

Analysis of Hair Samples of Mummies from Semna South (Sudanese Nubia)

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ABSTRACT Hair samples from 76 burials at Semna South (Sudanese Nubia) were examined using a variety of techniques. Electrophoresis and fluorescence microscopy indicated some oxidation of the cuticle and keratin protein had taken place. However, the cuticular structure and the lack of fluorescence of the cortex indicate that the low humidity and non-alkaline conditions preserved the physical and chemical properties of the hair well. Pigmentation, even allowing for oxidation of melanin, showed a higher proportion of lighter samples than is currently associated with the Nubian area. Hair form analysis showed medium diameter and scale count; the curling variables were intermediate between European and African samples. There was a high ratio of maximum to minimum curvature (a measure of irregularity), approached only by Melanesian samples. Meroitic and X-group burial types were not statistically significantly different (largely due to sample sizes), but the X-group, especially males, showed more African elements than the Meroitic in the curling variables. Principal components analysis showed the Semna sample to be significantly different from seven populations examined earlier.

Though several studies have been conducted on ancient hair, because of small sample sizes, few have allowed adequate statistical quantification, and none has dealt with Nubian material. Egyptian mummy samples have been examined in the past for color and structure by Pruner-Bey (1877), Virchow (1898), and reportedly by Minakow (1899). Woodbury and Woodbury ('32) and Trotter ('43) have examined ancient Peruvian material using metric techniques; they found the ancient hairs to generally fall in the range of modern variation. Brothwell and Spearman ('63) studied North African and other material using a variety of techniques, including microscopic examination, fluorescence microscopy, and reflectance spectrophotometry; they found the state of preservation of the samples closely related to environmental factors of the burial sites. More recently, Chiarelli et al. ('70/'71) studied ancient Egyptian samples with scanning electron microscopy, finding significant loss of cuticular scale edges. Using microscopic and macroscopic techniques, Titlbachová

and Titlbach ('77) studied Egyptian mummies in Czechoslovakian collections; they found generally good preservation, with the samples resembling modern European populations with significant African admixture.

This study analyzes hair samples from Semna South in Sudanese Nubia using several biochemical and metric techniques. The samples contain Meroitic (First Century A.D. to Fourth Century A.D.), X-group (Fourth Century to Sixth Century A.D.), and Christian period (Seventh Century to Tenth Century A.D.) material. Strouhal has pointed out ('77) that the physical relationship of Meroitic and Post-meroitic populations is not clear. It is still not known whether X-group burials represent a migration of an ethnically distinct people or change in situ of the Meroitics. It is more generally accepted that Christian period inhabitants were the descendants of the X-group. Hence this study adds perspective to the physical anthropology of the area.

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The hair samples were analyzed by quantitative hair form analysis (Hrdy, '73), electrophoresis of hair keratins (Hrdy and Baden, '73), qualitative hair pigmentation analysis (Martin and Saller, '62), and fluorescence microscopy (Brothwell and Spearman, '63). The findings of the quantitative hair form analysis were compared to four populations examined by Hrdy ('73).

MATERIALS AND METHODS

The sample consisted of 56 Meroitic, 15 X-group, and 5 Christian individuals from Semna South collected between 1966 and 1968 in the course of the excavations of the Oriental Institute of the University of Chicago directed by L. V. Zabkar (Zabkar, '73/'74, '78). Specific information on individual burials is located in Zabkar ('78). There was no embalming; mummification resulted from burial conditions alone. Burials were either of a simple pit grave type, or of more complex types, including separate burial chambers, ramps, and vaults. The hair was either attached to the skull or associated with the remains in the fill. Hair from infants under six months, and samples of insufficient size for measurement were excluded from the analysis. Age and sex determinations and burial type were according to the criteria of Zabkar ('78).

Electrophoretic studies were carried out as outlined in Hrdy and Baden ('73), with the addition of soaking the samples overnight in 0.05 M EDTA and 0.05 M Tris buffer at pH 9.6 to chelate heavy metals that interfere with chemical extraction of keratin. Fluorescence microscopy was done using the method of Brothwell and Spearman ('63), using 0.1% Acridine Orange dye at pH 4.9. Qualitative hair color analysis was performed with a Fischer-Saller hair color standard (Peabody Museum, Cambridge, Massachusetts) (Martin and Saller, '62).

Quantitative hair form analysis was carried out by the method of Hrdy ('73), using the principal components analysis variables: diameter (in microns, an average of several determinations); scale count (the number of curicular scale ridges per 0.52 mm); average curvature (the inverse of the radius of curvature); ratio of maximum to minimum curvature (a measure of regularity of hair curling); crimp (number of reverse twists along the hair shaft per unit distance); and ratio of natural to straight length (a measure of func-

tional hair shortening due to curling). Principal components analysis was performed using scores standardized on the seven population sample (Hrdy, '73) and the Semna sample.

RESULTS

Electrophoresis of alpha SCM-keratin protein from three samples (identification numbers: Meroitic N224-B, N455; X-group M107) showed similar patterns for all samples. There was a large band at the origin and a large band at the buffer from which represented SCMKB. This aberrant pattern indicates that the fibrous protein had aggregated at the origin, probably from cross linking of the protein chains.

Fluorescence microscopy on modern controls showed a greenish fluorescence throughout the cortex and cuticle, with areas of bright orange associated with fractures in the shaft, as reported by Brothwell and Spearman ('63). These fractures and areas of orange were more pronounced on hairs that had been bleached. Of nine Semna samples, all had a completely orange cuticle, with brighter orange highlighting the cuticular structure, which was intact on all samples. Debris clinging to the shaft was also bright orange. The cortex on all samples was greenish, except where the shaft was broken, which was orange. Hair which was blond or "bleached" appearing (M048, M061, M205, M228) fluoresced identically to the brown samples (M069, M098, M107, M188, M246). Macroscopically the hair was in generally good condition, with approximately one percent of the shafts damaged. Eight of the 76 samples had debris clinging to the shafts; the remainder were relatively clean. Two of the samples were braided.

Qualitative grading of the samples on the Fischer-Saller scale is shown in table 1. Samples that were graded on the red scale (I-VI) for degree of red pigmentation were also graded on the blond-brown-black scale (A-Y) for degree of black pigmentation. Twenty-six percent (29% of the Meroitic, 13% of the X-group) of the total sample had some red pigmentation, and 10.5% (8.9 Meroitic, 13% X-group) had "blond" pigmentation (Fischer-Saller category G or less).

The crude variables of the quantitative hair form analysis are presented in table 2. The results are also broken down for subpopulations of Meroitic, X-group, and Christian; male and female; and simple burial type and more com-

plex. Results from Hrdy ('73) for Northwest European, East African, Bougainville (Melanesian), and Japanese populations are presented for comparison. In no variable was the Meroitic significantly different from the X-group, male from female or simple burial type from non-simple. However, the X-group sample showed higher curling variables than the Meroitic, especially in males (the Christian group is too small to make valid comparisons). The sample as a whole was significantly different from the other populations in average curvature, ratio of maximum to minimum curvature, crimp, and ratio of natural to straight length. Diameter was significantly different from Japanese and Bougainville, and scale count significantly different from the European, Bougainville, and African populations.

Principal components analysis (Hrdy, '73) results on the first three components (accounting for 80% of the variance) are shown in table 3 for the total population, with comparative populations from Hrdy ('73). In component I, which is heavily loaded on general curling variables and scale count, the total sample centroid was significantly different from European and African samples, though it was definitely more European than African. Component II, loaded on diameter, was not significantly different from the comparison populations. Due to the large amount of irregularity (high ratio of maximum to minimum curvature values), the Semna sample had a higher score on component III, which was heavily loaded on that variable, than the African and European samples. Only Melanesian samples had a higher score on this component.

DISCUSSION

Hair keratin is remarkably stable due to cross-chain disulfide linkages. However, prolonged exposure to harsh conditions will alter the keratin. The Semna samples were in contact with sand for over a thousand years, and hence were at risk for oxidation of the protein molecules. There undoubtedly was some oxidation, as shown by the aggregation of the protein on electrophoresis and the orange fluorescence of the cuticle by fluorescence microscopy. However, the cortex did not have this oxidized pattern, unlike samples from Egypt examined by Brothwell and Spearman ('63), which fluoresced orange throughout. Since hair form is probably determined by physical

TABLE 1
Frequency distribution of Semna sample on blond-black pigmentation and red pigmentation hair color scales of Fischer-Satler

	Blond			Blond-brown			Brown						Brown-black		Black		Very red		Faint red											
	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	I	II	III	IV	V	VI
Meroitic	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	12	5	4	9	3	1			7	7	1			1
X-group	1	1								1	1	1	1	1	3	1	1	1	2	2	2	2			1	1	1			
Christian				1						1	1	1	1	1	1	1	1	1	1						1	1				1

TABLE 2

*Univariate statistics for Semna South, subpopulations, and comparison groups (Hrdy, '73).
Simple and complex refer to burial type*

		Diameter	Scale count	Average curvature	Ratio curvature	Crimp	Ratio length
Total Semna	\bar{x}	78.92	16.32	1.56	6.66	0.337	1.56
	s	14.40	3.36	1.44	9.51	0.265	0.59
	n	76	58	75	53	47	73
Meroitic	\bar{x}	80.93	16.51	1.47	6.53	0.329	1.49
	s	14.98	3.21	1.47	10.42	0.278	0.52
	n	56	45	55	37	35	53
X-group	\bar{x}	72.20	15.00	2.08	6.76	0.368	1.84
	s	13.59	4.34	1.55	7.51	0.245	0.80
	n	15	9	15	13	10	15
Christian	\bar{x}	76.60	17.10	1.00	7.85	0.325	1.40
	s	9.24	2.32	0.44	3.65	0.021	0.56
	n	5	4	5	3	2	5
Meroitic male	\bar{x}	85.14	16.20	1.43	4.80	0.296	1.46
	s	11.58	3.72	1.12	7.61	0.226	0.55
	n	21	14	21	12	12	19
Meroitic female	\bar{x}	80.57	16.60	1.68	10.25	0.294	1.54
	s	17.40	4.55	2.09	14.36	0.278	0.57
	n	21	18	20	15	15	20
Meroitic simple	\bar{x}	75.90	15.60	1.90	11.07	0.368	1.76
	s	8.61	2.49	1.66	16.89	0.404	0.64
	n	10	8	10	9	9	10
Meroitic complex	\bar{x}	82.14	16.40	1.37	5.36	0.306	1.42
	s	16.03	4.53	1.47	7.54	0.242	0.48
	n	44	36	43	25	25	41
X-group male	\bar{x}	75.20	18.60	2.33	10.87	0.340	1.79
	s	11.30	3.28	2.01	10.43	0.300	0.95
	n	5	2	5	5	3	5
X-group female	\bar{x}	71.13	14.00	2.14	4.58	0.380	2.04
	s	15.37	3.22	1.51	3.97	0.270	0.77
	n	8	5	8	7	6	8
X-group simple	\bar{x}	69.00	16.40	1.29	2.46	0.270	1.66
	s	25.16	1.62	0.16	1.89		0.63
	n	3	3	3	2	1	3
X-group complex	\bar{x}	73.00	14.30	2.28	7.54	0.382	1.89
	s	10.80	5.11	1.69	7.94	0.261	0.85
	n	12	6	12	11	9	12
Northwest Europe ('73)	\bar{x}	79.17	15.07	0.19	1.10	0.028	1.21
	s	11.27	1.80	0.13	0.28	0.056	0.31
	n	30	30	30	30	30	30
East Africa ('73)	\bar{x}	76.10	17.95	7.55	1.46	0.949	2.97
	s	15.83	2.04	1.78	0.43	0.569	1.39
	n	20	20	20	20	20	20
Japan ('73)	\bar{x}	95.53	15.47	0.07	1.00	0.000	1.01
	s	10.35	1.46	0.04	0.00	0.000	0.04
	n	30	30	30	30	30	30
Bougainville ('73)	\bar{x}	84.06	18.33	4.72	2.11	1.117	2.67
	s	13.15	2.00	0.85	0.82	0.806	0.75
	n	30	30	30	30	30	30

