

THE FUNCTION OF THE EDGE-GROUND COBBLE PUT TO THE TEST AN INITIAL ASSESMENT

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Edge-ground cobbles constitute one of the most common artifact types found in pre-Arawak sites of the Antilles. Even though the importance of these artifacts as cultural markers has been widely recognized, the probable use(s) that they served have not been systematically addressed thus far in the Caribbean. As a result, an experiment was conducted in order to replicate the type of wear expressions that are commonly observed in this type of artifact, based primarily on the results of the starch grain analyses that have been conducted on similar tools recovered from Panama and Colombia, which have shown the presence of cultigens such as sweet potato, manioc, and maize, among others, in their faceted margins. After using cobbles with similar properties as those found archaeologically for processing each of these foodstuffs into an edible paste, I reached the conclusion that this type of activity could indeed result in the production of the marginal facet that characterizes edge-ground cobbles. This opened the door to argue for the possibility that some of these cultigens could have been introduced by the earliest immigrants to the islands prior to the Saladoid expansion, and thus to advocate for further studies on this regard.

One of the most ubiquitous artifacts in archaeological contexts in Puerto Rico and the rest of the Caribbean is the edge-ground cobble (also known as edge-grinders, pebble grinders, edged cobbles, *pollissoir latreaux*, *manos simples* or *majadores laterales*). This tool type consists of an ellipsoidal or half-moon shaped cobble, in most cases of a meta-volcanic material, that presents a ground facet along its longest and thinnest margin (Figure 1). This faceted section tends to be convex in cross-section, presenting a distinct boundary with both faces of the artifact. In addition to the faceted margin, most specimens tend to

present battering marks in one of their ends, usually the one with the most pointed form.

This type of implement has been found since the earliest occupations of the islands dated circa 7000 BP, as well as in both early and late Ceramic Age sites, thus making it one of the lithic artifacts that presents the longest history of use in Caribbean. Edge-ground cobbles also have a wide distribution in the West Indies, being found in sites from Trinidad (Harris 1976; Boomert 2000) to Cuba (Febles and Baena 1995; Kozlowski 1974), thus indicating a technological continuity that crosscuts island boundaries.



Figure 1. Experimental edge-ground cobbles. From clockwise from top left, specimens 1 through 4

Even though this artifact is of such high occurrence, its use(s) have never been formally tested in the Antilles. The only suggestions about its function have been based on morphological criteria, usually being generically defined as “grinding stones.” However, no direct evidence of this use estimation nor of the type(s) of material(s) that were processed with these have been provided thus far.

Recent evidence of starch grain residues found in the faceted margins of edge-ground cobbles recovered from Archaic sites in Panamá and Colombia have indicated the presence of tubers such as manioc, sweet potatoes and yams (Castillo and Aceituno 2000; Piperno and Holst 1998; Piperno and Pearsall 1998). In some cases, maize starch grains were also recovered from these artifacts as well as from the milling stones over which these were used. Several tests conducted by Ranere (1975; 1980a; 1980b) indicated the possibility that processing tubers with cobble tools might produce the type of wear observed in the edge-ground cobbles. The information generated by

Ranere’s tests and the aforementioned starch grain studies are particularly intriguing, because the recent state of evidence from Puerto Rico and the rest of the Caribbean indicates that domesticated resources such as those represented in the starch residues in the tools from Panamá and Colombia were not available for consumption for the earliest populations of the Antilles.

The prevalent notion in the Caribbean is that tubers such as manioc, sweet potato and *lerén*, among others, were introduced along with ceramics by the earliest Huecoid and Saladoid migrants from South America around 2500 BP. It has also been traditionally assumed that bitter manioc was processed only in the way described in the Early Spanish Chronicles – by grating, juicing and baking the pulp – and thus the possibility of the use of an artifact such as the edge-ground cobble for preparing edible foods from this type of root crop would definitely demand that other cooking techniques be explored. For the rest of the tubers, estimations about their processing have been based strictly on the early Spanish ethnohistoric record, which indicates that these were either boiled or roasted. Maize on the other hand, tends to be considered an even later introduction to the islands, and that it played a secondary role to root crops in the dietary composition of Ceramic Age societies. It was supposedly consumed either uncooked in its tender state, baked, or boiled.

As a result of these issues, an experiment was modeled to assess systematically the function of this type of lithic artifact. Briefly stated, the experiment consisted of processing some of the foodstuffs

represented in the starch grain analysis, both tubers (i.e. manioc and sweet potato) and maize, with cobbles of similar characteristics to those observed in archaeological specimens in order to establish if these faceted margins could be produced by the manipulation of these cultivars. The use-wear produced on the experimental specimens was then compared to that observed in edge-ground cobbles found at the Paso del Indio site, located in north-central Puerto Rico, in order to determine if specific traces of use associated with each of the processed materials could be discriminated, thus shedding some light into the behavioral patterns associated with the production of this artifact type.

Previous Research

As previously noted, edge-ground cobbles have been recovered from a vast array of sites in both the Caribbean and Circum-Caribbean areas. These types of implements were originally documented by Willey and McGimsey (1954) in the Monagrillo site located in the Pacific coast of Panama, which dates back to 4500 BP (Cooke 1995). Further testing in Panama in sites such as Cerro Mangote (McGimsey 1956), Casita de Piedra, Trapiche (Ranere 1975; 1976; 1980a), and Abrigo de Carabali shelters (Ranere and Cooke 1995), among others, reaffirmed the presence of these implements. These implements have not been found yet north of Panama.

In South America, the southernmost occurrence of edge-ground cobbles was documented in the Las Vegas Culture of western Ecuador, with dates that go back to circa 10,000 BP (Stotterth 1985). In Colombia, these artifacts have been found in a great array of sites as early as 10,030 BP (Gnecco 2000). These implements have been unearthed from Colombian rock shelters (Ardila 1984; Botiva 1989) as well

as from open air sites, both inland and coastal (Bray 1984; Castillo and Aceituno 2000; Groot 1995; Rodríguez 1991; 1995). This type of tool has also been documented in Archaic sites of northern Venezuela (Rouse and Crucent 1963; Sanoja 1983).

The ubiquitous occurrence of this type of implement in Tropical Archaic sites of the Circum-Caribbean region has led to its consideration as the “most typical plant-processing lithic tool found in the early and middle Holocene sites in the Humid tropics” (Piperno and Pearsall 1998:187). The importance of this type of artifact as a cultural marker has also been established in the Caribbean for Archaic contexts associated to the Ortoiroid series (Alegria et al. 1955; Boomert 2000; Rouse 1992). For instance, Boomert (2000:74) has recently suggested that “Although the function of the edge grinders at the Ortoiroid sites of Trinidad and South American mainland is not sufficiently known, these implements should be considered as the type artifacts of the Ortoiroid series.”

In the Caribbean, the earliest occurrence of edge-ground cobbles has been documented in the Banwari Trace and Poonah Road sites of Trinidad, with dates that go back to circa 7000 BP (Boomert 2000; Harris 1976). These have also been unearthed from pre-Arawak contexts in Martinique (Allaire and Mattioni 1992:63), the Virgin Islands (Lundberg 1989), Cuba (Febles and Baena 1995; Kozlowski 1974), Haiti (Rouse 1960; Rouse and Moore 1985) and the Dominican Republic (Veloz Maggiolo 1980).

In Puerto Rico, Alegria et al. (1955) were the first to document the presence of this artifact type in their excavations at the Cueva Maria de la Cruz site located in the northeastern part of the island. Additional

work in pre-Arawak sites of the island lead to the recovery of edge-ground cobbles in coastal sites (Figueroa 1991; Veloz Maggiolo et al. 1975), as well as in inland rock shelters (Dávila 1981; 2003; Martínez 1994) and open air locations (Ayes 1988; Figueredo 1976; Febles 1996; Tronolone et al. 1984). In Puerto Rico, most pre-Arawak sites have been ascribed to the Corosan Ortoiroid subseries, and it has been agreed that the “Edge grinders are diagnostic of the subseries.” (Rouse 1992:66).

Edge ground cobbles also have been found in early Ceramic Age sites of Puerto Rico (Rodríguez 2001; Rouse and Alegría 1990; Walker 1985), leading Pantel (1986:49) to argue that “the pebble grinder can be regarded now as a preceramic and early Hacienda Grande ceramic phase tool.” The finding of these implements in early ceramic contexts served as evidence for Pantel (1986) and Rouse and Alegría (1990) for the acculturation of Archaic peoples by the Saladoid immigrants, or of “trait borrowing” from the former by the latter. However, I have recently identified edge-ground cobbles in early Ostionoid contexts (Rodríguez 2002) as well as in sites dating to the latest manifestation of this series (Rodríguez 2003a). This, along with the continuities that were observed in other segments of material culture, lead me to argue that the persistence of Archaic technological traditions in post-Saladoid contexts might indeed indicate that some of the styles that have been observed within the Ostionoid series reflect the remains of developed-Archaic societies (Rodríguez 2003b).

Even though the culture-historical implications of this artifact type have been widely discussed in the Caribbean, there has been a general scarcity of studies of the uses that these implements were subjected to.

Alegría et al. (1955) originally proposed that these were used for seed grinding, a notion carried over from Willey and McGimsey’s (1954) interpretation of Monagrillo materials. Almost three decades later, Allaire and Mattioni (1983) indicated that the most likely use that edge-ground cobbles served was as woodworking tools, perhaps associated with the manufacture of canoes. Since Allaire and Mattioni’s work, most of the interpretations regarding this type of artifact have been limited to the motion in which it was used. Walker (1985:186) estimated that these materials “were used in a very uniform motion, probably held with the wider side of the tool facing the user and moved towards and away from the worker on a hard surface.” Lundberg (1989:110) shared this view, and considered that these were “used on a concave surface or manipulated with rocking motions.” However, none of these authors provided estimations about the material that was processed with this type of implement.

The most influential interpretation in this regard has been that provided by Ranere (1975). He conducted archaeological tests aimed at reproducing the faceted margin of this type of tool, based on the wear observed in materials recovered from several Chiriqui River sites in Panama. During his work he was able to produce a ground facet in a cobble by grinding tubers. This lead him to hypothesize that this type of artifact was used for processing root crops (Ranere 1975:204). This interpretation seems to have been partially supported by the microbotanical and stone residue analyses conducted in sites where edge-ground cobbles have been found. In Panama, the remains of a variety of tubers (e.g., manioc, *lerén*, arrowroot, sweet potato and yams, among others), have been found in the faceted margins of these tools as well as in the surfaces of milling stones over which

these were supposedly used (Piperno and Holst 1998). Both edge-ground cobbles and milling bases also showed starch grains from maize and legumes. The presence of starch grains from sweet potatoes, arrowroot, and legumes was reconfirmed in the analysis of materials from the San Isidro (Piperno and Pearsall 1998:200) and the sites peripheral to the Porce River (Castillo and Aceituno 2000) of Colombia.

The initial tests carried out by Ranere to assess the function of this type of implement have profound implications regarding not only the probable use of this type of artifact, but also the introduction of cultigens to the tropical forests of Panama and other parts of the Intermediate Area. However, the published descriptions of the experimental procedure that lead to his conclusions have been quite general, thus limiting the replicability and the comparability of his results. In order to expand on Ranere's methodological approach to the replication of this artifact type, in the following section I will provide specific information about the experimental procedure that was followed and the objective and effective materials that were used.

Analytical Procedures

Objective Materials

It is commonly argued that in use-modified lithic artifacts, the type of raw material and its original morphology are the criteria of primary importance in the selection of objective pieces for their intended functions. As a result, a survey of the existing literature of similar implements from the Antilles and the Circum-Caribbean area was conducted in order to determine the average dimensions, morphology, and raw materials that were mostly represented in edge-ground cobbles. As previously noted, the most common types of raw materials selected were river rolled meta-volcanics,

including mostly, but not limited to, basalt, andesite, rhyolite and diorite. Their morphologies tend to vary from ovoid to triangular in shape, and their dimensions mostly range between 3 to 6 cm in thickness, 6 to 12 cm in width and 8 to 16 cm in length. Due to the fact that these were handstones that were used without any intentional modification to their original morphology, cobbles with comfortable shapes were procured from the Rio Espiritu Santo in northeastern Puerto Rico by archaeologists Jeff Walker and Elvis Babilonia, based on the aforementioned attributes (Table 1).

Effective materials

As indicated earlier, the selection of the materials to be processed was derived from the previously cited results of the starch grain residue analyses (Piperno and Holst 1998; Piperno and Pearsall 1998). Two of the identified tubers were processed in the present experiment: manioc and sweet potatoes. Commercially available manioc (*Manihot esculenta*) was used in this study. Even though a distinction has usually been made within this tuber species based on the amount of prussic acid that it contains, namely the bitter and the sweet varieties, as has been noted previously (Cobley 1979; Coursey 1973; Nye 1991), such differentiation has no real taxonomic value as the acid content in these tend to be highly variable even within a single crop. Also, as indicated by Sturtevant (1968:179), even when differences in toxic content have been cited, their "toxicity is not associated with morphological features of the plant." This lack of formal morphological distinctions has also been observed in the sweet potato (*Ipomea batata*), as its variations are based primarily on its color and appearance, which depend upon "the amount of carotenoid pigments present in the skin and flesh, and the presence or absence of anthocyanins."

(Redhead 1989:45). The type used in the present study is the commercially available “orange” variety.

The selection of the type of maize (*Zea mays*) was more complex as, unlike the tubers previously described, corn types tend to present marked variations dependent upon the differences in the chemical compounds deposited or stored in the kernel (Adams 1999). In the present case, dry feeding or “ear corn” was selected for processing due to the lack of availability of indigenous maize varieties. According to Bressani (1992:2), the kernels of this type of maize “have a thick, hard and vitreous endosperm surrounding a small, granular, starchy center.”

Finally, another aspect worth considering was the selection of the partner implement over which foodstuffs were to be processed with the edge-ground cobbles. In Puerto Rico, most of the edge-ground cobbles that have been uncovered lack any direct association with milling stones or metates, leading some investigators to suggest that these were used over wood boards, which are absent in the archaeological record because of their lack of preservation (Rodríguez 2001; Walker 1985). However, the discovery of one of these stone bases in the same feature and stratigraphic unit as an edge-ground cobble in the Paso del Indio site seems to indicate their related use, thus leading me to process the different foodstuffs over a meta-volcanic milling stone. Also, in Panama a milling stone/edge-ground cobble complex has been identified based on the co-occurrence of these two artifact types (Ranere 1975; Piperno and Holst 1998). Similar starch grains have also been recovered from the milling stones that have been found in association to the edge-ground cobbles, thus providing additional evidence for their

combined use (Piperno and Holst 1998). A single mid-grained basalt boulder (length = 268.2 mm; width = 115.3 mm; thickness = 78.0 mm; weight = 7600 g), which showed similar dimensions to that obtained from the Paso del Indio site, was used throughout this study in order to control the variability in wear traces which might have been produced by the use of different contact surfaces.

Use Motion

The replication of the use to which edge-ground cobbles were submitted was based both on ethographic and ethnohistoric data, as well as on previous indications derived from the wear traces observed in this type of tool. It should be noted at this point that the lack of detailed descriptions that exist in the ethnohistoric and ethnographic literature of simple food processing techniques, especially when complex strategies are observed in the same contexts, put severe limitations on the development of methods that mirrored those employed by indigenous societies. Thus, the techniques that were employed for processing these materials were highly intuitive and were aimed primarily at producing an edible paste from the different foodstuffs that were used.

Sweet potatoes and manioc were peeled and macerated in their raw state. This decision was based primarily on the fact that I think that it is very unlikely that this pronounced facet is produced by mashing boiled or baked tubers, specially when one considers the hardness of the raw materials that were commonly selected for use as edge-ground cobbles. Also, there is ethnographic evidence from northern South America of the processing of raw tubers by pounding and grinding in order to produce a paste that could later be cooked by different methods (e.g., Brinez 2002; Chagnon 1977; Lancaster et. al. 1982; Lowie 1946; Metraux

and Kirchhoff 1963). For instance, Chagnon (1977:35) indicates that among the Yanomami, “sweet manioc, a root crop that is boiled or refined into a rough flour by grinding it on a rock and then converting the flour into thick, round cakes of baked cassava bread.” Another example of the use of pounding of raw tubers for their further processing was provided by Métraux and Kirchhoff (1963:356) from the Andean Veneluezan Chaké, as they observed that they “pound manioc, mix it with water, and heat it in a calabash placed among hot stones

until it coagulates.”

Both sweet potatoes and manioc were initially split lengthwise along their fibers with the tool’s most pointed end, and then individual tuber fragments were pounded and ground perpendicular to their fibers, which seemed to be the most efficient method of reducing the tubers to a pulp (Figures 2 and 3). Similar to what has been done by Ranere (1980a:125), pounding was followed by dragging the material to the center of the milling stone. However, in



Figure 2. Manioc processing sequence.



Figure 3. Sweet potato processing sequence.

contrast to his approach in which the mass was “drawn towards the user”, in this case I collected the material in any direction that was necessary in order to accumulate it in the center of the base for its further processing, but always in a motion perpendicular to the widest portion of the tool in order to maximize the amount of paste that was recovered in each dragging operation.

The selection of a specific method for processing maize was more difficult than that used for tubers due to the vast array of ways in which it could have been processed, as is documented in both the ethnographic and ethnohistoric records. For instance, in one of the most cited Spanish chronicles of the Greater Antilles, Las Casas (1927:262) indicated that maize “was consumed tender or wet, as a soup with water.” On the other hand, Oviedo (1959:15) observed in the Tainos of the Dominican Republic that “when the ears are tender they are eaten almost as milk”, but he then indicated that these were roasted and eaten without further processing. Oviedo (1959:15) later observed in Cape Tiburon of El Darien that:

The Indian women grind it, with the full strength of their arms, in a concave stone with another round stone which they hold in their hands, just as painters are accustomed to grind their colors. As they grind, from time to time they pour in a little water which mixes with the meal. This produces a paste-like dough. A small portion of the dough is wrapped in a leaf which is used for this purpose, or in a corn husk, or in some other leaf. Then it is placed in the coals of a fire and baked. The dough becomes firm, takes the color of white bread, and a crust forms on the outside.

This type of processing seems to be appropriate for the production of the meal used in the confection of *guanimes*, a tamale-like food that was supposedly consumed by the Taino peoples of the Greater Antilles and whose name is Arawak in origin (Hernandez 1977:212).

In the present experiment, maize was soaked in water for 24 hours prior to its processing. This decision was partly based on the results of preliminary tests aimed at deciding the most efficient method in which grains could be processed over flat milling stones. After grinding dry kernels it quickly became evident that these would be very difficult to process over a borderless base because they jumped out of the milling stone when pounded due to their lack of confinement, although in the present case this could have resulted from the limited size of the stone base used in this study and my limited expertise in corn processing. It also became evident that it would be much more efficient to grind maize with the faces of these cobbles instead than with their margins, as more grains could have been impacted by each blow. Furthermore, the soaking of corn for its later processing has been observed among indigenous peoples in the Circum-Caribbean area such as the Emberú of El Darien (Isaacson 1984), who are one of the groups living closest to the location described in Oviedo’s account. After soaking, water was slowly added to the kernels while pounding them into a paste following a process similar to that described by Oviedo, with a use motion that mimicked that used for processing the tubers (Figure 4).

Each tool was used for a total of 12 hours, with observations about alterations of the use margins or any other salient feature being recorded at two hour intervals,



Figure 4. Corn processing stages.

although in cases where a discernable modification was observed in less time, it was recorded then. Two of the experimental cobbles were used to process manioc, another one maize, and the final one was employed on one side to process sweet potato and the other maize. During the experiment, the peeled tubers and maize grains were weighed before and after processing. For microscopic analysis, the protocol adhered to that developed by Adams (1989, 1999, 2002) for determining wear patterns on grinding tools. Each item was hand washed with tap water, and was then analyzed using a low magnification approach, varying from 10X to 70X. The wear patterns that were observed on the experimental specimens were then compared to those in the archaeological materials from

the Paso del Indio site, which served as the artefactual baseline in this study.

Results

Facet formation

In all specimens, detectable modifications were observed after processing both tubers and maize for a couple of hours. Invariably, I observed that the most intense modifications were registered in the first two hours of work in the form of smoothing in the areas of higher elevations of the tool's use surface (Figure 5). In the remaining time an intensification of the grinding or polish wear and the definition of the facet was observed. However, some differences were noted regarding the quickness in which a discernible facet was formed while processing the different types of materials, as well as in the intensity of the wear that was observed. In the case of tubers, the processing of both manioc and sweet potatoes took similar time spans to create visible alterations in the tools, although a discernible facet was created in each specimen at different time intervals. In the siliceous tuff specimen (#2), the facet was created after 2 hours of work, while in the andesite cobble (specimen 1) it was observed after 3 hours. In the basalt cobble, although some smoothed wear was also observed after the first two hours of work, a clear facet could not be produced even after the entire 12 hours of work. The wear observed in the three specimens used to process tubers was smooth, but none presented polishing of their use surface.

In the case of maize, marked alterations were observed in the specimens after their use for merely 15 minutes in the form of surface smoothing. In specimen 3 a noticeable facet was observed after just one



Figure 5. Specimen 1 unmodified (top) and after four hours of use (bottom).

and a half hour of work, while in specimen 4 no complete leveling of the use surface was produced even after the complete 12 hours of work had elapsed. This difference seems to be related to the original morphology of the use surface, as the one in specimen 3 was much more angular than that in specimen 4, which presented a more square outline. Both of these experimental specimens were made of basalt, and thus raw material hardness could be eliminated as a source of variation in the time taken for the formation of the facet, thus probably indicating that the original morphology of the use surface plays a major role in the time it takes for the creation of a discernible facet. It should also be noted that in specimen 4, the grinding wear of the side used for corn processing produced a brighter polish than the one employed to pound sweet potatoes. This could be a result of different factors, such as the higher silica content of maize, which serves as an abrasive agent during the grinding process. Also, the use of water when creating the paste and the oil contained in the kernels might have served as lubricants that increased the frictional energy of these materials, thus producing higher degrees of sheen (Adams 2002:36).

In general terms, it seems clear that the pounding that these cobbles were submitted to served as an indirect pecking mechanism that normalized the overall shape of the tool's use surface, while the grinding and dragging refined its morphology. The unidirectional orientation of the striations that are observed macroscopically were caused, not by a reciprocal movement as been previously suggested, but from the use of the tool always with its widest part facing the processed material so more mass could be collected in each dragging episode. I also noted that the pitted attrition that is observed on the ends of these tools tended to be produced by the initial splitting of the tubers, which created a wear similar to that observed in pecking stones. The use of the ends of the implement did not seem to be necessary in the processing of maize, as the initial pounding of the grains was done more efficiently with the use margin.

Another observation has to do with the reasons for the formation of a convex use surface when seen in cross section. Previously, it was argued that it was caused by the rocking motion in which these artifacts were used, which ground the use surface evenly during each stroke.

However, it rather seems that this morphology resulted, at least in part, from the accumulation of material at the center of the use surface during pounding which served as a protective coat, thus limiting the severing of this portion of the use surface. On the other hand, the collection of the processed material with the tool slightly slanted towards the direction of dragging tended to abrade the sides of the working surface, thus resulting in its convex morphology. This would also explain why the striations are more clearly visible near the corners of each facet than in their center (Figure 6). Also, visible polishing was formed in some of the specimens in the areas where these were being held.

During pounding, several flakes were detached from the corners of the working facets, especially from the fine-grained siliceous tuff cobble. The dangers of the detachment of small flakes from brittle materials while producing the paste could explain the preference of basic rocks over materials with conchoidal properties for their use as edge-ground cobbles. It should also be noted that comfort must have been major criteria for the selection of these cobbles for use, as this is a rather strenuous

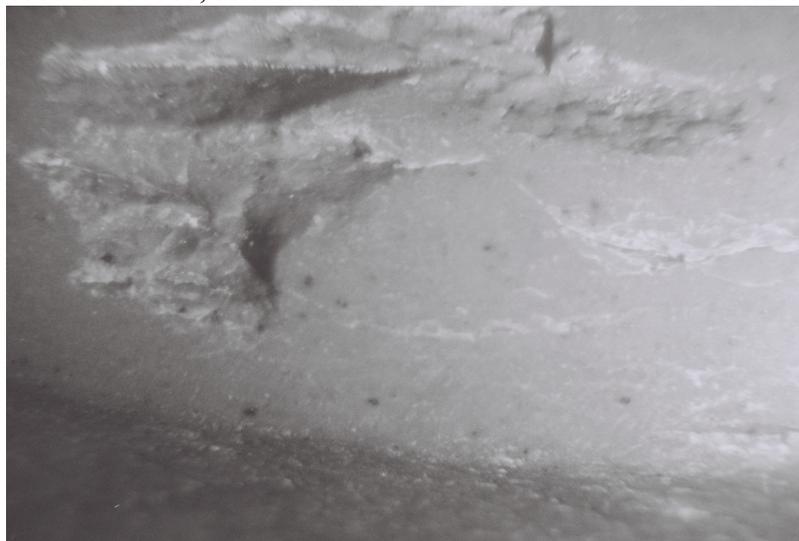


Figure 6. Corner striations in specimen 2 (10x).

activity and thus the duration of each food processing episode might have been extended with tools of higher comfort level. This might explain the general homogeneity in forms that are observed in this artifact type in different contexts.

Finally, it should be noted that the grinding base suffered some alterations during this process. These were limited exclusively to grinding wear in the center of the piece as well as some pocked depressions, most likely being produced during the pounding of the processed materials. No discernible concavity was produced in the contact surface of this base after the 60 hours of work.

Microscopic traces

At the microscopic level, the analysis of wear traces did not prove very useful as no specific wear patterns could be directly associated with each of the different processed materials. All of the artifacts showed similar striations when observed under the microscope, irrespective of the foodstuff that was processed. As previously noted, these striations were mostly unidirectional, although some randomly oriented ones were also noted. Even though the more marked striations were observed in the corners of the facets, some faint ones were also noted in the center of the tools, especially when these occurred over phenocrysts (Figure 7).

In addition to the striations, it was also observed that most of the grains of the faceted margins were worn flat, providing the surface with very leveled microtopography, although in some cases the interstices could still be observed. These interstices do

not seem to have received much alteration, as most of them presented a rough angular surface. This, however, was not the case in the siliceous tuff specimen (#2), in which the grinding leveled all of its grains, thus erasing the interstices and reaching the matrix of the rock.

Impact fractures were also observed in the use surface of edge-ground cobbles in the form of detached chips of material. These were rather shallow and tended to be confined to the central portion of the use surface, due to the fact that this was where the most forceful strokes were recorded during the pounding of the materials.

Unfortunately, when compared against the archaeological specimens no specific patterns could be discerned, as these showed high degrees of weathering thus masking

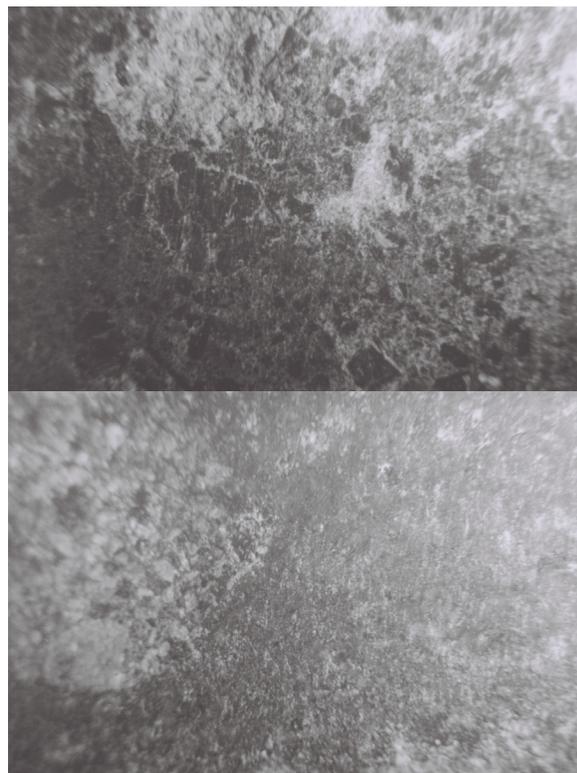


Figure 7. Unidirectional striations in experimental (top) (specimen 3) and archaeological (bottom) (PDI-1.4208) edge ground cobbles (10x).

their microscopic use signatures. However, most of them presented striations oriented in a direction similar to that observed in the experimental specimens, thus showing that at least their kinetics were similar (Figure 7). In most cases, the grains were also worn out, although this seemed to vary in the different artifacts depending on their raw materials, contact surfaces, and probably also on the amount of time in which these were used.

The limitations for isolating specific wear traces associated to each of the processed foods might be surpassed in the future with the use higher magnification microscopy, which might show discernible patterns that are otherwise invisible at the level of analysis used in this study. Also, a more representative archaeological and experimental collection of edge-ground cobbles as well as a better trained eye for identifying specific types of wear could immensely benefit the identification of specific use marks in the future. However, the fact that these are multifunctional implements should always be considered in their use interpretations, as this character definitely complicates the definition of the specific type of material(s) that was processed with each edge-ground cobble, as will be discussed below.

Discussion

As previously noted, the purpose of the present experiment was to determine if the processing of two types of tubers and maize could result in the formation of the distinguishing facet that is characteristic of the artifact type known as the edge-ground cobble. At the macroscopic level, this experiment corroborated Ranere's (1975) initial observations that tuber processing might produce the flattened ablation of the use surface that is characteristic of these implements. However, it expanded on his observations by showing that such use

alteration can also be created by the processing of maize, in this case in its soaked form. I recognize that the number of tests that were made in the present experiment are too limited to represent a statistically valid sample. However, hopefully this study promotes future experiments with these and other use-modified materials in the West Indies, which might shed some light on their possible role in food processing practices in pre-Colonial times.

It is also evident that many variables might come into play and account for a wide range of variability in the formation of both microscopic and macroscopic wear expressions in these tools, and that perhaps the processing of almost any type of foodstuff following similar kinetics over a comparable contact surface as that used in the present study might result in the faceting of their edges. Furthermore, it should be noted that this experiment only explored one of the many possible food processing strategies in which these tools could have been used and thus additional testing is required to characterize the differential wear that may be created by changing the combination of raw materials, foodstuffs, and processing techniques, since any of these might produce distinct patterns in the archaeological specimens.

As previously mentioned, the fact that these items seem to be multifunctional definitely limits the definition of a single set of wear expressions associated with this tool type, especially at the microscopic level. The multipurpose character of this type of implement becomes evident when one analyzes the results of starch grain analyses that have been conducted on those tools. For instance, from the facet of a single edge-ground cobble from Colombia, Piperno and Pearsall (1998:200) and Gnecco (2000:131)

indicate the presence of starch grains representative of at least three different types of tubers, grasses and legumes, while other from Panama had residues of two different types of tubers, and yet another one contained phytoliths from arrowroot as well as maize. Therefore, these results seem to show that a single tool was used to process a wide array of materials and that the micro-wear that will be observed in these implements will most likely be evidencing the last use to which these were submitted. Also, the common evidence of other use traces in these implements such as nutting and percussive wear, as well as the presence of red pigments (probably ochre) in the use margins of some of these specimens, signals the fact that these could have been submitted to other functions besides the ones explored in the present study such as pigment production and wood-working, among others.

Other uses which might have created these faceted edges have also been suggested in contexts culturally unrelated to the Circum-Caribbean area as well. For instance, Sims (1971) has reported “edged cobbles” from sites in northwestern California and has associated their use to hide processing. On the other hand, Crabtree and Swanson (1968) mentioned the use of similar items in the preparation of platforms for blade manufacture, while McGimsey (1956:156) indicated that edge-ground cobbles were related to “the preparation of large quantities of shellfish for consumption.” All of these are possible alternatives that need to be considered further and definitely show that any cobble tool whose margin is submitted to a similar use motion over a hard contact surface might produce a comparable facet. However, it should be noted that, for now, those three possibilities are very unlikely in the Antilles because: 1) hide processing has

not been documented anywhere in the Caribbean, where there were no hide-producing animals; 2) these items have been found in the Antilles in sites where no true-blade production has been documented; and 3) no shell remains have been found in most of the locations from which these implements have been uncovered.

Notwithstanding the previously cited limitations for defining a specific function for this type of artifact, there are some facts that show the importance to expand its analysis in the West Indies: that the processing of tubers and maize can produce the facet that is characteristic of this tool type; that the pounding of tubers and soaked maize produces a perfectly edible paste; that starch grains and phytoliths from domesticated tubers and maize have been found in the use surfaces of these tools in related areas; that these implements are restricted in the Circum-Caribbean area to sites related to the Northern South American Archaic Littoral Tradition; and that they have been recovered from Ortoiroid sites in the Caribbean, which have also been associated to the Northern South American Archaic Littoral Tradition. This line of reasoning definitely raises the possibility that some of the cultivars represented in the aforementioned starch grain analyses were introduced to the Antilles by the earliest Archaic immigrants, and thus opens the door to revisit some of the traditional notions that had been in place in Caribbean archaeology for almost a century.

First of all, regarding the introduction of manioc to the Antilles, it has always been presumed that in the absence of botanical proof of its cultivation, its consumption can only be evidenced on the basis of the presence of cassava griddles and bipolar grater teeth. This has led to the prevailing hypothesis that its introduction to the islands

can only be traced down to the Saladoid migration, which dates to circa 2500 BP. This, at the same time, has been based on the notion that the manioc variety that was mostly consumed by those Arawak groups was the bitter type and that, because of its high level of cyanogenic glucoside, it required complex processing techniques for its detoxification. These complex processing techniques include the grating of the bitter manioc with grater boards to produce a mass, which is then dewatered using a *cibucán* (a basketry squeezer) to remove its poisonous juices, and is then baked in a ceramic griddle to make cassava bread. However, in addition to the problems established by de Boer (1975) and Perry (2002) for establishing a direct correlation between the *budares*/grater teeth complex with cassava bread making, it has been argued that simple procedures such as air drying, soaking, boiling, dehydrating and *pounding* are efficient methods for reducing the cyanide content of manioc to tolerable quantities, and thus that the need for complex grating, squeezing and baking techniques are not essential for tuber detoxification (Cobley 1979; Cooke and Monduagwu 1978; Coursey 1973; Nye 1991; Roosevelt 1980). According to Cook (1995:178) pounding also results in starch release and aids to “reduce fibers inimical to nutrient absorption”. Furthermore, the dewatering of the pounded paste does not necessarily require the use of a *cibucán*, as it could have also been accomplished by manual squeezing and wood pressing (see Dole 1956 for a review; Rubin and Donalds 2003). Also, as has been demonstrated in this study, the pounding of tubers results in the production of a paste which could have been turned into edible foods in a variety of ways, such as bread, pellets or farihna, among other meals (e.g., Chagnon 1977; Levi Strauss 1946; Lowie 1946). All of this shows the possibility that the introduction of

this tuber to the islands, either its sweet or bitter varieties, might have preceded the advent of groups which practiced complex processing strategies of root crop processing.

It should also be noted that in Caribbean archaeology, the introduction of other tubers were also related to the migration of pottery-making groups, and that they were cooked using only “simple” methods which consisted of either baking or boiling them (e.g., Boomert 2000:96; Sturtevant 1969:179-184). However, this study has also shown that at least sweet potato can be processed into a paste, which could have been either mixed with other products to impart them with a sweeter taste, or turned into a bread as has been suggested by de Jesús (1978) and Redhead (1989), among other possible alternatives. In Puerto Rico, specially in the Loiza Municipality, a meal known as *cazuela* is still prepared (Cabanillas 1973), which consists of a mixture of sweet potato and manioc pastes that are wrapped in leaves and then either heated over a hot surface or boiled. Similar processing techniques could have been applied also to other tubers belonging to the South American complex, as defined by Sturtevant (1969:178), such as *yautía* (*Xanthosoma sagittifolium*), *marunguey* (*Zamia* sp.), and *lerén* (*Calathea allouia*), among others.

In the case of maize, it is commonly thought that the only ways in which it was consumed in the West Indies was either tender or roasted, and thus that “None of these forms of consumption would require the use of grinding equipment, further underscoring the possibility that the presence of grinding stones at Caribbean sites may have little or no bearing on the question of maize use at a particular site” (Newsom and Deagan 1994:207). Ranere

(1980a:125; 1980b:352) has also argued that the use of edge-ground cobbles for making corn flour is unlikely due to several factors including the unsuitability of their working surfaces for processing dry grains and the predominance of roots in the dietary composition tropical forest cultures, among others. Based on my limited experience in processing maize, I definitely concur with Ranere that edge-ground cobbles do not seem to be efficient tools for grinding dry maize, and would add to his argument the fact that the milling stones that are commonly used in association to edge-ground cobbles are not only flat, but usually made of fine-grained materials which do not contribute the rock-grit that aids in mortar or metate processing. Furthermore, the pecking that is usually applied to rejuvenate the manos in order to increase their grinding efficiency for corn-flour production is not observed in edge-ground cobbles. All of these observations seem to diminish the possibility that these were used in flour making although further testing is needed to make that assertion, especially when considering the morphology of the basin metates used for corn flour making in the southwestern United States (Adams 2002).

However, the present experiment has shown that a paste from soaked corn could have been efficiently produced with edge-ground cobbles over flat faced milling stones, thus adding another alternative to the ways in which maize could have been processed. Seeds such as primrose (*Oenothera* sp.), among others, documented in Archaic sites of the West Indies (Newsom 1993; Newsom and Pearsall 2003) could have also been processed in a similar fashion, probably resulting in a comparable grinding facet. A similar observation has been made by Adams (1999:500) based on her experimental studies with materials from the U.S. Southwest, as she stated that

“flat/concave manos and metates were designed to be more efficient tools than basin manos and metates for processing oily seeds, and that this design continued to be useful after the introduction of maize for processing soaked kernels.” The corn paste that was produced in the present experiment could have been wrapped in leaves and consumed either baked or boiled (e.g., Roosevelt 1980; Stone 1966), or used in soups or beverages (e.g., Isaacson 1984; Leigh 1983). In fact, as previously noted, the ethnohistoric accounts from the Greater Antilles make reference to the production of *guanimes*, which are basically pellets made of corn meal which are wrapped in leaves and then boiled or baked, in a similar fashion as that used in the confection of *cazuela*.

Recently generated data seems to show the possibility that some horticultural practices were registered in the islands prior to the migration of Saladoid societies. For instance, charcoal and pollen profiles taken in Puerto Rico and Vieques have indicated the presence of humanly induced forest fires probably related to swidden agriculture, as early as 5300 BP (Burney and Burney 1994; Sara et. al. 2003; Siegel et. al. 1999). Also, the import of plants from extra-Antillean sources such as yellow zapote and sapodilla has been documented in Puerto Rico, which according to Newsom (1993:322) were imported from the Caribbean Coast of Central America. Furthermore, maize pollen has been found in the Dominican Republic as early as 2000 BC (Fortuna 1981). The botanical data that has been produced thus far, however, is too limited yet to allow for any sound interpretations and thus more studies are urgently needed in order to have a clearer view of the plant-humans relations in pre-Arawak times in the Antilles.

Even though this type of artifact is apt to process a variety of foodstuffs, it seems to have been of limited efficiency if it is measured as “the amount of processed material per unit of time.” (Adams 1999:482). For instance, after 12 hours of work I was able to process approximately 16 cups of soaked maize, which is well below to the 2 cups per hour processed by Adams (2002:69) in her experimental work (Table 2). However, these two figures are not necessarily comparable as she ground soaked maize for producing a coarse flour while I pounded it to make a paste. Also, many other variables might skew these figures and make our results incomparable including the shape, raw material, size and weight of the utilized handstones, the size of the contacting surface of the milling stone, and the technical abilities in part of the experimenter, which in my case were very limited. However, in preliminary terms, these figures could be indicating that this artifact type might be related to tasks associated to daily household consumption instead of communal food preparation or surplus production for storage. For instance, if as indicated by Moscoso (1999:107), the consumption of manioc per person was of 50 pounds per month (approximately 1.7 pounds per day), then the most amount of paste that I produced in 6 hours could only feed approximately 5 people.

However, other variables beside the amount of processed food should be taken into consideration for assessing the relative efficiency of the edge-ground cobble/milling stone complex when compared to other food processing strategies. For instance, higher degrees of relative efficiency could be argued when one considers that it allowed a variety of foods to be processed with a singular tool kit, whose materials were not only readily available but also easily replaceable due to the ubiquitous occurrence

of suitable objective pieces in the islands and the lack of investment in manufacturing time.

This discussion on relative efficiency, however, might have nothing to do with the importance that was placed on this tool type as part of the *batterie du cuisine* used by pre-Colonial societies in the West Indies. The role of this type of implement, as well as others, should also be viewed in terms of a set of cooking preferences exercised in the confection of different types of foods, whose recipes were handed down from generation to generation. This might explain the intensity of the facetting observed on some specimens, which seems to indicate that at least some were used for extended periods of time. In this light, the persistence of this lithic artifact in post-Saladoid contexts needs to be examined beyond the mere functional or culture-historical aspect as it could indeed be showing the prevalence of a culinary repertoire whose origins go back well into the initial chapters of West Indian pre-Columbian history, some of which still lives in our food making traditions today.

Conclusion

Even though this study did not provide a definitive answer to the question of how the edge-ground cobbles were used, hopefully it served to demonstrate that this tool could have been employed for processing tubers and grains, and that it helped to raise the possibility that these were introduced to the Caribbean prior to the Arawak expansion from South America along with a set of food producing and cooking practices. This possibility will not be falsified until additional microbotanical studies are conducted and until detailed analyses and experiments on use modified lithic materials are carried out, which thus far are almost non-existent in Caribbean archaeological literature. More than half a century ago

Alegria et.al. (1955:120) stressed the importance of this type of implement for establishing the areas of provenience of the first inhabitants of the Caribbean. Now, the need to put careful attention to these “simple” tools needs to be stressed again as they might hold the clues for such complex questions in West Indian archaeology as the introduction of cultigens and multiple cuisines to the islands.

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References Cited

- Adams, Jenny L.
2002 *Ground Stone Analysis: A Technological Approach*. The University of Utah Press, Salt Lake City.
1999 Refocusing the Role of Food-Grinding Tools as Correlates for Subsistence Strategies in the U.S. Southwest. *American Antiquity* 64(13):475-498.
1989 Methods for Improving Ground Stone Artifacts Analysis: Experiments in Mano Wear Patterns. In *Experiments in Lithic Technology*, edited by Daniel S. Amick and Raymond P. Maulding, pp. 259-276. BAR International Series, Oxford.

- 1988 Use-Wear Analysis on Manos and Hide-Processing Stones. *Journal of Field Archaeology* 15:307-315.
- Alegria, R., H.B. Nicholson and Gordon R. Willey
1955 The Archaic Tradition in Puerto Rico. *American Antiquity* 21(2):113-121.
- Allaire, Louis and Mario Mattioni
1983 Boutbois et le Godinot: Deux gisements aceramiques de la Martinique. In *Proceedings of the IXth International Congress for Caribbean Archaeology*, edited by Louis Allaire and Francine M. Mayer, pp. 27-38. Centre de Recherches Caraibes, Montreal.
- Ardila, Gerardo I.
1984 *Chia: Un Sitio Precolombino en la Sabana de Bogota*. Fundacion de Investigaciones Arqueologicas Nacionales, Bogota.
- Ayes, Carlos
1988 Suplemento de Evaluación Arqueológica Tipo Fase II, Angostura, Florida Afuera, Barceloneta, Puerto Rico. Copies available at the Consejo para la Protección del Patrimonio Arqueológico Terrestre de Puerto Rico, San Juan.
- Boomert, Arie
2000 *Trinidad, Tobago and the Lower Orinoco Interaction Sphere: An Archaeological/Ethnohistorical Study*. Cairi Publications, The Netherlands.
- Botiva Contreras, Alvaro
1989 La Altiplanicie Cundiboyacense. In *Colombia Prehispanica: Regiones Arqueologicas*, edited by Alvaro Botiva, Gilberto Cadavid, Leonor Herrera, Ana Maria Groot de Mahecha and Santiago Mora, pp. 77-118. Empresa Editorial Universidad Nacional, Bogota.
- Bray, Warwick
1984 Across the Darien Gap. In *The Archaeology of Lower Central America*, edited by Frederick W. Lange and Doris Z. Stone, pp. 305-338. University of New Mexico Press, Albuquerque.
- Bressani, R.
1992 *Maize in Human Nutrition*. Food and Agriculture Organization of the United Nations, paper no. 25. Publications Division FAO, Italy.
- Brunez, Ana H.
2002 *Casabe: Simbolo Cohesionador de la Cultura Uitoto*. Editorial El Malpensante, Colombia.
- Burney, David A. And Linda Piggot Burney
1994 Holocene Charcoal Stratigraphy from Laguna Tortuguero, Puerto Rico, and the Timing of Human Arrival on the Island. *Journal of Archaeological Science* 21: 273-281.
- Cabanillas, Berta
1973 *El Puertorriqueno y su Alimentacion: Siglos XVI al XIX*. Editorial M. Pareja, Barcelona.
- Castillo, Neyla and Francisco J. Aceituno
2000 Un modelo de ocupacion durante el Holoceno Temprano y Medio en el noroccidente colombiano: El valle medio del Rio Porce. *ArqueoWeb* 2(2):1-15.
- Chagnon, Napoleon
1977 *Yanomamö: The Fierce People*. Holt, Reinhart and Winston, New York.
- Cobley, Leslie S.
1988 *Introduction to the Botany of Tropical Crops*. Longman, London.
- Cooke, Richard
1995 Monagrillo, Panama's First Pottery. In *The Emergence of Pottery: Technology and Innovation in Ancient Societies*, edited by William K. Barnett and John W. Hoopes, pp. 169-184. Smithsonian Institution Press, Washington.
- 1984 Archaeological Research in Central and Eastern Panama: A Review of Some Problems. In *The Archaeology of Lower Central America*, edited by Frederick W. Lange and Doris Z. Stone, pp. 263-304. University of New Mexico Press, Albuquerque.
- Cooke, R. D. and E. N. Maduagwu
1978 The Effects of Simple Processing on the Cyonide Content of Cassava Chips. *Journal of Food Technology* 13:299-306.
- Crabtree, Don E. and E. H. Swanson
1968 Edge-ground cobbles and blade-making in the Northwest. *Tebiwa* 11(2):50-58.
- Coursey, D. G.
1973 Cassava as Food: Toxicity and Technology. In *Chronic Cassava Toxicity: Proceedings of an Interdisciplinary Workshop*, edited by Barry Nestel and Reginald MacIntyre, pp. 27-36. International Development Research Center, London.
- Davila Davila, Ovidio
2003 *Arqueologia de Isla de la Mona*. Editorial del Instituto de Cultura Puertorriquena, San Juan.
- 1981 Cueva Los Gemelos: Un yacimiento preceramico de Morovis, Puerto Rico. Masters Thesis, Estudios Puertorriquenos, Centro de Estudios Avanzados de Puerto Rico y el Caribe, San Juan.
- de Boer, Warren R.
1975 The Archaeological Evidence of Manioc Cultivation: A Cautionary Note. *American Antiquity* 40(4): 419-433.
- de Jesús, Manuel
1978 El aje y la batata: Un mismo alimento indoantillano. In *El Aje: Un Enigma Decifrado*,

- edited by José Chez-Checo, pp. 29-41. Editora Alfa, Santo Domingo.
- Dole, Gertrude E.
1956 Techniques of Preparing Manioc Flour as a Key to Culture History in Tropical America. In *Men and Cultures*, edited by A. Wallace, pp. 241-248. University of Pennsylvania Press, Philadelphia.
- Einhaus, C. Shelton
1980 Stone Tools from La Pitahaya (IS-3). In *Adaptive Radiations in Prehistoric Panama*, edited by Olga F. Linares and Anthony J. Ranere, pp. 429-466. Peabody Museum Monographs No. 5.
- Febles, Jorge and Guillermo Baena
1995 Aplicación experimental de índices porcentuales y el factor de correlación a una muestra de superficies de piedra en volumen. In *Contribuciones al Conocimiento de Industrias Líticas en Comunidades Aborígenes de Cuba*, edited by Jorge Febles, Guillermo Baena, Reynaldo Perez, Santiago Silva and María B. Cruz, pp. 52-59. Editorial Academia, La Habana.
- Fernández de Oviedo y Valdes, Gonzalo
1959 *Natural History of the West Indies*. Translated and edited by Sterling A. Stoudemire. The University of North Carolina Press, Chapel Hill.
- Figueroa, Jesus
1991 La Fase Arcaica Cofresi y las culturas recolectoras de las Antillas. Masters Thesis, Estudios Puertorriquenos, Centro de Estudios Avanzados de Puerto Rico y el Caribe, San Juan.
- Figueredo, Alfredo E.
1976 Cano Hondo, un residuario precerámico en la isla de Vieques. In *Proceedings of the VIth International Congress for Caribbean Archaeology*, pp. 247-252. Guadeloupe.
- Fortuna, Luis
1981 Informe Palinológico. In *Estudio de Cuatro Nuevos Sitios Paleoarcáicos en la Isla de Santo Domingo*, edited by Elpidio Ortega and José Guerrero, pp. 83-89. Editora Taller, Santo Domingo.
- Gnecco, Cristóbal
2000 *Ocupación Temprana de Bosques Tropicales de Montaña*. Editorial Universidad del Cauca, Popayan.
- Groot, Ana M.
1995 Checua: Un aporte para el conocimiento del precerámico de la Sabana de Bogotá. In *Ambitos y Ocupaciones Tempranas de la América Tropical*, edited by Ines Cavalier and Santiago Mora, pp. 45-58. Fundación Erigea, Colombia
- Guarch-Delmonte, Jose M.
2003 The First Caribbean People, Part 1: The Paleoindians in Cuba and the Circum-Caribbean. In *General History of the Caribbean*, edited by Jalil Sued Badillo, pp. 93-118. UNESCO Publishing, Paris.
- Harris, David R.
1969 Agricultural Systems, Ecosystems and the Origins of Agriculture. In *The Domestication and Exploitation of Plants and Animals*, edited by Peter J. Ucko and G. W. Dimbleby, pp. 3-15. Aldine Publishing Company, Chicago.
- Harris, Peter O. B.
1976 The Pre-ceramic Period in Trinidad. In *Proceedings of the First Puerto Rican Symposium on Archaeology*, edited by Robinson, Linda S., pp. 33-64. Fundación Arqueológica, Antropológica e Histórica de Puerto Rico, San Juan.
- Hernández, Luis
1977 *Diccionario de Voces Indígenas de Puerto Rico*. Editorial Cultural, San Juan.
- Herner, Michael
1972 *The Jivaro: People of the Sacred Waterfalls*. University of California Press, Berkeley.
- Higuera-Gundy, Antonia
1991 Antillean Vegetational History and Paleoclimate Reconstructed from the Paleolimnological Record of Lake Miragoane, Haiti. Ph.D. Dissertation, Department of Botany, University of Florida, Gainesville.
- Isaacson, Sven Erik
1984 Observations on the Choco-Slash Mulch Culture, Colombia. In *Archaeological Investigations in Colombia*, edited by Thomas Myers, pp. 48-72. Archaeology Series no. 15, University of Colorado, Greeley.
- Kozłowski, Janusz
1974 *Pre-ceramic Cultures in the Caribbean*. Uniwersytetu Jagiellońskiego, Poland.
- Lancaster, P. A., J. S. Ingram, M. Y. Lim and D. G. Coursey
1982 Traditional Cassava-Based Foods: Survey of Processing Techniques. *Economic Botany* 36:12-45.
- Las Casa, Bartolomé de
1927 *Historia de las Indias*, Vol. II, Libro II. Editorial Alegre, Madrid.
- Leigh, Linda G.
1983 *The Ethnobotany of the Tukuna Indians, Amazonas, Colombia*. Empresa Editorial Universidad Nacional, Bogotá.
- Lowie, Robert H.
1946 The Poncararu. *Handbook of South American Indians*, edited by Julian Steward, vol. 1, pp. 561-566. Cooper Square, New York.
- Lundberg, Emily

- 1989 Preceramic Procurement Patterns at Krum Bay, Virgin Islands. Ph.D. Dissertation, Department of Anthropology, University of Illinois-Urbana, Illinois.
- Marcano, Gaspar
1971 *Etnografía Precolombina de Venezuela*. Instituto de Antropología e Historia, Caracas.
- Martinez, Roberto
1994 El yacimiento Arcaico de la Tembladera en Morovis, Puerto Rico. Masters Thesis, Estudios Puertorriquenos. Centro de Estudios Avanzados de Puerto Rico y el Caribe, San Juan.
- McGimsey, Charles R.
1956 Cerro Mangote: A Preceramic Site in Panama. *American Antiquity* 22(2):151-161.
- Metraux, Alfred and Paul Kirchhoff
1963 Andean Venezuelan Chake. In *Handbook of South American Indians*, edited by Julian Steward, vol. 4, pp. 349-368. Cooper Square, New York.
- Moscoso, Francisco
1999 *Sociedad y Economía de los Tainos*. Editorial Edil, San Juan.
- Newsom, Lee
1993 Native West Indian Plant Use. Ph.D. Dissertation, Department of Anthropology, University of Florida, Gainesville.
- Newsom, Lee, and Kathleen A. Deagan
1994 *Zea mays* in the West Indies: The Archaeological and Early Historic Record. In *Corn and Culture in the Prehistoric New World*, edited by Sissel Johannessen and Christine A. Hastorf, pp. 203-217. Westview Press, Boulder.
- Newsom, Lee, and Deborah M. Pearsall
2003 Trends in Caribbean Archaeobotany. In *People and Plants in Ancient North America*, edited by Paul N. Minnis, pp. 347-412. Smithsonian Books, Washington.
- Nye, Margaret M.
1991 The Mis-measure of Manioc (*Manihot esculenta*, Euphorbiaceae). *Economic Botany* 45(1):47-57.
- Oviedo y Valdez, Gonzalo Fernandez de
1959 *Natural History of the West Indies*. Translated and edited by Sterling A. Stoudemire. University of North Carolina Press, Chapel Hill.
- Pantel, Agamemnon Gus
1986 The Lithic Remains. In Monserrate Restudied: The 1978 C.E.A.P.R.C. Field Season at Luquillo Beach: Excavation, Overview, Malacological and Physical Anthropological Remains. Report submitted to the Centro de Estudios Avanzados de Puerto Rico y el Caribe, San Juan.
- Perry, Linda
2002 Starch Analyses Reveal Multiple Functions of Quartz "Manioc" Grater Flakes from the Orinoco Basin, Venezuela. *Interiencia* 27(11):1-10.
- Piperno, Dolores R. and Irene Holst
1998 The Presence of Starch Grains on Prehistoric Stone Tools from the Humid Neotropics: Indications of Early Tuber Use and Agriculture in Panamá. *Journal of Archaeological Science* 25:765-776.
- Piperno, Dolores and Deborah Pearsall
1998 *The Origins of Agriculture in the Lowland Neotropics*. Academic Press, San Diego.
- Ranere, Anthony J.
1980a Stone Tools and their Interpretations. In *Adaptive Radiations in Prehistoric Panama*, edited by Olga F. Linares and Anthony J. Ranere, pp. 118-145. Peabody Museum Monographs No. 5.
1980b Stone Tools from the Rio Chiriqui Shelters. In *Adaptive Radiations in Prehistoric Panama*, edited by Olga F. Linares and Anthony J. Ranere, pp. 316-353. Peabody Museum Monographs No. 5.
1976 The Preceramic of Panama: A View from the Interior. In *Proceedings of the First Puerto Rican Symposium on Archaeology*, edited by Linda S. Robinson, pp. 103-137. Fundacion Arqueologica, Antropologica e Historica de Puerto Rico, San Juan.
1975 Toolmaking and Tool Use Among the Preceramic Peoples of Panama. In *Lithic Technology: Making and Using Stone Tools*, edited by Earl Swanson, pp. 173-209. Mouton, Chicago.
- Ranere, Anthony J. And Richard G. Cooke
1996 Stone Tools and Cultural Boundaries in Prehistoric Panama. In *Paths to Central American Prehistory*, edited by Frederick W. Lange, pp. 49-77. University Press of Colorado, Niwot.
1995 Evidencias de ocupacion humana en Panama a postrimerias del Pleistoceno y a comienzos del Holoceno. In *Ambitos y Ocupaciones Tempranas de la America Tropical*, edited by Ines Cavelier and Santiago Mora, pp. 5-26. Fundacion Erigaie, Colombia
1984 The "Proyecto Santa Maria": A Multidisciplinary Analysis of Prehistoric Adaptations to a Tropical Watershed in Panama. In *Recent Developments in Isthmian Archaeology*, edited by Frederick W. Lange, pp. 3-30. BAR International Series 212, Oxford.
- Redhead, J.
1989 *Utilization of Tropical Foods: Roots and Tubers*. Food and Agriculture Organization of

- the United Nations, paper no. 47/2. Publications Division FAO, Italy.
- Rodríguez Ramos, Reniel
- 2003a La continuidad tecnológica del Arcaico al Post-Saladoide de Puerto Rico: Un vistazo desde la litica de Paso del Indio. Paper presented at the XXIIth International Congress of Caribbean Archaeology, Dominican Republic.
- 2003b The Crab-Shell Dichotomy Revisited: The Lithics Speak Out. In *Prehistory of Puerto Rico*, edited by Peter Siegel. University of Alabama Press. In press.
- 2002 Analisis tecnologico de la litica de Salto Arriba, Utuado, Puerto Rico. Technical report submitted to CSA Architects and Engineers, San Juan. Copies available at the Instituto de Cultura Puertorriquena, San Juan.
- 2001 Lithic Reduction Trajectories at La Hueca and Punta Candelero Sites, Puerto Rico. Masters Thesis, Department of Anthropology, Texas A&M University, College Station.
- Rodriguez Ramirez, Camilo
- 1991 *Patrones de Asentamiento de los Agricultores Prehistoricos en "El Limon", Municipio de Chaparral, Tolima*. Fundacion de Inestigaciones Nacionales, Bogota.
- 1995 Asentamientos de los bosques subandinos durante el Holoceno Medio. In *Ambitos y Ocupaciones Tempranas de la America Tropical*, edited by Ines Cavellier and Santiago Mora, pp. 115-123. Fundacion Erigaie, Colombia.
- Roosevelt, Anna C.
- 1980 *Parmana: Prehistoric Maize and Manioc Subsistence along the Amazon and the Orinoco*. Academic Press, New York.
- Rouse, Irving
- 1992 *The Tainos: Rise and Decline of the People who Greeted Columbus*. Yale University Press, New Haven.
- 1960 *The Entry of Man into the West Indies*. Yale University Publications in Anthropology, no. 61. New Haven.
- Rouse, Irving and Ricardo E. Alegria
- 1990 *Excavations at Maria de la Cruz Cave and Hacienda Grande Village Site, Loiza, Puerto Rico*. Yale University Publications in Anthropology, No. 20. New Haven.
- Rouse, Irving and Jose M. Cruxent
- 1963 *Venezuelan Archaeology*. Yale University Press, New Haven.
- Rubin, Jane G., and Adriana Donalds.
- 2003 *Bread Made from Yuca: Selected Chronicles of Indo-Antillean Cultivation and Use of Cassava 1526-2002*. Interamericas, New York.
- Sanoja, Mario
- 1983 Tipologia de concheros preceramicos del noreste de Venezuela. In *Proceedings of the IXth International Congress for Caribbean Archaeology*, edited by Louis Allaire and Francine M. Mayer, pp. 15-26. Centre de Recherches Caraibes, Montreal.
- Sara, Timothy R., Jose J. Ortiz Aguilu, and Lee A. Newsom
- 2003 Recent Paleoenvironmental Investigations on Vieques Island, Puerto Rico. Paper presented at the XXIIth International Congress for Caribbean Archaeology, Dominican Republic.
- Sauer, Carl O
- 1966 *The Early Spanish Main*. University of California Press, Berkeley.
- Sheets, Payson D., E. Jane Rosenthal and Anthony J. Ranere
- 1980 Stone Tools from Volcan Baru. In *Adaptive Radiations in Prehistoric Panama*, edited by Olga F. Linares and Anthony J. Ranere, pp. 404-428. Peabody Museum Monographs No. 5.
- Siegel, Peter E., John G. Jones, Deborah M. Pearsall, and Daniel P. Wagner
- 1999 Culture and Environment in Prehistoric Puerto Rico. Paper presented at the 64th Annual Meeting of the Society for American Archaeology, Chicago.
- Sims, Carl
- 1971 Edged Cobbles in the Pacific Northwest. *Tebiwa* 14(2):21-38.
- Stone, Doris
- 1966 Synthesis of Lower Central American Ethnohistory. In *Handbook of Middle American Indians*, vol. 4, pp. 209-233. Cooper Square, New York.
- Stotterth, Karen E.
- 1985 The Preceramic Las Vegas Culture of Coastal Ecuador. *American Antiquity* 50(3): 613-617.
- Strauss, Levi
- 1946 Nambicuara of Brazilian Amazon. In *Handbook of South American Indians*, edited by Julian Steward, vol. 4, pp. 363-372. Cooper Square, New York.
- Stutervant, William C.
- 1969 History and Ethnography of Some West Indian Starches. In *The Domestication and Exploitation of Plants and Animals*, edited by Peter J. Ucko and G. W. Dimbleby, pp. 177-200. Aldine Publishing Company, Chicago.
- Tronolone, Carmine A., Michael A. Cinquino, and Charles E. Vandrei
- 1984 Cultural Resource Reconnaissance Survey for the Vieques Naval Reservation. Copies available at the Puerto Rico State Historic Preservation Office, San Juan.

- Veloz Maggiolo, Marcio
1980 *Las Sociedades Arcaicas de Santo Domingo*.
Editora Taller, Santo Domingo.
- Veloz Maggiolo, Marcio, Juan Gonzalez, Edgar J.
Maiz, and Eduardo Questell
1975 *Cayo Cofresi: Un Sitio Precerámico de
Puerto Rico*. Editora Taller, Santo Domingo.
- Willey, Gordon R.
1971 *An Introduction to American Archaeology*.
Volume 2: South America. Prentice-Hall,
Englewood.
- Willey, Gordon R. and Charles R. McGimsey
1954 *The Monagrillo Culture of Panama*. Papers
of the Peabody Museum of Archaeology and
Ethnology, Harvard University, vol. 49, no. 2.
- Walker, Jeffrey B.
1984 A Preliminary Report of the Lithic and
Osteological Remains from the 1980, 1981 and
1982 Field Seasons at Hacienda Grande. Paper
presented at the Tenth International Congress for
Caribbean Archaeology, Martinique.