The Health and Nutrition of a Medieval Nubian Population

The Impact of Political and Economic Change

NUBIA HAS BEEN DESCRIBED as "the corridor to Africa" and also as the "connecting link" (Adams 1977) between civilizations of the Mediterranean basin and black Africa. These characterizations are not synonymous. Indeed, together they reflect the dynamic interaction of geography and behavior that has shaped the politics, economy, and biology of Nubia’s ancient populations. Nubia’s corridor quality is physical. It reflects the constraints of the desert within which the Nile, its floodplain, and the meager technologies of irrigation have sustained a ribbon of human populations throughout history.

Nubia’s connecting-link aspect is more biological, political, and economic than physical. Ongoing research on human remains from the medieval site of Kulubnarti in Nubia’s Batn el Hajar illustrates this point. The interactions between geography and the political and economic forces of history in shaping the biocultural evolution of the region’s medieval populations are clearly demonstrated in our investigations.

The Nubian Corridor

Nubia (see Figure 1) is that portion of the Nile valley from the First Cataract at Aswan to a less constant southern boundary near the Fourth Cataract in modern Sudan. Regionally, Nubia is subdivided into two segments: Lower Nubia, which extends from the First to the Second Cataract, and Upper Nubia, to the south. Today, Lower Nubia lies entirely below the waters of Lake Nubia, created by the Aswan High Dam.

The site of Kulubnarti is near the northern extreme of Upper Nubia known as the Batn el Hajar (belly of rock), which extends southward from the Second Cataract for approximately 100 miles. The Batn el Hajar has been described as the most barren and forbidding of all Nubian environments. The Nile in this region is filled with rocks and rapids separating a succession of tiny islands. The desert beyond the Nile is a virtually lifeless expanse of rocky Jebels (large outcroppings of rock) interspersed with pockets of sandy wadi. Although population densities varied through time, the area was never heavily populated and subsistence was always marginal:

The tortured landscape of bare granite ridges and gullies which characterizes this part of Nubia begins at the bank of the river itself; alluvium exists not as a continuous floodplain, but only in protected pockets and coves. Fields and tiny hamlets hug the banks wherever such soil is available, but for long stretches neither natural nor cultivated vegetation is to be seen. The narrow channel and steep riverbanks make agriculture difficult even where alluvium is present, because of the extreme differential between high and low Nile levels. At the slack season the surface of the stream may be fifty feet or more below the neighboring fields; in these circumstances irrigation is a practical impossibility without the aid of modern pumps. [Adams 1977:26]

The Economic and Political Setting

Throughout history the people of the Batn el Hajar lived in small villages of perhaps a dozen households dependent on small-scale farming for their livelihood. Agriculture was intensified where possible by building
Indeed, by the ninth century Lower Nubia (between Aswan and the Second Cataract) became an open economic zone between Moslem Egypt and Christian Nubia. This duality between Nubia's southern political and northern economic domains would have an important influence on the lives and circumstances of the tiny hamlets dotting the Batn el Hajar.

**Nubia's Medieval and Feudal Ages**

Within a century of Nubia's adoption of Christianity, Egypt fell to the armies of Islam. No sooner was the conquest of Egypt complete than an army of 20,000 Moslem soldiers was sent southward into Nubia. Although this and a second invasion in A.D. 651 penetrated as far as Dongola, Nubian forces prevailed, and a treaty known as the **Baqt** was established. The Baqt ensured Nubian independence, in exchange for which Moslems were allowed to travel, trade, and settle in the northern part of the kingdom.

Within this political setting Nubia's medieval age continued to unfold. The kingdom was ruled by 13 vassal kings under the supreme authority of the "Great King" at Dongola. The balance between Nubian-Egyptian political and economic relations was maintained as much by geography as by treaty. By the ninth century, Lower Nubia from the First Cataract at Aswan to the Second Cataract at Wadi Halfa was established as a free-trade zone; under the governance of the King's viceroy, the **Eparch**, this territorial arrangement contributed importantly to Nubia's economic life. However, to ensure against the gradual expansion of Islamic influence, the barren and rocky terrain of the Batn el Hajar became a closed zone—a virtual "granite curtain" through which travel was strictly controlled by the king. Evidence of customs stations at the upper and lower limits of the Batn el Hajar suggests that this inhospitable region served as a gateway between the free zone of Lower Nubia and the remainder of the Dongola kingdom.

This pattern prevailed until the mid-13th century when political changes in both Egypt and Nubia precipitated the decline of Nubia's medieval age. In Egypt, a new dynasty came to power. Known as the Mameluke sultans, they were originally a caste of warrior-slaves who gained power in A.D. 1250. They intensified Christian persecution at home and anti-Christian intervention abroad.

Nubia itself was ripe for intervention. Through a series of dynastic intrigues, a succession of princes captured the throne, using Nubian forces as well as Mameluke mercenaries to maintain power. Finally, in 1323 a Moslem prince ascended the Nubian throne and Christian control of Upper Nubia ended.

