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# Reconstructing life histories from biological data: a comparative bioarchaeological study of excavated human skeletons from five sites in Ghana

Pearl Stephanie N.O. Lamptey

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# Reconstructing life histories from biological data: a comparative bioarchaeological study of excavated human skeletons from five sites in Ghana.

*La reconstitution des histoires de vie par les données biologiques : une  
étude bioarchéologique comparative de squelettes humains provenant de  
cinq sites au Ghana.*

## Thèse de doctorat de l'université Paris-Saclay

École doctorale n° 570, Ecole Doctorale de Santé Publique (EDSP)  
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Graduate School : Santé Publique. Référent : Faculté de médecine

Thèse préparée dans le LAAB (Université Paris-Saclay, UVSQ), sous la  
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**Thèse soutenue en visioconférence totale, le mardi 30 Mai 2023,  
par**

**Pearl Stephanie N. O. LAMPTEY**

## Composition du Jury

Membres du Jury avec voix délibérative

**Antoine BALZEAU**, Doctor, Directeur de Recherche, Maître de Conférence, HDR,  
Muséum National d'Histoire Naturelle (MNHN), Président.

**Wazi APOH**, Professeur, Dean of the School of Arts, University of Ghana, Rapporteur  
& Examineur.

**Ursula WITTEWER-BACKOFEN**, Professeure, Doctor, Albert-Ludwigs University,  
Freiburg, Rapporteur & Examinatrice.

**Raphael A. ALABI**, Professeur, University of Ibadan, Nigeria, Examineur.

**Barbara TEBMANN**, Professeure, Freie Universität Berlin, Berlin, Examinatrice.

université  
PARIS-SACLAY

ÉCOLE DOCTORALE  
Santé Publique  
(EDSP)



★ musée du quai Branly  
LA OÙ DIALOGUENT LES CULTURES



**UNIVERSITY OF GHANA**  
DEPARTMENT OF ARCHAEOLOGY AND HERITAGE STUDIES



## **DEDICATION**

I dedicate this dissertation to God and my siblings. To my siblings, I hope this achievement inspires you to greater heights.

**Titre :** *La reconstitution des histoires de vie par les données biologiques: une étude bioarchéologique comparative de squelettes humains provenant de cinq sites au Ghana.*

**Mots clés :** **Bioarchéologie, Anthropologie biologique, Ostéobiographie, Modes d'alimentation, Paléopathologie, Modes de vie passés, Ghana.**

**Résumé:** Les archéologues cherchent à reconstituer les modes de vie des populations passées à l'aide de vestiges matériels, c'est-à-dire d'artefacts, d'écofacts et d'éléments. Mais qui raconte mieux votre histoire que vous-même ? Les spécimens biologiques ou biofacts (os et dents humains) peuvent révéler des aspects précieux de la vie humaine. Ainsi, à partir du squelette humain, l'histoire de la vie des "anciens" peut être reconstituée pour permettre de comprendre/appréécier les facettes des modes de vie passés, notamment la culture de la population, la diététique, l'environnement naturel et bâti, les préoccupations en matière de santé individuelle et publique, et les activités. Cette recherche s'appuie sur les concepts d'ostéobiographie, d'anthropologie biologique, de bioarchéologie et d'archéothanatologie. Bien que l'anthropologie biologique et la bioarchéologie soient largement appréciées pour leurs précieuses reconstitutions des modes de vie passés, la recherche sur les spécimens biologiques est assez limitée dans l'archéologie ghanéenne. Néanmoins, il existe peu d'études sur les restes humains dans la sous-région.

Cette thèse porte sur l'inventaire et l'examen comparatif des restes de squelettes humains (conservés au Musée d'archéologie depuis les 20<sup>e</sup> et 21<sup>e</sup> siècles) provenant de Sekondi, Begho, Ntereso, Yapei et Yikpabongo dans les régions de l'Ouest, du Bono, de la Savane et du Nord-Est du Ghana. Pour atteindre les objectifs de réhumanisation des restes humains et de reconstitution de la santé, de l'état alimentaire et de la paléo-activité des individus, la recherche a utilisé des méthodes anthropologiques métriques et non métriques en plus de la recherche ethnographique, de la parasitologie, de la tomographie assistée par ordinateur, de l'analyse par fluorescence X, de la datation par le radiocarbone, de l'analyse des isotopes stables et de la photographie.

Cette étude bioarchéologique impliquant la paléopathologie a révélé l'ostéobiographie de 25 individus (sexe, âge, pathologie et traumatisme) et a permis la reconstruction comparative inter- et intra-géographique des aspects sanitaires, du comportement alimentaire et de l'activité (paléo) des individus. Les restes humains (biofacts) étaient des voix actives et des indicateurs fiables de l'histoire de la vie intra-vitam des anciens individus. Ainsi, les perspectives de recherche complètent invariablement les récits des sites historiques et la compréhension des modes de vie passés pour expliquer ou compléter le présent.

**Title:** *Reconstructing life histories from biological data: a comparative bioarchaeological study of excavated human skeletons from five sites in Ghana.*

**Keywords:** **Bioarchaeology, Biological anthropology, Osteobiography, Dietary patterns, Paleopathology, Past lifeways, Ghana.**

**Abstract:** Archaeologists seek to reconstruct the lifeways of past populations through material remains, i.e., artifacts, ecofacts, and features. But who tells your story better than yourself? Biological specimens or biofacts (human bones and teeth) can reveal valuable aspects of human life. Thus, from the human skeleton, the life histories of the 'once alive' can be reconstructed to permit the understanding/appreciation of facets of past lifeways including population culture, dietetics, the natural and built environment, individual/ public health concerns, and activities. This research is substrated by the concepts of osteobiography, biological anthropology, bioarchaeology, and archaeothanatology. Although biological anthropology and bioarchaeology are widely esteemed for their valuable reconstructions of past lifeways, research on biological specimens is quite limited in Ghanaian archaeology. Nevertheless, there are few studies on human remains within the sub-region.

This thesis focused on the inventory and comparative examination of human skeletal remains (preserved in the Museum of Archaeology since the 20<sup>th</sup> & 21<sup>st</sup> centuries) from Sekondi, Begho, Ntereso, Yapei, and Yikpabongo across Ghana's Western, Bono, Savannah, and North-East Regions. To achieve the objectives of rehumanizing the human remains and reconstructing the health, alimentation status, and paleo-activity of the individuals, the research employed metric and non-metric anthropological methods in addition to ethnographic research, parasitology, computed tomography, x-ray fluorescence analysis, radiocarbon dating, stable isotope analysis, and photography.

This bioarchaeological study involving paleopathology revealed the osteobiography of 25 individuals (sex, age, pathology, and trauma) and aided the comparative inter- and intra-geographical reconstruction of the individuals' health aspects, dietary behavior, and (paleo) activity. The human remains (biofacts) were active voices and reliable indicators of the intra-vitam life histories of the ancient individuals. Thus, the research perspectives invariably complement the historical sites' narratives and the understanding of past lifeways to explain or complement the present.

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Praise the Lord my strength, who trains my hands for war and gives my fingers skill for battle.

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## LIST OF SCIENTIFIC PUBLICATIONS

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2. Bourdin, V., Lamptey, P. S. N. O., Mulier, G., Poupon, J., & Charlier, P. (2022). [Interest and limitations of a lead, cadmium, and arsenic leachability study to estimate the toxicity of ancient ceramics \(Ecuador & Ghana\). \*Ethics, Medicine and Public Health\*, 25, 100852.](#)
3. Lamptey, P. S. N. O. (2022). [Museums and Skeletons: prospects and challenges of cataloguing, storing and preserving human remains in the Museum of Archaeology, Ghana. \*Ethics, Medicine, and Public Health\*, 21, 100753.](#)

### *Under Review:*

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5. Lamptey, Pearl Stephanie N. O. & Charlier, Philippe (2023). Cross-regional assessment of dental pathologies: evidence for predicting oral health and stress among past Ghanaian populations.

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## SUMMARY

One of the main goals of archaeology as a science is to reconstruct the lifeways of past populations through material remains i.e., artifacts, ecofacts, and features. But who tells your story better than yourself? Biological specimens or biofacts (human bones and teeth) can reveal valuable aspects of human life. This research is substrated by the concepts of osteobiography, biological anthropology, bioarchaeology, and archaeoethanatology. Thus, from the skeleton, the life histories of the 'once alive' can be reconstructed to permit the understanding of facets of past lifeways including population culture, dietetics, the natural and built environment, individual/ public health concerns, and activities across borders. While such valued interpretations and reconstructions for understanding past lifeways are widely appreciated, skeletal analysis or bioanthropological research is quite limited in the context of Ghanaian archaeology.

Over the years, within the Ghanaian archaeological practice of interpreting and reconstructing the archaeological record, the intrinsic potential of human remains to provide or complement (with in-depth & objective data) the history of past populations has been minimally explored. Nevertheless, a few studies on human remains within the sub-region exist. Other times, besides taking photographic records and salvaging some of the remains (which end up in the storage of the Museum of Archaeology, University of Ghana), the rest are reinterred without further studies. This subtly compromises the holistic understanding of the osteobiographies and lifeways of ancient populations.

This thesis focused on the inventory and comparative examination of human skeletal remains from five sites in Ghana. This is based on the recognition that human skeletal remains are well-preserved reliable indicators and sources of intra-vitam life histories of past populations. The skeletal remains have been stored in the Museum of Archaeology since the 20<sup>th</sup> and 21<sup>st</sup> centuries having been excavated from the historical sites of Sekondi, Begho, Ntereso, Yapei, and Yikpabongo across Ghana's Western, Bono, and Northern regions.

The mixed research approach used involved literary studies to review pre-existing data: the Google Scholar Database and the library resources at the Department of Archaeology and Heritage Studies-Ghana, and the Quai Branly Museums' Media Library- Paris were consulted for materials for the literature search. The search focused on relevant themes in books and journal articles (1900-2022), including: "bioarchaeology", "biological anthropology", "standards of human skeletal analyses", "osteobiography", "paleopathology", "skeletal & dental pathologies", "the history of Ghana", "the history of study regions, and sites: Begho, Ntereso, Sekondi, Yapei, and Yikpabongo", "archaeoethanatology", "behavior/activity from human skeletons", "human skeletons and paleo-diet", and "dental pathologies and paleo-diet". For analytical methods, the search was made for articles on stable isotope analysis, x-ray fluorescence analysis, and computed tomography.

Additionally, the research employed metric and non-metric anthropological methods for the osteobiography of the individuals (sex, age, pathology, and trauma). Moreover, for a holistic overview, chronology, understanding, and documentation of the individuals' dietary, behavioral/ activity, and health aspects from the different geographical units, ethnographic research, parasitology, computed tomography, x-ray fluorescence analysis, radiocarbon dating, and stable isotope analysis were conducted. Photography was also used to document some recent community activities and the laboratory study of the human remains.

The research objectives were first to humanize the skeletal remains by assessing the minimum number of individuals (MNIs) and to biologically profile their osteobiographies through anthropometric and non-metric methods. The analysis revealed an MNI of 25 individuals: 14 (Sekondo), 4 (Begho), 2 (Ntereso), 4 (Yapei), & 1 (Yikpabongo). These individuals presented significant skeletal (40%) pathologies, including porotic hyperostosis, thalassemia, Brucella spondylitis, sinus inflammation, spina bifida occulta, head lice infestation, hypodontia, myositis ossificans, negative enthesopathy, and Allen fossa. Dental pathologies (60%) were caries, calculus, enamel hypoplasia, abscess, and hypercementosis. These pathologies provided a glimpse into the general health and oral hygiene of the past populations.

Furthermore, the parasitology of intracranial soil of some individuals showed no parasites, only vegetal structures, and computed tomographic examination illuminated the soil matrix in the endocranial cavity. Although no calcified tissues or carcinomas were recorded, the scans showed low-density blotches representing fat or decomposed organic materials. The radiocarbon date of mid-18th –early-19th century BC for a Yapei individual provided the site's relative date and chronology for cultural provenance by association.

Secondly, to provide a cross-regional reconstruction of past populations' nutrition/alimentation status and public health concerns. The dental pathologies shed light on the intra-vitam alimentation status of the individuals (calculus and caries are proxies of a carbohydrate-rich diet and high cereal/grain and legume content). This dietary pattern was partly confirmed by  $\delta^{13}\text{C}$  &  $\delta^{15}\text{N}$  values of -10.5‰ and 8.8‰, respectively, depicting a mixed orientation to  $\text{C}_4$  plants such as maize, millet, groundnut, and beans with riverine resources (fish), and terrestrial animal protein. Stable isotopes, thus, facilitated the reconstruction of the food sources ( $\text{C}_4$  plants, riverine, and terrestrial resources) of at least the Yapei and Sekondi (by inference) populations, even though the Sekondi inhabitants will substitute the riverine resources with marine. However, within Ghana, food resources are spread abroad along the trajectory of the various markets such that inhabitants away from the seas, lakes, and rivers can still get access to and enjoy the resources the marine/riverine sources provide.

Moreover, the significant dental wear among the individuals was associated with masticatory and non-masticatory functions. Masticatory functions probably involved the consumption of diets with abrasive substances like sand particles and the hypertrophy and gradual erosion of teeth with age. The non-masticatory engagement of the teeth was related to using the teeth as a 3<sup>rd</sup> hand in industrial and communal activities such as basketry and leatherwork. Additionally, the x-ray fluorescence analysis of calculus samples from the Begho individuals revealed a classical dietary composition of calcified aluminum silicate and no exposure of the two Begho individuals to industrial pollutants such as lead, mercury, antimony, arsenic, and chromium. The analysis enabled the reconstruction of the past alimentation status and public

health concerns of the two Begho individuals.

Lastly, the study sought to reconstruct the activity patterns of these ancient populations through activity-related skeletal lesions/markers and enthesal changes. The activity-related lesions and enthesal changes evident among the individuals included osteophyte formations, pits, bony spurs or exostoses, depressions on the bone, depletion of the compact bone, and distinct exposure of the spongy bone. The skeletons revealed the impact of activities such as farming, long hours of sitting, baby 'backing', acrobatics, dance movements, and squatting (involving extreme hyperflexion of the hip and knee). The effects are local and systemic osteoarthritis, hyper-vascularization at the joints or articular surfaces, muscle sprains, and detachments. For instance, negative enthesopathy on the left humerus at the level of the elbow projects that the individual (Begho, BG'21-E, 73.115) was either left-handed or involved in an activity that favored its extensive use and the probable atrophy of the right hand.

In sum, the skeletal analysis with the integrated methods enabled an insightful glean and reconstruction of the bio-histories/osteobiographies, past environment, and the alimentation status of the past populations. Paleopathology was a viable tool for reconstructing the health and activities (paleo-activities) of the individuals from the dental/skeletal pathologies and activity-related lesions. The x-ray fluorescence and stable isotope analyses illuminated the dietary patterns of the ancient populations and supported the contemporary orientation across the regions. Human skeletons are indeed active voices of the past of the individuals they represented, not static objects. The research perspectives invariably complement the interpretive contexts of the sites' historical narratives and understandings of past lifeways. Moreover, the study provides a comparative reference for future archaeological and epidemiological studies within the Ghanaian sub-region, Africa, and beyond.

## SOMMAIRE

L'un des principaux objectifs de l'archéologie en tant que science est de reconstituer les modes de vie des populations passées à l'aide de vestiges matériels, c'est-à-dire d'artefacts, d'écofacts et d'éléments. Mais qui raconte mieux votre histoire que vous-même ? Les spécimens biologiques ou biofacts (os et dents humains) peuvent révéler des aspects précieux de la vie humaine. Cette recherche s'appuie sur les concepts d'ostéobiographie, d'anthropologie biologique, de bioarchéologie et d'archéothanatologie. Ainsi, à partir du squelette, l'histoire de la vie des "anciens" peut être reconstituée pour permettre de comprendre les facettes des modes de vie passés, notamment la culture des populations, la diététique, l'environnement naturel et bâti, les préoccupations en matière de santé individuelle et publique, et les activités transfrontalières. Bien que ces interprétations et reconstructions permettant de comprendre les modes de vie passés soient largement appréciées, l'analyse des squelettes ou la recherche bioanthropologique sont assez limitées dans le contexte de l'archéologie ghanéenne.

Au fil des ans, dans le cadre de la pratique archéologique ghanéenne d'interprétation et de reconstitution des archives archéologiques, le potentiel intrinsèque des restes humains pour fournir ou compléter (avec des données approfondies et objectives) l'histoire des populations passées n'a été que très peu exploré. Néanmoins, il existe quelques études sur les restes humains dans la sous-région. D'autres fois, en plus de prendre des photos et de récupérer certains restes (qui finissent dans les réserves du musée d'archéologie de l'université du Ghana), le reste est réintroduit sans études supplémentaires. Cela compromet subtilement la compréhension holistique des ostéobiographies et des modes de vie des populations anciennes.

Cette thèse s'est concentrée sur l'inventaire et l'examen comparatif des restes de squelettes humains provenant de cinq sites au Ghana. Ceci est basé sur la reconnaissance du fait que les restes de squelettes humains sont des indicateurs fiables et bien conservés et des sources d'histoires de vie intra-vitam des populations passées. Les restes squelettiques sont

conservés au musée d'archéologie depuis les 20e et 21e siècles et ont été excavés des sites historiques de Sekondi, Begho, Ntereso, Yapei et Yikpabongo dans les régions ouest, bono et nord du Ghana.

L'approche de recherche mixte utilisée a fait appel à des études littéraires pour examiner les données préexistantes : la base de données Google Scholar et les ressources de la bibliothèque du département d'archéologie et d'études patrimoniales du Ghana et de la médiathèque du musée du Quai Branly à Paris ont été consultées pour obtenir des documents pour la recherche de littérature. La recherche s'est concentrée sur des thèmes pertinents dans des livres et des articles de journaux (1900-2022), y compris : "bioarchéologie", "anthropologie biologique", "normes d'analyse des squelettes humains", "ostéobiographie", "paléopathologie", "pathologies squelettiques et dentaires", "histoire du Ghana", "histoire des régions étudiées" et des sites : Begho, Ntereso, Sekondi, Yapei et Yikpabongo", "archéothanatologie", "comportement/activité des squelettes humains", "squelettes humains et paléodietétique" et "pathologies dentaires et paléodietétique". Pour les méthodes analytiques, la recherche a porté sur des articles concernant l'analyse des isotopes stables, l'analyse par fluorescence des rayons X et la tomographie assistée par ordinateur.

En outre, la recherche a utilisé des méthodes anthropologiques métriques et non métriques pour l'ostéobiographie des individus (sexe, âge, pathologie et traumatisme). En outre, pour obtenir une vue d'ensemble, une chronologie, une compréhension et une documentation des aspects alimentaires, comportementaux/actifs et sanitaires des individus dans les différentes unités géographiques, des recherches ethnographiques, la parasitologie, la tomographie assistée par ordinateur, l'analyse par fluorescence X, la datation au radiocarbone et l'analyse des isotopes stables ont été menées. La photographie a également été utilisée pour documenter certaines activités communautaires récentes et l'étude en laboratoire des restes humains.

Les objectifs de la recherche étaient tout d'abord d'humaniser les restes squelettiques en évaluant le nombre minimum d'individus (MNI) et d'établir le profil biologique de leurs

ostéobiographies par des méthodes anthropométriques et non métriques. L'analyse a révélé un MNI de 25 individus : 14 (Sekondo), 4 (Begho), 2 (Ntereso), 4 (Yapei), & 1 (Yikpabongo). Ces individus présentaient des pathologies squelettiques significatives (40%), dont l'hyperostose porotique, la thalassémie, la spondylarthrite à Brucella, l'inflammation des sinus, le spina bifida occulta, l'infestation par les poux, l'hypodontie, la myositis ossificans, l'enthésopathie négative et la fosse d'Allen. Les pathologies dentaires (60 %) étaient les suivantes : caries, tartre, hypoplasie de l'émail, abcès et hypercementose. Ces pathologies ont donné un aperçu de l'état de santé général et de l'hygiène bucco-dentaire des populations du passé. En outre, la parasitologie du sol intracrânien de certains individus n'a révélé aucun parasite, seulement des structures végétales, et l'examen tomодensitométrique a mis en évidence la matrice du sol dans la cavité endocrânienne. Bien qu'aucun tissu calcifié ou carcinome n'ait été enregistré, les scanners ont montré des taches de faible densité représentant de la graisse ou des matières organiques décomposées. La date radiocarbone du milieu du 18e siècle - début du 19e siècle avant J.-C. pour un individu Yapei a fourni la date relative du site et la chronologie pour la provenance culturelle par association.

Deuxièmement, il s'agit d'une reconstruction interrégionale de l'état nutritionnel des populations du passé et des problèmes de santé publique. Les pathologies dentaires mettent en lumière le statut alimentaire intra-vitam des individus (le tartre et les caries sont des indices d'un régime riche en hydrates de carbone et d'une teneur élevée en céréales/grains et légumineuses). Ce modèle alimentaire a été partiellement confirmé par les valeurs  $\delta^{13}\text{C}$  et  $\delta^{15}\text{N}$  de  $-10,5\text{‰}$  et  $8,8\text{‰}$ , respectivement, décrivant une orientation mixte vers les plantes C4 telles que le maïs, le millet, l'arachide et les haricots avec des ressources fluviales (poisson), et des protéines animales terrestres. Les isotopes stables ont donc facilité la reconstitution des sources alimentaires (plantes en C4, ressources fluviales et terrestres) au moins des populations Yapei et Sekondi (par déduction), même si les habitants de Sekondi remplaceront les ressources fluviales par des ressources marines. Cependant, au Ghana, les ressources alimentaires sont réparties à l'étranger le long de la trajectoire des différents marchés, de sorte que les habitants éloignés des mers, des lacs et des rivières peuvent

toujours avoir accès aux ressources fournies par les sources marines/fluviales et en profiter.

De plus, l'usure dentaire importante chez les individus était associée aux fonctions masticatoires et non masticatoires. Les fonctions masticatoires impliquent probablement la consommation de régimes alimentaires contenant des substances abrasives telles que des particules de sable, ainsi que l'hypertrophie et l'érosion progressive des dents avec l'âge. L'engagement non masticatoire des dents est lié à l'utilisation des dents comme troisième main dans des activités industrielles et communautaires telles que la vannerie et le travail du cuir. En outre, l'analyse par fluorescence X des échantillons de tartre des individus Begho a révélé une composition alimentaire classique de silicate d'aluminium calcifié et l'absence d'exposition des deux individus Begho à des polluants industriels tels que le plomb, le mercure, l'antimoine, l'arsenic et le chrome. L'analyse a permis de reconstituer l'état alimentaire passé et les préoccupations de santé publique des deux individus Begho.

Enfin, l'étude a cherché à reconstituer les schémas d'activité de ces populations anciennes par le biais de lésions/marqueurs squelettiques liés à l'activité et de modifications enthésiennes. Les lésions liées à l'activité et les changements enthésiens évidents chez les individus comprenaient des formations d'ostéophytes, des fosses, des éperons osseux ou des exostoses, des dépressions sur l'os, un appauvrissement de l'os compact et une exposition distincte de l'os spongieux. Les squelettes ont révélé l'impact d'activités telles que l'agriculture, les longues heures passées en position assise, l'accouplement, les acrobaties, les mouvements de danse et la position accroupie (impliquant une hyperflexion extrême de la hanche et du genou). Les effets sont l'arthrose locale et systémique, l'hyper-vascularisation au niveau des articulations ou des surfaces articulaires, les entorses musculaires et les décollements. Par exemple, l'enthésopathie négative sur l'humérus gauche au niveau du coude projette que l'individu (Begho, BG'21-E, 73.115) était soit gaucher, soit impliqué dans une activité qui favorisait son usage intensif et l'atrophie probable de la main droite.

En résumé, l'analyse du squelette à l'aide des méthodes intégrées a permis de glaner et de reconstruire les bio-histoires/ostéobiographies, l'environnement passé et le statut



alimentaire des populations passées. La paléopathologie s'est avérée un outil viable pour reconstruire la santé et les activités (paléo-activités) des individus à partir des pathologies dentaires/squelettiques et des lésions liées à l'activité. Les analyses par fluorescence des rayons X et par isotopes stables ont mis en lumière les habitudes alimentaires des populations anciennes et confirmé l'orientation contemporaine dans les différentes régions. Les squelettes humains sont en effet des voix actives du passé des individus qu'ils représentent, et non des objets statiques. Les perspectives de recherche complètent invariablement les contextes d'interprétation des récits historiques des sites et la compréhension des modes de vie passés. En outre, l'étude fournit une référence comparative pour de futures études archéologiques et épidémiologiques dans la sous-région ghanéenne, en Afrique et au-delà.

# 1 GENERAL INTRODUCTION

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## 1.1 ORGANIZATION OF SECTIONS

The thesis comprises five sections: a general introduction, parts I, II & III, and conclusions & perspectives. Part I has four chapters, and parts II & III have two subdivisions. The general introduction section provides an overview of the research. It presents the research problem, aim and objectives, and some principal questions that belie the research. Also, the section provides some data (geography and socio-economic life) on the study region-Ghana. Part I of the thesis presents the provenance research on the remains from the five sites and aspects of the disciplines of archaeology and archaeoethnology in Ghana. Part II offers a comprehensive examination and reconstruction of the health and alimentary status of the past populations, and part III addresses the cross-regional reconstruction of the pattern of (paleo) activity of the individuals, in addition to snippets of contemporary activities across sites. The thesis closes with a conclusion and the way forward (the fate of the human remains).

## 1.2 OVERVIEW

The science of archaeology involves the investigation into past lives or lifeways by inferring ideology, the social, religious, and political organization, as well as the environment and behavior/activity "from the context and patterns of material remains" (Sutton, 2020a, p. 1) to reconstruct these lifeways. Such reconstructions often lead to a holistic comprehension and appreciation of the history of past and present populations while addressing community, regional and global issues. Material relics and biological remains (human and animal) are indicative of human existence and occupation, and the "very presence of human remains affects archaeological interpretations" (Stutz, 2018, p. 324) as essential elements in archaeological studies (Sutton, 2020b). This is because

biofacts (in the context of this study, human bones and teeth) serve as direct hard tissue evidence or sources from which valuable information on the intra-vitam quality of life, including culture, health, and activity of past populations, can be gleaned (Buikstra & Bolhofner, 2019). Compared to other biological remains, bones, and teeth are well preserved in the archaeological record and their interpretive potential in correlation to their relationship with other material cultural and biological remains is enormous. The term 'biofacts' is hereafter discussed in relation to human skeletal remains and their inherent characteristic as 'eyes to the past'. This unique feature belies the term bioarchaeology which is the study of human biological remains within their cultural (archaeological) context (Larsen, 2015, p. 3).

The proponents of bioarchaeology propose the centrality of human remains within proper contexts in the research on human variations, conditions, and adaptations. Skeletal remains are objective complements to other sources of data since they reveal aspects of human life/behavior, adaptation to the environment, and social systems not explicit in the archaeological, historical, and ethnographic accounts (Larsen, 2015). As a subfield of archaeology, bioarchaeological studies move from the norm of archaeological research and descriptive parameters to an integrated interpretive framework that inquires into issues ranging from past identities, health/ pathology, diet, social organization, and biological and cultural variations (Buikstra & Bolhofner, 2019; Larsen, 2002, 2012, 2015; Mays, 2010; Pettitt et al., 2006). Also, lifestyles, i.e., behavioral patterns or activities and adaptations to the natural and built environment in the quest to address questions of anthropological origin (human existence, adaptations, and livelihoods). Bioarchaeology takes its root from Graham Clark's reference to zooarchaeology, as the study of animal bones from archaeological sites (Clark, 1972). This was later refined in definition by Jane Buikstra to include the scientific study of all or a subset of biological remains: humans, plants, and animals (Buikstra, 1977) through explicit bio-cultural approximations (Tiesler, 2013, p. 14).

Thus, skeletal analysis is pertinent for the understanding of 'people'. Like Tiesler (2013), other schools of thought stress the engagement of a series of theoretical and methodological concepts such as 'biosocial archaeology' for skeletal analysis. The contextualization and centralization of skeletal remains as fundamental parts of the archaeological discipline (Buikstra, 2019; Larsen, 2002, 2015; Tiesler, 2007, pp. 31–40). Moreover, Martin et al. (2013) emphasize the importance of contextual information within the interpretive framework of skeletal analysis. The archaeological record is the secondary or tertiary setting of buried human remains, and this setting is impregnated with explicit information (and other archaeological finds) meaningful to social phenomena, lifeways, skeletal analysis, interpretations, and reconstructions (Beaudry et al., 1996). Within the discipline of bioarchaeology is the archaeothanatological component zooming into the socio-cultural dimensions of handling & interring the dead (orientation & grave goods), and cultural sensitivities or perceptions of death.

The explicit data presented in the context of the archaeological record must be documented appropriately because the context could be lost once the record is disturbed. However, the context of archaeological specimens extends beyond the archaeological record to include other inferred and documented data on socio-economic dynamics, environmental settings, dietary patterns, cultural and biological variations, time frame, and other conditions that substrated life, survival, and identity (Larsen, 2015, p. 3). All these life aspects fitly combine to unravel the materiality and plasticity of the remains for a better understanding of the life course. Larsen (2002, 2012, 2015) also notes that determining the relationship between biology and behavior/lifeways is central to bioarchaeological studies. It involves exposing/infering the evidence of life from the biological tissues of the people who intentionally or unintentionally interacted within and with varied aspects of the bio-cultural environment (Buikstra, 2019b, p. 164) spacio-temporally. Therefore, the dichotomy between the 'bio-behavior' relationship depends on the individual agents in the interaction chain in diverse environments built by

individualistic & collectivist ideologies, preferences, and systems. These factors must be appreciated in recounting the life histories of the individuals the skeletal remains belong.

After exhumation, it is ethically allowed for cautious scientific analysis to begin for the reconstruction of past lifeways in light of appreciating the scientific values of human remains (Walker, 2000). However, due to religious, community, or descendant sensitivities surrounding skeletal analysis or (mis)handling the dead, there must be a mutual understanding or a rational commonality between the scientific, religious, and social towards addressing conflicting values (Department for Culture, Media and Sport, 2005; Walker, 2000). In this ambit, the multifaceted nature of bioarchaeology is amplified in combination with theories pinched from the social sciences and humanities (Buikstra, 2019) to aid the life course narrative on past & present populations.

This study principally hinged on the life course theory. This theory is based on the principle that the biological and the cultural are intertwined. Although the former precedes the latter, culture or cultural orientation shapes and can alter the biological makeup/ component of humans. Inversely, the biological can dictate one's cultural selection and behavior. Within this thesis, the assessment & characterization of individual and regional variabilities (case studies): osteobiographies, paleopathological examinations, behavior, and lifestyles, including dietary patterns, were considered in line with the population perspective/ approach to understanding the human condition (Larsen, 2015). Within this approach, biological, environmental, and cultural diversities were not placed as rigid/ static proxies for explaining the presence or absence of patterns, but as contributing agents to patterns: the expression (in acute or severe degrees) of patterns/ practices, and effects on and among the individuals. I do not, in any case, present the human remains as the sole material memories of the past, but as indispensable tools to buttress the historical, ethnographical, and (archaeological) material cultural remains to elucidate the human condition and past lifeways.

Furthermore, the concept of context (skeletal provenance, site histories, and emic perspectives) guided discussions on life histories.

### **1.2.1 Statement of Research Problem**

The conduct of standard or adequate on-site and laboratory analyses of human skeletal remains chanced on during fieldwork or exhumed in Ghanaian archaeological contexts is narrowed by two obstacles yet to be overcome. On the one hand is limited expertise in the disciplines of bioarchaeology, biological, and forensic anthropology. As a result, besides taking photographic records and salvaging some of the remains, the rest of the human remains are often reinterred without further studies. The salvaged remains end up in the storage of the Museum of Archaeology- Department of Archaeology and Heritage Studies (DAHS)- University of Ghana. Moreover, in the event of reinternment, the on-site analyses or classifications are restricted to superficial age and sex determinations and recording of the presence (including the richness) or absence of grave goods. On the other hand, funding for comprehensive bioarchaeological and skeletal analyses is lacking. This has been a handicap to the systematic study of excavated human remains in Ghana.

The human remains were brought in by early and contemporary pioneers of archaeology in Ghana from various sites such as Begho (1970), Sekondi (1954), Yikpabongo (2007), Tando, Yapei (1970), Ntereso (1960), Rim, and Bantama. While analyses of their associated artifacts (for example, potsherds/ ceramics, figurines, beads, and smoking pipes) have long been done and scientific papers published, the analyses of these human remains have stalled. The delayed analyses of the human skeletal remains have created a void in our understanding of the bio-histories (age, sex, and stature), bio-variants of the individuals, and the life histories of the ancient populations, including complementing data on past nutrition (dietetics), insights into paleopathology, public health concerns, and activity.

Even with what is known from pottery/ceramics, and historical & ethnographic accounts from the excavated sites, skeletal remains could offer more on the human condition and lifeways, and sometimes what is unavailable in the above material sources. Although some examinations of human skeletal remains in Ghana have been undertaken (Asare, 2018; Lamptey, 2019; Renschler & DeCorse, 2016; Schaffer & Agorsah, 2010), there remain gaps in the Ghanaian literature and the (non-inclusive) data at the disposal of archaeologists pertaining to in-depth human skeletal analysis (osteobiographies and comprehensive pathological examinations). In effect, studies on and evidence of human biological variation, gendered activity-related changes, paleopathology, paleo-demography, population movement through space and time, and dietetics from the human skeletons within the Ghanaian region are limited.

The few physical examinations done on human skeletal remains in Ghana rely on standard descriptions and measurements generated based on skeletal samples from other parts of the world. Thus, comprehensive bio-archaeological and anthropological analyses of human skeletons to create a database on anthropometric and non-metric skeletal variations and paleopathological examinations are lacking. The provision of analytical parameters for skeletal samples within the West African region is long overdue. The database could be a step in the right direction to help classify human skeletons from this part of the world. The development of expertise and ample funds at the disposal of archaeologists will bolster the comprehensive examination of human skeletal remains from excavated sites and crime scene forensic investigations involving human remains and repatriation issues.

My observation from interacting with the human remains from the Begho site in 2018 revealed that apart from the remains becoming more fragile by the years, the documented provenience information attached is gradually being lost. A timely approach like this thesis research was necessary to salvage as much information as possible from the biofacts and what is left of the associated written information. It is expedient that site histories and

contextual interpretations based on artifacts be complemented by sophisticated and objective analyses of biofacts (where available) in addition to ethnographic analogies, typology, and use-wear analysis. Hence, the focus of this thesis was to meticulously engage bioarchaeological and anthropological approaches to 'squeeze out the juice' of information in the human remains to complement the known and reveal the unknown past lifeways of the Sekondi, Begho, Ntereso, Yapei, and Yikpabongo sites.

### **1.2.2 Aim of Study**

This research sought to glean and reconstruct the bio-histories, paleo-environment, and past nutrition/ alimentation status of the past populations (excavated from Begho, Ntereso, Sekondi, Yapei, and Yikpabongo) comparatively. As well as to reconstruct/predict the health and paleo-activities of the individuals represented in the skeletal sample.

### **1.2.3 Significance of the Study**

The research findings and perspectives would complement the interpretive contexts of the sites' historical narratives, material culture, and understandings of past lifeways. The research will also serve as a reference database for skeletal analysis within the Ghanaian and West African regions.

### **1.2.4 Research Objectives**

The key objectives driving the research include the following:

1. To conduct a provenance study (assessing the minimum number of individuals (MNIs) and profiling biological characteristics) on the skeletal remains in storage.
2. To document the cultural and environmental contexts from which the human remains came.
3. To record and assess skeletal pathologies for the interpretation of the general health of the individuals.



4. To record and examine dental pathologies to determine oral health and stress among the individuals across sites.
5. To provide a cross-sectional reconstruction of the individuals' alimentation status and public health concerns.
6. To reconstruct the paleo-activities of these ancient individuals through activity-related skeletal markers and enthesal changes.

### **1.2.5 Research Tools and Methodology**

This study employed the mixed research approach by integrating the quantitative and qualitative research methods in interrogating biological and non-biological data. The approach involved the tools of literary studies to review pre-existing data. Such literary materials were sourced from the Google Scholar Database, library resources at the Department of Archaeology and Heritage Studies-Ghana, and the Quai Branly Museums' Media Library- Paris. Relevant books and journal articles published (1900-2022) on varied platforms on "bioarchaeology", "biological anthropology", "standards of human skeletal analyses", "osteobiography", "paleopathology", "skeletal & dental pathologies", "the history of Ghana", "the history of study regions, and sites: Begho, Ntereso, Sekondi, Yapei, and Yikpabongo", "the provenience of the human remains (study samples)", "archaeoethanatology", "behavior/activity from human skeletons", "human skeletons and paleo-diet", "dental pathologies and paleo-diet". For analytical methods, articles on "stable isotope analysis", "x-ray fluorescence analysis", and "computed tomography" were accessed.

Additionally, the research employed metric and non-metric anthropological methods used in studying the osteobiography of individuals (sex, age, pathology, and trauma). Moreover, for a holistic overview, the analysis of the chronology, documentation of individuals' dietary, behavioral/ activity, and health aspects from the different geographical units, ethnographic research, parasitology, computed tomography, x-ray

fluorescence analysis, radiocarbon dating, and stable isotope analysis was conducted. Photography was also used to document some recent community activities and the laboratory study of the human remains.

### **1.2.6 Research Questions**

The key research questions that guided the research include the following:

1. What are bio-histories of the minimum number of individuals (MNI) represented in the skeletal assemblage of each site?
2. What are the human remains' cultural and environmental contexts, and how can these be useful in archaeoethanatomical reconstructions?
3. What skeletal & dental pathologies are evident in the skeletal assemblage?
4. Are the skeletal pathologies capable of reconstructing the health of the individuals?
5. How can the prevalence or otherwise of dental pathologies help infer oral health and stress among the populations?
6. How promising are activity-related skeletal markers in reconstructing past activities?
7. What bio-archaeological and bio-anthropological lessons and insights on the remains (individuals) can shed light on past lifeways and complement site histories?
8. What are the parasitological insights into burial contexts?
9. How valuable are X-ray fluorescence and CT examination in skeletal analysis?
10. What is the stable isotope revelation on the respective sites' dietetics and the environmental contexts?

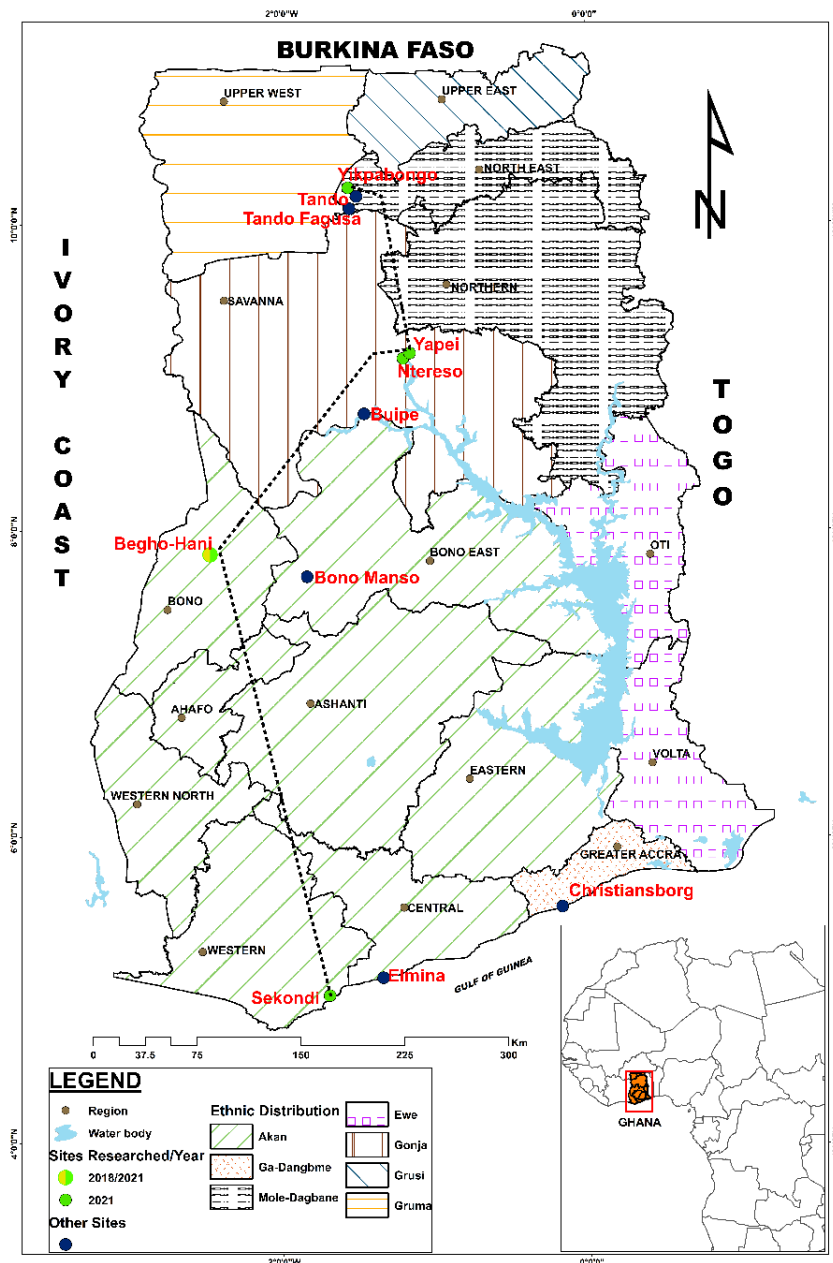
### 1.3 BACKGROUND OF STUDY REGION, GHANA

Ghana is located at a latitude of 7.9465°N and a longitude of 1.0232°W in West Africa (Map 1.1). West Africa has had a past of colonization and slavery, with episodes of the trans-Saharan and trans-Atlantic slave trades. These histories have been extensively discussed from genesis to legacies, along with their material cultural impressions on Ghana (then, the Gold Coast) and involving parties (Anquandah, 1979, 1982, 1985, 1995; Anquandah et al., 2007; Bredwa-Mensah, 1999; Perbi, 2004; Stahl, 2014, 2016, 2020). As such, only highlights of Ghana's history are featured in this work. Masked within the net of trade/ exchange, the European powers: first the Portuguese in the 15<sup>th</sup> century and later the Dutch, English, Sweden, Denmark, France, and Brandenburg in the 17<sup>th</sup> and 18<sup>th</sup> centuries, established superiority over states and kingdoms in West African (Bredwa-Mensah, 1999).

The quest for domination and monopolization of the Atlantic trade grew and consequently increased the establishment of trading stations along the coastal areas of West Africa. The first trading base in Ghana is the Elmina Castle (São Jorge de Mina), built by the Portuguese in 1482. Successive trading posts sprang up from the 16<sup>th</sup> through to the early 19<sup>th</sup> centuries (*Ghana Museums & Monuments Board*, n.d.). Within the West African region, the English and the French built other trading posts and settlements during the 17<sup>th</sup> and 18<sup>th</sup> centuries along the Senegal and Gambia river valleys, respectively (Bredwa-Mensah, 1999; DeCorse et al., 2010; Wood, 1967). It is on record that by the 17<sup>th</sup> century, many European forts had dotted Ghana's coastline (Bredwa-Mensah, 1999, p. 28; DeCorse, 2010; Dickson, 1969, p. 46; Lawrence, 1963, 1969).

Ghana (a former British colony), is peopled successively by diverse ethnic groups. According to Ward (1958, p. 62), "...the Portuguese landed on the coast at the time when the nations which people it, were themselves just arrived or still arriving". The *Guans* settled in 1350, the *Fante* around 1400, followed by *Ga*, *Akwamu*, *Adansi*, the *Moshi*, and *Dagomba* (Ward, 1958, pp. 62–63). The end of the 15<sup>th</sup> century chalked the period of great

migrations within the Gold Coast (Ward, 1958, p. 63). This coast played an essential role in the trans-Saharan and trans-Atlantic trades in merchandise and enslaved people. The forts and castles (however, not limited to these) bespeak the extent and the impact of the transaction on the sub-region. Currently (2018-now), Ghana's divide is 16 Regions ("Map & Regions in Ghana," n.d.) and 216 local administrative districts that steer affairs in a bottom-up hierarchy.



**Map 1. 1: Ghana's location in West Africa, showing study sites pinned in green and other areas marked in blue dots from which human remains have been recorded by blue dots. (Map by Kelvin Asare 2022).**

### **1.3.1 Insights into Ghanaian History: Technology, Settlement & Architecture**

A depth of written records on the historical chapter of Ghana and West Africa have been compiled by diverse scholars. In addition, other archaeological, anthropological, ethnographic, ethnohistoric, and ethnolinguistic studies brewed within the Region, mélanged with varied theoretical and methodological approaches since the 19<sup>th</sup> century to now, have been insightful and provide avenues for the intellectually stimulated of (new) theoretical frameworks. To mention a few, see (Anquandah, 1979, 1982, 1985, 1995, 2002, 2006; Anquandah et al., 2007; Anquandah, 2014; Anquandah & Kankpeyeng, 2014; Bredwa-Mensah, 1999; Chouin & Decorse, 2010; Davies, 1961b, 2014; Gavua, 2015; Gavua & Apoh, 2011; Renschler & DeCorse, 2016; Stahl, 2014, 2015, 2016, 2020). Moreover, these researches have offered essential insights and evidence to the peopling of Ghana, among other West African countries, and the means to rewrite the nation's history. This approach is invariably beneficial to liberate the nation from the 'box' of Eurocentric historical perspectives. Much of what is known about Ghana's history ranges from climate, culture, settlement, urbanization and social complexity, political organization, agriculture/ food production, metalworking/technology, and crafts specialization from archaeological, anthropological, ethnographic, historical, and ethnolinguistic revelations.

Ghana has developed spatio-temporally through several linear measuring parameters or industries- the Stone Age, Iron Age, Mesolithic, and Neolithic (with specialized and sophisticated tools- microliths). These developments have been coupled with sedentism, agriculture, ironworking/metallurgy, comparative trajectories of urbanization, and social complexity across the region. These aspects will not be discussed in detail as ample research already exist. In brief, the Kintampo culture complex associated with the Neolithic period, for instance, characterized several sites with significant evidence and records of early sedentism and food production, a distribution found in all vegetational zones of the forest margin and southern part of the savannah woodland (Anquandah,

1993; Davies, 1980; Flight, 2011; Stahl, 1986; Watson, 2010). Some particular archaeological identifiers of the Kintampo culture are local ceramics with impressed decorations, varieties of stone axes, celts, and products of the lithic industry: lunate microliths scrapers, blades, and arrowheads (Dickson, 1969, p. 11). Additionally, wattle-and-daub houses, fine stone tools, bracelets, small polished axes, coarse pottery stamped with square-toothed combs, terracotta flattened cigars, polishers for small beads of ostrich eggshell (Davies, 1961b).

Another significant development in Ghana's history is the evidence of ironworking from archaeological, ethnohistoric, and ethnolinguistic exposés. The diffusionist theory of the knowledge and techniques of metallurgy is marked from Meroe, across the Sahara to Neolithic West Africa, and later to Ghana about A.D 500 and 1000 (Dickson, 1969, p. 12). Although iron-working brought sophistication into material culture assemblage, i.e., more efficient tools for hunting, land clearing, and warfare, it did not completely replace the stone industry; the two technological industries co-reigned until the late 16<sup>th</sup> century (Dickson, 1969, p. 12). Evidence of this is from celts association with '*Tuyeres*' (associated with iron smelting and smithing) found in 16<sup>th</sup>-century sites excavated at Sekondi and the use of iron pieces as currency in Ashanti in the late 16<sup>th</sup> century (Dickson, 1969, pp. 12–13). Even today, the grinding stone is still in use for preparing meals and herbs (in traditional medicinal practices) in most Ghanaian homes.

Ghana's settlement history and population size have remarkably changed: from about the 13<sup>th</sup> to the end of the 16<sup>th</sup> centuries from the rippling effects of domestication and agriculture. The surge in population due to food sufficiency is supported by the arrival of Malaysian food crops such as Asian yam, taro, and plantain (Dickson, 1969, p. 49; Flight, 2011). In most cases, agriculture impacted societies and settlements and food sufficiency boosted population growth and consequently increased settlement size. Settlement accounts of the earliest architectural type depicted circular or rectangular wattle-and-

daub, circular poles-woven mats, and thatch structures evident by the 15<sup>th</sup> century in Southern Ghana and Ashanti- Brong-Ahafo, more circular forms by the end of the 17<sup>th</sup> century in the South-east coastal plains (Dickson, 1969, pp. 51–52), and evolved building with daub bricks. Northern Ghana's settlements are characterized by circular walled compound homes of round huts with conical or flat roofs from the 15<sup>th</sup> century, followed by rectangular structures with flat earth roofs and interior courtyards in the 17<sup>th</sup> century (Dickson, 1969; El-Wakkad, 1961). Typical examples of flat earth roofs are the distinct buildings of Tongo Hills in the Upper East Region of Ghana. There is continuity of the conical and flat-roofed architectural style and family organization of nucleated compounds in Northern Ghana attributed to eco-sustainability and to provide safety/defense from intruders and foster family unity or bond, respectively. Conversely, in the southern parts and cities of the country, the wattle & daub-styled and nucleated compound housing structure has changed drastically to the preference for sophisticated individual homes of bricks and cement. However, some small towns maintain the wattle-and-daub structures as sleeping places, kitchens, or storehouses for their farm produce.

### **1.3.2 Dynamics of Trade & Datation of Domestic Slavery**

The European contact was dynamic and complex in nature. The trade in gold wax, ivory, kola, and hides in the 15<sup>th</sup> century and slaves in the 18<sup>th</sup> century (Bredwa-Mensah, 1999, p. 29) in exchange for rum/gin, gunpowder, and other foreign merchandise, significantly impacted the landscape and people. The contact and trade relations largely led to the emergence and urbanization of some African towns, such as Whydah, Dahomey, Oyo, Accra, Cape Coast, and Elmina (Bredwa-Mensah, 1999). Additionally, it led to the exploitation of goods and the spread of Eurocentric ideologies and techniques and bits of changes in some aspects of the Ghanaian culture: education, religion, subsistence, settlement/architecture, and socio-political organization. Moreover, the Euro-African transactions fostered the assimilation of the 'European' into the 'local'. The Euro-local relationship in the region is most often than not evident in material cultural assemblages

of the archaeological record. However, not all material vestiges and the presence or absence of certain categories of material culture can be ascribed to the contact period when evaluating the archaeological record (DeCorse, 1992, 1993). Could the continuity of some burial and religious practices like in-house burials and household shrines been a sort of resistance to the contact?

Within the Ghanaian and West African region, a sort of hegemonic rule existed and trade/exchange with the Sahara was ongoing in addition to indigenous slavery prior to the coming of the Europeans (Akurang-Parry, 2002; Kankpeyeng, 2009; P. Lovejoy, 1979; Perbi, 2004). Though not certain when indigenous slavery began in Ghana, a fact and the basis of some arguments about slavery in Africa is that domestic slavery pre-dated the trans-Atlantic slave trade, co-existed with it, and extended a while after slavery had been abolished (Kankpeyeng, 2009, p. 211). Kankpeyeng (2009) indicates that some hinterland relics: water cistern at *Salaga*; tunnels; rock shelters; the *Gwollu* and *Nalerigu* defensive walls (markers of resistance to slave-raiding); transit camps (the *Pikworo* slave camp near Paga); slave markets (*Salaga* and *Saakpuli*); shrines and slave cemeteries, attests to the existence and flourishing of the indigenous and trans-Saharan slave trade in Northern Ghana (Kankpeyeng, 2009).

According to Kankpeyeng (2009, p. 211), trans-Saharan slave trafficking in Ghana existed for over 600 years before the first fort on the Ghana coast. Meanwhile, Perbi (2004) pins domestic slavery to between the 1<sup>st</sup> to the 15<sup>th</sup> centuries A.D, based on interior and coastal trading activities among the Mande-speaking people pre-Portuguese arrival, Portuguese testimonials of 'local' trade in slaves and goods (Perbi, 2004, p. 17), and the sale of Congo and Benin slaves at Elmina by the Mande in the 1480s (Dickson, 1969, p. 42). At the peak of the trans-Saharan trade around A.D 1500, Ghana's geography and resources were her advantage in receiving goods from Western Sudan and North Africa (Perbi, 2004). Some of the goods for which gold was exchanged included hides, ostrich feathers, slaves,



cowries, perfumes, beads, and horses from about the 10<sup>th</sup> century A.D and slaves, beads, cotton cloth, and 'qua qua' cloth from Benin State, Dahomey, and Ivory Coast in the 15<sup>th</sup> century A.D. (Perbi, 2004, pp. 16–17). Although slavery cannot be contextualized in recent years, the post-contact period is somewhat sailed by post-colonial and neo-colonial winds and factors and the considerable rippling effects are witnessed by the inhabitants of the various erstwhile colonies.

## **2 PART I: PROVENANCE RESEARCH OF REMAINS FROM THE WESTERN, BONO, SAVANNAH, AND NORTHEAST REGIONS OF GHANA**

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## 2.1 INTRODUCTION

This section of the thesis consists of four chapters presenting the site contexts of the excavated remains, some highlights of archaeology in Ghana, and the development of archaeoethnology in Ghanaian archaeological practice. Also, this section elaborates on the methodology, results, and challenges of the bioanthropological assessment of the human skeletons (which permitted the 'humanizing' of the remains).

Provenance research on human remains incorporates in its execution, the context of the remains: historical, archaeological, and ethnographic references to help tell the life course story of a people who once lived. Within this framework is the concept of osteobiography, meaning that from the human skeleton, bioarchaeologist/anthropologists can define and reconstruct the multifaceted aspects of an individual's identity and life story/experiences (Buikstra, 2019a; Hosek & Robb, 2019; Robb, 2002; Robb et al., 2019; Saul, 1976). The osteological data reveals more about the individual or population life course than textual biographies would. Thus, without textual biographies, osteobiographies can be a stand-alone 'face of the past' (Robb et al., 2019). According to Robb (2019), biases in osteobiographical accounts are limited, i.e., osteobiographies are more objective in revealing the life course. The provenance research is intended to reveal the life course of the individuals, not the continuation of 18<sup>th</sup>-century eugenicist practices.

Intra-vitam records and experiences unveiled through bioanthropological assessment of human remains include, among others, sex, age, stature, skeletal and dental pathologies/health, trauma, gendered/idiosyncratic activities, dietary patterns, status, environmental context, episodic and long-term adaptation and interactions with geographical and human elements, culture, and population mobility (Larsen, 1995, 2002, 2012, 2015; Robb et al., 2019; Weiss, 2017). The archaeological and historical should be adequately integrated to enable the extraction of information from the archaeological specimens to complement interpretations. Moreover, the methods and procedures for extraction should be objectively selected and appropriated.

## **CHAPTER 1**

### **RESEARCH SITES AND SKELETONS IN CONTEXT**

#### **2.2 OVERVIEW**

This chapter of part I provides a background to the importance of context in archaeological and bioarchaeological studies. It explores the geography of the research sites and documents the archaeological/funerary contexts of the skeletal remains.

#### **2.3 THE PLACE OF CONTEXT IN ARCHAEOLOGY/ANTHROPOLOGY**

Human skeletal remains are excellent mirrors of the lives of the individuals they represent. Such remains indicate their biological and physical interactions and responses to the environment (sociocultural and natural). They embody an individual's identity and adaptation strategies to the immediate environment and social practices. To substantially comprehend and appreciate a people's inter and intra-adaptive systems' trend/ chain of events, researchers tend to read such indicators from their biological and cultural remnants, i.e., skeletal remains and material cultural relics. Walker (2000) notes that human skeletons provide comparative data to enable interpretations of past lifeways. They either complement, confirm or debunk what has been gleaned from artifacts and ecofacts. Since human skeletal remains are reflections of the bio-history and the environment of the decedent, the information from the anthropological analysis is evidence/ proxies to their health and well-being, dietary history, and past lifeways, with significant pointers to sociocultural practices, ancestry, and demography (Larsen, 2002, 2015). In other words, skeletons are 'active' agents that act as windows into the lives of the individuals they represent.

It is imperative to note that context radiates meanings on ideologies and practices to a large extent (Beaudry et al., 1996). Material remains of existence: artifacts, ecofacts, bio-

facts, and features within the archaeological record cannot be analyzed in isolation but within their appropriate contexts to allow the flow of meaning and interpretations. According to Ortner & Putschar (1981, p. 35), data acquired during the excavation of any archaeological specimen will provide valuable information on provenience. Associated grave goods can also give insights into mortuary rituals and the cultural context of burials. The context of skeletal remains involves the geographical location of the site and the 3-dimensional information of the archaeological provenience and the orientation of the skeleton. Additionally, the conditions of the archaeological record upon recovery of the remains, the archaeological horizon or date, as well as cultural associations with other materials or artifacts and events should be noted as part of the context. It also includes any documented (historical) data on the remains, sociocultural dynamics, and the environmental settings within which the individuals existed (Larsen, 2015). These are important variables for analysis and reconstruction.

Human remains' depositional contexts and orientations may differ in primary or secondary contexts for single and multiple burials; be they of long-term or episodic depositions (Nikita et al., 2019; Osterholtz, 2018). Therefore, interpretations must be context and site-specific, as varied meanings can be read from different recovery contexts. Although contexts may vary, they are invariably bound up with meaning necessary for context-specific interpretations. According to Beaudry et al. (1996, p. 281), "the recovery of meaning is predicated on the recovery of context...meanings cannot exist in the absence of contexts". On this ambit, and in agreement with scholars like Martin et al. (2013) and Sutton (2020a), interpretations of bone deposits or human remains must consider the recovery and taphonomic history, the sociocultural and environmental contexts, and associations between the remains and other artifacts due to their pertinence to reconstruction/ interpretations.

