



Hemp in ancient rope and fabric from the Christmas Cave in Israel: talmudic background and DNA sequence identification

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ABSTRACT

The “Christmas Cave”, a cave in the Qidron Valley near the Dead Sea and Qumran, has yielded a complex collection of plant-derived rope and fabric artifacts. Using polymerase chain reaction (PCR) to amplify DNA of the samples, we estimated the sizes and determined restriction patterns and base sequences of chloroplast genes, primarily *rbcl* (gene for the large subunit of ribulose biphosphate carboxylase). DNA was successfully extracted from all samples, but was limited to sizes of approximately 200–300 base pairs. As expected, the DNA extracted from the samples was identified as coming primarily from flax (*Linum usitatissimum* L.), but two samples had a significant fraction, and all samples had at least a trace, of hemp (*Cannabis sativa* L.) DNA. Artifacts from the Christmas Cave were thought to date from Roman times, but it was thought possible that some could be much older. Accelerator mass spectrometry (AMS)-based ¹⁴C dating confirmed that the samples contained representatives from both the Roman and Chalcolithic periods. This paper provides a synthesis of DNA, isotope, and literary analysis to illuminate textile history at the Christmas Cave site.

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1. Introduction

DNA analysis can identify the biological source of archaeological artifacts. This is true for many plant-based artifacts. Plant cells contain plastids, such as chloroplasts in leaves—often many copies—and plastids contain DNA sequences that are useful for identification. There is a great deal of information available concerning the base sequences of plastid genes in different plants, much of it gathered for use in determining evolutionary relationships. This information can be applied to objects like textiles and baskets.

At first glance, it may be surprising that DNA persists in manufactured objects, and some processes—e.g. mordanting—do break

down DNA. However, even present-day rope is made with natural fibers that receive a minimum of treatment, and the rope contains fragments of tissue with intact organelles (Dunbar and Murphy, 2009). We expect that treatments of fibers in the past were less stringent and the products from which they were made more likely to retain plastids and nuclei.

It may be even more surprising that DNA persists in ancient objects, since we can expect the rigors of time, with accompanying hydration, desiccation, and temperature extremes, to break down biological molecules. In fact, that does occur (Smith et al., 2003). But DNA may show a degree of resistance under certain conditions. Indeed its structure may have evolved in part to increase its stability (Lazcano et al., 1988). There have been many reports of ancient DNA isolated from, for example, mammoths preserved in glaciers (Gilbert et al., 2007), human mummies (e.g., Caramelli et al., 2008), wood (Liepelt et al., 2006), and rope (Mukherjee

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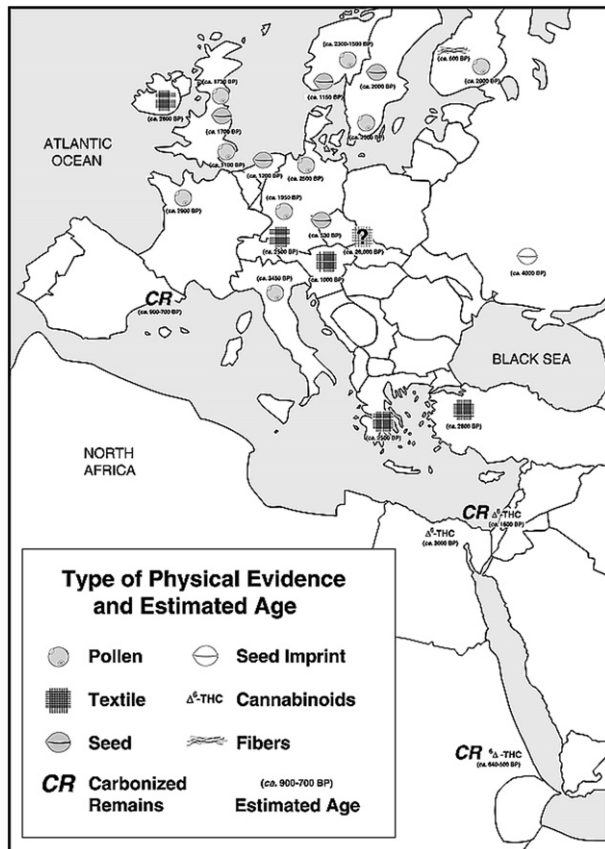


Fig. 1. Evidence of ancient uses of hemp in Europe and Asia Minor (Fleming and Clarke, 1998).

et al., 2008). The degradation of DNA results in a gradual reduction in its length as the polymeric strands become fragmented, but even relatively short fragments retain useful information in their base sequences.

