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Research Article

Keywords: ethnoarchaeology, gastropods, foragers, central Africa

Posted Date: June 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9860748/v1

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Archaeological and Anthropological Sciences on September 4th, 2026. See the published version at https://doi.org/10.1007/s12520-026-02560-z.

Eating escargot: Seasonal Terrestrial Gastropod Exploitation by Forest Foragers in the Ethnoarchaeological Record of Central Africa

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In the prehistoric record, the presence of small-sized resources including gastropods are often viewed as markers of increased dietary breadth, declining foraging efficiency and/or as evidence of flexible subsistence efforts involving diversified foraging efforts. However, researchers often find it difficult to distinguish natural gastropod accumulations from those created by anthropogenic processes. Here we report on the context, profitability and methods of the seasonal hand collecting and processing of terrestrial gastropods based on the observations of contemporary Central African forest foragers. In this context, gastropods were exploited in response to temporary and seasonal reductions in the availability of meat and changes in labor force demands that allowed women and children to engage in this activity. Analysis of faunal remains from a wet season encampment presented here show how different kinds of gastropod processing are reflected in the ethnoarchaeological record. Analyses of these data validate some of the current characteristics used by archeologists to identify anthropogenic gastropod assemblages. Overall analyses of these characteristics show that the degree of burning, specimen completeness and spatial distribution of snail shells parallels that of other small-sized fauna. Some characteristics, such as shell completeness and spatial association, can reflect different preparation techniques that, in this case, may be indicators of ethnic identity and site clean-up activities. These data also have implications how terrestrial gastropod consumption might be reflected in other kinds of archaeological evidence. The example discussed here can serve as a model to help archeologists distinguish diversified seasonal foraging from larger-scale dietary shifts.

Keywords: ethnoarchaeology, gastropods, foragers, central Africa

Prehistoric Mollusk and Gastropod Exploitation

The prehistoric exploitation of smaller-sized prey, including those that are sessile or slow-moving, is often viewed as a characteristic of dietary expansion associated with declining foraging efficiency and/or as markers of flexible subsistence patterns associated with a diversified foraging effort. Theoretical rationale derived from foraging theory and applied to zooarchaeological analysis routinely uses prey body-size as a proxy for rank and identifies smaller-sized resources as low-ranked relative to larger-bodied prey (see Lupo 2007). As high-value and large-sized prey become less abundant on the landscape, smaller-bodied prey enter the diet in response to declining foraging efficiency. An application of this rationale is exemplified by the Late Pleistocene-Early Holocene Broad Spectrum Revolution (BSR) which was often characterized by dietary diversification and/or resource intensification by the inclusion of smaller-packaged resources with high handling costs and in some locations ultimately lead to the emergence and spread of food production (e.g., Flannery 1969; Stiner 2001). The BSR is thought to be driven by demographic factors and/or ecological processes that ultimately reduced the abundances of high-value and large-sized game (e.g., Stutz et al. 2009; Jenz 2016; Weiss et al. 2004). However, the exploitation of small game is well documented as early as Plio-Pleistocene with evidence from Bed I, Olduvai Gorge, Tanzania (Fernández-Jalvo et al. 1999). Small fauna displaying evidence of anthropogenic exploitation (e.g., cutmarks, burning etc.) are present, sometimes in substantial quantities, in a number of Early to Middle Pleistocene zooarchaeological assemblages (also see Blasco and Peris 2012, Blasco et al. 2013, Blasco et al. 2019; Gaudzinaski-Windheuser et al. 2023, 2026; Milošević et al. 2025). While there is no clear consensus on how these resources fit into the overall diet, some believe small-game utilization was incidental to the main subsistence activity of large-game acquisition through hunting and/or scavenging. Others view Early and Middle Paleolithic exploitation of small game resources as part of a flexible foraging pattern, possibly associated with a diversified labor force, that allowed hunter-gatherers to engage at different trophic levels and respond to fluctuating ecological conditions (see Venkataraman et al. 2026). These two views are not necessarily mutually exclusive and can be responses related to similar processes. Where they differ is on the scale of application and degree of archaeological reflection. Large scale dietary shifts due to declining foraging efficiency, such as the BSR, is associated with technological, ecological and demographic shifts reflected in the archaeological record (see for example see Stiner 2001, Stiner et al. 2000; Stutz et al. 2009; Jenz 2016; Weis et al. 2004). Seasonal shifts based on foraging flexibility has far more subtle archaeological consequences and can be very challenging to identify in the archaeological record. However, given the explanatory potential of this view, researchers have focused on identifying those resources which may have offered significant seasonal benefits.

While mollusks in prehistoric contexts have long been viewed as important evidentiary lines for reconstructing paleoenvironments (see Chytr´y et al. 2019; Limondin-Lozouet et al. 2025; Rizer et al. 2009; Yanes et al. 2011), the last few decades have increasingly focused on archaeological evidence for the consumption of marine mollusks (especially bivalve species) spanning as far back as the Lower and Middle Paleolithic (see Colonese et al. 2011; Klein and Steele 2013; Palconit et al. 2025; Marean et al. 2007; Niespolo et al. 2021). Palconit et al. (2025) reports some of the earliest evidence from Quarto delle Cinfonare, Italy dating to 300,000 years BP. Stronger evidence for marine mollusk exploitation appears in a number of Neanderthal age sites in the Mediterranean Basin (e.g.,

Colonese et al. 2011; Cortés-Sánchez et al. 2011; Stringer et al. 2008). Cortés-Sánchez et al. (2011) for instance report some of the earliest evidence for the exploitation of several different marine bivalve and mollusk species around 150,000 yrs BP by Neanderthals in Cueva Bajondillo (Southern Spain). In South Africa, evidence from Pinnacle Point Cave 13B and other sites (Klasies River, Blombos, Ysterfontien) suggest systematic shellfish exploitation during the Middle Stone Age (Klein and Steel 2013; Marean et al. 2007). Marine mollusks (and some gastropods) in these contexts are viewed as being easy to collect resources that were supplementary to terrestrial fauna and seasonally exploited (see Colonese et al. 2011: Stiner et al. 2000). However, the exploitation of some, but not all, of these mollusks may require technological investments, predictive spatial and seasonal knowledge. For instance, the successful exploitation of some marine mollusks requires in-depth knowledge of lunar and tidal cycles to access intertidal environments (Fa 2008; Klein and Bird 2016). It also requires predictive knowledge of the ecological conditions that can influence the edibility of certain species (e.g., Moss 1993). One of the most widespread and common marine neurotoxins associated with the consumption of shellfish is saxitoxin which accumulates in response to specific ecological conditions especially algal blooms (Ansdell 2013). When ingested, saxotoxin can result in paralytic poisoning and cause severe neurological symptoms, paralysis and even death. The seasonal exploitation of marine mollusks (especially shellfish) could also be a significant nutritional supplement because these resources contain long-chain omega-3 fats (EPA and DHA) that support cell structure, organ function and regulate inflammation in modern human populations (Klein and Bird 2016).

In addition to marine mollusks, a small but growing body of evidence points to the prehistoric exploitation and consumption of terrestrial gastropods (i.e., land snails) which could also have served as seasonally exploited dietary supplements and/or be a marker of the dietary transition associated with the adoption of a broader or more diversified diet and/or resource intensification (de Pablo et al. 2014; Lubell 2004). The earliest documented evidence for cooking and consumption of land snails is detailed by Wojceiszak et al. (2023) at Border Cave dating to 170,000 years ago. In their concise overview, they note that the consumption of land snails does not robustly appear in the archeological record until 10-15,000 years BP in Africa and not before 49-36,000 years BP in Europe. However, they also point to several possible examples that could indicate the consumptive exploitation of terrestrial African gastropods as early as the MSA based on unpublished evidence from Mumba-Höle Cave, Tanzania dating to 49.1±4.3 ka yr BP (see Wojceiszak et al. 2023). In Europe, some of the earliest evidence of land snail exploitation is reported from Cova de la Barrida (Spain) and dates to 31.3-26.9 ka yr cal BP (de Pablo et al. 2014). The exploitation of terrestrial mollusks is well supported at sites dating from Upper Paleolithic-Epipaleolithic-Mesolithic around the Mediterranean Basin and during the Holocene, especially in North Africa (e.g., Cortés-Sánchez et al. 2011; de Pablo et al. 2011; Estrada et al. 2009; Girod 2011; Hunt et al. 2011; Jordá et al. 2011; Lloveras et al. 2011; Lubell 2004, Lubell and Barton 2011; Lubell et al. 1976; Taylor et al. 2011). As further described below and unlike marine mollusks, terrestrial gastropods do not require specialized technology to collect or process but may require predictive knowledge to locate high density patches of gastropods. More importantly, the consumption of terrestrial gastropods could provide significant nutritional benefits that rival those associated with marine mollusks.

Despite these findings, evaluating the role of small fauna, especially mollusks, in Paleolithic diets remains challenging. Part of the problem is that larger-sized fauna have greater visibility in archaeological assemblages

relative to smaller-sized prey (Gaudzinaski-Windheuser et al. 2023). Furthermore, many early excavations did not use excavation and recovery techniques aimed at recovering small fauna. Other factors such as preservation and identification bias and taphonomic processes which can differentially modify remains can also mitigate against recovery of small fauna. This is particularly a challenge for archaeologists investigating the role of gastropods in prehistoric subsistence because both terrestrial and marine malacofauna can be deposited naturally in archaeological contexts by nonhuman predators and through other natural processes (e.g., aestivation or hibernation, storm surges and floods, and bioturbation). Terrestrial gastropods, for instance, can naturally accumulate in many different contexts. The natural deposition of terrestrial gastropods can occur when these species become attracted to and feed off organic debris deposited at sites. Some gastropod species intentionally bury themselves during aestivation and may naturally inhabit caves and other locations that also serve as places of human habitation (de Pablo et al. 2014; Wojceiszak et al. 2023).

Consequently, current scholarship is focused on identifying different characteristics that can be used as markers of anthropogenic accumulations (see Table 1). Among the lines of evidence used to support an anthropogenic origin of terrestrial gastropod accumulations is monospecific taxonomic composition and close spatial association of shells with artifacts and/or thermal combustion features and other kinds of artifacts and features (i.e., grass mats; see Wojceiszak et al. 2023). In addition to the association with thermal combustion features, evidence of burning displayed directly on shells or as reflected by mineralogical changes in shell chemistry is viewed as evidence of preparation techniques and consumption (Wojceiszak et al. 2023). When exposed to thermal temperatures as low as 250°C, shells undergo a mineralogical transition from aragonite to calcite with the latter eventually decomposing at higher temperatures (Milano et al. 2016). Homogeneity in shell-size is also often viewed as evidence of human selectivity in prey size. Others find that high concentrations of complete shells relative to fragments are more common in anthropogenic than natural concentrations (de Pablo et al. 2014). This is based on the observation that nonhuman organisms are more likely to consume the entire snail, and the shell fragments will come out in the animals' feces and potentially display evidence of digestive acids in disaggregated specimens (de Pablo et al. 2014).

However, most of the characteristics that are used to determine the anthropogenic origins of terrestrial gastropod assemblages are based on limited experimental evidence and ethnographic observations (but see Tanyitiku 2022). To build an ethnoarchaeological foundation for making inferences about the use of the giant West African snail (*Archachatina marginata*, hereafter GWAS), we report some of the first observations of contemporary forest foragers collecting and processing GWAS in the Central African Republic. In these contexts, snails are seasonally collected by hand and processed using simple technology. Evidence presented from an ethnoarchaeological faunal assemblage associated with seasonal GWAS exploitation offers an ideal opportunity to explore conventional markers of anthropogenic assemblages as identified by researchers.

Table 1: Examples of Characteristics of Anthropogenic Terrestrial Gastropod Assemblages[1]

Site/Location	Date	Evidence of Anthropogenic Consumption/Processing	Reference
Arenel de la Virgens, Casa Corona/Spain	8,600-7,800 cal BP	Multispecies Association with thermal features Homogeneity in shell size	de Pablo et al. 2011
Capsian sites/ North Africa	10,000-7,000 yrs BP	Monospecific assemblage composition Dense middens Largely unbroken shells Associated with other artifacts	Lubell et al. 1976
Balma del Gai/ Spain	12,240+/-110 BP 8,930+/-140 BP	Monospecific assemblage composition Approximately 42% shells complete or nearly so Lack of burning or thermal alteration Homogeneity in shell size	Lloveras et al. 2011
Cova de Barrida/ Spain	31,300-26,900 cal BP	Monospecific assemblage Approximately 41% shells complete or nearly so Associated with combustion features and artifacts No evidence of thermal alteration Homogeneity in shell size	de Pablo et al. 2014
Border Cave/ South Africa	170,000 yrs BP	Heat altered gastropod shells (aragonite-calcite concentrations) Association with grass matts, combustion features, artifacts, other faunal remains Monospecific assemblage composition Shell fragments burned and unburned	Wojceiszak et al. 2023

[1]Other kinds of evidence have been used to infer anthropogenic origins for mollusks such as freshwater and marine shellfish. This includes extensive fracturing and the lack of water erosion and microwear damage on shells (Palconit et al. 2025). Here we focus exclusively on terrestrial gastropods.

Resource Characteristics of Terrestrial Gastropods: Giant West African Snails (*Archachatina marginata*)

Several different edible terrestrial gastropods exist in Africa and comprise an important traditional consumptive resource for many populations, especially in West and Central Africa. Information discussed here pertains to GWAS, which are naturally distributed across forested areas of Western and Central Africa. Importantly, GWAS can also be used for nonedible products such ornamentation, decorative or nonutilitarian items, and gastropod meat products are used in traditional medicines (Bamidele et al. 2018; Miller et al. 2018). Here we focus on characteristics of GWAS as an edible resource, such as nutritional value, potential negative consequences of consumption, and the ecological circumstances of acquisition.

Although GWAS are farmed and fed optimal growth diets in some parts of West Africa, especially Nigeria, wild caught snails gathered from rural and undeveloped areas still comprise a large segment of those that are consumed and marketed. Wherever possible the nutritional data reported here are from wild caught snails because farmed individuals are usually larger, heavier and yield higher protein meat than specimens that are wild caught. The nutritional value of terrestrial gastropod meat is very rich in protein (37-51% of meat dry weight) and proportionally compares favorably to other meat sources such as fish, chicken, and beef (Adeyeye et al. 2020; Ohimain et al. 2024). Recent stable isotopic work of regional, common food resources consumed by some of the focal populations described below also demonstrates that the nitrogen signature of GWAS meat is comparable to that of certain small-sized mammal species from the same forest (Edwards 2025), further supporting the potentially importance of this resource as a dietary protein. In addition, terrestrial gastropod meat, although very lean and low in fat, is mineral rich (especially in zinc, iron, magnesium, phosphorous and iodine) and contains all 9 essential amino acids (Etukudo et al. 2024; Tanyitiku 2022). The meat is also a good source of polyunsaturated fats including omega-3 and omega-6 (Adeyeye 2012; Pathak et al. 2025) but has proportionally lower amounts of long chain fatty acids such as EPA and DHA than marine mollusks. Importantly, the meat of terrestrial gastropods is a very rich natural source of calcium and contains a higher proportion of calcium than marine mollusks (Wright et al. 2018). Calcium values as high as 421-472 mg/100g have been recorded for GWAS, but lower values of 201-207 mg/100g are also known (see Fagbuaro et al. 2006). The high calcium values reported for these species makes them a significant dietary source of calcium (Etukudo et al. 2024) that compares favorably to cow's milk (120-130 mg/100 mL). This makes gastropods an important nutritional supplement to forest diets which have very few alternative natural sources of calcium.

Despite the nutritional benefits associated with terrestrial gastropods, GWAS are known vectors for a wide variety of bacterial pathogens. A recent study found several different pathogens (i.e., *E. coli*, *Salmonella* spp., *Listeria* spp. and *Yersinia* spp.) associated with different terrestrial land snails (including GWAS) recovered from urban contexts. These pathogens are not eliminated by preparation techniques and could present deleterious health risks to human populations (Tanyitiku et al. 2022). However, the bacterial pathogen burden of GWAS and other terrestrial gastropods is directly linked to the immediate ecology. In urban contexts, far more bacterial pathogens are found in the soils than in rural areas (Zhang et al. 2023). Thus, the bacterial load associated with GWAS reflects the environmental load and, in natural settings, these species are less likely to be associated with high bacterial loads.

Of the edible African gastropods, GWAS are naturally found in humid and warm forested areas of West and Central Africa. In these regions, the snails are more active during the wet than the dry season(s). When the temperatures are too hot and/or the climate too dry, the snails aestivate by withdrawing into the shell and forming an epiphragm (or mucus seal) over the opening (Ademolu et al. 2016). As with other giant land snails, GWAS protect themselves during aestivation by burrowing into the upper 10-15 cm of the soil (Cobbinah 1997). Most research suggests this is an individualistic response and there is no evidence that GWAS form gregarious groups or patches during dormancy (but see Fischer et al. 2012), and this pattern extends to their active state. While GWAS are nocturnal omnivorous detritus feeders, they are not randomly or uniformly distributed across the landscape (Ajayi et al. 1978; Okafor-Elenwo et al. 2021). They can be encountered in many different localities, but distinct patches are found where favorable ecological conditions, especially suitable microhabitats, are limited. In these areas, higher densities of snails are found relative to other areas (Dodiya and Poriya 2023; Okafor-Elenwo et al. 2021). The differences in distribution and density may be due to variability in important minerals in the soil such as calcium, which support shell growth or other factors. GWAS generally dislike disturbed soils especially those resulting from agricultural activities (Agbugba et al. 2023).

Observations of Forest Foragers Collecting and Processing Gastropods

Observations and interviews of snail collecting and processing were made in 1999-2003 during several wet seasons between June and August. The detailed participant observations reported here were made in the villages of Grima and Ndele in the Lobaye prefecture of the Central African Republic as part of a long-term ethnoarchaeology project (see Fig. 1). Ndele was located 54 km from the nearest larger town and could only be reached by a footpath through the forest. Grima was located along a dirt road that was rarely traversed by vehicles at the time of the study. In this region, forest populations were comprised of ethnolinguistically distinct but interacting groups including Bofi and Aka forest foragers (formerly pygmies) and several different groups of food producers. Ecological descriptions of this area are published elsewhere (Lupo and Schmitt 2002, 2005; Schmitt et al. 2024). In general, the area is considered a dry Congolian rain forest with high humidity and seasonal rainfall patterns. The subsistence activities of the forest foragers and local farmers in these villages are also detailed in prior publications (Lupo and Schmitt 2002, 2005). At the time of this study, forest products, especially wild game, comprised approximately 50% of the food consumed by the local populations. Most of the terrestrial prey species acquired by forest foragers were small-sized (<10 kg) and the most common species captured include blue duikers (*Philantomba monticola*), giant pouched rats (*Cricetomys gambianus*), Cephus monkeys, brush-tailed porcupine (*Atherurus africanus*), tree pangolin (*Phataginus tricuspis*), small carnivores, reptiles, and birds. Medium-sized prey (<10 to 25 kg) such as Peter's duiker (*Cephalophus callipygus*) and Bay duiker (*Cephalophus dorsalis*), and forest hogs (*Potamocherus porcus*) were less commonly taken especially in Grima. Very large-bodied prey (>25 kg) such as yellow-backed duiker (*Cephalophus silvicultor*), forest buffalo (*Syncerus caffer*) and elephants (*Loxodonta africanus*) were present but very rarely encountered. Plant species including several wild edible yam species (*Dioscorea* spp.), mushrooms, nuts and seeds, a variety of fruit, and leaves from *Gnetum africanum* (or koko) were eaten. In both villages, GWAS

alongside other insects and their products (e.g., termites, caterpillars, and honey) served as important seasonal resources.

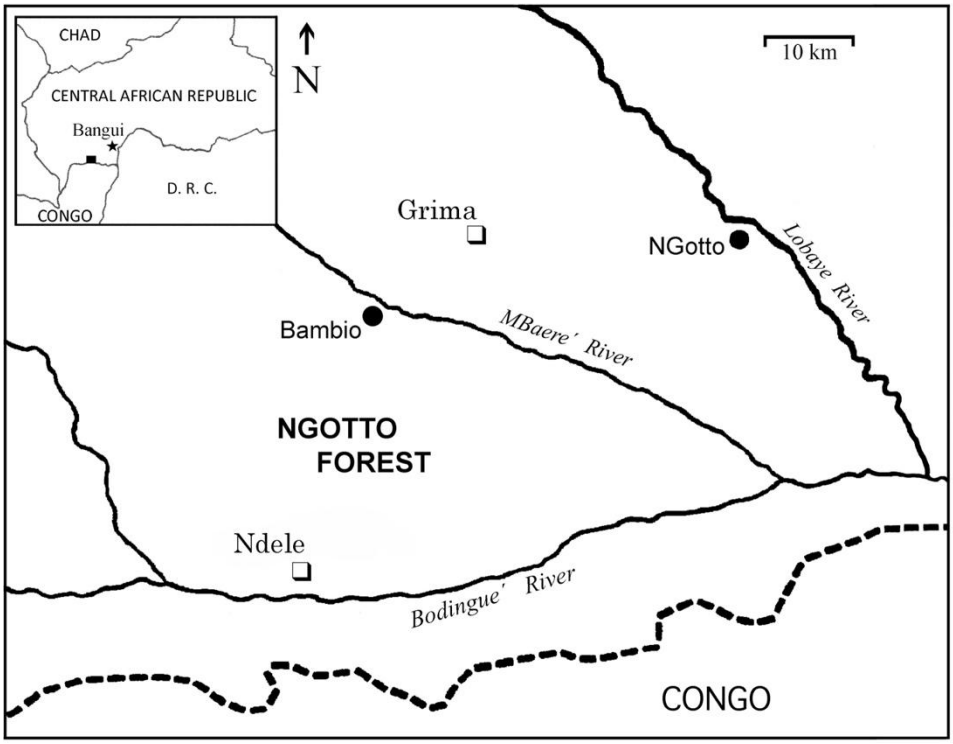


Fig. 1: Locations of two villages referenced in this study (after Lupo and Schmitt 2002).

The availability of prey animals does not vary seasonally in this area. However, there are seasonal differences in the use of different hunting technology that influence the number of prey taken and amount of meat brought into camp by hunters and the distribution of available labor. Comparisons between the dry and wet seasons in the number of carcasses acquired by hunting and brought into both villages suggests that more mammalian meat is acquired during the dry season in comparison to the wet season. In Grima, the acquisition rate of prey (calculated as number of carcasses per day) was 16% higher in the dry season than the wet. In Ndele, the acquisition rate during the dry season was substantially higher (96%) than during the wet season. These seasonal differences were largely due the deployment of different hunting technology used by hunters. Specifically, cooperative net hunts, which capture large numbers of animals (mostly blue duikers), were more often used during the dry than the wet season (see Lupo and Schmitt 2005). These hunts have been described extensively in elsewhere and involved large labor pools that included men, women, and children. During the wet season, hunting continued but net hunts were considerably less common because the rain damaged the fiber nets and the moisture made them heavier to transport into the forest. In the wet season hunters relied on hand capture, spear hunting, the use of traps and snares, and sometimes bow and poisoned arrows. The wet season was also the period when there was less agricultural work in the village for food producers. Forager women were often hired by farmer households to do agricultural fieldwork in the dry season. In both villages, the combination of fewer group or cooperative hunting expeditions and less agricultural work during the wet season allowed women foragers to pursue other available forest resources and spend more time foraging for wild products.

At the time of this research, some foragers and farmers had established multifaceted interrelationships that were often characterized by obligatory trade/labor relationships involving the exchange of forest products (e.g., meat, honey, plant resources, and insects) for village products (e.g., manioc, clothing salt, and oil). One of these villages, Ndele, also hosted a lively bushmeat market with commercial vendors frequently visiting the camp to purchase or trade for meat (see Lupo 2016; Lupo and Schmitt 2017). Although forest products were traded and sold to commercial vendors in both villages, gastropods were collected solely for local consumption and trade with local farmers. There was no commercial trade or external market for GWAS at the time of this study. However, recent commodification of snails as a forest product in this area has changed acquisition strategies (Edwards 2025).

The collection of GWAS was a common and dedicated wet season activity largely conducted by forest women (with infants) and children. On rare occasions, forager men and farmer women would accompany these collecting parties. Usually, when forager men participated it was for short periods of time during the foraging trip. The men would walk into the forest with the women but become diverted collecting or pursuing other resources they encountered (usually game). Even though the stated goal of the foraging expedition was to look for snails, collecting expeditions were episodic and embedded with generalized forest foraging. The collection bouts usually lasted approximately 1 to 2 hours and ended when women temporarily broke off to pursue or collect other resources or rest. Most often women would break off to hunt giant pouched rats or collect other forest resources, especially nuts from *Irvingia gabonensis* (payo; see Edwards et al. 2025) and seeds from *Treculia africana* (fbusa), as well as fruit and koko leaves to a lesser degree. The entire foraging trip usually lasted 5 to 6 hours. However, during the wet season precipitation was common in the afternoons and rain would typically end foraging trips.

We accompanied forest foragers on 18 GWAS collecting trips and supplemented this information with interviews with foragers and farmers about land snail collecting and processing. Most of the information reported here pertains to direct observations and interviews that were made in Ndele. In Ndele, collecting trips were initiated by 2 to 4 women accompanied by children walking on an undeveloped dirt road and opportunistically collecting snails that were sparsely encountered and usually found near the edges of the disturbed ground. In these disturbed areas, foragers encountered 1 snail every 8 minutes on average. Eventually, these parties left the road and walked onto make-shift paths into the forest to known patch locations where snails were encountered far more frequently. In these forested locations, foragers encountered about 1 snail every 2.6 minutes on average. Most of these patches were associated with *Irvingia gabonensis*. Snails were often found on tree trunks/branches and/or attached to the leaves of trees or living vegetation but were rarely found on the ground. The latter was primarily due to the detritus, which littered the forest floor making the snails invisible. Some snails were knocked off tree trunks or branches with long, makeshift poles and, in a few cases, small children climbed up a tree trunk to retrieve snails. The collected snails were usually placed in one or more women's collecting basket and transported to a location near the residential camp. At these locations, the snails were partitioned into separate Marantaceae leaf packets. Some of these packets were destined for trade or sale to farmers, while others were used for domestic consumption by the collector and their family (see Figs. 2 and 3).



Fig. 2: Live newly collected GWAS.



Fig. 3: Live snails collected by foragers in a leaf packet prior to processing.

Live snails were usually prepared and consumed on the same day that they were collected and were not stored for later consumption. Although Tanyitiku (2022) describes methods used by urban dwellers and street vendors in West Africa to preserve snail meat such as sun drying and smoking, none of these preservation techniques were used in this area. In Ndele and Grima, collected snails were traded or sold alive and still in their shells, extracted meat was never exchanged or sold. The snails were processed for consumption in a variety of different ways, and some preparation techniques were associated with specific ethnic groups. Forest foragers more often used a wider variety of processing techniques than the farmer populations. To remove the shell, foragers usually broke the shell while the snail was alive. They often used their hands to crush the shells but would also use a knife handle or wooden baton to break the shells (see Fig. 4). The foragers would then pick out the larger and more visible pieces of shell before washing and cooking the meat (see Fig. 5). Both foragers and farmers often used a thin stick or knife blade to lever the meat out of the shell while the snail was still alive leaving the shells unbroken. This processing method was preferred by food producer populations. Farmers also practiced whole snail skewering which involved placing live snails in a shallow pan of water (see Figs. 6 and 7) and waiting until the snails raised their pneumostome (breathing hole) above the water. The snails were then skewered through the foot on a thin wooden stick and roasted directly over the fire. Usually, the shell fell off while the snails were being roasted. This preparation technique was only used by food producers, not foragers.



Fig. 4: Forager woman processing snails with a makeshift wooden baton and anvil.



Fig. 5: Processed snail meat after being removed using a wooden baton.

With the exception of the last processing method described above, extracted meat was cleaned by washing it in water after it was removed from the shell and before consumption. Tanyitiku (2022) describes washing procedures used by urban dwellers in West Africa that involve mixing the deshelled meat in water with limestone, lime or salt to reduce the slimy exude and feces. However, in this rural context the procedure was a fairly simple process involving one or more rinses with water with no additives. Rinsing snail meat prior to consumption is essential because it can help remove attached feces, mucus, shell fragments, and other gritty materials, especially soil.

In this context, most meal preparation and cooking usually took place outside the domicile at unprepared thermal combustion features. Snails were cooked in a variety of ways. One of the most widely used methods was to skewer and roast the snails over a fire like a kabob (see Fig. 7). Snail meat was also placed in a pot as part of stew that might involve vegetables, and/or meat from other animals. Alternately, snail meat was sauteed in a shallow pan over a fire. The shells and their fragments were not used for nonconsumptive purposes but were discarded in different ways depending on how the snails were processed. If the meat was levered from the shells, complete unburned shells were often discarded in leaf packets or thrown into trash middens. Shell fragments that were picked from the meat were swept or thrown into existing internal or external thermal combustion features.



Fig. 6: Food producer threading whole live snails on wooden skewer.



Fig. 7: Whole snails skewered prior to roasting.

In comparison to other resources, especially terrestrial mammalian prey, snails were a low return resource (as measured by kcals per hour). The mean post-encounter return rate for hand-collecting snails which includes the amount of time it takes to collect and process but excludes cooking time is 194 kcal per hour (SD=188 kcal per hr).

Other common resources, such as net-hunting small duikers were equally low return with post-encounter return rates of 106-215 kcal per hour (after Lupo and Schmitt 2005: Table 2). However, net-hunting was primarily a dry season activity and in comparison to other kinds of prey and hunts conducted during the wet season such as hand collecting, snares, and spears, snails were the lowest ranked prey item (Lupo and Schmitt 2005: Table 2). However, snail collecting was lower risk in comparison to other kinds of hunting activities. While the yield from collecting snails as measured by the liveweight of unprocessed snails varied (average =750 gm, StD=851gm), it was always successful. By way of comparison, certain prey species are associated with a much higher rate of failure (Lupo and Schmitt 2005: Table 2).

Sungu: Wet Season Camp

Sungu was a wet season forest forager camp documented and recorded in 2001 about 4 months after it had been abandoned. Many of the foragers who occupied Sungu lived also occupied Grima during the dry season. As part of data collection, researchers interviewed an individual who occupied Sungu with his family. The camp was occupied for approximately 3 1/2 months during the wet season (June, July and August) of 2000. It was situated off the edge of a forest in a wet savanna, surrounded by tall grasses, ferns, and scattered trees. Confirmed activities which took place during the period when the site was occupied included snail collection and hunting by hand, snares and spears.

The site spans some 3, 375 m^2 and was occupied by 120 people (58 adults, 62 children and infants). It consisted of about thirty domestic features and most of these were traditional dome-shaped circular structures made from a cane framework covered by Marantaceae and/or palm leaves (see Fig. 8), but there were at least six rectangular structures made with poles, and bamboo, palm, or Marantaceae leaves. Other features included two small chicken coops, exterior ash and charcoal mixed trash dumps, and thermal features in the form of unprepared fires located within and outside most domestic features. At least two unprepared roasting pit features for giant pouched rats, pangolins, and caterpillars were identified by the individual who occupied the site. These consisted of informal and unlined rectangular-shaped fire pits with make-shift bamboo grills situated between 18-24 inches above the fire. The average area of the domestic brush domed structures (as measured from the inside walls) was 3.62 m^2 and average maximum height inside the structure was 138.8 cm. Most, but not all, residential features had an interior and exterior unprepared fire (average area of interior: .41m^2, average area of external .31m^2). A total of five separate ash/charcoal dumps outside of domestic structures were found on the site and each was within 3 to 4 meters of a domicile (see Fig. 9).



Fig. 8: Remains of a cane-domed structure. Note palm leaves in the background which were originally covering the frame. The wooden poles inside the hut are the remains of a bed.



Fig. 9: Example of an ash/charcoal dump outside a domicile.

Sungu was mapped and all visible bones were collected from the surface of the entire identified site (including ash/charcoal midden areas). The surface was a loose sandy matrix, so some bones were likely missed during collection. At least 3 dried leave packages containing complete GWAS shells and dried snail eggs were found on the sites surface behind domiciles. These were recorded but the shells were not collected. A sample of 11 thermal

combustion features (8 interior and 3 exterior fires) including one of the identified roasting features were mapped and test excavated. Test excavation units were judgmentally placed over exposed surface areas of the combustion features. These minimally measured between 50 x 50 cm with some units measuring a bit larger depending on the size of the feature, and the depth of the fill that varied most were excavated to a depth of 2 to 3 cm below the surface and/or where sediment staining and burned materials disappeared. The excavated sediments were passed through a ¼ in mesh screen and all of the bone and shell fragments were collected.

Analysis of Sungu Assemblage Zooarchaeological Assemblages

The Sunga faunal assemblage presents an opportunity to evaluate some of the different characteristics used by researchers to infer an anthropogenic origin of terrestrial gastropod assemblages. In this analysis, these characteristics are comparatively evaluated relative to other fauna in the assemblage rather than as standalone traits. This comparative analysis of fragmentation and burning only considers small-bodied prey (<10 kg) because of the known differences in butchering and processing activities between large and small prey. Here we examine taxonomic composition, the proportion of complete specimens, the prevalence of burning displayed by specimens, and the spatial distribution of remains relative features. Table 2 reports the assemblage composition and abundances as measured by NISP for the Sungu encampment. Some of these values differ from those previously reported in Lupo and Schmitt (2005) because of an increased access to additional comparative specimens later in time. Furthermore, the snail component of the assemblage was unreported in the prior publication.

The taxonomic composition of the assemblage contains a wide range of species and while it contains the remains of duikers, it is not dominated by these species unlike previously reported dry season ethnoarchaeological assemblages (see Lupo and Schmitt 2005: Table 6). In prior analysis comparing the richness and evenness among Central African ethnoarchaeological sites, Sungu has greater richness and evenness compared to dry season sites (Lupo and Schmitt 2005: Table 6). The range of species represented in Sungu is dominated by prey that were hand or snare captured such as pangolins, giant pouched rats, tortoises, monitor lizards, small carnivores and GWAS. The latter were monospecific (see Fig. 2). Even though there are several different sub-species of edible giant terrestrial mollusks in the Central Africa, none of these have been recorded in this part of the forest and collection was focused on one species.

The three most numerous species in the assemblage include pangolin, GWAS, and giant pouched rats. Of these, pangolin remains are inflated in comparison to other specimens because the counts include scales which represent 96% of the total NISP for this species. If scales are excluded from consideration, giant pouched rats represent the highest NISP. Similarly, gastropod abundances are also inflated because the NISP includes whole and fragmentary shell fragments. GWAS shells are very friable and quickly broke into tiny fragments. The average fragment size for collected snail shells was 12.17 mm, but smaller pieces likely escaped collection. If fragments are eliminated from consideration and only complete shells are counted, GWAS represents the most abundant species as measured by NISP.

Because many of the species in the assemblage are smaller in body size, the proportion of complete bones is larger than might be expected for larger bodied prey that often have bones fragmented during butchery and culinary processing. Of all the small-sized mammalian species (<10 kg in body weight), the highest proportion of complete NISP are palm civet, GWAS, and giant pouched rats. Of these, approximately 37% of the NISP include whole intact snail shells and almost all of these (except one) were found associated with the dried leaf packets mentioned above. A 2x2 contingency test comparing NISP completeness vs incompleteness of snails to all other small bodied fauna (<10 kg, excluding pangolin scales) shows that there is no difference in the prevalence of complete specimens among small prey (X^2=2.52, df=1, p=.11).

Table 2 also shows visible burning displayed by the faunal specimens. Burning here was evaluated solely by surface discoloration based on visual inspection not mineralogical changes to the shell. For small game in Sungu, giant pouched rats and pangolins have the largest numbers and proportions of burned remains. Most of the burned remains for pangolins were scales, but when these were excluded the proportion and number of burned bones was elevated in comparison to other fauna (skeletal NISP 17 or 53% were burned). Proportionally slightly fewer GWAS or 31% of the NISP were burned compared to other small game. Burning was only displayed by GWAS fragments, not complete shells. A chi^2 comparing the incidence of burning displayed by GWAS to other small prey remains (<10 kg, excluding pangolin scales) shows similarity in treatment (X^2=.24, p=.62 with a Yates correction) across small fauna and snails.

Analysis of the spatial association of the faunal remains in Sungu considers all specimens in the assemblage. As reported, spatial concentrations of complete GWAS shells were found associated with the remains of leave packets behind domestic features (see Table 3). Shell fragments were most often found associated with thermal combustion features (i.e., interior and exterior fires and roasting pits) and less often in other parts of the site especially hut interiors. A X^2 goodness-of-fit calculated among the three site areas where shells were found (thermal features, interior charcoal lenses and exterior areas in between domiciles) shows that these remains are unequally distributed among these locations (X^2=12.93, df:2, p=.0016). In general, far fewer shell fragments were associated with charcoal/ash lenses than other areas. Comparisons of the incidence of shell fragments within thermal combustion features to other areas of the site (lenses and exterior areas between domiciles combined) do not significantly differ (X^2=.43, df: 1, p=.51). In general, snail shells were not more often associated with thermal combustion features than any other location on site. When the spatial distribution of snail remains is compared to all other faunal remains recovered from the site, the distribution of GWAS across the site appears to be similar to all other fauna. A comparison between GWAS remains and all other fauna (excluding pangolin scales) is X^2=3.4609, df=1, p=.062837 and shows a p-value is slightly greater than .05 for a two-sided test. However, and while this is not statistically significant, it does suggest that GWAS remains were slightly more frequently associated with combustion features in comparison to other animal remains. There are, however, some differences in shell NISP between interior and exterior combustion features. Thermal combustion features that are exterior to domiciles have somewhat higher proportions of shell fragments relative to other bones than interior thermal combustion features (20.2% versus 14.7 of NISP %). But the sample size of shells in exterior to interior thermal combustion features is too small to demonstrate statistically robust differences and far fewer interior fires were tested in comparison to exterior fires.

Not surprisingly, almost all the burned shell fragments were associated with thermal combustion features (interior and exterior).

Table 2: Sungu Assemblage Composition and Distribution of Burning

Taxa or animal group/Common name	NISP	%NISP burned (NISP burned)	%NISP complete[1] (NISP complete)
Gastropods			
Archachatina marginata/ West African Giant Land snail	84	31 (26)	37 (31)
Mammalian Small Prey (<10 kg body weight)			
Nandinia binotata/Palm civet	21	5 (1)	60 (12)
Philantomba monticola/Blue duiker	34	29 (10)	23.5 (8)
Cricetomys gambianus/Giant pouched rat	98	47 (46)	31 (30)
Atherurus africanus/Brushy-tailed porcupine	2	0	50 (1)
Phataginus tricuspis/Tree pangolin[2]	457	73 (334)	97 (443)
Herpestidae/Mongoose	1	0	0
Cercopithecoidea monkey, undifferentiated	31	16 (5)	22.5 (7)
Mammalian Medium prey (10-25 kg body weight)			
Medium Duiker[3]	16	6 (1)	31 (5)
Potamochoerus porcus/Red river hog	5	0	0
Reptiles			
Varanus niloticus/ Nile monitor lizard	37	35 (13)	13.5 (5)
Kinixys erosa/Land tortoise	4	0	0
Serpent	4	0	75 (3)
Very Small mammals (<1 kg)			
Undifferentiated small mammals[4]	19	79 (15)	
Unidentified bone fragments[5]	143	64 (92)	
Total Number of Bone Fragments	956	(543)	

[1]NISP that are complete are nearly complete.
[2]Pangolin NISP is inflated because it includes 440 scales or about 96% of the NISP. Pangolins are completely covered in scales, and these could represent one animal. Similarly, NISP complete is largely scales not skeletal elements.
[3]Medium-sized duikers likely include the most commonly caught species in this area such as Bay duiker (*Cephalophus dorsalis*) and Peter's duiker (*Cephalophus callipygus*), but possibly other species.
[4]Undifferentiated bones from small fauna defined here as <1 kg body weight. Includes two undifferentiated squirrel remains reported in Lupo and Schmitt 2005.
[5]Unidentifiable bone fragments are included here for completeness and are not considered as counts in any of the analyses discussed here.

Table 3: Spatial Association of Sungu Faunal Remains[1]

Taxon	NISP Interior Fire	NISP Exterior Fire	NISP Hut Interior	NISP Ash/charcoal Exterior	NISP Exterior Area
Blue duiker	1	1	1		31
Monitor lizard	13		7		17
Civet	1				20
Snails	20	19		13	32
Giant Pouched rat	27	21	2	11	37
M. Duiker	2		1		13
Monkey	8				23
Pangolin	60	9			388

1: Only faunal remains with NISP > 5 are considered here.

Discussion of Results

The anthropogenic origin of the snails in Sungu assemblage was established via interviews with the camp occupants. In concert with observations of GWAS collecting and processing described above, this allowed an ideal opportunity to evaluate the range of characteristics currently used to establish the anthropogenic origin of gastropods in prehistoric assemblages. Here we compared several common characteristics (completeness of specimens, incidence of burning and spatial association with combustion features) of GWAS remains relative to other prey in the assemblage. However, rather than using these as stand-alone characteristics, this analysis employed a comparative approach. Overall, the analyses shows that GWAS remains received similar treatment as other small game on the site. This is important because it means that similarity in treatment with other faunal remains can also be used as further evidence of anthropogenic origins.

The analysis found high frequencies of complete snail shells associated with an anthropogenic assemblage. In this case, complete shells were associated with vegetable collecting packets. However, shell fragments were also present, and these were slightly more likely associated with thermal combustion features. In addition, shell fragments were more likely to display visible evidence of burning than complete shells. However, and again, it is possible that the incidence of burning displayed by shells was higher than reported here because changes in shell chemistry resulting from the exposure to fire were not evaluated in this sample. While whole shell and fragments were often associated with features and artifacts (leaf packets), the association did not significantly differ from that of other fauna in the assemblage. There was a slight tendency for shell fragments to be more commonly associated with thermal features than other locations and in comparison to other remains.

At least some of the characteristics analyzed here can also reflect the method of preparation. Ethnoarchaeological observations showed that snail shells were sometimes discarded complete when the meat was levered from the shell. This activity is reflected in Sungu by the clusters of complete snail shells associated with dried leave collection packets. Because snails were almost always consumed on the same day that they were collected and levered meat was never traded or sold, this also reflects on-site consumption by foragers. Fragmentary shells were also found in the Sungu assemblage, and these likely result from the shell-crushing methods described above. While shells fragments were found associated with thermal combustion features, we suggest this association was most likely the result of site clean-up or incidental to consumption (i.e., people throwing shell bits into the fire as they consume the snails). Observations of forest foragers show that while fire was used to cook snail meat, it was not required to remove the meat from the shells. At least some of the preparation techniques described here, whole snail skewering practiced by food producers, could result in burning on snail shells. Clearly, there are other methods for preparing terrestrial land snails not observed or reported in this context. For instance, historical sources in North Africa discuss the use of roasting pits for preparing land snails. In this context, the snails were placed into prepared roasting pit that was dug into the sand in which a fire was started and eventually the charcoal removed. Then the snails were placed in the pit which was covered with hot sand and a fire was built on top. According to Robbins (1847:105) it took about 15 mins to cook the snails in the pit. This kind of processing technique could result in large numbers of burned

or heat altered shells and shell fragments associated with thermal combustion features (see for example Lubbell et al. 1976).

Archeological Implications of Terrestrial Gastropod Exploitation

In this ethnoarchaeological context, terrestrial land snails were largely collected, consumed and/or traded by forest foragers during the wet season. During the wet season, there was a decrease in the number of terrestrial animals and amount of meat brought into camp. Furthermore, the main labor force used to collect of this resource were women and children who were not deployed in other activities. GWAS were a fairly low-ranked resource in comparison to most terrestrial game, but their inclusion in the diet here represents a seasonal resource pursued when the availability of other protein sources was temporarily limited rather than an overall indicator of dietary shift. In this case, terrestrial gastropods could provide an important source of critical nutrients, especially calcium, which were quite restricted in other wild resources.

In prehistoric contexts, researchers might expect the seasonal exploitation of a nutritionally high-value resource under similar circumstances such as when available labor pools were not engaged in other activities that could provide higher returns, when other protein sources were seasonally depressed due to behavior depression and/or changes in hunting technology, and/or where there are significant nutritional benefits derived from seasonal resources. While it might be expected that gastropods would enter the diet in response to declining foraging efficiency and reductions in high ranked prey, seasonal shifts in foraging patterns can potentially mimic larger-scale shifts and should also be considered as a possible explanation for the appearance of small-sized resources, such as snails. In this particular ethnoarchaeological example, previously reported differences among assemblages in evenness and species richness in concert with other seasonal indicators can help distinguish large-scale declining foraging efficiency from seasonal responses. Wet season assemblages, in this context, had higher species richness and more even distribution than dry season assemblages which tend to be less diverse and more uneven. While distinguishing critical nutritional deficits can be challenging (Lupo 2025), the value of small resources such as gastropods cannot be underestimated. Important and limited nutrients can elevate the value of small resources beyond their caloric value or post-encounter return rate.

Gastropod Taphonomy and Allied Evidence

In the zooarchaeological record, the consumption of terrestrial gastropods appears relatively late. However, as discussed by de Pablo et al. (2011) the under-reporting of shells and shell fragments remains a problem. Gastropod shells tend to be highly friable and fall apart during collection. Furthermore, past assumptions about what was important in prehistoric subsistence may have led researchers to minimize the presence of small resources such as snails as dietary indicators or attribute them to natural deposition. Ongoing and future excavations aimed at collecting and analyzing sediments and micro-debris may increase the number of sites containing these resources. Furthermore, while the shells themselves represent a direct source of evidence, some of the preparation techniques described here can mitigate against the recovery of highly visible shell remains. As described, forest foragers often processed the snails by crushing the shells into fragments. Food producers reported that they did not process snails

by this method because they wanted to avoid consuming shell fragments. During the preparation and consumption of snail meat, foragers often tried to pick out larger-sized shell fragments but some of the small fragments likely were consumed and expelled in feces. This could potentially lead to fecal remains with characteristics that overlap with those created by nonhuman consumption or equifinality. Differences in the amount and size-range of shell fragments and other taphonomic indicators could be used to distinguish human from nonhuman remains. This possibility is not investigated here but could well be a subject of future investigations.

The consumption of land snails could also be implicated by other kinds of indirect archaeological evidence. The consumption of terrestrial gastropod meat can result in the ingestion sediments. Sophisticated methods of washing GWAS meat, as described by Tanyitiku (2022), can remove all of the grit from the meat. However, simpler techniques used in this rural context never completely removed the sediment from the meat. In authors' experience, and despite multiple washings prior to consumption, GWAS meat almost always contained grit from sediments. In an archaeological context, the consumption of gritty foods is often inferred from surface tooth enamel damage. For instance, recent analysis of tooth enamel surfaces identified highly abraded buccal surfaces in of *Homo antecessor* specimens from Atapuerca, Spain (1.2-.8 mya) (Pérez- Pérez et al. 2017). Pérez- Pérez et al. (2017) argue that this indicates the ingestion of mechanically demanding and grit loaded foods that differs from the diets of neanderthals and other hominins. While there is no direct evidence that *H. antecessor* consumed terrestrial gastropods, enamel abrasion could potentially result from the consumption of gritty snail meat. Additionally, tiny shell fragments might also be recovered from dental calculus. For example, dental calculus studies of some of these specimens at site Sima Del Elefante, which has the oldest remains dating to 1.2 mya, shows the consumption of gathered invertebrates (e.g., insect parts) (Hardy et al. 2017). These kinds of analyses could augment the rare and often fragmentary evidence of gastropod consumption.

Conclusions

This paper reports some of the first ethnoarchaeological observations of forest foragers exploiting GWAS for consumption. In this context the exploitation of terrestrial gastropods is often pursued by women (often accompanied by children) as part of a flexible seasonal strategy when protein sources are limited and where these labor pools are not diverted by other activities. These observations are tied to the analysis of an ethnoarchaeological faunal collection to evaluate some of the different characteristics researchers often use to infer an anthropogenic origin of terrestrial gastropod assemblages. These analyses underscore the validity of some of these characteristics but also point to additional information on snail processing techniques that can be inferred from these same data. These observations can serve as models for the prehistoric inclusion of lower-ranked small-prey items as part of a seasonal strategy rather than a marker of a larger dietary shift. Current scholarship suggests the appearance of flexible dietary patterns supported by a diversification of labor efforts and potentially including low-ranked resources emerged as early as the Early and Middle Pleistocene (Venkataraman et al. 2026). Given that some of these resources, such as land snails, do not require specialized technology and can provide a high nutritional supplement, gastropods may have served as an important seasonal resource for millenia.

Statements and Declarations

Competing Interests

The authors declare no financial, employment, or non-financial competing interests. The ethnoarchaeological research described here was supported by grants to Lupo and Schmitt from National Science Foundation under grant agreement (BCS-003988) and the L.S.B Leakey Foundation.

Compliance with Ethical Standards

The ethnoarchaeological research described here complied with the guidelines and received approval from the Institutional Review Board (IRB) of Washington State University. All Central African participants gave informed consent to participate in this research.

Author Contributions

K. Lupo and D. Schmitt obtained the funding for this research, contributed to the original study conception, design and data collection. J. Fancher assisted in the excavation and recovery of Sungu. The first draft was written by K. Lupo. Both authors (Lupo and Edwards) subsequently contributed to the refinement of the manuscript and analysis.

Acknowledgements

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