In relation to this study remains, only limited information on the context of recovery or excavation provenience of the study samples was available. However, what is clear is that

these remains were excavated from different sites in different regions of the country. Hence, no one context can be ascribed to the individuals in the assemblage. The remains, with an iota of surety, have only been marked and some briefly mentioned in some articles. For instance, Oliver Davies' field photo catalog in the Department of Archaeology conservation laboratory has a record of the remains from Sekondi. Also, the cranium from Yikpabongo is mentioned in an article by Kankpeyeng and colleagues (2011, p. 210). Many details of the context of the Yapei, Ntereso, and Begho skeletal remains are not available. They are probably in the inaccessible researcher's field journals and record forms and were inaccessible because the researchers were either unavailable or had passed on at the time of the study. Alternatively, some provenience information was salvaged from the deteriorating paper tags and labels attached to the burial boxes containing the human remains. This information provided clues about the context of the remains: level, year of excavation, and associated materials. In most cases where paper tags/ labels have been destroyed by termite activity, humidity, or other poor storage conditions, it is estimated that a great deal of valuable data has been lost and the context of the remains compromised. Thus, in such unfortunate situations with limited contextual information, the biohistories of the remains are the most useful in revealing the past.

## 2.4 REGIONAL SITE OVERVIEW AND CONTEXTS OF THE REMAINS

The discussion has been arranged according to regions from the Southern to the Northern parts: Western, Bono, Savannah, and North-East.

### 2.4.1 Western Region

**Sekondi**, with coordinates: 04°55'00"N 01°46'00"W, is referred to as '*Succondee*' in the accounts of Meredith (1812, p. 73) and '*Sekonde*' by the inhabitants, from the corrupted word '*Esekumi*'. Sekondi "lay on the 13-meter marine terrace" (Davies, 1961b, p. 3) and surface configurations characterized by microliths. The founders of Sekondi (a woman named Nana Ewua Aluku and an isolated family) called the land where they settled Sekondi. The land later accommodated the Dutch and the British and their Forts in 1640 (Fort Orange) and 1682 (Fort George), respectively. The two Forts were undeniably linked in business with other Forts in the Western Region. For example, Fort Dixcove/ Metal Cross at Dixcove (1683), and Fort Batenstein (1656).

The presence of the Dutch and British forces separated the land into Dutch Sekondi and British Sekondi. Dutch Sekondi is toward the coast called Sekondi, and British Sekondi is called *Essikadu*, inland, North of Dutch Sekondi. Dutch Sekondi is four miles from '*Taccorary*', now Takoradi, another Dutch settlement on the Gold Coast. Davies found evidence of Portuguese settlement in Sekondi, suggesting the extension of the Portuguese interaction on the coast (Davies, 1961b, p. 3). History has it that during the era of slave raiding and trade, lots of the inhabitants from the two sections fled to different places for protection. The town is bounded by numerous suburbs, some of which are *Kojokrom*, *Essikadu*, *Kansowodo*, and *Ashiam*. Initially occupied by the Ahantas, Sekondi is presently inhabited by a conglomerate of tribes, including the Fantes, Ewe, and people from the North. The culture is a blend of Christianity, Islam, and traditional practices. Sekondi is known as a twin town to the Oil City of Ghana- Takoradi; the Twin-city, Sekondi-Takoradi, is the regional capital of the Western Region.

The topography of the town is both high & low lands with closely arranged nucleated settlements of rectangular concrete buildings, which look like a slum, but with well-segmented communities and named streets. Meredith notes the geography of the site as "hills and dales" on the coast and "flatlands bounded by small hills crowned by lofty trees" inland (Meredith, 1812, p. 77). However, oral accounts reveal more trees on the coast than inland. According to Meredith, the town Sekondi, in the 19<sup>th</sup> century, was "...undoubtedly..., the richest on the Gold Coast" (Meredith, 1812, p. 73), characterized by coves, harbors, and abounded with timber and limestone for building (Meredith, 1812, pp. 73–77) while it hosted European trading posts and settlements. Moreover, in the 20<sup>th</sup> century, Davies (1961b) records that the inhabitants of Sekondi (Dutch Sekondi) were positioned South of Orange Fort, where chiefly tombs were found. The slopes were characterized by hut platforms, and the floors were marked by broken pottery and burnt materials (p. 3). Sekondi also houses the ruins of industrial interactions of the 18<sup>th</sup> and 20<sup>th</sup> centuries (including the railways and commercial buildings) and currently the Naval Base of the Ghana Armed Forces.

The landscape of Sekondi is neither rocky nor conducive for farming activities as it is overcrowded with settlements. The mainstay of the inhabitants is fishing, industrial jobs, and petty trading. Produce like yam, groundnuts, cocoa, cassava, maize, rice, sugar cane, cocoyam, and oil palm (providing oil and wine) come from Kumasi, Techiman, Accra, Senchi, and the suburbs (*Kojokrom, Essikadu, Kansowodo, and Ashiam*), in the past by train and currently by buses to be purchased on market days. Both the past & contemporary communities enjoy various delicacies from these crops. The meals included *Aky3k3, Fomfum, Ableyo, Asata, Apiti, Lolotsi, Aboboi, Fufu, and Apepremsa*. These dishes have not evolved much from what they were in the past. On the subject of funeral practices, Christians bury their deceased with coffins and grave goods without regard for orientation. Conversely, Muslims inter the dead without coffins and grave goods, but with respect for orientation, i.e., North-South facing Mecca. Although interesting, it is uncertain whether the flexed or extended bodies were Christian or Muslim paleo-burials.



## ***Context of Sekondi Research Material***

The 14 human remains from this site are anticipated to be from the Middle Stone Age period, excavated in 1954/ 1963 from an area suspected to be for rituals or episodic burials. Their record can be found in a photo catalog of the excavator, Oliver Davies (name also indicated on most of the wrappings in individual boxes), in the conservation laboratory of the Department of Archaeology and Heritage Studies, UG. In this catalog are the photographs (in black and white; some are of relatively poor quality) of the human remains in-situ. Behind the photos are assigned unit numbers and recovery levels of the remains. Some of these remains were also mentioned and displayed in (Davies, 1961b)- *Native Culture in the Gold Coast at the time of the Portuguese Discoveries*. The context of the burials, as indicated behind the photographs recovered from the photo register, has been tabulated (Appendix A). These bear references, for example, OD 63/591, suggesting the excavator's name, year, and catalog number. Note that '...' depicts unreadable information. For in-text referencing of the context of the remains, the catalog codes of Oliver Davies were used.

In addition to the contexts (from each photo, as could be read) indicated in the tables of Appendix A, Davies recorded that the graves were stone pile graves, with most of the burials sealed by small stones and a few with large stones and that "nearly all the bodies had been partly mutilated...by decapitation...several skulls un-associated with other bones" (Davies, 1961b, p. 4) in addition to disarticulated human and animal bones. "..., all the bodies had been ritually buried, and the mutilations must have been ritual" (Davies, 1961b, p. 4). Moreover, he describes a typical ritual context of the remains where one or more stone beads of pinkish quartz are placed/ tied around each head, and strings of shell beads are strung around the neck and sometimes the arms of individuals. Again, pots and at least one greenstone axe were associated with all the bodies (Davies, 1961b, p. 4). Also associated with the burials were shells and fish bones; huge heaps nearby were suggestive of domestic middens or ritual meals (Davies, 1961b, p. 4).

Having mentioned the nature of Christian burials and considered the associated grave relics of these burials, most of them would probably be Christian burials. In describing the orientation of the skeletons, Davies notes, "two undisturbed flexed bodies one on top of the other" (Davies, 1961b, p. 4) and others in lateral recumbent or flexed position as though they were sitting (Davies, 1961b). The skeletal remains are more fragmented than seen in the photographs; this could be because they were exhumed in their fragile state without consolidation. It was also impossible to validate decapitation (by cut marks on the foramen magnum or any of the cervical vertebrae) due to the heavy fragmentation of the remains.

Below is an individual assessment of the orientation and depositional character (primary or secondary) of six out of 11 Sekondi remains based on observation and the examination of both persistent and labile joints. Labile joints have been explained by Duday and colleagues (Duday et al., 2009, 2014) as joints that are quickly ruined during decomposition. In contrast, persistent joints are those that take a longer time to separate during or after the decomposition of soft tissues. The former comprises connections between the hands, distal parts of the foot, cervical vertebrae, the hip, the shoulder blade, and ribs, and the latter, the ball and socket joint of the femoral head to the acetabulum of the pelvis and the metatarsals. Thus, an existing anatomical connection between labile joints and the general adherence of the remains can be used to ascertain the primary character of burials and the time elapsed between death and decomposition (Duday et al., 2009, 2014). He further noted that the body's orientation in the archaeological record results from the initial depositional direction or orientation and the effects of gravity on the bones as soft tissues decompose (Duday et al., 2009, 2014). Hence, joint dissociations characteristic of secondary burials should be assessed with caution since disassociations can be influenced by scavenger activities, earth movements, and taphonomic processes (Duday et al., 2009, 2014).

## 1. Sekondi excavation, Pit IV F & M (see Appendix A)

The burial noted as Pit IV F & M was found in the Northern part of the trench (the hand trowel points to the North, but the individual is facing the East) by Oliver Davies. It's a collective burial of two individuals (picture showing the lower and well-preserved individual) (**Figure: 2.1**). The individual is lying on the left side; the rib cage rests on the left upper arm/ humerus with the hand under the lower jaw. The right hand (flexed at the elbow) and the femora are resting on the femur of another individual, and the leg is bent at the knee. Based on the existing anatomical connection of the right femoral head to the acetabulum of the pelvis and the metatarsals (persistent joints) and the labile joints of the carpals, metacarpals, and phalanges, this burial is primary.



**Figure 2. 1: Sekondi excavation Pit IV F & M, 2nd skeleton (Figure 4 in Davies, 1961: 9. Reference in records: OD 63/591, 641, 642, 643, 644; see Appendix A. Sketch by Author).**

## 2. Burial C, Sekondi VII C-D, SK'21-C 73.88 (see Appendix A)

The skeleton was found at Level 4.3' of the unit/trench with beads, celt, and shell beads by Oliver Davies. A pot was on the right elbow (OD 63/621). The individual is lying on the left side; the leg is flexed at the knee, and the right hand is flexed at the elbow. The left hand is likely to be under the jaw. Some labile joints are visibly intact on the right hand; this suggests a primary burial.



**Figure 2. 2: Individual SK'21-C 73.88: Burial C, Sekondi VII C-D, Skeleton @ Level 4.3' (Figure 5 in Davies, 1961: 10. Reference in records: OD 63/596, 621 & 622; see Appendix A. Sketch by Author).**

### 3. Burial Da, SK'21-73.81 (see Appendix A)

Burial Da, SK'21-73.81 was found at level 5.0' by Oliver Davies, a pot was on the stomach or chest (removed, but the hole is evident in the picture), and celts. Possibly one leg has been removed. The individual is lying on the right side. The left arm is flexed at the elbow, and the lower limbs are bent at the hip joint and the knee. The burial is likely primary.



**Figure 2. 3: Individual SK'21-D 73.81: Burial Da, burial at L-5.0', a pot was on the stomach (removed, depression hole in the image is indicated by the blue circle on the sketch), and probably one leg has been removed. (Reference in records: OD 63/612, 613, 614; see Appendix A. Sketch by Author).**

#### 4. Burial F (see Appendix A)

Burial F (OD 63/616), SK'21-F 73.94 is to the West of the pit (which contained burial Da). The skeleton is a skull and leg bones lying vertically. The individual is lying on the right side. The left arm is flexed at the elbow, and the lower limbs are flexed, possibly at the hip joint and the knee. The burial is likely primary.



**Figure 2. 4: Individual SK'21-F 73.94: Burial F. Sekondi VII D 1<sup>st</sup> & 2<sup>nd</sup> skull: 1<sup>st</sup> skull with leg bones lying vertically. (Reference in records: OD 63/615, 616; see Appendix A. Sketch by Author).**



## 5. Burial E (see Appendix A)

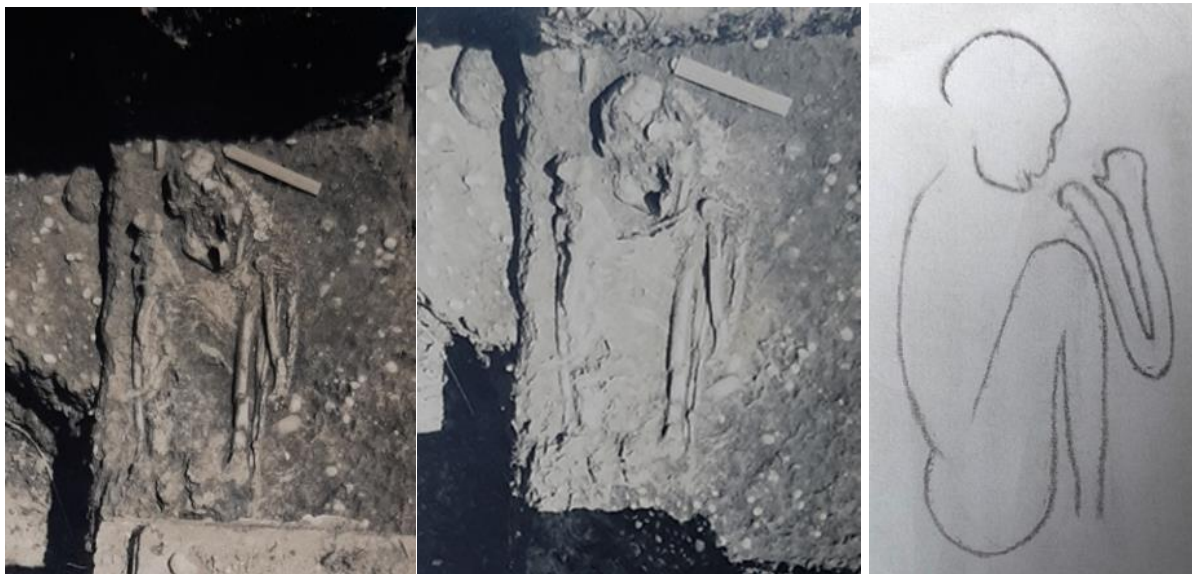
Burial E, SK'21-E 73.82, the skeleton was at level 5.2'. The skull had ostrich shell beads strung around it. The skull seems to have been placed between the skeleton's upper and lower limbs, probably, a confirmation of the decapitation noted by the excavator (Davies, 1961: 4). The orientation of the burial is uncertain, but it appears that the individual is lying on the left side with the left leg flexed at the knee. The burial is likely primary from the labile joint of the hip, which is still in anatomical connection to the pelvis.



**Figure 2. 5: Individual SK'21-E 73.82: Burial E, Sekondi VII E-F. Skeleton @ L-5.2' Skull with bead strip around (Figure 10 in Davies, 1961: 14. Reference in records: OD 63/595, 596, 597; see Appendix A. Sketch by Author).**

## 6. Burial M, Sekondi VII C-D, SK'21-73.87 (see Appendix A)

Skeleton at level 3.9' of the trench, the ruler is pointing at beads and shell beads. The individual is lying on the left side, the right femur is flexed at the pelvis, and the right leg is flexed at the knee. The right arm & forearm (flexed at the elbow) lie outside the bent leg. An anatomical connection is visible between the hand bones, coupled with the position of the skull, and this suggests a primary burial.



**Figure 2. 6: Individual SK'21-M 73.87: Burial M, Sekondi VII C-D. Skeleton @ L-3.9' from the Southeast corner. (Figure 6 in Davies, 1961: 11. Reference in records: OD 63/618 619 & 620; see Appendix A. Sketch by Author).**



## 2.4.2 Bono Region

### ***Begho/ Hani-Begho***

Begho was a complex prehistoric society in the Bono Region (7°51'00"N 2°29'00"W) of Ghana. Ample archaeological works have been carried out at this site: notably Anquandah (1981, 1995), Bravmann & Mathewson (1970), Konadu (2010), Posnansky (1970, 2010, 2015), Propheet (1966), and Shinnie & Ozanne (1962). Varied site dates have been produced over the years and stipulated between the 10<sup>th</sup> and the early 19<sup>th</sup> centuries BC (Anquandah, 1981, 1995; Bravmann & Mathewson, 1970; Posnansky, 1970, 2015; Propheet, 1966). The Hani people currently inhabit the prehistoric landmark of Begho, hence, Hani-Begho. Begho is known to have played a valuable role in the trans-Saharan trade. The town was a strategic trade route and a cosmopolitan market center connecting to other trading routes, including Jenne, fuelling the trade in commodities like gold, kola, salt, ceramics, ivory, hand-crafted narrow-stripped dyed textiles, and iron implements within the region (Bravmann & Mathewson, 1970; Posnansky, 2015, pp. 108–109).

The urbanization of Begho was a result of booming trading activities in the Tain Basin, and it was probably the largest city-state between the 13<sup>th</sup> and 19 centuries (Posnansky, 2015). The Begho society was stratified into quarters: the Brong quarter, a settlement for the chiefs; the Kramo quarter, a settlement for the Muslim Mande traders; the Dwabirim quarter, a residence of specialist traders and market center; the Dapaa quarter, the iron smelting site; the Dwimfuor quarter, the artisanal center and the home of Blacksmiths and coppersmiths (Anquandah, 1995; Posnansky, 1970, 2015) and two other quarters, Nkwankramu and Donkontereso were discovered in 2018 during a field survey.

Posnansky projects a maximum of 10,000 people during Begho's prime with an approximate population of about 2,500- 2,800 people (Posnansky, 2004, p. 34, 2015, p. 101). The town's architectural style has evolved from wattle and daub structures to rectangular mud-brick houses with concrete plastering and aluminum roofing sheets (Lampthey, 2019). The Hani-Begho populace is predominantly farmers cultivating: Pearl

millet (*Pennisetum glaucum*), white and yellow yam (*Dioscorea alata & cayenensis*), taro (*Colocasia esculenta*), sorghum (*Sorghum bicolor*), dry rice (*Oryza glabberima*), oil palm (*Elems guineensis*), okra (*Abelmoschus esculentus*) and pepper (*Capsicum annum*). They also cultivate cashew (*Anacardium occidentale*) on both commercial and small scales (for subsistence) while benefiting from game in nearby and far-off forests (Lamptey, 2019). They harvest the bark, leaves, and roots of specific plants/trees for artisanal and medicinal purposes. For instance, the 'Acheampong' leaves (*Chromolaena odorata*) are preferred for their medicinal and preservative properties (Lamptey, 2019).

### **Context of Begho Research Material**

In 2018, six boxes of human remains from Begho were analyzed for a Master's thesis (Lamptey, 2019). In 2021, two boxes of human remains were found in storage. I believe these should have been worked together with the 2018 but were only found in 2021 due to the lack of an updated inventory of storage collections. These boxes of human remains are noted to have been brought to the department by Merrick Posnansky from archaeological excavations at the Brong quarter in 1970, 1972, and 1975 and the Kramo quarters in 1971 and 1979. The remains in the two boxes are from the 1970 excavations at the Brong Quarter and the 1971 Kramo Quarter excavations. The accessioning numbers 'B1' and 'K1' confirmed their origin from the respective quarters. It should be noted that the only source of provenience information for the remains in the two boxes are the inscriptions on the boxes and the deteriorating paper labels accompanying the remains. Find the context description of the Begho remains in Table 2.1. The remains will hereafter be addressed by their 2021 study inventory numbers assigned.

**Table 2. 1: Context of Begho Research Material**

<b>SITE</b>	<b>BOX INFORMATION</b>	<b>REMAINS ID NO.</b>	<b>CONTEXT/PROVENIENCE</b>
Begho	Bg. 70 & 71. Burial F	BG'21- 73.116 (70 B1)	Human remains were excavated in 1970 in the Brong quarter (B1).  Animal bones in a cloth bag labeled: WAT Project, Begho, 1971, area K1 Level I 50-80, is from the Kramo quarter.  MNI= 1 + Bones fragments of a baby (probably belonging to a different burial).
Begho	Bg. 70 Bones, Bg 70 H & E	BG'21-73.115 (Bg. 70, E)	Excavated in 1970.  MNI= 1
Begho	Bg. 70 Bones, Bg 70 H & E	BG'21-73.118 (Bg. 70, A)	Excavated in 1970.  MNI= 1 + the mandible of a dog.

### 2.4.3 Savannah Region

**Ntereso**, this prehistoric site with coordinates: (9° 7' 46" N 1° 12' 17" W) is uniquely defined yet closely similar to the characteristics of the Kintampo complex sites. The Ntereso site was discovered in 1952 by Oliver Davies along the Damango - Tamale road in the Savannah Region. The village is two and a half kilometers south of the White Volta (Carter & Flight, 1972; Davies, 1967) and three villages before Yapei. The village is initially known as *Ntere* after the White Volta River. The inhabitants of *Ntere*, the custodians of the river and aids to anyone wanting to cross the river, were without a chief. Following the coming of the Gonja, *Ndewura Japka* led successful raids for the *Ntere* people and was later enskinned as chief of the village, leading to the name, Ntereso, meaning *Ntere* town with a leader. The people of Ntereso speak the Gonja language. Threads of radiocarbon dates have emerged from the site: 1630±130 (SR-52) AD, 1320 ±100 (SR-81) AD, 1240 ±120 (SR-61) AD, and 60 ±110 (SR-90) A.D (Davies, 1964), situating the site between the 13<sup>th</sup> and 17<sup>th</sup> centuries BC.

The principal activity in the past was fishing, which is now supplemented by farming, both of which are the preserve of the men, although women and children help out. The White Volta is the source of diverse fish species for the community. Some of the crops cultivated are groundnut, maize, Pearl millet, beans, pepper, and yams on a subsistence and commercial basis. Records of the domestication of taro and other crops, in addition to goats and chicken at Ntereso, date back to the Kintampo culture complex period in West Africa in 2500-1400 BCE (Flight, 2011; Stahl, 1986). Moreover, some perennial crops like the shea and baobab trees immensely benefit the inhabitants. The shea tree, for instance, which grows in the wild, is a lucrative resource for families and the community and if harnessed extensively, can be a huge revenue source for the country. The tree provides food through the fruits, and the nut is the raw material for oil, cream, and soap.

Being a predominantly Muslim community, the three major festivals in the village are the Eid celebrations and the Fire and Damba festivals. Oral accounts revealed barter trading, iron smelting, and basketry at Ntereso in the 19<sup>th</sup> century BC. Although barter trading no longer exists, the village maintains commercial trading links with Buipe, Yapei, Tamale, Kumasi, and

Damango. Ironworking and the crafts of basketry and pottery making are continued on a limited scale. The raw material for basketry is sourced locally from bamboo sprouts.

### ***Context of Ntereso study material***

Two burial boxes containing two human skulls, each with soil endocrinal. The researcher/excavator is Oliver Davies, as inferred from an attached label. The year of excavation and the context of these remains are uncertain, but likely in 1960. The box information for the remains are O8 C and Burial O5 B, but the study ID assigned are NT'18-73.90 and NT'18-73.91, respectively.

### ***Yapei***

Another prehistoric town in the Central Gonja District (9° 9' 4" N 1° 8' 59" W), in the Savannah Region, North of Ghana. Yapei is the immediate village after the White Volta; the town is subdivided into sections, some of which are Yapei Town, Quarters, Dhalsalam, and Talbonre. Oral accounts revealed that the Gonja ancestors migrated from Yilikpala, a village on the opposite side of the river, to the present area following game hunting, such as antelopes, grass cutters, monkeys, and other wild species. The Ewes, the Mossi, and Dagombas later joined the Gonjas. Four main chieftaincy gates are recognized in the community. The town is made up buildings of mud huts and concrete buildings enclosed in nucleated compounds.

One individual has been dated by <sup>14</sup>C between the mid-18<sup>th</sup>- early 19<sup>th</sup> century BC (Table:1.1), so by association, the site is a pre-18<sup>th</sup> century site. Yapei is a predominantly Muslim community with some Christians and Worshippers of traditional religion. Three major festivals in the village are the Eid celebrations and the Fire and Damba festivals. The predominant activities in the community are fishing and farming alongside animal husbandry, kente weaving, small-scale cosmetology enterprises, petty trading, and a few white color jobs. There is a record of batter trading, silver working, basketry, ceramic, and pipe making at Yapei. Despite the considerable change in activities, there is some continuity in the crafts of basketry,

cloth weaving, fishing, husbandry, and farming. Some women do collect shea fruits for the same purpose as at Ntereso. As mentioned earlier, the shea nut harnessing and the shea butter processing techniques are similar across the two communities. These activities mentioned above are the livelihoods of the settlers.

**Context of Yapei Research Material**

Accompanying the finds from excavations at this site were two boxes of human remains. Although the researcher/excavator and year of excavation are uncertain, they could have been brought in by Oliver Davies, Merrick Posnansky, or subsequent researchers on the site. Some information on the paper wrappings was used to infer the year and excavator for the remains, i.e., 1970 or later, and Professor Merrick Posnansky, respectively (see Table 2.2 for additional information). Not much is known about the context of the remains from this site.

**Table 2. 2: Context of Yapei Research Material**

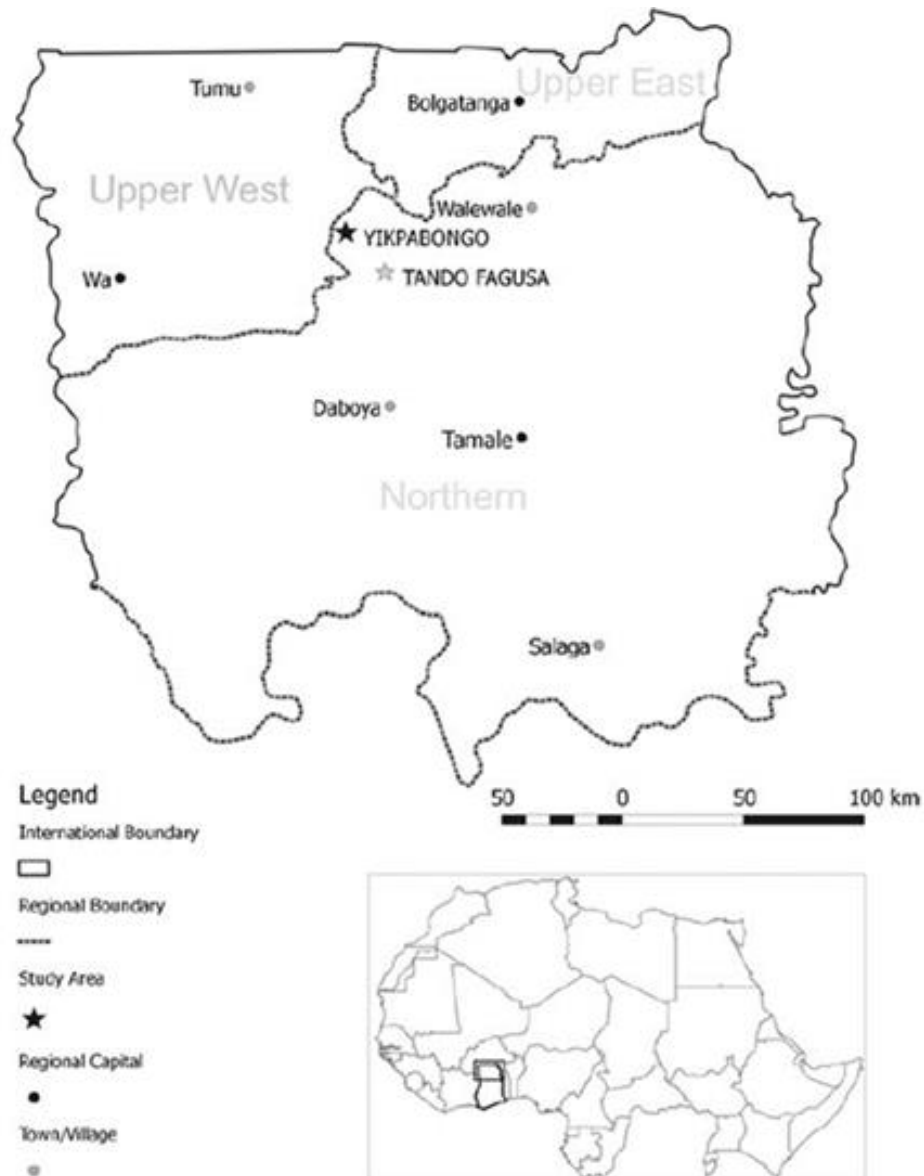
<b>SITE</b>	<b>BOX INFORMATION</b>	<b>REMAINS ID NO.</b>	<b>CONTEXT/ PROVENIENCE</b>
Yapei	Yapei	YP' 18- 73.106	The year of excavation is unknown. However, the date (1970) on the newspaper wrapping may suggest that the remains were excavated in 1970 or later.  Probably excavated by Professor Merrick Posnansky.  Contains 1 MNI.
Yapei	Yapei	YP' 18- 73.105	Contains 3 MNI

#### 2.4.4 North-east Region

**Yikpabongo**, 9km North-west of Tando-Fagusa (Maps: 1.1 & 1.2), is a prehistoric village in the Sisili and Kulpawn valleys within the Voltaian basin. Yikpabongo is part of the ancient sites referred to as Komaland sites in Northern Ghana based on similar (archaeological) material culture configuration, monuments/relics, ceramic artworks: pottery and terracotta sculptures/figurines (also known as '*Kronkronbali*' meaning 'olden days' children') of magnificent features and decorations (Anquandah & Van Ham, 1985, p. 6; Appiah-Adu et al., 2016, p. abs). Komaland elevates between 140 and 200 meters, with uniform topography: gentle slopes and low scarps (Anquandah & Van Ham, 1985, p. 10). The Gur-speaking population: Mamprusi, Koma (of which Yikpabongo is a part), and Sisala (Anquandah & Van Ham, 1985, pp. 10–11) occupy the valley. Yikpabongo is referred to as 'ruins of the forest' by the ancestral founder of the village, recounted in oral history. The social organization of the village is in clans (*Habondeng, Bakondeng, and Barisi*), with families living in nucleated compounds linked by walls (Anquandah & Van Ham, 1985, p. 11). The architectural style is cylindrical mud structures with conical grass-thatched roofing and mud flat-roofing with drain pipes (Anquandah & Van Ham, 1985, p. 11). The people of Yipkabongo, like the Dagomba and Gonja, celebrate the Damba and Fire festival in addition to other Muslim-related celebrations.

The contemporary community of the area is the '*Koma*' or '*Komba*' settlers speaking the '*Komun*' or '*Koming*' language. The primary occupation of people is farming in the rainy season- March to October, for subsistence and semi-commercial sustenance; categorically, backyard gardening on a small scale and large farms are located 1-2 kilometers away from the village, according to Anquandah & Van Ham (1985, p. 11). Some produce include guinea corn, millet, groundnuts, tomatoes, yam, cassava, and onions. Hunting, pastoralism, gathering of wild crops (shea fruits), and rearing animals like sheep, goats, guinea fowls, chicken, and cows also form part of the subsistence culture of the Komaland settlers. There is a history of crafts specializations in pottery making, leather production, and metalworking at Komaland. Anquandah & Van Ham (1985) note that there was traditional potting at Yikpabongo until

1950 by *Sisala* potters, and the blacksmiths of the *Barisi* clan manufactured metal implements like knives, hoes, and cutlasses at Yikpabongo. But these crafts have been discontinued in production in the village.



**Map 2. 1: Yikpabongo in the Northern region of Ghana (Reproduced from Kankpeyeng et al., 2013).**



The Komaland site is characterized by house mounds and stone circle mounds. These have been interpreted as burial mounds based on the presence of human remains (Anquandah & Van Ham, 1985) or shrine contexts where the figurines and other material culture are depicted as objects, supernatural agents aiding the connection of the spiritual to the natural world for varied purposes (Kankpeyeng et al., 2013; Kankpeyeng et al., 2011). The interpretation is also grounded on the richness of the material culture assemblage of querns, stone discs, terracotta figurines (of varied zoomorphic and anthropomorphic depictions), grinding stones, and local ceramics. What distinguishes the stone circle mounds from the house mounds is that the former is smaller and consists of large quantities of pottery in addition to the material assemblages mentioned above. While the latter is larger, having a varying material composition in addition to scatters of pottery and few grinding stones (Kankpeyeng et al., 2011: 209). It has been suggested that the contexts with human remains in association with figurines and other cultural objects point to complex practices related to burials and indigenous spiritism attached to cultural practices, represented in traditional religion, rituals, and aspects of indigenous medicine (Anquandah & Van Ham, 1985; Kankpeyeng et al., 2011, 2013; Kankpeyeng & Nkumbaan, 2009). Mounds of varying dimensions have also been recorded at *Savi*, the capital of the *Whydah/ Hueda* Kingdom, centering about 60 km on the coast of Benin. The mounds represented domestic refuse dumps, collapsed houses/settlements, a palace complex, and a system of substantial ditches enclosing the cluster of fallen structures and embankments (Kelly, 1997, p. 356).

Excavations in 1985 dated the Yikpabongo site to AD 1579±135 (K 414) by Thermoluminescence dating (Anquandah & Van Ham, 1985, p. 31). While Anquandah (1998, p. 82) noted that the Komaland civilization spanned between the 12<sup>th</sup> to the 18<sup>th</sup> century AD, subsequent research has reversed the date of occupation in the Koma area and mound formation in Northern Ghana to between the 6<sup>th</sup> and 12<sup>th</sup> century AD by Radiocarbon and Thermoluminescence dating (Kankpeyeng et al., 2011, pp. 209–210, 2013, p. 480; Kankpeyeng & Nkumbaan, 2009, p. 200). In January 2010, a skull recovered from a stone circle mound (YK10-3) with teeth placed at the East of the head and the jaw to the South, and the

long bones were placed beneath the jaw. This remains has been radiocarbon dated to Cal AD 1010 to 1170 (1170 +/- 40BP) (Kankpeyeng et al., 2011, p. 210). Another elaborate burial (YK10-4) from a house mound dated to CalAD 540 to 650 (1470 +/- 40BP) (Kankpeyeng et al., 2011, p. 209). This predates the Yipkabongo settlement to the early 6<sup>th</sup> century. Meanwhile, pre-Saharan complexity in Northern Ghana is supported by excavated material culture assemblage and iron implements (Kankpeyeng & Nkumbaan, 2008). The materials: cowry shell (used as currency in Ghana in the past Johnson, 1970a, 1970b) and motifs of camel riders (camels were vehicles in the trans-Saharan trade for the conveyance of goods and people from one point to another), attest to ancient Koma's participation in the trans-Saharan Caravan trade linking Egypt and North Africa (Anquandah & Van Ham, 1985, p. 46).

### ***Context of Yikpabongo Research Material***

In January 2007, Kankpeyeng and colleagues recovered from a stone circle mound from unit YK07-2-D2 a single skull facing the ground, with over 48 ceramic discs beneath it. The skull was associated with some figurines and potsherds and accompanied by no postcranial bones. The researcher interpreted the context as a secondary burial akin to ritual activity in ancient shrines (Kankpeyeng et al., 2011, p. 210). The information on the box is Yikpabongo site (YK07-2-D2), and the study ID assigned to the remains is YK'21, Unit 1/C-D 3.

## **2.5 CONCLUSION**

The chapter provided an overview of the respective study sites and the available provenience information on the study samples. As mentioned earlier, details of the provenience of some of the human remains were unavailable during the study period. Most likely, the excavators of the remains would have much to say. Unfortunately, some of them have passed on, and others are unavailable to confirm the context of the individuals. Although little is known about some individuals' provenience, the bioanthropological analysis will hopefully reveal substantial information as compensation.

## **CHAPTER 2**

### **ARCHAEOLOGY & ARCHAEOETHANATOLOGY**

#### **2.6 OVERVIEW**

This chapter of part I discusses the state of the archaeological practice in Ghana and its implications on funerary or archaeoethanatomical studies to bolster the understanding of past lifeways.

#### **2.7 ARCHAEOLOGICAL PRACTICE IN GHANA AND ITS IMPLICATIONS ON ARCHAEOETHANATOLOGICAL STUDIES**

West African archaeology and the period of the trans-Saharan slave trade hold great promise for elucidating the material aspects of African life prior to colonial rule. The African continent had its incredible way of life and formidable administration preceding the coming of the Europeans. The European amalgamation into African populations brought a tagging of indigenous knowledge systems and social organizations as prehistoric and uncivilized because they were trapped in oral accounts, customs, folklore, dance, music, and art forms rather than in hard-covered documents with catchy front pages. The data from these media is essential historical antecedents on which studies of African life and material culture from the political, economic, social, and cultural can be based and interpreted.

Similarities and dichotomies of the proliferation of practices can neither be considered in a vacuum. Pre-colonial burial customs and other indigenous knowledge systems are diversified in perspective. For instance, excavations at Elmina in the Central region of Ghana yielded burials beneath the houses (DeCorse, 1992), and Posnansky (1999, p. 34) noted that burials within homes were not exclusively Akan practice. A similar case of in-house (room or compound) burial was reported in the now-inundated Bui community (Apoah & Gavua, 2016, p. 217) with the construction of the Bui dam on the borders of the Northern and Brong-Ahafo regions of Ghana in 2009. Again, in a town called Agomeda in the Southern part of Ghana,

in-compound burials have been recorded among the royal families (ethnographic research in January 2020), a practice to memorialize dead chiefs and members of the royal family.

It is important to note that practices or lifeways can be ethnic, community, or clan-specific and based on customary rites. In this regard, in-house burying will not be exclusive to Ghana or the West African sub-region. A similar practice of burying in-house has been reported from four slave quarters (1670-1780) at the Seville plantation, North coast of Jamaica (Armstrong, 2011; Armstrong & Fleischman, 2003). Burials are ubiquitous in nature, and in whichever case, in-house burials or common burial grounds should be treated as different contexts with dynamic interpretations.

Much of Ghana's archaeology across the length and breadth of the country has focused on four of the five fields of anthropology: sociocultural, linguistic, archaeological, and applied, and less on the physical/biological field. As mentioned, enormous work has been done on slavery and its impacts, colonial fortifications and trade relations, subsistence, settlement histories, technological change, indigenous knowledge systems, and developmental archaeology. These, in addition to other topics of prehistoric and historical significance between culturally defined subgroups/groups within the region, have been extensively discussed (Agorsah, 1992; Anquandah, 1981, 1982, 1995, 2014; Anquandah et al., 2007; Appiah-Adu et al., 2016; Kankpeyeng, 2009; Kankpeyeng et al., 2011, 2013; Kankpeyeng & Nkumbaan, 2009; Osei-Tutu & Smith, 2018; Posnansky, 1973, 2004, 2015; Stahl, 2016), to mention a few.

Subsequently, analyses, reconstructions, and interpretations have been primarily based on historical accounts and material cultural remains (artifacts, ecofacts, and features in the archaeological record), such as ceramics, stone tools, beads, and ruins of buildings, mounds, forts, and castle, indigenous cosmology, and practices within the region. Deductions are made in addition to archaeological facts, by analogy with ethnographic data and connotations but less frequently with or from human skeletal remains, to tap their objective and revelatory abilities into past lifeways. With this development, insights into funerary/mortuary practices,

dietary patterns, and cultural behaviors may be skewed or require more information that the analysis of human remains could have complimented. This, I say not about all contexts but to those whose material assemblage included human remains and could not be analyzed for some reasons.

From the above, it is clear that there is much to be done on skeletal analyses regarding archaeology in Ghana. Suffice it to say, the intrinsic and extrinsic potentials of skeletal remains to actively participate in reconstructing the past lifeways of individuals/populations have been marginalized. As Sofaer (2006, p. 2) noted, "archaeological practices tend to focus on artifacts surrounding the bodies rather than the bodies themselves, which are natural potential material resources" for elucidating meaning and behavioral practices. This is because of their direct interaction with the environment and other socio-cultural factors. Notwithstanding the vast array of information acquired from studying human remains and their contribution to understanding social life and identity, human skeletons have less frequently been explicitly employed for analysis, interpretation, and reconstruction of past lifeways- in the case of Ghanaian archaeology.

There have, however, been a couple of researches (Asare, 2018; Davies, 1961a, 1961b; Lamptey, 2019; Renschler & DeCorse, 2016; Schaffer & Agorsah, 2010) within sites in the Central, Eastern, and Savannah regions of Ghana. These have engaged the potency of human skeletal remains to provide glimpses into past lifeways: dietetics, health, culture/activity, social organization, and its complexities. For instance, Oliver Davies (1961a) outlines most archaeological works in Ghana in the 20<sup>th</sup> century. First at Yapei, beside Achimota Cricket pitch, Kokobin and the entrenchments in the Oda area, Biseasi, and Vume Dugame on the Lower Volta. These works mainly focused on the analyses (description and classification) of artifacts, predominantly pottery/potsherds, pebble/stone tools, and celts. There is mention of the recovery of human remains in Biseasi and the Vume Dugame sites, except in Yapei and the subsequent places. For the former, substantial classification and examinations were carried out and included age, sex, and stature determinations. Very little was context and

behavior inferred from the remains. Schaffer and Agorsah have also analyzed 16 human skeletal remains from Kormantse in the Central region of Ghana. The remains were associated with 17<sup>th</sup>-century artifacts from which they assessed behavior (farming) from activity-related markers on the proximal femur, osteobiographies, and general skeletal health (Schaffer & Agorsah, 2010). The skeletal analysis of the recovered populations infused the interpretation with perspectives on demographic connections and cultural encounters at Kormantse.

Additionally, Asare (2018) conducted residue analysis on human teeth and local ceramics to look out for chemical compounds (drug-related) enmeshed in the teeth, which helped infer the health of the individuals and medicinal practices in the community. Again, Renschler and DeCorse (2016) examined 100 individual skeletons excavated from the coastal town of Elmina of the 15<sup>th</sup> to the 19<sup>th</sup> centuries- the period of European contact, trade, and colonization. Excerpts include the bio-history of the MNI, evidence of habitual pipe-smoking from pipe-smoking facets in adult dentition (**Figure 2.7 i**), dental modification (**Figure 2.7 ii**), dental infection, and mild-moderate cases of linear enamel hypoplasia in some individuals. They also reported a relatively high prevalence of porotic hyperostosis and *Cribia orbitalia* among the analyzed sub-adults and a correlation between the physiological stress markers and “events of disruption in physiological homeostasis” (Renschler and DeCorse, 2016: 40).



**Figure 2. 7: i) Pipe-wear facet displayed in the dentition of an adult (Locus B) and ii) a probable incisor filing (Locus A) (Figures 4 and 5 in Renschler and DeCorse, 2016: 38 & 39).**

Lastly, Lamptey (2019) analyzed eight skeletal remains from the 10<sup>th</sup>-19<sup>th</sup> century cosmopolitan trading town, Hani/Begho site in the Savannah region of Ghana to assess their bioarchaeological contribution to understanding the lifeways of the past population of Hani/Begho. The Begho skeletal analysis revealed extensive occlusal wear related to age and masticatory behavior (**Figure 2.8 i**). The study gave insights into intra-vitam food components: grains and other food types and the extensive exploitation of kola nuts and rice with sand particles consumed in the Begho area. Moreover, artificial diastema creation and trephination (**Figure 2.8 ii**) were associated with “unconscious aspects/ consequences of some traditional medical practices” (Lamptey, 2019, p. 96). Lastly, the remarkable funerary practice of applying and stuffing the corpse with a concoction made of a gin known as ‘schnapps’ and ‘Acheampong’ (*Chromolaena odorata*) leaves to delay autolysis and putrefaction before the advent of the orthodox mode of preserving the dead in the morgue before burial. Of note, families who do not have the luxury of affording a space in the mortuary for their deceased still adopt this practice in the community (Lamptey, 2019, p. 19). These works have undoubtedly revealed more details about the behavioral, cultural, and environmental factors that imprint one’s life course.



**Figure 2. 8: i) Complete alveoli resorption with occlusal wear on available teeth. ii) trephination on the skull of an old adult (Figures 5.12 and 5.11, respectively in (Lamptey, 2019).**

Human skeletal remains should be regarded as a material culture with historical significance (Sofaer, 2006) because of the agency they embody as evidence or 'windows' to the past that archaeologists strive to unravel about contemporary societies through material remains such as ceramics, beads, and shells. Since this aspect is so minimally represented in Ghanaian archaeological practices, so has the assimilation of bioarchaeology, funerary archaeology, or archaeoethanatology been delayed. Within these contexts, understanding the plasticity body and its materiality will aid the understanding of the lifeways of past populations (Sofaer, 2006), where the bones are actively transformed from just bodies into substantial agents of aspects of history (Sofaer, 2006, p. 77). As the body is influenced by biological, cultural, social, and environmental factors (Ingold, 1998, pp. 26–27; Sofaer, 2006, p. 77; Thomas, 2002, p. 33), so are all practices, including funerary.

The concept of 'plasticity' as a critical variable in bioarchaeological studies (Sofaer, 2006) and studies on human biology, changes, and adaptations have been referred to as the "systematic changes within a person in his or her structure and/or function" (Lerner, 1984, p. xi) or the ability to be molded. Consequently, change is expected through conscious and unconscious choices made during a life course, and the body's characteristics will be the evidence of idiosyncratic choices. These characteristics are further registered in the bones and can be read for the individual's life history (Weiss, 2017). Advances in the archaeological practice are on-course, incorporating bioarchaeology, individual identity and variation, the life course, and social theory (Baker & Agarwal, 2017); the bioarchaeology of care (Tilley, 2015; Tilley & Oxenham, 2011; Vlok et al., 2017); pathologies and their medical or epidemiological significance (Baker & Bolhofner, 2014; Marsteller et al., 2011; Vlok et al., 2017), as well as funerary studies (Duday et al., 2009, 2014; Nilsson Stutz, 2016; Stutz, 2010, 2018; Tiesler, 2007, 2013).

The objective of 'archaeoethanatology' is to reconstruct the attitudes of ancient populations toward death by focusing on the study of the remains of the body and analyzing activities linked to the management and treatment of the corpse (Duday et al., 2009, 2014).



Archaeoethanatology posits that burials or contexts with human remains should begin with the body as the center of interest (Duday et al., 2009, 2014). This is not to undervalue grave goods because, like the body, they play significant roles in interpretations and reconstructions, from relative chronology to the status and the socio-cultural affiliation of the decedent or burial. Archaeoethanatology goes beyond focusing on the loss of a social being (Stutz, 2008, 2010, p. 33), as traditional discussions of the archaeology of death projected. It involves factors including the body itself and conceptualizations about death. Such ideologies are represented in the material relics of funerary practices, shedding light on faith or religious affiliations, social organization and activities (including rituals), and hierarchy of political power among the living and employed as a strategy to express and overcome grief and bereavement. Thus, the material and behavioral culture associated with mortuary practices are noteworthy in archaeoethanatomical discussions. Archaeological investigations across the borders of the country do take cognizance of the context of burials upon discovery: the elements present/absent, placement and orientation of the body, the direction of the face for religious connotations, particularly the North-south, facing the East orientation for Muslim burial); categories of grave goods for status relations; composition and placement of grave goods for ritual associations and necrophobic inferences.

## **2.8 CONCLUSION**

Currently, Ghanaian archaeology incorporates some archaeoethanatomical dynamics into assessing the archaeological record containing human remains. The interpretive framework extends beyond the analysis of material cultural relics to include burials by considering the quality and quantity of grave goods, the orientation of the decedent, the individual and community sensitivities, and cultural perceptions of death, funerary practices, and handling of the decedent. With much funding, Ghanaian archaeological practices can extend the tentacles to include a more comprehensive bioanthropological study of human remains, bearing in mind that osteobiographies are more reliable and complementary sources of information on cultural and biological characteristics.

## **CHAPTER 3**

### **BEYOND BONES, NOT OBJECTS**

#### **2.9 OVERVIEW**

This chapter sought to humanize the remains, involving the determination of the minimum number of individuals (MNIs) in each assemblage from the respective sites and the assessment of the osteobiography (age, sex, stature, skeletal and dental pathologies, activity-induced markers, as well as non-metric skeletal traits) of the individuals to recount at least some aspects of their life course. In addition to the osteobiography of the individuals, some details on the funerary enterprise of the inclusion of grave goods were recorded ([Chapter 1 of this part](#)).

#### **2.10 INTRODUCTION**

As mentioned, the primary research data is the human skeletal remains in the museum's storage. The remains represent individuals who were once alive with inherent dignity (Walker, 2000), and it was my responsibility to dignify them by objectively observing and assessing the various characteristics that personalize them. There is one justifiable possibility for the appreciation and involvement of human remains in their appropriate contexts in research. That is to view them in their materiality as voices to the past and agents of and with sociocultural embodiment (Sofaer, 2006; Stutz, 2008, 2018). As the body interacts with the culture developed within specific or multi-environments, the biological absorbs the cultural experiences of the individuals. In almost all cases, the biological makeup influences cultural preferences, but cultural orientation shapes or can alter biological characteristics over time. Living human subjects are the best proxies for their life experiences, and so are the dead. Even after the decomposition of one feature of the body (the soft tissues) and the breakdown of the social and gendered framework, the other (the skeleton) is capacious to illuminating aspects of the life course as experienced by the individuals they represent. Because the

biological and the cultural are variably enmeshed, the imprints thereof can be inferred from the bilateral analysis of the two or the unilateral scrutiny of one. If we lose interest in the body, we stand the chance of neglecting possible answers and solutions to past individual and population ideologies, preferences, practices, and engagements.

The place of skeletons in interpretive archaeology is more of active voices than silent static artifacts. The materiality of bones permits complementary and objective access into the life course: personhood, cultural preferences/ behavior, health, and interactions with the environment and other factors. As noted earlier, who/what tells your life story better than yourself? Other than the people themselves, not what they have used or what others think of them, but what they present from imprinted experiences. If we desire an all-inclusive archaeology, it ought to be an all-inclusive appreciation of the content of the archaeological record, the detailed analysis of contexts, and the finds. From the perspective of culturally organized practice and environmental influences, biological adaptations, assimilation, and acclamation can be deduced from the bone of the individuals who directly or indirectly practiced and experienced it.

## **2.11 METHODOLOGY**

Anthropological assessment of the remains provided insights into the osteobiography (sex; age; pathology, activity, and trauma). The methods for the various aspect of the anthropological assessment have been categorized below, and the coding systems used have been summarized in Tables 2.3-2.11. Biological anthropometric and non-metric observations provided data on the osteobiographies. In addition to the osteobiographies, substantial information on the funerary enterprise, including grave goods associated with the remains, was recorded. Radiocarbon dating of YP'18 73. 106 was intended for a relative date for the remains.

Anthropological data was recorded, considering possible skeletal variations between the

regions regarding pathologies and activities. According to Bonogofsky (2011, p. 182), geographically distinct populations will present inter and intra-dichotomies and similarities among samples via anthropometric or nonmetric examinations. Craniometrics was not employed for variability analysis in the study because it is not an objective of this research, and about 60% of the remains were fragmentary. However, non-metric observation of factors such as masticatory behavior, dietetics, pathology, and activity in general, capable of influencing variability in individuals, was looked at. Individual variations in skull shape may result from multiple factors, including masticatory, dietary, technological influences, and age (Bonogofsky, 2011, pp. 24–25). Regarding sex, cranial width increases slightly in middle-aged women and widens significantly in the vaults of older men due to masticatory processes (Sjøvold 1995). However, the masticatory function is dependent on environmental food resources. Aging also influences craniofacial robusticity, where older females tend to mimic adult males and vice versa. Pathologies and activities are also capacious in changing the morphology of individual skeletons in terms of reduced bone mass and general skeletal integrity, which may sometimes mislead age estimations. The methods for the anthropological assessments have been sectioned below.

### **2.11.1 Radiocarbon Dating**

C14 was also carried out at Beta Analytic Testing Laboratory, Miami-USA. All the work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), was corrected for total isotopic fraction, and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% of the <sup>14</sup>C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1-sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively

rounded to 30. The Conventional Radiocarbon Age was corrected for total fractionation effects, and where applicable, calibration was performed using the 2020 calibration database INTCAL20 (Reimer et al., 2020) and Ramsey's (2009) probability method.

### **2.11.2 Method for MNI: Skeletal and Dental Inventory**

As part of the MNI, non-metric observation of the remains to determine the various elements present and absent was studied by White and Folkens (2005) and White et al. (2011). It involved inventorying both cranial and post-cranial skeletal components present and absent using the scoring system of Buikstra and Ubelaker (1994) compared with Osteoware (Table 2.3). The MNIs in each burial box from the respective sites were noted, and the available provenience information associated with the human remains was reviewed. The taphonomy of the skeletons: surface and bone condition, bone color and secondary coloring, curatorial modification, and adherent materials of the skeletal samples were assessed to provide the basis for determining bio-histories and pathologies. The dental inventory of the teeth in the maxilla and mandibles was scored against Buikstra and Ubelaker (1994, p. 49) (Table 2.4). Also, isolated teeth were recorded. Note that to create a conforming chart, the coding for the completeness of the remains was interchanged, but the code depictions remained the same (see Table: 2.3). Only skeletal elements above 20% completeness which could be sided were drawn on the inventory sheet adopted from (Roksandic, 2003) and modified by the author (Appendix B).

**Table 2. 3: Coding for Elements Present & Completeness**

<b>Score: on the inventory sheet</b>	<b>Buikstra and Ubelaker, 1994 :p.7</b>	<b>Osteoware</b>	<b>Score: to create the chart</b>
<b>0</b>	missing	(Blank )	<b>0</b>
<b>1</b>	>75% present	Complete; cortex intact (At least 75% of the bone is present)	<b>3</b>
<b>2</b>	25-75% present	Partial or Damaged (25 - 75% of the bone is present)	<b>2</b>
<b>3</b>	<25% present	Fragmentary or badly eroded (less than 25% is present)	<b>1</b>

**Table 2. 4: Coding for Dental Inventory**

<b>Score</b>	<b>B&amp;U Table 2, p. 49</b>
1	present, not in occlusion
2	present, in occlusion (in alveolus)
3	missing tooth and alveolus
4	missing tooth, alveolus resorbing or fully resorbed (antemortem loss)
5	missing tooth, alveolus is not resorbing (postmortem loss)
6	missing, congenital
7	present, too damaged to be measured
8	present, unobservable (e.g., in a crypt)

### **2.11.3 Methods for Biodata: Age & Sex Determination**

The determination of age, and sex, form part of the osteobiography of a skeletal sample of a John-Doe or Jane-Doe (the name given to an unidentified male or female skeleton, respectively). There is a tone of research on these variables leading to multivariate methods for determining the sex and age of human remains. Skeletal components during life undergo a series of age and sex-related morphology or changes resulting from growth and bone remodeling, and the resulting alteration/ morphogenesis is evident at the gross and microscopic levels (Ortner & Putschar, 1981). According to Ortner and Putschar (1981, p. 30), all age determination methods collaborate to establish the link between morphological changes in the skeleton and the individual's age at the time of death. Non-metric observations against standard descriptions of specific cranial and post-cranial skeletal markers enabled age determinations and sex estimation.

Age-at-death determinations were assessed using cranial-suture closure composite ectocranial scores of the Vault and Lateral-Anterior sites for comparative results (Meindl & Lovejoy, 1985). This method was used on only 5% of the remains. Additional methods included observing and coding the appearance and fusion of the epiphyses of bones as well as other secondary ossification centers (apophyses) using Buikstra and Ubelaker (1994, pp. 40–42) and Schaefer et al., (2009) for fusion age. The last methods for age-at-death estimation were the observation of the morphology of the pubic symphysis according to Todd (1921) (only possible in one case) and the morphology of the auricular surface of the sacroiliac joint (Buikstra & Ubelaker, 1994, pp. 25–32; Lovejoy et al., 1985, pp. 18–27). Where possible, Age-at-death was assessed based on dentition; the development or eruption sequence was compared against the method in Buikstra and Ubelaker (1994, pp. 50–51). Teeth are resilient to taphonomic processes in the archaeological record and are reliable for many comparative and evolutionary studies because of their adaptive significance to the individuals' age, health, diet, and environment (White et al., 2011). To fully identify a tooth, the variables to be recorded are the tooth category (incisor, canine, premolar, or molar); dentition type (permanent or deciduous); upper or lower arcade (White et al., 2011, p. 103).

	<b>Buikstra and Ubelaker, 1994: p. 32 - 35</b>		<b>Osteoware on Mann 1991</b>	<b>Mann et al., 1991 Co-obliteration</b>			<b>Buikstra and Ubelaker, 1994: p. 41</b>
<b>Score</b>		<b>Suture</b>	<b>Age of fusion</b>		<b>Years</b>	<b>Score</b>	
<b>0</b>	Open suture	IN	20-25		<20	<b>0</b>	Open: epiphysis & diaphysis are completely separate; no bony union.
<b>1</b>	Minimal closure	AMP	50+	IN	20-24	<b>1</b>	Partial fusion/union
<b>2</b>	Significant	PMP	25-35	IN+PMP	25-29	<b>2</b>	Complete fusion: all aspects of the epiphysis are united
<b>3</b>	Complete	TP	Lateral 35+, medial 40+	IN+PMP+TP	30-50	<b>9</b>	Unobservable/ trait or element missing
<b>9</b>	Area missing/trait unobservable						

**Table 2. 5: Age Determination: Cranial-Suture Closure & Post-Cranial Fusion**



**Table 2. 6: Age Determination: Ecto-Cranial Composite Scores (Meindl & Lovejoy, 1985)**

<b>Vault sites</b>	<b>Composite score</b>	<b>Mean age</b>
Mid-lambdoid	1-2	30.5
Lambda	3-6	34.7
Obelion	7-11	39.4
Anterior-sagittal	12-15	45.2
Bregma	16-18	48.8
Pterion	19-21	51.1

<b>Lateral-anterior sites</b>	<b>Composite score</b>	<b>Mean age</b>
Pterion	1	32.0
Midcoronal	2	36.2
Sphenofrontal	3-5	41.1
Inferior Sphenotemporal	6	43.4
Superior Sphenotemporal	7-8	45.5
	9-10	51.9
	11-15	56.2

**Table 2. 7: Age Determination: Auricular Surface Morphology (Buikstra & Ubelaker, 1994, p. 25; Lovejoy et al., 1985)**

<b>Phase</b>	<b>Age</b>	<b>Description</b>
1	20-24	Billowing and very fine granularity.
2	25-29	Reduction of billowing, but retention of youthful appearance.
3	30-34	General loss of billowing, replacement by striae, and distinct coarsening of granularity.
4	35-39	Uniform coarse granularity, reduced billowing, and striae. Transverse organization poorly defined; slight retro-auricular activity; no macro-porosity.
5	40-44	A transition from coarse granularity to a dense surface; may take part over islands on the surface of one or both faces. Occasional macro-porosity; may depend on the degree of densification. Slight to moderate retro-auricular activity.
6	45-49	Completion of densification with complete loss of granularity; no transverse organization, billows, or striae.
7	50-59	A dense irregular surface of rugged topography and moderate to marked activity in the pre-auricular areas.
8	60+	Breakdown with marginal lipping macro-porosity; increased irregularity & marked activity in pre-auricular areas.

Sex estimations were carried out by direct non-metric observation in conjunction with standard classifications and descriptions of specific craniofacial and pelvic skeletal indicators. The pelvis was the main target, recognized as the best criteria for sex determination (White et al., 2011), with an 85%-95% accuracy compared to the skull, with a 45-55% accuracy. The pelvis features used for the determination are the greater sciatic notch, characteristics of the subpubic region, and the periauricular sulcus. The pelvis reflects fundamental differences in anatomy and functions associated with reproduction (childbearing). For instance, the shape and dimensions of the sacrum, in conjunction with the pelvic inlet and outlet of the female, reflect the childbearing function. However, caution should be taken because genetics could alter one's pelvic outlook; some females may have an androcentric pelvis. Craniofacial markers were used as secondary support (Stuart-Macadam & Kense, 1982) or as a primary approach in cases where the pelvis was absent.

Notwithstanding the margin of accuracy with using the skull and pelvis characteristics, the research considered both for assessing sexual dimorphism. In their absence, the general rule-of-thumb for sexual dimorphism that male bones are more robust than females (Nikita & Karligkioti, 2019) was used but with caution because robustness is relatively influenced by idiosyncratic and culturally-specific activities across populations. In cases where only the skull was assessed for sex determination, a '?' is attached to the estimate to indicate a low accuracy. The observations were scored according to standard descriptions and methods discussed in Buikstra and Ubelaker (1994, pp. 18–21), Tables 2.8 and 2.9, respectively. Determination of the sex of immature individuals was not attempted.

**Table 2. 8: Sex Determination- Skull**

<b>Score</b>	<b>Buikstra and Ubelaker, 1994: p. 20 &amp; 21</b>	<b>Ferembach et al., 1980: p. 523</b>	<b>Ascadi &amp; Nemeskeri, 1970</b>
<b>0</b>	Undetermined sex (insufficient data available)	<b>Score: 1-5</b>	<b>Score: 1-5</b>
<b>1</b>	Female	(rather than -2 to +2)	(rather than -2 to +2)
<b>2</b>	Probable female		
<b>3</b>	Ambiguous sex		
<b>4</b>	Probable male		
<b>5</b>	Male		
<b>9</b>	Unobservable/trait missing.		

**Table 2. 9: Sex Determination- Os Coxae**

	<b>Greater Sciatic Notch</b> Buikstra and Ubelaker, 1994: P. 18.		<b>Elements of the Subpubic Region</b> Buikstra and Mielke, 1985 & Phenice, 1969.		<b>Preauricular Sulcus (PS)</b> Buikstra and Ubelaker, 1994: P. 18.
<b>Score</b>		<b>Score</b>		<b>Score</b>	
<b>0</b>	Undetermined sex (insufficient data)	<b>0</b>	Undetermined sex (insufficient data)	<b>0</b>	Not defined/ Absence of Preauricular sulcus
<b>1</b>	Typical female	<b>1</b>	female	<b>1</b>	PS present; wide; exceeding 0.5 cm and deep; intersected by bony ridges/ composed of a series of lobes; extends along the entire length of the Inferior auricular surface (IAS).
<b>2</b>	Female	<b>2</b>	Ambiguous	<b>2</b>	PS present; broad; greater than 0.5cm but shallow; irregular groove base; bony ridges may be present; extends along the entire length of the IAS.

<b>3</b>	Ambiguous	<b>3</b>	Male	<b>3</b>	PS is well defined but narrow; less than 0.5cm deep; walls either undulating /smooth; extends along the entire length of the IAS; sharp narrow bony ridge present on the inferior edge of the PS.
<b>4</b>	Male	<b>9</b>	Unobservable/ Trait missing	<b>4</b>	PS is narrow, less than 0.5cm; shallow and smooth wall depression; lies below only the posterior part of the auricular surface; sharp bony ridge may be found on the inferior edge of the sulcus; if present, it doesn't extend to the entire length of the sulcus.
<b>5</b>	Typical male				

### 2.11.4 Methods for Biodata: Stature

Although the metric analysis was limited in the research due to the fragmentary nature of the cranial and postcranial remains, about 57% of the total assemblage, stature was assessed for only two adult individuals from Yapei and Begho which had an overall code of completeness of about 90%. Calculations were made using the complete femora, tibiae, and humeri of the two individuals against Trotter & Gleser (1952) and Bass (1995) for Black females and males, respectively. Calculations are considered approximations with significant error margins. The measurements were not taken with an osteometric board, but a long centimeter rule and the results were converted to meters.

**Table 2. 10: Formula for Stature Estimation**

<b>Element</b>	<b>The equation for Blacks Females, Trotter &amp; Gleser, 1952: 495, 1977: 355).</b>	<b>The equation for Blacks Males, Bass 1995.</b>
Femur	$2.28 (\text{femur in cm}) + 59.76 \pm 3.41$	$2.10 (\text{femur in cm}) + 72.22 \pm 3.91$
Tibia	$2.45 (\text{tibia in cm}) + 72.65 \pm 3.70$	$2.19 (\text{tibia in cm}) + 85.36 \pm 3.96$
Humerus	$3.08 (\text{humerus in cm}) + 64.67 \pm 4.25$	$2.88 (\text{humerus in cm}) + 75.48 \pm 4.23$

### **2.11.5 Methods for Biodata: Pathology**

Diagnosing dental and skeletal pathologies are categorized as part of the bio-history of skeletal samples. There is a tone of research on these variables leading to multivariate methods for determining pathology. For skeletal pathologies, the study used Buikstra (2019a), Buikstra & Ubelaker (1994, p. 115), Nikita (2016) Nikita & Karligkioti (2019) & Ortner (2003). Dental pathologies such as dental wear of the incisors, canines, premolars, and molars were recorded according to Buikstra & Ubelaker (1994, pp. 52–53). Other studies were consulted for more information on the different pathologies observed on remains.

Other dental pathologies assessed were caries, calculus, abscess, and hypercementosis through non-metric observation of the maxillary and mandibular teeth. Caries were observed on the occlusal and interproximal surfaces, at the cemento-enamel junction, and the roots of teeth. The absence or extent of the pathology was coded according to the modified anthropological non-metric coding of Buikstra and Ubelaker (1994, p. 55). Calculus was assessed on teeth in occlusion and isolated at the buccal, lingual, and interproximal surfaces. The absence and amount of mineralized plaque accumulation were coded according to Buikstra and Ubelaker (1994, p. 56). Abscess (a fenestration or drainage channel in the alveolar at the root apex) was observed on the buccal and lingual surfaces of the maxillae and mandibles, laterally and bilaterally, according to Buikstra and Ubelaker (1994, p. 55). However, rating the presence and absence of abscesses based only on visible canals may limit the prevalence assessment of the lesion among populations (Ogden, 2007, p. 28) because some cases do not present external fistulas. While dental enamel hypoplasia was recorded based on the number of hypoplastic lines and pits on the teeth after (Bereczki et al., 2019, p. 182), hypercementosis was noted based on the thickness and opacity of the teeth roots.



### **2.11.6 Methods for Biodata: Trauma**

To note trauma on the skeletal remains, antemortem and perimortem blunt and sharp (including high-velocity projectile) force impact on the skeletal series were considered. The assessment was to look for fractures (healed, in the early stages of healing, or with no signs of recovery), scrape and cut marks, projectile entry, and exit points, etc. The intent was not to establish the cause of death but to note any traumatic signatures left on the skeleton resulting from activities or general causes. Ante-mortem trauma refers to any defects or injury to the bone before death; these undergo significant healing responses as the person continues to live due to bone remodeling. Other factors, such as the age, and health of the individual, the location of the injury, and the severity of the injury (Wedel & Galloway, 2013), play a part in the healing and preservation of the trauma on the bone or the section of injury.

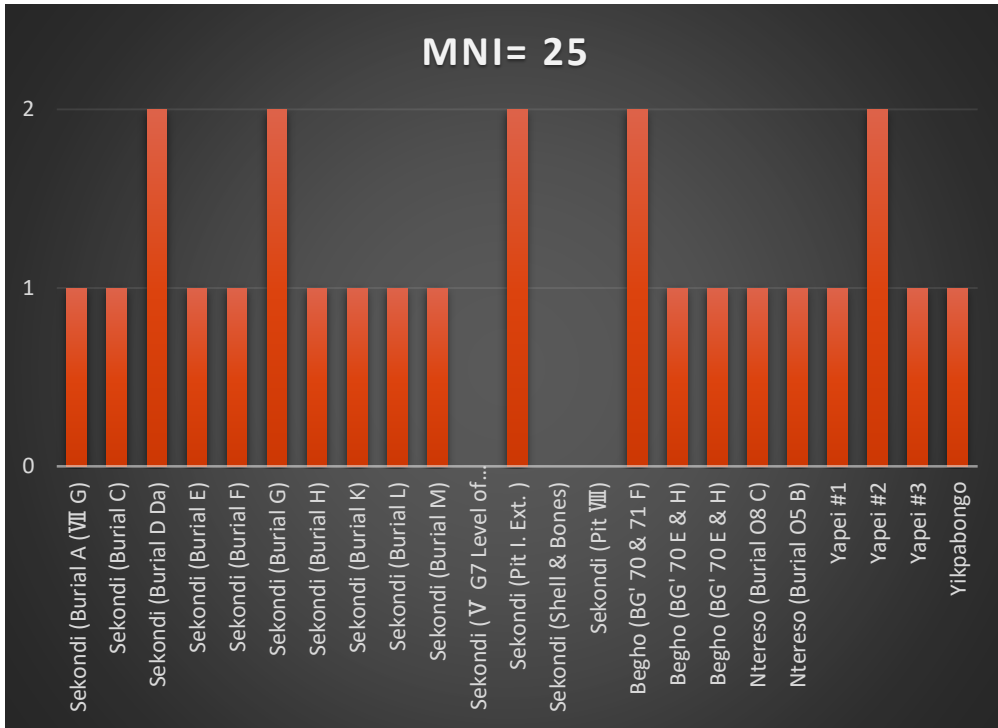
On the other hand, perimortem traumas are defects or impacts to the bone near death or causing death. These, unlike antemortem traumas, do not show signs of healing. Perimortem trauma is mostly associated with the manner of death (Sauer, 1998). They are, however, more prone to being confused with post-mortem breaks on dry bones (with considerable loss of moisture, less bone flexibility, and the ability to absorb strain/pressure on the bone) because of the relatively no sign of healing response and sharp edges. But Wedel and Galloway (2013, p. 50) outlined some criteria for differentiation: staining /color of fractured surfaces, location of the injury, fracture pattern and angle, context-dependent damage or clues, such as carnivore modification, excavation damages, taphonomic alterations and the analysis of clothing or skin for bullet holes (in forensic cases). Post-mortem breaks and taphonomic destructions such as weathering, compression, including scavenger activities (gnawing marks and teeth perforations) were observed through the lens of Buikstra & Ubelaker (1994, pp. 95–106).

### **2.11.7 Ethnographic Research**

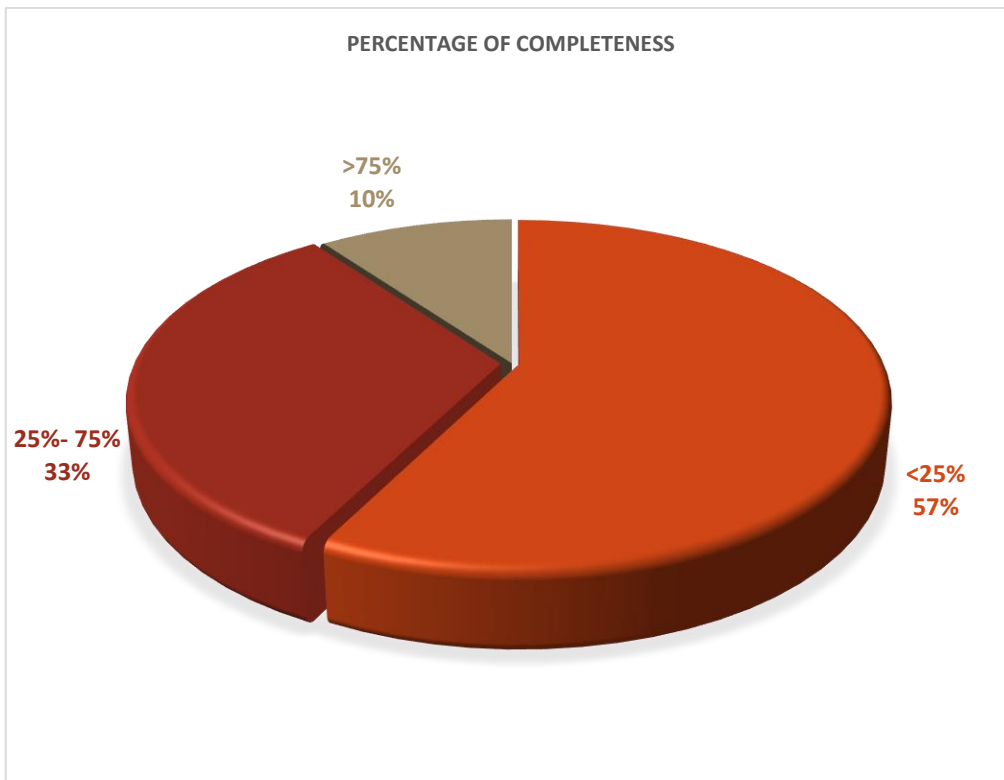
Ethnographic data were collected at Sekondi, Ntereso, and Yapei in 2022. For Begho, the ethnographic data in 2019 of 88 respondents were consulted. These involved semi-structured individual interviews and focus-group discussions (of 2-9 persons) to gather emic viewpoints on archaeoethanatomical practices (funerary archaeology), settlement and disease history, and cultural practices. The research employed random, purposeful, and snowballing sampling strategies. Direct ethnographic research at Yikpabongo was not conducted; 2017 field observations and personal conversations with three Komaland researchers were useful. At Yapei, 54 people were interviewed: 31 were old adults, 18 were middle adults, and five were young adults at 33: 21 male-female proportion. The 48 respondents at Ntereso were 29 old adults and 19 middle adults at a 28:20 male-female ratio. Additionally, 56 people (22 males & 34 females) were interviewed at Sekondi. The ratio of old adults to middle adults was 26: 30. The approach enabled a blended perspective in the comparative analyses.

## **2.12 RESULTS- *BIOLOGICAL ANTHROPOLOGICAL ASSESSMENT***

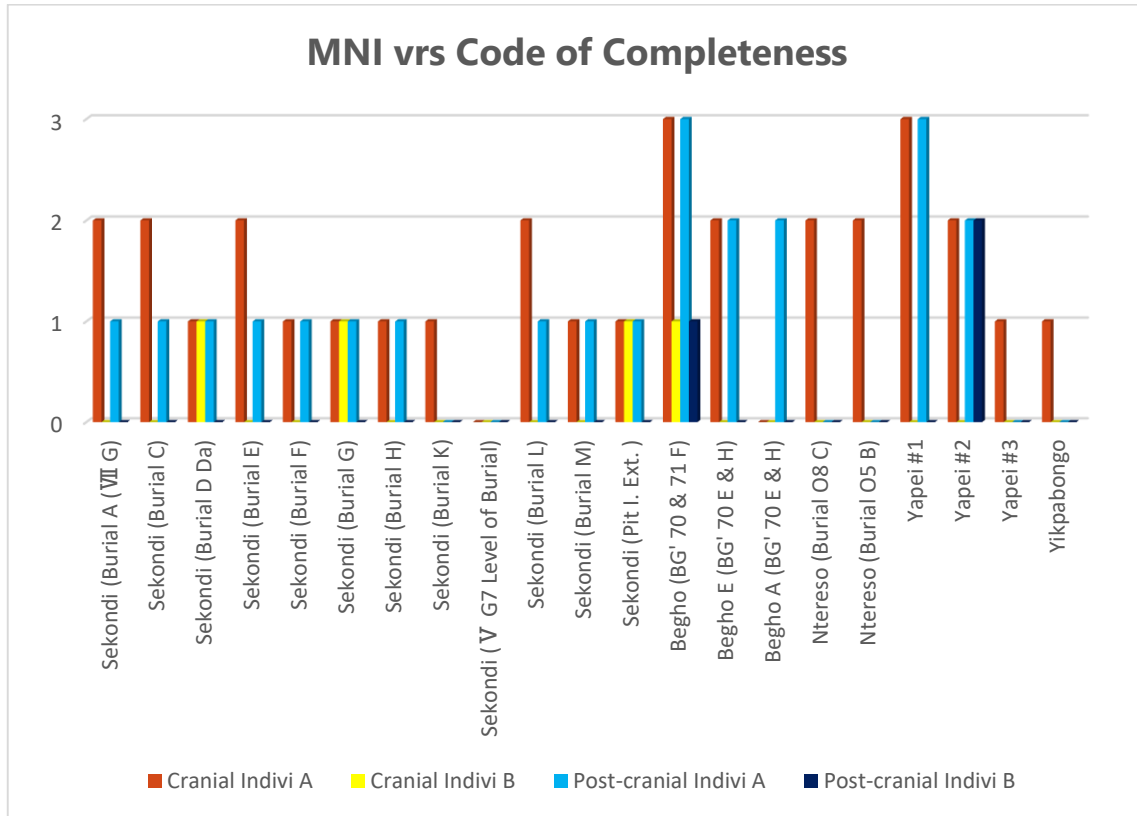
The anthropological assessment of the human remains from the five sites revealed the MNIs as 25 individuals. From Sekondi were 14 individuals, Begho, four individuals, four from Yapei, two from Ntereso, and one from Yikpabongo (Chart 2.1). References to the anthropological data of the various individuals have been presented below in Tables: 2.13.1-2.17.1. Secondly, from a total of 25 individuals, 10% were > 75% complete, 33% were between 25%-75% complete, and 57% were very fragmentary (of <25% complete), including assemblages that had multiple individuals (Charts 2.2 & 2.3). The skeletal collection comprised 12 adults with unassigned age categories due to limited skeletal elements and indicators for aging resulting from extreme fragmentation. Notwithstanding, there was one fetus, one infant, one child, one adolescent, two young adults, six middle adults, and one old adult (Chart: 2.4). Sex determination using the pelvis (of about 85%-95% accuracy compared to the skull) 2:2 ratio of males to females, while for those of a lesser accuracy (45%-55%) using the head is 2:6, males and females. However, the sex of 13 individuals was undeterminable (Chart: 2.5). Stature estimation for 57% of the remains was limited due to the fragmentation of postcranial bones. Only the stature of 2 individuals was determined: Begho BG'21-F 73.116 (70 B1) using the right femur and Yapei YP'18-73.106 using the left femur and left tibia.



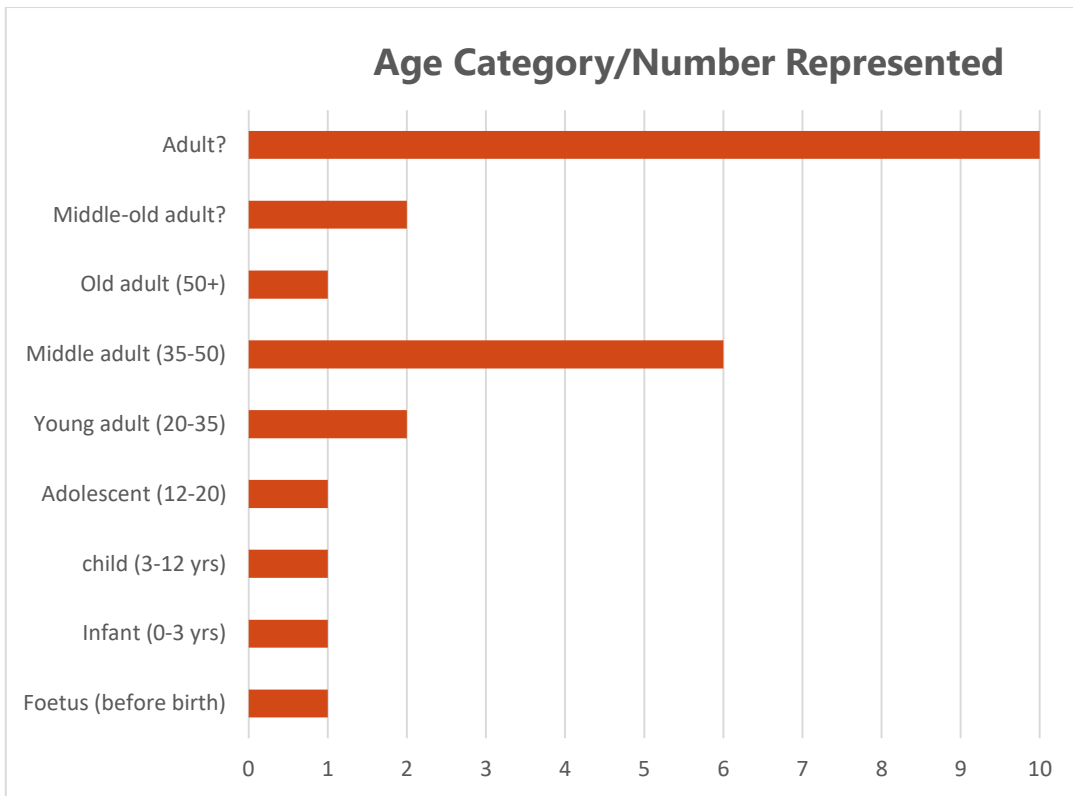
**Chart 2. 1: The minimum number of individuals per site.**



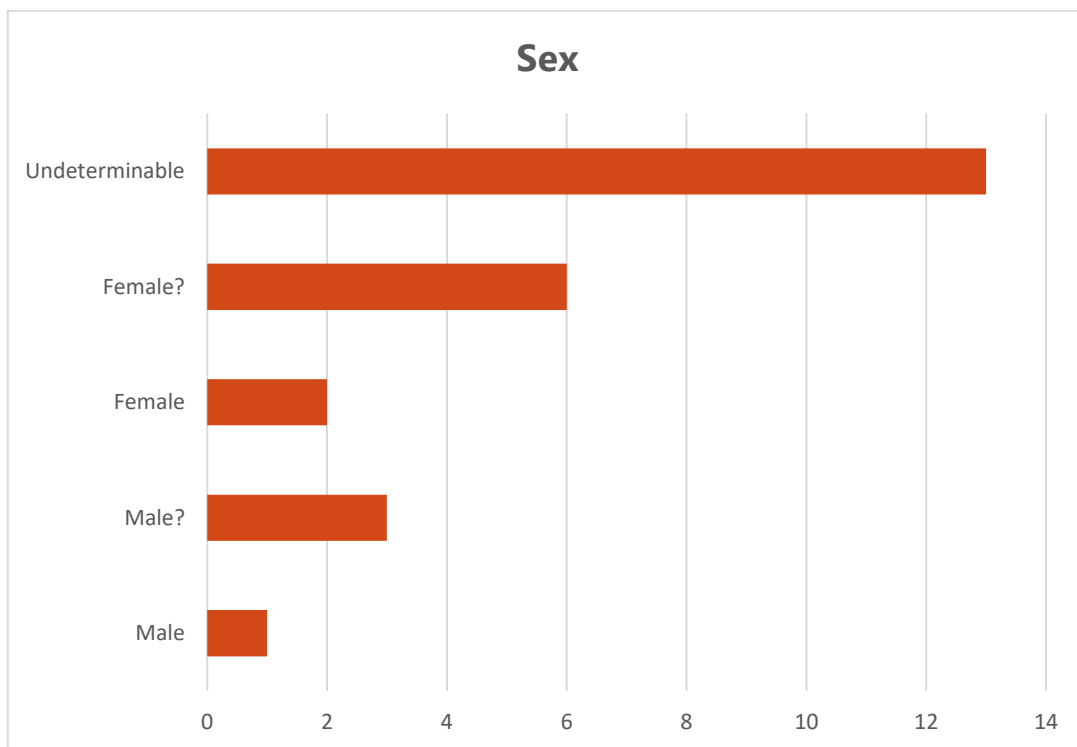
**Chart 2. 2: General percentage of completeness.**



**Chart 2. 3: The number of individuals per site and their code of completeness according to cranial and postcranial bones. 0 = unavailable/missing, 1 = <25% complete, 2 = 25%-75% complete, and 3 = > 75% complete.**



**Chart 2. 4: Age estimated and number represented among 25 MNI.**



**Chart 2. 5: Sex determined for 25 individuals.**

Trauma assessment of the individuals was limited due to the fragmentary nature of the human remains. With much certainty, no antemortem fractures were observed; of the 33% of almost complete remains, no blunt or sharp force trauma was identified on cranial and post-cranial bones. It should be noted that the very fragmentary nature of about 57% of the remains grossly limited trauma assessment. However, some antemortem defects like high porosity (with pitting) and bone exostosis/ myositis ossificans evident on the remains were associated with hyper-vascularization of joints and muscle attachment points resulting from muscle detachments. Nonetheless, these were recorded as pathologies. No trauma in the perimortem context was identified among the skeletal samples from all five sites in both well-preserved and poorly-preserved remains.

Comparatively, the study samples were characterized by post-mortem breakage/destruction either from the burial environment by soil compression and taphonomic processes or tool impact from the excavation process. Also, significant weathering was observed on the fragmentary postcranial bones. Most of the remains were in smaller fragments and exhibited crumbling and compression defects, making it impossible to identify or side- a typical characteristic of post-mortem fractures (Galloway, 1999). There were no gnawing marks on the remains. However, there were four canine carnivore tooth perforations on the proximal section of the left fibular of a middle adult male from Begho. Likewise, three canine carnivore tooth perforations on the proximal section of the left femur were found on a young adult female from Yapei.

The anthropological assessment recorded 16 pathologies on the skeletal remains. These pathologies ranged from dental to bony lesions represented among the 21 individuals (NB: the remaining four are the 2<sup>nd</sup> individuals of <25% complete, who showed no lesions) (Chart: 6). Dental pathologies constituted 60%, while skeletal pathologies were 40%. Of the 16 pathologies, porous hyperostosis was prevalent in 13/21 individuals from Begho, Ntereso, Sekondi, and Yapei, accounting for 18% of the total pathologies. Of the four sites, porotic hyperostosis was found on two of three individuals from Begho (Tables: 2.14.1 & 2.14.2); on

one Ntereso individual (Table: 2.15.1); on two Yapei individuals (Tables: 2.16.1 & 2.16.2), but high on eight out of the 11 individuals from Sekondi (Tables: 2.13.1, 2.13.2, 2.13.3 & 2.13.5-2.13.10). Osteoarthritis constituted 4% of the total pathologies, represented in Begho (Table: 2.14.1) and Yapei (Tables: 2.16.1 & 2.16.2) individuals. Other pathologies observed included bone exostosis, lice infestation, sinus inflammation, negative enthesopathy, hypervascularization, hypercementosis, spina bifida occulta, thalassemia, and Allen's fossa ranged between 1%-4%.

Calculus prevailed in 15/21 individuals making 21% of the total assemblage. It was found present between the stages of minimal and medium in 10 individuals (Tables: 2.13.1- 2.13.7 & 2.13.9- 2.13.11) from Sekondi and two Yapei individuals: YP'18-73.105 (Table: 2.16.2) & YP'18-73.106 (Table: 2.16.1), and Begho individual BG'21-E 73.115 (Table: 2.14.2). Besides, calculus was expressed between the stages of minimal to large in Begho individual BG'21-E 73.116 (Table: 2.14.1), in Ntereso individual NT'18-73.91 (Table: 2.15.2) and Sekondi individual SK'21-H 73.84 (Table: 2.13.7). Dental caries was 18% in 13/21 individuals. To begin with, caries was present in all but individuals SK'21-E 73.82 (details in Table: 2.13.4) and SK'21-K 73.85 (Table: 2.13.8) of the Sekondi assemblage; also observed in two of the Yapei individuals: YP'18-73.105 (Table: 2.16.2) & YP'18-73.106 (Table: 2.16.1) and in Begho individual BG'21-E 73.115 (Table: 2.14.2). Caries was absent in BG'21-E 73.116 (Table: 2.14.1) and BG'21-A 73.118 (Table: 2.14.3). While caries was present in the isolated teeth of NT'18-73.91 (Table: 2.15.2), it was unobservable in NT'18-73.90 (Table: 2.15.1) because the teeth were in occlusion, held together by the soil in the endocranial cavity.

The rest of the dental pathologies followed as enamel hypoplasia, abscess, and cementum hyperplasia in the order of prevalence. Enamel hypoplasia is 13%, common in 9/21 individuals. One to two hypoplastic lines were found on the teeth of Sekondi individuals (details in Tables: 2.13.1, 2.13.3, 2.13.6 & 2.13.8) and also present on the teeth of Begho (Tables: 2.14.1 & 2.14.2), Ntereso (Table: 2.15.1) and Yapei (Tables: 2.16.1 & 2.16.2) individuals. Lastly, abscess constituted 6%, observable in the mandible of Sekondi burial F (Table: 2.13.5),



bilaterally in the mandible of Begho individual BG'21-E 73.115 (Table: 2.14.2), and the maxilla of Yapei individual YP'18-73.105 (Table: 2.16.2). In general, the Sekondi individuals recorded the highest percentage of dental pathologies, i.e., 69% in caries, 50% in abscess, 44% in enamel hypoplasia, 66% in calculus, and 5% in hypercementosis. Begho and Yapei reported equal percentages of abscesses, enamel hypoplasia, and calculus, while hypercementosis was relatively low in all cases. Six of the 21 individuals had none of the dental pathologies, four combined caries and calculus, three combined caries, enamel hypoplasia, and calculus. Two individuals had both enamel hypoplasia and calculus, while six combined up to four dental pathologies on multiple levels of the teeth.

No dental alterations were noticed on the individuals' teeth (in occlusion and isolated). The occlusal surface changes and asymmetries, especially on the labial teeth, were due to dental wear, and changes in the interproximal regions resulted from carious lesions in pits and grooves. Likewise, cranial modifications were impossible to observe on the remains because of their fragmentary nature and the presence of compact soil in the endocranial cavity of some of the individuals. The skulls of Sekondi and Ntereso individuals with intracranial masses presented external integrities of probable compression by soil pressure from the burial environment. Only an adult male from Begho, BG'21-F 73.116 (70 B1), without intracranial mass, showed a slight asymmetry of the inter-mastoidal distance. However, this seems taphonomical rather than an intentional cranial modification.

The tables below (2.13.1- 2.17.1) present the details of the anthropological data recorded on each individual under the sections: site and identifying number, the minimum number of individuals in each box, taphonomy & bone condition, sex, age, and pathology. Additional observations and comments on the contents of each box were also noted.

### 2.13 RESULTS- *14C* DATING

No dates could be generated for the bone sample of the Sekondi individual (SK'21-F 73.94), probably not enough collagen to conclude. But the adult male from Yapei was dated to 220 +/- 30 BP, thus, between the mid-18<sup>th</sup> - early 19<sup>th</sup> C. BC (Table: 2. 11 & [Appendix B](#)).

**Table 2. 11: Radiocarbon Date for an Adult Male, Yapei-YP'18 73.06.**

Laboratory number Beta-649883	Conventional Radiocarbon Age <b>220 ± 30 BP</b>
95.4% probability	<p><b>(48.1%) 1731-1806 cal AD (219 - 144 cal BP)</b></p> <p>(35.5%) 1640-1687 cal AD (310 - 263 cal BP)</p> <p>(11.8%) 1926-Post cal AD 1950 (24 - Post cal BP 0)</p>
68.2% probability	<p>(30%) 1765-1799 cal AD (185 - 151 cal BP)</p> <p>(27.5%) 1646-1674 cal AD (304 - 276 cal BP)</p> <p>(7%) 1942-Post cal AD 1950 (8 - Post cal BP 0)</p> <p>(3.7%) 1744-1750 cal AD (206 - 200 cal BP)</p>

**SEKONDI:** there were 14 individuals from this site out of 11 boxes.

**Table 2. 13. 1: Sekondi, SK'21- A 73.80**

Site & ID	Sekondi SK'21- A 73.80
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25%-75% cranial and &lt;25% postcranial</p> <p><b>2.</b> Smooth, postmortem scrape marks on some parts and light soil residue on the surface.</p> <p><b>3.</b> Bone color is grey, with some dark grey patches on some cranial bones.</p> <p><b>4.</b> The skull looks compressed, probably resulting from soil pressure. The superior posterior parietal bones are not available. The intracranial soil stabilizes the fragmented bones.</p>
Curatorial Modifications	Some skeletal elements have been glued and are marked with black ink.
Sex	Female?
Age	<p><b>1.</b> Middle adult.</p> <p><b>2.</b> 25-29 (IN+PMP); or above?</p>
Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Frontal</b>, degree = barely discernible; location: adjacent to the sutures; activity: healed.</p> <p><b>Parietals</b>, degree = porosity only; location: adjacent to the sutures and near bosses; activity: healed + active lesions.</p> <p><b>Occipital</b>, degree = porosity with coalescence of foramina, no thickening; location: adjacent to the sutures and near bosses/in squamous, and activity: healed + active lesions.</p> <p><b>2. Calculus</b> = minimal (stage 1) on 27, medium (stage 2) on 17, 21, and large (stage 3) on 26. On isolated un-sided molars = stages 1 &amp; 2.</p>

	<p><b>Caries</b> = at the interproximal surface of 21 and Developing root caries on one of the isolated molars.</p> <p><b>Abscess</b> = none.</p> <p><b>Enamel hypoplasia</b> = none.</p> <p><b>Hypercementosis</b> = none.</p>
Additional Comments	<ol style="list-style-type: none"> <li>1. The remains were associated with greenstone flakes, ostrich shell beads, and local ceramics.</li> <li>2. The adhering soil (with glue) possibly conceals interproximal caries.</li> </ol>

**Table 2. 13. 2: Sekondi, SK'21-C 73.88**

Site & ID	Sekondi SK'21-C 73.88 (Figure: 2.2)
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25-75% cranial and &lt;25% postcranial bones.</p> <p><b>2.</b> No weathering on skull bones, but stage 1 weathering on available postcranial bones. The remains are poorly preserved.</p> <p><b>3.</b> Light brown; however, the loamy soil gives some bone surfaces a somewhat black color.</p> <p><b>4.</b> The soil in the endo-cranial keeps the fragmented bones stable. Black spot coloration on the left side of the cranium around the occipital half and available parietal and temporal bones.</p>
Curatorial Modifications	Some of the skeletal fragments have been glued.
Sex	Undeterminable.
Age	Middle- Old adult based on available dentition and extensive wear.
Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Frontal</b>, degree = barely discernible; location: adjacent to the sutures; activity: healed.  <b>Parietals</b>, degree = porosity only; location: adjacent to the sutures and near bosses; activity: healed + active lesions.  <b>Occipital</b>, degree = porosity with coalescence of foramina, no thickening, location: adjacent to the sutures and near bosses/squamous, activity: healed + active lesions.</p> <p><b>2. Calculus</b> = minimal (stage 1) on 16, 23, 33, 36, 42, 45 &amp; 47, medium (stage 2) on 13, 24, 37 &amp; 48, and large (stage 3) on 17 &amp; 27.  <b>Caries</b> = on the occlusal surface of 14, 15 &amp; 16, and at the interproximal surface of 47.  <b>Abscess</b> = none.  <b>Enamel hypoplasia</b> = one hypoplastic line on 37 and two on 13 &amp; 23.</p> <p><b>Hypercementosis</b> = general in available teeth.</p> <p><b>3.</b> Thickened and opaque roots, in addition to discoloration, suggestive of periodontal disease in the cause of life.</p>

Additional Comments	<p><b>1.</b> Two celts, one granite stone bead, one reddish locally-made glass bead, ostrich shell beads, postcranial bones consistent with the lower limb, and isolated teeth were associated with the remains.</p> <p><b>2.</b> Due to adhering soil and the fragmentary nature of the skeletal elements, a detailed inventory of the composite skull elements, estimation of sex, and age from the cranial and postcranial indicators could not be done. A CT examination was carried out.</p> <p><b>3.</b> The teeth crown of 42 &amp; 48 are concealed by calculus, and the crown of 45 is of insufficient height to observe hypoplastic lines or spots.</p>

**Table 2. 13. 3: Sekondi, SK'21- D 73.81**

Site & ID	Sekondi SK'21- D 73.81 (Figure: 2.3)
MNI	2 (two right halves of the temporal bone)
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial and postcranial bones.</p> <p><b>2.</b> Fragmentary; no significant weathering observed. Some of the bones/fragments are covered or embedded in the soil, which could be masking other possible surface conditions.</p> <p><b>3.</b> Bone color is light brown, but there are black spots on some of the fragmented cranial bones.</p>
Curatorial Modifications	Some of the cranial bones and potsherds have been glued together.
Sex	Female? for both individuals (based on two gracile right-sided mastoids)
Age	Young adult and old adult (two different wear categories for different dentitions).
Pathology	<p><b>1.</b> Porotic hyperostosis on some cranial bones: degree = porosity and coalescing foramina with increased thickness; location = adjacent to sutures and near bosses and activity = active at the time of death on some bones, healed + active lesions on others.</p> <p><b>2. Calculus</b> = minimal (stage 1) on 16 &amp; 47 to medium (stage 2) on 48, unobservable for the rest (teeth were absent).</p> <p><b>Caries</b> = at the cemento-enamel junction of 46.</p> <p><b>Abscess</b> = none.</p> <p><b>Enamel hypoplasia</b> = none. <b>Hypercementosis</b> = none.</p>
Additional Comments	<p><b>1.</b> Very fragmentary; most of the indicators of sex and age are not visible/ available to assess.</p> <p><b>2.</b> The remains were associated with ceramic sherds, shells, quartz flakes, and ostrich shell beads.</p>

**Table 2. 13. 4: Sekondi, SK'21-E 73.82**

Site & ID	Sekondi SK'21-E 73.82 (Figure: 2.5)
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25%-75% cranial bones with a mass of loamy soil in endo-cranial and soil residue on ecto-cranial surfaces, and &lt; 25% postcranial bones.</p> <p><b>2.</b> Fragmentary; black coloration on some of the bone fragments.</p> <p><b>3.</b> Bone color is brown, but some elements are dark.</p> <p><b>4.</b> Yellow coloration on the buccal surfaces of teeth.</p>
Curatorial Modifications	Some of the skeletal fragments have been glued, and some of the potsherds have been glued.
Sex	Undeterminable.
Age	Adolescent
Pathology	<p><b>1.</b> No pathologies were observed on the skull or postcranial bones.</p> <p><b>2. Calculus</b> = minimal (stage 1) on 42; Absent on the labial and buccal surfaces but unobservable on the occlusal and interproximal surfaces due to soil.</p> <p><b>Caries</b> were absent on the labial and buccal surfaces and unobservable on the occlusal and interproximal surfaces.</p> <p><b>Abscesses</b> were absent on the labial and buccal surfaces and unobservable on the lingual surfaces due to soil endo-cranial.</p> <p><b>Enamel hypoplasia</b> = two hypoplastic lines on 12, indicating intra-vitam stress or malnutrition.</p> <p><b>Hypercementosis</b> = none</p>
Additional Comments	<p><b>1.</b> This is a young individual. Some long bone epiphyses (of proxy femurs and proxy radius available) and sacral bone (S2? &amp; S3?) have not fused. However, this individual was coded as an adolescent because all permanent dentition is present. The visible billowing on the pubic symphyseal face= Phase 1? or Phase 2? Places this individual in the age range of 18-21? (according to Todd 1921).</p> <p><b>2.</b> The remains were associated with potsherds, celts, ostrich shell beads, three stone flakes, and local glass beads.</p>



**Table 2. 13. 5: Sekondi, SK'21-F 73.94**

Site & ID	Sekondi SK'21-F 73.94 (Figure 2.4).
MNI	1
Taphonomy & Bone Condition	<ol style="list-style-type: none"> <li>1. &lt;25% cranial and &lt;25% postcranial</li> <li>2. Fragmentary, no significant weathering observed. Smooth bone surfaces.</li> <li>3. Bone color is Brown.</li> </ol>
Curatorial Modifications	Some of the bone fragments have been glued.
Sex	Male?
Age	Adult (from teeth).
Pathology	<ol style="list-style-type: none"> <li>1. Porotic hyperostosis on some cranial bones: degree = barely discernible, porosity only and coalescing foramina with increased thickness; location = adjacent to sutures and near bosses/in squamous and activity = active at the time of death and healed + active lesions.</li> <li>2. The evidence of thalassemia or chronic malaria on cranial bones; was diagnosed based on the thickened cranial bones with extreme porosity (Figure: 3.2-3.4).</li> <li>3. <b>Calculus</b> = minimal (stage 1) on 15, 25, 37 to medium (stage 2) on 16 and 33.  <b>Caries</b> = at the cemento-enamel junction of 25.  <b>Abscess</b> = on the buccal surface of 35.  <b>Enamel hypoplasia</b> = none.  <b>Hypercementosis</b> = none.</li> </ol>
Additional Comments	<ol style="list-style-type: none"> <li>1. Very fragmentary; most of the indicators of sex and age are not visible/available to assess.</li> <li>2. In the box were partially reconstructed pots with sherds, Ostrich shell beads, one coarse granite scrapper, one quartz flake, one red stone, and one red-stone scrapper.</li> </ol>

**Table 2. 13. 6: Sekondi, SK'21-G 73.83**

Site & ID	Sekondi SK'21-G 73.83
MNI	2 (from different mandible pieces in size, color, and morphology)
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial and postcranial bones.</p> <p><b>2.</b> Fragmentary, smooth surfaces, no significant weathering observed, and light soil residue covering fragment surfaces.</p> <p><b>3.</b> Bone color is brown.</p>
Curatorial Modifications	Some potsherds have been glued.
Sex	Female? & Undeterminable for the 2 <sup>nd</sup> .
Age	<p>1<sup>st</sup> individual= Middle adult? (based on permanent dentition available and significant wear, code 8 for PM<sup>1</sup> &amp; PM<sup>2</sup>. However, code 2 for M<sup>3</sup>)</p> <p>2<sup>nd</sup> individual = Adult?</p>
Pathology	<p><b>1.</b> No bone pathologies were observed on available bones.</p> <p><b>2.</b> Dental: <b>Calculus</b> = minimal (stage 1) on 16, 17, 22 &amp; 27 and medium (stage 2) on 25.</p> <p><b>Caries</b> = on the occlusal surface of teeth 25 and 36.</p> <p><b>Abscess</b> = none.</p> <p><b>Enamel hypoplasia</b> = none.</p> <p><b>Hypercementosis</b> = none</p>
Additional Comments	<p><b>1.</b> The remains were very fragmented; the packaging contained mixed fragments of skeletal elements. Most of the indicators for sex and age are not available to be assessed but for a piece of the temporal bone with mastoid and supra-meatal crest.</p> <p><b>2.</b> The remains came with shell beads, shafted beads (reddish and one whitish glass bead), one fully reconstructed pot, a partly rebuilt pot, and sherds.</p>

**Table 2. 13. 7: Sekondi, SK'21-H 73.84**

Site & ID	Sekondi SK'21-H 73.84
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial and &lt;25% postcranial.</p> <p><b>2.</b> No weathering was observed on the available cranial bones. But significant weathering on the fragmented limb bones.</p> <p><b>3.</b> Bone color is white to light brown.</p> <p><b>4.</b> Poorly preserved, very fragmented, light soil residue on some cranial bones.</p>
Curatorial Modifications	Some skeletal elements have been marked with black ink.
Sex	Female?
Age	<p><b>1.</b> Young adult (significant dental wear)</p> <p><b>2.</b> 25-29 (IN+PMP); or above?</p>
Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Frontal</b>, degree: barely discernible; location: adjacent to sutures; activity: healed + active lesions. <b>Parietals</b>, degree = porosity only; location: adjacent to sutures and near bosses; activity: healed + active lesions. <b>Occipital</b>, degree = coalescing of foramina, no thickening; location: adjacent to suture and near bosses, and activity: healed + active lesions.</p> <p><b>2.</b> Dental: <b>Calculus</b> = minimal (stage 1) on 16, 17, possible 37, 38, 47 &amp; 48. Medium (stage 2) on probable 18, 26 &amp; 46 and large (stage 3) on the surface of 27 (the tooth surface is covered by what looks like calculus).</p> <p><b>Caries</b> = on occlusal surfaces of 16, 27 (the tooth surface is partly covered by what looks like calculus), and 36.</p> <p><b>Abscess</b> = none.</p> <p><b>Enamel hypoplasia</b> = 1 hypoplastic line on 36 but absent on available teeth.</p> <p><b>Hypercementosis</b> = present on available teeth roots.</p>
Additional Comments	<p><b>1.</b> The remains were associated with ostrich shell beads and three varied-sized celts.</p> <p><b>2.</b> Due to the fragmented nature of the remains, a detailed recording of various skeletal elements could not be done; only a group</p>

count is possible. **NB:** To avoid wrong siding because of glued soil on the surface and some broken crowns & roots, the count of all available teeth was =26. Thus, to record dental pathologies, only possible molars were considered, and a general assessment of all teeth present.

**3.** Abscess was unobservable in the maxilla and mandibular processes because they were unavailable. However, discoloration of teeth roots present may indicate periodontal diseases in the cause of life.

**Table 2. 13. 8: Sekondi, SK'21-K 73.85**

Site & ID	Sekondi SK'21-K 73.85
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial bones, no postcranial bones. The soil in the endocranial keeps the fragmented bones stable.</p> <p><b>2.</b> No weathering was observed on the available cranial bones.</p> <p><b>3.</b> Bone color is white/ash with dark grey coloration on some parts of the fragmented cranial bones.</p> <p><b>4.</b> Poorly preserved. A detailed inventory of the composite skull elements, estimation of sex, and age from the cranial indicators could not be done.</p>
Curatorial Modifications	Some skeletal elements have been glued and marked with black ink.
Sex	Undeterminable.
Age	Adult
Pathology	<p><b>1.</b> Porotic hyperostosis on fragmented cranial bones range from barely discernible, porosity only, and porosity with coalescence of foramina without thickening. Location = adjacent to sutures and near bosses (not certainly). Activity = active at the time of death and healed + active lesions.</p> <p><b>2.</b> Dental: <b>Calculus</b> = none  <b>Caries</b> = none.  <b>Abscess</b> = none.  <b>Enamel hypoplasia</b> = none.  <b>Hypercementosis</b> = none.</p>
Additional Comments	<p><b>1.</b> There were teeth available. Hence, assessing wear, caries, abscess, enamel hypoplasia, and hypercementosis was impossible.</p> <p><b>2.</b> A CT scan is recommended.</p> <p><b>3.</b> In the box were local glass beads, two celts, and a lump of iron slag.</p>

**Table 2. 13. 9: Sekondi, SK'21-L 73.86**

Site & ID	Sekondi SK'21-L 73.86
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25%-75% cranial and &lt;25% postcranial.</p> <p><b>2.</b> Fragmentary cranial bones, the soil endo-cranial keeps the fragments stable and light soil ecto-cranial. Very fragmentary postcranial bones. Stage 1 weathering on available bone fragments.</p> <p><b>3.</b> Bone color is light brown to ash/grey.</p> <p><b>4.</b> Dark spots on the right side of the skull, anterior-posterior. Black coloration of three mandible pieces.</p>
Curatorial Modifications	Some teeth roots have been glued. All three pots have been reconstructed; complete (1 <sup>st</sup> ) and partial (2 <sup>nd</sup> & 3 <sup>rd</sup> ).
Sex	Undeterminable.
Age	Middle adult (based on permanent dentition and extensive wear observed).
Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Frontal</b> degree = porosity with coalescence of foramina, no thickening; location = near bosses and activity = healed + active lesions. <b>Parietals</b> degree = barely discernible on some bones and porosity only on others; location cannot be ascertained; activity = healed + active lesions. <b>Temporal</b> (left) degree = barely discernible; location = temporal fossa/ adjacent to sutures, and activity: healed.</p> <p>Other locations: external acoustic meatus (superior); degree = porosity only, and activity= active at the time of death. Sphenoid: degree = coalescing foramina with increased thickness, location = left greater wing, and activity= healed + active lesions.</p> <p><b>2.</b> Dental: <b>Calculus</b> = minimal (stage 1) on 14,15, 17,18, 22, 27, 34, 35 – 38, 42 &amp; 47. Medium (stage 2) on 13, 21, 41, 46, and 48. Large (stage 3) on 11.</p> <p><b>Caries</b> = at the cemento-enamel junction of 13, mirror caries at the cemento-enamel junction of 25 &amp; 26 (reveal by CT examination), and on the occlusal surface of 42.</p> <p><b>Abscess</b> = none observed.</p>

	<p><b>Enamel hypoplasia</b> = 2 hypoplastic lines on 13 &amp; 41(although the surface is partially concealed by calculus).</p> <p><b>Hypercementosis</b> = none.</p> <p><b>3.</b> The lines of enamel hypoplasia indicate intra-vitam stress or malnutrition.</p>
Additional Comments	<p><b>1.</b> CT scan revealed a pebble of about 3 cm in the mouth, root impression in the endocranial matter, and mirror caries at the cemento-enamel junction of teeth 25 &amp; 26.</p> <p><b>2.</b> Included in the box were one whole black pot, one brown pot - reconstructed in half, and another black pot under reconstruction. Ostrich shell beads, one celt, one reddish-like glass bead, and two cowries (West African species, noted by excavator).</p>

**Table 2. 13. 10: Sekondi, SK'21- M 73.87**

Site & ID	Sekondi SK'21- M 73.87 (Figure: 2.6)
MNI	1
Taphonomy & Bone Condition	<ol style="list-style-type: none"> <li>1. &lt;25% cranial and postcranial bones</li> <li>2. Fragmentary. Stage 1 weathering on available bone surfaces.</li> <li>3. Bone color is tan to light brown; however, the soil color gives some elements a black/loamy color.</li> <li>4. Black coloration on some cranial bone fragments.</li> </ol>
Curatorial Modifications	Some cranial bone fragments have been glued.
Sex	Undeterminable.
Age	Middle-old adult? (based on significant crown loss of available teeth)
Pathology	<ol style="list-style-type: none"> <li>1. Porotic hyperostosis on some cranial bones ranging from barely discernible, porosity only, and porosity with coalescence of foramina with thickening. The location is uncertain due to the fragmentary nature of the remains, and the activity is active at the time of death with some healed lesions.</li> <li>2. Dental: <b>Calculus</b> = minimal (stage 1) on 14, medium (stage 2) on 25, unobservable for the rest (teeth too damaged to assess).  <b>Caries</b> = at the occlusal and interproximal surface of 15 and 24, respectively.  <b>Abscess</b> = none.  <b>Enamel hypoplasia</b> = none (most teeth had crowns too damaged to assess).  <b>Hypercementosis</b> = none.</li> </ol>
Additional Comments	<ol style="list-style-type: none"> <li>1. Very fragmentary, individual inventory of complete skeletal elements was impossible. Only general groupings and counting were done.</li> <li>2. Most teeth are missing, significant crown loss on the available teeth, and others were too damaged to be recorded.</li> <li>3. The remains were associated with ostrich shell beads, celt, reddish local glass beads, quartz scrapper, and a greenstone flake.</li> </ol>



**Table 2. 13. 11: Sekondi, SK'21-73.89 (Pit 1 Extension)**

Site & ID	Sekondi SK'21-73.89 (Pit 1 Extension)
MNI	2 From differently sized and colored (black and light brown) fragments, especially two right pieces of mandibles.
Taphonomy & Bone Condition	<ol style="list-style-type: none"> <li>1. &lt;25% cranial and postcranial bones</li> <li>2. Fragmentary with post-mortem scrap marks likely resulted from the excavation tool.</li> <li>3. Bone colors are black and light brown.</li> <li>4. Mixed packaging of cranial and post-cranial bone fragments</li> </ol>
Curatorial Modifications	None
Sex	Male? & Female?
Age	Adults
Pathology	<ol style="list-style-type: none"> <li>1. No pathologies were observed on bone fragments.</li> <li>2. Dental: <b>Calculus</b>= minimal (stage 1) on 27, 28, and 46. Medium (stage 2) on 11 (for the male?) <b>Caries</b> = on the occlusal surface of 46 (for the male?) <b>Abscess</b> = none observed. <b>Enamel hypoplasia</b> = none observed. <b>Hypercementosis</b> = none.</li> </ol>
Additional Comments	<ol style="list-style-type: none"> <li>1. The remains are very fragmented; the packaging contains mixed fragments of skeletal elements. Individual recording of the elements was impossible; only a general count of bone fragments in each wrapping was done. The various sex and age indicators were not available to be assessed.</li> <li>2. The remains were associated with ostrich shell beads, six celts, seven stone tools, or scrapers. 121 shells, seven local ceramic sherds, two reddish stones, 10 stone pebbles, and two stone flakes.</li> </ol>

**BEGHO:** Four individuals were from this site out of three boxes.

**Table 2. 14. 1: Begho, BG'21-F 73.116 (70 B1)**

Site & ID	Begho BG'21-F 73.116 (70 B1)
MNI	1 + (bone fragments of a baby or one-year-old).
Taphonomy & Bone Condition	<p><b>1.</b> &gt;75% cranial and postcranial bones, and &lt;25% cranial and postcranial bones of a baby.</p> <p><b>2.</b> Well preserved; smooth bone surfaces; some parts covered with light soil. No weathering was observed.</p> <p><b>3.</b> Bone color is brown on all but the lumbar vertebrates (slightly dark).</p> <p><b>4.</b> Three carnivore tooth punctures on the left proximal fibula. They measure about 1.2 cm between 1 &amp; 2, 1.3 cm between 2 &amp; 3, and 1.7 cm between 3 &amp; 4 (counting from the proximal end to the distal end).</p> <p><b>5.</b> There is a difference in the morphology of the left and right mastoid processes. There is also asymmetry in the bi-mastoid breath.</p>
Curatorial Modifications	Some of the bone fragments have been glued. Some of the cranial bones have been glued to each other. Mandible glued on the left side @ canine.
Sex	Male.
Age	<p><b>1.</b> Middle adult 40-44 (based on auricular surface morphology)</p> <p><b>2.</b> 45.2 (based on only vault composite scores)</p>
Stature	<b>162.52 ± 3.91 (from the right femur)</b>
Pathology	<p><b>1.</b> Porotic hyperostosis on some cranial bones: <b>Frontal and the glabella region</b>, degree = porosity only, activity = active at death. Also, barely discernible degree near bosses (the surface is partially concealed by soil and glue), and a healed activity is evident. <b>Parietals</b>, degree = porosity with coalescence of foramina, no thickening on the left and coalescing foramina with an increased thickness on the right; location = both adjacent to sutures and near bosses, and activity = healed + active lesions.</p>

**Occipital**, degree = coalescing foramina with increased thickness, site = within the squamous portion, and activity healed + active lesions. **Temporal**, degree = porosity only in some areas and porosity with coalescence of foramina, no thickening, location = around the external acoustic meatus, supra-meatal crest, and the posterior end of the zygomatic arc; activity = healed + active lesions.

2. Spina bifida occulta of S3-S4 (**Figure: 3.10**). An opening at the level of the bone but closing with organic tissues. Can it be an epigenetic trait?

3. Spinal osteoarthritis, elevated ring on C3-C7, code = 7.2.2; barely discernible ring on T1-T12 code= 7.2.1, and elevated ring on L2-L5 code= 7.2.2.

4. Bone exostosis, resulting from the calcification and ossification of a muscle detachment at the extremity of the left 1<sup>st</sup> rib and the adjacent face of the sternal manubrium, an effect of trauma or hemorrhage or possibly the sign of past infection (**Figure: 4.1**).

5. Bone exostosis on a rib (probably 3<sup>rd</sup>) resulting from hemorrhage, calcification, then ossification of a muscle detachment to the vertebrae, possibly due to the same trauma that affected the 1<sup>st</sup> rib (**Figure: 4.2**).

6. Bone exostosis on the laterals of the occipital posterior to mastoids and at the inferior portion of the manubrium close to the sternal angle on the left.

7. Signs of lice infestation are evident at the level of the occipital bone (**Figure: 3.11**).

8. Hyper-vascularisation/ hyperactivity of the ball-and-socket and the hinge articulation of the tibiofemoral joint. It is represented as holes/cavities (1-2 mm) between the inter trochanter region, around the neck of the right femur, distal ends of femurs, and proximal ends of the tibiae.

9. Evidence of Brucellosis, indicated by a candle-dripping lesion on the vertebral body of the lumbar vertebrae (**Figure: 3.6**).

10. Hypodontia of the maxillary lateral incisors (**Figure: 3.12**).

	<p><b>11. Dental = Calculus</b> = minimal (stage 1) on 11, 15, 16, 18, 21, 23, 27, 32, 45, 46, 47 &amp; 48. Medium (stage 2) on 13, 14, 25, 26, 28, 31, 33, 34, 35, 41, 42, 43 &amp; 44. Large (stage 3) on 24 &amp; 36.</p> <p><b>Caries</b> = none.</p> <p><b>Abscess = none</b> observed.</p> <p><b>Enamel hypoplasia:</b> two hypoplastic lines on 18, 33, 34, 43, and one on 16 &amp; 36 (although calculus conceals a significant part of the crown surface).</p> <p><b>Hypercementosis</b> = none.</p> <p><b>12.</b> The lines of enamel hypoplasia indicate intra-vitam stress or malnutrition.</p>
Additional Comments	<p><b>1.</b> The remains were associated with animal bones; more distinctly was the mandible of a dog. And some local ceramic sherds.</p> <p><b>2.</b> The bone fragments of the baby were not inventoried; they were too fragmented and impossible to identify or side.</p>

**Table 2. 14. 2: Begho, BG'21-E 73.115 (Bg. 70, E)**

Site & ID	Begho BG'21-E 73.115 (Bg. 70, E)
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial and 25%-75% postcranial bones.</p> <p><b>2.</b> Upper limbs, mandible, maxilla, and right parietal are well preserved, but stage 2, 3, &amp; 4 weathering on some postcranial bones (clavicle and humerus). The ribs and other bones are very fragmentary.</p> <p><b>3.</b> Bone color is brown but grey at the occipital.</p> <p><b>4.</b> Green coloration on the available metacarpals and some phalanges.</p> <p><b>5.</b> Rootlet impression and the effect of humidity at the occipital.</p>
Curatorial Modifications	The broken mandible was glued together.
Sex	Male?
Age	Adult.
Pathology	<p><b>1.</b> Porotic hyperostosis on the right <b>Parietal</b> = coalescing foramina with increased thickness, location = adjacent to sutures and near bosses, and the activity = healed + active lesions. On the <b>mandible</b> = between teeth 36-47, is the coalescing of foramina with increased thickness; the activity is healed + active lesions.</p> <p><b>2.</b> Negative enthesopathy at the level of the anconeus muscle at the elbow on the left distal humerus (<b>Figure: 4.5</b>). Vascularisation of an anatomical variation that developed from the insertion of muscles at the elbow level (a sign of hyperactivity of the elbow). This can also be used to suggest that this individual was left-handed.</p> <p><b>3.</b> Dental: <b>Calculus</b>: minimal (stage 1) on 18, 17, 15, 14, 21, 22, 23, 25, 27, 32, 31&amp; 47. Medium (stage 2) on 13, 16, 28, 38, 37, 35, 34, 33, 42, 43, 44 &amp; 48.</p> <p><b>Caries</b> on the occlusal, interproximal and buccal surfaces at 16, 15, 14, 11, 22, 37, 36, 45, 46 &amp; 47.</p> <p><b>Abscess</b>: lingual perforation at 45 &amp; 35 with buccal drainage channel at the level of the mandibular foramen. This, coupled with the</p>

	<p>infection at the level of the teeth, is the cause of the porosity in the mandibular region.</p> <p><b>Enamel hypoplasia:</b> one hypoplastic line on 33 and two on 32 (signs of stress or malnutrition during life).</p> <p><b>Hypercementosis</b> = none.</p>
Additional Comments	<ol style="list-style-type: none"> <li>1. No lower limb bones and pelvis.</li> <li>2. Most of the indicators for sex and age were not available to be scored.</li> <li>3. The hand bones have a green coloration due to their proximity to copper rings.</li> <li>4. The lines of enamel hypoplasia indicate significant intra-vitam stress or malnutrition.</li> </ol>

**Table 2. 14. 3: Begho, BG'21-A 73.118 (Bg 70, A)**

Site & ID	Begho BG'21-A 73.118 (Bg 70, A)
MNI	1
Taphonomy & Bone Condition	<ol style="list-style-type: none"> <li>1. 25%-75% postcranial bones.</li> <li>2. Smooth bone surfaces.</li> <li>3. Bone color is brown.</li> <li>4. Preserved, minimal postmortem breakage.</li> </ol>
Curatorial Modifications	The epiphyseal ends of the long bones have been glued to the bones.
Sex	Undeterminable.
Age	Six years
Pathology	<ol style="list-style-type: none"> <li>1. Signs of hyper-vascularization at the knee level, although physiological, it has a relationship with physical activity (<b>Figure: 4.4</b>).</li> <li>2. Allen's fossa at the femoral necks (<b>Figure: 4.4</b>): an activity sign for horse riding (horse riding position) or other active positions requiring incessant articulation.</li> </ol>
Additional Comments	<p>Only the lower limbs and pelvic bones were in the same box with H &amp; E. No skull.</p> <p>The epiphyseal ends of the lower long bones are unfused; they have just been glued together.</p> <p>No dentition to assess dental pathology.</p>

**NTERESO:** this site produced two individuals from 2 boxes.

**Table 2. 15. 1: Ntereso, NT'18-73.90**

Site & ID	Ntereso NT'18-73.90
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25%-75% cranial with a mass of clayey soil in endo-cranial and soil residue on ecto-cranial surfaces; fragments and isolated teeth. No postcranial bones.</p> <p><b>2.</b> Stage two weathering all over the surface.</p> <p><b>3.</b> Black circular ink-like coloring posterior inferior to the insignia.</p> <p><b>4.</b> The adhering soil keeps the fragmented cranial bones intact. The skull is compressed on both sides resulting from soil pressure during burial- much so that the splanchnocranium could not be seen or identified (what can be seen are the two opposite holes (to be the orbits) and the buccal teeth and rootlets).</p> <p><b>5.</b> Poorly preserved, as a result, inventory of the composite skull elements (except for teeth which could be seen trapped in the soil), estimation of sex and age from the cranial indicators was impossible.</p>
Curatorial Modifications	None
Sex	Undeterminable.
Age	Adult.
Pathology	<p><b>1.</b> No pathologies were observed on the skull.</p> <p><b>2.</b> Dental: <b>Caries</b> = unobservable on teeth in occlusion but absent on isolated teeth.  <b>Abscess</b> = none observed.  <b>Enamel hypoplasia</b> = none.  <b>Hypercementosis</b> = none</p>
Additional Comments	<p><b>1.</b> Although the adhering teeth were not removed to assess wear, caries, abscess, and LEH so as not to destroy the remains, the CT examination revealed significant dental wear on the molars and no caries.</p>



	<p><b>2.</b> The CT examination of the skull revealed pebbles, voids, rootlet impressions, and a circular dark-grey patch at the inferior portion of the skull of fat or organic residue (<b>Figure: 3.1</b>).</p>
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	<p><b>3.</b> Dental wear of teeth in occlusion was unobservable because of the soil intracranial.</p>
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**Table 2. 15. 2: Ntereso, NT'18-73.91**

Site & ID	Ntereso NT'18-73.91
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> 25%-75% cranial with a mass of clayey soil in endo-cranial and soil residue on ecto-cranial surfaces; fragments and isolated teeth. No postcranial bones.</p> <p><b>2.</b> Rootlet impressions on the occipital bone.</p> <p><b>3.</b> Black ink spot on the greater wing of the left sphenoid.</p> <p><b>4.</b> Moderate preservation of available cranial bones. The soil intra-cranial keeps the fragmented cranial bones intact. The skull is compressed on both sides, much so that the splanchnocranium cannot be seen (what can be seen are partial nasal bones), resulting from soil pressure in the burial environment.</p>
Curatorial Modifications	None
Sex	Undeterminable.
Age	Adult
Pathology	<p><b>1.</b> Porotic hyperostosis on the cranial bones: right <b>parietal</b> = porosity with coalescence of foramina, no thickening, and on the left parietal, the degree is coalescing of foramina with increased thickness. Location = adjacent to sutures and near bosses, the activity = healed + active lesions. Occipital = porosity with coalescence of foramina, no thickening, location = adjacent to sutures and in the squamous portion, and the activity = healed + active lesions.</p> <p><b>2.</b> Dental: <b>Calculus</b>= minimal (stage 1) on possible 35, 43, and un-sided incisors and premolars. Medium (stage 2) on possible 33, 42, 45, 47, and 48. Large (stage 3) on possible 31, 41.</p> <p><b>Caries</b> = on the occlusal surface of 43 &amp; 48 at the cemento-enamel junction of probable upper premolar, the cemento-enamel junction of 47 at the interproximal aspect, and the cemento-enamel junction of 23 &amp; 33.</p> <p><b>Abscess</b> = none observed.</p> <p><b>Enamel hypoplasia</b> = two hypoplastic lines on an un-sided upper premolar.</p> <p><b>Hypercementosis</b> = none</p>

Additional Comments	<p><b>1.</b> Dental pathologies for this individual were assessed on isolated teeth. In order not to destroy the skull, whose bones were held together by the compact soil, the adhering teeth were not removed to assess wear, caries, abscess, and LEH.</p> <p><b>2.</b> The CT examination of the skull revealed pebbles, voids, rootlet impressions, a circular dark-grey patch of fat or organic residue, and petrous bones of no anomaly.</p> <p><b>3.</b> Due to the nature of the remains, a detailed inventory of some cranial elements, estimation of sex, and age determination could not be done. Some isolated teeth were inventoried even though, due to wear and broken roots, no possible siding was done.</p>
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**YAPEI:** there were four individuals from this site from 2 boxes.

**Table 2. 16. 1: Yapei, YP'18-73.106**

Site & ID	Yapei YP'18-73.106
MNI	1
Taphonomy & Bone Condition	<ol style="list-style-type: none"> <li>1. Well preserved, &gt;75% cranial and postcranial.</li> <li>2. Stage one weathering on the right parietal bone around the superior temporal line; prominent on the diaphyses of lower limbs (femurs and tibias) and the pelvis.</li> <li>3. Partly covered by soil in glue.</li> <li>4. Postmortem damage on the left parietal and frontal bone at the left coronal suture: along the bossing and medially.</li> <li>5. Proximal epiphyseal breakage on the humeri; damage/breakage of the proximal and distal epiphyseal ends of the femurs, tibias, and foot bones (L &amp; R).</li> <li>6. Three probable carnivore tooth (canine) punctures on the left proximal diaphysis of the femur anteriorly. They measure about 1.4 cm between 1 &amp; 2 and 2.5 cm between 2 &amp; 3 (counting from proximal to distal).</li> </ol>
Curatorial Modifications	Cranium: the temporal process of the zygomatic bone is glued to the temporal bone. The left pterygoid plate is glued to the adjacent alveolar process. Mandible: right portion is glued at the region from tooth 45, running through the mental foramen down to the inferior margin of the chin.
Sex	Female
Age	<ol style="list-style-type: none"> <li>1. 34.7- 41.1 based on vault and lateral-anterior sutural composite scores.</li> <li>2. 40-44 based on the auricular surface morphology.</li> </ol>
Stature	166.9 ± 3.14 and 175.6 ± 3.70 cm (from the left femur and the left tibia, respectively)

Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Parietals</b>, degree = porosity with coalescence of foramina, no thickening, location = adjacent to sutures and near bosses, and activity = healed + active lesions. <b>Occipital</b>, degree= porosity with coalescence of foramina, no thickening, location = adjacent to sutures and in the squamous portion, and activity = healed + active lesions. <b>Temporal</b>, degree = porosity with coalescence of foramina, no thickening, location = adjacent to sutures and near bosses 6.2.5, and activity = healed + active lesions. On the <b>sphenoid are</b> macro &amp; micro-porosity on the greater wing and the pterygoid plates, and the activity = active at the time of death. Right maxilla = healed + active lesions on the alveolar process and margin.</p> <p><b>2.</b> Left <b>pelvic bone</b>: macro-porosity – anteriorly (around the greater sciatic notch and the anterior inferior iliac spine) and posteriorly- (superior-medial (around the acetabulum and on the pubis portion), the activity = active at the time of death.</p> <p>Right <b>pelvic bone</b>: macro &amp; micro-porosity posteriorly on the superior portion of the iliac, around the acetabulum and the pubis. Anteriorly: around the ischium. Macro-porosity on the auricular surface.</p> <p><b>3.</b> Osteoarthritis: barely discernible osteophyte expansion on L2-L5. The lipping degree of L2-L5 and T12 was coded as 8.1.2 = sharp ridge sometimes curved with spicules. The extent of the circumference of the affected vertebral bodies was 1/3 - 2/3.</p> <p><b>4.</b> Slight asymmetry between the left and right inferior articular facets due to osteoarthritis with slight lipping on the left side.</p> <p><b>5.</b> Femurs: holes/cavities (1-2mm) between the inter trochanter region and around the neck and distal ends. These are signs of hyperactivity of the articulation during life/ hyper utilization of the hip. The cavities are also visible on the proximal and distal ends of the tibias.</p> <p><b>6.</b> Hyper-vascularization (hyperactivity) at the knee level and enthesopathy at the level of the anterior tuberosity of the tibia. This may infer 'climber' activity (<b>Figure: 4. 2</b>). Porous/ vascularized lesions at the proximal and neck region of the left femur depict hyperactivity of the ball-and-socket joint (<b>Figure: 4. 1</b>).</p> <p><b>7.</b> Bone exostosis, resulting from calcification and ossification of the</p>
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	<p>partial detachment of ligament at the level of the psoas major and the iliacus or the lesser trochanter- posterior-medially (3 cm curving superiorly) (Figure: 4.3). It probably results from direct or indirect trauma or hypertrophy of the region or muscle. It might be related to <b> 4 </b></p> <p><b>8. Dental: Calculus</b> = minimal (stage 1) on 43 &amp; 44.</p> <p><b>Caries</b> = on the occlusal surface and at the cemento-enamel junction of 17.</p> <p><b>Abscess</b> = none observed.</p> <p><b>Enamel hypoplasia</b> = two hypoplastic lines on 43. Indicative of intra-vitam stress or malnutrition.</p> <p><b>Hypercementosis</b> = none.</p>
Additional Comments	<p><b>1.</b> Soil is glued to the skull. It is probably resulting from an application of consolidants. <b>2.</b> Adherent soil could be masking other surface conditions.</p>

**Table 2. 16. 2: Yapei, YP'18-73.105**

Site & ID	Yapei YP'18-73.105
MNI	1/2
Taphonomy & Bone Condition	<p><b>1.</b>Skull: 25%-75%; postcranial: 25%-75% preserved.</p> <p><b>2.</b> Rootlet impression on the frontal bone and covered with light soil residue.</p> <p><b>3.</b> Postmortem cavities in the vertebral bodies result from insect activity during the putrefaction stage and general decomposition process.</p> <p><b>4.</b> Yellowish coloring on the right parietal bone, along the superior temporal line, down to the fragment of the temporal bone. Slight yellowish coloring inferior to the squamous portion of the occipital.</p> <p>Endocranially, -yellow to brick red coloring along the anterior, middle, and posterior cranial fossa. There is a yellowish coloration on the posterior lateral surface of the left humerus.</p>
Curatorial Modification	The right portion of the occipital has been glued to the opposite parietal bone. The right ulna has been glued close to the mid-shaft.
Sex	Female (presence of peri-auricular sulcus).
Age	<p><b>1.</b> Significant wear on teeth in occlusion and alveoli resorption of 16-18 may suggest middle-old adult.</p> <p><b>2.</b> 25-29 based on the assessment of (IN+PMP) and 25-40 based on (IN+PMP+TP), suggesting young-middle adult.</p> <p><b>3.</b> 40-44 According to auricular surface morphology.</p>
Pathology	<p><b>1.</b> Porotic hyperostosis on cranial bones: <b>Parietals:</b> degree = barely discernible, location = adjacent to sutures, and the activity = healed. <b>Occipital:</b> degree = porosity with coalescence of foramina, no thickening, location = adjacent to sutures, and the activity = healed + active lesions.</p> <p><b>2.</b> Osteoarthritis: elevated ring on probable L1 &amp; L4 show significant, the osteophyte degree is coded as 7.2.2. sharp ridges</p>

	<p>curled with spicules characterized the articular facets of L1-L4: L1-L3, although some rings were broken. L4 had extensive spicule formation. The circumference affected for L1-L3 is 1/3- 2/3 and &gt;2/3 for L4.</p> <p><b>3.</b> Bone exostosis, resulting from calcification then ossification of the Yellow ligament at the posterior part of the canal on L2 and L1 (but that of L1 is broken) (<b>Figure: 3.5</b>); about half an inch and may have resulted in less elasticity in between the vertebrates. This is a sign of aging, corresponding to the age range given by the morphology of the auricular surface.</p> <p><b>4.</b> Maxillary sinus inflammation related to the infection at the region of the teeth by mirror caries at teeth 14 &amp; 15 and abscess at tooth 14 (<b>Figure: 3.9</b>).</p> <p><b>5.</b> Dental: <b>Calculus</b> = minimal (stage 1) on 13 &amp; 14. Medium (stage 2) on 15; and isolated M1 &amp; M2: M1 = 1 and M2 = 2.</p> <p><b>Caries</b> = mirror caries at the cemento-enamel junction of 14 &amp; 15, and on an isolated un-sided M1 is a non-carious pit or pulp exposure on the lingual surface of the crown. The alveolar margin is extensively resorbed.</p> <p><b>Abscess</b> = at the buccal surface of 14.</p> <p><b>Enamel Hypoplasia</b> = one hypoplastic line on 14 &amp; 15 and two on 13. Indicative of intra-vitam stress or malnutrition.</p> <p><b>Hypercementosis</b> = present on available teeth.</p>
Additional Comments	<p><b>1.</b> Ante-mortem loss of teeth 18, 17, &amp; 16 and significant wear on 15,14,13 could suggest an old adult.</p> <p><b>2.</b> Associating this individual is fetal bones of 36 weeks in-utero (Table 15.2).</p>



**Table 2. 16. 3: Yapei, ID: Fetus**

Site & ID	Yapei ID: Fetus
MNI	2/2
Taphonomy & Bone Condition	<b>1.</b> 25%-75% postcranial <b>2.</b> Clean and significantly preserved postcranial bones.
Curatorial Modifications	None
Sex	Undeterminable.
Age	36 weeks
Pathology	<b>1.</b> No pathologies were observed on available skeletal elements.
Additional Comments	1. No cranial bones.

**Table 2. 16. 4: Yapei, YP'18-73.102**

Site & ID	Yapei YP'18-73.102
MNI	1
Taphonomy & Bone Condition	<ol style="list-style-type: none"><li>1. &lt;25% cranial bones.</li><li>2. Available is a left parietal bone, the left squamous portion of the temporal bone, and the left zygomatic bone. The isolated molars (2 &amp; 3) may belong to this individual.</li></ol>
Curatorial Modifications	None
Sex	Undeterminable.
Age	Adult?
Pathology	<ol style="list-style-type: none"><li>1. Minimal wear on two isolated teeth is coded as 4 and 2, respectively.</li><li>2. No pathologies were observed on available skeletal elements.</li></ol>
Additional Comments	<ol style="list-style-type: none"><li>1. Two isolated teeth were found exogenous to this individual.</li></ol>

**YIKPABONGO:** one individual from this site.

**Table 2. 17. 1: Yikpabongo, YK'21, Unit 1/C3-4.**

Site & ID	Yikpabongo YK'21, Unit 1/C3-4
MNI	1
Taphonomy & Bone Condition	<p><b>1.</b> &lt;25% cranial bones</p> <p><b>2.</b> Only the right half of the calvarium was present. No post-cranial bones. Suspected to be from a ritual context.</p> <p><b>3.</b> Loamy soil in endo-cranial and lightly on ecto-cranial surfaces. Postmortem breaks of the zygomatic bone and along the edge of available right cranial bones with some fragments.</p>
Curatorial Modifications	None
Sex	Undeterminable.
Age	Adult?
Pathology	<p><b>1.</b> No pathologies were observed on the bones available.</p> <p><b>2.</b> Dental: <b>Caries</b> =unobservable.</p> <p><b>Abscess</b> = unobservable.</p> <p><b>Enamel Hypoplasia</b> = unobservable.</p> <p><b>Hypercementosis</b> = unobservable</p>
Additional Comments	<p><b>1.</b> No teeth available.</p>

## 2.14 SUMMARY OF RESULTS

From the data collection, the total number of individuals in the skeletal assemblage was 25; 14 were from Sekondi, four were from Begho, two were from Ntereso, four were from Yapei, and one was from Yikpabongo (Chart 2.3). Of this number, 10% were > 75% complete, 33% were between 25%-75% complete, and a majority of 57%, being very fragmentary, were <25% complete (Charts 2.1 & 2.2). Five bone assemblages from Sekondi, Begho, and Yapei had more than one individual. Regarding age estimation, six individuals were confidently estimated to be in the middle-adult category, two individuals in the young adult category, and two in the middle-old adult category. In the one range were fetus, infant, child, adolescent, and old adult. About eight individuals were generally determined as adults because they lacked age indicators or elements to assess an age range accurately (Chart 2.4).

On the other hand, sex determination was categorized as male/female for individuals assessed using the pelvic, in addition to cranial sex indicators, and as male?/female? for individuals assessed based on only cranial indicators or bone morphology. The (?) depicts a low accuracy of 45%- 55%. Individuals who lacked cranial and pelvic sex indicators and were too fragmentary to assess the sex feature were coded as undeterminable (Chart 2.5). Of the 16 pathologies recorded, 40% were skeletal, and 60% were dental. Porotic hyperostosis was prevalent (18%) in 13/21 individuals. While the Sekondi assemblage recorded the highest cases of porotic hyperostosis, it presented absolutely no record of osteoarthritis. Osteoarthritis, bone exostosis, and hyper-vascularization represented 4% and 3/21 individuals. Other pathologies of 1% were evident in only one/ two individuals (Charts 3.1 & 3.2). Calculus was dominant (21%) in 15/21 individuals; although calculus was recorded in most Sekondi individuals, it was more severe in Begho individual BG'21-E 73.116, Ntereso individual NT'18-73.91, and Sekondi individual SK'21-H 73.84. Caries prevailed (18%) in 13/21 individuals, and enamel hypoplasia was common (13%) in 9/21 individuals. Abscess was in 4/21 individuals representing 6% in the skeletal series. Hypercementosis was not prominent in the series, only 4%.

## **2.15 CHALLENGES TO THE PROVENANCE RESEARCH**

The fragmentary nature of the bones, about 57% of the total assemblage being <25%, made it difficult to accurately assess sex, age, stature, explicit cranial and postcranial trauma, and bilateral non-metric traits in those individuals. To aid in sorting assemblages with more than one MNI, different sides and sizes of available elements, like the pieces of mandibles and temporal bones, were used to guesstimate the composition of individuals (left, right, and paired elements). For sex determination, relatively thick and robust mandibles were considered probable male, while gracile mandibles were likely female. However, bone morphology changes with age, so robust-gracile categorizations may be insufficient. In other instances, duplicate teeth sets and different teeth types (deciduous & permanent) were used to record the composition and age of individuals within the assemblage.

Another challenge was bone completeness; most bone packaging included mixtures of bone fragments. Of the five burial assemblages of commingled bone fragments belonging to more than one individual (Chart 2.1), it was challenging to sort and inventory which elements of which individual was present in the assemblage. To mitigate this challenge, priority was accorded to the criteria of differential sides, sizes, and colors of distinct elements (temporal bones and mandibles) to establish the MNIs. However, as mentioned earlier, using the bone color criterion for sorting is limited because body orientations and taphonomic processes within the burial environment can impose varied effects on the skeleton. As a result, no one sorting based on bone color is of an accurate composition. Regarding samples where the MNIs were more than one but the isolated permanent teeth available were not duplicated, it was difficult to assign 'ownership'; which individual owns which tooth or teeth. The mitigation strategy was, therefore, a general count of the available teeth in sets (I, C, PM, M) to avoid misrepresentation.

## 2.16 CONCLUSION

The provenance studies, or better still, the anthropological assessment, fulfilled its objective of 'humanizing the remains' by revealing valuable data about the individuals' age, sex, stature, pathologies: for skeletal and dental health, chronological age (for one individual), and on funerary contexts/ archaeoethanatomical practices and perceptions. This information will complement erstwhile and future site understanding of the populations from the respective sites. For instance, the 16 pathologies recorded among the 21 individuals stem from nutritional or environmental stress and activity etiologies, informing the general (including oral) health of the populations. Again, the high calculus and caries across all sites, but Yikpabongo, suggests increased consumption of carbohydrate-rich foods and refined sugar intake. The high dependence on carbohydrate-rich foods increasing calculus and caries contributed to the presence of dental pathologies like abscess and hypercementosis among some individuals. The contemporary population is also at risk of gingival inflammation, abscess, and hypercementosis due to the carbohydrate-rich dietary orientation. A separate article on the relationship between dental pathologies and oral health and developmental, nutritional, and functional stress of the ancient Ghanaian populations has been submitted for publication (paper under review). This clue on intra-vitam alimentation status supports dietary reconstructions from grain studies and residual analysis from ceramics.

Although much could have been done if the remains were better preserved, osteobiographies revealed more life histories of the people to which almost no textual biographies are available or impossible to access. Even if there were textual biographies, how representative would they be of the assemblage? Considering it is the prominent and the 'most-achieved' who have stories to tell per social standards. The bioanthropological and bioarchaeological methods through the osteobiography lens provided 'identity' to these individuals.

## **CHAPTER 4**

### **REPRESENTATION OF INDIVIDUALS FOR PALEO-DEMOGRAPHY: CONFLICTING THE NUMBER OF ELEMENTS (NE) WITH THE MINIMUM NUMBER OF INDIVIDUALS (MNI).**

#### **2.17 OVERVIEW**

This chapter discusses the relationship and conflict encountered in identifying the minimum number of individuals (MNIs) from the number of elements (NE) of the extensively fragmented skeletal remains exhumed from the five sites (Map: 1.1). It also outlines challenges faced in the assessment of the MNIs of the fragmentary remains and how the conflict between the NE and MNI compromised the extent of bone-to-bone interaction within the assemblage.

#### **2.18 INTRODUCTION**

In the quest to understand past populations through material relics (artifacts, ecofacts, and biofacts), archaeologists consult written records and draw clues from oral accounts and contemporary practices (ethnographic data) and salvaged data from the archaeological record. Within the archaeological record, the functional relationship between the material relics and their inter/ intra-associations with other materials presents contexts essential for analyses, interpretations, and reconstructions of past lifeways (Beaudry et al., 1996). Archaeologists examine the materials and the web of associations to understand the materials' interdependence to decipher meanings within particular archaeological contexts in order to represent/reconstruct past events or objects. Representation can thus be highlighted from the information matrix borne from material associations. Moreover, adequate representation of materials depends on the quantity and quality of information gathered within the context. Therefore, appropriate recording and documenting strategies must be engaged during excavation, data collection/ recovery, and analysis of finds to limit misrepresentations and skewed interpretations.

Archaeological representation of skeletal deposits varies from primary to secondary burials from long-term or episodic practices (Nikita et al., 2019; Osterholtz, 2018), within which there will be a commingling of skeletal elements on varied minimal or extensive levels. Some of the factors instigating the commingling of skeletal elements discussed by (Nikita et al., 2019; Osterholtz et al., 2014; Osterholtz, 2018) include decomposition, the duration of the deposit, the orientation of the deposit, scavenger activities/bioturbation, field commingling from the excavation and packaging process as well as laboratory commingling during skeletal analysis and curation. Some laboratory commingling stems from poor field practices, such as improper labeling and documentation, leading to the loss of contextual information. Regardless of the nature/quality and quantity of the assemblage, the bioarchaeologist is responsible for ascertaining the MNI before proceeding with detailed (demographic) studies. The MNIs in a skeletal assemblage are the total estimates of individuals responsible for all elements in the collection (Adams & Konigsberg, 2004, p. 138; White et al., 2011, p. 337). While the NE discussed here is similar to what White et al. (2011) noted as the maximum number of individuals; "determined by counting all non-joining, non-matching elements" (White et al., 2011, p. 338) in the assemblage, this pool encompasses all bone elements in the collection.

Regarding the quality and quantity of data, ascertaining the MNIs of a recovered assemblage of  $\geq 75\%$  complete skeletal elements is accompanied by fewer difficulties than sorting out fragmentary commingled remains of  $< 25\%$  complete. The analysis of the latter will be painstaking and time-consuming, involving methods like macroscopic examination (Naji et al., 2014), DNA sequencing (Schultz et al., 2008), and pair-matching or element matching to specific individuals (Nikita et al., 2019). Likewise, osteometric sorting of fragments based on bone size and shape, age, sexual dimorphism, bone color, non-metric and bilateral skeletal traits, and articular or interproximal facets evident on bone fragments can aid the assessment (Byrd & Adams, 2003; Byrd & LeGarde, 2014; White et al., 2011, p. 337). Furthermore, metric methods/ algorithms for element pairing and MNI assessment exist (Adams & Konigsberg, 2004; Nikita, 2014; Thomas et al., 2013). However, their applicability to extremely fragmented



assemblages can still be a challenge, particularly, classification based on bone color, because different orientations in the grave cut and points of contact with the soil may result in the differential coloration of the skeleton.

## **2.19 THE CONFLICTING RELATIONSHIP BETWEEN 'NE' AND 'MNI.'**

The relationship between material remains and probable events or occurrences depends on the quality of data used to represent the associations at hand. Representation can be a concept, process, or framework by which objects reflect purpose, meaning, or events through object-to-object interaction to assist understandings of past/current activities. Moser (2009) depicts archaeological representations as "two- or three-dimensional, visual or textual, static or performative ...that depict past cultures, archaeological sites, or the material remains of ancient societies" (2009, p. 1048). However, the extent to which recovered materials can represent and stimulate seemingly holistic outlooks of (past) events depend on four perspectives. These include the research objectives, the subjectivity of researchers, the volume of information gathered (quantity), and the degree of completeness (quality) of the data to be reconstructed.

Representative archaeology is directly proportional to the context-specific reconstruction of finds; an object can reflect its full meaning only in its whole state, although a part can be helpful. For instance, a ceramic vessel type can be guessed from the fragments available, but once the pieces have been reconstructed from the rim type, neck, and base, a clear picture of the vessel (jar or bowl) can be ascertained. This phenomenon applies to bone fragments and the accuracy to which they account for the number of individuals in a burial environment or bone assemblage. Bone fragments or the NE tend to exaggerate the composition of individuals or the MNIs with fragmentation, and this conflict is the center of discussion in this section.

The number of material remains in the archaeological record, or the recovered assemblage

may not always allude to quantities when explaining an event, behavior, or practice. For instance, more ceramic sherds in an archaeological stratum may not represent many ceramic vessels (jars or bowls) or the artifacts' extensive production and use. This is because vessel disintegration results in a pool of sherds, and the sherd count may not produce individual vessel quantities used within sites. Instead, identifying distinct parts such as the rim, neck, and base and aspects of surface treatments, decorations, paste characteristics, and temper/degreaser could suggest the relative number of vessels represented within the sherds. Similarly, the more bone fragments (if not a mass grave site or with evidence of multiple skulls) in an assemblage do not necessarily denote the maximum number of individuals and vice versa until recording, reassembling, and further laboratory classifications are done.

The NE would only produce its MNIs when distinct skeletal parts have been correctly identified and reassembled, with caution of duplicate counts (Adams & Konigsberg, 2004). Hence, specific, non-engaging, and non-matching elements may lead to more than one individual. Nevertheless, not all non-articulating fragments belong to different individuals because the joint congruence and attachment points may have either decomposed, been modified by taphonomic factors, disintegrated, or missed in the recovery, handling, and transport process (R-H-T journey). Imperatively, it takes expertise and the laborious work of reuniting the remains to patch up an individual and draw up a list of well-classified individuals for analysis.

To quantify the number of individuals in human bone assemblages for demographic studies, algorithms, including the Lincoln index (LI), the most likely number of individuals (MLNI), and the MNI methods have been extensively discussed and employed (Adams & Konigsberg, 2004; Lyman, 1987; Ubelaker, 1974). The LI and the MLNI have been proposed as superior methods for reconstructing demography from commingled samples providing accurate demographic estimates (Adams & Konigsberg, 2004; Nikita et al., 2019). However, these methods' strengths and pair-matching approaches are only linked to maximum recovery and

high preservation. These approaches are limited when applied to extensively fragmented and poorly preserved remains, hence, can amplify miscalculations and the misrepresentation of populations in the assemblage. For extremely fragmentary remains, Nikita and colleagues (2019, p. 20) recommend the MNI method.

Another difference between the MNI and the LI methods is that the former is related to the number of individuals represented in the recovered assemblage, while the latter reveals the original number of individuals in the deposited assemblage (Adams & Konigsberg, 2004). Although MNI is slightly limited by significant taphonomic loss, its propensity to compensate for recovery losses and ascertain the number of populations in the recovered pool, not the initial deposit, is high. Moreover, taphonomic losses are uncontrolled and inevitable. Buikstra and Ubelaker (1994) propose a percentage-based and feature-based approach to estimating MNIs. The former is for relatively complete remains using the code of completeness of the bone elements, while the feature-based method is for commingled remains or bone fragments. The feature-based approach (non-metric sorting) involves ascertaining the MNIs by identifying distinctive parts of bones by bone name, side, and segment (Buikstra & Ubelaker, 1994) and counting the duplicates. Applications of the feature-based approach have proven valuable for determining the MNIs of fragmentary assemblages (Osterholtz et al., 2014). After carefully assessing the quality and quantity of my data, taphonomic and recovery losses, fragmentation, and the moderate preservation of the remains, the MNI characterization and the feature-based sorting approach, were found apt for reconstructing the population count in the assemblage.

## 2.20 METHODOLOGY

The study employed the quantitative research approach, using the MNI method hinged on the feature-based sorting technique of distinct elements (Buikstra & Ubelaker, 1994; Osterholtz et al., 2014). This method was appropriate and adaptable to the assemblage because of the fragmentary nature of the remains. The left and right elements were sorted, and an estimate was calculated using the 3<sup>rd</sup> method proposed and discussed by Adams and Konigsberg (2004, p. 139), i.e.,  $L + R - P$ , where L is the sum of all left bone elements, R is the sum of all right elements, and P is notable parts. Drawing on the White et al. (2011, p. 338) steps to identify the MNI from the NE in the bone assemblages and the Ubelaker (2002) approach to studying commingled remains, non-human elements such as fish bones, shell beads, and animal bones were sorted out of the assemblage. After which, the human bones and teeth were separated. Elements that could be sided were separated into left and right sides using White and Folkens (2005). The left and right non-matching sides (based on morphology, age, and bone color) were counted, and relative pairs were subtracted from each category. Duplicates of the temporal bones and pieces of mandibles were calculated and added to the 'individual' pool.

Additionally, where fragments were impossible to pair, but a relative size dichotomy and bone morphology existed, the MNI was based on the biological profile of sex and age (infant, sub-adult, or adult) (Nikita et al., 2019). Biological profiling of the human bones to identify the MNI was done by placing bones into adult or sub-adult categories; based on the degree of fusion of ossification centers. Sex determination was based on the robust or gracile nature of the bone and sexually dimorphic indicators on the pelvis and the skull bones (Buikstra & Ubelaker, 1994). By combining the feature-based and biological profiling approach, possible conflicts consistent with the analysis of the bone fragments and the identification of the number of individuals in the assemblages during the analysis were controlled.

## 2.21 RESULTS

Therefore, the MNI of the 20 skeletal assemblages from the five sites was 25. Of the 25 individuals, 10% were > 75% meaning significantly complete, 33% were between 25%-75% complete, and 57% in fragments; of <25% complete ([Chart: 2.2](#)). Five burial assemblages out of the 20: Sekondi burials D; G and Pit I Extension, Begho burial F, and Yapei YP'18-73.105, had a mixture of bone fragments belonging to two individuals ([Charts: 2.2 & 2.3](#)); details have been provided in Table 2.18.1. Note: the burials with skeletal assemblages of fragments belonging to more than one MNI have been highlighted in the Table.

**Table 2. 18. 1: Skeletal assemblages with more than one MNI vrs their NE.**

<b>Site &amp; ID</b>	<b><i>Sekondi SK'21- D 73.81 (Burial D)</i></b>
MNI	2 (two right halves of temporal bone)
Bone Completeness	<25% cranial and postcranial bones.
Number of Elements	294
Age & Sex	Young and old adult age; females
<b>Site &amp; ID</b>	<b><i>Sekondi SK'21-G 73.83 (Burial G)</i></b>
MNI	2 (from different mandible pieces in size and color, and morphology)
Bone Completeness	25%-75% cranial with a mass of loamy soil in endo-cranial and < 25% postcranial bones.
Number of Elements	302
Age & Sex	Middle adult female and an adult of undetermined sex
<b>Site &amp; ID</b>	<b><i>Sekondi SK'21-73.89 (Pit 1 Extension)</i></b>
MNI	2 (determined from two non-joining right fragments/pieces of mandibles of different morphology and color (black and light brown).

Bone Completeness	<25% cranial and postcranial bones, very fragmentary
Number of Elements	884
Age & Sex	Adults; male & female
<b>Site &amp; ID</b>	<b>Begho BG'21-F 73.116 (70 B1) (Burial F)</b>
MNI	1 + (bone fragments of an infant- one-year-old).
Bone Completeness	>75% cranial and postcranial bones <25% cranial and postcranial bones for the baby.
Number of Elements	288
Age & Sex	35-50 years & 1 year old; male & undetermined
<b>Site &amp; ID</b>	<b>Yapei YP'18-73.105 (as Yapei #2 in charts and graphs)</b>
MNI	1 + fetal bones
Bone Completeness	Skull: 25%-75%; postcranial: 25%-75% & 25%-75% postcranial fetal bones
Number of Elements	58
Age & Sex	25-44 years & 36 weeks; female & undetermined

## 2.22 DISCUSSION

The MNI, feature-based, and biological profiling method helped to represent the MNIs in the assemblages, so much so that even individuals of <25% bone elements could be identified. Bone fragments or the NE may either represent or misrepresent the MNI. And as mentioned earlier, the quantity of the fragment should not be the absolute means of predicting an individual(s); instead, a means to bring order into the assemblage. More fragments could give a count of one MNI, whereas fewer fragments with duplicate distinctive skeletal parts may indicate more than one MNI. For instance, the results have shown that the five bone assemblages with elements between <25% and 25%-75% elements had duplicate skeletal elements: cranial or post-cranial, belonging to more than one individual. Judging maximum individuals based on the mass of fragments may be misleading. Therefore, the possibility of fewer elements containing the remains of multiple individuals and the reverse should be considered.

Buttressing the above is a report of the skeletal analysis of human remains from Vume Dugame on the Lower Volta, Ghana (Davies, 1961a). An aspect of the report read, 'there is a series of skull fragments as well as several incomplete limb and girdle bones... in fact, a number of them have been articulated and reunited ...; so the number of individuals represented is far smaller than the number of fragments...' (Davies, 1961a, p. 36). After reconstruction, the MNI turned out to be fewer despite the NE. This further stresses the conflict between the number of elements and the minimum number of individuals in an assemblage. Therefore, the focus should be on the distinct duplicate parts likely to represent multiple individuals when assembled instead of the number of fragments.

Misrepresentation of fragments of artifacts and bones and misinterpretation of finds in both the archaeological record and the recovered assemblage may occur if researchers do not collect detailed data within the archaeological record or define which data is more relevant to the research, hence deserving the most attention. Alternatively, pseudo-representation of fragments can occur when depositional and taphonomic processes, as well as "significant

taphonomic loss” (Adams & Konigsberg, 2004, p. 138), are ignored. Notably, human remains experience significant diagenesis from weathering, disintegration, abrasion, and erosion of bone surfaces moving along the often tortuous path of decomposition (Haglund & Sorg, 2001; Sorg & Haglund, 1996). According to Wedel & Galloway (2013), the high dispersal rate of fragments resulting from perimortem blunt force trauma and the impact of high-velocity projectiles during decomposition is compounded by taphonomic processes such as bioturbations and rain/runoff water (Wedel & Galloway, 2013, p. 12). These factors are worth considering during recovery, analysis, reconstruction, and interpretation.

Additionally, excavation as a recovery method negatively impacts material/ cultural relics, especially human remains, when carried out by amateurs in the respective field. Maximum recovery is often affected by factors such as taphonomy, type of deposit (proper or indiscriminate interment), and the recovery approach. In some cases, the remains will have to be block lifted to maintain the associational integrity of the fragile bones. Otherwise, the researcher/ bioarchaeologist stands the chance of flouting the human dignity and preservation ethics of studying human remains (Walker, 2000, pp. 19–26) because essential elements and information may be left behind. As seen from the Sekondi human remains, there appears to be no correlation between the photographic record of the remains in-situ and the excavated remains in the storage boxes. The photographs depict partly complete elements of the individuals, while the recovered remains in the storage boxes are fragments; see the example of Burial C (**Figure: 2. 9 i/ii**). The absence or poor representation of artifacts and human osseous tissues in the archaeological record and the recovered assemblage may have cultural significance and implications on the archaeological practice. Thus, the former pertains to rituals or the cultural practice of burying body parts separately for a traditional group, religion, or ethnic reasons, and the latter to amateur destructive excavation where the exhumation of the remains may be in part or particular elements may be missed.

Regarding the destructive nature of excavation on biofacts and artifacts and the propensity for fragile skeletal remains to experience significant damage or fragmentation during



recovery, handling, and transportation (thereby increasing the number of bone elements), efforts like ample documentation (including photographs) and careful handling are required. These tactics would minimize or compensate for further damages. The elements of the recovered assemblage should be treated distinctly, and patchworks approached more objectively to aid analysis, reconstruction, and interpretation to avoid misrepresenting the bone fragments.





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**Figure 2. 9: i) Photographic record of Burial C Sekondi VII C-D, Skeleton in-situ @ level 4.3' (Reference: OD 63/596, 621 & 622, Photo: Oliver Davies), ii) Content of the storage box for Burial C Sekondi VII C-D (Photo: Author's digital collection).**

## **2.23 CONCLUSION**

Fragmentary remains of both artifacts and bones are challenging to classify and analyze. In effect, reconstruction and interpretation can be skewed or incomplete. Identifying the population counts in a recovered skeletal assemblage is crucial for human remains and their association with paleodemographic studies. Thus, finding the appropriate approach can help mitigate the conflicts of estimating the number of individuals represented in a bone count to stimulate a better classification and demographic representation of the content. This chapter elaborated on the pertinence of representation in bioarchaeological studies and the dynamics presented by the archaeological record and the recovered assemblage involved.

To represent the MNI in the NE, bioarchaeologists, biological anthropologists, and forensic anthropologists must open-mindedly allow patchworks and separation based on duplicate distinct elements in the assemblage to gradually unravel individuals. Instead of superficially juxtaposing the minimum number of individuals with the number of bone elements, an objective and gradual reveal is the way to go. Of a fact, complete reconstruction from an absolute representation of elements is rare, but the attempt must be all-inclusive. The goal is to represent the populations in the recovered assemblage as much as possible. The study recommends more sophisticated analyses of the bone fragments through macroscopy, histological analysis, and DNA for a more objective and accurate identification of individuals in fragmentary assemblages.

I have presented details of the health and activity of these individuals and other aspects of their life course in the subsequent parts.

**3 PART II: COMPREHENSIVE EXAMINATION AND  
RECONSTRUCTION OF THE HEALTH & ALIMENTATION  
STATUS OF THE PAST POPULATIONS.**

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### 3.1 INTRODUCTION

This part is sectioned into two chapters. The first chapter attempts to predict the health of the past population from evident skeletal and dental pathologies, and chapter two presents a cross-sectional nutrition or alimentation status and the public health concerns of the past populations.

Pathology is the study of diseases among populations, and paleopathology involves the differential diagnosis of skeletal lesions from antiquity and documenting their presence in past populations while studying their evolutionary trajectory among contemporary populations. Over the century, there has been a renaissance of paleopathological examinations and understanding, shifting from more descriptive works/ parameters to intentional understandings of antemortem characterizations and evolution of diseases, distinguishing them from postmortem alterations (Brothwell, 1965; Buikstra, 2019a; Buikstra & Ubelaker, 1994; Ortner, 2003; Ortner & Putschar, 1981; Wells, 1964; Williams, 1929). In paleopathology, the fundamental objective is to obtain as much background information on the skeleton as possible and to evaluate the skeletal lesions as observed (Ortner, 2003) in line with comorbidities.

A broad spectrum of lesions can be characterized by observing the general skeletal morphology and comparing regular vs. abnormal traits locally or generally expressed on the bone. The ontogenesis of some pathologies is age, sex, and activity-related, as well as population and geography-specific. Also, the association of diseases with humans or animals stems from environmental adaptation and the extent of its expression in either specimen depends on immunity, genetic signatures, disease susceptibility, and lifestyle (Buikstra, 2019a). Thus, diagnosis of diseases in the skeletal record will require survival and preservation of the lesion on the bone (Ortner, 2003). Given this, not all diseases experienced from infancy/childhood will be evident on the (adult) skeleton due to the superpower of bone remodeling and in special cases where the decedent does not live long enough for the lesion to leave its mark on the bone. This understanding influenced the diagnosis of diseases in the

adult and non-adult skeletal remains.

According to Wood et al. (1992), osteological evidence of diseases depends on two factors/theories: heterogeneous frailty and selective mortality. Heterogeneous frailty means that varied age groups will acquire or experience diseases and even show symptoms differently. Regarding selective mortality, death haunts the most physiologically vulnerable people irrespective of age. In this ambit, case-specific diagnoses of pathologies were conducted, considering exceptions like individual genetic variations, environmental and behavioral differences, and differential diagnosis of evident pathologies where necessary. Individuals and populations may experience morbidity variably, based on factors that may never be known through pathological or epidemiological studies (hidden variables). Given this, known variables of the presence and influence of diseases evident on the individuals were recorded, bearing in mind that there may be more to what is observed and thought to have happened. I do not, therefore, generalize the factors explained or presented here as definite descriptions of the health or oral health of the past populations but as contributing variables potent and important for inference of the general health and oral health of the individuals.

A better understanding and application of the factors above and their influences on the probabilities of various morbid conditions are of great importance to skeletal analysis and facilitate pathological examinations and the understanding of pathology (Ortner & Putschar, 1981). Also, it allows to control possible confusion, misdiagnosis, and misinterpretation.

## **CHAPTER 1**

### **PALEOPATHOLOGY AS THE MAIN TOOL FOR GLOBAL HEALTH RECONSTRUCTION FOR PAST POPULATIONS**

#### **3.2 OVERVIEW**

This chapter of part II discusses the pathologies recorded on the human remains from all sites and how the skeletal and dental evidence of disease can aid the reconstruction of the health of the ancient populations.

#### **3.3 INTRODUCTION**

The study recorded cross-sectional data on dental and skeletal pathologies. It assessed the pathological prevalence across the sites to predict/ interpret the general health (including oral health) of the populations across the region. Because the environment and culture affect the biological, the bone shows traces of the diseases that had ample time to imprint the bone. In other words, the individual survived the disease or endured for a long time before death. The association of pathologies to humans or animals stems largely from adaptation to the environment, if not genetically underlaid, and the extent of its expression in either specimen depends on immunity, disease susceptibility, and lifestyle (Buikstra, 2019a), more like the survival of the fittest. Osteological depictions of diseases are a revelation of population or individual intra-vitam health challenges emanating from aspects of the environment in which they existed. These environmental aspects include effects of dietary patterns, activity, or genetic responses to the environment within which morbid and comorbid variables will differ because of selective morbidity and heterogeneous frailty (Buikstra, 2019a).

In addition to bioanthropological assessment, computed tomography examination was carried out on five of the crania with soil endocranial for paleopathological insights into the soil matrix for sclerotic tissues or calcified carcinoma and to determine whether the

intracranial mass was preserved brains or not. Parasitological analysis was also conducted on 8 soil samples from the cranial cavity of the remains from Sekondi, Ntereso, and Yikpabongo. The aim was to look out for parasites that could have been present in the burial environment following decomposition and taphonomic processes. Moreover, x-ray fluorescence analysis of three calculus samples extracted from the maxillary and mandibular teeth of two Begho individuals was intended to identify oxides and elemental components of the mineralized plaques to ascertain the risk of industrial pollution to lead, arsenic, mercury, chromium, and antimony via the food-water chain during the 10<sup>th</sup>-19<sup>th</sup> centuries. And the composition of compounds relative to the dietary patterns of the people.

### **3.4 METHODOLOGY**

To elucidate pathologies and other conditions on the individuals to provide insights into the health of these populations, the study employed, in addition to the bioanthropological examination of teeth, cranial and postcranial bones, and computed tomography examinations of the external and internal characteristics of the skulls with soil endocranial and lumbar vertebrae suspected for *Brucella spondylitis*. Also parasitological analysis of the intracranial soil in the skulls of some of the individuals and x-ray fluorescence analysis of calculus samples from Begho individuals. For details on the bioanthropological method, refer to the methodology of Chapter 3 in Part I.

#### **1. Analytical Method: Computed Tomography Examination**

The examination was carried out on five of the crania with soil endocranial. The skulls were from Ntereso: adult individuals- NT'18-73.90 and NT'18-73.91 and Sekondi individuals: SK'21-A 73.80; middle adult (probably female), SK'21-C 73.88; middle-old adult individual, and SK'21-L 73.86; middle adult (presumably female). Additionally, the lumbar vertebrae (L2-L5) of an individual from Begho suspected of brucellosis were examined to better describe the



destruction of the anterior-superior margin of the vertebral body. The CT imaging was undertaken at the Radiology Department of the Korle-Bu Teaching Hospital using the Toshiba Aquilion One 640-slice CT scanner. Slices were taken of 0.5 mm and the standard skull protocol of 5.0 mm (fine and dense slices, respectively) for the digital documentation and assessment of the crania's global external aspects and the soil matrix to investigate trapped sclerotic organic tissues or calcified carcinoma.

The auto-run files were viewed with the Merge PACS™ software in the bone window at pre-defined window width (WW) of 2000 HU and a center level (CL) of 500 HU. To contrast for emphasis, some figures were captured at an HU other than the pre-set. HU- Hounsfield unit is the CT attenuation of a tissue density named after Sir Godfrey Hounsfield (Kamalian et al., 2016). Although most slices were taken at 5.0 mm on the axial plane/protocol of the head, the figures were formatted at varied resolutions in single, double, and triple slides in the sagittal and coronal multiplanar reconstructions. The films were examined based on the high-low-density principle, in that high-density tissues with high HU appeared brighter than low-density tissues with low HU as dark shades. The bone window was chosen over the brain window because the remains are from archaeological contexts with dense intracranial mass which appears as bright white with the loss of dense artifacts to assess in the brain window. Even though the bone window sacrifices the detection of less dense structures like blood vessels and the brain, other less dense features such as airspace (-1000 HU), muscles/ soft tissues (20- 40 HU), fat (-30 to -70 HU), and cerebrospinal fluid/water (0 HU) (Kamalian et al., 2016; Lev & Gonzalez, 2002) will respectively appear in black, grey, dark grey/darker and dark shades (Broder & Preston, 2011). The lumbar vertebrae slices were viewed and formatted to 3-D views using the Radiant Viewer software.

## **2. Analytical Method: Parasitology**

Parasitological analysis was conducted on 8 soil samples from the cranial cavity of the remains from Sekondi, Ntereso, and Yikpabongo. This was conducted at the Laboratoire Anthropologie, Archaéologie, Biology (LAAB) at Université de Versailles Saint-Quentin-en-Yvelines (UVSQ) using the Leica DM750 binocular microscope. The microscope was connected to a Macbook for wider viewing. Samples (fine component) were scooped out of zip lock bags with a spatula, measuring 0.02g onto a microscope slide; a non-specified amount of Sodium chloride copper 0.9% was dropped on the samples on the slides, and a second slide was put on the solution. The solution was viewed under varied/alternated resolutions of 10x /0.25 and above to detect parasitic structures that could be present in the soils. This was done five times (5x) for each sample; the total was  $0.02g \times 5 = 0.10g$ .

## **3. Analytical Method: X-Ray Fluorescence**

X-ray fluorescence analysis of three calculus samples extracted from the mandibular teeth (32, 33, 34, 35, 37, 38 & 42, 43, 44, 47, 48) of an adult individual (male?) BG'21-E 73.115 (Bg. 70, E) and from the maxillary (11, 13, 14, 21, 23 & 24) and mandibular (31- 37 & 41- 48) teeth of a 40- 45-year-old male BG'21-F 73.116 (70 B1). The extracted calculus from the maxillary and mandibular teeth were treated as independent samples; thus, three calculus samples from two individuals were prepared for analysis. The analysis was conducted at the Earth Science Department of the Applied and Basic Sciences School of the University of Ghana. The analysis was undertaken using the Rigaku NEX CG x-ray fluorescence machine calibrated (Multichannel Analyzer) with a borosilicate bead for the relationship between the spectrum data channels and the energy of the fluorescent x-rays.

The extracted calculus was ground using a mortar and a pestle and weighed on powder paper; pre-weighing was not done because of the small sample quantity. After grinding, the powdered samples weighing 3.5g were poured into a sample cup, covered, and loaded into

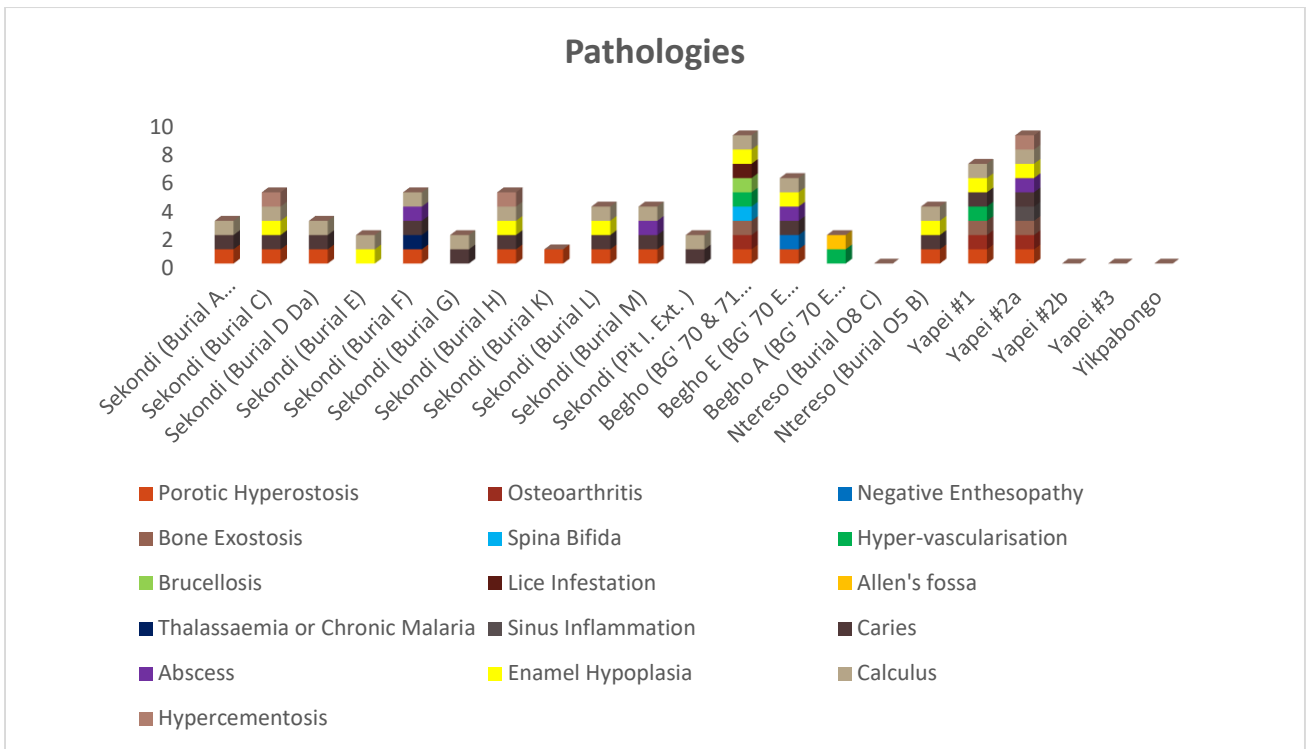
the assigned sample chamber position in the Rigaku NEX CG x-ray fluorescence machine. The samples were run for about 15-20 minutes along with the Rigaku NEX CG XRF fundamental parameters (FP) double determination approach and a helium gas test flow rate of 0.660ml/min. The presence of Helium gas permitted the measurement of lighter elements such as Si, Al, Na, and Mg. The FP method involved the use of the QuantEZ<sup>®</sup> software for controlled spectrometer functions and data analysis of the excitation source, element-element interactions, and beam intensity of each element (detected by a high-performance Silicon Drift Detector). As well as band overlaps, incidence angle & wavelengths, and mass absorption coefficients to calculate the elemental and molecular concentrations in the calculus as percent levels. The Rigaku NEX CG's FP produced semi-quantitative determinations of the concentrations with minimal standards.