With those considerations in mind, we resolved to identify DNA in fibers of samples of rope and cloth that have been found in an archeological site near Qumran and the Dead Sea. Microscopic observations have identified various samples of cloth from caves above Qumran as flax, cotton, and wool (Walton Rogers, 2003 and personal communication). Muller et al. (2004, 2006, 2007), using X-ray micro-diffraction, identified flax and cotton in Qumran samples. But there have been indications of the early use of hemp in East Asia (Mukherjee et al., 2008) and in Europe and Asia Minor (Fig. 1). Our objective was to learn whether the DNA of materials from an archeological site near the Dead Sea could confirm the presence of hemp or other fibers. We expected the use of DNA sequence information to confirm the identity of the major component (as flax), but also to indicate whether fibers from hemp or another plant species form a detectable fraction of one or more samples. As will be shown, our data do indicate that flax-linen dominates in every sample tested and that there is a small amount of hemp DNA in most samples.

2. Background

Samples described in this paper came from the “Christmas Cave” (herein abbreviated “CC”). The CC is located in the Judean Desert on the west bank of the Dead Sea, in the Qidron Valley, 1 km south of Qumran – (ICS coordinates 189887/121095)(Fig. 2). Its name commemorates the day on which it was discovered by John Allegro

in 1960 (Allegro, 1965, pp. 6–15). In 2007, the cave was surveyed again by Roi Porat and Hanan Eshel (Porat et al., 2007; Eshel, 2009). They confirmed that the finds have no connection to the Qumran Caves (see also Shamir and Sukenik, 2010). This cave served as a refuge, beginning in the Chalcolithic Period and afterwards at the end of the Great Revolt in 73 CE and again in the Bar Kokhba Revolt in 135 CE. (Porat et al., 2009) Among the archaeological finds from this cave are wool and linen textiles from various periods. This assortment of textiles, in contrast to those found in Qumran – which are exclusively linen – is similar to those found in Masada (Belis, 2003, p. 211, 219, Sheffer and Granger-Taylor, 1994). In the opinion of Dr. Orit Shamir of the Israeli Antiquities Authority, comparison to the textiles found in The Cave of Letters (Granger-Taylor, 2006; Yadin, 1963) is more exact, those being generally coarser than the Masada textiles (personal correspondence).

Because this site is not considered part of the Qumran complex of caves, Humpert and Gunneweg’s (2003) inclusion of these textiles in the Qumran group of findings is confusing. The introduction (p. XIX) under the subheading “textiles” does not mention the CC at all, notwithstanding its textile finds being included in the subsequent chapters. The CC finds all appear numbered as category “QCC”(=“Qumran Christmas Cave”), and some have been given a parallel “QUM” number (Belis, 2003, p. 221; Müller et al., 2003, p. 277). In Humpert and Gunneweg (2003) Walton Rogers reports her analysis of some of these fibers, referring to them simply as coming from “a site in the Dead Sea region”, which is correct under any circumstances.

These cordage and textile samples were stored since their discovery at the Rockefeller Museum in Jerusalem, examined at École Biblique et Archéologique Française de Jérusalem (EBAF), and only recently relocated to the Israel Antiquities Authority. The articles had been bundled in batches from the various loci within the CC. Due to the difficulty of dating these samples, either by physical observation or by genetic testing, we chose to confirm the ages of selected samples through ^{14}C dating (see below).

It is generally accepted, based on both literary sources and archaeological finds, that the primary fibers in use in the 1st–4th centuries CE in the Land of Israel were sheep wool, goat and camel hair, and flax-linen¹. Additional fibers, such as hemp, cotton and silk are mentioned, albeit infrequently, in contemporary rabbinical literary sources, but have not been previously corroborated by archaeological finds of the period (Baginski, 2001; Shamir, 2001; Crowfoot and Crowfoot, 1961). This research project focuses on the genetic identification of vegetable fibers constituting cordage and textiles found in the CC. It has always been assumed that the fiber used in articles of this type is flax, which is well known as being widespread in the Land of Israel in this period, and is mentioned numerous times in the contemporary rabbinical literature (Mishnah; Toseftah and the Jerusalem Talmud)². As stated in the introduction, this assumption has been validated by optical microscopy (Walton Rogers, 2003) and X-ray diffraction (Müller et al., 2004, 2006, 2007). Nevertheless, it is difficult to distinguish cellulosic bast fibers such as flax and hemp by these means

¹ See: ASTM D 6798-02 *Standard Terminology Relating to Flax and Linen*. 2003. West Conshohoken, PA. “Flax” refers to the plant and its fiber. “Linen” refers to the products produced from spinning onwards in the production process. Both the Hebrew and Aramaic languages do not discern between these two designations, often causing ambiguity.

² The Mishnah, Toseftah and Jerusalem Talmud are all works redacted in the Land of Israel. Documentation of material culture appearing in all of them should be relevant to our research. The Mishnah (and probably Toseftah) represents 225 CE *terminus ante quem* and probably long before 70 CE *terminus post quem*. The Jerusalem Talmud, which is a work expounding on the Mishnah, is 350 CE *terminus ante quem*.

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