TABLE 3

Scaled component scores for Semna South and comparison populations

	Component I		Component II		Component III	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Semna	-0.344	0.862	-0.108	0.985	0.258	1.187
N.W. Europe ('73)	-0.761	0.274	-0.674	0.756	-0.349	0.497
East Africa ('73)	1.640	0.697	-0.636	1.064	-0.329	0.708
Japan ('73)	-0.654	0.173	0.345	0.635	-0.499	0.129
Bougainville ('73)	1.002	0.704	-0.075	0.953	1.015	1.429

arrangements of the alpha helical proteins within the cortex (Hrdy and Baden, '73), the apparent limitation of oxidation to the cuticle in the Semna sample argues for the maintenance of hair form in the samples in spite of their age. In line with this is the large variability in hair form (rather than the uniformity that one would expect if a uniform environmental force was acting on the sample), and the lack of macroscopic cuticular and shaft damage. Also arguing for intact keratin is the large number of samples with intact cuticle, as opposed to the ancient Egyptian sample analyzed using scanning electron microscopy by Chiarelli et al. ('70/'71). In general, low humidity and non-alkaline conditions are optimal for preservation of keratin; both conditions were met in the Semna samples.

As Brothwell and Spearman ('63) point out, reddish-brown ancient hair is usually the result of partial oxidation of the melanin pigment. This color was seen in a large proportion of the Semna sample, and also noted by Titlbachová and Titlbach ('77) on Egyptian material, where it also may have resulted from the mummification process. However, the large number of blond hairs that are not associated with the cuticular damage that bleaching produces, probably points to a significantly lighter-haired population than is now present in the Nubian region. Brothwell and Spearman ('63) noted genuinely blond ancient Egyptian samples using reflectance spectrophotometry. Blondism, especially in young children, is common in many dark-haired populations (e.g., Australian, Melanesian), and is still found in some Nubian villages (J. Zabkar, personal communication). Only one sample (M197) showed cuticular damage and irregularities definitely consistent with bleaching, although bleaching could not be ruled out in some of the blond samples.

The average diameter of the Semna sample was close to both the N.W. European and East African samples, which are of medium thickness. Of the variables that best distinguish European and African samples, the total Semna sample was closer to the European on average curvature, crimp, and ratio of length. The ratio of curvature, however, was higher than either, indicating a degree of irregularity approached only by Melanesian samples. Obviously the sample has a greater degree of African admixture than the Egyptian hair

sample described by Titlbachová and Tiltbach ('77), which had three of 14 samples showing "Negroid elements." Although there is not a consistent statistically significant difference between the X-group and Meroitic samples, it is interesting that the X-group sample, especially the males, had higher curling variables, indicating more of an African element. Although larger sample sizes are needed for statistically significant results, the results here are consistent with the evidence summarized by Strouhal ('77) for skeletal material, which shows X-group very similar to Meroitic, but having increased negroid elements.

The principal components analysis showed the Semna population in a unique position on the three component space when compared to seven other populations (Hrdy, '73). The combination of high ratio of curvature with moderate diameter and curling differentiates the sample from the Melanesian, European, African, and Mongoloid groups.

The Semna sample had high coefficients of variation compared to four other populations, especially in scale count, average curvature, and ratio of curvature. This high intra-population variability undoubtedly reflects the heterogeneous nature of the Nubian population during the Meroitic and Post-meroitic periods.

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