundamental basis for the idea that antler gives deviant radiocarbon ages.

The bone and antler data for the ancient caribou (Table 1) differ by an almost identical amount, 5.6‰. As the measurement accuracy obtained for these samples was higher than that for the recent ones, this is a statistical difference of 1.3 standard deviations, which is a little more than one would expect for two measurements on the same prepared sample. This minor difference could reflect one or more of several possible causes: 1) simple random measurement probability, 2) a small overestimate of measurement accuracy by the laboratory, 3) slight differences in the level of contaminant elimination in these two poorly preserved samples, or 4) a real difference in the short-term and long-term averages for the antler and bone. It would be very difficult to establish which of these contribute to the observed radiocarbon concentration difference, but as it corresponds to an age difference of only 65 radiocarbon years, the outcome would be of no significance for either future measurement procedure or archaeological interpretation.

Conventional radiocarbon ages (as defined by Stuiver and Polach, 1977) for the ancient samples may then be calculated as 2920 ± 25 B.P. for the antler and 2985 ± 45 B.P. for the cranium. At the present level of archaeological analysis, the 65 ^{14}C-year difference is not significant, and either date is in complete accord with expectation for the

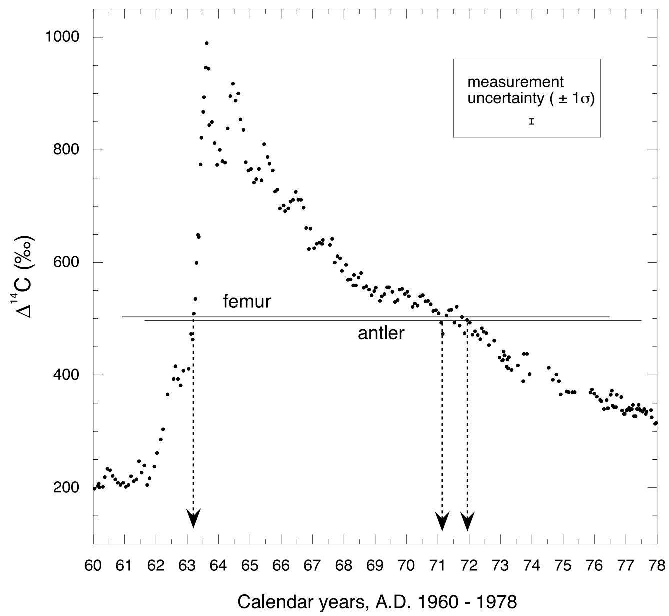

FIG. 1. Measured bone and antler radiocarbon concentrations for the recent caribou plotted as horizontal lines crossing the atmospheric radiocarbon "bomb curve" for the Northern Hemisphere (Levin et al., 1985). The intersections of the caribou determinations with the curve give the possible times for bone and antler formation, as shown by the arrows. The height of the bar in the inset box represents measurement uncertainty over the range of ±1 standard deviation; it is too small to influence interpretation.

site. Thus, the best dating estimate for this animal is the weighted average of these two results, or 2935 ± 22 B.P. This is well within the expected time range, and the archaeological implications of this determination are to be discussed by the excavators (T. Møbjerg and A.B. Gotfredsen, pers. comm. 2002).

CONCLUSIONS

Radiocarbon concentration measurements on an antler and a bone sample from each of a recent and an ancient caribou showed no age differences of significance to radiocarbon dating of these materials. It would appear that the old myth of a general problem with dating caribou antler is groundless. Caribou antler may in fact be a material of choice for radiocarbon dating, because it was so often used for tool manufacture and because, unlike marine materials, it requires no reservoir correction. However, there remains the possibility that the ancient hunter used even more ancient antler or bone for tool manufacture. It may have been that this practice was the basis of the early difficulties with caribou antler dating.

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REFERENCES

FRIEDLI, H., LOSTSCHER, H., OESHGER, H., SIEGENTHALER, U., and STAUFFER, B. 1986. Ice record of $^{13}C/^{12}C$ ratio of atmospheric CO_2 in the past two centuries. Nature 324:237–238.

LEVIN, I., KROMER, B., SCHOCH-FISCHER, H., BRUNS, M., MÜNNICH, M., BERDAU, D., VOGEL, J.C., and MÜNNICH, K.O. 1985. 25 years of tropospheric ^{14}C observations in central Europe. Radiocarbon 27(1):1–19.

NELSON, D.E., and McGHEE, R. 2002. Aberrant radiocarbon dates on an Inuit arrowhead. Arctic 55(4):345–347.

STUIVER, M., and POLACH, H.A. 1977. Discussion: Reporting of ^{14}C data. Radiocarbon 19(3):355–363.

STUIVER, M., REIMER, P.J., and BRAZIUNAS, T.F. 1998. High-precision radiocarbon age calibration for terrestrial and marine samples. Radiocarbon 40(3):1127–1151.

TAKAHASHI, C.M., and NELSON, D.E. 2002. Radiocarbon dating and stable isotope analysis of antler and bone from Greenland. Archaeometry Laboratory Internal Report 2002–2, Archaeology Department, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada.