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THE PALEONTOLOGY AND EVOLUTION OF CERION II: AGE AND FAUNA OF INDIAN SHELL MIDDENS ON CURAÇAO AND ARUBA

Stephen Jay Gould

Abstract. *Cerion uva* has been found in great abundance in three Meso-Indian (preceramic) shell middens on Curaçao. Shells from all three sites yield radiocarbon ages of about 4000 years B.P. Different groups of Meso-Indians from Venezuela reached Curaçao and the nearby island of Cubagua at about the same time. A Neo-Indian (ceramic) midden on Aruba is approximately 1500 radiocarbon years old. Lists of the molluscan fauna from all sites contain only intertidal and shallow water species. Collecting areas can be specified by noting differences among sites in the presence of species from various environments (rocky intertidal, mangrove, shallow grassy and shallow rocky).

In the shell middens, *Cerion* presents two outstanding features: 1) almost all shells have had the apical whorls removed artificially and, 2) shells are larger than any living today. The apical whorls were removed by striking; flint tools found at the sites accomplish this task easily. This was done to release the internal vacuum and allow the animal to be sucked out through the normal aperture. Larger shells might indicate, since modern *Cerion* is so phenotypically variable, that the climate of Curaçao 4000 years ago was more moist (and therefore more hospitable) than today. But there is no independent evidence for more rainfall at that time. If the effect is mainly genetic, these shells might come from relict populations, adapted to the pluvials of the previous glaciation. *Cerion uva* has been found in a shell midden in Venezuela; this establishes the reciprocity of trade between mainland and offshore islands.

INTRODUCTION

Only a few mollusks have won entry into the Papiamento language of the Dutch Leeward Islands. These are mostly edible species — *kiwa* (*Cittarium pica*), *karko* (*Strombus gigas*), and *tapa koncha* ("cover shell" — a general name for chitons). Yet

Cerion uva, the ubiquitous pulmonate of these islands, stands out for the plethora of names attached to it, names that distinguish small from large and beach from bush. Nevertheless, *Cerion* plays almost no role in the economy of these islands today — though one of its names, *kokolishi kalakuna* (turkey shell), reflects the fact that it is sometimes fed to turkeys as a source of lime. It is never eaten, save as an aphrodisiac by some older residents who believe that sea shells preserve sexual potency (and do not realize that this halophilic pulmonate, which lives just landward of *Tectarius muricatus,* does not come from the sea). But to another people, the original Indian inhabitants of Curaçao, *Cerion uva* was a major source of food, for the oldest middens of the island are crammed with their shells.

Of the many shell sites that have been studied (Van Heekeren, 1960: 103–109, for review of archaeological work and Van Heekeren, 1963), *Cerion* is known only from the older, preceramic middens of Curaçao. Whenever it occurs, it presents two peculiarities: shells are far larger than the largest living *C. uva,* and most all have had the apical whorls removed artificially.

Thanks to the kindness of Father Paul Brenneker and Mr. Elis Juliana, local collectors, folklorists, and historians (and my informants for the opening paragraph), and Dr. F. Creutzberg, Director of the Biological Station at Piscadera Baai, Curaçao, I had the opportunity to study the shell sites during the summer of 1968. In this paper, I shall review the archaeological setting of these islands, report on radiocarbon dating of the shell sites, tabulate the fauna of each and present environmental interpretations, and discuss the occurrences of *Cerion* with special reference to the peculiarities mentioned above.

CARIBBEAN PREHISTORY AND DESCRIPTION OF SITES

The Dutch Leeward Islands are tied, geographically, to Venezuela. Aruba, only 27 km from the mainland, lies on the coastal shelf, in easily navigable waters. Curaçao and Bonaire are more distant (64 and 87 km respectively), and the passage is deeper (up to 1500 m) and more treacherous (Van Heekeren, 1960: 103). The early colonization of these islands must be discussed in the context of Venezuelan archaeology (Cruxent and Rouse, 1958–59, 1969; Rouse and Cruxent, 1963; Rouse, 1960, 1964, 1966).

The Pre-Columbian inhabitants of Venezuela and the Caribbean are designated Paleo-, Meso-, or Neo-Indians on the basis of technology and inferred economy. Although the three stages do express a chronological progression, none of their artifacts function as "index fossils" in establishing contemporaneity throughout the Caribbean, for the traits of a new stage are attained at different times by different peoples. There were, for example, still some preceramic Meso-Indians on Haiti and Western Cuba when Columbus arrived (Rouse, 1966).

The original inhabitants of the New World were Paleo-Indians, "hunters of mammoths and other large land mammals" (Rouse, 1966: 125). Their stone tools have been found in Venezuela and designated as markers of the Joboid Series. They date, approximately, from 17,000–7,000 B.P. The oldest radiocarbon date for Joboid charcoal is 16,870 years B.P. (Rouse and Cruxent, 1963). In earlier works, Cruxent and Rouse held that Paleo-Indians were not sea-farers, but Paleo-Indian sites have recently been found at Mordán in the Dominican Republic and dated to at least 4560 radiocarbon years B.P. They believe, moreover, that the Mordán site is predated by another at Casimira that may be as much as 7,000 years old (Cruxent and Rouse, 1969). Although the mainland source of these first Hispaniolans is not known, these finds indicate that some Paleo-Indians crossed considerable stretches of ocean, probably on rafts and by accident (Cruxent and Rouse, 1969).

Much scholarly agitation of late has been directed to the issue of whether or not Paleo-Indians were responsible for the extermination of large land mammals (Martin and Wright, 1967). In any event, their demise drew our pre-agricultural people to the sea and inaugurated Meso-Indian culture, characterized by "relatively few stone tools. Projectile points are made of bone rather than stone and shell artifacts are common, reflecting the maritime orientation" (Rouse, 1966: 126). Meso-Indian artifacts in Caribbean Venezuela belong to the Manicuaroid Series and date, approximately, from 7,000 to 3,000 years B.P. The oldest radiocarbon date for mainland Venezuelan Meso-Indians is 5750 B.P. (Rouse and Cruxent, 1963). There is an extensive Meso-Indian site on Cubagua, another of Venezuela's offshore islands. Charcoal from the base of this deposit dates at 4275 radiocarbon years B.P.

The subsequent Neo-Indian culture is "marked by pottery making and fully developed agriculture" (Rouse, 1966: 126). The invention of pottery was the crucial archaeological event that inaugurated the Neo-Indian period; therefore Meso-Indian and earlier sites are often designated simply as "preceramic." Agriculture, with manioc as a staple crop, and pottery were developed in the Orinoco Valley during the 2nd millennium B.C. During the 1st millennium B.C., some Neo-Indians moved out to the coast and became sea-farers. Displacing Meso-Indians as they went, they migrated to the coastal islands, up the Lesser Antilles and reached the Greater Antilles ca. 250 A.D. and the Bahamas ca. 1000 A.D. This displacement was still occurring when Columbus reached the New World (Cruxent and Rouse, 1969).

The *Cerion* sites of Curaçao are all Meso-Indian in nature. I studied the following three sites:

1. Rooi Rincón — North coast, west of Hato Airfield; in soil at the base of a small cave in a raised Pleistocene reef that also houses the larger cavern of Hato and several others; approximately 40 m above present sea level and 1 km from the coast. This well-known site was excavated by Cruxent in 1965 (Tamers, 1967) and by Van Heekeren in 1960 (Van Heekeren, 1963). Crudely chipped stone tools and flint flakes are common but, after digging for 14 days, Van Heekeren found only one other artifact, a shell disc bead (Van Heekeren, 1963: 5). The naturally broken columellar tips of *Strombus gigas* are similar in form to some of the fashioned shell gouges common in the Manicuaroid deposits of Cubagua (Cruxent and Rouse, 1958–59); they may have been used for digging meat out of shells. Many other natural objects could have been used as tools. Particularly suspect are the smoothly eroded and fairly pointed branches of the stag horn coral, *Acropora cervicornis,* that are fairly common at this site and at Kintján (site 2). These, obviously, have no nutritional value and must have been carried to the site for some other purpose. Other objects, land crab claws for example, might have been used for digging meat from shells after their own contents had been consumed. I found a few bits of charcoal: some of the shells are strongly scorched. Cruxent says of this deposit: "A Meso-Indian complex of collectors with industry of stone chips. Classified as a marginal development of El Jobo. No archaeologic station of this type presently known in Venezuela" (*in* Tamers, 1967: 244).

2. Kintján — Near south coast, east of Willemstad. The area, a hillslope, is being cleared for construction and shells are loose at the surface; their presence in a small area indicates original concentration in a coherent deposit. Flint chips and crude stone tools are, as at Rooi Rincón, common at this site.

3. Tafelberg — Near south coast, just east of the Tafelberg Santa Barbara. Only a few shells could be collected from the recently blasted rubble of these phosphate workings. Mr. Harry Evers, engineer at the Tafelberg phosphate workings, informs me that, prior to the blasting, the shell heap was a coherent deposit with two layers, marine shells at the base and decapitated *Cerion* at the top. I found no artifacts at this much disturbed site.

Dr. P. Wagenaar Hummelinck, pre-eminent natural historian of these islands, has told me (personal communication, 1970) of one additional *Cerion* locality at Hato Cave; I have not seen this site. He also states that he knows of no other *Cerion* site on any of the three islands.

For comparison, I add to the *Cerion* sites of Curaçao one later, Neo-Indian deposit from Aruba:

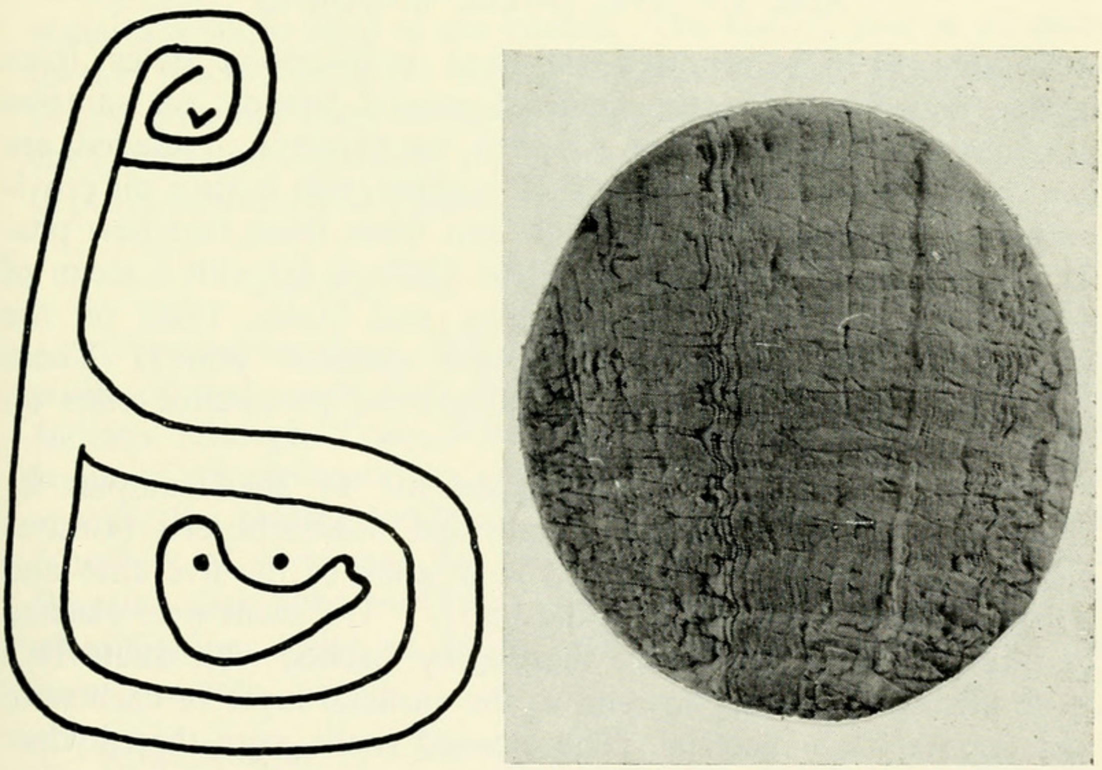

Figure 1. Artifacts from Ceru Canashito, Aruba.
1a) left: rock drawing, presumably depicting a pregnant woman.
1b) right: shell disc made from *Melongena melongena*. Actual height: 43 mm.

4. Ceru Canashito — North slope of this limestone terrace. I chose this among the many Neo-Indian sites of Aruba for two of its outstanding features. Good skeletal material has been collected from the caves near its summit (Tacoma, 1959), and these caves contain some of the best of the celebrated and mysterious rock paintings of these islands (Hummelinck, 1953, 1957). One of these, probably depicting a pregnant woman, is reproduced as Figure 1a. (There is, of course, no reason to assume that the rock drawings are contemporaneous with the shells; Van Heekeren (1960), in fact, suspects that they were fashioned by Meso-Indians and venerated by later inhabitants.) Shells occur at all levels of the slope, but are concentrated by gravity at the base in an inhomogeneous deposit. Sherds of a coarse, unornamented, grit-tempered pottery are common. Shell artifacts include the columellar points of *Strombus gigas* and the unperforated shell disc, made from the outer whorl of *Melongena melongena,* shown in Figure 1b. Such unperforated shell discs are common on the islands; their function is unknown (Van Heekeren, 1960: 112).

AGE OF THE SHELL MIDDENS

Tamers (1967) reported the first radiocarbon dates from archaeological sites in the Dutch Leeward Islands; all samples were charcoal and all were supplied by Cruxent. Included are five dates for the Rooi Rincón shell midden, two from a pit previously excavated by Van Heekeren and three from two new pits. The dates range from 3900 ± 50 to 4490 ± 60 with a mean of 4194 radiocarbon years (see Stuiver and Suess, 1966 on the relationship between radiocarbon and calendar years). These are the only dates previously calculated for preceramic sites on these islands.

Radiocarbon ages were determined for 11 shell samples by Geochron Laboratories, Inc., Cambridge, Massachusetts (*Chama macerophylla* and *Cittarium pica* from each of the five sites and *Anadara notabilis* from Ceru Canashito). "The shells were cleaned of foreign material and were thoroughly leached with dilute HCl in an ultrasonic cleaner to remove the surficial layer of carbonate and expose fresh material. The cleaned shells were then hydrolyzed to recover CO_2 for the analysis" (personal communication from H. W. Krueger of Geochron). Dates are based on a half-life of 5570 years and referenced to 1950 A.D.

Dates based on shells are not as reliable as those determined for pure carbon (charcoal), for $CaCO_3$ is often altered by percolating, acidic groundwaters. I was anxious to determine the correspondence between shell and charcoal dates for Rooi Rincón; I found no charcoal at any of the other sites. All dates are shown in Table 1.

The correspondence at Rooi Rincón is satisfactory, and all preceramic sites of Curaçao are about 4000 radiocarbon years old. This date is particularly interesting since it corresponds so well with the base of the great Meso-Indian site at Punta Gorda, Cubagua Island (p. 21). The artifacts of this Cubagua complex of the Manicuaroid series differ greatly from those of Rooi Rincón (Cruxent and Rouse, 1958–59) and we must assume that different groups of Meso-Indians from Venezuela colonized the coastal islands at about the same time.

The great spread of dates for the Neo-Indian site of Ceru Canashito can be explained in two ways. It is a very inhomogeneous deposit of shells artificially concentrated at the base of a slope and may represent a long span of habitation. Alternately, the *Cittarium* date could be spuriously young. *Cittarium* has been and remains a staple food of the islands. The *kiwa* is sold at all native market places; shells are carried and discarded all over the island. If this date has been falsified by the inclusion of a fairly modern shell, then the Canashito midden may represent a more coherent deposit, about 1500 radiocarbon years old.

FAUNA OF THE SHELL MIDDENS

In presenting these faunal lists, I have excluded the micromolluscs that could have played no role in the economy of the Indians (though *Truncatella* and other rissoids are reasonably common as accidental transports). In each site, there are a few species that clearly dominate; these are merely listed as common. Numbers of specimens are given for other species. I have used Warmke and Abbott (1961) and Coomans (1958) as guides to identification; order of listing and family allocations follow the former source.

1. Rooi Rincón

AMPHINEURA

Acanthopleura granulata — common

GASTROPODA PROSOBRANCHIA

Trochidae

Cittarium pica — common

Turbinidae

Astraea tecta — 1

Astraea tuber — 1

Neritidae

Nerita peloronta — 11

Nerita versicolor — 6

Nerita tesselata — 4

Littorinidae

Nodilittorina tuberculata — 4

Echinus nodulosus — 1

Tectarius muricatus — 10

Vermetidae

Petaloconchus mcgintyi — 3

Strombidae

Strombus gigas — 4 apices and 3 columellas

Muricidae

Murex brevifrons — 8

Magilidae

Coralliophila abbreviata — 2

Coralliophila caribbea — 1

Fasciolariidae

Leucozonia nassa — 1

Xancidae

Vasum capitellum — 1

GASTROPODA PULMONATA

Cerionidae

Cerion uva — common; 18 of 129 specimens have intact apices

BIVALVIA

Arcidae

Arca zebra — 12 valves

Arca imbricata — 4

Anadara notabilis — 4

Mytilidae

Brachidontes exustus — 2

Pteriidae

Pinctada radiata — 13

PECTINIDAE
Pecten ziczac — 2
LIMIDAE
Lima scabra — 10
OSTREIDAE
Ostrea frons — 12
Crassostrea rhizophorae — 9
CHAMIDAE
Chama macerophylla — common
Pseudochama radians — 2

Nonmolluscan remains: a few branches of stag-horn coral (*Acropora cervicornis*), land crab claws (common), a few barnacles, fish bones and a small fragment of an echinoderm test.

Not all these animals were eaten. Many, especially among the snails, are small and rare at the site (turbinids, magilids, fasciolariids, and xancids); others (*Petaloconchus* and barnacles) cement to other shells and surely won a free ride on their edible hosts (probably *Chama*).

The main food sources were the land snail *Cerion,* land crabs, intertidal chitons, the intertidal and just subtidal snail *Cittarium* and the shallow water clam, *Chama;* all are very abundant and easily gathered. Less common but still important as food sources are the conch *Strombus gigas, Nerita peloronta,* and *Murex brevifrons* among the snails (the last two artificially broken in characteristic ways — Figs. 2 and 3) and arcids, oysters, and limids among the clams.

The shells provide an excellent picture of the environment from which they were gathered. All the major intertidal rock-clingers are represented (all three common West Indian *Nerita,* chitons, and the famous homeomorphic series *Nodilittorina-Echinus-Tectarius*). These species inhabit rocky shores in areas of active surf. All other species can be found in less than 10 feet of water on a varied bottom containing reefy and rocky areas (*Chama, Arca, Lima*) and stretches of sand and grass (*Anadara, Strombus*). There may have been a lagoon with mangroves nearby, for many important elements of the mangrove-root community are present (*Murex brevifrons, Ostrea frons, Crassostrea rhizophorae,* and *Brachidontes exustus*).

Van Heekeren (1963) stated, correctly no doubt, that the shells were collected on the nearby north coast (Fig. 4b). Since

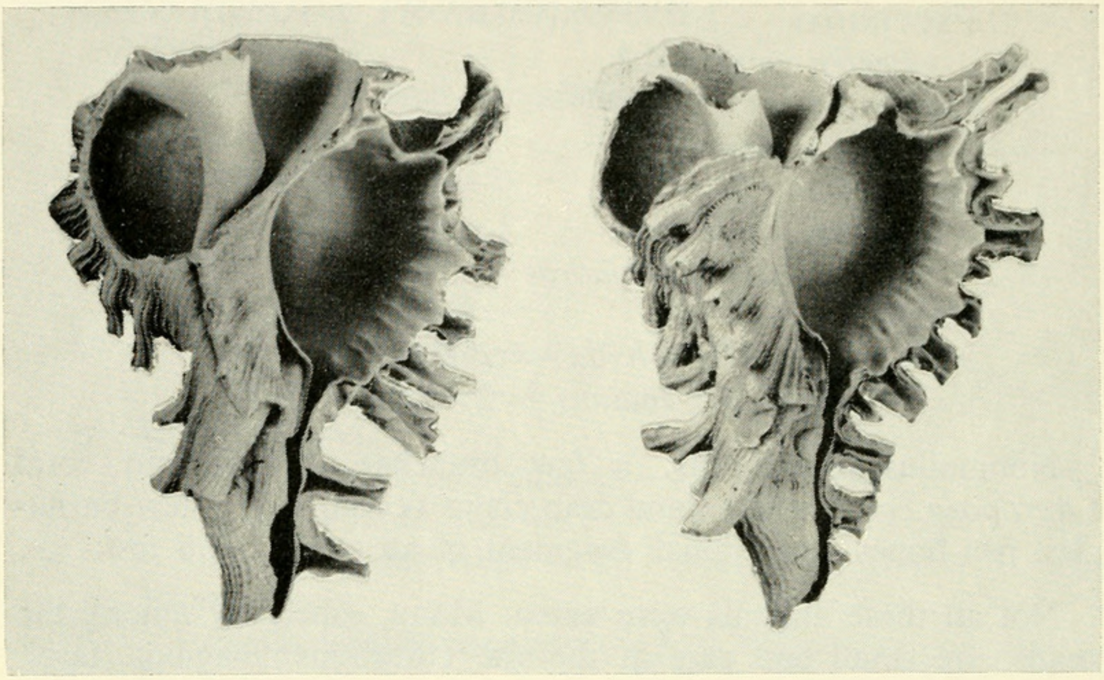

Figure 2. *Murex brevifrons* shells from Kintján (left) and Rooi Rincón (right). Note characteristic breakage pattern in both. This can be achieved by placing the shell face down upon its aperture and striking the apex. Actual height of Kintján specimen: 54 mm.

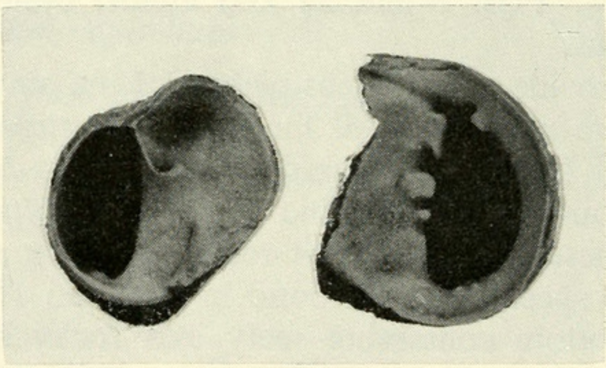

Figure 3. Neritids from Rooi Rincón broken in characteristic fashion. Left: apertural portion from rear; Right: apertural portion from front. Such a break is made by placing the shell face down upon its aperture and striking the body whorl with a blunt object. This is also the natural breakage pattern in most cases. Right-hand fragment is 18 mm high.

the unremitting trade winds blow against this coast (producing a strong surf most unconducive to shell gathering), Van Heekeren suggested that sea level at this earlier time was 6–7 m higher than today. This would submerge the extensive raised reef that forms the lower terrace all around Curaçao and produce a broad area of calmer, shallow water. (And from the supposed extent of this change in level, he postulated a great age for the deposit and classified it, tentatively, as Paleo-Indian.) This hypothesis of a major shift in sea level is unnecessary for two reasons: 1) With an age of 4000 radiocarbon years, any eustatic fall in level is ruled out; if anything, mean sea level then was a bit lower than today (Redfield, 1967; Milliman and Emery, 1968). This leaves tectonic uplift. Curaçao has, indeed, been uplifted during the Pleistocene (the oldest terrace, atop the Tafelberg, lies at 140–200 m, but 7 m in 4000 years is not likely). 2) The trade winds do produce a strong surf along the north coast. But Rooi Rincón lies on that part of the coast that runs due east-west; here the winds run along the coast and the waters are fairly calm. Modern *Cerion* populations illustrate the climatic results of changes in coastal direction. *Cerion* lives atop the first terrace all along the coast. In areas continually buffetted by the strong dry wind, they aestivate for much of their lives and remain small as adults; they grow bigger in calmer areas. A graph of *Cerion* size vs. distance from Westpunt (Fig. 4a) is a good map of coastal direction (Fig. 4b). *Cerion* is small where the coast runs north-south and large where it runs east-west. They reach their greatest size at Rooi Rincón. Thus, Rooi Rincón lies in the only area of Curaçao that provides good conditions for shell gathering on the north coast.

2. Kintján

GASTROPODA PROSOBRANCHIA

TROCHIDAE

Cittarium pica — common

STROMBIDAE

Strombus gigas — common

CYMATIIDAE

Charonia variegata — 1

MURICIDAE

Murex brevifrons — 3 (broken as at Rooi Rincón, Fig. 2)

Melongenidae

Melongena melongena — 2

GASTROPODA PULMONATA

Cerionidae

Cerion uva — common, 7 of 347 specimens have intact apices

BIVALVIA

Arcidae

Arca imbricata — 13

Barbatia cancellaria — 3

Anadara notabilis — common

Pteriidae

Pinctada radiata — 3

Pectinidae

Pecten ziczac — 7

Limidae

Lima scabra — 6

Figure 4. Correlation of coastal direction and shell size.

4a) left: map of Curaçao. 1. Rooi Rincón at point where coast runs east-west. 2. Kintján. 3. Tafelberg. 4. Schottegat (where shells at Kintján were collected).

OSTREIDAE

Ostrea frons — 7

Crassostrea rhizophorae — 6

CHAMIDAE

Chama macerophylla — common

Nonmolluscan remains: branches of stag-horn coral (*Acropora cervicornis*), barnacles, and fish bones.

The shallow water fauna of Kintján is very similar to that of Rooi Rincón, both in species composition and order of dominance (*Chama* and *Cittarium* followed by *Strombus,* arcids, oysters, and limids). Since shells are not so common at Kintján, several species, rare and unimportant at Rooi Rincón, are not found here.

4b) right: Mean shell heights (20 adults per sample) for local populations living in similar microhabitats directly on the first terrace along the east coast of Curaçao. Shells are largest where trade winds do not hit coast directly.

I found no land crabs at Kintján, but *Cerion uva* is even more common here than at Rooi Rincón. There is, however, one outstanding difference between the two sites: there are no intertidal rock-dwellers at Kintján (neritids, littorinids, or chitons), while all the common forms are found at Rooi Rincón. This difference permits us to specify the collecting area for Kintján shells.

The entire periphery of Curaçao is framed by an uplifted Pleistocene reef; intertidal forms are common all around the coast. But the central areas are underlain by volcanic rocks that erode more easily than the coastal limestone. During the last glacial period, when sea levels were lower, extensive drainage systems were developed on the volcanic terrain; these breached the harder limestone rim in only a few places. These valley systems were drowned when sea level rose and produced the outstanding protected harbors that characterize all three islands: narrow inlets with expansive inland waters. Willemstad, the capital of Curaçao, is built on both sides of the largest harbor, the Schottegat. The inland shores of the Schottegat are volcanic; in the absence of strong surf and a rocky coast, the rock-dwelling intertidal forms do not inhabit these shores. I conclude that the Kintján shells were collected in the Schottegat (Fig. 4b); the extensive, calm, shallow waters provided an excellent site for gathering.

3. Tafelberg

GASTROPODA PROSOBRANCHIA

TROCHIDAE

Cittarium pica — several fragments

LITTORINIDAE

Tectarius muricatus

GASTROPODA PULMONATA

CERIONIDAE

Cerion uva — common, 5 of 111 have intact apices

BIVALVIA

ARCIDAE

Arca imbricata — 1

CHAMIDAE

Chama macerophylla — common

The site has been thoroughly disturbed by blasting.

4. Ceru Canashito

AMPHINEURA

Acanthopleura granulata — 4 plates

GASTROPODA

TROCHIDAE

Cittarium pica — 8

TURBINIDAE

Astraea tecta — 1

NERITIDAE

Nerita tessellata — 3

LITTORINIDAE

Tectarius muricatus — 5

MODULIDAE

Modulus modulus — 1

CERITHIIDAE

Cerithium algicola — 1

Cerithium litteratum — 1

STROMBIDAE

Strombus gigas — common

MURICIDAE

Murex pomum —7

Murex brevifrons — 1

Thais deltoidea — 1

MELONGENIDAE

Melongena melongena — common

XANCIDAE

Vasum muricatum — common

BIVALVIA

ARCIDAE

Anadara notabilis — common

PTERIIDAE

Pinctada radiata — 1

LUCINIDAE

Codakia orbicularis — common

CHAMIDAE

Chama macerophylla — common

Pseudochama radians — 1

Intertidal rock-dwellers are found here, but the series is not nearly so complete as at Rooi Rincón (only one *Nerita, Tectarius,* but neither *Echinus* nor *Nodilittorina*). Among shallow water forms, there are two major differences between Canashito and both Rooi Rincón and Kintján. The Curaçao sites contained a suite of mangrove-dwellers that are completely absent here (Canashito yielded one *Murex brevifrons,* a common mangrove form, but *Murex pomum,* an open water species absent from both Curaçao sites, is the common *Murex* here). In addition, Canashito contains a suite of shells (*Modulus,* the two *Cerithium* species and, especially, the common *Codakia orbicularis*) that inhabit grass and algal beds; none of these occur in the Curaçao deposits. The shells were probably collected in calm waters off the leeward south coast, near the site of the present airport.

CERION UVA IN THE PRECERAMIC MIDDENS OF CURAÇAO

In all three preceramic middens of Curaçao, the most common molluscan shell is that of the land snail *Cerion uva.* These shells present two outstanding features: more than 80 percent in each locality have lost their apical whorls and shells are larger and more variable than modern specimens.

1. *Removal of the apical whorls.* By reason and experiment, one of a list of possible proposals can be identified as the cause of removal. I list the suggestions made to me by many friends and colleagues.

A) Natural removal
B) Artificial removal
  i) by biting
  ii) by rubbing
  iii) by crushing (striking with the shell held upright)
  iv) by slicing (striking with the shell placed on its side).

Although the apical whorls form the weakest part of the shell, I do not believe that they could have been lost naturally by so many specimens. I have extensive collections of much older fossils from fissure-fills on Aruba. These tumbled, often down several meters, into the fissures, suffered strong compaction, underwent tectonic uplift and still retain, in almost all cases, the apical whorls. I have never seen a natural accumulation, either recent or fossil, in which many specimens are missing their apical whorls.

After suffering one dental misfortune, I am quite sure that the tops cannot be bitten off. Apices can be removed by rubbing either against limestone or volcanic rock, but the process is much too laborious and time-consuming. I am convinced that the tops were removed by striking. They were not crushed by striking the top of the shell while holding the bottom against a substrate (and keeping the shell vertical), for this process invariably breaks the lower lip of the aperture before crushing the top. If, however, the shell is placed on its side, horizontally against the substrate, the top can easily be removed by striking with a sharp instrument. In fact, the flint chips and stone tools of Rooi Rincón and Kintján, are excellent devices for this purpose. With a bit of practice, the apices can be removed with a single blow.

This leaves open the question of why the apices were removed. I can imagine three interpretations:

A) Removal is unrelated to eating; the shells were used for an ornamental or other purpose.

B) When the top is removed, the animal can be sucked out through the apical hole thus produced.

C) Removal of the top aids, somehow, in sucking the animal out through its normal aperture.

I cannot imagine what nongastronomical purpose so many thousand decapitated shells could have served. Moreover, the following demonstration that decapitation is an aid to removal of the animal argues strongly against A.

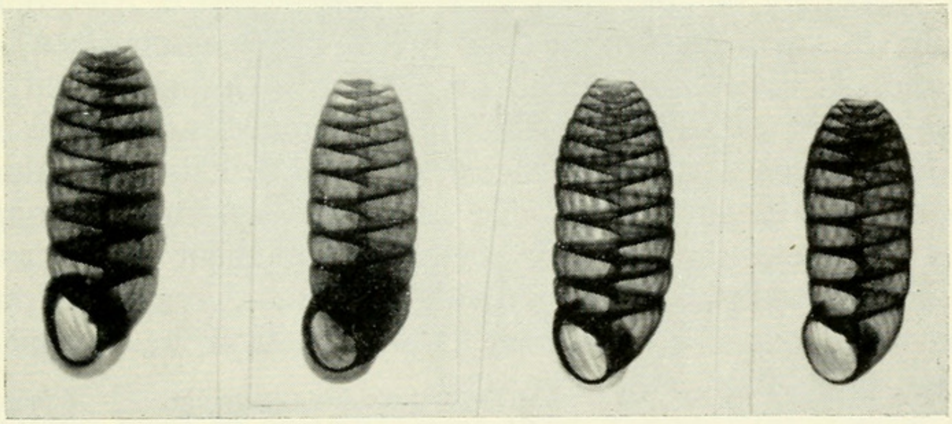

Figure 5. X-ray photographs of decapitated *Cerion uva* from Kintján (left 2 specimens) and Rooi Rincón (right 2). Since internal whorl partitions are intact, animal was not removed through apical hole. