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Article

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Dental insights into the biological affinities of the inhabitants of Gabati over a period of cultural transition

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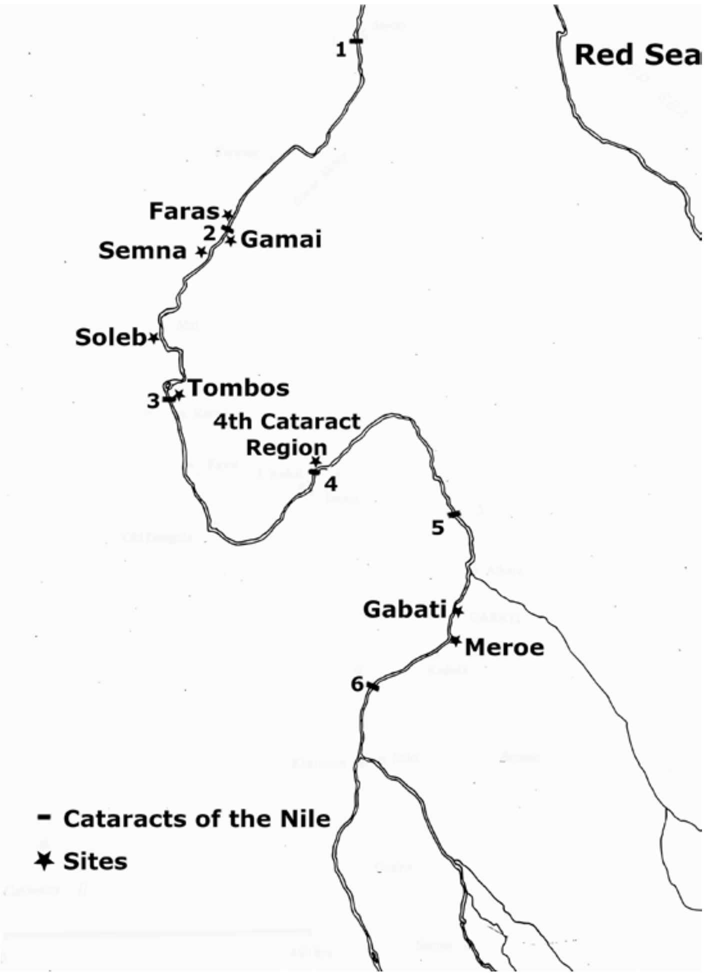

Figure 1. Map of ancient Nubia.

Gabati is located below the 5th Cataract of the Nile (Figure 1), 40km north of Meroe, the capital of the Kushite empire from *c.* 300 BC–350 AD (Edwards 2004, 141). The cemetery at Gabati contains graves dating to the late Meroitic (*c.* 200 BC–200 AD), post-Meroitic (*c.* 550–700 AD), and medieval periods (*c.* 900–1200 AD), and represents a rare example of a non-elite burial complex in the heart of the Meroitic empire (Edwards 1998, 194-208). The site provides a window into the changes that occurred before, during, and after the fall of the empire. Biological distance studies can enhance understanding of cemetery sites, providing an opportunity to see if cultural shifts are accompanied by biological changes. Biological distance (biodistance) is a measure of biological divergence/relatedness within and between groups. Biodistance studies are based on morphological differences in the skeleton and dentition, both metric and non-metric, which have been found to be a good genetic proxy (Hefner *et al.* 2016). Recording skeletal collections in this manner is repeatable, cost effective and can be used when DNA is irretrievable, as has been the case in hot, dry areas like the Nile Valley.

During the period in which the graves were in use, the empire had reached the zenith of its power, extending from the 1st Cataract at Aswan to the confluence of the Blue and White Nile Rivers below the 6th Cataract (Welsby 2005, 39). Although there was a level of cultural homogeny throughout the kingdom, with an official written language and religion (Zabkar 1975; Rilly and De Voogt 2012), evidence of regional differences in both the material culture and burial record is clear (see Edwards 1996; Wolf and Nowotnick 2006; Usai *et al.* 2014; Sakamoto 2016; Bushara *et al.* 2017). Biodistance studies have hinted at this, with skeletal assemblages from the Meroitic period showing greater affinities with samples that are geographically close over those that are temporally adjacent (Irish 2005; 2008).

Cultural changes between the Meroitic and following post-Meroitic and medieval periods can be observed at Gabati, but there are also some signs of continuity (Edwards and Judd 2012). The post-Meroitic graves are characterised by single burials, interred in a contracted position, orientated north-south, and covered by tumuli. This form of burial is observed throughout Nubia during this period (Edwards 1998, 205). Body position and orientation are the same as in the Meroitic period, but mounds were used to cover the graves, and multiple interments were the norm (Edwards 1998, 194-197). Additionally, the Meroitic graves from Gabati were systematically robbed, most likely during the Meroitic period (Edwards and Judd 2012, 77), which may indicate the cemetery was not in continuous use. This may account for the gap between the latest date for Meroitic burials (*c.* AD 200) and the earliest date for post-Meroitic/medieval burials (*c.* AD 550) at Gabati (Edwards 1998, 198; Edwards and Judd 2012, 78).