This, however, did not mean the end of Christianity in Nubia. A Christian "shadow kingdom" known as
Dotowa emerged in the north with a capital at Gebel Adda, some 40 miles north of the Second Cataract. Ruled by a former vassal king, Dotowa probably represents a continuation of the traditional dynasty of Makouria itself.

With the collapse of the Dongola kingdom and the emergence of Dotowa, Nubia moved from a medieval to a feudal period. In Lower Nubia the shift was marked by an aggregation of population into fewer and larger settlements. However, in the Batn el Hajar the pattern differed:

This rocky and inhospitable region, which had never before supported more than a scattering of tiny hamlets, is dotted over with remains of Late Christian communities both large and small... There can be little doubt that this poor and isolated region, by-passed by the main caravan routes of the Middle Ages, served as a major refuge for populations fleeing from the political disturbances in the north. [Adams 1977:513]

In addition to serving as a refuge area, the Batn el Hajar also experienced a period of heightened economic isolation. At Kulubnarti, the absence of imported goods toward the end of the feudal period is conspicuous. Of the catalogued objects found, less than 10 percent were of foreign manufacture, and most probably they date from the 18th and 19th centuries. Among the uncatalogued potsherds, the percentage of imported wares was infinitesimal (Adams 1984). In addition to isolation, economic specialization dwindled to nothing, and Nubia reverted to the subsistence economy of much earlier days.

**Archaeology at Kulubnarti**

Fortunately, the natural dryness of the Batn el Hajar has produced an abundant record of remains at Kulubnarti that significantly add to our understanding of the circumstances of Nubia’s last Christians. Ruins excavated at Kulubnarti in 1969 provide an important glimpse into the lives of Nubia’s feudal society. During the 14th century, houses were converted from simple living to defensive structures. Living quarters were limited to the second floor and were accessed by retractable ladders (see Figure 2). The defensive character of late Christian domestic architecture was obvious, finding its fullest expression in the two-story house. One house was further elaborated into a true feudal castle (see Figure 3), which faced the river and dominated the countryside for many miles. “Here, then, we can recognize the genesis of the Nubian castle, and perhaps also of a feudal order” (Adams 1977:516).

With the advent of these defensive architectural features, tiny hamlets such as Kulubnarti were transformed from medieval villages dominated by their churches into feudatories dominated by their castles. Church-building fell into decline and the churches themselves became a marginal feature of the feudal village. It was under these political and social conditions that the Christians of Ku-

**Figure 2**

Late Christian house demonstrating the defensive nature of these structures.

Kulubnarti continued until the Ottoman Turks annexed Lower Nubia in the 16th century.

**The Human Remains**

Excavation of the architectural and cultural remains by Adams in 1969 suggested that Kulubnarti may have been among the most recently occupied Christian settlements in the region. Kulubnarti is a large island approximately three-quarters of a mile long, adjacent to the modern west-bank village of Kulb, about 80 miles south of Wadi Halfa. Two cemeteries were discovered during the excavations; one was located on the island, the other on
the west bank adjacent to the contemporary village of Kub. The island-mainland distinction did not exist during the region’s medieval and feudal periods—the island became geographically distinct with the construction of the Aswan Dam, and today, during the dry season, the portion of the Nile separating the two areas often dries entirely.

Logistics would not permit excavation of the cemeteries in 1969; therefore, a second expedition directed by Van Gerven was undertaken ten years later. The bodies of 218 individuals were disinterred from the island cemetery and 188 were exhumed from the cemetery on the west bank. While the initial survey of the cemeteries suggested that both were from the late Christian period, analysis of pottery within the graves as well as grave architecture during the 1979 expedition indicated that the island cemetery represented a population mainly from the early Christian period. Beyond an absence of features associated with the late Christian period, the presence of pre-Christian graves at the far eastern (perhaps beginning) end of the cemetery added additional, circumstantial support for this interpretation.

In contrast to the island cemetery, the mainland cemetery contained numerous features associated with the late Christian period. These included the presence of vaulted brick tombs (most notably one containing an intact bed burial), as well as a clear transition from Christian (east-west oriented) to Moslem (north-south oriented) burial styles. There is every indication that the cemetery has been in continuous use since at least A.D. 1100. Local folk tradition also suggests this (Van Gerven et al. 1978). Indeed, the Moslem portion of the cemetery remains in use to the present.

Dating of the cemeteries was based entirely on artifacts and architectural associations; therefore, the exact chronology of individual graves could not be determined. Fluorine analysis of skeletons from each cemetery also proved inadequate as a dating method for this population (Connelly et al. 1994). However, the evidence does support a diachronic, though likely overlapping, series spanning the Christian period from early medieval to late feudal times. Therefore, the island cemetery (21-S-46) will be referred to as the early Christian population and the mainland cemetery (21-R-2) will be referred to as the late Christian population.

The remains from both cemeteries were in excellent condition. Due to an almost total lack of rainfall (less than one millimeter per year) many individuals were naturally mummified. Many adults and newborns alike were found wrapped in their burial shrouds with hair, nails, skin, and organs preserved. Even last trimester fetuses were preserved in pottery vessels. In several cases, newborns were found with their umbilicus still tied with twine.

The remarkable preservation of these human remains, spanning the Christian period, has allowed an assessment of many of the biological aspects of mortality, growth, development, nutrition, and disease. In so doing, we have been able to evaluate the impact of political and economic change on the health and adaptation of K卢bnnari’s Christian population.

**Subadult Mortality**

The most fundamental measure of adaptation in any human community is survival. For ancient populations, inferences are made about survival from mortality. While paleodemographic reconstructions have been criticized, the K卢bnnarti remains are demonstrably well suited for such analysis. The preservation of soft tissues made sexing, even of many subadults, extremely reliable (Mittler and Sheridan 1992). The presence of virtually complete skeletons allowed the utilization of multiple aging criteria in a manner approved by paleodemography’s harshest critics.

A comparison of mean life expectancy values (see Figure 4) computed from composite life tables (Swedlund and Armelagos 1969) illustrates a dramatic difference in infant mortality between the early and late populations at K卢bnnarti. Indeed, at birth early Christians had an average life expectancy of only 10.6 years, compared to 18.8 years for their late counterparts. From this age onward life expectancies for the two populations converge, but the early population continued to experience higher mortality throughout the subadult period. During the adult period, however, the pattern is reversed, and from age 18 through 43, the later population experienced somewhat higher mortality. This pattern remains unaltered when the life table values computed from the raw age data (Weiss 1973) are adjusted using Gompertz function (Greene et al. 1986).
Taken together, the most striking difference in mortality between the two populations occurred during infancy and childhood. Interestingly, it was during the early period that such mortality was most extreme.

The differences in subadult mortality at Kulubnarti can be used to frame two alternative, though not mutually exclusive, hypotheses. First, what appeared as lower mortality among the late Christian infants and children may reflect an actual lowering of fecundity. If true, this would suggest a decline in the adaptive success of the late Christian population, particularly among the reproductive-age adults. Under these conditions we would expect to see skeletal evidence for increased stress among the late adults.

Alternatively, the differences in subadult mortality may reflect an actual improvement in the survival of infants and children. A strong association between mortality and subadult stress would support this interpretation and suggest an improvement in the adaptation of Kulubnarti’s late Christian population. These two possibilities will be considered in light of the stress data.

**Subadult Stress**

**Childhood Anemia**

The most frequent skeletal pathology observed among the Kulubnarti children is a form of porotic hyperostosis known as *cribra orbitalia* (a cribrous or porous lesion in the upper orbit). This malady appears related to the expansion of red blood cell–producing tissues within the orbital bone and begins as a fine porosity of the eye orbit. In severe cases the lesion expands to form a coral-like bony outgrowth within the orbit itself (see Figure 5). Carlson and coworkers (1974) attributed the condition in populations from Lower Nubia to iron-deficiency anemia resulting from an iron-poor diet combined with parasitic infections and weaning diarrhea.

![Figure 5](image)

*Figure 5*
Active cribra orbitalia in a four-year-old Nubian child from Kulubnarti.

Conditions at Kulubnarti clearly support the iron-deficiency hypothesis. There, as elsewhere in Nubia, food resources consisted primarily of cereal grains, with little consumption of animal protein. Unfortunately, while cereals contain iron, they also contain fiber, phytate, phosphorus, and tannins, which inhibit iron uptake (Rheinhold 1982). The problem is compounded in contemporary Nubia, and was no doubt aggravated in the past, by parasitic infestations such as hookworm. Such parasites cause significant iron loss due to intestinal bleeding. It is also clear that the condition is most severe among young children. When lesions in an active state of formation are distinguished from those showing some degree of healing, the majority of individuals older than five years of age show some degree of recovery (Mittler and Van Gerven 1994).

A similar childhood pattern was observed for Lower Nubia (Wadi Halfa), however, the condition was apparently more prevalent at Kulubnarti. The maximum lesion frequency among Lower Nubian children was 32 percent (Carlson et al. 1974), while frequencies reached 84 percent and 82 percent for the early and late populations at Kulubnarti (see Figure 6). This regional difference corresponds well to the greater economic prosperity of Lower Nubia throughout the Christian era. As noted earlier, Lower Nubia was a free-trade zone enjoying the benefits of commerce with Egypt, while the villages of the Batn el Hajar were in an economic and political backwater. Moreover, the much wider floodplain in the Wadi Halfa area allowed the growing of more fodder crops and more animals for food.

**Growth Interruption**

A second approach to the assessment of childhood stress at Kulubnarti has involved the analysis of several
growth-related aspects of the skeleton and dentition. From the standpoint of dentition, the most informative evidence has come from the analysis of enamel hypoplasias—dental defects that appear as bands on the enamel (see Figure 7). Resulting from the disruption of ameloblast (enamel-forming cell) activity and corresponding deficiency in enamel thickness (Goodman et al. 1980), hypoplasias typically appear as zones of depressed enamel. Because they form sequentially with age along the tooth crown, their position on the crown can be measured and the data used to estimate age of occurrence. These age data can, in turn, add an important demographic dimension to the analysis of childhood stress.

Although far too generalized to permit diagnosis of specific disease or dietary conditions, hypoplasias have been clearly associated with periods of physiological stress and interrupted growth. While a number of factors including poor nutrition may underlie their appearance, there is little doubt that, in contrast to cribra orbitalia, bouts of infectious disease play a major role in their formation.

The investigation of enamel hypoplasia was conducted on a sample of 31 early and 56 late Christian individuals (Van Gerven et al. 1990). The criterion for inclusion of these individuals was the presence of at least one mandibular canine sufficiently unworn to permit observation of the condition. The mandibular canine was chosen for two reasons: (1) it is highly sensitive to hypoplastic events, and (2) the age of occurrence of hypoplasias could be estimated using a standardized model developed by Goodman and coworkers (1980). Such estimates are, however, subject to error, such as individual differences in childhood growth as well as adult tooth size (Berti and Mahaney 1992). Additionally, populational differences in average tooth size can lead to errors particu-

![Figure 7](image)

**Figure 7**
Linear hypoplasia of the mandibular canine.

![Figure 8](image)

**Figure 8**
Percentage of individuals in each cemetery expressing enamel hypoplasias.

larly when the model population differs from the population under investigation. While inaccuracies resulting from individual differences could not be controlled in the present analysis, the Kulubnarti canines were virtually the same size on average as Goodman’s model. Thus, use of the canine minimized a principal source of error in age estimation.

The frequency of hypoplasias in both Kulubnarti populations (see Figure 8) is extremely high, with 100 percent of the subjects expressing at least one hypoplastic event. As with the frequency of cribra orbitalia, this is more than twice the frequency (40 percent) reported for the more prosperous populations of Lower Nubia (Hilson 1978, 1979).

The early Christian sample has a modal frequency of three hypoplasias, while the late sample is bimodal at three and five. The most striking differences, however, occur at the distributional extremes. The early population has 8 percent fewer individuals than the late group with only one hypoplasia, and 5 percent more with seven or eight. This contrast at the extremes is suggestive of higher stress among the early Christian children.

Examination of hypoplasias by age of formation also supports this suggestion. Both early and late samples (see Figure 9) show a rapid increase in incidence between birth and age four. After that, however, the populations diverge. While the late Christian incidence drops rapidly, the early children show no decline for an additional 1.5 years. This prolonged period of hypoplastic activity among the early children corresponds well to their mortality. Not only are probabilities of dying higher for the early children, mortality also remains high longer.

Additional support for this interpretation comes from an examination of circannual patterning. Among the early children (see Figure 10), a majority of adjacent hy-
other factor may have been a short but cold period of bitter winter winds, which might have taxed the resiliency of even the healthiest individuals (Adams 1977). Whatever factors prevailed at Kulubnarti, it appears from our data that the late population was less stressed overall and more likely to recover when conditions permitted.

Disease, Development, and Death

Although both cribra orbitalia and enamel hypoplasia indicate episodes of childhood stress, it is also important to assess the extent to which they occur together as part of an overall childhood stress syndrome, and to address whether they may have an impact on childhood mortality (Mittler et al. 1992). Among children from birth through five years of age (the period during which both lesions undergo active formation) the correspondence between the two conditions is striking (see Figure 11). The associated correlation coefficient ($r = 0.98$) is highly significant ($p < 0.01$).

There is also a close correspondence (see Figure 12) between lesion frequencies and the probability of dying through the first five years (Van Gerven et al. 1981). Following age five, however, frequencies of cribra orbitalia continue to increase while the frequency of hypoplasias and probability of dying subsides. As previously discussed, this is due to the nature of the variables. Whereas probabilities of dying and hypoplasia reflect only new occurrences (of death or defect) for each age category, cribra orbitalia frequencies include both newly formed lesions and all of those formed earlier in life. This cumulative effect increases with each successive age category until age 12 when all cases show some degree of healing. Following age 12 the healing process itself reduces the affected sample.

---

Figure 9
Early and late population relationships showing age of hypoplasia formation.

Figure 10
Early and late population relationships showing time intervals between adjacent hypoplasias (in six-month intervals).

Figure 11
For the combined early and late cemetery sample: the relationship between cribra orbitalia, enamel hypoplasia, and probability of dying.
probably involving chronic nutritional difficulty combined with recurrent bouts of infectious disease. While the specific details of this syndrome may never be known, it is clear that it was a major factor in early childhood mortality, and most severe during the early period.

**Growth and Development**

The childhood stress hypothesis also gains support when patterns of skeletal growth are examined. It has been well documented that bone growth and development respond more readily to environmental stress than does the genetically programmed eruption of the dentition. More specifically, the rate of skeletal maturation slows considerably in individuals and populations experiencing nutritional stress (Stini 1975 and Tanner 1978). Since both dental and skeletal maturation proceed in accordance with chronological age, they should under normal conditions approximate one another. Consequently, when estimates of age based on the dentition yield higher figures than those based on the skeleton, the discrepancy may be interpreted as evidence for retarded skeletal development.

**Table 1**

<table>
<thead>
<tr>
<th>Early cemetery (21–S–46)</th>
<th>Late cemetery (21–R–2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N = 21)</td>
<td>(N = 23)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DA</strong></td>
<td><strong>DA</strong></td>
</tr>
<tr>
<td><strong>SA</strong></td>
<td><strong>SA</strong></td>
</tr>
<tr>
<td><strong>SA–DA</strong></td>
<td><strong>SA–DA</strong></td>
</tr>
<tr>
<td><strong>SA+DA</strong></td>
<td><strong>SA+DA</strong></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td><strong>Sex</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DA</th>
<th>SA</th>
<th>SA–DA</th>
<th>SA+DA</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>12</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>-1</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>-1</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>-2</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>-3</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>-3</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>-4</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>-4</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>0</td>
<td>100</td>
<td>M</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>-5</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>12</td>
<td>-6</td>
<td>67</td>
<td>M</td>
</tr>
<tr>
<td>18</td>
<td>12</td>
<td>-6</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>17</td>
<td>-2</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>24</td>
<td>5</td>
<td>126</td>
<td>F</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>-8</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>17</td>
<td>-3</td>
<td>85</td>
<td>M</td>
</tr>
<tr>
<td>21</td>
<td>19</td>
<td>-2</td>
<td>90</td>
<td>M</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>0</td>
<td>100</td>
<td>M</td>
</tr>
<tr>
<td>22</td>
<td>24</td>
<td>2</td>
<td>109</td>
<td>F</td>
</tr>
<tr>
<td>23</td>
<td>16</td>
<td>-7</td>
<td>70</td>
<td>M</td>
</tr>
<tr>
<td>23</td>
<td>23</td>
<td>0</td>
<td>100</td>
<td>F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DA</th>
<th>SA</th>
<th>SA–DA</th>
<th>SA+DA</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>12</td>
<td>-2</td>
<td>86</td>
<td>M</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>-2</td>
<td>86</td>
<td>F</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>0</td>
<td>100</td>
<td>F</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>-2</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>14</td>
<td>-1</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>1</td>
<td>107</td>
<td>F</td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>-4</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>-4</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>123</td>
<td>-4</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>15</td>
<td>-2</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>12</td>
<td>-5</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>0</td>
<td>100</td>
<td>M</td>
</tr>
<tr>
<td>18</td>
<td>16</td>
<td>-2</td>
<td>89</td>
<td>F</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>-4</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>15</td>
<td>-3</td>
<td>83</td>
<td>M</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>1</td>
<td>105</td>
<td>F</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>1</td>
<td>105</td>
<td>F</td>
</tr>
<tr>
<td>19</td>
<td>18</td>
<td>-1</td>
<td>95</td>
<td>F</td>
</tr>
<tr>
<td>19</td>
<td>19</td>
<td>0</td>
<td>100</td>
<td>F</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>-4</td>
<td>80</td>
<td>M</td>
</tr>
<tr>
<td>21</td>
<td>23</td>
<td>2</td>
<td>109</td>
<td>F</td>
</tr>
<tr>
<td>22</td>
<td>18</td>
<td>-4</td>
<td>82</td>
<td>F</td>
</tr>
<tr>
<td>22</td>
<td>17</td>
<td>-5</td>
<td>77</td>
<td>M</td>
</tr>
</tbody>
</table>

* DA = dental age; SA = skeletal age.
* Average SA–DA = -2.4 (early cemetery); -1.9 (late cemetery).
* Average SA+DA = 86.5 (early cemetery); 89.0 (late cemetery).
Independent estimates of skeletal and dental age were made for 21 early and 23 late Christian period subadults ranging in age from 12 to 23 years (Moore et al. 1986). The two samples included all remains for which adequate dental and skeletal age comparisons could be made (see Table 1). Individuals were first placed in dental age categories based on the eruption sequence presented by Ubelaker (1978). These categories were then further adjusted according to estimates of dental attrition based on the method described by Miles (1963).

Skeletal age was estimated using standard criteria for epiphyseal union (Stewart 1979). Nine separate sites of union were scored, including the proximal and distal humerus, proximal and distal femur, iliac crest, primary elements of the innominate, ischial tuberosity, distal radius, and medial clavicle. A final skeletal age estimate was then determined using a modification of the Tanner-Whitehouse method for the evaluation of skeletal maturity (Tanner 1978).

For the combined samples, 70.5 percent of the individuals examined had a dental age exceeding their skeletal age, while only 13.6 percent had a skeletal age greater than their dental age (see Figure 13). Seven individuals (15.6 percent) produced no difference between the two calculations. This bias in the direction of skeletal growth retardation is highly significant ($p < 0.01$).

A comparison between the two samples indicated that subadults from the early population experienced greater growth retardation, with skeletal age averaging 13.4 percent below dental age. Skeletal age among the late children fell on average 11 percent below dental age.

Sex differences in the skeleton do not appear until near the end of the growth period, therefore analysis of maturation patterns by sex is seldom undertaken with archaeological remains. In the case of Kulubnarti, however, 23 of the 44 individuals in the combined sample were sufficiently mummified to permit positive diagnosis. Among the females there was no significant difference between skeletal and dental age; skeletal age fell on average 2.3 percent ahead of dental age. Males, on the other hand, showed significant skeletal retardation ($p < 0.05$) with a mean skeletal age 14.7 percent below dental age.

Comparison by sex revealed a consistent pattern of heightened female resiliency (Sheridan and Van Gerven 1994). Among females, life expectancies during childhood were longer, dental hypoplasias appeared later and abated sooner, porotic hyperostosis was less frequent, and skeletal retardation was virtually absent. The interpretation of these results as reflecting a sexually dimorphic response to childhood stress gains support from the study of living children. Such research has demonstrated that females are less affected than males by a variety of stressors, including nutritional stress.

**Adult Stress and Mortality**

Taken together, the investigations of childhood mortality, growth, development, and disease reveal a consistent pattern of greater subadult stress during early Christian times. This pattern does not, however, continue through the adult years. Indeed, from age 15 through 45 it is the early population that experienced an increased mean life expectancy (see Figure 5).

This pattern may be explained by new stresses that appeared in the lives of the young adults during the later period. Greene et al. (1986) noted a close correspondence between the late Christian life table and Weiss's model table MT:20–60 (Weiss 1973:130). Weiss has suggested that such a mortality pattern might occur in a population subjected to warfare. Given the heightened political tensions that prevailed between Egypt and Nubia during late Christian times and the multiple incursions of Egyptian forces, some increase in adult stress, particularly among young adults, would not be surprising.

**Fracture Patterns**

An examination of fracture rates reported by Burrell and coworkers (1986) lends support to this interpretation. From early to late Christian times there was a 30 percent increase in fractures of the upper limb at Kulubnarti. In addition, the highest fracture rate was now found among younger rather than older males. These data provide strong evidence for an increase in stress among males during the late Christian period.

The question, then, is whether the apparent increase in adult stress might have lowered fecundity and thereby created an illusion of reduced infant mortality mistakenly interpreted as a real reduction in stress. In short, does evidence for adult stress support the alternative to the
present hypothesis of improved health and adaptation in the late Christian population at Kulubnarti?

Osteoporosis

The analysis of female osteoporosis (bone loss) provides strong evidence against such an interpretation. An analysis by Moore (1987) and Van Gerven and coworkers (1990) of femoral midshaft sections from 50 Kulubnarti females revealed significant (p < 0.05) reductions in percent cortical area (osteoporosis) from young adulthood through old age (see Figure 14). What is important, however, is the difference in bone loss between the early and late Christian samples. Compared to their late Christian counterparts, the early period females lose progressively more bone throughout their reproductive years. A difference of 1 percent in the 20s increases to a difference of 8.5 percent by the mid-40s (p < 0.05).

This pattern of divergence in the premenopausal years is informative. Martin et al. (1985) demonstrated that young Wadi Halfa females with osteoporosis turned over 3.8 mm² of bone per year compared to 2.8 mm² by older (likely postmenopausal) females. The younger skeletons were not just aging—they were being mined (through bone turnover) for minerals needed by the developing fetus and neonate. In this light, it is likely that the premenopausal differences observed at Kulubnarti reflect environmental stress in conjunction with pregnancy and lactation. This being the case, it appears that the early Christian females were more reliant upon body stores than their later Christian counterparts. Alternatively, it might be argued that reduced female bone loss in the later Christian sample is, itself, a reflection of reduced fecundity. If this were the case, however, a comparable shift would not be expected in the male samples.

A sample of 50 male femora (see Figure 15) produced a comparable diachronic shift (Moore 1987 and Van Gerven et al. 1990). While showing no significant bone loss with advancing age (as is typical for males), the early Christian sample had significantly less bone (p < 0.05) than their late counterparts.

While less apparent than the manifestations of stress observed among the subadults, the adults of Kulubnarti continue to show the patterns of stress begun in infancy. It appears that the adults experienced a reduction in stress between the early and late periods except in the case of upper limb fractures. Overall, the evidence clearly does not support a hypothesis of reduced fecundity.

Conclusions

Each analysis conducted to date leads to the same conclusion: from the standpoint of the population’s most important component, its children, the people of Kulubnarti were better bioculturally adapted in the late Chris-
Whether or not this immigration from the north was a source of improved health at Kulubnarti, it was a source of increasing genetic continuity between the Batn el Hajar and Lower Nubia. A craniometric comparison of the Kulubnarti populations with Christian remains from Wadi Halfa (Van Gerven 1982) demonstrated a significant morphological convergence between Wadi Halfa and the late Kulubnarti population. In addition to the influx of a northern population, changes in the political circumstances of the Batn el Hajar may have also played a role in improving the health of local populations. Following the breakup of the unified kingdom of Makouria around 1365, there appeared a series of more localized political entities in Lower Nubia and the Batn el Hajar. The people of Kulubnarti enjoyed a greater degree of political autonomy and may have been subject to no external taxing authority.

The possible association between this political and economic decentralization and improved human health and survival is not unprecedented in ancient Nubia. The Meroitic period (ca. 350 B.C. to A.D. 350) was one of considerable cultural achievement and political unification in Nubia. In contrast, the Ballana (formerly X-Group) period (ca. A.D. 350–550) that followed was politically decentralized, poorer but more self-sufficient (Adams 1977). Yet, a comparison of life expectancies and probabilities of dying revealed an increase in life expectancy during Ballana times at Wadi Halfa (Armelagos 1968). As an explanation, Armelagos suggested that political unification and authority may have worked more hardships than benefits on communities such as Wadi Halfa during Meroitic times. In contrast, a decline in centralized political authority with an increase in economic autonomy may have had a positive effect.

It would appear that a similar argument can be made for Kulubnarti during Christian times. In terms of infant and childhood mortality, this population experienced greatest stress during the period of political unification when they were but a small contributing satellite to a centralized and distant authority. In contrast, political and economic changes during the last centuries of the Christian period left the populations of the Batn el Hajar increasingly independent. As measured by the biological well-being of infants and children, the period of village autonomy was less stressful.

Among the adults it appears the daily pressures of economic and political survival were also affected. There was a slight but consistent increase in mortality and trauma frequency. It is nevertheless quite possible that the general health of the adults improved. Patterns of age-related bone loss for both the males and females would support this contention. It can also be argued that the dramatic improvement in subadult survival more than compensated for the slight increase in adult mortality.

According to Greene et al. (1986), subadult mortality during the early Christian period would have required a birth rate of 0.069 to maintain a stable population. This rate is almost certainly beyond the human biological limit (estimated to be approximately 0.055). In contrast, a birth rate of 0.045 would have maintained the late population—an estimate well within the range of 0.040 to 0.050 observed in many areas of the world today (Greene et al. 1986). It appears from these demographic data that had conditions not improved at Kulubnarti, the population would have steadily declined.

As a final observation, it appears that two lessons can be learned from the Kulubnarti research. First, generalizations about the costs and benefits of political and economic achievement must be made with great caution and due respect for the many complexities involved. Second, from the perspective of culture history, the analysis of human remains can add an important biocultural perspective to our understanding of the social, political, economic, and geographic forces that shape the adaptation of ancient societies. It must nevertheless be added that the Kulubnarti results, though highly suggestive, are not conclusive since these are two among scores of Christian cemeteries in the Batn el Hajar. Regrettably, none of the others have been excavated with any degree of thoroughness.

Notes

Acknowledgments. We wish to thank Julie Sarsoni, Brian Magee, and Drs. Mark R. Schurr, Barbara Tedlock, and Alan Goodman for their many helpful comments in the preparation of this manuscript. This research was funded in part by NSF grant No. 9077-555B, the Institute for Scholarship in the Liberal Arts (University of Notre Dame), the Office of Research Faculty Research Program (University of Notre Dame), and the Wenner-Gren Foundation for Anthropological Research.


References Cited

Adams, William Y.
Armelagos, George J.
Berti, Peter R., and Michael C. Mahaney
1992 Quantification of the Confidence Interval of Linear Enamel Hypoplasia Chronologies. In Recent Contributions to the Study of Enamel Developmental Defects. Journal of
Goodman and Luigi Capasso, eds.
Bocquet-Appel, J., and C. Masset
1982 Farewell to Paleodemography. Journal of Human Evolu-
1985 Paleodemography: Resurrection or Ghost. Journal of
Burrell, Lydia L., Mary C. Mass, and Dennis P. Van Gerven
1986 Patterns of Long-Bone Fracture in Two Nubian Ceme-
Carlson, David S., George J. Armelagos, and Dennis P. Van
Gerven
1974 Factors Influencing the Etiology of Cribrum Orbitalia in
Connelly, Michael P. E., Susan G. Sheridan, and Mark R.
Schurr
1983 Antemortem Fluoride Levels in an Ancient Nubian
Population. American Journal of Physical Anthropology,
Supplement 13:143.
Garn, Stanley M., and C. G. Rohman
1980 Interaction of Nutrition and Genetics in the Timing of
Growth and Development. Pediatric Clinics of North Amer-
Goodman, Alan H.
1993 On the Interpretation of Health from Skeletal Remains.
Goodman, Alan H., George J. Armelagos, and Jeremy C. Rose
1980 Enamel Hypoplasias as Indicators of Stress in Three
Prehistoric Populations From Illinois. Human Biology
52:515–528.
Greene, David L., Dennis P. Van Gerven, and George J.
Armelagos
1986 Life and Death in Ancient Populations: Bones of Con-
Hilson, S.
1978 Human Biology and Variation in the Nile Valley in Re-
lation to Environmental Factors. Ph.D. dissertation, Univer-
sity of London.
1979 Diet and Dental Disease. World Archaeology 11:147–
162.
Hummer, James R., and Dennis P. Van Gerven
1982 Tetracycline Labeling in a Christian Population from
Lasker, George W.
Martin, Deborah L., Alan H. Goodman, and George J. Armelagos
1985 Skeletal Pathologies as Indicators of Quality and Quan-
tity of Diet. In The Analysis of Prehistoric Diets. B. Gilbert
Miles, A. E. W.
1963 The Dentition in Assessment of Individual Age in Skele-
Mittler, Diane M., and Susan G. Sheridan
1982 Sex Determination in Subadults using Auricular Sur-
face Morphology: A Forensic Science Perspective. Journal of
Mittler, Diane M., and Dennis P. Van Gerven
1994 Development and Demographic Patterns of Cribrum Or-
bitalia in a Medieval Christian Population from Sudanese
Mittler, Diane M., Dennis P. Van Gerven, Susan G. Sheridan,
and Rosemary Beck
1992 The Epidemiology of Enamel Hypoplasia, Cribrum Orbi-
talia, and Subadult Mortality in an Ancient Nubian Popula-
tion. In Recent Contributions to the Study of Enamel
Developmental Defects. Journal of Paleopathology Mono-
graph Publications 2:143–150. Alan H. Goodman and Luigi
Capasso, eds.
Moore, Katherine
1987 Osteopenia in a Medieval Population from Sudanese
Moore, Katherine, Susan Thorpe, and Dennis P. Van Gerven
1986 Patterns of Dental Eruption, Skeletal Maturation, and
Stress in a Medieval Population from Sudanese Nubia.
Rheindhold, J. G.
1982 Dietary Fiber and the Bioavailability of Iron. In Nutri-
tional Bioavailability of Iron. C. Kies, ed. Pp. 143–161. Wash-
ington, DC: American Chemical Society Press.
Roberts, D. F.
246.
Sheridan, Susan G.
1992 Minor and Trace Element Distributions in Bone: Re-
construction of Diagenetic, Dietary, and Disease Patterns in
an Ancient Nubian Population. Ph.D. dissertation, Univer-
sity of Colorado, Boulder.
Sheridan, Susan G., and Dennis P. Van Gerven
1994 Sex Differences in Stress Response in Human Remains
from Sudanese Nubia. American Journal of Physical An-
thropology, Supplement 18:201.
Stewart, T. Dale
1979 Essentials of Forensic Anthropology. Springfield, IL:
Charles C. Thomas.
Stini, William A.
1975 Adaptive Strategies of Human Populations under Nutri-
tional Stress. In Biosocial Interrelations in Population Adap-
tation. E. S. Watts, F. E. Johnson, and G. W. Lasker, eds.
Swedlund, Alan C., and George J. Armelagos
Annales: Economie, Sociétés, Civilization
Tanner, J. M.
1978 Fetus into Man. Cambridge, MA: Harvard University
Press.
Ubelaker, Douglas H.
Van Gerven, Dennis P.
1982 The Contribution of Time and Local Geography to Cra-
niofacial Variation in Nubia’s Batu el Hajar. American
Van Gerven, Dennis P., and George J. Armelagos
1983 Farewell to Paleodemography? Rumors of its Death
Have Been Greatly Exaggerated. Journal of Human Evolu-
Van Gerven, Dennis P., George J. Armelagos, and A. L. Rohr
1978 Continuity and Change in Cranial Morphology of Three
Van Gerven, Dennis P., Rosemary Beck, and James R.
Hummert
1990 Patterns of Enamel Hypoplasia in Two Medieval Popu-
lations from Nubia's Batn et Hajar. American Journal of
Physical Anthropology 82:413–420.
Van Gerven, Dennis P., James R. Hummert, Katherine Moore,
and Mary K. Sandford
1990 Nutrition, Disease, and the Human Life Cycle: A Bioeth-
ography of a Medieval Nubian Community. In Primate Life
Van Gerven, Dennis P., Mary K. Sandford, and James R.
Hummert
1981 Mortality and Culture Change in Nubia's Batn et Hajar.
Journal of Human Evolution 10:305–408.
Weiss, Kenneth M.
1973 Demographic Models for Anthropology. American An-
1992 The Osteological Paradox: Problems of Inferring Pre-
historic Health from Skeletal Samples. Current Anthropol-
ology 33:343–358.