### 3.5 RESULTS

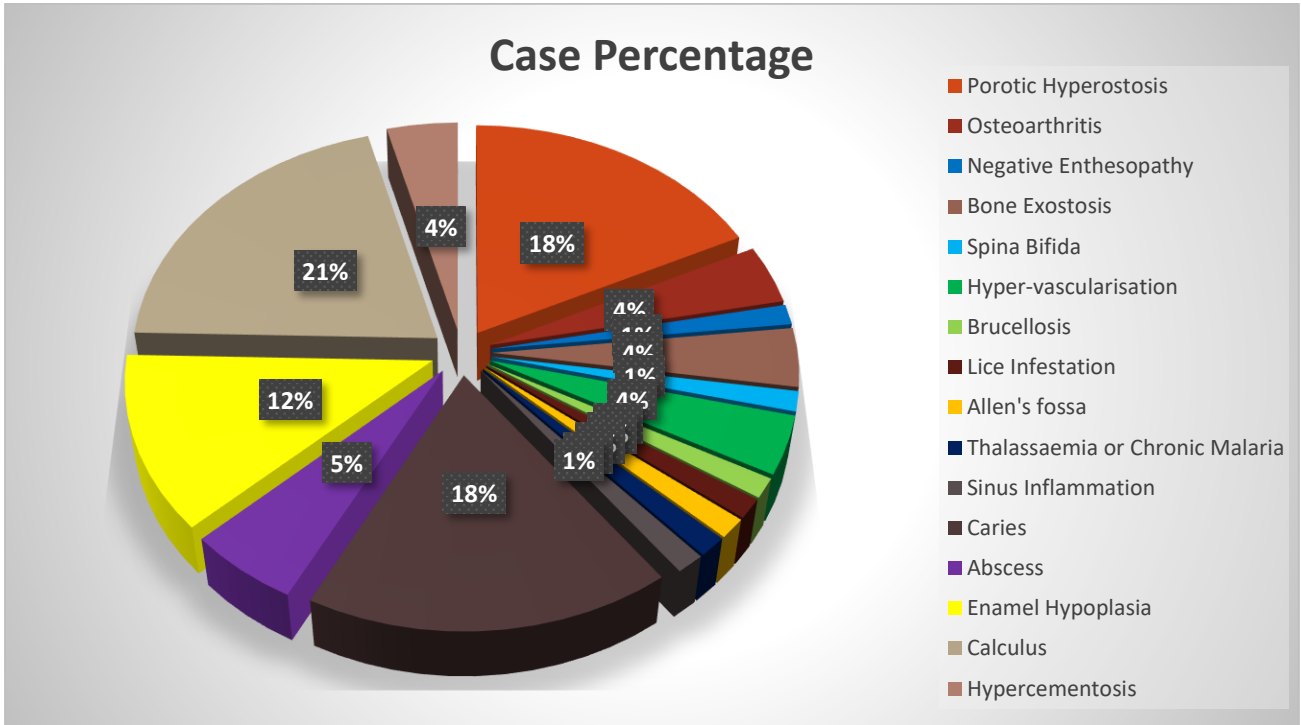
#### ***Bioanthropological Analysis***

The assessment revealed 16 pathologies: 40% skeletal and 60% dental, indicative of the health of the past populations from the respective sites. The pathologies included 5% abscess (Ab.), 4% bone exostosis (Bn exo.), 1% Brucella spondylitis (B. spondy.), 18% caries (Car.), 21% calculus (Cal.), 1% Allen's fossa (A. fossa), 12% enamel hypoplasia (E. hypo.), 4% hypercementosis (Hyper C.), 4% hypervascularization (Hyper V.), 1% lice infestation (Lice inf.), 1% negative enthesopathy (Neg. entheso.), 4% osteoarthritis (OsteoA.), 18% porotic hyperostosis (P. hyperos.), 1% spina bifida occulta (S. B. occulta), 1% sinus inflammation (Sinus inf.), and 1% thalassemia (Thala.). Details have been represented in Charts 3. 1 & 3. 2. Porotic hyperostosis was prevalent in 13 of 21 individuals, while osteoarthritis, bone exostosis, hypercementosis, and hyper-vascularization represented 4% in the assemblage. The pathologies of 1% were evident in only one/ two individuals (Charts 3.1 & 3.2). While the Sekondi assemblage recorded the highest cases of porotic hyperostosis, osteoarthritis was unobservable because of the absence of most postcranial bones and the heavy fragmentation of available postcranial bones.

The dominance of calculus (21%) in 15/21 individuals was incredible; although calculus was recorded in most Sekondi individuals, it was more severe in Begho individual BG'21-E 73.116, Ntereso individual NT'18-73.91, and Sekondi individual SK'21-H 73.84. In 13 of 21 individuals, caries was present at the occlusal, interproximal, and CEJ (cemento-enamel junction), and the non-specific stress marker, enamel hypoplasia (13%), was common in 9/21 individuals. Abscess was in 4/21 individuals representing 6% in the skeletal series. The pathologies will be discussed along the sub-divisional lines of stress, nutrition, infection/health, oral health, and activity.



**Chart 3. 1: Distribution of pathologies among individuals across sites.**



**Chart 3. 2: Case divisions of pathologies.**

	Skeletal Pathologies											Dental Pathologies				
Sites	P. hyperos.	OsteoA.	Neg. entheso.	Bn. exos.	S.B. Occulta	HyperV.	B. spondy	Lice Inf.	A fossa	Thala.	Sinus Inf.	Car.	Ab.	E. Hypo.	Cal.	HyperC.
Sk.(A)	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Sk. (C)	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
Sk. (D Da)	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Sk. (E)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Sk. (F)	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0
Sk. (G)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Sk. (H)	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
Sk. (K)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sk. (L)	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Sk. (M)	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
Sk. (Pit I. Ext. )	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Bg (F)	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	0

Bg (E)	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0
Bg(A)	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Nt (O8 C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nt (O5 B)	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Yp #1	1	1	0	1	0	1	0	0	0	0	0	1	0	1	1	0
Yp #2a	1	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1
Yp #2b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yp #3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

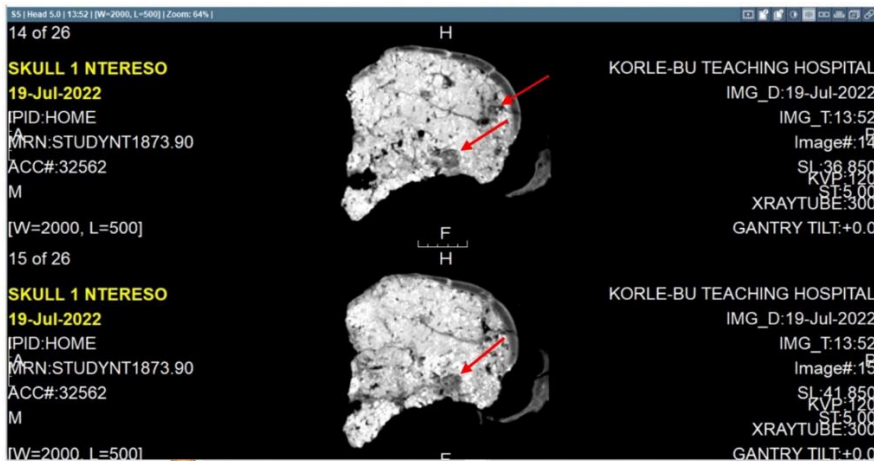
**Table 3. 1: Represented Pathologies across Sites: 1= present, 0=absent.**

## **CT Examination**

Details of the examination have been presented in a different article (under review); therefore, only highlights will be presented here. In the bone window, high-density artifacts and low-density blotches characterized the view. For instance, Ntereso adult individual: Ntereso, NT'18-73.90 had some high-density materials, probably stones/pebbles (shown as white spots) and voids or air bubbles in black and root impressions. In the calcified matrix was a circular dark-grey blotch at the inferior portion and a dark-grey stain at the posterior section of the cranium (**Figure: 3.1**). There were also post-mortem cranial bone fragmentation, compact matrix fragmentation, and dental pathologies such as mirror caries at the cemento-enamel level of 25 & 26 of Sekondi middle adult (female?), burial L, SK'21-L 73.86. there was interproximal caries on tooth 25 of Sekondi middle adult (female), burial A, SK'21-A 73.80, in addition to an abscess; labial perforation at the level of tooth 15. Also, the analysis detected petrous bones (with no anomaly). No pathologies: infarction and calcified carcinomas were evident.

The intracranial filling did not correspond to a mineralized or almost fossilized brain characteristic of which there would have been distinct white and grey matter. However, the dark-grey colorations indicated decomposed low-density materials/tissues, including fat, between 20 to -70 HU. Interestingly, the scans revealed a necrophobic practice of pebble-in-mouth in one individual from Sekondi. From the examination, the external aspects of the skulls resulted from soil compression with the burial environment and not intentional cranial modification. Furthermore, the scan of the lumbar vertebrae of the individual from Begho suspected of *Brucella* spondylitis **Figures 3.6-3.8** (emphasized by the extent of osteophytic development (yellow arrows), revealed a gibbus deformity (blue arrows), and voids (green arrows) discussed in relation to the suspected lesion ([details in \*Brucella\* spondylitis in the health section](#)).





**Figure 3. 1: Adult individual: Ntereso, NT'18-73.90 showing external cranial aspect, pebbles, voids, rootlet impressions, and circular dark-grey patches of fat or organic residue (red arrow). The skull is in sagittal orientation.**

***Parasitology***

The details are presented in Table 3.2. The soils from the endocranial cavity of individuals: Sekondi SK'21-73.86, Sekondi SK'21-73.85, and Ntereso: NT'18-73.91 revealed only plant-based substances, while all the other samples had no evidence of parasites or plant-based materials.

**Table 3. 2: Parasitology Analysis of Soil Samples**

Site	Context	Unit	The result is under 10 $\mu$ /0.25 resolution and above.
Sekondi: SK'21-73.82	Burial E	0.02g x 5 = 0.10g	Nothing
Sekondi: SK'21-73.86	Burial L	0.02g x 5 = 0.10g	Vegetal
Sekondi: SK'21-73.85	Burial K	0.02g x 5 = 0.10g	Vegetal
Sekondi : SK'21.73.80	Burial A (VII G)	0.02g x 5 = 0.10g	Nothing
Sekondi: SK'21-73.87	Burial M	0.02g x 5 = 0.10g	Nothing
Ntereso: NT'18-73.91	Burial 05 B	0.02g x 5 = 0.10g	Vegetal
Ntereso: NT'18-73.90	Burial 08 C	0.02g x 5 = 0.10g	Nothing
Yikpabongo:YK'21, U1	YK'07, Unit 1/C-D 3	0.02g x 5 = 0.10g	Nothing

### ***X-ray Fluorescence***

A separate article has been prepared on this analysis ([Appendix E](#)); hence only highlights are presented here. The elements and molecule fingerprints (59 and 55, respectively) were automatically generated non-destructively from the calculus samples of the Begho individuals. The calculus from the mandibular teeth of the adult male individual of Begho, burial E (BG'21-E-73.115), and the maxillary and mandibular teeth of the middle adult male from Begho; burial F (BG'21-F- 73.116) showed high levels of oxygen, calcium, phosphorus, silicon, and aluminum. The mandibular and maxillary teeth of individual BG'21-F- 73.116 revealed high CaO, P<sub>2</sub>O<sub>5</sub>, SiO<sub>2</sub>, and Al<sub>2</sub>O<sub>3</sub> molecules compared to the maxillary teeth of Begho individual BG'21-E- 73.115. However, Ferric oxides were not much different for the two individuals ([Appendix D. 1- D. 6](#)). The calculus composition is of classical aluminum silicate with insignificant to no trace of industrial pollutants such as chromium, lead, mercury, arsenic, chromium, and antimony.

### **3.6 DISCUSSION- *HEALTH***

#### ***Porotic hyperostosis***

From the analyses of complete skulls and fragments of cranial bones, porotic hyperostosis (18%) was prevalent in the sites, representing 13 of the 20 individuals. Nevertheless, it was more prominent among Begho, Sekondi, and Yapei individuals and less represented in the individuals from Ntereso and Yikpabongo. Even though Charlier (2008) mentions that porotic hyperostosis seldom appears on the frontal and occipital bones, the distribution of this lesion on the cranial vaults of some of the study samples was localized at either the frontals, parietals, temporals, occipitals, sphenoid, and mandibles. It was impossible to identify the exact location of the lesion for the fragmented cranial bones. Also, appearing on the frontal bosses, bilateral surfaces of the parietals (adjacent to the sagittal and lambdoid sutures), or the squamous portion of the occipital of the crania of some individuals, the lesions were scored within the activity stages of active, healed/ remodeled, and mixed reaction. These categorizations corresponded to porosity only, barely discernible lesions, and porosity with coalescence of foramina with or without increased thickening of the cranial bone surfaces (Tables 2.13.1-2.17.1 above) according to Buikstra & Ubelaker (1994, p. 115) adapted from Stuart-Macadam (1985) parameters for recording hyperostotic lesions.

A multifactorial cause is affiliated with the emergence and development of porotic hyperostosis. On the one hand, the lesion has been discussed in relation to chronic or episodic malnutrition (Armelagos, 1990), the compensation for the accelerated loss of red blood cells in anemic cases; acquired iron deficiency anemia, iron deficiency, or insufficient absorption of iron (Stuart-Macadam, 1982, 1992). According to Prost (1988, p. 101), "iron deficiency anemia and folate deficiency are delayed effects of nutritional inadequacy". The nutritional or dietary correlation to porotic hyperostosis was substantially supportive since population pressure in agrarian societies meant burdened food resources where group portions/ intake may be reduced. Also, the increased consumption of cereals and legumes which contain an antinutrient compound (phytates) that limit intestinal mineral absorption of iron and zinc

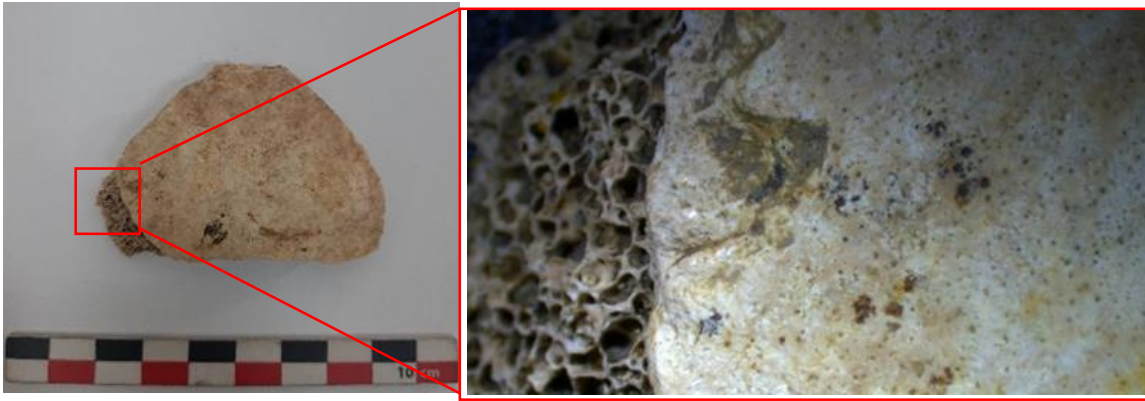
from diets (Graf & Eaton, 1990; Silva & Bracarense, 2016), coupled with the decreased intake of iron-rich foods could contribute to low iron levels.

Ghana, in 1983-84 experienced an episode of famine, a very devastating season in the country's history. This season could have contributed to acute malnutrition at the population level post-season in adults and children due to inadequate nutritional needs. Malnutrition at the population and family levels all contribute to the drop in individual iron levels, reduced absorption rate, and the consequent compensation of red blood cells in the bone marrow. On the other hand, Charlier proposed a susceptibility to porotic hyperostosis from foodborne illness via food poisoning from lead, arsenic (2008, p. 437), and bacteria (e.g., Salmonella). However, Stuart-Macadam (1992) finds that diet has a minimal influence on the development of porotic hyperostosis and stresses the importance of iron in the maintenance and protection of the human body (Stuart-Macadam, 1992: 40). He further argues for a morbidity etiology to porotic hyperostosis, inferring that low iron level or short-term hypoferrremia is the body's adaptation mechanism to diseases. But while this condition (being anemic) reduces the body's susceptibility to diseases, including bacterial and fungal infections, it has adverse effects on the bone marrow.

Additionally, as a reflection of an early age inflammation or developmental health stress, porous lesions may be left as signatures of some diseases on the skull. In this case, a more active hyperostotic lesion will be evident during childhood, and the healed activity will be observed in adult remains (Stuart-Macadam, 1985). For instance, measles is a contagious disease that can have serious complications such as encephalitis and the inflammation of nervous tissues. This vector is noted as one of the six-killer diseases afflicting children. The child experiences a significant stress phase with this disease and with links affecting the cerebral membrane, the overlying bone may be affected due to the inflammation underneath. Furthermore, Stuart-Macadam (1992) put forward a linear relationship between an individual's pathogen load, the development of anemia, and, consequently, porotic hyperostosis spatiotemporally. He acknowledged, however, that the 20<sup>th</sup> century saw a

decline in the lesions with adequate sanitation and hygienic measures (Stuart-Macadam, 1992: 42). In some urban sectors and most rural areas in Ghana, sanitation and waste management are yet to improve. For most parts, poor sanitation compounds the breeding of parasites and exposure to infections. Hence the sanitation/hygiene theory supports the increased porotic hyperostosis in the study populations. Again, Stuart-Macadam (1992) has discussed that inhabitants of lowland and coastal sites with proximity to the equator have high porotic lesion index than the 'highlanders' (Ubelaker, 1984) because of favorable conditions that fuel the thriving of pathogens (p: 42), irrespective of dietetics (Walker, 1986). This phenomenon can be an explanation for the significant porotic lesions found on 8 individuals from the coastal town of Sekondi in comparison to the rest of the individuals from Begho, 2 (a non-coastal and non-riverine town), and Ntereso, 1 and Yapei, 2 (both being riverine towns).

Due to the correlation of porotic hyperostosis to diseases and environmental stresses/conditions (Stuart-Macadam, 1991, 1992), the skeletal response to childhood anemia: porotic hyperostosis and cribra orbitalia (Steckel & Kjellström, 2018; Stuart-Macadam, 1985) may persist into adulthood if episodes of the environmental influence equally persist. The lesion may, however, be evident at varied degrees of activity: active porosity, a healed appearance, or mixed reaction with coalesced foramina, except adulthood inception of anemia. For example, **Figure: 3. 4** shows external cranial porotic hyperostosis from barely discernible, porosity only, porosity with coalesced foramina to coalesced foramina with and without thickening on some cranial bones. Whether the lesion is an extension of childhood stress or was acquired much later in life is uncertain.



**Figure 3. 2: Significant changes (expansion) in the trabeculae bones of a thickened cranial bone of an adult individual from Sekondi- SK'21-F 73.94.**



**Figure 3. 3: Showing changes in the trabeculae matrix in the same cranial bones of the same individual.**



**Figure 3. 4: Cranial bones of an adult individual from Sekondi: SK'21-F 73.94 showing signs of porotic hyperostosis with varied degrees of activity.**

Moreover, the lesion may emanate from excessive red blood cell production (polycythemia vera) in the matrix of the (flat) bones or thalassemia; of the beta/alpha strains (Charlier, 2008). Thalassaemia is a blood disorder that destroys red blood cells, significantly reducing hemoglobin levels or producing abnormal forms of hemoglobin (Cooley, 1925). Thus, on the one hand, high iron intensities may suscept the medullary cavity to expansion. On the other hand, low iron levels may force the interstices of the bone to compensate for the blood loss, creating tension and changes (expansion) in the internal matrix of the bones and thinning of the external compact bone (**Figures: 3. 2 & 3. 3**) (Stuart-Macadam, 1991, 1992). The result is porosity on the interior and exterior surfaces of the crania. Again, malaria has concomitant effects on an individual's red cells or hemoglobin levels (Mohandas & An, 2012; White, 2018), causing or worsening episodes of anemia.

Being endemic in West Africa before and towards the 20<sup>th</sup> century and in the tropics, malaria affects infants, children, pregnant women, and adults. It is still a leading threat to the World's population, notably in the sub-Saharan African region, with substantial cases and deaths worldwide (WHO, 2020). The ethnographic study revealed that malaria and measles were dominant in the early 19th century, plus other water-borne diseases like bilharzia and hepatitis B at Yapei and Ntereso. Malaria and measles were also recorded at Sekondi. Symptoms of malaria include fever, and anemia, leading to acute encephalopathy with multi-organ failure (WHO, 2020). The effects of thalassemia/ chronic malaria (in relation to anemia) in the internal matrix and outer table of the flat cranial bones is the development of vertical trabeculae, described as a "brush hair" (Charlier, 2008, p. 437) or "hair-on-end" (P. Stuart-Macadam, 1982, 1992, p. 40).

Some studies have noted that hemoglobinopathies evoked from altered red cells offer a level of protection against diseases/parasite infections (Mohandas & An, 2012). Additionally, a water-borne disease like elephantiasis (Lymphatic filariasis) protects against anemia (Dolo et al., 2012). Could this be why Yapei and Ntereso individuals had fewer porotic lesions? It's concluded that any disease increasing blood cell production in the bone marrow and bone

marrow volume would cause porotic hyperostosis, typical of all the above examples. Considering the prevalence of porotic hyperostosis (18%) in the assemblage, in 13/21 cases with a high acclimation of the lesion to the coastal town of Sekondi, a cross-regional projection of nutrition, health, and environmental stress in relation to the dimensions discussed above is possible. Coupled with substantial evidence of one or two hypoplastic lines representing 13% of the 21 contexts: 9 individuals from Sekondi, Begho, Ntereso, and Yapei of the Western, Bono, and Savannah regions, respectively.

### ***Osteoarthritis***

Osteoarthritis was extensively expressed on the vertebral bodies of a middle adult male from Begho, BG'21, 73.116, with the severity of elevated rings on C3-C7, barely discernible lipping on T1-T12, and elevated rings on L2-L5. Also, the middle adult females from Yapei showed spinal osteoarthritis on the L2-L5 & T12 (for YP'18-73-106) and L1-L5 (YP'18-73.105, **Figure: 3. 5**) with varied degrees of lipping and affected circumference. Again, on the L2 of YP'18-73.105 was a bony outgrowth depicting the calcification, then ossification of the yellow ligament (**Figure: 3. 5**). As mentioned earlier, the adult male from Begho had significant evidence of spinal osteoarthritis; bony spurs or lipping at the superior and inferior margin of the vertebral bodies of the spine, and around the occipital condyles. Slight osteophyte formation pathogenic to osteoarthritis was also observed at the proximal and distal articular regions of the femora, tibiae, and humeri, but absent on the radii and ulnas. Osteoarthritis could not be observed in individuals from Yikpabongo, Ntereso, and Sekondi because the elements available were a calotte, crania with insufficient bone markers, and very fragmented postcranial long bones, respectively. This situation suggests that a holistic appreciation of activity and stress lesions is possible when >50% of skeletal remains are available for assessment.

Multifactorial etiologies of osteoarthritis have been extensively proposed and discussed to

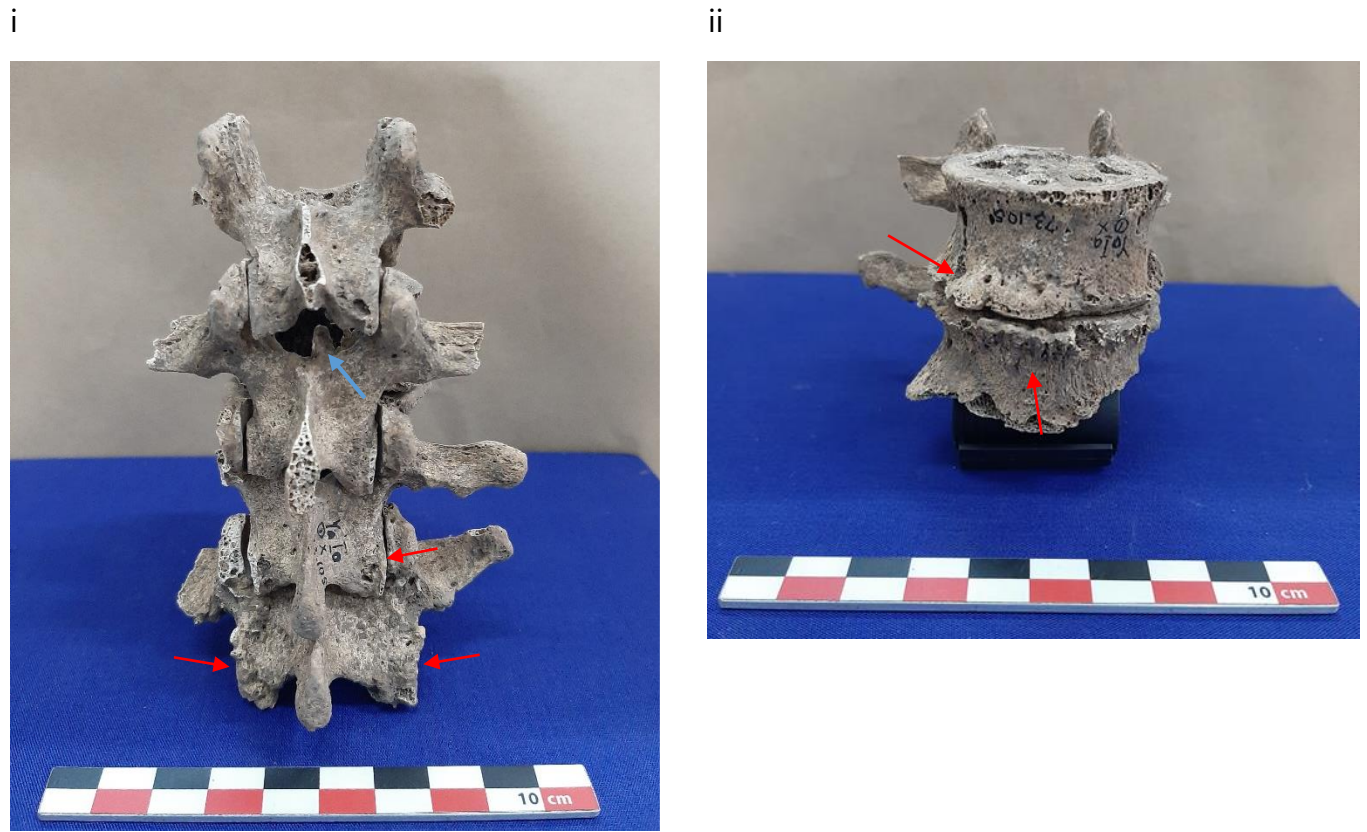


include age, diseases, e.g., rubella for secondary osteoarthritis in small joints (Blakely & Detweiler-Blakely, 1989), activity: sports and occupation (Thelin et al., 2004; Weiss & Jurmain, 2007), climate/ environmental factors; colder and wetter environments coupled with reduced sunlight and subsequent deficiency in vitamin D (Kalichman et al., 2011). Other scholars have also pinned osteoarthritis and its severity to the root of the genetic makeup of a person, and anatomical variants such as long tibiae, knee cartilage volumes and shallow acetabula (Weiss & Jurmain, 2007), and obesity and body mass index for (hand) osteoarthritis (Guilak, 2011; Kalichman & Hernández-Molina, 2010). Nonetheless, the age-related and gendered-activity correlations have been widely discussed (Guilak, 2011; Palmer et al., 2016; Weiss, 2017; Weiss & Jurmain, 2007) in response to the wear and tear of the protective cartilage on or around the joint and the repetitive manual use of joints. This pathology is typically evident among older adults over 65, but young adults can also develop osteoarthritis (in the spinal and other joints). I believe the age link holds because constant remodeling occurs over the years, with or without activity.

Significant joint wear and tear can be due to inflammation (Guilak, 2011; Sandell & Aigner, 2001; Weiss & Jurmain, 2007), injury, and occupational stress on the joint. Within the skeletal assemblages, the classical lesion of osteoarthritis observed is the formation of osteophyte formation (the last characteristic of osteoarthritis) and polished bone surface (eburnation) (Weiss, 2017, pp. 72–73). Due to the regularity and ease of identifying osteoarthritic patterns on remains, they are the most common proxies for status and class-based activities, gendered and specific activities, and changes in subsistence activities (Eshed et al., 2010; Garvie-Lok, 2010; Larsen, 1995; Nicholas, 2007; Palmer et al., 2016; Robb et al., 2019). Whereas mechanical load or stress is necessary to maintain cartilage remodeling and repair for healthy joints (Guilak, 2011), excessive pressure on joints can affect bone growth and accelerate degenerative changes at joints beyond repair (Grodzinsky et al., 2000; Sandell & Aigner, 2001).

This draws to mind the activity links because of constant remodeling throughout the life course as people engage in activities of all kinds at the mercy of the joints; in all three sections

of the spine, and ball & socket joints of the upper arm and hips, and the hinges joints of the elbow, knee, hands, and feet. Due to the exclusive osteophyte locations on the study samples, osteoarthritis will be discussed more as an activity-related marker in the first chapter of the last part of the thesis.



**Figure 3. 5: Osteoarthritis depicted by periosteal reaction/ extensive lipping (ii) and bony spicules on the articular facets (i) (red arrows) on the lumbar vertebrae of an old adult female, Yapei- YP'18- 73.105. Note the bone exostosis (about half an inch) resulting from calcification, then ossification of the yellow ligament at the posterior part of the canal on L2 and L1 (but that of L1 is broken) (blue arrow) which may have restricted intra-vertebral elasticity. This is a sign of aging, corresponding to the age range given by the morphology of the auricular surface (old adult).**

## ***Brucella spondylitis***

The *Brucella* species: *melitensis*, *abortus*, and *suis*, are the main causative agents in humans. Brucellosis is a zoonotic disease through the food and occupation transmission chain. It is associated with ingesting protein, unpasteurized milk, and fresh cheese from infected animals or handling infected animals (Gür et al., 2003). In Ghana, cattle (in the northern, southern, and coastal savannah areas) are the most common carriers (Oppong, 1966; Turkson & Boadu, 1992). While the control of the spread of the disease has been the consumption of pasteurized dairy products and vaccinations (S19, RB51) (Craighead et al., 2018) against the disease. The most vulnerable to the infection are males, although it also affects women and children (Glasgow, 1976; Sharif et al., 1989; Sharifi et al., 2014) provided they are in contact with infected animals or consumed unpasteurized dairy products or improperly cooked meat of infected livestock. In the year 2000, Kubuafor and colleagues (2000) revealed a negative risk of *B. abortus* among the high-risked groups: six veterinarians, six butchers, 21 herders, and 12 environmental health inspectors) or in the control group of 30 people, probably due to the existing vaccination program. However, the worldwide seroprevalence of brucellosis has been well-recorded, particularly in Africa (Amegashie et al., 2017; Bamaiyi, 2016; Chota et al., 2016; Djangwani et al., 2021).

Related pathogens may spread to the liver, spleen, and lymph nodes, but common osteoarticular localizations are in the sacrum and lumbar vertebrae (D'Anastasio et al., 2011, pp. 149–150; Gür et al., 2003; Nas et al., 2001), the sacroiliac joint and at any level of the spine (Ariza et al., 1985; D'Anastasio et al., 2009; Glasgow, 1976; Gür et al., 2003; Nas et al., 2001, 2007, 2009; Ortner, 2003; Rajapakse et al., 1987; Rajapakse, 1995). *Brucella spondylitis* is depicted by sclerotic reactions, thickening of the trabecular matrix, periosteum inflammation, and "paucity of the associated paraspinal soft tissue disease, a moderate epidural paravertebral extension of the inflammatory process" (Sharif et al., 1989: 424). Vertebral brucellosis is, however, less destructive (in most cases, the integrity of the vertebral architecture is not compromised) than tuberculosis which is characterized by a combination

of “severe vertebral collapse, paraspinal abscess extending beyond the area of vertebral disk involvement and gibbus deformity” (Sharif et al., 1989: 424). A differential diagnosis of Brucella epiphysitis may consider other variants like tuberculosis and staphylococccic spondylitis (D’Anastasio et al., 2011).

The infection results in significant changes in the vertebrae; with focal osteomyelitis or epiphysitis of the anterior-superior margin of the thoracolumbar vertebrae, or diffused inflammation, involving the entire vertebral body, neighboring disks, and vertebrae (Sharif et al., 1989). Sharif et al. (1989) stated that the lower lumbar spine constitutes 68% of the lesion sites compared to 9% of multi-level spinal lesions (Madkour,1989). From studies on spinal brucellosis, individuals tend to suffer from severe back pain associated with the infection (Nas et al., 2001; Rajapakse et al., 1987). Cases of Brucellosis have been reported in the Bronze Age from Jericho (Brothwell, 1965) (Brothwell, 1965) and Jordan (Ortner & Frohlich, 2007; Rashidi et al., 2001).

One case of Brucella spondylitis was observed on the lumbar vertebrae of a middle adult male from Begho BG'21-F 73.116 (70 B1) (**Figures: 3. 6-3. 8**). This health condition was determined based on the erosion of the anterior surface of the lumbar vertebral bodies (**Figures: 3. 6-3. 7**) and the destruction/ epiphysitis of the anterior-superior margin/ rim of L3- L5 (Figure: 32). The anterior aspects of the vertebrae present a candle-dripping lesion extending down to the inferior margin. This feature is noted to be produced by the metaplastic ossification of the anterior longitudinal vertebral ligament (Capasso, 1999). Aside from these lesions, CT investigations revealed voids in the anterior-superior and superior-posterior aspects of the lumbar vertebrae L2 and at the superior-posterior regions of L3-L5 (green arrows). Distinctively, the void at the inferior-posterior portion of L3 is rather taphonomic. The presence of voids in the internal matrix of the vertebral bodies and other factors have been noted as signs of Brucella infection (D’Anastasio et al., 2011; Ortner, 2003). There appears to be a slight collapse- gibbus deformity of the lumbar vertebra L5 at the inferior-posterior aspect of the vertebral body (**Figure: 3. 8** blue arrows below pointing up). Besides spinal

distortion, multi-level vertebral collapse or gibbus deformity can induce significant pain in the host following limited flexibility. The diagnosis of Brucella spondylitis was therefore maintained due to the evident epiphysitis of the anterior-superior rim of the vertebrae (red arrows; **Figure: 3. 8**) and the candle-dripping lesion on the anterior aspects of the vertebral body (orange arrows, **Figures: 3. 6-3. 7**). Coupled with the extensive osteophyte formation on the vertebrae, a mechanical occupational influence can be proposed.

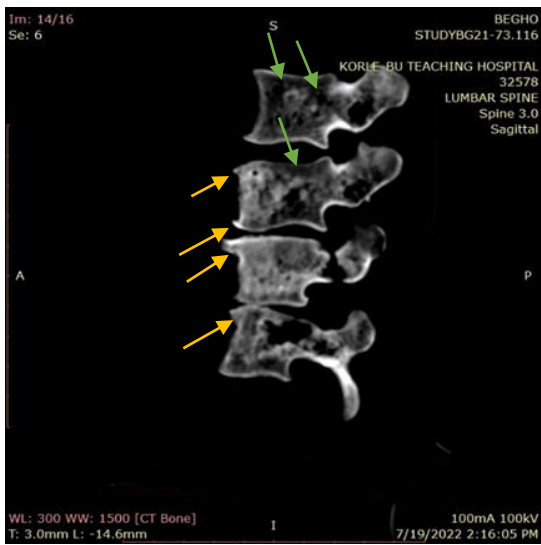


i)

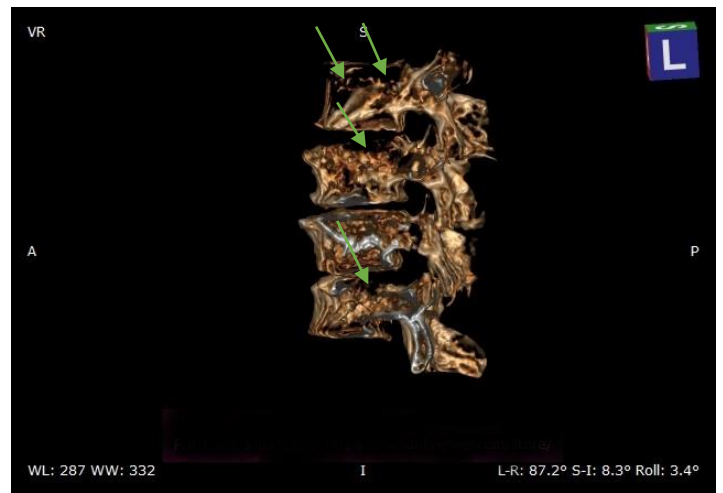


ii)

**Figure 3. 6: i & ii) Lumbar vertebrae of an adult male from Begho, BG'21-F 73.116 (70 B1) suspected of Brucella spondylitis. Note the candle-dripping lesions (orange arrows) resulting in metaplasia of the intervertebral ligament and the severity of the sub-periosteal porosity in the vertebral bodies. Also, notice the multifocal lytic lesions on the vertebral bodies of the L3-L5.**



i)



ii)

**Figure 3. 7: i & ii) CT scans of L2-L5 showing distinct non-taphonomic voids (green arrows) and extensive osteophytic lesions (yellow arrows) (Lateral views).**



**Figure 3. 8: A destruction of the anterior-superior rim of L3-L5 with extensive osteophytic reactions (red). The blue arrows indicate a probable gibbus deformity. Superior is up.**



### ***Sinus inflammation***

Sinusitis of the maxillary, nasal, and frontal sinuses due to the inflammation of the mucus-producing lining in the sinus is not uncommon. The inflammation leaves distinct signatures within the internal matrix of the facial skeleton. Sinus inflammation of the maxillary sinus was recorded on an individual from Yapei, YP'18-73.105. This pathology could be due to the dental abscess on the buccal surface of tooth 14. Compounding the infection in the alveolus is mirror caries at teeth 14 & 15. The evident hypercementosis is the offshoot of bacteria colonization, extensive mirror caries, significant periodontal regression, and the extensive masticatory and non-masticatory use of the teeth (as a 3<sup>rd</sup> hand) (Massé et al., 2022; Pinheiro et al., 2008) (**Figure: 3. 9**). Hypercementosis and alveolar bone resorption are occupationally linked to fish net mending, leatherworking, or basketry. In this case, the tooth and the supporting bone get inflamed because of the constant friction associated with stabilizing or ripping the raw materials for work. The individual is

from a riverine community, where the inhabitants predominantly engage in fishing and basketry. The non-masticatory use of the teeth as a 3<sup>rd</sup> hand probably compounded infections at the level of the teeth, inflaming the adjacent sinus.



**Figure 3. 9: Inflammation of the maxillary sinus of an adult female maxilla (lateral view), Yapei, YP'18-73.105. It probably results from the infection (mirror caries at the cemento-enamel junction of teeth 14 & 15 and abscess at tooth 15) at the level of the teeth and alveolar bone resorption.**

## ***Spina Bifida Occulta***

Spina bifida occulta is an osteological condition characterizing the opening of the sacral spinal or the medial sacral crest. Extending from S1-S5 and at different levels in the sacral region, the opening of the laminae or spina bifida occulta is referred to as sacral spina bifida occulta (SSBO) (Singh, 2013: 14). Spina bifida occulta is a mild form of Spina bifida which is the absence of the bony dorsal wall (protecting the spinal cord) on the sacrum due to the non-fusion of the vertebral arches at the spinous process (Weiss, 2017:104). Its congenital genesis is related to a maternal deficiency in vitamin B12 or folate (Weiss, 2017:104).

Sacral spina bifida occulta is morphologically distinct from the sacral hiatus, which lies above the sacral cornua between S4 and S5 or at S5. Individuals with spina bifida are highly vulnerable to spondylolysis (Eisenstein, 1978; Sakai et al., 2010), among other factors, anatomical variation to the vertebrae, and increased stress (Weiss, 2017:105-107). Sacral spina bifida occulta was observed on the sacrum of an adult male from Begho. The morphology of the open canal is similar to type IV SSBO described by Singh (2013:16). To this type of sacral spina bifida occulta with relatively normal vertebral body fusion, Singh (2013:18) proposes a genetic etiology involving a double mutation of *Foxc2* and *Pax9* genes in addition to decreased secretion of molecules. On the contrary, Hol et al. (1996) did not find a correlation between *Pax9* mutation and neural tube defects (NTDs), but rather a link between *Pax3* mutation and additional environmental factors for NTDs of which spina bifida is a part.

The sacrum of this adult male from Begho had its dorsal wall open below S3 down to S5 (**Figure: 3. 10**). The length of the open sacral canal is 35mm with a width of 13mm. The ventral surface is normal with fused bodies. However, post-mortem damage and reconstruction are evident on S1 and the proximal end of S4. There are few porosities on S4 and S5. Dorsally, the lateral sacral crest is damaged bilaterally- relatively taphonomic. There existed a slight asymmetry and difference in the morphology of the auricular surface of the sacrum forming the sacroiliac joint of the os coxae and sacrum but no evident spondylosis of the vertebrae.





**Figure 3. 10: Spina bifida occulta of S3-34. Adult male sacrum. Begho, BG'21-F 73.116 (70 B1).**

### ***Lice infestation***

Lice infestation (head lice- *Pediculus humanus capitis* and body lice- *Pediculus humanus humanus*) results in physical and psychological irritation. Physically, extensive head lice activity causes constant itching and scratching of the scalp, which inflames the underlying skin tissues and the periosteum of the skull bones (local or general). Lice release toxins (in saliva) that tend to inflame scalp tissue and, after a while, the underlining bone. The periosteal inflammation from arthropod toxins released during host feeding (Jones et al., 1996), secondary infection of the scalp (Canadian Pediatric Society, 2008), and incessant scratching consequently superficially remodels the bone with rough and porous bone characteristics and depression (Capasso & Di Tota, 1998). This condition leaves lesions similar to porotic hyperostosis in compensation for the inflammation. An extended environmental explanation of lice infestation is hygiene-related; infested water bodies and unclean environments may be incubation centers for lice, and the sharing of combs, clothing, bedding, and close head or body contacts speeds the transmission. Secondary eczema, anemia, and impetigo correlate with pediculosis (Capasso & Di Tota, 1998; Mumcuoglu et al., 1991).

Porotic lesions indicative of lice infestation was observed on an individual from Begho in the squamous portion of the occipital bone (**Figure: 3. 11**), typical of an earlier record of lice infestation in the supra-inion region (Capasso & Di Tota, 1998). A concrete hypothesis cannot be constructed about the environment in which this individual lived because the record of the lesion in the assemblage is too limited to conclude. The porotic lesion in the external table of the squamous portion of the occipital of the individual is very similar to hyperostotic lesions but should not be confused due to its seemingly localized nature.

Although Frankowski (2002, 2010) mentions that head lice do not transmit diseases as against body lice, hair and body lice have been found as vectors for the human-to-human transmission of *Y. pestis* and *B. Quintana* in Cote D'Ivoire (Piarroux et al., 2013), Rwanda, Burundi (Fournier et al., 2002) and a medieval plague site in France (Tran et al., 2011). These bacteria could be endemic to societies increasing mortality at the family or community levels with severe illnesses.



**Figure 3. 11: Porotic lesions of head lice infestation at the squamous of the occipital bone of an adult male from Begho, BG'21-F 73.116 (70 B1). The skull also shows slight asymmetry in the alignment of the mastoid processes, not reflective at the foramen magnum.**

## ***Hypodontia***

Hypodontia, a type of dental agenesis, is the congenital absence of one to six teeth anywhere in the dental arcade but frequently of the upper lateral incisors and the upper and lower 2nd premolars (*Hypodontia (Missing Teeth)*, n.d.; *Tooth Agenesis*, n.d.; Kokich Jr, 2002). Missing teeth translates from dental lamina disorder leading to teeth developmental /formation defect in the alveolar. It can be inherited through autosomal and X-linked recessive and dominant genes from biological parents (Eshgjan et al., 2021; *Hypodontia (Missing Teeth)*, n.d.; *Tooth Agenesis*, n.d.). Several studies have recorded dental agenesis among varied populations with differing frequencies amid sexes but high in females than males (Gracco et al., 2017; Polder et al., 2004; Rakhshan & Rakhshan, 2015) and in Africa (Dosumu et al., 2009; Kakrabah-Quarshie et al., 2012; Roberts & Chetty, 2018; Yemitan et al., 2016). Harris and Clark (2008) found hypodontia more prevalent in Black Americans than Whites. Kakrabah-Quarshie and colleagues also found hypodontia and hyperdontia more rampant in females than males (Kakrabah-Quarshie et al., 2012). Its relative geographical prevalence, regardless of sex and age, amplifies the genetic causal agent.

A single case of bilateral hypodontia of the maxillary lateral incisors of a 40-45-year-old male (**Figure: 3. 12**) from the 10th-19th century prehistoric town of Begho, Ghana (Anquandah, 1981; Bravmann & Mathewson, 1970; Posnansky, 2015). This individual had >75% cranial and post-cranial bones complete. His stature is  $162.52 \pm 3.91$ , estimated from the right femur (Bass, 1995). Due to the solid hereditary links to dental agenesis, this individual could have also inherited this condition and persisted from childhood to adulthood. Among other skeletal and dental pathologies observed on the individual, this individual with a mandibular teeth ratio of 2:1:2:3 presented a typical antemortem tooth loss of 38 with almost complete alveolar resorption. Thus maxillary permanent dental ratio was 1:1:2:3 due to the bilateral absence of the permanent lateral incisors. Owing to the nature of the alveolar margin and spacing between the central incisors, the canines, and premolars; (13 & 14, 11 & 21, and 23 & 24), it's a typical case of hypodontia of the lateral incisors, and the attribution to antemortem tooth loss from dental infections, trauma/avulsion, or cultural modification of teeth evulsion

(Mower, 1999) is not a possible explanation.

For this individual, I observed an asymmetry in the height of the maxillary central incisors with a wide diastema/ gap between the central incisors and significant gaps among the maxillary teeth. Also, there is a slight difference in malar bone morphology; the left is more robust than the right. The morphologically different zygomatic bones possibly result from the asymmetric maxillary central incisors. Gaps in-between existing teeth and ectodermal disorders are characteristic of hypodontia (*Hypodontia (Missing Teeth)*, n.d.; *Tooth Agenesis*, n.d.). Besides, antemortem teeth loss and subsequent alveolar margin resorption tend to increase interdental gaps. I acknowledge that lateral incisors can sometimes take the morphology of canines (with pointed edges as fangs) exist, so careful attention was given to the canines to assess metric and non-metric morphological changes.

What intra-vitam discomforts did he experience? Were there traditional orthodontic treatments or replacements at the time? This condition projects the oral health concerns of the individual since hypodontia impacts mastication, speech, jawbone morphology, and general orofacial facial appearance and psychological well-being (*Hypodontia (Missing Teeth)*, n.d.; *Tooth Agenesis*, n.d.; Jordan et al., 2021; Kakrabah-Quarshie et al., 2012; Roberts & Chetty, 2018), especially with the loss of more than 6 (oligodontia and anodontia). Asymmetric dental height might have made mastication difficult for this individual and contributed to the increased dental wear. Hypodontia impacts the orofacial morphology of its subjects, and even though orthodontic interventions exist, not all have the luxury to benefit from them.



**Figure 3. 12: Adult male (40-45 years) with congenital absence of maxillary lateral incisors and asymmetry of the maxillary central incisor height. Begho burial F: BG'21- 73.116.**

### ***Nil Toxicity***

The relatively low levels of lead, chromium, mercury, arsenic, and antimony and their corresponding oxides in the calculus samples showed minimal exposure to or contamination of the industrial pollutants in food or water intake. The high components of calcium suggest a rather high protein component in foods consumed by these populations. The values from the XRF analysis of the calculus sample of individual BG'21-F- 73.116 corresponds with the insignificant traces of lead, cadmium, and arsenic found in ceramic samples associated with this individual. However, a fairly high concentration of arsenic of 10.30  $\mu\text{g/L}$  was found in one ceramic sample from Sekondi: burial G (SK'21-G 73.83) (See Bourdin et al., 2022), slightly above the 10  $\mu\text{g/L}$  limits of arsenic concentration by French laws (*Arrêté Du 11 Janvier 2007 Relatif Aux Limites et Références de Qualité Des Eaux Brutes et Des Eaux Destinées à La Consommation Humaine Mentionnées Aux Articles R. 1321-2, R. 1321-3, R. 1321-7 et R. 1321-38 Du Code de La Santé Publique - Légifrance, n.d.*).

## ***Dental Pathologies***

More on the dental pathologies (DPs) of the ancient population from Ghana has been discussed in a separate article; hence, only a summary will be presented here. The dental pathologies observed to infer oral health were caries, calculus, abscess, enamel hypoplasia, and hypercementosis accounting for 60% of the total pathologies. These were valuable for reconstructing past populations' dietary components, oral hygiene, and nutritional and environmental stress. Calculus was 35% dominant in 15/21 individuals, caries was 30% in 13/21 individuals, enamel hypoplasia was 21%, the abscess was 9%, and hypercementosis/cementum hyperplasia was 7%. In general, the Sekondi individuals recorded the highest percentage of dental pathologies, i.e., 69% in caries, 50% in abscess, 44% in enamel hypoplasia, 66% in calculus, and 5% in hypercementosis. Begho and Yapei reported equal percentages of abscesses, enamel hypoplasia, and calculus, while hypercementosis was relatively low in all cases.

Six of the 21 individuals had none of the DPs, seven combined two DPs including caries & calculus, and four individuals combined three DPs also including caries & calculus. Additionally, four individuals combined up to four dental pathologies on multiple levels of the teeth (Chart 3.5). The ratio of males to females with two or more dental pathologies, including caries and calculus, was 4:6. The vast percentage of undeterminable cases compromised the determination of the sex prevalence of dental pathologies. The ratio of individuals with two or more dental lesions whose sex could not be determined and undeterminable individuals with no pathologies was 5:6. Due to the irregularities in age distribution, a correlation between the age categories and dental plaques could not be established discretely. Cumulatively, all adults in the study samples (except teeth lost antemortem and postmortem) had two or more dental lesions. The adolescent in the group had minimal calculus and two hypoplastic lines on tooth 12, while the sub-adults presented.

Caries were expressed more in molars and premolars, while calculus was observed on either the buccal or the labial teeth or both. Increased plaque accumulation and caries invariably



instigate periodontal diseases such as abscesses, hypercementosis, and gingival inflammation (Dumitrescu & Kawamura, 2010; Hujuel, 2009; Hujuel & Lingström, 2017). Also, low micronutrients like magnesium, calcium, and vitamins B12, C, and D can increase periodontal diseases, in addition to dental trauma and extreme wear (Bonsall & Pickard, 2015; Hujuel & Lingström, 2017; Krall et al., 2001; Leggott et al., 1991; Zong et al., 2016).



**Figure 3. 13: The mandible of an adult male? -BG'21-73.115 (Bg. 70, E), showing periodontal regression, occlusal surface caries, bilateral caries at teeth 36 & 46, and mirror caries between 45 & 46. The infection and resulting abscesses: single lingual perforation at 35 & buccal drainage channels at 45 (at the level of the mandibular foramen) contribute to the porosity evident in the mandible. Calculus has been removed for XRF analysis.**



**Figure 3. 14: The maxilla of the same individual-BG'21-73.115 (Bg. 70, E), showing periodontal regression and abscesses at 12 (labial alveolar channel) and 26 (labial & lingual perforations). Calculus was extracted from some of the teeth for XRF analysis.**

### 3.7 CONCLUSION

The cross-sectional prevalence of skeletal and dental pathologies across the sites provided avenues for illuminating health and oral hygiene as part of public health concerns of the erstwhile populations because the diseases left imprints on the bones. I have discussed the effects of diseases such as congenital/ chronic anemia, iron-deficiency anemia, malaria, and measles in the medullary cavity and the external integrity of the skeleton. It is surprising how hemoglobinopathies and water-borne diseases like elephantiasis (Lymphatic filariasis) can preserve an individual from anemia. Also, brucellosis, a zoonotic disease, has destructive effects on the skeleton- *Brucella* spondylitis. Similarly, I have presented cases of sinus inflammation as an extended effect of dental pathologies and localized head lice infestation whose skeletal lesion mimics porotic hyperostosis. Body and head lice have the propensity to spread the bacterium *Y. pestis*, which may compromise individual and public health. Parasitology and computed tomography examination revealed no parasite from the endocranial soil mass analyzed. The x-ray fluorescence analysis revealed that the Begho individuals were not exposed to industrial pollutants like lead, mercury, antimony, and arsenic.

The dental pathologies observed: caries, calculus, abscess, enamel hypoplasia, and hypercementosis, were informative on the oral health and dietary composition of the people. As proxies to carbohydrate-rich diets, the prevalence of calculus and caries showed a high dependence on carbohydrate-rich food across the sites, even in the country. Abscesses, hypercementosis, and gingival inflammation are comorbidities of caries and calculus emanating from carbohydrate-rich diets, excessive sucrose, and sugar intake, apart from subjection to extreme masticatory and extra-masticatory pressure. The good news is that well-balanced meals, including vitamins D, C, and calcium, can attenuate the prevalence of these dental pathologies among the contemporary population. The presence of enamel hypoplasia in the complex projects acute developmental stress linked to nutritional deficiencies and environmental impacts. The discussions on the health of the past populations contribute to the paleopathological discourse in the Ghanaian and West African regions.



## CHAPTER 2

### WHAT I ATE: UNRAVELING DIETETICS/ ALIMENTATION STATUS OF PAST POPULATIONS

#### 3.8 OVERVIEW

This last chapter of part II presents a cross-regional discussion of the dietary pattern of the individuals inferred from dental pathologies, ethnographic accounts, x-ray fluorescence analysis of calculus samples, and stable isotope analysis of the bone of one individual from the coastal town of Sekondi and another from the riverine town of Yapei.

#### 3.9 INTRODUCTION

Again, the skeleton (bones and teeth) records intra-vitam dietary compositions. From the teeth, dietary reconstructions can be macroscopically assessed through the frequency of dental pathologies such as caries and calculus (Flensburg et al., 2019; Kunikita et al., 2017; Mayes, 2016; Towle et al., 2017). Although multifactorial, the former has been associated with increased consumption of carbohydrates (Temple & Larsen, 2007) and cariogenic grains (Dodds, 1960), fruits, honey, and starchy cereals (Lingstrom et al., 2000). Whereas the latter has been linked to the consumption of proteins (Lillie, 1996; Lillie & Richards, 2000). Others have found that diets high in carbohydrates and low in protein contributed to the prevalence of calculus and caries (Lillie & Richards, 2000). The nature of diets can be inferred from the location of caries and the accumulation of plaques. In that, coarse and abrasive diets reduce occlusal surface caries (Hillson, 2008b) and heavy calculus formation at the interproximal and gingival region (Tomczyk et al., 2013). Dental wear of teeth crowns can also illuminate the nature of diets (coarse/abrasive or fine) and, associated with isotope analysis, can shed light on the food resources exploited by individuals across the respective regions. While abrasive diets may prevent calculus and caries to some extent, they gradually wear off the enamel of teeth (reduced cusp integrity) and dentine over time. Some scholars have proposed status and healthy or well-balanced diets from unworn teeth. Dental wear is also age and activity-

related. With the constant masticatory and non-masticatory use of teeth, wear is inevitable as a person ages.

X-ray fluorescence analysis of teeth or calculus samples supports dietary reconstructions of past populations from the molecules and elements it exudes. These components are compounds from food and water trapped in the substances (calculus, teeth & bones), therefore, not alien to the host's environment. They allow the inference of past dietary orientation. Stable isotope analysis is well-praised for its usefulness in revealing the type of environment and the dietary pattern of individuals and populations (Lillie & Richards, 2000; Richards et al., 2003; Richards & Trinkaus, 2009; Shishlina et al., 2012; Stojanovski et al., 2020; Tauber, 1981). Milton (1999) 1999 was able to characterize that Homo diets were of better quality (lower in fiber, lignin, plus meat) than hominoids from isotope analysis. Other studies have probed to find the micronutrients of paleo-diets of hunter-gatherers and modern humans, noting that the former had diets higher in animal protein, micronutrients of vitamins and minerals, and dietary fiber from wild plants, and lower in carbohydrate and saturated fatty acids; neutrally-balanced diets (Cordain et al., 2000; Eaton & Konner, 1985; Konner & Eaton, 2010). Modern diets have evolved; they are substantially acidic because of the high cereals/grains content and are also relatively higher in sodium because most of our foods are highly processed, reducing the fiber. Tauber (1981) revealed that a prehistoric Denmark man's dietary composition was predominantly seafood-based.

Isotope analysis ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) can reconstruct the dietary composition and pattern over time. The 13-carbon isotope ( $\delta^{13}\text{C}$ ) in human bone reflects the plant-based diet ratio of  $\text{C}_4$  to  $\text{C}_3$  plants consumed and trapped in the bones. The  $\text{C}_3$  plants are crops usually cultivated in temperate regions or climates, including wheat, rice, and barley. Their photosynthetic pathway against  $^{13}\text{C}$  gives them a stable  $^{13}\text{C}$  value of -20‰ to -35‰ (Kohn, 2010; Sofeso et al., 2012). While  $\text{C}_4$  plants like corn, millet sugarcane, beans, and other plants adapted to warm environments have a  $\delta^{13}\text{C}$  value of -9‰ to -14‰ with an average of -12‰ (Sofeso et al., 2012). On the other hand, 15-Nitrogen isotopes ( $\delta^{15}\text{N}$ ) vary according to trophic levels to

project the ratio of animal protein in the diet.  $\delta^{15}\text{N}$  allows marine and terrestrial dietary reconstruction, with isotopic values of 0‰ and -7‰ to -8 ‰, respectively. Thus, low  $\delta^{13}\text{C}$  and low  $\delta^{15}\text{N}$  inform a high plant-based or vegetarian diet with some terrestrial animal protein and high  $\delta^{13}\text{C}$  and high  $\delta^{15}\text{N}$  reflect a dependence on seafood, while average values of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  would depict a mixed diet (Shishlina et al., 2012). The characterization of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  from bones and teeth can reflect the status, culture, subsistence patterns /activities, and migration pattern of an individual or entire population (Lillie & Richards, 2000; Richards et al., 2003; Richards & Trinkaus, 2009; Stojanovski et al., 2020). Isotopic values from bones are subject to bone remodeling, capturing the 5- 10-year period of life before death, and the teeth provide a record of a person's life course beginning from when the tooth started developing.

Teeth and bone can illuminate short and long-term changes in dietary patterns over time, either from shifts in subsistence patterns, migration, or depletion of resources in the same environment. According to Wasinger et al. (2019: abs), stable isotopes, combined with other methods, present a novel way to establish the broad spectrum of dietary capacity and infer environmental and lifestyle trends in populations. Schulting et al. (2021)  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  analyses of human remains revealed Lucayan populations' dietary trends and the extent of dependence on near-shore marine resources. Other studies have also measured carbon isotope from bone collagen to decipher marine, terrestrial, and plant resources in palaeo-diets (Chisholm et al., 1982, 1983; Tauber, 1981; Vogel & Merwe, 1977). Heritable diseases at a population level can also be traced from the dietary orientation identified. Therefore, the stable isotope and radiocarbon combination will help situate activity, the environment, and pathologies within a chronological framework and facilitate comparative assessment among the various study sites and regions.

### **3.10 METHODOLOGY**

This section relied on physical observation of dental pathologies with a bioanthropological 'eye', x-ray fluorescence analysis of calculus samples, ethnographic data on dietary patterns, and stable isotope ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) revelation of the dietary components of one individual from the coastal town of Sekondi and another from the riverine town of Yapei.

#### **3.10.1 Bioanthropological Assessment**

The observation and scoring of dental pathologies, such as caries and calculus at the interproximal, occlusal, buccal, and lingual surfaces, followed the standards (Buikstra & Ubelaker, 1994, pp. 54 & 56). Dental wear assessment on the incisors, canines, premolars, and molars involved noting the extent of crown wear to the root (Buikstra & Ubelaker, 1994, pp. 52–53).

#### **3.10.2 X-ray Fluorescence Analysis**

X-ray fluorescence analysis of three calculus samples extracted from the maxillary and mandibular teeth of two Begho individuals. This was to identify oxides and elemental components of the mineralized plaques relative to the dietary patterns of the people, in addition to ascertaining the risk of industrial pollution to lead, arsenic, mercury, chromium, and antimony via the food-water chain during the 10th-19th centuries (for details on this method, see the [methodology of chapter 1 in this section](#)).

#### **3.10.3 Ethnographic Research**

Ethnographic data were collected at Sekondi, Ntereso, and Yapei in 2022. The ethnographic data from Begho in 2019 of 88 respondents were consulted. All four ethnographic research

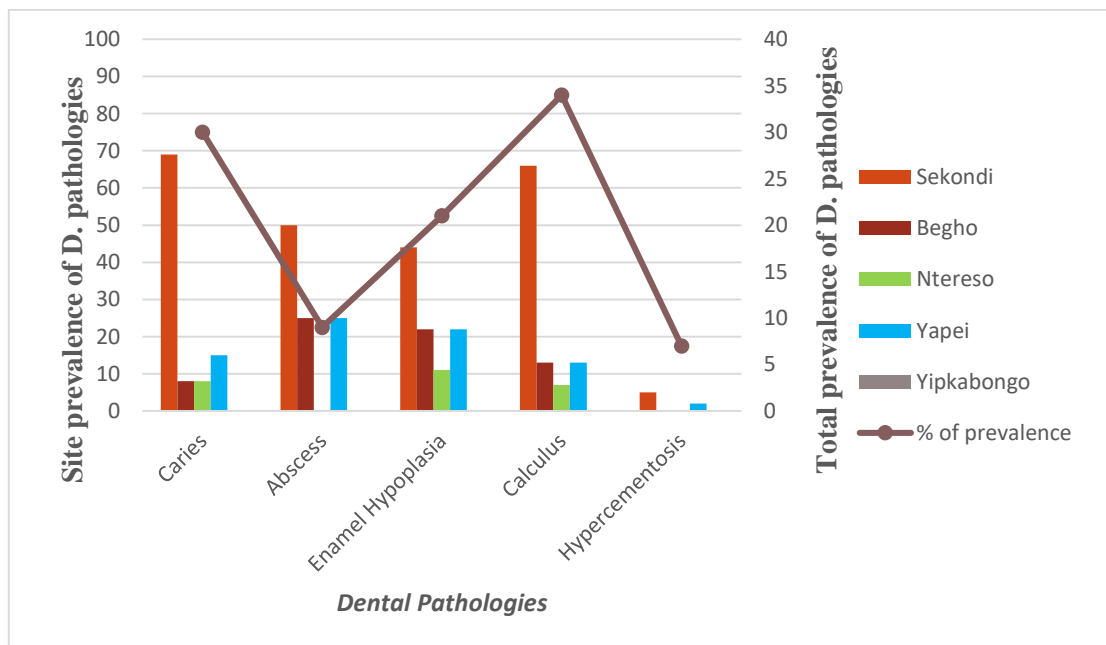
involved semi-structured individual interviews and focus-group discussions (of 2-9 persons) to gather emic perspectives on cultural practices and dietetics in the various site communities. The research employed random, purposeful, and snowballing sampling strategies at the sites. Direct ethnographic study Yikpabongo was not conducted, but 2017 field observations and personal conversations with three Komaland researchers provided data on the dietary patterns in the community. At Yapei, out of the 54 people interviewed, 31 were old adults; 18 were middle adults, and five were young adults at 33: 21 male-female proportion. Data collection at Ntereso involved 48 respondents: 29 old adults and 19 middle adults at a 28:20 male-female ratio. Additionally, 56 people were interviewed at Sekondi. The ratio of old adults to middle adults was 26: 30. The approach enabled a blended perspective in the comparative analyses of the sites.

#### **3.10.4 Analytical Methods: Stable Isotope Analysis**

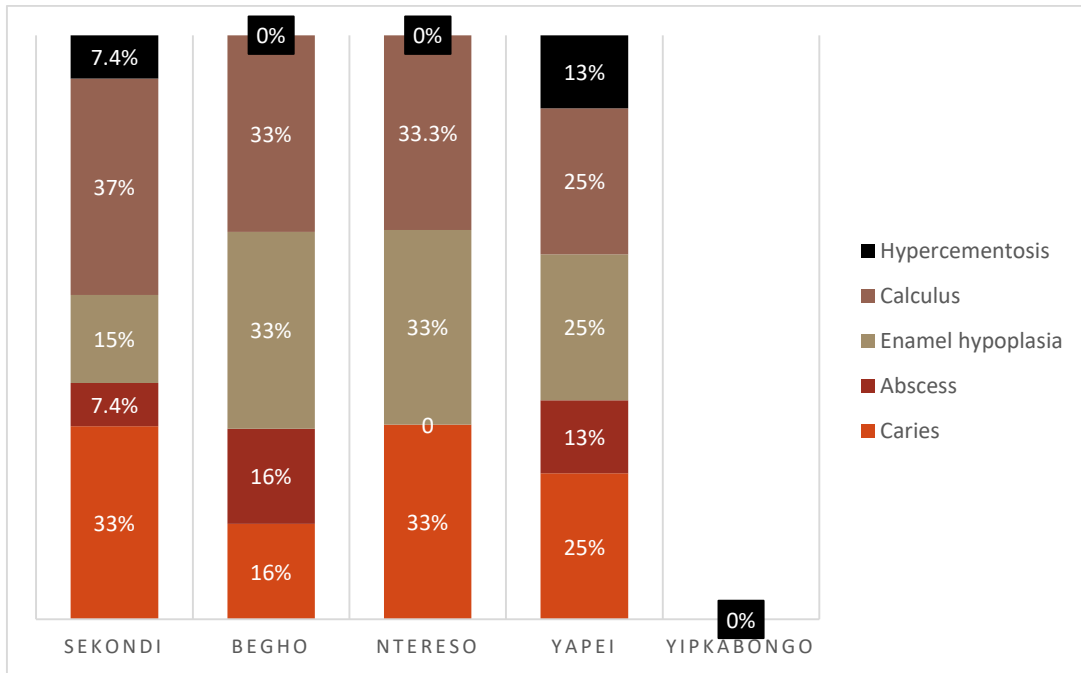
Two samples of human bone from Sekondi (SK'21-F 73.94) and Yapei (YP'18-73.106) were submitted to the Beta Analytic Testing Laboratory, Miami, USA, for  $^{14}\text{C}$  dating and stable isotope analysis. Stable Carbon ( $\delta^{13}\text{C}$ ) and Nitrogen ( $\delta^{15}\text{N}$ ) isotopes were analyzed using the same bone collagen prepared for  $^{14}\text{C}$  dating.  $\delta^{13}\text{C}$  values are on the material itself (not the AMS  $\delta^{13}\text{C}$ ).  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values are relative to V-PDB. Bone collagen was used to enable an insightful glean into dietetics for the source of the protein component of the individual between 5-10 years of life before death and whether there was a change in the diets of the two individuals. From this, the people's behavior in the environmental context can be inferred.

### 3.11 RESULTS- DENTAL PATHOLOGIES

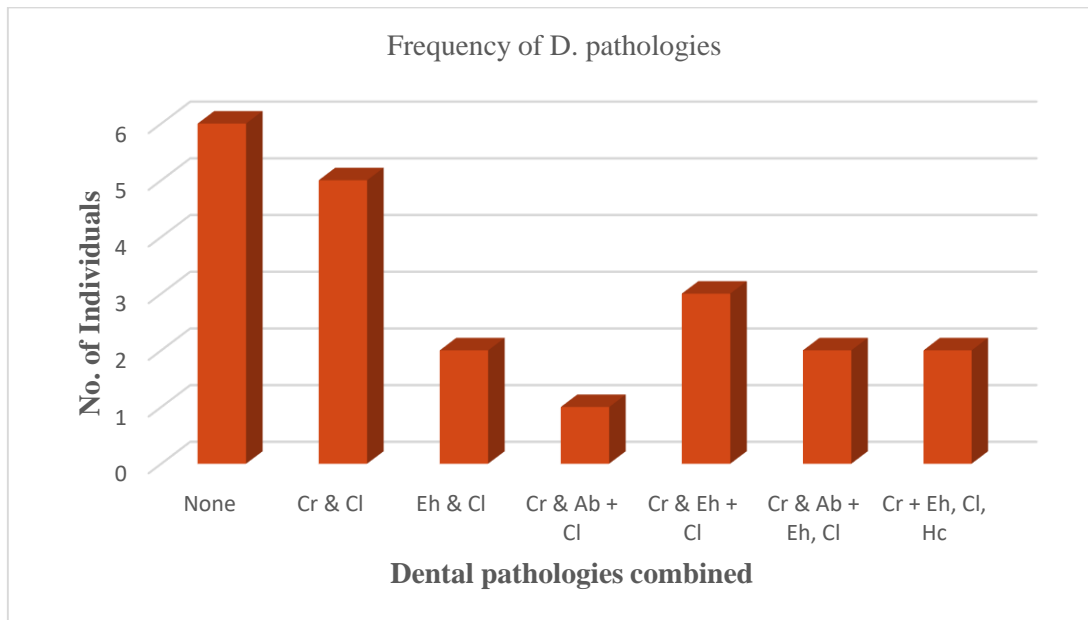
Regarding dental pathologies, caries, calculus, abscess, enamel hypoplasia, and hypercementosis accounted for 60% of the total pathologies. The site-specific prevalence of dental pathologies and the contribution of each is represented in Charts 3.3 & 3.4. The frequency of double and multiple-level dental pathology among the individuals in the assemblage is presented in Chart 3.5. These were valuable for reconstructing past populations' dietary components, nutritional, and environmental stress. Caries were expressed more in molars and premolars, while calculus was on either the buccal or the labial teeth or both. Calculus was 35% dominant in 15/21 individuals, and caries was 30% in 13/21 individuals. While enamel hypoplasia was 21%, the abscess was 9%, and hypercementosis/cementum hyperplasia was 7%. In general, the Sekondi individuals recorded the highest percentage of dental pathologies, i.e., 69% of caries, 66% of calculus, 50% of abscess, 44% enamel hypoplasia, and 5% hypercementosis. Begho and Yapei reported equal percentages of abscesses, enamel hypoplasia, and calculus, while hypercementosis was relatively low in all cases.



**Chart 3. 3: Site prevalence of dental pathologies combined with the total prevalence of each dental pathology.**



**Chart 3. 4: The contribution of each dental pathology represented in each site.**



**Chart 3. 5: The number of individuals with no or combining two or more dental pathologies among 21 individuals.**

### **3.12 RESULTS- *DENTAL WEAR***

Significant dental wear was observed from the teeth in occlusion and isolated ones. For example, YP'18- 73.106 had full cusp removal on 15 & 17, coalesced dentinal patches on 16, point or hairline dentine exposure on 43, and unworn 44. All other teeth were unavailable/missing. For YP'18-73. 105, the isolated un-sided M2 and M3 had a blunted cusp and full cusps removal, respectively. Teeth 13 and 14 had large dentine exposure, and tooth 15 had several large dentine exposures; all other teeth for this individual were absent.

For the Ntereso individuals, dental wear of teeth in occlusion was unobservable because of the soil endocranial. However, CT examination revealed complete dentine exposure with intact rims of the upper molars of NT'18-73.90. Most of the teeth of the Sekondi individuals were isolated and too damaged to assess, and others were missing, except that of five individuals: SK'21-73.80, SK'21-73.82, SK'21-73.83, SK'21-73.87, and SK'21-73.94 who had some teeth in occlusion and other isolated. These individuals had dental wear patterns ranging from full cusps removal, coalesced dentine patches, large dentine exposure to a severe loss of crown heights, and enamel rim to the extent that the crown surface shape is similar to the root shape. Begho individual 73.115 had less dental wear (polished facets) on the incisors and canines but wear on the molars and premolars ranged from polished and small facets to full cusps removal to a severe loss of crown heights. Begho individual BG'21-F 73.116 had a distinct line of exposed dentine on the central incisors and moderate dentine exposure on the canines. The lateral incisors of this individual were congenitally missing. The wear pattern of the molars and premolars of this individual ranged from blunted cusps with spotted dentine exposure to full cusps removal and several dentine exposed with no coalescence. Some isolated teeth were associated with the Yikpabongo individual but were too damaged assess.



### **3.13 RESULTS- *STABLE ISOTOPES AND X-RAY FLUORESCENCE ANALYSIS***

The Sekondi individual was excluded because of inadequate bone collagen for  $^{14}\text{C}$  and  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values from the bone collagen of the adult female (YP'18-73.106) from Yapei were  $-10.5\text{‰}$  and  $8.8\text{‰}$ , respectively.

The x-ray fluorescence analysis of the two individuals from Begho (BG'21-F-73.116 and BG'21-E-73.115) revealed a dietary composition of increased calcium, sodium, phosphorus, and silicon indicative of calcified aluminum silicate. See [Appendix D.1-D.6](#) for the details of the element and molecule components of the calculus samples. This research has been discussed (Lamprey et al., 2023) (Appendix E).

### **3.14 DISCUSSION-*DENTAL PATHOLOGY & DIET***

Caries at the interproximal region and CEJ indicate extensive plaque build-up between teeth and along the gingiva from soft, sticky, and non-abrasive diets (Tomczyk et al., 2013), whereas less occlusal surface caries represent a relatively coarse diet (Hillson, 2008a). In this case, occlusal surface caries will be less, but dental wear will be extreme. The study recorded more minimally-expressed occlusal surface caries and fewer extensively-expressed interproximal and CEJ caries. The diet composition of most Ghanaian foods is less coarse across all the regions, made from processed grains/cereals like wheat, rice, maize, millet, and tuber crops like cassava, yam, and plantain, respectively. The fact that there was some occlusal surface enamel demineralization means that paleo-diets were either not abrasive enough or the resulting occlusal surface caries is the effect of the high carbohydrate content of the foods.

In line with the prevalence of calculus and caries across the sites emanating from a high dependence on carbohydrate-rich, sugary, and starchy foods, including fermentable carbohydrates (Hujoel, 2009; Hujoel & Lingström, 2017; Lillie, 1996; Lillie & Richards, 2000) are possible explanations. Similarly, Lingström, van Houte, & Kashket (2000) note that the high intake of fruits, honey, and starchy cereals increases dental caries. The average carbohydrate percentage in a typical Ghanaian diet is high, especially in rural areas. The composition mainly comprises grains, cereals, legumes, and tuber crops supplemented with marine, riverine, and lacustrine fish and terrestrial animal protein such as beef, mutton, pork, and eggs. Increased plaque accumulation and caries invariably instigate periodontal diseases such as abscesses, hypercementosis, and gingival inflammation (Dumitrescu & Kawamura, 2010; P. Hujoel, 2009; Hujoel & Lingström, 2017). Also, low micronutrients like magnesium, calcium, and vitamins B12, C, and D can increase periodontal diseases, in addition to dental trauma and extreme wear (Bonsall & Pickard, 2015; Hujoel & Lingström, 2017; Krall et al., 2001; Leggott et al., 1991; Zong et al., 2016). The significant enamel hypoplasia recorded among the complex depicts a relatively high developmental and nutritional stress in the respective individuals.

### **3.15 DISCUSSION- *DENTAL WEAR & DIET***

Significant dental wear was observed on all the teeth available (in occlusion or isolated), except for a middle adult male- 40-45 years from Begho (BG'21-F 73.116) who presented minimal occlusal wear. Dental wear is related to hypertrophy of the teeth involving the mechanisms of abrasion and attrition, partly evolving from masticatory and extra-masticatory use/practices. For instance, abrasion and attrition are caused by the extensive consumption of grains or foods with sand particles (abrasives). The wear process commences with the gradual loss of surface enamel and dentine from teeth-to-teeth or teeth-to-object friction, followed by a build-up of secondary dentine to protect the pulp chamber (Larsen 1997:248).

As mentioned earlier, while abrasive diets prevent interproximal and occlusal surface plaque build-up and eventual bacterial-informed demineralization of the teeth, such diets and the presence of abrasive substances can gradually reduce the mechanical integrity of the teeth. Masticatory behavior has direct links with dental wear, and the gradual erosion of the enamel is possible from acidic plaque solutions around the teeth. There is also dental wear or enamel erosion due to aging (with intensified teeth use). However, induced enamel erosion exists among industrial workers in chemical factories (Mower, 1999: 40), where harsh chemicals in food and water may demineralize the enamel over time. It will take an activity or practice to be habitual on the occlusal surface of teeth to cause a wearing effect (Alt and Pichler, 1998: 388). However, interproximal wear and grooving have been recorded (Brown & Molnar, 1990; Molnar, 2008; Mower, 1999) from extrinsic factors or extra masticatory activities such as leatherworking, basketry, and something as unexpected as habitual tooth picking.

It's important to note that bruxism can also wear off the enamel (even to dentine exposure or complete loss of crown height) and result in occlusal surface asymmetry of teeth. The wear patterns may not differ from the wear induced by abrasive materials in food or by impact from using the teeth as a 3<sup>rd</sup> hand. Only in exclusive cases, such as pipe-wear facets (Renschler & DeCorse, 2016), will the pattern differ (**Figure: 2.7**). Teeth as 3<sup>rd</sup> hands are common in occupations such as leatherworking or basketry (Brown & Molnar, 1990; Schulz, 1977, p. 90).

Variants in the abrasive nature of the processed materials produce differential wear patterns. Abrasive and attrition processes have also been utilized to support interpretations relating to subsistence, dietary habits, and social or sexual differentiation (Molnar, 2008; Mower, 1999, p. 41). For instance, status can be deduced from teeth when wear patterns are correlated with dietary components and oral health. In the same vein, sexual dimorphism can be assessed by comparing wear patterns in the occlusal, labial, lingual, and buccal surfaces of male and female teeth (Molnar, 2008).

### **3.16 DISCUSSION-STABLE ISOTOPE SIGNATURES & DIET**

The  $\delta^{13}\text{C}$  of -10.5‰ value for the middle adult female falls within the  $\delta^{13}\text{C}$  signature (-9‰ to -14‰) of  $\text{C}_4$  plants consumed, i.e., plants adapted to arid environments (Chisholm et al., 1982). That is to say, her dietary protein (plant) was from  $\text{C}_4$  plants such as maize, millet, sugarcane, beans, and groundnut, typical of the Yapei community and even the Savannah region. Her  $\delta^{15}\text{N}$  value (8.8‰) depicts a high-quality animal protein composed of species of the middle trophic level (fish & meat). This relatively high  $\delta^{13}\text{C}$  value and  $\delta^{15}\text{N}$  value projects a combination of  $\text{C}_4$  plants, riverine resources, and terrestrial animal protein (goats, sheep, cattle, and chicken).

For an agrarian society such as Yapei, the high  $\delta^{13}\text{C}$  value is expected, and the average  $\delta^{15}\text{N}$  value reflecting the incorporation of seafood or different kinds of riverine fish into the diet is unsurprising because of the community's proximity to the White Volta. It is not certain whether the individual's dietary composition had been constant since childhood, but for the 5-10-year period before her death, her  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values from her bone collagen show that she was accustomed to relatively high protein composition from  $\text{C}_4$  plants, fish (riverine) resources, and terrestrial animal protein (goats, sheep, cattle, and chicken). The contemporary population still follow this mixed subsistence dependence on riverine and terrestrial resources, even though individual food habits and preferences may slightly differ.

Since Yapei and Ntereso are geographically close with similar environmental conditions and subsistence patterns, it is anticipated that the Ntereso individuals will have similar  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values. The Sekondi individuals, however, would have presented much higher  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values for their dependence on marine resources from the sea and food crops from the suburbs that rushed into the community. The  $\text{C}_4$  plant characterization is not exclusive to Yapei; it cuts across the regions with a high dependence rate. Only in some rural and urban sectors of the country will there be a change in the consumption rate of  $\text{C}_4$  plants or probably a  $\text{C}_3 + \text{C}_4$  orientation with wheat and rice. Food resources from temperate, arid, marine, lacustrine, and riverine environments, including terrestrial animals of the various regions and other imported resources, dangle across the country via the trajectory of trade and the markets. As a result, the inhabitants away from the above and other important resources, still benefit to satisfy their nutritional needs.

Based on this phenomenon of the cross-district/cross-regional movement of consumables via the trade chain, the individuals from Begho and Yikpabongo may have had analogous  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values, and any variance be associated with regional differential adaptations, individual preferences, and intermittent scarcity of food resources. According to Posnansky (2004, pp. 39–40), Begho inhabitants had a protein-rich diet; an individual animal (domesticated) protein intake of at least 250g per week, which possibly increased in seasons with abundant supplementary game resources. He also notes that about 50 varieties of plants, including, oil palm and lemons/limes form part of Begho diets (Posnansky, 2004, pp. 39–40). At Yikpabongo, the inhabitants are enriched by the abundance of cattle, guinea fowl, and other domesticates, supplemented by plant resources.

Widely different isotopic values will be characteristic of migrants into the Ghanaian sub-region shortly before death or inhabitants of remarkably high social status with the luxury of incorporating exogenous foods rather than a local diet change.

### 3.17 CONCLUSION

This chapter has presented discussions on dental pathologies, including occlusal wear, x-ray fluorescence results on calculus samples, and  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of bone collagen of an individual and how these project the alimentation status or dietary pattern of the individuals represented in the skeletal assemblage.

The dental pathologies, namely caries, calculus, abscesses, enamel hypoplasia, and hypercementosis, are predicated on one another. Calculus and caries have been discussed in relation to the high intake of carbohydrate-rich foods, sucrose, and fermentable carbohydrate diets. The non-coarse nature of foods increases plaque build-up, and over time, oral acidity heightens from the breakdown of trapped carbohydrates and mineralization of the plaques in between the teeth and along the gingiva. Bacterial colonization instigating demineralization of the enamel and dentine further inflames the pulp cavity. Pulpitis extends to the apex of teeth resulting in a drainage canal/fistulation in the alveoli, thus, abscess. Hypercementosis results from dental infection and extreme masticatory and non-masticatory (teeth as a 3<sup>rd</sup> hand in supporting implements and ripping organic materials in some occupations) pressure on the teeth. Enamel hypoplasia is the upshot of nutritional deficiencies and developmental stress. Since the dietary composition of populations was relatively non-abrasive, the extreme dental wear observed could emanate from the masticatory force of chewing and crushing bone and enamel erosion due to teeth use over time.

The XRF result of the calculus analysis from the Begho individuals of calcified aluminum silicate is expected from the plants and animal resources consumed in the community. Lastly, the  $^{13}\text{C}$  and  $^{15}\text{N}$  isotope revelation of the dietary pattern of the Yapei individual enabled the reconstruction of the dietary orientation of the individuals from the Savannah region to  $\text{C}_4$  plants in addition to riverine and terrestrial animal protein and, by inference, those from the Western, Bono, and North-east regions to a probable combination of  $\text{C}_3$  and  $\text{C}_4$  plants, marine, riverine, and lacustrine resources plus terrestrial animal protein.

## **4 PART III: CROSS-REGIONAL ACTIVITY PATTERNS OF THE PAST & CONTEMPORARY POPULATION**

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## 4.1 INTRODUCTION

Activity forms the bases of population subsistence, environmental adaptation, and general livelihood. The skeleton remodels, with the action of osteoblasts, to mirror the active past of individuals, bearing all the mechanical pressures exerted on the body. Additionally, bones store records of pressure-induced changes and injuries from occupation, general activities, and socio-culturally modifications/ alterations to the body. Bone remodeling and enthesal changes are independent phenomena; the activities of osteoblasts & osteoclasts are bound to happen irrespective of the aforementioned factors because degenerative changes are also invoked as a person ages and in response to inflammation or trauma. However, the prominence of enthesal degeneration may be predicated on age and activity-related trauma.

Entheses are points of muscle attachment on bones by tendons or ligaments (Hawkey & Merbs, 1995; Nikita & Karligkioti, 2019; Weiss & Jurmain, 2007) or the regions where joint capsules attach to bones, experiencing much stress concentrations (Benjamin et al., 2002, 2006). Enthesal changes, therefore, designate all changes (including bone ruggedness/robustity) at the entheses of skeletal remains, including those of pathologic etiology (Foster et al., 2014; Hawkey & Merbs, 1995; Jurmain, 2010; Villotte & Knüsel, 2013). These marks are expressed as bony spurs, bony ridges, erosive changes: pits or cysts (Hawkey & Merbs, 1995; Weiss, 2007), and proliferative changes: mounds or crests (Foster et al., 2014) at the muscle attachment points on bones. Enthesal changes are a neutral lens to look into stress, bone degeneration, and other characteristics of bone function (Jurmain, 2010) and not to generalize changes evident on the bone due to pathologies or stress and activities.

Of the two sites of muscle attachments on bones (originating & inserting points), the insertion point is more unstable and affected by muscle contractions than the origin (Nikita & Karligkioti, 2019). They, thus, experience more enthesal changes and enthesopathies, i.e., changes at the muscle attachment points due to disease or injury following the detachment of muscles, unassociated with pain or discomfort (Jurmain, 2010, p. 3). I focused on activity-related lesions and enthesal changes for insights into the past populations' activities.



## **CHAPTER 1**

### **MY WORK, MY LIFE: OSTEOLOGICAL EVIDENCE OF ACTIVITY & ENTHESEAL CHANGES**

#### **4.2 OVERVIEW**

This chapter of the last part of the thesis sought to predict/reconstruct past activity by examining activity-related lesions & enthesal changes on the skeletons of past populations and to present aspects of the influence of recent activities in the various communities.

#### **4.3 INTRODUCTION**

Individual and population-level activities evolve, but they seldom change totally. Although significant continuity is associated at these levels, change is possible, especially with a foreign influence. As habits aren't easily broken, so are their imprints on bones not hardly recognized. As such, some skeletal lesions can infer individual or group activities with distinct trends. All activities engage the musculoskeletal system involving the joints and muscles with significant force/pressure along single or multiple planes. And due to the remodeling characteristic of bones, the most-engaged joints tend to adapt to all the pressure from the array of activities the person executed-hypertrophy (often depicted), while the minimally-used ones suffer atrophy. With the involvement of muscles, muscle attachment points adopt a more robust appearance with habitual strenuous activities. Hyperflexion and hyperextension of joints affect the articulations, inform muscle detachments, and the wear and tear of ligaments & tendons. Skeletal evidence of activity should be looked at carefully because of their multi-etologies and normal degenerative changes on bones throughout the life course.

#### **4.4 METHODOLOGY**

Bioanthropological assessment of the human skeletal remains was carried out to identify activity-related skeletal markers and enthesal changes on the remains using (Buikstra & Ubelaker, 1994; Nikita & Karligkioti, 2019) together with an array of descriptive methods and studies on activity and enthesal changes on skeletal remains (presented in the discussions).

## **4.5 RESULTS AND DISCUSSIONS- *ACTIVITY MARKERS***

### ***Osteoarthritis***

As stated earlier, osteoarthritis constituted 4% of the total pathologies, found extensively expressed on the vertebral bodies of a middle adult male from Begho, BG'21, 73.116, with elevated rings on C3-C7, barely discernible lipping on T1-T12, and elevated rings on L2-L5 (Table: 2.14.1). Also, the middle adult females from Yapei showed spinal osteoarthritis on the L2-L5 & T12 (for YP'18-73-106) and on L1-L5 (for YP'18-73.105) with varied degrees of lipping and affected circumference (Tables: 2.16.1 & 2.16.2). What is common among these three cases is the frequency of spinal osteoarthritis. Osteoarthritis was not observed in individuals from Yikpabongo, Ntereso, and Sekondi because the elements available were a calotte, crania with insufficient bone markers, and very fragmented postcranial long bones, respectively. The assessment of osteoarthritis in other individuals would have been possible if maximum vertebral elements and the upper and lower limbs were available, considering similar activities across communities.

Within the bioarchaeological discourse and the skeletal record, osteoarthritis is the most common type of arthritis affecting joints (Weiss & Jurmain, 2007). Some of the multifactorial etiologies of osteoarthritis proposed and discussed include diseases, e.g., rubella, activity: sports and occupation, climate/ environmental factors, genetic/ hormonal makeup, and anatomical variants, and obesity and body mass index for (hand) osteoarthritis (Blakely & Detweiler-Blakely, 1989; Guilak, 2011; Kalichman et al., 2011; Kalichman & Hernández-Molina, 2010; Thelin et al., 2004; Weiss & Jurmain, 2007). Nonetheless, the age-related and gendered-activity correlations have been widely discussed (Guilak, 2011; Palmer et al., 2016; Weiss, 2017; Weiss & Jurmain, 2007) as in response to the wear and tear of the protective cartilage on or around the joint, the repetitive manual use of joints, injury, and occupational stress on the joint represented as bony spurs/lipping and eburnation. Distinct locations of osteophytic formations enable the reconstruction of class-based activities (Palmer et al., 2016), gendered activities (Garvie-Lok, 2010; Nicholas, 2007), and occupational shifts/changes (Eshed et al.,

2010; Larsen, 1995). Whereas degenerative changes at joints are bound to happen, they can be aggravated by excessive pressure on joints (Grodzinsky et al., 2000; Sandell & Aigner, 2001) or extended movements beyond the limits of the joint's plane as would be in hyperflexions and hyperextensions.

Farming is common in Sekondi and Begho, and farming, fishing, and shea butter processing are the mainstays in Yapei and Ntereso. These strenuous activities have the adequate potential of imposing significant stress on the joints of the individuals from the sites, as recorded. These occupations involve the active engagement of the vertebral column joints, with extreme flexion and extension of the upper (including the carpal and metacarpophalangeal joints) and lower limbs and hyperflexion of the hip joint as in a squatting position. Unsurprisingly, the three individuals mentioned above from Begho and Yapei recorded spinal osteoarthritis, seeing that crop cultivation, animal husbandry, fishing, and shea processing (the preserve of women) are the main subsistence supports in these communities.

Thelin et al. (2004) note higher rates of osteoarthritis among farmers with barn animals and a relationship between hip osteoarthritis and farming. Regarding the latter, athletic farmers were more prone to hip osteoarthritis than non-athletic farmers. But, is the resulting osteoarthritis secondary to athletic injuries or primary from the stress of the farming activity? Given this, other primary and secondary diagnosis of spinal osteoarthritis is reasonable. Even though no lipping was identified on the hand bones of the individuals (partly due to the absence of most of such bones), the limited functionality of the hands and feet, emanating from stiffened interphalangeal joints, was observed during the ethnographic research among older men and women at Sekondi, Begho, Yapei, and Ntereso, probably due to labor and aging. Basketry and straw weaving could be potential causes of hand osteoarthritis because of the force involved in twisting and turning raw materials. Kalichman & Hernández-Molina (2010) found a link between hand osteoarthritis and manual labor, particularly among women. As mentioned earlier, fishing is the preserve of the men and farming is a uni-activity, but

women dominate the shea business.

### ***Articular hyper-vascularisation***

Hyper-vascularization was observed in a middle adult female from Yapei, YP'18-73.106, at the knee level and enthesopathy at the level of the anterior tuberosity of the tibia (**Figure: 4. 2**), including hyperactivity of the femoral neck (**Figure: 4. 1**). This may infer habitual kneeling and 'climber' activity. Again, physiological hyperactivity at the knee level associated with physical activity was observed in a six-year-old Begho individual, BG'21-A 73.118. There was also hyper-vascularisation/ hyperactivity of the hinge articulation of the tibiofemoral joint represented as holes/cavities (1-2mm), between the inter trochanter region, around the neck of the right femur, around the distal ends of femurs, and proximal ends of the tibias of a middle adult male from Begho, BG'21-F 73.116.

Articular vascularization is not an uncommon phenomenon. Hyper-vascularisation of articulating surfaces of joints has been of immense concern to scholars and is used as a differential diagnosis to the straining or overworking of joints. Articular hyper-vascularisation also results from infections and joint inflammations due to severe or acute trauma. The extensive use of joints triggers the overworking of the blood vessels in the adjoining bones or muscles in the joint. Additionally, hypertrophy may, in part, result in wear and tear of the cartilage, ligaments, and the detachment of muscles. It also may accelerate osteoblast's functionality leading to accelerated new bone formation as the joints are being worked. Lesions of hyper-vascularization or hypertrophy of a joint are extreme porosity at the region and the emergence of bony spurs or exostosis, particularly at the articulation surfaces and the proximal and distal ends of bones. Seeing that the people of Begho, Sekondi, Ntereso, Yapei, and Yikpabongo are involved in the strenuous activities of fishing, farming, kneeling or bending to grind shea nuts, and basketry, it is not uncommon that the joints of their upper & lower limbs and the proximal & distal ends of their long bones are actively engaged. The proximal and distal ends of the metacarpals and phalanges may show dents and pits, indicating joint over-use. Vigorous masticatory functions may result in hyper-vascularization

of the temporomandibular joint (TMJ) and periodontal regression of the alveolar margin.



**Figure 4. 1: Porous/ vascularized lesions at the proximal and neck region of the left femur depicting hyperactivity of the ball-and-socket joint of a middle adult female (40-45 years) from Yapei, YP'18-73.106. There are three teeth (canine) perforations on the shaft.**



**Figure 4. 2: Hyper-vascularization at the knee level and enthesopathy at the level of the anterior tuberosity of the left tibia indicative of 'climber' activity. The same middle adult female, Yapei, YP'18-73.106.**

## 4.6 RESULTS AND DISCUSSIONS- *ENTHESEAL CHANGES*

### ***Bone exostosis & Myositis Ossificans***

Bone exostosis was found on an adult male (Begho: BG'21-F 73.116 (70 B1) at the i) mastoids and the laterals of the occipital, ii) at the inferior portion of the manubrium close to the sternal angle on the left, iii) at the extremity of the left 1<sup>st</sup> rib and iv) at the adjacent face of the sternal manubrium (**Figure 4. 3**), possibly the effect of trauma, hemorrhage or past infection. Also, bone exostosis resulting from hemorrhage, calcification, then ossification of a detached muscle/ tissue on the superior aspect of a right-sided rib (probably the 3<sup>rd</sup> rib) to the vertebrate (**Figure 4. 4**), possibly from the same trauma or past infection as on the 1<sup>st</sup> rib on the of the same individual. Myositis ossificans was present at the level of the psoas major and the iliacus/at the area of the lesser trochanter, posterior-medially (3 cm, curving superiorly) (**Figure 4. 5**).

As mentioned earlier, muscle attachments or insertion points are more vulnerable to movement contractions than the originating points (Nikita & Karligkioti, 2019). This mechanical differentiation suggests that bone exostosis will be commonly evident at insertion points due to the possibility, or better still, the frequency of muscle detachments. Bone exostosis results from the vascularization, calcification, and then ossification of detached muscle and localized traumata. In relation to trauma, myositis ossificans is linked to muscle trauma (Baud & Kramar, 1991; Jurmain, 1991) or injury (Nuovo et al., 1992) to muscles and soft tissues followed by inflammation of the area, vascularization, and calcification by osteoblast action then ossification of deposited bone (Walczak et al., 2015). Usually on the linea aspera, but can be found at any point on the skeleton, including fingers and forearms (Nuovo et al., 1992), where a muscle may be detached or torn. The lesion is atypical of horse riders or individuals performing activities that require straining of the gluteal muscles: G. minimus, G. medius, and G. major (Molleson & Blondiaux, 1994).





**Figure 4. 3: Bone exostosis, resulting from the calcification, then ossification of a muscle detachment at the extremity of the left 1<sup>st</sup> rib and the adjacent face of the sternal manubrium, an effect of trauma or hemorrhage or possibly the sign of past infection. Adult male, Begho, BG'21-F 73.116 (70 B1). Superior view (left) and lateral view (right).**



**Figure 4. 4: Bone exostosis resulting from hemorrhage, calcification, then ossification of a muscle detachment on a right rib to the vertebrate, an effect of the same trauma or hemorrhage or possibly the sign of past infection at the level of the first rib and manubrium. An adult male from Begho, BG'21-F 73.116 (70 B1). Superior view.**



**Figure 4. 5: Myositis ossificans at the region of the psoas majors and the iliacus muscles posterior-medially on the right femur of an adult female, YP'18- 73.106. The bony feature measures about 3cm and is curved superiorly (Anterior view).**



### ***Cervical Fossa of Allen/ Allen's Fossa***

Allen's fossa was bilaterally identified on the anterior surface of the femoral neck (close to the head) of a 6-year-old child from Begho, measuring about 1.4 cm (**Figure: 4. 6**). Allen's fossa is a type of activity indicator facet found at the reaction area (Angel, 1964) on the anterior surface of the femoral neck (Capasso et al., 1999; Weiss, 2017). Due to its morphology and usual location (on the femoral neck), Allen's fossa is classified as a pressure facet; one of the activity indicator features in the form of indents or grooves at non-articular regions (Capasso et al., 1999; Weiss, 2017). On the femur, it is marked by a cribriform faint depression of 1 cm<sup>2</sup> or more, slight cortical bone depletion, and the exposure of spongy or trabeculae bones (Finnegan & Faust, 1974) as the zona orbicularis or the annular ligament on the femoral necks wears off (Göhring, 2021). Allen's fossa is slightly different from Poirier's facet, also of an activity etiology (Capasso et al., 1999; Weiss, 2017). Poirier's facet is the extension of the articular surface of the femoral head towards the neck on the anterior surface of the femur.

Poirier's facet is associated with limited flexion pressure from the action of iliopsoas during movement, more rigorous activities (Angel, 1964), or the overuse of the (hip) joint or in a routine horse-riding position and squatting (Capasso et al., 1999; Weiss, 2017) not age or environment-related. Göhring (2021) notes that the cervical fossa of Allen is often confused with Poirier's facet or femoral plaque; other activity-related traits are recorded in the reaction on the femoral neck. For characterization, the location of Allen's fossa is "near the anterior superior margin of the femoral neck close to the border of the head" (Finnegan & Faust, 1974, p. 7), Poirier's facet depicts changes at the "articular surface of the femoral head toward the anterior portion of the femoral neck" (Finnegan & Faust, 1974, p. 8). While femoral Plaque, possibly age-related, is defined as "an overgrowth or bony scar... extending from the area of Poirier's facet on the femoral head down to the femoral neck" (Angel, 1964; Finnegan & Faust, 1974).

The lesion described as Allen's fossa is similar to what Radi and colleagues (2013) describe as cribra. The wear could be due to pressure from the ilium in extreme flexion and intra-rotation of the thighs during sleep (Meyer, 1924), from inflammation or the pull of the capsular ligament in flexion and extension motions (Angel, 1964; Trinkaus, 1975). Other activity correlates are routine squatting (Charles, 1893), the extent of flexion and abduction during locomotion (Angel, 1964; Trinkaus, 1975), extreme thigh extension in running or walking downhill with environmental and cultural relations (Angel, 1964), sitting cross-legged (Charles, 1893) and horseback riding (Molleson & Blondiaux, 1994), resulting in morphological variations in the anterior aspect of the proximal femur (particularly at the head-neck region). Confounding factors may be involved in expressing Allen's fossa in an individual or group, except in similar or monotonous activities.

Allen's fossa can be observed in sub-adult and adult skeletons (Göhring, 2021). Although the trait is not morphologically different based on sex or sexually dimorphic in manifestation (Göhring, 2021), Angel (1964) discussed that the expression of the trait in women and children is limited because the muscle strength needed for the rotary force to tighten the ligament is insufficient compared to males. Other variations may ripple from other pathological conditions and vascular deficits (Göhring, 2021) and, less significantly, individual variants in the femoral neck-shaft angle, muscular stresses on the trochanters, femur length, and knee joint use (Angel, 1964).

Its presence on a 6-year-old could suggest mechanical stress at the hip at an early age. Due to its pressure etiology from squatting and extension of the hip walking or running downhill, this child's hip could have been actively engaged by routine squatting or hip extension over a long period. One of the possible explanations for this is the routine practice of baby 'backing' in Africa and Ghana in particular. This practice actively engages the ligament fiber in the joint capsule and significantly extends the interaction of the zona and iliopsoas at the extreme extension across the back of the mother, assuming a similar position to a horse rider. Thus, the reaction area of the femoral neck undergoes a sort of passive hypertrophy all the

while the baby was at the back of the mother before the age of six. The hypertrophy of the hip joint at that early age resulted in hyper-vascularisation in the cortical and spongy bone matrices and the consequent reduction of cortical bone density at the region. Also, because of reduced bone density at that age, porosity or extensive pitting with exposed trabeculae will characterize the area.

It is, however, likely that the child was engaged in a different activity that exerted significant pressure on the hip joint or the muscles at the femoral neck to induce this facet. Another explanation is the high probability of the activity of squatting because it's a normal resting pose most adopted by infants (Weiss, 2017). This posture renders the hip and knee joints hyper-flexed and the ankle and subtalar joints hyper-dorsiflexed (Aria et al., 2003). Squat facets have been found on the distal femoral condyle, distal tibia, and the talar neck of South African Late Stone Age Foragers (Dlamini & Morris, 2005) and other skeletal samples such as peasants from Wharram Percy, London (Mays, 1998), Australian aborigines (Pounder, 1984), Neanderthals (Trinkaus, 1975), and an East African hominin (DeSilva & Papakyrikos, 2011). Unlike (Angel, 1964; Capasso et al., 1999; Göhring, 2021), Kostick (1963) reported based on his study on the femora of Yoruba populations that, the distal femur is more vulnerable to activity-induced facets like squatting, represented by Martin's lateral distal femur condylar facet, By this more definite squat facets are those found on the posterior superior femoral distal condyle and grooves on the femoral intercondylar line (Trinkaus, 1975), on the superior posterior condylar surface and distal tibia (Dlamini & Morris, 2005). Squatting facets resemble habitual kneeling facets and other activity-induced facets and extensions on the distal femora and tibias (Capasso et al., 1999; Dlamini & Morris, 2005; Trinkaus, 1975; Wood, 1920).



**Figure 4. 6: Post-cranial bones of a 6-year-old child (BG'21-A- 73.118) showing Allen's fossa on the anterior surface of both femoral necks.**

Aside from the numerous arguments correlating squatting facets to activities, some scholars engage the role of genetics due to its presence and prevalence in fetal tali. Barnett (1954) found a high prevalence of squatting facets in European fetuses. However, these fetal tali facets do not persist into adulthood (Singh, 1959, p. 549) and have been attributed to the position the lower extremities of the fetuses assume in utero (Sewell, 1904, 1906). But tali facets in Indian fetuses can be maintained, amplified, or modified in adulthood pertaining to squatting or assuming a similar position (Singh, 1959). Singh (1959) further argues that the presence of tali facets and their durational modifications in Indian adults and fetuses are acquired and not inherited.

### ***Negative enthesopathy***

This enthesal change was observed on the left distal humerus (**see arrow on Figure: 4. 7**) at the level of the elbow of an adult (male?) from Begho, BG'21-E 73.115, where the anconeus muscle is situated (at the lateral epicondyle of the humerus originating posteriorly from the distal humerus to the proximal ulna). It appears that the anconeus muscle, an origin site, possibly detached sometime in this individual's life, and because it aids in forearm extensions at the elbow, the condition is discussed as a sign of hyperactivity or the over-use of the elbow/arm. Due to its distinct pathogenesis and location on the individual, negative enthesopathy can also be used to suggest that he was left-handed- a feature completely dissociated from social or cultural influences. However, negative enthesopathy can be anatomically variable among males and females because of gendered activities and the associated intensities/traumata. This pathognomonic condition involves inflammation and vascularisation of a muscle insertion/origin area or an enthesis due to trauma. It can be classified under erosive enthesal changes due to its characteristic pitting and association with muscle overuse and microtrauma. Although "muscle use may result in more bony entheses without injury" (Weiss, 2017, p. 49).



**Figure 4. 7: Negative enthesopathy at the level of the anconeus opposite the coronoid fossa of the left distal humerus. Adult male from Begho, BG'21-E 73.115 (Anterior view).**

## 4.7 CONCLUSION

I have discussed activity-induced lesions and enthesal features predicated on injury/trauma, the effects of activities at the entheses, and enthesopathy/ pathologically-induced changes to insertion or originating points adapted for activity reconstructions. These were osteoarthritis, hyper-vascularization, myositis ossificans, Allen's fossa, and negative enthesopathy.

Some diseases have activity etiologies and can enable the prediction of activities. However, activity descriptions of morbidity were quite tricky to assess because multiple activities can compound the severity of those pathologies expressed on the bone, and it's almost impossible to pin a pathology to a single action. For instance, osteoarthritis has multiple etiologies, and it would be inaccurate to relate it with only activity, although particular activities contribute to its expression on the bone. Spinal osteoarthritis, however, sheds light on the impacts of manual labor, such as farming and carrying heavy loads. The fact that osteophyte formations were at least prominent on the lumbar vertebrae suggests excessive strain on the lower back from bending or sitting, and its prevalence among the aged supports the extended years of manual labor. Also, the limited functionality in the hands and foot bones (possibly interphalangeal osteoarthritis) of the older adults in the various communities is both age and labor-related. The genetic etiology is secluded since no genetic studies have been done, and familial patterns were not observed.

Hypervascularization at articulations, Allen's fossa, and myositis ossificans at the entheses project extreme occupational and non-occupational pressure and trauma that could have resulted in the reaction at the articular and enthesal sites and the detachment of muscles. Negative enthesopathy, although physiological in origin, gives an insightful picture of the dexterity (left-handed) of the individual. His left-handed orientation, rather genetic but also from hypertrophy of that hand, could have rendered the right hand slightly atrophied.

The activity markers and enthesal changes on the skeletons valuably illuminated the consequences of life course activities and trauma on the bone.

## CHAPTER 2

### CONTEMPORARY ACTIVITIES IN PICTURES

#### 4.8 OVERVIEW

This chapter of the last part of the thesis exhibits some aspects of the activities of the contemporary populations across the sites: Sekondi, Begho, Ntereso, Yapei, and Yikpabongo. Some of the activities cut across, while others are site-exclusive.

#### 4.9 INTRODUCTION

Man has always been on the go. We are preoccupied with one task or another for most of our lives, and sometimes we have to juggle multiple activities. Our various activities influence us psychologically, socially, and economically. The subsistence strategies of people sustain them through their life course. They encompass the means of acquiring food and water resources and other activities by which a people or community is sustained. Distinct individual and group activities exist in the various communities explored, but the activities exhibited here are snippets that pertain to the livelihoods of the people (potentially impacting their skeletons in one way or another) recorded during the ethnographic field research. Short descriptions of the activities accompany the images.

It is important to recognize that despite significant continuities in some of the activities at Sekondi, Begho, Ntereso, and Yapei presented here, there have been some changes over time. Continuity implies a sustainable strategy for subsistence, and while change may not necessarily depict resistance, it sometimes means the evolution of better subsistence options. This chapter is intended to give a sense of the energy, effort, and pressure involved in executing the various activities. By extension, if the erstwhile populations were engaged in similar or laborious ones, their skeletons recount a fair story. This is because while activities satisfy the psycho-socio-economic demands of man, physiologically, it affects our musculoskeletal system.

## **4.10 METHODOLOGY**

### **4.10.1 Ethnographic Research**

Ethnographic data were collected at Sekondi, Ntereso, and Yapei in 2022. The ethnographic data from Begho in 2019 of 88 respondents were consulted. These involved semi-structured individual interviews and focus-group discussions (of between 2-9 persons) to gather emic perspectives on cultural practices and the activity of the inhabitants in the various site communities. The research employed random, purposeful, and snowballing sampling strategies at the sites. Direct ethnographic study Yikpabongo was not conducted; rather, 2017 field observations and personal conversations with three Komaland researchers provided some data on the past and contemporary activities in the community. At Yapei, out of the 54 people interviewed, 31 were old adults, 18 were middle adults, and five were young adults at 33: 21 male-female proportion. Data collection at Ntereso involved 48 respondents: 29 were old adults, and 19 were middle adults, at a 28:20 male-female ratio. Additionally, 56 people were interviewed at Sekondi. The ratio of old adults to middle adults was 26: 30. The approach enabled a blended perspective in the comparative analyses of the sites.

### **4.10.2 Photography**

Photography is a valuable tool for recording and retaining the details of a behavior/action. Samsung Galaxy A50 was used to capture and document some of the activities in the various communities in JPEG and video formats.



## 4.11 RESULTS & DISCUSSIONS

### 4.11.1 Let's Till the Land- Farming

While farming is a limited activity at Sekondi, it's a major bustle in Begho, Ntereso, Yapei, and Yikpabongo on small and commercial scales. Across the respective regions, this activity is the preserve of the men, although women and children help intermittently grow 'small' crops like pepper (*Capsicum annum*) and okro (*Abelmoschus esculentus*), weeding, harvesting, and transporting the yield to the house. According to Posnansky (2004), Begho farmers have in memory the names of over 500 valuable plants for food and medicine. The farmers take advantage of the annual rainy season (June & October) to cultivate crops such as maize (*Zea mays*) (**Figure: 4. 8**), pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), beans (*Phaseolus vulgaris*), groundnut (*Arachis hypogaea*), tiger nuts (*Cyperus esculentus*), cashew (*Anacardium occidentale*), oil palm (*Elaeis guineensis*), watermelon (*Citrullus lanatus*), and yam (*Dioscorea alata & Dioscorea cayenensis*). However, grains, legumes, spices, and tuber crops, are from neighboring towns like Buipe, Tamale, Kumasi, and Techiman. Farming implements were acquired from local blacksmiths who re-work raw materials bought from the suburbs. The strain involved in the (habitual) manual tilling of acres of farmland can immensely impact the skeleton as it degenerates joints of the spine and of the upper and lower limbs.



**Figure 4. 8: A typical maize farm at Yapei.**

#### 4.11.2 Wood & Fire

At Yapei and Ntereso, this activity involves chopping down redundant trees and gathering the logs (**Figure: 4. 9**) for domestic use and sale. Some logs are also gathered for charcoal making (**Figure: 4. 10**). This activity is both a necessity and a business. Those at the forefront of this venture carry bundles of the branches and logs, usually from the forest, to their homes, where they are sorted, and some are bundled for exchange/sale. The inhabitants are privy to the technique of charcoal making, usually the domain men of particular households. They find a secluded space and dig a wide circular pit where the logs are set ablaze long enough to burn the wood but not too long to render them in ashes. When the logs are half burnt, the pit is covered with sand, and the trapped heat gradually completes the burning process at a lower temperature over days. After, the mound is opened and the charcoal is left to cool. The charcoal is later gathered and packaged for sale. These folks do not keep track of time as much as those in the urban sectors do, so the burning duration is observed/ tracked by indigenous knowledge from continued practice. Carrying the heavy logs across a distance over time can result in the prominence of the mastoids of males/females, produce bony outgrowths on the laterals of the occipital condyles, and osteophytic formations on the cervical and lumbar vertebrae. At least, currently, trucks help convey the logs and bags of charcoal from the forest to the community, reducing the workload.



**Figure 4. 9: A pile of branches and logs left to air-dry.**





**Figure 4. 10: Charcoal in the making; a mound of burning wood to be left for days and afterward the resulting charcoal will be gathered for sale within and outside the community.**

### 4.11.3 Fishing

With proximity to the White Volta River (**Figure: 4. 11**), the inhabitants of Yapei and Ntereso have the luxury of supplementing their protein intake with different kinds of fish every year. Different fish from the sea also supplements the diets of the Sekondi inhabitants. Men (young and old adults) are at the forefront of this activity regarding canoe carving, fish net mending, net-setting in the river, and pulling out the net. Afterward, men and women, including children (six years and above), remove the fish from the net. Some children and adolescents (6-17 years) also go fishing or accompany their parents after school. Women (mostly the fishermen's wives) are the fishmongers (who smoke and sell some of the fish). The long hours at sea and sitting on canoes without proper back support inflict pressure on the spine.



**Figure 4. 11: A section of the White Volta from the Ntereso- Yapei bridge.**





**Figure 4. 12: A conventional fish trap still in use at Yapei.**

**Figure 4. 13: Fishing net in the making from plastic twine.**







**Figure 4. 14: On the White Volta, young, middle, and old adults working on the day's catch.**



**Figure 4. 15: Fish from the White Volta in June 2022.**





**Figure 4. 16: Fish smoking at Yapei.**

#### 4.11.4 The Shea Business @ Yapei & Ntereso

The shea tree is as useful as the baobab tree at Yapei, Ntereso, and Yikpabongo. Every part of the tree is resourceful, from food, medicine, and soap, to cream. The shea business and its processes have been discussed below. Women are likely to develop spinal osteoarthritis and hypervascularization of their joints because they are at the forefront of the start-to-finish of this activity. Including gathering and carrying the fruits from the forest or outskirts of town, deshelling the nuts, grinding the nut (kneeling/sitting/bending to grind on a grinding stone until the advent of milling machines), and kneading the paste (by hand). Children also help in the gathering and deshelling of the nuts. Some households bundle huge quantities of nuts and sell them to shea butter processing companies within the country.

- a) Harvesting/gathering shea fruit from the 'wild' or outskirts of town and drying to de-pulp them.



**Figure 4. 17: i) The Shea fruit. Photo: (Stravens & Mangnus, 2018), ii) Drying the harvested/ collected shea fruit to de-pulp (get rid of the epicarp and mesocarp) for the nut before boiling (Photo: Author's digital collection).**



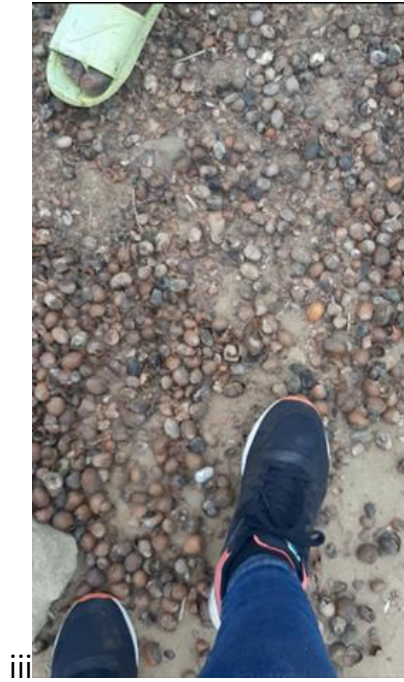
b) Drying the de-pulped nuts after boiling



**Figure 4. 18: i/ii) Drying the nut after boiling. Photo: i- (Stravens & Mangnus, 2018), ii- Author's digital collection.**

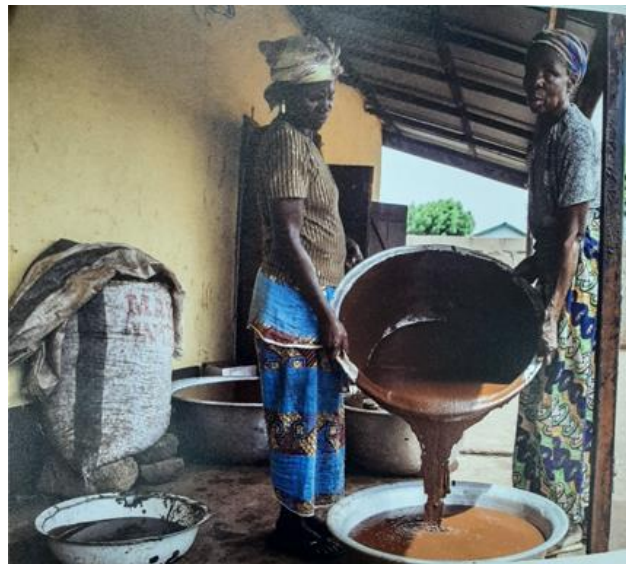
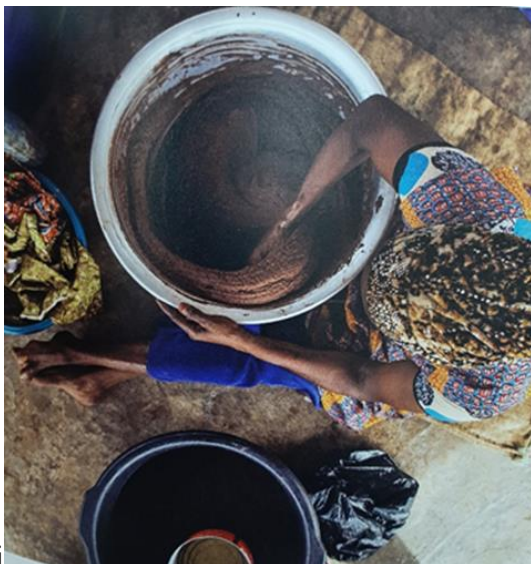
c) Manual deshelling of the nuts (crushing the nutshells by stamping & beating, on-stone crushing, or rubbing against the floor). The nuts are carefully sorted and taken to the mill for grinding. In the past, nuts were ground on grinding stones.





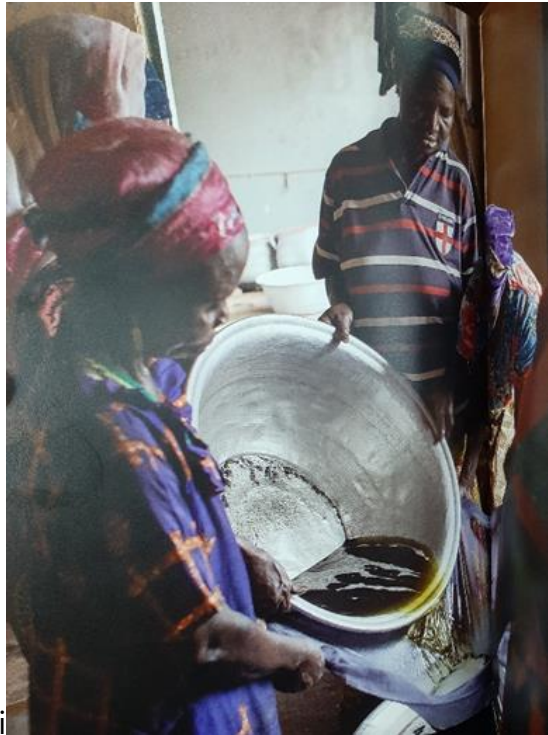
**Figure 4. 19: (i-iii) Mechanisms of crushing the dried nuts to remove the nut shells, i) beating/hitting with clubs, ii) stone-on-stone crushing, and iii) foot-stamping (Photos: Author's digital collection).**

d) Kneading the ground nut paste and boiling the paste to extract the oil and other raw materials for soap making.



**Figure 4. 20: i) Kneading of the nut paste after grinding to agitate the oils; ii) the paste is mixed with water after kneading and poured into a basin for boiling.**





iii

**iii) The floating oil is scooped into a basin, strained to rid the final product of impurities, and left to cool. (Photos: (Stravens & Mangnus, 2018))**



**Figure 4. 21: Shea butter, solidified shea oil (Photo: Author's digital collection).**

#### 4.11.5 Basketry @ Ntereso

This craft specialization is gradually fading from the community. At Ntereso, only one old adult male makes conventional baskets as hencoops (**Figure: 4. 21**) with bamboo-like branches (**Figure: 4. 19**). People no longer make baskets for domestic use; they rather buy already-made baskets hawked in the markets. The youth creatively craft useful household artifacts (**Figure: 4. 18**) with the raw materials. Also, some people weave straws into mats for varied domestic use (**Figure: 4. 22**). A similar craft was observed at Aflao in the Volta region of Ghana, where some inhabitants weave palm branches into mats (**Figure: 4. 23**). The mats were used as blinds or curtains, household fences, boundary demarcation, and other domestic purposes. The mats are economical compared to concrete walls. The only difference is that, at Aflao, palm branch weaving is an active venture for men, women, and children. There is a discontinuity in the craft of basketry at Yapei. Posnansky mentions the craft of basket weaving for domestic use at Begho in the 1970s (Posnansky, 2004, p. 40). Mechanically, this craft will, over time, result in hypervascularization of the hand bones and hand osteoarthritis. In the event of the involvement of the teeth in ripping raw materials and supporting strands, interproximal grooving and occlusal surface wear may be compounded depending on the material being worked on.



**Figure 4. 22: Bamboo-like branches; raw material for basketry and other woven crafts.**





**Figure 4. 23: i/ii) Some of the artifacts made of bamboo-like branches are showcased for sale. In view are 'lazy' chairs, mini tables, and a mini bed.**





**Figure 4. 24: (i/ii) Conventional hencoops made as baskets with bamboo-like branches**







**Figure 4. 25: Woven straw mat at Ntereso used as a covering to a urinal (may double as a bathhouse)**



**Figure 4. 26: Some palm-branch fence mats at Aflao, Volta region.**

#### 4.11.6 Cloth weaving @ Yapei & Ntereso

The pods of a Kapok tree (*Ceiba Pentandra*) locally known as *Seri* contain a fluffy silk-like material used as the filling for pillows in the past. This fluffy silk-like material is also processed into yarns and woven into fabrics called *calico* (with a texture similar to the Ashanti kente) to be sewn into dresses. Dresses made of this fabric in white are considered ceremonial for enskinment and to accompany a decedent. Other dyed or colored types can be worn any day. No contemporary evidence of cloth weaving was observed at Sekondi and Begho, but oral accounts reveal that it was a booming enterprise. The prolonged sitting time and engagement of the upper and lower limbs in yarn making and weaving will impact the skeleton over the years.



**Figure 4. 27: A Kapok pod containing white fluffy silk-like material used as pillow stuffing and cloths (from processed yarns).**



**Figure 4. 28: Processed yarns from the fluffy silk-like material of the Kapok pods.**





**Figure 4. 29: Weaving the yarns into fabrics.**



**Figure 4. 30: A roll of fabric made from the yarns. This will be sewn together to make clothes.**

## **4.12 CONCLUSION**

This chapter has presented short descriptions and images of some activities at Sekondi, Begho, Ntereso, Yapei, and Yikpabongo. The activities include farming, fishing, basketry, cloth weaving, shea butter processing, and other manual labor. These activities form the basis of the people's livelihoods, sustaining and giving them a sense of living and engagement. However, the intensity of energy required to execute these activities can grossly impact muscle attachment points; increase rugosity, muscle detachments, and joint degeneration over time. The inhabitants are introduced to these activities at an early age (as sub-adults), and others engage in them for their lifetime. All the while, the skeletal system remains at the mercy of these activities with all the pressure and injuries. Although other factors may have influenced the activity-related lesions observed among the individuals, the activities described above may have contributed to their expression.

## 5 CONCLUSION & PERSPECTIVES

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This research focused on the inventory and comparative study/analyses of the human remains from five sites across Ghana's Western, Savannah, Bono, and Northeast Regions. These remains, from Begho, Sekondi, Yapei, Ntereso, and Yikpabongo, respectively, have been in the Museum of Archaeology (DAHS) storage since the mid-20<sup>th</sup> century, and 2007 for the individual from Yikpabongo. The three parts of the thesis were targeted at addressing the [research objectives](#). The remains have been subjected to in-depth anthropological and bio-archaeological analyses, in addition to analytical techniques, for example, parasitology, computed tomography examinations, as well as x-ray fluorescence and stable isotope analyses to ascertain the life histories of the ancient populations of the five sites and to reveal the interpretative contributions of human remains to the understanding of past lifeways and the environment of the respective sites.

Part I elaborated in four chapters relevant themes on provenance research on human remains, namely the contexts of the remains, the implications of archaeological practice in Ghana on archaeo-osteological studies on human remains, and the details of the anthropological examination of the remains, i.e., the osteobiographies of the past populations from Sekondi, Begho, Ntereso, Yapei, and Yikpabongo. It also presented probable conflicts in representing the MNI from the number of elements of the fragmentary skeletal assemblages and challenges to the provenance research. Part II discussed in two chapters the health and alimentation status of the individuals, and part III revealed, in two chapters, some activity-related markers on the osseous tissues and presented a glimpse into some contemporary activities within the communities.

The discussions have revealed that osteobiographies are more reliable for the life course of those who were once alive. As active voices of the past, the skeletons provided the biological profile of the ancient individuals of whom no social and medical records probably exist and elucidated other aspects of their life, including health, alimentation, and activity patterns. The

quest to re-humanize the remains was achieved with biological anthropological methods. In the end, 25 individuals were identified from the fetus to old adult age range. The sex distribution was two females, two males, six uncertain females, two uncertain males, and 13 undetermined cases. 16 skeletal (40%) and dental (60%) pathologies were recorded from the individuals.

The health of ancient populations was assessed based on skeletal lesions that could infer diseases they suffered over the years, and their oral health was deduced from dental pathologies: calculus, caries, abscess, enamel hypoplasia, and hypercementosis. Some skeletal lesions were porotic hyperostosis, spina bifida occulta, Brucella spondylitis, head lice infestation, hypodontia, and hyper-vascularization of joints. The skeleton also records all intra-vitam musculoskeletal pressures emanating from activities involving prolonged bending, squatting, extensive joint use, and muscle detachment, discussed in relation to hand and spinal osteoarthritis, myositis ossificans, and articular hyper-vascularization. The masticatory and non-masticatory functions compounded some of the dental diseases. The XRF analysis of calculus samples revealed no exposure of the Begho inhabitants to industrial pollutants like lead, arsenic, antimony, mercury, and chromium, which was necessary for public health concerns.

The research recommends Scanning Electron Microscopy (SEM) on the calculus samples to look out for crystals or fiber trapped in these mineralized plaques, which may support the non-masticatory occupational use of teeth. The parasitology and CT examination detected no parasites from the endocranial soil mass and no calcified carcinoma but low-density blotches representing fat or other decomposed organic materials. While the study acknowledges the probable influence of genetic factors, the examinations and diagnoses rendered here enabled the reconstruction of the health of the past populations. The pathologies discussed in relation to the health of the populations can serve as a reference for paleo-epidemiological studies on Ghanaian or African populations for assessing public health concerns over the years.

Regarding dietetics, the prevalence of the dental pathologies recorded, exposed the alimentation composition of the ancient populations to be high in carbohydrates/ fermentable carbohydrates, sugar, and sticky fruits. The interproximal location of caries depicted the non-abrasive nature of the diets. However, significant dental wear points to bruxism and the possibility of some abrasive particles in the diets of the past population. The  $^{13}\text{C}$  and  $^{15}\text{N}$  isotope revelation on the Yapei individual to  $\text{C}_4$  plants, in addition to riverine resources and land animal protein, was expected considering the Ghanaian soil is accustomed to the cultivation of these plants and their proximity to the White Volta River. This revelation has allowed, by inference, the prediction of the alimentation status or dietary pattern of the Ntereso, Sekondi, Begho, and Yikpabongo individuals. The data on the dietary and activity patterns of the individuals complement archaeological reconstructions of past lifeways accrued from material cultural remains such as ceramics and bottle types, molluscs, and implements. The activity-related lesions and enthesal changes helped to reconstruct the paleo-activity and enabled a better understanding of the extent to which activity impacts the inner substrate of the human body.

The research standpoints and insights complement the interpretive contexts of the sites' historical narratives and understandings of past lifeways. The anthropological data adds to the database on Ghanaian populations, which future studies can reference. The data would be useful to archaeologists and epidemiologists for comparative analyses with living and dead samples within the Ghanaian sub-region and beyond. For the former, the research stimulates a better understanding of ancient and present populations regarding changes and continuities in health patterns and activity influences revealed by the osseous tissues. The paleopathological reconstructions provide a comparative platform for interpreting and understanding population health and paleo-activity. Moreover, the paleopathological evidence of health patterns can be valuable for epidemiologists to track disease evolution over time, complemented by a second-hand insight into their effect on osseous tissues. This enables enhanced assessments of public health concerns to propose better solutions.

### **The way forward: to curate or rebury?**

What lies the fate of these individuals? Should they be maintained for teaching and research as scientific mirrors or restituted to their communities of origin for reburial and closure? Regarding the former, I have already discussed the Museum of Archaeology's potential to handle and store these remains in its collections for research purposes (Lampthey, 2022). On a recent visit to the museum, I saw tremendous improvement in storage organization and condition. It is uncertain whether the ephemeral intake of other archaeological finds from the Departments' annual field schools and independent research by students and faculty will allow ample room for the ethical safeguarding of the remains from now to the future. How proactive will further research on the individuals be? What curatorial measures will be taken to ensure the preservation of the integrity of the remains? The option of re-interment depends on existing social connections and the recipients' reception (the community heads).

What sort of internal conflict would the internal/ indigenous restitution instigate, rooting from ownership and autonomy of decisions among community heads to descendants? Without the knowledge of ancestry, how can this conflict be resolved? How can the holders explain why the remains were exhumed and held over the years? The excavators probably had the permission of the then-community heads, but what's the proof? Perhaps representatives of the Department can calm the socio-sensitivities by explaining the scientific intention to glean past lifeways for present understandings and comparisons. Reports detailing methods employed to re-humanize the human remains from 'archaeological finds' to individuals for broader population paradigms can be presented to the various communities. The recipients should be allowed to decide the 'afterlife' of the individuals, to rebury or donate for teaching and learning purposes. Regarding the latter, and as mentioned earlier, the scientific and the social must cooperate, i.e., the scientific environment must be conducive to respecting the inherent dignity of the individuals while the social, via community or public archaeology initiatives, gradually warms up to their scientific potential to shed light on past lifeways and public health concerns.

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**APPENDIX A: PHOTOGRAPHIC REFERENCE OF THE CONTEXT OF THE SEKONDI HUMAN REMAINS.**

Site	Box Number	Remains ID No.	Context/Provenience
Sekondi	Burial A (VII G)	SK'21- A 73.80	<ul style="list-style-type: none"> <li>• Sekondi: West, VII G, Burial A &amp; pot behind (OD 63/608).</li> <li>• Sekondi VII G. Skull at corner of old pit level 5.0' Burial A (OD 63/608)</li> </ul>
Sekondi	Burial C (VII C-D), 1956	SK'21-C73.88	<ul style="list-style-type: none"> <li>• Sekondi VII C-D. Skeleton @ level 4.3'; associated with beads, celts, cairns, and shell beads. Pot on the right elbow. Burial C (OD 63/596, 621 &amp; 622)</li> </ul>
Sekondi	Burial D Da	SK'21-73.81	<ul style="list-style-type: none"> <li>• Sekondi VII D. Pots and bones at about level 5.3'. 4<sup>th</sup> burial disengaged at L-5.0', associated with two celts, 1 projecting from the wall at the end of the ruler. The ruler points at a quartz artifact. Pot 7 on the stomach is removed (cut hole seen), and probably one leg is removed. BURIAL Da (OD 63/612, 613, 614, 617 &amp; 618)</li> </ul>
Sekondi	Burial E	SK'21-73.82	<ul style="list-style-type: none"> <li>• Sekondi VII E-F. Skeleton @ level-5.2'; skull with bead strip around and partial skeleton. Burial E (OD 63/595, 596 &amp; 597)</li> </ul>
Sekondi	Burial F	SK'21-73.94	<ul style="list-style-type: none"> <li>• Sekondi VII D 1<sup>st</sup> &amp; 2<sup>nd</sup> skull Burial F. Burial D is in the shadow, in the pit (OD 63/615).</li> <li>• Sekondi excavation Pit IV F. Upper burial at (D)-3.7' and cleaned on 1/12/54 (OD 63/638).</li> <li>• Sekondi excavation Pit IV F &amp; M. 2<sup>nd</sup> skeleton &amp; surrounding bone cleaned. Trowel points at the bead</li> </ul>

			<p>(OD 63/641).</p> <ul style="list-style-type: none"> <li>• Sekondi excavation Pit IV F &amp; M. bends 2<sup>nd</sup> skeleton dismembered behind &amp; two leg bones (OD 63/641).</li> <li>• Sekondi excavation Pit IV F &amp; I. Lower burial skull with stone beads in-situ (OD 63/641).</li> </ul>
Sekondi	Burial G	SK'21-73.83	<ul style="list-style-type: none"> <li>• Sekondi VII E East corner Burial at level- 5.4'. Skull, left arm &amp; one... (legs &amp; 2 pots around) from North-west. BURIAL G (OD 63/599 &amp; 600).</li> <li>• Sekondi VII E. L3.0-3.5 Pebble cairn appearing in the East (OD 63/601, 602 &amp; 607).</li> <li>•</li> </ul>
Sekondi	Burial H.	SK'21-H 73.84	<ul style="list-style-type: none"> <li>• Sekondi VII E. Pebble cairn on...with a skull at the base is marked by a ruler at level-7.0' Burial H (OD 63/604, 605 &amp; 606).</li> </ul>
Sekondi	Burial K	SK'21-K 73.85	<ul style="list-style-type: none"> <li>• Sekondi VII C Pit with cairn to the base of the floor at level- 6.5'. Pebble cairn at level- 3.7'. Burial at level- 6.7' ... skull &amp; leg bones around the cairn. The ruler points at two ...beads Burial K (OD 63/607, 610, 611 &amp; 612).</li> </ul>
Sekondi	Burial L	SK'21- L 73.86	<ul style="list-style-type: none"> <li>• Sekondi VII C-D. Burial at level- 6.0'. (OD 63/623).</li> <li>• Sekondi excavation Pit V D, at the boundary of V.E, a skull, pot &amp; bead, V G ...at the base (OD 63/630 &amp; 631).</li> <li>• Sekondi excavation, second skull in the ground/ gravel Pit V G with cowry (OB 63/631 &amp; 632).</li> </ul>
Sekondi	Burial M	SK'21-73.87	<ul style="list-style-type: none"> <li>• BURIAL M. Sekondi VII C-D skeleton @L-3.9' from North-West. West corner of VII D (OD 63/618 &amp; 619).</li> </ul>

			<ul style="list-style-type: none"> <li>Associated with celt and the ruler points at beads, shell beads by face (OD 63/620).</li> </ul>
<b>Sekondi</b>	Pit I. extension, scattered bones. below the surface. Material from lower ends 1.2-12.	SK'21-73.89	<ul style="list-style-type: none"> <li>Sekondi excavation Pit I extension IV, a heap of pebbles that supported the skull &amp; pot at the base of the excavation (OD 63/589 &amp; 594).</li> </ul>

# APPENDIX B: RADIOCARBON DATE AND <sup>13</sup>C & <sup>15</sup>N ISOTOPE VALUES FOR MIDDLE ADULT FEMALE, YP'18-73.106



**Beta Analytic**  
TESTING LABORATORY

Beta Analytic, Inc.  
4985 SW 74<sup>th</sup> Court  
Miami, FL 33155 USA  
Tel: 305-667-5167  
Fax: 305-663-0964  
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

## REPORT OF RADIOCARBON DATING ANALYSES

Philippe Charlier

Report Date: January 13, 2023

Musee du quai Branly - Jacques Chirac

Material Received: December 19, 2022

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
-------------------	--------------------	--	--

<b>Beta - 649883</b>	<b>Yapel-YP-18-73.106</b>	<b>220 +/- 30 BP</b>	IRMS δ13C: -10.5 o/oo IRMS δ15N: +8.8 o/oo
	(48.1%) 1731 - 1806 cal AD	(219 - 144 cal BP)	
	(35.5%) 1640 - 1687 cal AD	(310 - 263 cal BP)	
	(11.8%) 1926 - Post AD 1950	(24 - Post BP 0)	

Submitter Material: Bone (Non-heated)

Pretreatment: (bone collagen) collagen extraction; with alkali

Analyzed Material: Bone collagen

Analysis Service: AMS-Standard delivery

Percent Modern Carbon: 97.30 +/- 0.36 pMC

Fraction Modern Carbon: 0.9730 +/- 0.0036

D14C: -27.02 +/- 3.63 o/oo

Δ14C: -35.57 +/- 3.63 o/oo (1950:2023)

Measured Radiocarbon Age: (without d13C correction): 100.21 +/- 0.36 pMC

Calibration: BetaCal4.20: HPD method: INTCAL20

Carbon/Nitrogen: CN : 3.2 %C: 41.61 %N: 14.94

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the <sup>14</sup>C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 4.20

## Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL20)

---

(Variables:  $\delta^{13}C = -10.5$  o/oo)

**Laboratory number**    **Beta-649883**

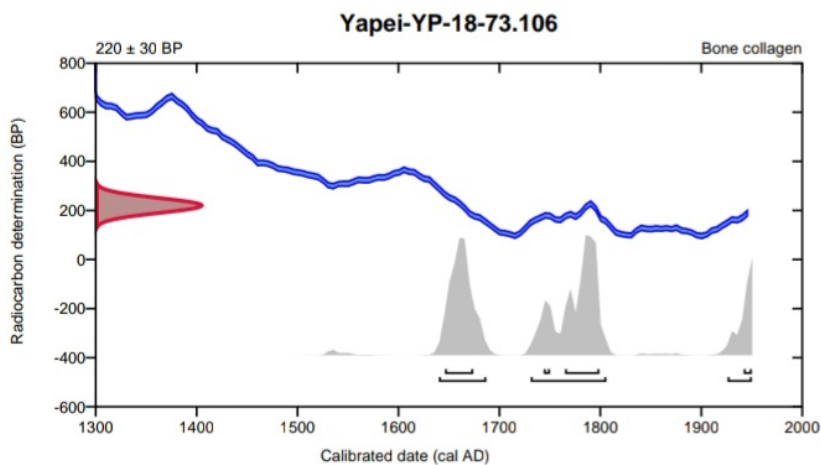
**Conventional radiocarbon age**    **220 ± 30 BP**

95.4% probability

(48.1%)	1731 - 1806 cal AD	(219 - 144 cal BP)
(35.5%)	1640 - 1687 cal AD	(310 - 263 cal BP)
(11.8%)	1926 - Post cal AD 1950	(24 - Post cal BP 0)

68.2% probability

(30%)	1765 - 1799 cal AD	(185 - 151 cal BP)
(27.5%)	1646 - 1674 cal AD	(304 - 276 cal BP)
(7%)	1942 - Post cal AD 1950	(8 - Post cal BP 0)
(3.7%)	1744 - 1750 cal AD	(206 - 200 cal BP)



### Database used

INTCAL20

### References

#### References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

#### References to Database INTCAL20

Reimer, et al., 2020, *Radiocarbon* 62(4):725-757.

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## Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • Email: beta@radiocarbon.com

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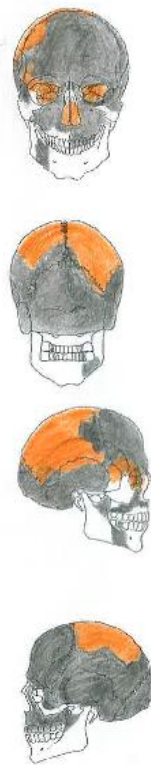
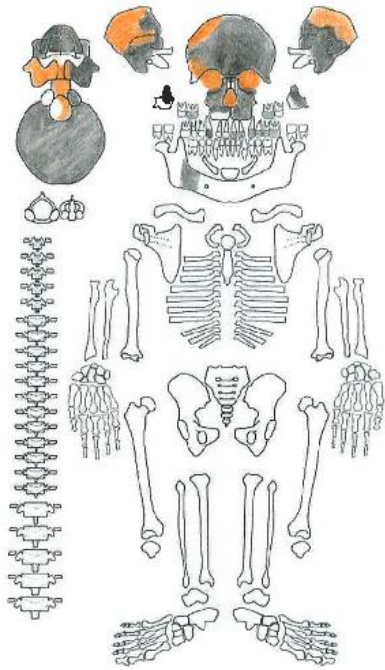


# APPENDIX C: GRAPHICAL SKELETAL INVENTORY




Sekondi SK'21- A 73.80

SKETCHES OF ALL BONES AND ELEMENTS PRESENT

SITE: Sekondi  
SKELETON ID. NO. SK'21- 73.80  
CATEGORY: .....



### Legend

-  Bone present
-  Soil
-  Bone absent/too fragmented

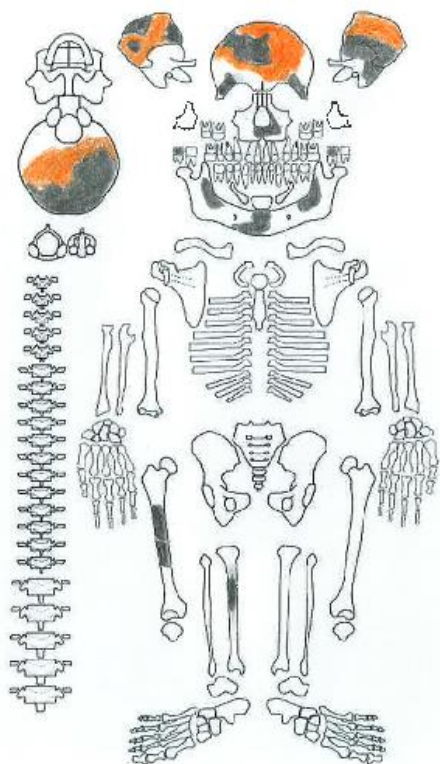
Sekondi SK'21-C 73.88

✓✓ FINAL INVENTORY OF ELEMENTS PRESENT

SITE: SEKONDI  
SKELTON ID. NO. SK'21-73-88 C  
CATEGORY: ADULT

**Legend**

- Bone present
- Soil
- Bone absent/too fragmented



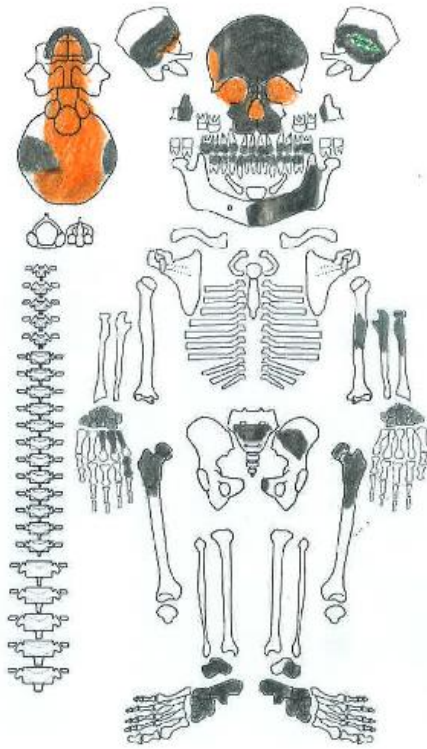
Sekondi SK'21-E 73.82

SKELETAL DEPARTMENT OF FORENSIC SCIENCE

SITE: SEKONDI

SKELTON ID. NO. SK'21-73.82 E

CATEGORY: .....



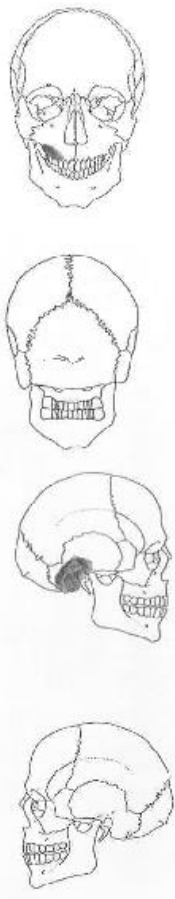
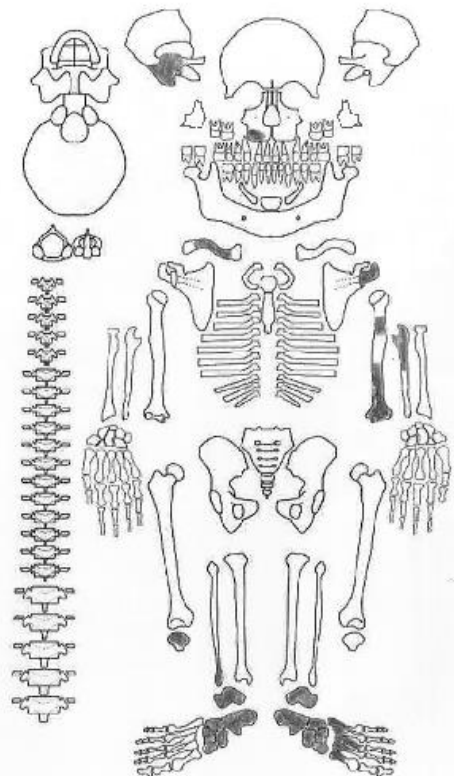
**Legend**

-  Bone present
-  Soil
-  Bone absent/too fragmented
-  Shell beads

Sekondi SK'21-G 73.83

SKLETAL INVENTORY OF HUMANS PRESENT

SITE.....SEKONDI.....  
SKLETON ID. NO. ...SK'21 73.83 G...  
CATEGORY.....



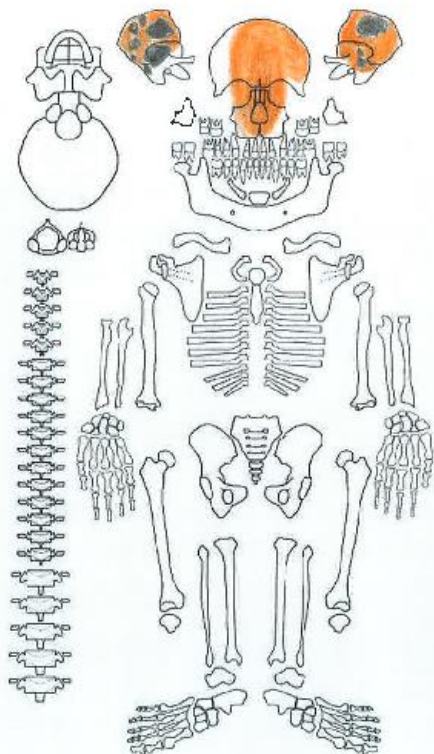
**Legend**

- Bone present
- Bone absent/too fragmented




Sekondi SK-21-K 73. 85

SKELETAL INVENTORY OF ELEMENTS PRESENT

SITE..... Sekondi  
SKELETON ID. NO. ... SK-21-K 73. 85  
CATEGORY.....



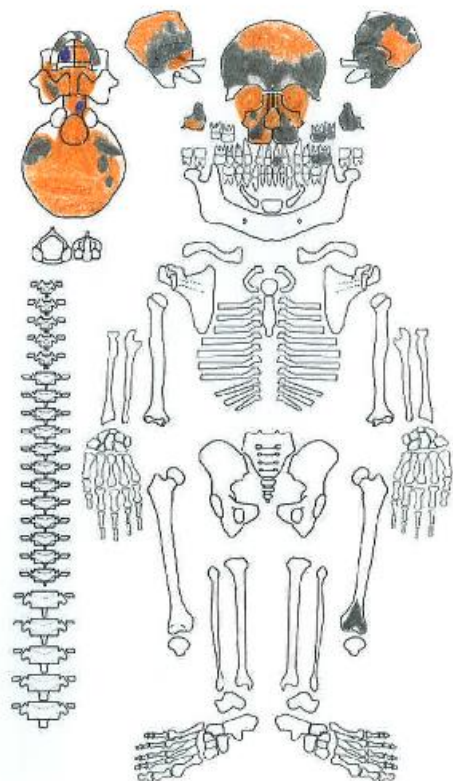
**Legend**

-  Bone present
-  Soil
-  Bone absent/too fragmented




Sekondi SK'21-L 73.86

INVENTORY OF ELEMENTS PRESENT

SITE SEKONDI  
SKELTON ID. NO. SK'21 73-86 L  
CATEGORY.....



**Legend**

-  Bone present
-  Soil
-  Bone absent/too fragmented

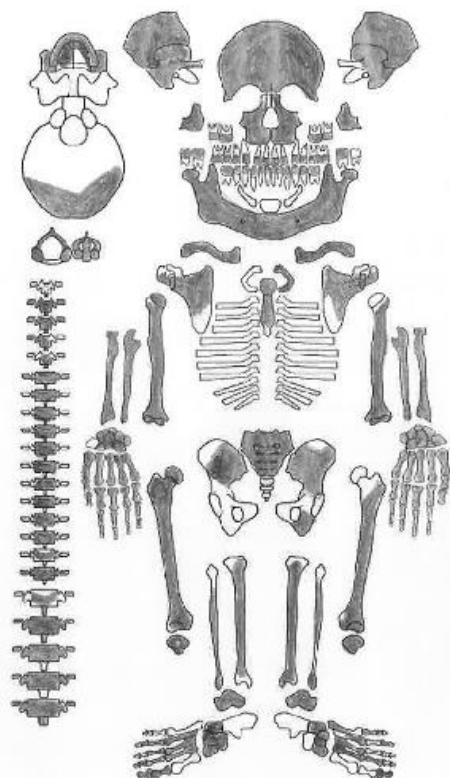
Begho BG'21-F 73.116

SKELTAL INVNTORY OF COLLEGE'S PRES. RT

SITE..... Begho

SKELTON ID. NO. BG 21 - 73.116 (BG'21-F)

CATEGORY.....



**Legend**

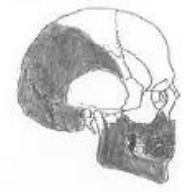
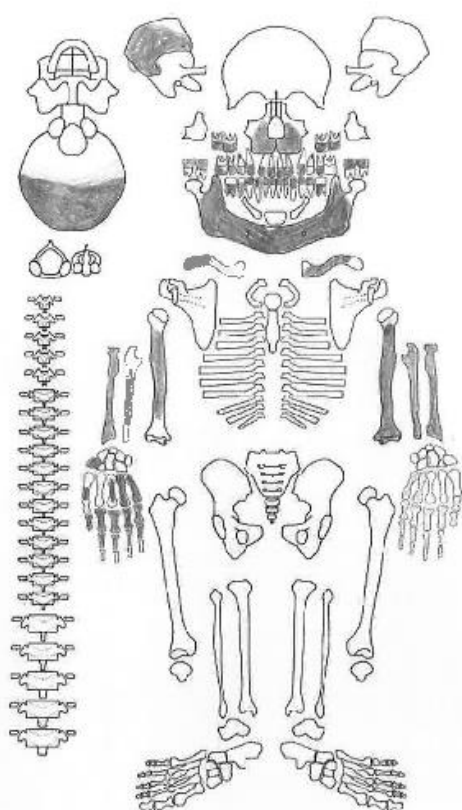
- Bone present
- Bone absent/too fragmented



Begho BG'21-E 73.115

SKULL AND INVENTORY OF ELEMENTS PRESENT

SITE..... BG'21-E  
SKELETON ID. NO. .... BG'21-E 73.115 (By 23 E)  
CATEGORY.....



**Legend**

- Bone present
- Bone absent/too fragmented



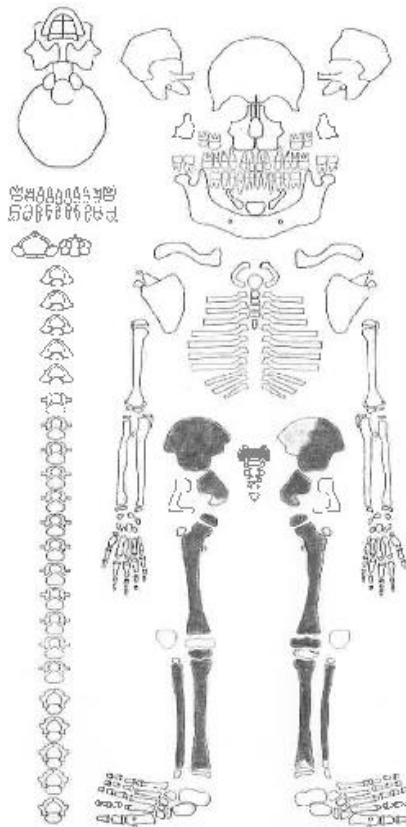
Begho BG'21-A 73.118

SKELETAL INVENTORY OF ELEMENTS PRESENT

SITE BEGHO

SKELTON ID. NO. BG'21-73-118 (G 70A)

CATEGORY CHILD



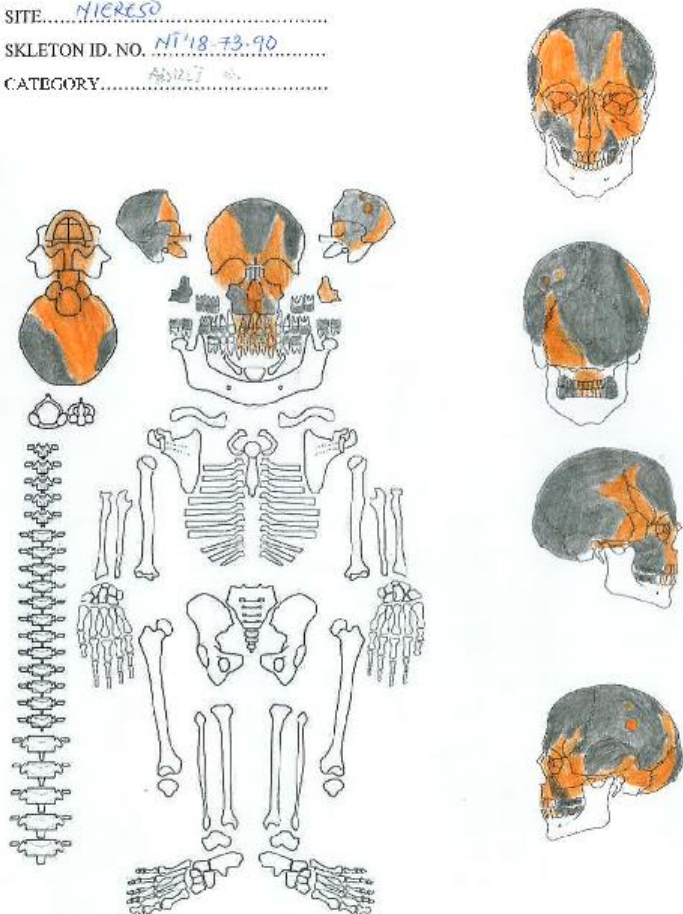
**Legend**

- Bone present
- Bone absent/too fragmented




Ntereso NT'18- 73.90

SKULL INVENTORY OF ELEMENTS PRESENT

SITE NTERESO  
SKELTON ID. NO. NT'18-73-90  
CATEGORY ADULT



**Legend**

-  Bone present
-  Soil
-  Bone absent/ too fragmented

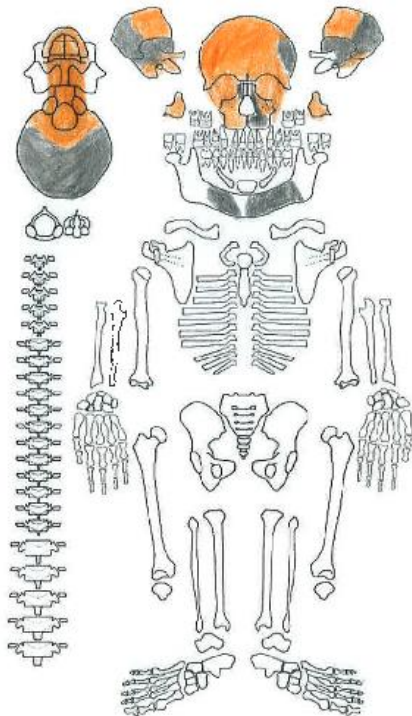
Ntereso NT'18-73.91

SITE: STA. INVENTORY OF ELEMENTS PRESENT

SITE..... NT'18-73.91

SKELTON ID. NO. NT'18-73-91

CATEGORY.....



**Legend**



Bone present



Soil

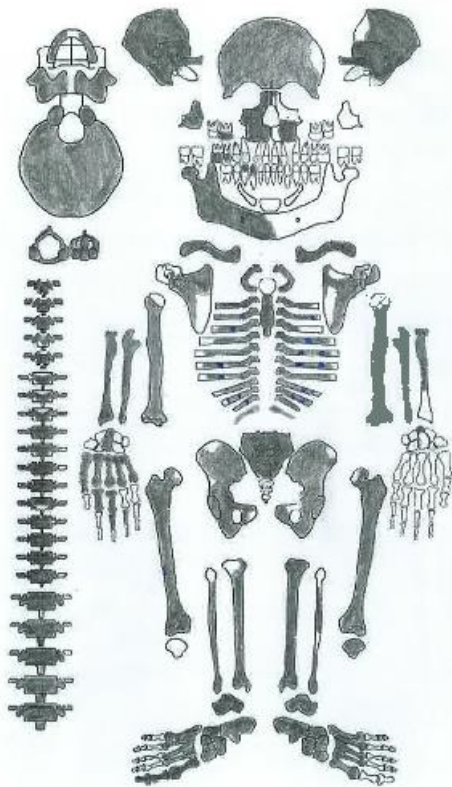


Bone absent/ too fragmented

Yapei YP'18- 73.106

SKULLALINVENTORYELEMENTS PRESENT

SITE... YAPEI .....  
SKLETON ID. NO. YP'18 73.106 .....  
CATEGORY... ADULT .....



**Legend**

- Bone present
- Bone absent/too fragmented

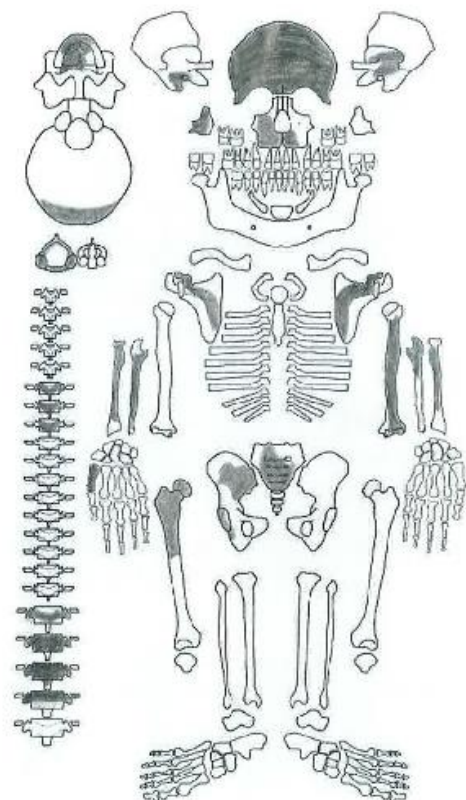
Yapei YP'18-73.105

SKULL INVENTORY OF LIAOJIN 5 "PRES" 5

SITE Yapei

SKELTON ID. NO. YP'18 73-105

CATEGORY.....



**Legend**

- Bone present
- Bone absent/too fragmented

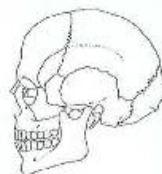
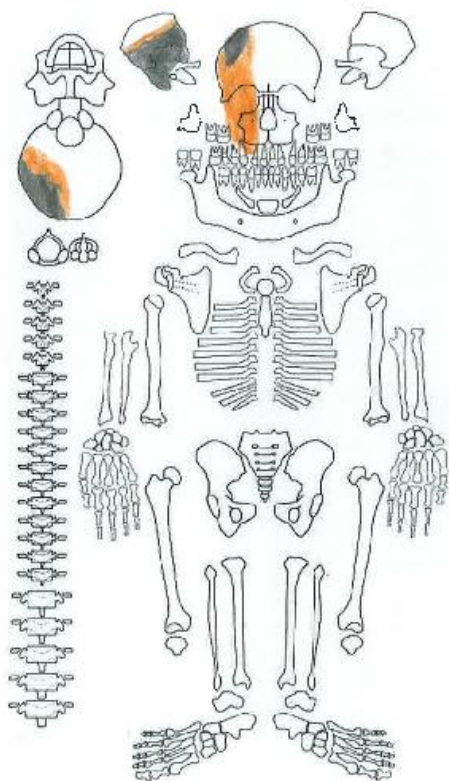
Yikpabongo YK'21, Unit C-D

SKELETAL INVOLVEMENT OF LUMBARIS PRESENT

SITE.....YIKPABONGO.....

SKELETON ID. NO. YK'07, UNIT 1.....

CATEGORY.....



**Legend**



Bone present



Soil



Bone absent/too fragmented

**APPENDIX D.1: DETAILED ELEMENT COMPOSITION IN CALCULUS FROM THE MANDIBLE OF INDIVIDUAL BG'21 E-73.115**

Type	FP analysis				
Folder	<Common>				
File	BG'21 E-73.115 Md_E				
Counts	All				
Analysis date	5/20/2022 8:16				
Sample name	BG'21 E=73.115Md_E				
Application	BG'21 E-73.115 Md_E				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
O	59.6	59.9	mass%	2	<b>59.7</b>
Ca	16.4	16.2	mass%	2	<b>16.3</b>
Si	9.89	9.87	mass%	2	<b>9.88</b>
P	8.04	7.96	mass%	2	<b>8</b>
Al	4.23	4.26	mass%	2	<b>4.24</b>
Fe	0.589	0.583	mass%	2	<b>0.586</b>
Na	0.422	0.4	mass%	2	<b>0.411</b>
Ti	0.235	0.231	mass%	2	<b>0.233</b>
Mg	0.192	0.176	mass%	2	<b>0.184</b>

K	0.145	0.137	mass%	2	<b>0.141</b>
Zr	0.0979	0.1	mass%	2	<b>0.0991</b>
S	0.0611	0.0625	mass%	2	<b>0.0618</b>
Mn	0.0238	0.0244	mass%	2	<b>0.0241</b>
Cl	0.024	0.0234	mass%	2	<b>0.0237</b>
Sr	0.0203	0.0199	mass%	2	<b>0.0201</b>
Zn	0.0151	0.0147	mass%	2	<b>0.0149</b>
V	0.004	0.0029	mass%	2	<b>0.0035</b>
Cu	0.0026	0.0019	mass%	2	<b>0.0023</b>
Cr	0.0021	0.0013	mass%	2	<b>0.0017</b>
Ni	0.0018	0.0016	mass%	2	<b>0.0017</b>
Ta	ND	0.0016	mass%	1	<b>0.0016</b>
Y	0.0009	0.001	mass%	2	<b>0.0009</b>
Pb	0.0011	0.0008	mass%	2	<b>0.0009</b>
Rb	0.0008	0.0008	mass%	2	<b>0.0008</b>
Br	0.0007	0.0007	mass%	2	<b>0.0007</b>
Au	0.0006	0.0007	mass%	2	<b>0.0006</b>
Ga	0.0005	ND	mass%	1	<b>0.0005</b>
Hg	0.0005	0.0006	mass%	2	<b>0.0005</b>
Co	ND	ND	mass%	0	<b>0</b>
Ge	ND	ND	mass%	0	<b>0</b>
As	ND	ND	mass%	0	<b>0</b>
Se	ND	ND	mass%	0	<b>0</b>



Nb	ND	ND	mass%	0	<b>0</b>
Mo	ND	ND	mass%	0	<b>0</b>
Ru	ND	ND	mass%	0	<b>0</b>
Rh	ND	ND	mass%	0	<b>0</b>
Pd	ND	ND	mass%	0	<b>0</b>
Ag	ND	ND	mass%	0	<b>0</b>
Cd	ND	ND	mass%	0	<b>0</b>
In	ND	ND	mass%	0	<b>0</b>
Sn	ND	ND	mass%	0	<b>0</b>
Sb	ND	ND	mass%	0	<b>0</b>
Te	ND	ND	mass%	0	<b>0</b>
I	ND	ND	mass%	0	<b>0</b>
Cs	ND	ND	mass%	0	<b>0</b>
Ba	ND	ND	mass%	0	<b>0</b>
La	ND	ND	mass%	0	<b>0</b>
Ce	ND	ND	mass%	0	<b>0</b>
Pr	ND	ND	mass%	0	<b>0</b>
Nd	ND	ND	mass%	0	<b>0</b>
Hf	ND	ND	mass%	0	<b>0</b>
W	ND	ND	mass%	0	<b>0</b>
Ir	ND	ND	mass%	0	<b>0</b>
Pt	ND	ND	mass%	0	<b>0</b>
Tl	ND	ND	mass%	0	<b>0</b>

Bi	ND	ND	mass%	0	<b>0</b>
Th	ND	ND	mass%	0	<b>0</b>
U	ND	ND	mass%	0	<b>0</b>
Sc	ND	ND	mass%	0	<b>0</b>

**APPENDIX D.2: DETAILED ELEMENT COMPOSITION OF CALCULUS FROM THE MANDIBLE OF INDIVIDUAL BG'21 F-73.116**

Type	FP analysis				
Folder	<Common>				
File	BG'21 F-73.116 Md_E				
Counts	All				
Analysis date	5/20/2022 8:35				
Sample name	BG'21 F- 73.116Md_E				
Application	BG'21 F-73.116 Md_E				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
O	64.4	65.9	mass%	2	<b>65.2</b>
Ca	17.6	17.2	mass%	2	<b>17.4</b>
P	9.2	9.03	mass%	2	<b>9.12</b>
Si	4.83	4.7	mass%	2	<b>4.76</b>
Al	1.96	1.87	mass%	2	<b>1.91</b>
Na	0.715	ND	mass%	1	<b>0.715</b>
Fe	0.468	0.454	mass%	2	<b>0.461</b>
Mg	0.335	0.337	mass%	2	<b>0.336</b>
Ti	0.146	0.142	mass%	2	<b>0.144</b>

Zr	0.103	0.103	mass%	2	<b>0.103</b>
K	0.0835	0.0832	mass%	2	<b>0.0834</b>
S	0.0584	0.0568	mass%	2	<b>0.0576</b>
Sr	0.0299	0.029	mass%	2	<b>0.0294</b>
Cl	0.0287	0.0283	mass%	2	<b>0.0285</b>
Mn	0.0234	0.0226	mass%	2	<b>0.023</b>
Zn	0.0211	0.021	mass%	2	<b>0.0211</b>
V	0.0026	0.0029	mass%	2	<b>0.0028</b>
Cu	0.0021	0.0024	mass%	2	<b>0.0022</b>
Co	0.002	0.0015	mass%	2	<b>0.0017</b>
Ni	0.0017	0.0017	mass%	2	<b>0.0017</b>
Y	0.0008	0.0008	mass%	2	<b>0.0008</b>
Cr	0.0008	0.0007	mass%	2	<b>0.0007</b>
Rb	0.0007	0.0007	mass%	2	<b>0.0007</b>
Ir	0.0008	0.0007	mass%	2	<b>0.0007</b>
Pb	0.0007	0.0007	mass%	2	<b>0.0007</b>
Br	0.0007	0.0006	mass%	2	<b>0.0006</b>
Au	0.0007	0.0005	mass%	2	<b>0.0006</b>
Ta	0.0006	0.0005	mass%	2	<b>0.0005</b>
Pt	0.0004	0.0005	mass%	2	<b>0.0005</b>
Tl	0.0005	ND	mass%	1	<b>0.0005</b>
Hg	ND	0.0004	mass%	1	<b>0.0004</b>
Ga	0.0001	0.0002	mass%	2	<b>0.0002</b>

Ge	ND	ND	mass%	0	<b>0</b>
As	ND	ND	mass%	0	<b>0</b>
Se	ND	ND	mass%	0	<b>0</b>
Nb	ND	ND	mass%	0	<b>0</b>
Mo	ND	ND	mass%	0	<b>0</b>
Ru	ND	ND	mass%	0	<b>0</b>
Rh	ND	ND	mass%	0	<b>0</b>
Pd	ND	ND	mass%	0	<b>0</b>
Ag	ND	ND	mass%	0	<b>0</b>
Cd	ND	ND	mass%	0	<b>0</b>
In	ND	ND	mass%	0	<b>0</b>
Sn	ND	ND	mass%	0	<b>0</b>
Sb	ND	ND	mass%	0	<b>0</b>
Te	ND	ND	mass%	0	<b>0</b>
I	ND	ND	mass%	0	<b>0</b>
Cs	ND	ND	mass%	0	<b>0</b>
Ba	ND	ND	mass%	0	<b>0</b>
La	ND	ND	mass%	0	<b>0</b>
Ce	ND	ND	mass%	0	<b>0</b>
Pr	ND	ND	mass%	0	<b>0</b>
Nd	ND	ND	mass%	0	<b>0</b>
Hf	ND	ND	mass%	0	<b>0</b>
W	ND	ND	mass%	0	<b>0</b>

Bi	ND	ND	mass%	0	<b>0</b>
Th	ND	ND	mass%	0	<b>0</b>
U	ND	ND	mass%	0	<b>0</b>
Sc	ND	ND	mass%	0	<b>0</b>

**APPENDIX D.3: DETAILED ELEMENT COMPOSITION OF CALCULUS FROM THE MAXILLA  
OF INDIVIDUAL BG'21 F-73.116**

Type	FP analysis				
Folder	<Common>				
File	BG'21 F-73.116 Mx_E				
Counts	All				
Analysis date	5/20/2022 8:55				
Sample name	BG'21 F- 73.116Mx_E				
Application	BG'21 F-73.116 Mx_E				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
O	50.5	49.4	mass%	2	49.9
Ca	19.9	20.1	mass%	2	20
Si	14.3	14.4	mass%	2	14.4
P	7.95	8.04	mass%	2	7.99
Al	5.18	5.18	mass%	2	5.18
Fe	1	1.01	mass%	2	1.004
Na	ND	0.61	mass%	1	0.61
Ti	0.357	0.369	mass%	2	0.363
Mg	0.304	0.304	mass%	2	0.304

K	0.204	0.203	mass%	2	0.204
Zr	0.129	0.132	mass%	2	0.13
S	0.0646	0.0654	mass%	2	0.065
Mn	0.0376	0.0373	mass%	2	0.0374
Sr	0.0292	0.0294	mass%	2	0.0293
Cl	0.0227	0.0228	mass%	2	0.0227
Zn	0.0217	0.0213	mass%	2	0.0215
V	0.0064	0.0053	mass%	2	0.0058
Cu	0.0043	0.0039	mass%	2	0.0041
Cr	0.0025	0.0031	mass%	2	0.0028
Ni	0.0028	0.0027	mass%	2	0.0027
Co	ND	0.002	mass%	1	0.002
Pb	0.0013	0.0013	mass%	2	0.0013
Y	0.0012	0.0012	mass%	2	0.0012
Rb	0.0011	0.0012	mass%	2	0.0011
Pt	ND	0.0009	mass%	1	0.0009
Au	0.0008	0.0009	mass%	2	0.0009
Br	0.0007	0.0009	mass%	2	0.0008
Ir	ND	0.0008	mass%	1	0.0008
Ga	0.001	0.0005	mass%	2	0.0007
Hg	0.0007	ND	mass%	1	0.0007
Sn	0.0003	ND	mass%	1	0.0003
Ge	ND	ND	mass%	0	0



As	ND	ND	mass%	0	0
Se	ND	ND	mass%	0	0
Nb	ND	ND	mass%	0	0
Mo	ND	ND	mass%	0	0
Ru	ND	ND	mass%	0	0
Rh	ND	ND	mass%	0	0
Pd	ND	ND	mass%	0	0
Ag	ND	ND	mass%	0	0
Cd	ND	ND	mass%	0	0
In	ND	ND	mass%	0	0
Sb	ND	ND	mass%	0	0
Te	ND	ND	mass%	0	0
I	ND	ND	mass%	0	0
Cs	ND	ND	mass%	0	0
Ba	ND	ND	mass%	0	0
La	ND	ND	mass%	0	0
Ce	ND	ND	mass%	0	0
Pr	ND	ND	mass%	0	0
Nd	ND	ND	mass%	0	0
Hf	ND	ND	mass%	0	0
Ta	ND	ND	mass%	0	0
W	ND	ND	mass%	0	0
Tl	ND	ND	mass%	0	0

Bi	ND	ND	mass%	0	0
Th	ND	ND	mass%	0	0
U	ND	ND	mass%	0	0
Sc	ND	ND	mass%	0	0

**APPENDIX D.4: DETAILED MOLECULAR COMPOSITION OF CALCULUS FROM THE MANDIBLE OF INDIVIDUAL BG'21 E-73.115.**

Type	FP analysis				
Folder	<Common>				
File	BG21 E 73 115 Md				
Counts	All				
Analysis date	5/20/2022 6:56				
Sample name	BG21 E 73 115 Md				
Application	BG21 E 73 115 Md				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
CaO	33.3	33.1	mass%	2	33.2
SiO <sub>2</sub>	27.8	27.8	mass%	2	27.8
P <sub>2</sub> O <sub>5</sub>	24.5	24.5	mass%	2	24.5
Al <sub>2</sub> O <sub>3</sub>	10	10	mass%	2	10
Fe <sub>2</sub> O <sub>3</sub>	1.37	1.36	mass%	2	1.36
Na <sub>2</sub> O	1.26	1.46	mass%	2	1.36
TiO <sub>2</sub>	0.61	0.604	mass%	2	0.607
MgO	0.303	0.354	mass%	2	0.329
SO <sub>3</sub>	0.251	0.25	mass%	2	0.25
K <sub>2</sub> O	0.246	0.241	mass%	2	0.243

ZrO2	0.208	0.212	mass%	2	0.21
MnO	0.0508	0.0529	mass%	2	0.0518
SrO	0.0412	0.04	mass%	2	0.0406
ZnO	0.0307	0.0314	mass%	2	0.031
V2O5	0.0121	0.0146	mass%	2	0.0134
Co2O3	0.005	0.0048	mass%	2	0.0049
CuO	0.0044	0.005	mass%	2	0.0047
NiO	0.0035	0.0035	mass%	2	0.0035
Cr2O3	0.0036	0.0033	mass%	2	0.0034
Y2O3	0.0016	0.0015	mass%	2	0.0016
Ta2O5	0.0019	0.0011	mass%	2	0.0015
HgO	0.0013	0.0013	mass%	2	0.0013
Rb2O	0.0013	0.0012	mass%	2	0.0012
Ir2O3	0.0012	ND	mass%	1	0.0012
PbO	0.0013	0.0011	mass%	2	0.0012
Au2O	0.0011	0.001	mass%	2	0.001
Ga2O3	0.0005	0.001	mass%	2	0.0008
As2O3	0.0002	0.0003	mass%	2	0.0002
GeO2	ND	ND	mass%	0	0
SeO2	ND	ND	mass%	0	0
Nb2O5	ND	ND	mass%	0	0
MoO3	ND	ND	mass%	0	0
RuO2	ND	ND	mass%	0	0

Rh <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
PdO	ND	ND	mass%	0	0
Ag <sub>2</sub> O	ND	ND	mass%	0	0
CdO	ND	ND	mass%	0	0
In <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
SnO <sub>2</sub>	ND	ND	mass%	0	0
Sb <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
TeO <sub>2</sub>	ND	ND	mass%	0	0
Cs <sub>2</sub> O	ND	ND	mass%	0	0
BaO	ND	ND	mass%	0	0
La <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
CeO <sub>2</sub>	ND	ND	mass%	0	0
Pr <sub>6</sub> O <sub>11</sub>	ND	ND	mass%	0	0
Nd <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
HfO <sub>2</sub>	ND	ND	mass%	0	0
WO <sub>3</sub>	ND	ND	mass%	0	0
PtO <sub>2</sub>	ND	ND	mass%	0	0
Tl <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
Bi <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0
ThO <sub>2</sub>	ND	ND	mass%	0	0
U <sub>3</sub> O <sub>8</sub>	ND	ND	mass%	0	0
Sc <sub>2</sub> O <sub>3</sub>	ND	ND	mass%	0	0

**APPENDIX D.5: DETAILED MOLECULAR COMPOSITION OF CALCULUS FROM THE MANDIBLE OF ADULT MALE, BEGHO BG'21 F-73.116.**

Type	FP analysis				
Folder	<Common>				
File	BG'21 F- 73. 116 Md				
Counts	All				
Analysis date	5/20/2022 7:15				
Sample name	BG21 F 73 116 Md				
Application	BG21 F 73 116 Md				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
CaO	43.8	43	mass%	2	43.4
P2O5	31.4	31.5	mass%	2	31.4
SiO2	15.5	15.5	mass%	2	15.5
Al2O3	5.53	5.44	mass%	2	5.48
Fe2O3	1.51	1.46	mass%	2	1.49
Na2O	ND	0.874	mass%	1	0.874
MgO	0.77	0.767	mass%	2	0.768
TiO2	0.469	0.511	mass%	2	0.49
SO3	0.295	0.29	mass%	2	0.293

ZrO <sub>2</sub>	0.292	0.283	mass%	2	0.287
K <sub>2</sub> O	0.177	0.176	mass%	2	0.176
SrO	0.0836	0.0808	mass%	2	0.0822
MnO	0.0654	0.0647	mass%	2	0.065
ZnO	0.0603	0.057	mass%	2	0.0586
V <sub>2</sub> O <sub>5</sub>	0.0139	0.0125	mass%	2	0.0132
Co <sub>2</sub> O <sub>3</sub>	0.0068	0.0075	mass%	2	0.0071
BaO	0.0066	ND	mass%	1	0.0066
CuO	0.0072	0.0055	mass%	2	0.0063
NiO	0.0038	0.0035	mass%	2	0.0036
Cr <sub>2</sub> O <sub>3</sub>	0.003	0.0019	mass%	2	0.0024
Ta <sub>2</sub> O <sub>5</sub>	0.0011	0.0034	mass%	2	0.0022
Y <sub>2</sub> O <sub>3</sub>	0.002	0.002	mass%	2	0.002
HgO	0.0019	0.0016	mass%	2	0.0018
PbO	0.0019	0.0015	mass%	2	0.0017
Rb <sub>2</sub> O	0.0016	0.0016	mass%	2	0.0016
Au <sub>2</sub> O	0.0012	0.0016	mass%	2	0.0014
Ga <sub>2</sub> O <sub>3</sub>	0.0011	ND	mass%	1	0.0011
As <sub>2</sub> O <sub>3</sub>	0.0002	0.0005	mass%	2	0.0004
GeO <sub>2</sub>	ND	ND	mass%	0	0
SeO <sub>2</sub>	ND	ND	mass%	0	0
Nb <sub>2</sub> O <sub>5</sub>	ND	ND	mass%	0	0
MoO <sub>3</sub>	ND	ND	mass%	0	0

RuO2	ND	ND	mass%	0	0
Rh2O3	ND	ND	mass%	0	0
PdO	ND	ND	mass%	0	0
Ag2O	ND	ND	mass%	0	0
CdO	ND	ND	mass%	0	0
In2O3	ND	ND	mass%	0	0
SnO2	ND	ND	mass%	0	0
Sb2O3	ND	ND	mass%	0	0
TeO2	ND	ND	mass%	0	0
Cs2O	ND	ND	mass%	0	0
La2O3	ND	ND	mass%	0	0
CeO2	ND	ND	mass%	0	0
Pr6O11	ND	ND	mass%	0	0
Nd2O3	ND	ND	mass%	0	0
HfO2	ND	ND	mass%	0	0
WO3	ND	ND	mass%	0	0
Ir2O3	ND	ND	mass%	0	0
PtO2	ND	ND	mass%	0	0
Tl2O3	ND	ND	mass%	0	0
Bi2O3	ND	ND	mass%	0	0
ThO2	ND	ND	mass%	0	0
U3O8	ND	ND	mass%	0	0
Sc2O3	ND	ND	mass%	0	0



**APPENDIX D.6: DETAILED MOLECULAR COMPOSITION OF CALCULUS FROM THE MANDIBLE OF ADULT MALE, BEGHO BG'21 F-73.116**

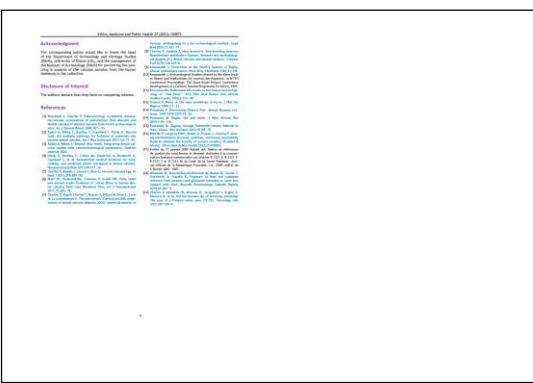
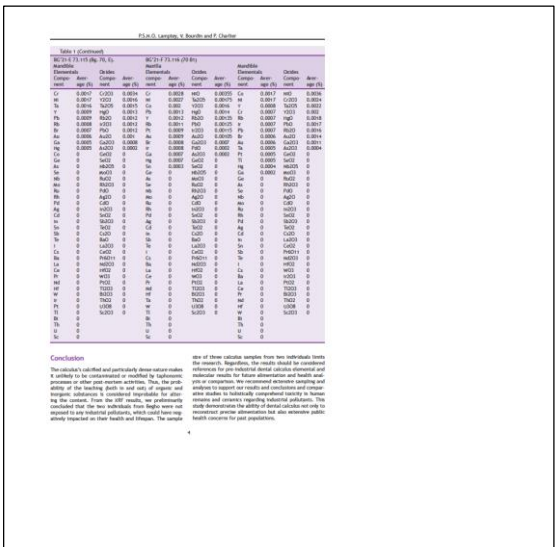
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File	BG'21 F- 73. 116 Mx _202205201300				
Counts	All				
Analysis date	5/20/2022 13:00				
Sample name	BG21 F 73 116 Mx				
Application	BG21 F 73 116 Mx				
[Analyzed result]					
<b>Component</b>	<b>Result 1</b>	<b>Result 2</b>	<b>Unit</b>	<b>Number</b>	<b>Average</b>
SiO <sub>2</sub>	32.9	32.9	mass%	2	32.9
CaO	31.8	31.6	mass%	2	31.7
P <sub>2</sub> O <sub>5</sub>	20	20	mass%	2	20
Al <sub>2</sub> O <sub>3</sub>	10.4	10.5	mass%	2	10.45
Fe <sub>2</sub> O <sub>3</sub>	1.64	1.64	mass%	2	1.64
Na <sub>2</sub> O	1.1	1.26	mass%	2	1.18
TiO <sub>2</sub>	0.684	0.683	mass%	2	0.6835
MgO	0.547	0.577	mass%	2	0.562
K <sub>2</sub> O	0.276	0.271	mass%	2	0.2735

SO3	0.202	0.201	mass%	2	0.2015
ZrO2	0.19	0.2	mass%	2	0.195
MnO	0.0558	0.0552	mass%	2	0.0555
SrO	0.0401	0.0394	mass%	2	0.03975
ZnO	0.0314	0.0309	mass%	2	0.03115
V2O5	0.0136	0.0105	mass%	2	0.01205
Co2O3	0.007	0.0068	mass%	2	0.0069
CuO	0.0051	0.0053	mass%	2	0.0052
Cr2O3	0.005	0.0049	mass%	2	0.00495
NiO	0.0036	0.0035	mass%	2	0.00355
Ta2O5	0.0019	0.0016	mass%	2	0.00175
Y2O3	0.0016	0.0016	mass%	2	0.0016
HgO	0.0015	0.0013	mass%	2	0.0014
Rb2O	0.0014	0.0013	mass%	2	0.00135
PbO	0.0012	0.0013	mass%	2	0.00125
Ir2O3	0.0012	0.0011	mass%	2	0.00115
Au2O	0.0011	0.001	mass%	2	0.00105
Ga2O3	0.0007	0.0007	mass%	2	0.0007
PdO	ND	0.0002	mass%	1	0.0002
As2O3	0.0003	0.0001	mass%	2	0.0002
GeO2	ND	ND	mass%	0	0
SeO2	ND	ND	mass%	0	0
Nb2O5	ND	ND	mass%	0	0

MoO3	ND	ND	mass%	0	0
RuO2	ND	ND	mass%	0	0
Rh2O3	ND	ND	mass%	0	0
Ag2O	ND	ND	mass%	0	0
CdO	ND	ND	mass%	0	0
In2O3	ND	ND	mass%	0	0
SnO2	ND	ND	mass%	0	0
Sb2O3	ND	ND	mass%	0	0
TeO2	ND	ND	mass%	0	0
Cs2O	ND	ND	mass%	0	0
BaO	ND	ND	mass%	0	0
La2O3	ND	ND	mass%	0	0
CeO2	ND	ND	mass%	0	0
Pr6O11	ND	ND	mass%	0	0
Nd2O3	ND	ND	mass%	0	0
HfO2	ND	ND	mass%	0	0
WO3	ND	ND	mass%	0	0
PtO2	ND	ND	mass%	0	0
Ti2O3	ND	ND	mass%	0	0
Bi2O3	ND	ND	mass%	0	0
ThO2	ND	ND	mass%	0	0
U3O8	ND	ND	mass%	0	0
Sc2O3	ND	ND	mass%	0	0

# APPENDIX E: SCIENTIFIC PUBLICATIONS

## Lamptey, P. S. N. O., Bourdin, V., Charlier, P. (2023)



Environ. Monit. Assess. (2022) 226:100

Original Article

### Interest and limitations of a lead, cadmium, and arsenic leachability study to estimate the toxicity of ancient ceramics (Ecuador & Ghana)

V. Bourdin<sup>1,2,3,4</sup>, P.S.N.O. Lamptey<sup>5,6</sup>, G. Muller<sup>1</sup>, J. Poupon<sup>1</sup>, P. Chastler<sup>1,7</sup>

**Keywords:** Ancient ceramics, Lead, Cadmium, Arsenic, Leachability, Toxicity, Ancient Ecuador, Ancient Ghana

**Abstract:** This study presents the results of a leachability study on ancient ceramics from Ecuador and Ghana, aimed at estimating their toxicity. The study was conducted in two phases: first, a leachability study was performed on 18 samples from Ecuador and 17 samples from Ghana, and second, a toxicity study was performed on the leachate. The results show that the leachability of lead, cadmium, and arsenic is generally low, and that the toxicity of the leachate is also low. However, the study also identified some limitations, such as the variability of the leachability results and the potential for contamination of the leachate during the study.

Environ. Monit. Assess. (2022) 226:100

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**Abstract:** This study presents the results of a leachability study on ancient ceramics from Ecuador and Ghana, aimed at estimating their toxicity. The study was conducted in two phases: first, a leachability study was performed on 18 samples from Ecuador and 17 samples from Ghana, and second, a toxicity study was performed on the leachate. The results show that the leachability of lead, cadmium, and arsenic is generally low, and that the toxicity of the leachate is also low. However, the study also identified some limitations, such as the variability of the leachability results and the potential for contamination of the leachate during the study.

Environ. Monit. Assess. (2022) 226:100

Figure 1: Representative samples of 18 ancient ceramics from Ecuador. The figure shows 18 small images of various ceramic fragments, some with scale bars. The fragments are labeled with numbers 1 through 18.

Figure 2: Representative samples of 17 ancient ceramics from Ghana. The figure shows 17 small images of various ceramic fragments, some with scale bars. The fragments are labeled with numbers 1 through 17.

Figure 3: Representative samples of 17 ancient ceramics from Ecuador. The figure shows 17 small images of various ceramic fragments, some with scale bars. The fragments are labeled with numbers 1 through 17.

Table 1: Selection of 24 samples from a set of archaeological Ecuadorian ceramics dated 18 samples from a set of archaeological Ecuadorian ceramics

Identification No.	Area of excavation	Q number	Context - occupation of excavation	Elements of date (archaeology)	Site - Epoch
1	Banana, Campa	Q1040	200-300 AD	200-300 AD	No slip middle
2	Banana, Campa	Q1047	200-300 AD	200-300 AD	No slip middle
3	Banana, Campa	Q1048	200-300 AD	200-300 AD	Buffed slip on the convexity
4	Banana, Campa	Q1049	200-300 AD	200-300 AD	Buffed slip on the convexity
5	Banana, Campa	Q1050	200-300 AD	200-300 AD	Buffed slip on the convexity
6	Banana, Campa	Q1051	200-300 AD	200-300 AD	Buffed slip on the convexity
7	Banana, Campa	Q1052	200-300 AD	200-300 AD	Buffed slip on the convexity
8	Banana, Campa	Q1053	200-300 AD	200-300 AD	Buffed slip on the convexity
9	Banana, Campa	Q1054	200-300 AD	200-300 AD	Buffed slip on the convexity
10	Banana, Campa	Q1055	200-300 AD	200-300 AD	Buffed slip on the convexity
11	Banana, Campa	Q1056	200-300 AD	200-300 AD	Buffed slip on the convexity
12	Banana, Campa	Q1057	200-300 AD	200-300 AD	Buffed slip on the convexity
13	Banana, Campa	Q1058	200-300 AD	200-300 AD	Buffed slip on the convexity
14	Banana, Campa	Q1059	200-300 AD	200-300 AD	Buffed slip on the convexity
15	Banana, Campa	Q1060	200-300 AD	200-300 AD	Buffed slip on the convexity
16	Banana, Campa	Q1061	200-300 AD	200-300 AD	Buffed slip on the convexity
17	Banana, Campa	Q1062	200-300 AD	200-300 AD	Buffed slip on the convexity
18	Banana, Campa	Q1063	200-300 AD	200-300 AD	Buffed slip on the convexity

Table 1 (Continued)

Identification No.	Area of excavation	Q number	Context - occupation of excavation	Elements of date (archaeology)	Site - Epoch
19	Sabán	Q1071	PTI Occupation	PTI Occupation	Delimited on both sides
20	Sabán	Q1072	PTI Occupation	PTI Occupation	Delimited on both sides
21	Sabán	Q1073	PTI Occupation	PTI Occupation	Delimited on both sides
22	Sabán	Q1074	PTI Occupation	PTI Occupation	Delimited on both sides
23	Sabán	Q1075	PTI Occupation	PTI Occupation	Delimited on both sides
24	Sabán	Q1076	PTI Occupation	PTI Occupation	Delimited on both sides
25	Sabán	Q1077	PTI Occupation	PTI Occupation	Delimited on both sides
26	Sabán	Q1078	PTI Occupation	PTI Occupation	Delimited on both sides
27	Sabán	Q1079	PTI Occupation	PTI Occupation	Delimited on both sides
28	Sabán	Q1080	PTI Occupation	PTI Occupation	Delimited on both sides
29	Sabán	Q1081	PTI Occupation	PTI Occupation	Delimited on both sides
30	Sabán	Q1082	PTI Occupation	PTI Occupation	Delimited on both sides
31	Sabán	Q1083	PTI Occupation	PTI Occupation	Delimited on both sides
32	Sabán	Q1084	PTI Occupation	PTI Occupation	Delimited on both sides
33	Sabán	Q1085	PTI Occupation	PTI Occupation	Delimited on both sides
34	Sabán	Q1086	PTI Occupation	PTI Occupation	Delimited on both sides

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Figure 4: Ceramic shards from Sabán. The figure shows several small images of ceramic fragments, some with scale bars. The fragments are labeled with numbers 1 through 17.

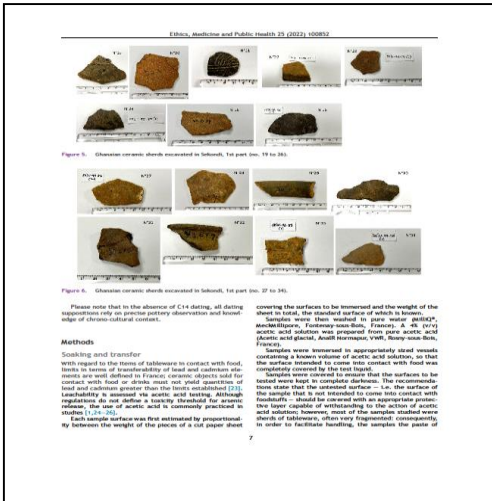


Figure 5. Etioan ceramic sheets treated in laboratory, lot part (no. 19 to 34).

Figure 6. Etioan ceramic sheets treated in laboratory, lot part (no. 27 to 34).

Please note in the absence of C1 dating, all dating responsibilities rely on precise pottery observation and knowledge of Etioan cultural context.

**Methods**

**Soaking and transfer**  
With regard to the items of laboratory in contact with food, items in terms of impermeability of lead and cadmium were tested and used in the form of ceramic vessels. The contact with food or drink does not yield quantities of lead and cadmium greater than the toxic equivalent (TEQ). Lead-tolerance is measured by acid testing. Although regulations do not define a history threshold for arsenic, cadmium and lead, the maximum allowed concentration is 10 mg/kg.  
Each sample surface was first estimated by proportional between the weight of the piece of a red paper sheet

covering the surface to be immersed and the weight of the sheet in total, the standard surface of which is known. Etioan vessels were then washed in three stages: initially, with distilled water; then, with 10% acetic acid solution prepared from pure acetic acid (AnalaR and distilled, AnalaR for metals, VWR, Europe) and then, with distilled water.

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 5).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 6).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 7).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 8).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 9).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 10).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 11).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 12).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 13).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 14).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 15).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 16).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 17).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 18).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 19).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 20).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 21).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 22).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 23).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 24).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 25).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 26).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 27).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 28).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 29).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 30).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 31).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 32).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 33).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 34).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 35).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 36).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 37).

Etioan vessels were immersed in approximately equal vessels containing a known volume of acetic acid solution, so that the surface intended to come into contact with food was completely covered by the liquid (Figure 38).

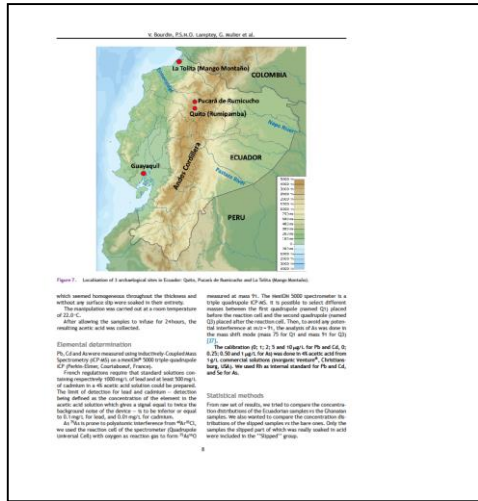


Figure 7. Localization of archaeological sites in Ecuador: Guano, Pichincha and La Soga (Bogotá).

The concentration was estimated as a mean concentration of 22.0 mg/kg.

**Chemical determinations**  
Pb, Cd and Cu were measured using inductively coupled plasma atomic emission spectrometry (ICP-AES) with a PerkinElmer AAS-9000 spectrometer (PerkinElmer, Shelton, CT, USA). The detection limit was 0.1 mg/kg for Pb, Cd and Cu. The accuracy was checked using certified reference materials (CRM) and spiked samples.

The detection limit for lead was 0.1 mg/kg.

The detection limit for cadmium was 0.1 mg/kg.

The detection limit for copper was 0.1 mg/kg.

The detection limit for arsenic was 0.1 mg/kg.

The detection limit for zinc was 0.1 mg/kg.

The detection limit for iron was 0.1 mg/kg.

The detection limit for manganese was 0.1 mg/kg.

The detection limit for calcium was 0.1 mg/kg.

The detection limit for magnesium was 0.1 mg/kg.

The detection limit for potassium was 0.1 mg/kg.

The detection limit for sodium was 0.1 mg/kg.

The detection limit for aluminum was 0.1 mg/kg.

The detection limit for silicon was 0.1 mg/kg.

The detection limit for phosphorus was 0.1 mg/kg.

The detection limit for sulfur was 0.1 mg/kg.

The detection limit for chlorine was 0.1 mg/kg.

The detection limit for fluorine was 0.1 mg/kg.

The detection limit for bromine was 0.1 mg/kg.

The detection limit for iodine was 0.1 mg/kg.

The detection limit for barium was 0.1 mg/kg.

The detection limit for strontium was 0.1 mg/kg.

The detection limit for yttrium was 0.1 mg/kg.

The detection limit for zirconium was 0.1 mg/kg.

The detection limit for niobium was 0.1 mg/kg.

The detection limit for molybdenum was 0.1 mg/kg.

The detection limit for technetium was 0.1 mg/kg.

The detection limit for ruthenium was 0.1 mg/kg.

The detection limit for rhodium was 0.1 mg/kg.

The detection limit for palladium was 0.1 mg/kg.

The detection limit for silver was 0.1 mg/kg.

The detection limit for cadmium was 0.1 mg/kg.

The detection limit for mercury was 0.1 mg/kg.

The detection limit for thallium was 0.1 mg/kg.

The detection limit for lead was 0.1 mg/kg.

The detection limit for tin was 0.1 mg/kg.

The detection limit for antimony was 0.1 mg/kg.

The detection limit for arsenic was 0.1 mg/kg.

The detection limit for selenium was 0.1 mg/kg.

The detection limit for tellurium was 0.1 mg/kg.

The detection limit for bismuth was 0.1 mg/kg.

The detection limit for polonium was 0.1 mg/kg.

The detection limit for astatine was 0.1 mg/kg.

The detection limit for francium was 0.1 mg/kg.

The detection limit for radium was 0.1 mg/kg.

The detection limit for actinium was 0.1 mg/kg.

The detection limit for thorium was 0.1 mg/kg.

The detection limit for protactinium was 0.1 mg/kg.

The detection limit for uranium was 0.1 mg/kg.

The detection limit for neptunium was 0.1 mg/kg.

The detection limit for plutonium was 0.1 mg/kg.

The detection limit for americium was 0.1 mg/kg.

The detection limit for curium was 0.1 mg/kg.

The detection limit for berkelium was 0.1 mg/kg.

The detection limit for californium was 0.1 mg/kg.

The detection limit for einsteinium was 0.1 mg/kg.

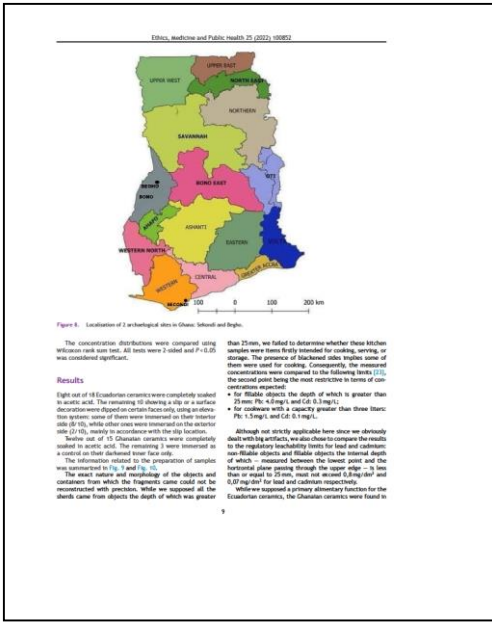


Figure 8. Localization of archaeological sites in Guano, Pichincha and La Soga.

The concentration distributions were compared using a two-sample t-test. The results were considered significant.

**Results**  
Eight out of 16 Etioan ceramic vessels were completely treated in the system. The remaining 8 vessels were treated in the system with 10% acetic acid solution. The results showed that the concentration of lead and cadmium was significantly lower in the treated vessels compared to the untreated vessels.

The mean lead concentration for the treated vessels was 0.2 mg/kg, while for the untreated vessels it was 2.2 mg/kg.

The mean cadmium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean copper concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean arsenic concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean zinc concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean iron concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean manganese concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean calcium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean magnesium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean potassium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean sodium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean aluminum concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean silicon concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean phosphorus concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean sulfur concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean chlorine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean fluorine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean bromine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean iodine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean barium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

Identificator number	Surface treated	Volume of acetic acid (ml)	Volume of water (ml)
1	White ceramic	10	10
2	White ceramic	10	10
3	White ceramic	10	10
4	White ceramic	10	10
5	White ceramic	10	10
6	White ceramic	10	10
7	White ceramic	10	10
8	White ceramic	10	10
9	White ceramic	10	10
10	White ceramic	10	10
11	White ceramic	10	10
12	White ceramic	10	10
13	White ceramic	10	10
14	White ceramic	10	10
15	White ceramic	10	10
16	White ceramic	10	10
17	White ceramic	10	10
18	White ceramic	10	10
19	White ceramic	10	10
20	White ceramic	10	10
21	White ceramic	10	10
22	White ceramic	10	10
23	White ceramic	10	10
24	White ceramic	10	10
25	White ceramic	10	10
26	White ceramic	10	10
27	White ceramic	10	10
28	White ceramic	10	10
29	White ceramic	10	10
30	White ceramic	10	10
31	White ceramic	10	10
32	White ceramic	10	10
33	White ceramic	10	10
34	White ceramic	10	10

**Discussion**  
The results of this study show that the concentration of lead and cadmium was significantly lower in the treated vessels compared to the untreated vessels. This indicates that the use of acetic acid solution for cleaning ceramic vessels can reduce the concentration of these metals on their surfaces.

The mean lead concentration for the treated vessels was 0.2 mg/kg, while for the untreated vessels it was 2.2 mg/kg.

The mean cadmium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean copper concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean arsenic concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean zinc concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean iron concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean manganese concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean calcium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean magnesium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean potassium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean sodium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean aluminum concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean silicon concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean phosphorus concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean sulfur concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean chlorine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean fluorine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean bromine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean iodine concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

The mean barium concentration for the treated vessels was 0.1 mg/kg, while for the untreated vessels it was 1.1 mg/kg.

Element	Mean concentration (mg/kg)	Standard deviation (mg/kg)	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)
Pb	0.2	0.1	0.1	0.3
Cd	0.1	0.05	0.05	0.15
Cu	0.1	0.05	0.05	0.15
As	0.1	0.05	0.05	0.15
Zn	0.1	0.05	0.05	0.15
Fe	0.1	0.05	0.05	0.15
Mn	0.1	0.05	0.05	0.15
Ca	0.1	0.05	0.05	0.15
Mg	0.1	0.05	0.05	0.15
K	0.1	0.05	0.05	0.15
Na	0.1	0.05	0.05	0.15
Al	0.1	0.05	0.05	0.15
Si	0.1	0.05	0.05	0.15
P	0.1	0.05	0.05	0.15
S	0.1	0.05	0.05	0.15
Cl	0.1	0.05	0.05	0.15
F	0.1	0.05	0.05	0.15
Br	0.1	0.05	0.05	0.15
I	0.1	0.05	0.05	0.15
Ba	0.1	0.05	0.05	0.15
Sr	0.1	0.05	0.05	0.15
Y	0.1	0.05	0.05	0.15
Zr	0.1	0.05	0.05	0.15
Nb	0.1	0.05	0.05	0.15
Mo	0.1	0.05	0.05	0.15
Tc	0.1	0.05	0.05	0.15
Ru	0.1	0.05	0.05	0.15
Rh	0.1	0.05	0.05	0.15
Pd	0.1	0.05	0.05	0.15
Ag	0.1	0.05	0.05	0.15
Cd	0.1	0.05	0.05	0.15
Hg	0.1	0.05	0.05	0.15
Tl	0.1	0.05	0.05	0.15
Pb	0.1	0.05	0.05	0.15
Sn	0.1	0.05	0.05	0.15
Sb	0.1	0.05	0.05	0.15
As	0.1	0.05	0.05	0.15
Se	0.1	0.		



Table 13: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 13. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

Table 14: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 14. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

Table 15: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 15. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

Table 16: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 16. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

Table 17: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 17. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

Table 18: Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability. The table is divided into three sections: 'Chemical workers', 'Non-chemical workers', and 'All workers'. Each section contains columns for 'Country of origin', 'Number of observations', 'Time of day', 'Temperature', 'Relative humidity', and 'Incubability'. The 'Incubability' column shows the number of observations and the percentage of food intake incubated.

Figure 18. Comparison of Distribution Between Working and Non-Working Conditions of Chemical Workers in PPE Use and Food Intake Incubability, pp. 62

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Original Article

### Museums and Skeletons: prospects and challenges of cataloguing, storing and preserving human remains in the Museum of Archaeology, Ghana

P.S.N.O. Lamptey<sup>a,b,c</sup>

<sup>a</sup>Faculté de Médecine, Université Paris Saclay, 41, rue Galvani 91191, 94276 Le Kremlin-Bicêtre cedex, France

<sup>b</sup>Laboratoire Archéologie, Biologie (LAA&B), 2, avenue de la Source de la Rivière, 91193 Montigny-Lez-Tours, France

<sup>c</sup>Department of Archaeology and Heritage Studies (DAHS), University of Ghana, P.O. Box LG 2, Accra, Ghana

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**KEYWORDS**  
Cataloguing;  
Human remains;  
Museum;  
Preserving;  
Storing

**Summary**  
Background – The conversation on heritage preservation and safeguarding is associated with the responsibility of a specialised institution – the museum. However, without proper guidelines and resources, a museum's function as a guardian of the past or history of populations and material culture cannot be effectively and ethically executed. This article assessed the prospects and challenges of cataloguing, storing and preserving human remains and the prospects for scientific analyses and exhibition in the Museum of Archaeology at the Department of Archaeology and Heritage Studies, University of Ghana.

**Archaeology** – The qualitative method was employed involving the tools of observation and open conversational interview views.

**Results** – Such findings on contributing factors to the subject matter of the article included unfavourable storage conditions and the unavailability of an updated archival system for the remains, insufficient supply of biological anthropologist and lack for the museum's specialist staffs engaging handling human remains, constrain the possibility of harnessing their objective voice in research, interpretation and reconstruction of the remains.

E-mail address: psnlamptey@gmail.com  
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P.S.N.O. Lamptey

**Discussion** – To address these challenges, conducive and monitored storage environments; holistic inventory system; capacity building and partnerships; safety and access controls; minimal / reversible treatments and preservative conservation are required to reduce the "risk" of the human remains. The priority of exhibiting/displaying human remains in the museum is unlikely, to be honest, however, will be for the purposes of teaching and learning in a controlled environment.

**Conclusion** – The observation of ethical measures for storing, cataloguing, handling and preserving human remains in the museum is expedient. Without urgency, the "little focus" in management may slow the preservation of the human remains for posterity, in spite of efforts to maintain and sustain the museum's capacity for safeguarding the ossuous tissues and heritage.

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**Introduction**  
The appreciation of history and the development of archaeology from antiquarian through to the period of subjective analysis/interpretation of culture and adaptive strategies, as well as material remains, give rise to institutions that fuel the course of heritage preservation. One of such is the museum, designated for housing, preserving and curating objects of historical, aesthetic, scientific and cultural interest for an all-inclusive posterity agenda, including educational and cultural heritage assessment projects, community or public archaeology purposes as well as for pleasure. The museum as defined by the International Council of Museums (ICOM) is "a non-profit making, permanent institution in the service of the society and its development and open to the public, which acquires, conserves, researches, communicates, and exhibits for the purpose of study, education and enjoyment, material evidence of the people and their environment" ([1], p. 11). In other words, museums function as repositories for the care and management of material vestiges of past populations. Are these tasks burdensome for the Museum of Archaeology to fulfil with regards to the human remains in its custody? And are there some underlying factors hindering the capacity for successful/unsuccessful? The Museum of Archaeology has and is holding the historical and scientific value of Ghanaian heritage and creating awareness for sustainable practices of handling and preserving the tangible and intangible aspects of culture.

**Aim and reflections**  
The research aimed at assessing the place of human skeletal remains from archaeological contexts in the Museum of Archaeology as a safeguarding institution. The objectives included firstly, discussing the challenges of the museum pertaining to cataloguing, storing and preserving human remains. Secondly, assessing the museum's capacity to house human remains in the future either from excavations or institutions.

Major questions that underlain the research included the following:  
• what is the situation of handling, cataloguing, storing and preserving human remains in the museum and the priority of these practices to affect the quantity and quality of information to be gleaned from the remains?;  
• what are the museum's criteria/efforts to preserving the integrity of the human remains and the prospects and challenges for scientific analysis?;  
• what is the probability of exhibition and the tendencies involved?

**Background: museums and skeletons**  
The incorporation of the "public factor" into museums began in the late 17th century, through the creation of university museums, supporting teaching and research in universities and for the public [2]. An example is the Ashmolean, which first interested in the preservation of natural history and the public [3]. Later in the 18th century was a movement of concern for the preservation of natural specimens, human artistic and scientific creations in museums [4]. From these movements evolved different types of museums, including art, natural history, science and technology. "Museums remain vital sources and resource networks for affirmative interactions, affirming people's diverse histories, shared country and achievements and the collective heritage of all" ([5], p. 7). Museums are also valuable depositories of knowledge and memory institutions "for the increase and diffusion of knowledge" [6].

Museums exhibit may vary depending on the theme and the audience targeted. But generally objects may range from past to present cultural relics of a society/state. Museums are set up to collect, preserve, interpret, and display objects of artistic, cultural, or scientific significance [7] and safeguard them for other purposes beneficial to the society. Some museums' focus are particular objectives: education over conservation, vice versa or both of them. For

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example, the Museum of Archaeology favors both education and conservation of material culture. Varied audiences may view museum roles differently; for a curator, the institution may be a way to support public education, serving both the academic community and the general public. While to students and communities, the museum may be that unique space housing tangible aspects of history, involving formal and informal education about populations in the country.

Development is anchored on education [8]; therefore, to be ignored of one's own culture regardless of any knowledge (formal education) acquired is to be blind in one eye and shortighted to the other. Socially, museums help educate the populace in positive ways while providing the foundation on which future generations can understand and appreciate the history and culture of the land. Politically, museums are non-partisan venues in the country addressing through exhibitions issues pertaining to citizenry identity and governance [9]. Economically, the museum institution is a way to generate revenue for the nation. According to [7], p. 48, "a healthy museum community can be seen as a gauge of the economic health of a city, and a way to increase the sophistication of its inhabitants". Moreover, with unique and aesthetic display of varied cultural vestiges, museums instill a sense of responsibility to appreciate different cultures. This attitude prevents ethnocentrism in the society [10].

Gradually, community leaders in Ghana are gravitating towards the idea of community development through museums [7], p. 48. On top of the increasing interest in archaeological targets, community history and heritage preservation, there have been a number of calls for development in the communities of Begho (Ghanaian region); Abosse (Eastern region); Ho, Kpando and Keta (South-Northern region). These calls aimed at demanding from archaeologists, museums to showcase the finds from archaeological and ethnographic researches carried out in the community. Such requests have successfully resulted in a nod-out in 2020 for the construction of museums in the Keta-South Municipality [11]. These projects will foster the development and tourism boost of three towns: *Redranano, Adidzino and Adidzino* in the municipality [11]. Similarly, a rehabilitation work on a 155-year-old church building into a modern relic (with a reception, printing press, bookstore, museum, library and church archive) is underway in Ho [11].

Human remains from varied contexts or modes of acquisition can be found in museums, scientific or personal collection all over the world. For instance, the British Museum is housing over 6000 human remains [12]. German museums and scientific collections have in their care tens of thousands of human remains [13], and a lot more in museums in the United States, South Africa and across borders. Human remains possess "unique status within museum collections" ([14], p. 7). On the one hand, they are potent for research and teaching and on the other, they may represent a sensitive, "personal, cultural, symbolic, spiritual or religious significance to individuals and/or groups" ([14], p. 7). In view of this, reasons for their presence in museums, for example, trophies, research/education, care, safeguard/storage or display must be justified. These perspectives must be actively addressed in relation to the attitudes/sensitivities of descendants and communities, and

the ethical/legal frameworks associated with handling and maintaining the integrity of the human remains. ICOM outlines some standards for the care for and display of human remains including, "must do so with dignity and in appropriate environmental conditions and the remains must only be displayed or be used scientifically in circumstances where the highest professional standards can be implemented" ([1], p. 46). Also, any display or handling of human remains must be done with respect for the principles of dignity, integrity and preservation ([15], p. 26). To incorporate human remains into a museum's exhibits aims, careful consideration of the pros and cons involved are necessary. As part of the pros of analyzing human remains is that students, researchers and the general public will have a general knowledge about them and appreciate the quantum of valuable data that can be gleaned from human remains. These include information regarding: (i) human reduction, adaptation and genetic relationships; (ii) population relationships through genetics and morphology; (iii) past demography and health; (iv) diet, growth and activity patterns; (v) disease and probable causes of death; (vi) history of disease and of medicine; (vii) burial practices, beliefs and attitudes; and (viii) the diversity of cultural practices in which the body and its parts are used" ([14], p. 8). Contravise, the cons, when museums overlook ethical and legal obligations to human remains in relation to handling, storage, cataloguing, preservation, research and display, they may stand the risk of not only breaching ethics and disregarding the dead, but also pricing the sensitivity of concerned families.

Although museums are at liberty to set up their own operative guidelines for acquisition, research and sampling, storage and display, curation and repatriation, it is legally appropriate for museums and other institutions holding human specimens or skeletal remains to do so within established legal and ethical frameworks as checks and balances. Such frameworks [1,7,16–20] set out the procedural and ethical principles that should be followed in handling human remains. These guidelines cover decision-making on care/management, access, research, storage, conservation, display and claims for return.

**Museums in Ghana**  
There are a number of museums in Ghana whose operations are overseen by the Ghana Museums and Monuments Board (GMMB). They include the National Museum, Accra (1957), the WEB Du Bois Centre Museum and the Kwame Nkrumah Memorial Park Museums in Accra. Among these are other private museums such as the Police Museum, in Greater Accra region, the Military Museum, Ashanti Museums and the Manhyia Palace Museum in the Ashanti region. However, the eight main museums listed on the GMMB website [21] are:  
• the Volta Regional Museum (1973), Ho, Volta region, Accra, Greater Accra region;  
• the Volta Regional Museum (1973), Ho, Volta region, Accra, Greater Accra region;  
• the Cape Coast Castle Museum, (1974), Cape Coast: Central region;  
• the St. George's/Elmina Castle Museum (1997), Elmina: Central region.

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- the Upper East Regional Museum, (1972), installed in current location (1971), Bolgatanga: Upper East region;
- the Usher Fort Museum, (2007), Accra: Greater Accra region;
- Fort Apollonia Museum of Ntema Culture and History (2019), Bono: Western region;
- Fort Saint Anthony Museum, Accra (2012), Accra: Western region.

The museums in Ghana are diversified in vision/focus and modes of operation. For instance, the Upper East Regional Museum and the Volta Regional Museum provide insight into the traditions and history of the geographical area. The Cape Coast Castle Museum, Elmina Castle Museum, and Usher Fort Museum offer guided tours on the relics of slave trade in Ghana, and exhibits displaying the rubrics of the trade, Euro-African interactions, and aspects of contemporary culture (Kwame), the Museum of Science and Technology provides visitors with a look into Ghana's scientific development through exhibits of objects of scientific and technological interest. Other museums in Ghana are, the Museum of Archaeology and the Museum of Natural and Cultural History and Biotechnology at the Shai Hills Forest Reserve (Dangme West District, Greater Accra region). The latter, which officially opened in March 2020, offers an entrance to some animal remains (skins and bones) from the forest reserve and from the Ilesha National Park in the Sissala-Nan region of Ghana, and a photo gallery of biodiversity in the park. Regardless of the themes and focus of the aforementioned museums, the ultimate aim is to educate guests on the past and contemporary history in Ghana through display of traditional material culture and artefacts of historic significance relating to subsistence, crafts specialization and social and political organization.

**The Museum of Archaeology**  
The museum, located at the Department of Archaeology and Heritage Studies (DAHS), University of Ghana (UG), of the size 6.3 × 32 m<sup>2</sup>, constitutes the focus of discussion. The Museum of Archaeology started as a teaching museum in the 60s and has since served as a "laboratory for teaching and learning" ([22], p. 19). It is a wider student and public audience through guided tours, permanent and temporary exhibitions. The museum records between 900-1000 visitors per year, mostly student groups, diplomats and foreign nationals. The source of findings for the museum is through donations, no allocated resources from the university or department. The Museum of Archaeology exhibits a variety of objects ranging from artefacts and objects including the famous Koma B&K Akan terracotta figures, Krobé beads, ceramics and terracotta collections, donated cultural vestiges, and other finds from various excavations. Other exhibits are Oldowan, Acheulian and microblith stone tools, a permanent exhibit of iron smelting, and casts of hominid crania (Fig. 1). The museum has four storage rooms, the main storage room located inside the museum, the terraces room and two storage annexes situated about 30m and 100m away from the museum respectively. The storage are collections and archaeological finds including animal and human skeletal remains since the inception of the department. The human remains are from archaeological contexts,



Figure 1. A section of the Museum of Archaeology (photos Lamptey, P.S.N.O.).

examined during excavations (individual projects and field schools organized by the department) in the 1960s and following, from a number of archaeological sites within the country, none of these remains are on display. The museum safeguards materials from archaeological works across the borders of the country after analysis, interpretation and publication.

**Methodology**  
This paper employed the qualitative research methodology to gather ample data on the state of skeletal remains in the storage of the Museum of Archaeology. The tools of data collection were observation and open interview. Observations made by the author during her undergraduate to master's studies and graduate assistantship at the department provided the research with questions and discussions. An open conversational interview was conducted with lecturers in the department, and the principal technician by purposeful sampling to solicit "richer" perspectives purposefully on the subject. A conversation guide (*Guide d'entretien*) was prepared for the conversational interview but not followed strictly. The sample size of the interviewees varied was 7 out of 15 lecturers. The lecturers of varied courses (males), lecture and curator of the museum (females), and the principal technician (male) of the department, all of them being of Ghanaian nationality. Permission was sought from all respondents for the conversation to be recorded and the responses were transcribed and saved to answer the research questions.

Most of the respondents either participated in the projects that brought in the human remains or had knowledge of their presence in the museum. In place of the main excavation (some impossible to reach and others passed-on), it was anticipated that the respondents were in the best position to explain their participation in the care for the human remains, to carry out scientific analysis, and shed light on the current state and fate of the human remains. Suggestions on prospects for skeletal analysis and exhibition in the department were noted. Data was also gathered



on the needs of the museum which to some extent are the obstacles to the full realization of its potential.

Results

The respondents acknowledge that one of the main challenges of the museum is storage space and storage management. In fact, there is a distinction between the museum's storage space and the storage space for the department. As a result, most materials from archaeological works mostly find their way into the museum's storage rooms. This development over the years is flooding up the available storage space uniquely intended for museum collection. Respondents asserted that, the museum is currently almost close to standard in West Africa and is over the years improving on its management and setup strategies. They acknowledge however that, the conditions in the storage are not favorable for the long-term preservation of the human remains. Hence, the need for a decontamination and reorganization of the storage rooms to move them up to standard.

Another challenge in relation to storing and cataloguing human remains is label damage. Any of the details of contextual information: the year and unit of excavation, level of recovery, project type and consistency on the paper labels have faded or are fading away. This is not only because they have been in the storage for about 61 years, but also because ink generally begins to fade over a long period of time. Another contributing factor to label damage is insect (termite) activities in the storage which have eroded some paper labels in crumbly and pieces. Apart from the effects of insect activity on the paper labels, they could create porous pathologies and marks on the skeletal samples and this might mislead analysis and interpretation of skeletal remains. Parasitic pathogens resulting from insect activities have not yet been recorded, just a cautionary future analysis.

Moreover, the museum lacks an electronic inventory system to catalogue the human remains. What is available is a notepad recording of the remains that were brought in; however, the register has not been updated for a long while. Due to the lack of an electronic inventory system, the human remains in the storage, in coming out and going specimens are not well tracked. In addition, the boxes and crates of most contextual information is the curator to create the archive.

Lately, the Ghanaian laboratories concerning curatorial and analyses of human remains have been aware of lack of funding and limited expertise to work on them. Another is the research foci/interests in which case, the analyses of other archaeological finds with less presentations over the human remains, with a meagre appreciation for the scientific value of human remains for future reference to related analysis, the prospects of many non-destructive scientific analysis are dependent on the availability of expertise and research funds. Also, funds for long-term preventive conservation are not readily available. Additionally, there is a general consideration and respect for the religious/public sensitivity in handling (posting, carrying and exhibiting) human remains. On this ambit, it is unlikely for the museum to showcase the human remains in its collection except for

the purpose of teaching and experiential learning in a controlled environment in the department.

Discussion

The results have been discussed in four sections below:

Storing human remains

Storing human remains is more than finding a clear space on the shelves to rest them on. It has to do with the protection and preservation of handling with the appropriate and sustainable conditions to keep them intact for the intended purpose or future analysis. According to the Department for Culture, Media and Sport (DCMS), "a strategy for the curatorial and care of human remains, include such matters as sustainable storage conditions, security, conservation policies, environmental conditions and loans to other institutions" (14, p. 19). These conditions were noted as able to ensure that the long-term well-being of the remains is not compromised.

The storage facilities of the Museum of Archaeology ought to be mindful of the conditions for the collections. Particularly, human skeletal remains and their corresponding labels should be protected from humidity and insect activity. All these factors have the tendency to either if not completely deteriorate (over a span of time) the skeletal remains and the labels. Although, the museum runs on a temperature of 18–25 °C, the storage rooms don't have a specific/controlled temperature, therefore, either hot or cool in the dry and rainy seasons, respectively. The objects materials (dry) in the storage are either subjected to 25–30% or 17–18 °C for wet seasons, respectively. The average storage humidity range of 45–50% for dry remains and 25–30% or 17–18 °C for wet remains, not subject to storage fluctuations. The insect (termite) activities in the storage rooms is a major cause of the deterioration of the paper labels accompanying the remains, resulting in the loss of label contextual information.

Adding up to the challenges of unfavorable conditions of storage, the humidity and temperature changes is the absence of designated spaces for the remains. The human remains are contained in wooden boxes with width and height of about 60 cm x 30 cm x 30 cm or 60 cm x 15 cm x 15 cm, depending on the elements available. These boxes are arranged on shelves together with other boxes and bags of materials from excavations or collectors to the storage. This results in the uncontrolled movement of the remains in the event of a search for particular bags or materials. A situation that leads to the competing place with other archaeological materials in the storage vault. The ideal is to have separate storage rooms for human remains and other materials. But since this seems to be difficult to attain, the museum considered team working with experts and the project will also involve the installation of a humidistat and appropriate insect control, the fitting of clear sealed walls, and the replacement of deteriorating labels in addition to other storage management practices. This will be consistent with

the preventive conservation and collectors care noted by Cole (17) and (18), p. 16.

The use of storage challenges for the museum goes beyond a concern for the human remains to include an issue involving the bioarchaeological research. What is the possibility of a timely expansion of the storage vault and a clear distinction of storage spaces for the department and for the museum. It is unlikely that the museum's storage capacity would meet present and future collectors from excavation or reburial projects.

Cataloguing and availability of researchers for sampling or examining human remains

Cataloguing is a way of creating order among museum collections. It involves the physical and intellectual organization of museum objects into a systematic order. Accessioning is a cataloguing tool to practice of assigning numbers to collectors to aid in collections management and identification. Without these identifiers on human remains, the skeletal remains can be impounded and curators will be unable to responsibly account for them. Accessioning involves marking some contextual information onto the object or bone with a waterproof ink. Considering the idiosyncrasy of human skeletal remains, it is advised that labeling and marking should be done with caustic and alkaline ink printed onto acid free paper. For human remains, the labeling system ought to be considered and appropriately placed to avoid concealing lesions. This will help create clues in the storage and for long-term identification, meet research needs by not crowding markers necessary for pathology diagnosis and skeletal measurements.

What has been done on the human remains, regarding accessioning, is inconsistent. General cleaning and marking with an abbreviation of site name, year, unit number and inventory number of objects. Regarding cataloguing, what is available is an inventory in a hardcopy book catalogue of the remains with their accessioning numbers and inventory numbers. There is not yet a computerized list and description of all the human remains in the storage. Considering the possibility of ink fade over a long period of time, a timely electronic inventory including context, description and treatments, as recommended by Cole (19), p. 198, is also advised. Involving students and staff in preparing an electronic inventory into the museum's collection management system will, if all standards be met, provide an estimate of incoming and out-going specimens, control access, maintain organized handling and give some level of closure to the human remains.

Consolidation of the human remains in the 1960s were done by the researchers at the time. The human remains were placed in boxes with other archaeological materials and museum objects and also carried out some site collection. This has been done recently with regard to skeletal analysis of the remains, not much information is available. However, it is clear that the human remains were not adequately funded to meet requirements of the use and age of the objects, and all other diagnostic visit. As a result of limited

antropologists, some early epigraphic archaeologists of the department in the 1960s and following, under the guise of scientific analyses, have transported remains outside the shores of Ghana without return. But for a master's thesis involving the bioarchaeological examination of human skeletal remains from a prehistoric site in the Savannah region (21), there has not been much skeletal analysis in the department. This work was supervised by a Professor of Developmental Archaeology and Anthropology in the Department. In consultation with a Pathologist from the Korlebu Teaching Hospital in Accra. Additionally, one other comparative bioarchaeological examination of human remains in Ghana, of about 100 individuals, was at Elmina in the Central region (24).

From the above, it is obvious that some expertise is available but not enough. However, the department has not in place measures to advance the museum's role as a teaching museum. For instance, the department has a Bachelor's Degree course in Introduction to Human Osteology and Forensic Anthropology involving some basics in handling human remains, and a Masters' Studies Program at the Masters and PhD levels to train students on museum practices, storage management and conservation of museum artifacts. This is a step in the right direction to build expertise for handling remains and managing museum collections.

Risk arguments on handling human remains

The contemplation on the viability or potency of the cause of death or pathogens to skeletons and their infectivity rate are subtle issues of concern at the department. This subject has been discussed extensively by scholars (22–27). The question then is: what is the viability rate and the probability of a pathogen to survive, reproduce or stabilize to cause a threat to curators and researchers sampling or examining human remains? Cole (17) gives some based on environmental conditions that:

The risk of infection from skeletonized remains is low generally because of the natural desiccation and mummification process begun to die on the death process over weeks and then becoming naturally mummified over months and years. However, some remains may grow increasingly more viable and then become infectious after a long period of time. The risk of infection from skeletal remains is low generally because of the natural desiccation and mummification process begun to die on the death process over weeks and then becoming naturally mummified over months and years. However, some remains may grow increasingly more viable and then become infectious after a long period of time.

The justification for the risk of contact or infection involved in handling (posting, carrying, sampling and examining) human remains essentially lies in the category of the history and functions of museums, and human remains associated with human remains that are not 100 years old (28). A study by (29), p. 74, states that "human remains are 100 years old" (31). At the latter age, pathogens are unlikely to survive or reach their infection. Antona and Pflieger, argue that "pathogenic bacteria and viruses that were the cause of death, disease, insecticide, and other archaeological or osteo-fossilized contacts do not represent a health risk to archaeologists and museum personnel. In

contrast, organic pesticides and heavy metals represent a real threat" (32), p. 214.

It can be deduced from the above arguments that, it is not necessarily the human remains that pose risks or are sources of contamination but the contexts, for example, in completely sealed bags and containers, and pest infestations (37), p. 99. These contexts trap in bacteria, fungi, and viruses, opportunistic niger and Aspergillus fumigatus and concentrations of ammonia gas, hydrogen sulfide and formaldehyde used to treat the cadaver may cause allergic reaction including pneumonia (in cases as the tombs of Ramon Isard King Itakamim (33)). In Ghana, coffin carry from wood with metals to "casket" (casket), and these contexts may present different cases of contamination. Hence, with or without the possibility of infection and deterioration of the age of the remains, it is advisable to adhere to all safety protocols in handling the remains in order to stand the risk of being infected or dying. No alarming health trends have been recorded with regard to handling (posting and examining) the human remains in the storage of the Museum of Archaeology yet.

Preserving human remains

Preservation involves the conscious effort, i.e. timely interventions taken to minimize the deterioration or mutilation as an object or place. However, interventions, treatments and consolidation methods for conservation should be minimal and carefully considered in order to maintain the inherent dignity and scientific value of the remains over a long period. The dynamics of cultural heritage has led to a shift in understanding conservation from a complex system of identifying, caring for and using heritage. This development has resulted in decisions to safeguard and protect the historic significance/value or heritage for posterity. In Torry, notes that:

Today, conservation is understood to encompass any action designed to maintain the significance of a heritage object or place, and it is a process that starts at the moment a place is recognized as having cultural values and ended only for protection. In the past and the present, conservation is an attempt to control and direct change (37), p. 158.

What has been done so far as conservation on the human remains in the storage (since the 1960s), and is confirmed by the practical technician (from recent conservation works), are in four stages. From minimal handling and on-site consolidation of remains (when necessary) using PVA (Polyvinyl acetate) glue and acetone (measurements depend on the elements available) to handle fragile remains for lifting and transportation. Secondly, cleaning (removal of soil residue without water) and wrapping with fragers, and five papers, or put in separate zip-lock bags then in wooden boxes and taken to the storage. Also, without the consolidation and cleaning stages are sometimes skipped. In such cases, the remains are only marked and put in wooden boxes for the storage. The conditions are either reversible and stable as recommended by (37), p. 51 and Article 9 of (30).

Only that, some of the consolidants have been applied on bone surfaces with layers of dirt, concealing surface continuity, lesions and textures. As part of conservation, the curatorial team ensures adherence to the 3 principles of integrity, dignity and preservation (35), p. 307, when handling the remains in storage and their analysis. The team is also taking significant steps at the curatorial, management and conservation of the human remains in line with museum standards and recommendations (31), p. 95–102; (36), p. 14–16, to ensure the long-term preservation of both the remains and the quantity and quality of data to be gleaned from them.

To benefit from the potential of conservation strategies for the preservation of all materials housed, Bello & Mohamed (7) propose a shift from traditional methods of storage in-house or in cases and exhibiting intermittently to the technological assistance of virtual museums (7), p. 47. They argue that a technological intervention in virtual and media formats will help to substantially reduce the risk involved in collections care and management, such as theft and degradation due to poor storage conditions among others while improving documentation. A technological intervention in addition to minimal approaches and case-specific decisions to treatments, supportive storage and good handling techniques as conservation practices (31), p. 371, will agree with De la Torre's proposal of a five-step approach to digital conservation of museum collections' heritage (31), p. 164, with regards to human skeletal remains. The museum management can adopt a flexible conservation approach where the dignity of the remains will be respected and preserved, and the scientific value exploited simultaneously.

Recommendations for the study

The research proposes the following measures for sustainable measures for cataloguing, storage and collections management and handling.

To begin with, researchers at the department should at the least attach some contextual information when submitting the human remains for cataloguing and be instrumental to the research in storage and their analysis. As part of the site's archive after analysis are completed, the remains should be returned to the museum. The curatorial team can work at creating a more dedicated & designated storage area for the human remains with more containers, and also incorporate the digital inventory practices into the collection management system. That way, the research outcome from the respective sites and display appropriate 3D photographs of the remains, with permission from the appropriate authorities, can be deposited there for teaching and learning purposes without physical handling of the remains. In addition to the department's partnership with the Norwegian University of Science and Technology to build expertise through exchange programs, more partnerships can be sought for to train more curators for the museum.

All safety measures for stabilization including using padded labels, ring of polyethylene foam and used boxes must be strictly followed to maximize protection and minimal damage. Minimum and reversible curatorial methods should be strictly adhered to according to standard policies

and protocols. For example, tapes instead of permanent glue or plastic filler should be used for reconstruction works on bone fragments. Organic pesticides should be consolidated before being applied to avoid joint falls pulling away/breaking off surrounding bone. Insecticides should be used sparingly and applied by acid-free tissue pads, not glued back into the artifacts. For health safety reasons, curators and staff should wear gloves and masks before and after the use of disposable nitrile gloves to avoid (32). Regarding conservation, it is noteworthy that, human skeletal remains like other artifacts as metals once excavated deteriorate faster in the absence of consolidants. Hence, as such possible human remains should be stored in the same recovery environment or in controlled conditions after treatments. Antona & Tyler (38), p. 40 also postulates that storage solutions must conform to the variable aspects of human remains: their specific nature, the different cultural contexts and burial environments.

The goal is to maintain the integrity and scientific value of the skeletal remains for the reason (i) they are being housed: research, teaching and learning, salvage and conducting. This means implementing the appropriate storage measures to ensure that the storage environment is conducive for the collections and their labels. Thus, regular storage checks for insects (pests and termites), humidity, humidity/temperature swings and other potential threats to avoid the consequent problems. Finally, the museum needs to be autonomous in operation, have well-documented storage spaces, and be well recognized as an educational center in the university with adequate funding and more dedicated work force properly oriented on handling human remains. In turn, the museum can beef up its care and management capacity to efficiently and effectively execute its vision as a teaching museum and guardian of the human remains.

Conclusion

Museum life every institution require the necessary conditions to thrive as guardians of history in both tangible and intangible forms. The team of factors and technicians who have dedicated their time to man the Museum of Archaeology have done great conservation works on metal objects, ceramics, textiles and other artifacts over the years and are safeguarding these materials' respective of the limited resources. The consolidation of the human remains since the 1960s, shows low sustainable conservation for the stabilization of bio-facts and artifacts.

Maximizing the potential of material culture artifacts and bio-facts as vectors of behavior is to ensure that they are in good shape for sufficient data to be harvested from them. When human remains are well preserved, it maximizes the quantity and quality of data that can be gleaned from them. Both short and long-term preservation of human remains depends largely on organizational framework, activities managed and monitored storage conditions, stabilization of the remains, holistic inventory system and standardized research practices. These will guarantee the preservation of the dignity and value of the human remains. How museums manage, care for and value their collections matters significantly as teaching museums and guardians of the human

and their heritage simultaneously while creating a stimulation for the holistic appreciation of culture.

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Disclosure of Interest

The author declares that she has no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jmep.2022.100753>.

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Year	Author	Title	Journal	Volume	Page
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1999	Alexander EP	Museum matters: their museum and their influence	Walnut Creek	AltaMira Press	1-448
2009	Robert Hoagland et al.	The role of museums in the 21st century	ICOM	2016	9-11
2016	ICOM	Museum, ethics and cultural heritage	London	Routledge	
2018	Bello BW, Mohamed AS	Impact of technology on traditional museum collection storage and management	Int J Computer Sci Mobile Comput	2018	46-51
2019	Antona DN	Human remains in museums and collections	Berlin	Springer	1-54
2020	DOI	Let's conserve our heritage sites and buildings	Preserve	April	
2021	Antona DN, Maun E, Maun H, Panagiotou G	Towards a bonding code of ethics for the conservation and display of human			