Multiple biodistance studies have looked at relationships among samples from Lower Nubia and Upper Nubia (Johnson and Lovell 1995; Irish 2005; Irish 2006; Irish 2008; Schillaci *et al.* 2009; Godde 2010; Godde 2013; Irish 2014; Schrader *et al.* 2014); however, due to the dearth of material, the Meroitic period in the southern part of Upper Nubia (below the 5th Cataract of the Nile) has not yet been fully explored and set within its regional context. Two biodistance studies using the Gabati collection (Vollner 2016; Streetman 2018), found that Gabati was distinct from other Nubian medieval assemblages located between the 2nd and 4th Cataracts of the Nile. The divergence of Gabati from the other collections could be indicative of the area below the 5th Cataract following the same patterning observed farther north, where collections from the same region share greater affinities to those from the same temporal period. Vollner's study (2016, 103), based on craniometric data, also found significant differences between the Meroitic and post-Meroitic periods in the Gabati collection, which were attributed to diachronic changes rather than population discontinuity. Further, the Gabati assemblage was reported to have higher than average phenetic (i.e. similarities/differences based on observable characteristics) variation, attributed to either external gene flow (from different group(s) coming into the area) or genetic drift (i.e. the mechanism of evolution that can cause genetic trait frequencies to fluctuate in populations) (Vollner 2016, 130). Conversely, research using cranial non-metric traits conducted by Streetman (2018) on the post-Meroitic and medieval individuals from Gabati revealed that the collection was homogeneous, showing low levels of within-group variation. It was suggested that the cemetery may contain a family group rather than a community (Streetman 2018, 161). Differences in the findings from both studies could be due to the difference in data sets, as cranial metrics and cranial non-metrics have been shown to represent different elements of the genome (Herrera *et al.* 2014).

Adding to the previous research from the Nile Valley and Gabati (as above), dental non-metric traits will be used to investigate how the individuals buried at Gabati relate to other Nubian groups. Inter-sample affinities will be used to identify whether the regional patterning observed in other areas of Nubia during the Meroitic period is apparent in the Meroitic heartland. Furthermore, the dental data will be used to expand upon the cranial traits research of Vollner (2016) and Streetman (2018) to assess if the phenetic distinctiveness of Gabati in the post-Meroitic/medieval periods is part of the same regional model. Additionally, population continuity between the Meroitic and post-Meroitic/medieval periods at Gabati will be investigated to see if the presence of external gene flow indicated in earlier research (Vollner 2016) is evident.

Materials and Methods

Gabati

The cemetery was discovered in 1993, as part of a survey undertaken by the Sudan Archaeological Research Society, near the village of Gabati in Upper Nubia (Edwards 1998, 1). The main part of the cemetery was dated to the Meroitic period. A total of 64 graves were excavated and 142 individuals recovered (Edwards and Judd 2012, 75). Another 50 graves consisting of 54 individuals from the post-Meroitic (36 individuals) and medieval periods (18 individuals) were also excavated (Judd 2012, 175-178).

The skeletal collection is curated at the British Museum and contains males, females and children. Dental preservation varied depending on the time period, with only 16.8% of teeth recovered from the

	Meroitic	post-Meroitic/medieval	Total
No. of Individuals	84	37	121

Figure 2. Number of individuals used in the study.

Meroitic individuals compared with 75% and 73% in the post-Meroitic and medieval periods, respectively (Judd 2012). Furthermore, many of the Meroitic graves were robbed and reused in antiquity. As such, not all individuals had complete dentitions. Only individuals with at least one permanent tooth, either erupted or forming within the jaws of children, were included in the study. Figure 2 details the number of individuals analysed.

Comparative collections

Comparative collections were chosen to represent Lower and Upper Nubia, and also when the cemetery was in use. Further details can be found in Figure 3 (also see Figure 1). The data were recorded by Joel D. Irish (JDI) (Irish 2005; Schrader *et al.* 2014), except for Gabati and sites from the 4th Cataract region

Collection	Site(s)	Time period	Date	N	Location[a]
Gabati (GABM, GABPM) a	Gabati	Meroitic, post-Meroitic, medieval	200 BC–AD 700	121	BM
Upper Nubia					
Tombos (TOM)[c]	Tombos	Late New Kingdom/ 3rd Intermediate	1212–1069 BC	147	PU
3-Q-33 (3Q33)	4th Cataract	Meroitic	100 BC–AD 350	29	BM
PM4C (PM4C)[d]	4th Cataract	post-Meroitic	AD 350–550	30	BM
3-J-23 (3J23)	4th Cataract	medieval	AD 500–1500	109	BM
Lower Nubia					
Pharaonic (PHA)	Faras to Gamai; Soleb	New Kingdom	1650–1350 BC	70	ASU, PAN
Meroitic (MER)	Faras to Gamai;	Meroitic	100 BC–AD 350	94	ASU, PAN
X-Group (XGR)	Faras to Gamai;	post-Meroitic	350–550 AD	62	ASU, PAN
Christian (CHR)	Faras to Gamai	medieval	350–1350 AD	41	ASU, PAN

[a] Abbreviation used to denote the site in graphs and tables. [b] Curation at: ASU = Arizona State University, BM=British Museum, PAN = Panum Institute, PU = Purdue University. [c] Tombos sample had previously been dated to the Napatan period (Schrader *et al.* 2014) but the date was revised in a later publication (Buzon *et al.* 2016). [d]Assemblage comprised from 4-M-53, 3-O-1 and 3-Q-33.

Figure 3. Details of sites used in the study.

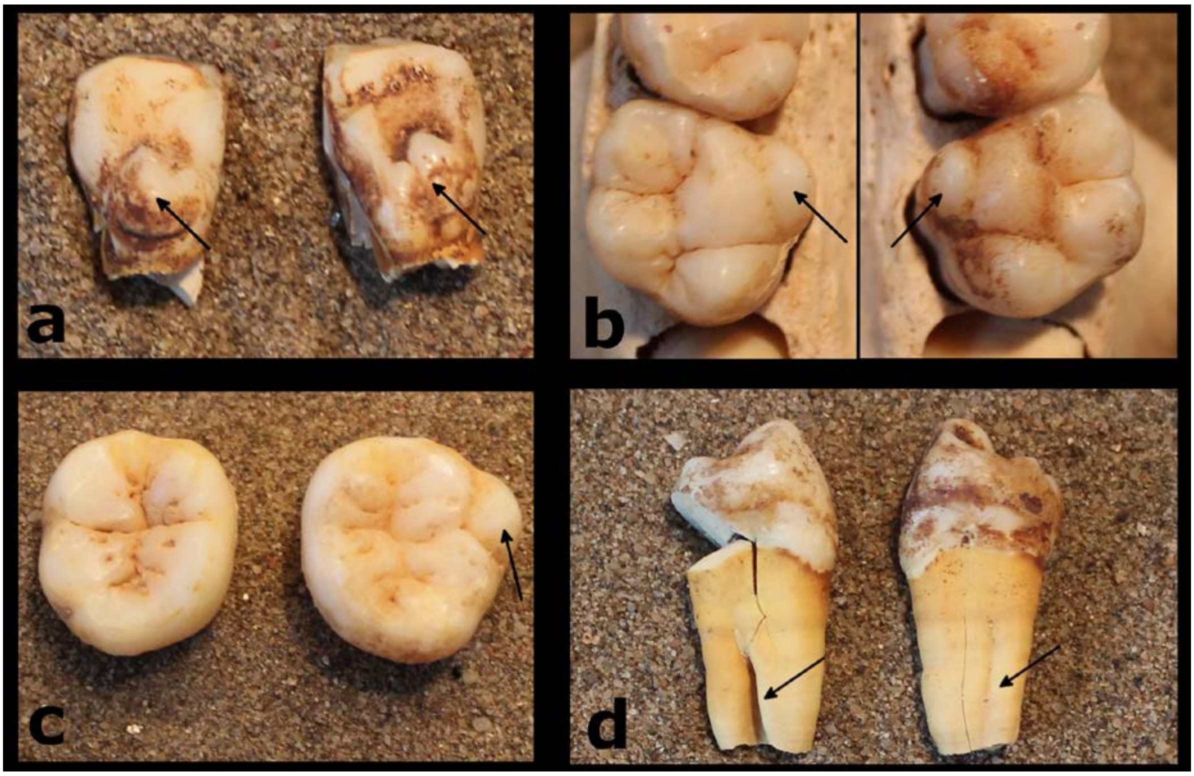

Figure 4. Examples of asymmetric trait expression: a) Slight asymmetry in expression of tuberculum dentale on upper 2nd incisors; b) Slight asymmetry in expression of Carabelli's cusp on the upper 1st molars; c) Marked asymmetry in expression of protostylid on lower 3rd molars; d) Marked asymmetry in expression of Tomes' root on lower 1st premolars.

recorded by the author (ELWP). ELWP was trained by JDI, and subsequent interobserver error tests were performed to assess any discrepancies in recording. The minimal differences between observers were random and not statistically significant.

Data collection methods

Thirty-six dental and osseous non-metric traits from the Arizona State University Dental Anthropology System (ASUDAS) were recorded. These have been utilised successfully in previous biodistance studies, including others from the Nile valley (Irish 2005; Irish 2006; Schillaci *et al.* 2009; Schrader *et al.* 2014), and exhibit a high genetic component in expression (Scott 1973; Larsen 1997; Scott and Turner 1997; Hlusko *et al.* 2007). Scores were recorded for both right and left sides where possible as there can be asymmetry in the degree to which traits are expressed in individuals. In cases where asymmetry is present, the side with the maximum expression is recorded, see Figure 4 for examples. This approach ensures that the greatest genetic expression is scored (Scott and Irish 2017). Following the standard ASUDAS approach, the sexes were pooled, given that minimal levels of sexual dimorphism have been observed in previous studies (Turner *et al.* 1991; Scott and Irish 2017).

Analytical Methods

To allow basic evaluation of the data, results for each individual were dichotomised into categories of present or absent using standard breakpoints (Figure 5). After dichotomisation, the medieval data showed a low number of instances (i.e. <10) in all but four traits. As such, it was decided to pool the post-Meroitic and medieval data. The post-Meroitic period has often been seen as a protoculture to the medieval period in Nubia (Edwards 2004, 212). Once the results were dichotomised, further analysis was undertaken via univariate and multivariate methods.

Trait		Gabati Meroitic	Gabati post-Meroitic/medieval
Winging UI1*	%	0.00	7.69
(+ = ASU 1)	n	19	26
Labial curvature UI1	%	31.82	10.34
(+ = ASU 2-4)	n	22	29
Palatine torus	%	7.41	10.71
(+ = ASU 2-3)	n	27	28
Shoveling UI1 *	%	27.27	27.78
(+ = ASU 2-6)	n	11	18
Double shoveling UI1*	%	0.00	0.00
(+ = ASU 2-6)	n	24	29
Interuption groove UI2*	%	15.79	8.00
(+ = ASU +)	n	19	25
Tuberculum dentale UI2*	%	66.67	22.73
(+ = ASU 2-6)	n	12	22
Bushman canine UC	%	22.22	8.70
(+ = ASU 1-3)	n	9	23
Distal accessory ridge UC*	%	25.00	23.53
(+ = ASU 2-5)	n	4	17
Hypocone UM2	%	79.41	79.41
(+ = ASU 3-5)	n	34	34
Cusp 5 UM1*	%	8.33	0.00
(+ = ASU 2-5)	n	12	17
Carabelli's cusp UM1	%	31.58	46.43
(+ = ASU 2-7)	n	19	28
Parastyle UM3	%	2.70	7.41
(+ = ASU 1-5)	n	37	27
Enamel extension UM1	%	7.69	16.67
(+ = ASU 1-3)	n	13	24
Root number UP1	%	71.19	42.31
(+ = ASU 2+)	n	59	26
Root number UM2	%	78.95	57.14
(+ = ASU 3+)	n	57	28
Peg-reduced UI2	%	4.00	3.57
(+ = ASU P or R)	n	25	28
Odontome P1-P2*	%	0.00	6.90
(+ = ASU +)	n	31	29

Figure 5. Dental trait frequencies (%) and number of individuals (n).

Trait		**Gabati Meroitic**	**Gabati post-Meroitic/medieval**
Congenital absence UM3*	%	9.84	5.71
(+ = ASU -)	n	61	35
Mid line diastema UI1	%	18.18	18.18
(+ ≥ 0.5 mm)	n	11	22
Lingual Cusp LP2	%	93.33	90.32
(+ = ASU 2-9)	n	30	31
Anterior Fovea LM1	%	45.45	29.41
(+ = ASU 2-4)	n	11	17
Mandibular torus*	%	0.00	0.00
(+ = ASU 2-3)	n	39	30
Groove pattern LM2	%	12.77	11.76
(+ = ASU Y)	n	47	34
Rocker Jaw	%	38.10	44.83
(+ = ASU 1-2)	n	42	29
Cusp number LM1	%	9.38	6.06
(+ = ASU 6+)	n	32	33
Cusp number LM2*	%	23.91	35.29
(+ = ASU 5+)	n	46	34
Deflecting wrinkle LM1*	%	40.00	23.08
(+ = ASU 2-3)	n	10	13
C1-C2 crest LM1*	%	22.22	0.00
(+ = ASU +)	n	9	11
Protostylid LM1	%	7.89	11.11
(+ = ASU 1-6)	n	38	27
Cusp 7 LM1	%	11.76	6.67
(+ = ASU 2-4)	n	34	30
Tomes root LP1*	%	25.00	3.70
(+ = ASU 3-5)	n	32	27
Root number LC*	%	1.89	0.00
(+ = ASU 2+)	n	53	32
Root number LM1*	%	2.94	0.00
(+ = ASU 3+)	n	68	30
Root number LM2	%	96.49	71.43
(+ = ASU 2+)	n	57	28
Torsomolar angle LM3	%	32.43	40.74

*indicates traits that were removed through the data editing process.

Figure 5 (continued). Dental trait frequencies (%) and number of individuals (n).

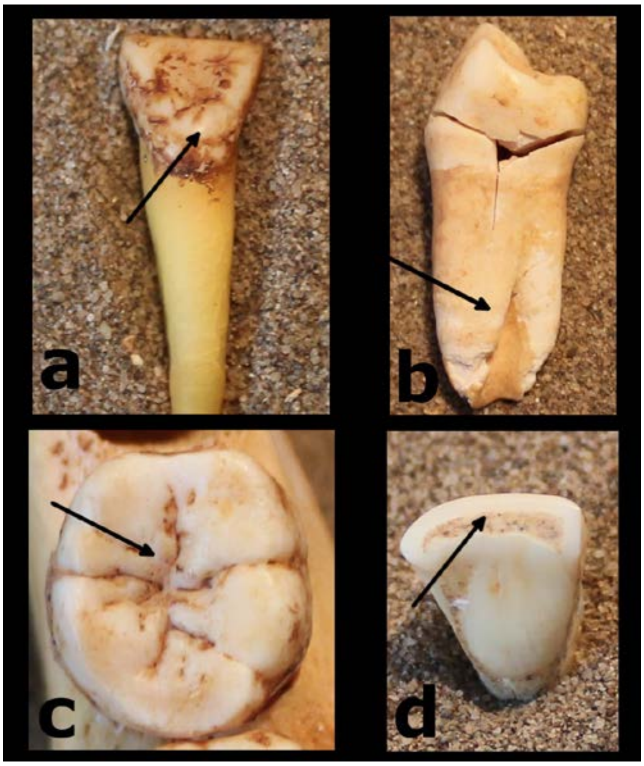

Figure 6. Examples of non-metric dental traits:
a) Tuberculum dentale on upper 2nd incisor; b) Tomes' root on lower 1st premolar; c) C1-C2 crest on the Lower 1st molar; d) Labial curvature of upper 1st molar.

Inter-sample biodistances were calculated using the Mean Measure of Divergence distance statistic (MMD). The MMD has been used effectively in multiple biodistance studies. It handles missing data and small sample sizes well when the Freeman and Tukey angular transformation is incorporated (Freeman and Tukey 1950; Sjøvold 1973; Green and Suchey 1976; Sjøvold 1977). Significant differences are assessed by comparing the MMD distance with its standard deviation (Sx). If the MMD is 2X greater than Sx, the null hypothesis of identical sample pairs is rejected at the 0.025 level (Sjøvold 1977; Harris and Sjøvold 2004). The closer the MMD value is to zero the higher level of affinity the sample pairs share. Although including the maximum number of traits when using the MMD is advised, they should be selectively edited to improve results (Sjøvold 1977). The process is three-fold. Firstly, traits with consistently high or low frequencies observed across the collections being studied need to be removed. Secondly, any traits that are most or least likely to drive variation between the samples can be deleted. Lastly, strongly intercorrelated traits should be removed from analyses. Trait frequencies were assessed using the data in Figure 5. Principal components analysis (PCA) was employed to identify traits that were not useful in driving variation. Kendall's tau-b test was used to identify any highly inter-correlated traits (Irish 2005, 2006).

	Gabati Meroitic	**Gabati post-Meroitic/medieval**
3-Q-33	**0.0815**	**0.0566**
Meroitic	**0.0524**	**0.0508**
Pharaonic	**0.0837**	**0.0919**
Tombos	**0.0950**	**0.1313**
PM4C	0.0218	**0.0840**
X-Group	0.0401	**0.0788**
3-J-23	0.0200	**0.0719**
Christian	**0.0896**	**0.1302**
Gabati Meroitic	0.0000	0.0329
Gabati post-Meroitic/ medieval	0.0329	0.0000

Significant values ($p \leq .025$) in bold.

Figure 7. 36-Trait Mean Measure of Divergence results.

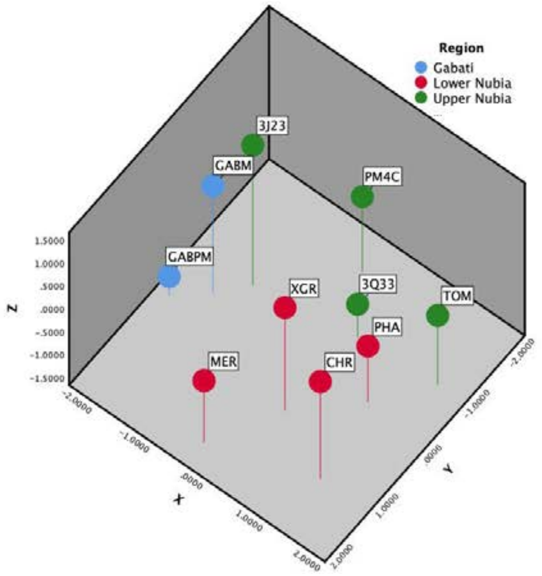

Figure 8. Multi-dimensional scaling of 36 Trait MMD results for Gabati and comparative samples. Three-letter sample abbreviations are defined in Figure 3.

To illustrate how samples related to each other Multi-Dimensional Scaling (MDS) was used. MDS uses the MMD values to create a graphic representation of the distances between samples.

Results

Dental trait frequencies

Figure 5 lists the results from scoring the 36 dental traits from Gabati, divided into Meroitic and post-Meroitic/medieval. The percentage of individuals exhibiting each trait is shown along with the total number of individuals. The data from Figure 5 reveals that the two assemblages are similar, except for higher instances of Labial curvature of the Upper 1st Incisor, Tuberculum dentale on the Upper 2nd Incisor, C1-C2 crest on the Lower 1st Molar and Lower 1st Premolar Tomes root in the Meroitic sample compared to the post-Meroitic/medieval sample (see Figure 6).

36-Trait MMD analysis

The results of the 36-trait MMD comparison can be found in Figure 7. Meroitic Gabati (GABM) is significantly different (p=0.025 level) from five of the nine comparative assemblages, including all other Meroitic collections. The Meroitic Gabati sample (GABM) is most similar to Site 3-J-23 (MMD, 0.020) and the post-Meroitic 4th Cataract collection (PM4C) (MMD, 0.022), both of which are from further north in Upper Nubia. Although the Gabati Meroitic collection (GABM) is not significantly different from the post-Meroitic/medieval sample (GABPM), an MMD value was calculated (MMD, 0.033), indicating some difference. The GABPM is significantly different from all other comparative collections. Figure 8 is the MDS of the 36-trait MMD values. The MDS model is a good fit for the data, with Kruskal's Stress Test 1 = 0.082 and r^2= 0.927. The MDS shows regional patterning, with the Lower Nubian and Upper Nubian assemblages grouping together. The Gabati samples are distinct from these two groups, except 3-J-23 which is positioned near GABM. The only temporal patterning is apparent in the earliest sites: the Pharaonic (PHA) sample dated to the New Kingdom period and Tombos (TOM) dated to the late New Kingdom and Third Intermediate Period (Buzon *et al.* 2016), which are placed closely together.

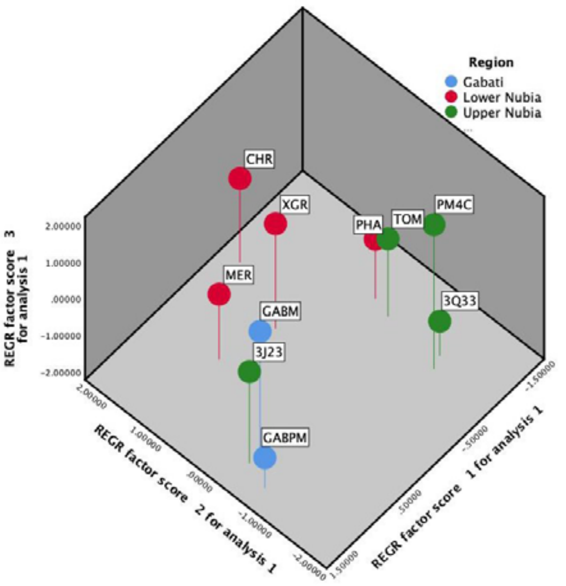

Figure 9. Multi-dimensional scaling of PCA results for Gabati and comparative samples. Three-letter sample abbreviations are defined in Figure 3.

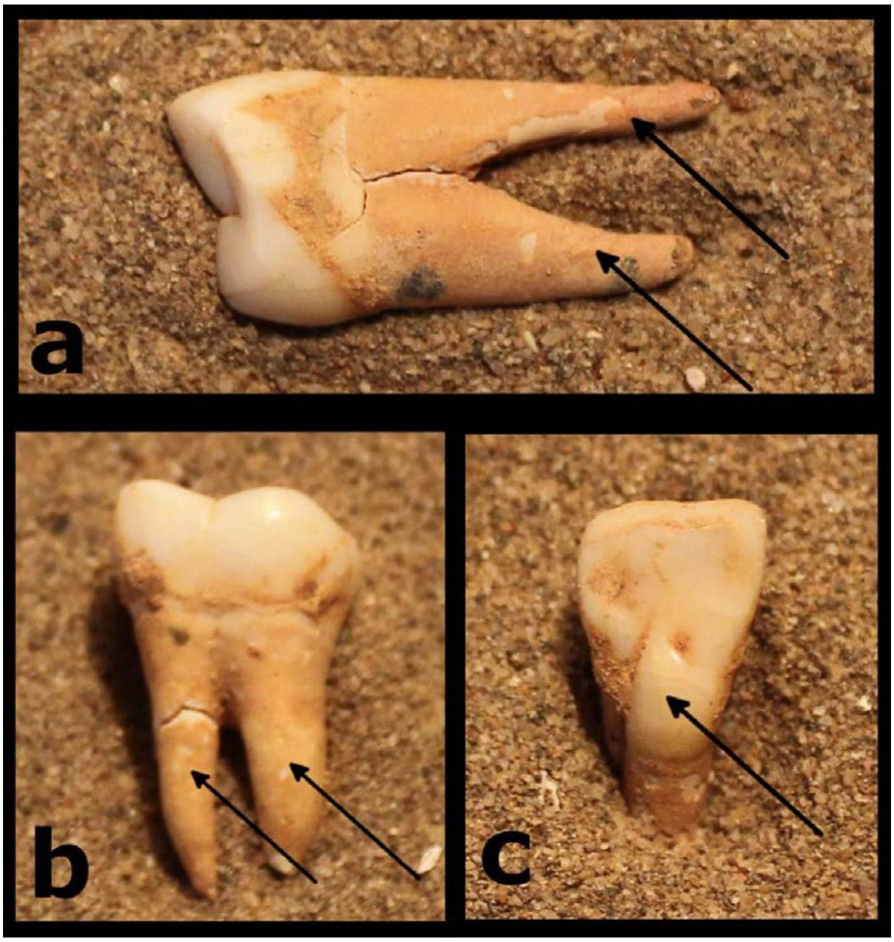

Figure 10. Examples of non-metric dental traits: a) Root number of upper 1st premolar; b) Root number of lower 2nd molar; c) Tuberculum dentale on upper 2nd incisor.

	Gabati Meroitic	Gabati post-Meroitic/medieval
3-Q-33	0.0645	0.0643
Meroitic	0.0466	**0.0880**
Pharaonic	**0.1311**	**0.1877**
Tombos	**0.1428**	**0.2222**
PM4C	**0.1019**	**0.1863**
X-Group	0.0330	**0.1386**
3-J-23	0.0263	**0.0812**
Christian	0.0731	**0.2032**
Gabati Meroitic	0.0000	0.0176
Gabati post-Meroitic/medieval	0.0176	0.0000

Significant values ($p \leq .025$) in bold.

Figure 11. 20-Trait Mean Measure of Divergence results.

Principal Component Analysis

Figure 5 was reviewed to identify traits with consistently low frequencies across all 10 samples. Traits removed at this stage were: odontome on the 1st and 2nd premolars, root number of the lower canine and root number of the lower 2nd molar. PCA was used to expose which of the remaining 33 traits are most important in driving inter-sample variation. The first four components are responsible for 70.1% of the total variance among samples. As such, any trait with a weighting of less than 0.5 across these components was removed. MDS was used to visually represent how the trait weightings over the first three components were distributed (Figure 9). Only the first three components (accounting for 60% of the variation) were used so that the MDS could be compared with the other scatterplots, with only three dimensions. In Figure 9, as with Figure 8, there is a general grouping of Upper Nubian and Lower Nubian samples, with the exceptions of 3-J-23, which is closer to the Gabati samples, and the Pharaonic (PHA) sample, which is nearer the Upper Nubian collections. Again, the Gabati samples are distinct from the others, except 3-J-23. The Gabati samples are separated along the z-axis, which applies to the 3rd component. Looking at the results from PCA weightings, it seems that higher frequencies of tuberculum dentale on the upper 2nd incisor, root number of the upper 1st premolar and root number of the lower 2nd molar caused these two samples to diverge (see Figure 10).

20-Trait MMD analysis

After editing, 20 traits remained and were subjected to MMD analysis (Figure 11). Details of which traits were removed can be found in Figure 5. The Meroitic Gabati sample is less divergent from the other collections, only yielding significant differences with the Tombos (TOM), Pharaonic (PHA) and post-Meroitic 4th Cataract (PM4C) assemblages. The Meroitic Gabati (GABM) sample shares the closest affinity to later Gabati (MMD, 0.0176), and is similar to 3-J-23 (0.0263). The Gabati post-Meroitic/medieval (GABPM) assemblage is slightly less distinct, now indicating a similarity with 3-Q-33 (MMD, 0.0643); however, it is still significantly different from the other seven samples. The MDS of the 20-trait MMD analysis is presented in Figure 12. Again, regional grouping can be observed. Upper Nubians are closer to the Gabati samples, mirroring the geographical relationship. The Lower Nubians are more closely grouped than the Upper Nubian assemblages. Temporal patterning is only visible for the earlier collections, Tombos (TOM) and Pharaonic (PHA). The MDS is a good fit for the 20 trait MMD values, with Kruskal's Stress Test 1 =

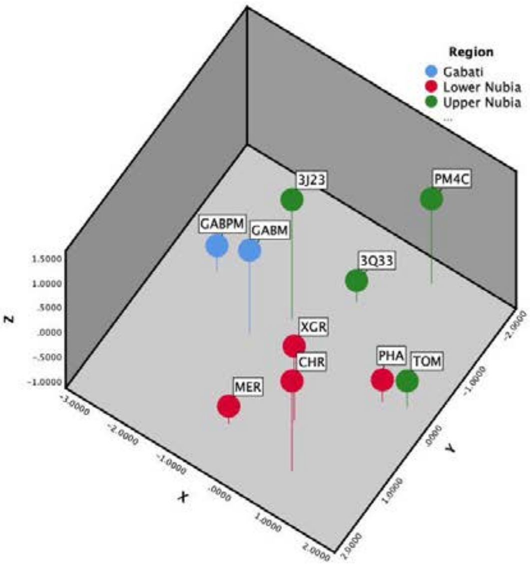

Figure 12. Multi-dimensional scaling of 20 Trait MMD results for Gabati and comparative samples. Three-letter sample abbreviations are defined in Table 1.

0.099 and $r^2 = 0.899$.

Discussion

Gabati is one of the largest Meroitic burial collections from below the 5th Cataract of the Nile, the heartland of the Meroitic empire (Edwards and Judd 2012, 75). Positioned so close to Meroe and as an example of non-elite burials, it has provided an important insight into this later phase of the Meroitic period. Additionally, the presence of later post-Meroitic and medieval burials offers a window into the transitional period following the hegemony of the Meroitic empire.

The data from Meroitic Gabati indicates that the pattern of regionality, seen in both Lower and Upper Nubia, could also be applicable to the area below the 5th Cataract. All three MDS plots (Figures 8, 9, and 12) show that the collections group by region, whereas temporal patterns are less evident. The two earliest samples, Pharaonic (PHA) and Tombos (TOM), are grouped together in both the 36- and 20-trait analysis. Both samples date to the New Kingdom and there is evidence that Egyptian immigrants or those with mixed Egyptian/Nubian heritage may have been present (Irish 2005; Buzon 2008; Buzon *et al.* 2016). The presence of Egyptians or those of mixed heritage in both the Pharaonic (PHA) and Tombos (TOM) samples may account for the phenetic similarities between the two collections, even though they are from different regions. In the 20-trait analysis Meroitic Gabati (GABM) is not significantly different from the other Meroitic collections, i.e., Meroitic (MER) and Site 3-Q-33 (3Q33), but has closer affinities to the others. This indicates that while there may have been some movement of people throughout Nubia during the Meroitic period, there is no evidence of mass migration or the repopulating of regions. The Meroitic period has been found to be much more variable than the Napatan period, both in burial practices and material culture (Edwards 2004, 141-181). It has been proposed that due to the varied nature of the different regions under control, the Meroitic state used local elites to control different areas. These groups would pay homage and taxes to Meroe (Edwards 2004, 164). As the empire expanded, the lands newly under control would have had existing populations and regional cultures. While the elites who controlled these areas may have adopted new Meroitic practices, they may not have been imposed in rural areas like Gabati. This could explain the variation seen in the material culture and dental data.

The observed regionality also extends to the post-Meroitic and medieval periods. Although the two Gabati samples are phenetically similar, the post-Meroitic/medieval sample is distinct from the other collections. This is mirrored in later Upper Nubian samples, post-Meroitic 4th Cataract (PM4C) and Site 3-J-23. It has been suggested that cultural changes after the fall of Meroe were due to the establishment of regional groups under the control of Meroe or people outside the empire moving into Nubia (Shinnie 1996, 324). This could be the reason why the post-Meroitic samples from Gabati (GABPM) and Upper Nubia are different from the others, indicating a new gene flow from outside Nubia. The medieval collection from Upper Nubia (Site 3-J-23) is very similar to the Meroitic Gabati sample, suggesting that people from the south moved into the 4th Cataract region during this period.

The two Gabati samples (GABM and GABPM) are not significantly different (p=0.025 alpha level) from each other in either the 36-Trait or 21-Trait MMD analysis. This suggests population continuity. As the assemblages come from the same cemetery any notable biodistance is interesting, potentially indicating outside gene flow. A previous biodistance study, based on craniometrics, found significant differences between the periods at Gabati (Vollner 2016, 103). Additionally, Vollner (2016, 130) found that Gabati had higher than average phenotypic variation, probably due to gene flow. However, it should be noted that this finding is based on treating the Gabati cemetery as a single assemblage. The post-Meroitic burial practice shows marked differences from the earlier graves, with the use of tumuli, single burials and evidence of ritual fires. There is also continuity from the Meroitic period, with the positioning and orientation of bodies similar in both periods (Edwards 1998, 207). The differences in burial practice coupled with the continuity observed could indicate that a new group moved into the area and co-habited with the existing population, creating new cultural practices. This could have added to the phenetic variation but not created a significant difference between the samples. Conversely, the cemetery may have fallen out of use for a period. The radiocarbon dates for the post-Meroitic are much later than the latest date for Meroitic graves (Edwards 1998). A study by Streetman (2018, 161) using cranial non-metric traits found the Gabati post-Meroitic/medieval assemblage to be homogenous, perhaps representing a familial group. Perhaps these later burials represented a smaller group that moved to the site in the post-Meroitic period. Due to phenetic similarities between the Gabati samples (36-trait MMD = 0.0329, 20-trait MMD = 0.0176), if the post-Meroitic inhabitants did represent a new group, then this group likely originated in the same region (i.e. below the 5th Cataract).

Alternatively, biodistance studies using metrics and non-metric traits have been shown to correlate to different parts of the genome, mitochondrial DNA and nuclear DNA respectively (Herrera *et al.* 2014; Hubbard *et al.* 2015; Irish *et al.* 2020). The conflicting results from the two studies (Vollner 2016; Streetman 2018) could be related to differences between the two aspects of the genome rather than a change in the population. This would be supported by the dental data as the biodistance between the samples was small and not significant.

Conclusion

The dental data from Gabati revealed that the area south of the 5th Cataract displays differences from other Nubian collections. These seem to be part of a wider pattern observed throughout Nubia, where collections are grouped by region rather than period. Comparable data has shown that this regional patterning continued into the post-Meroitic/medieval periods. The Gabati collection adds to the existing corpus of dental non-metric trait data collected throughout the Nile Valley and Africa. Furthermore, they contribute new insights into the genetic relationships of people from the heartland of the Meroitic kingdom. Hopefully as more data are collected from cemetery sites in the more southern reaches of Nubia, the genetic picture of this important region will become even clearer.

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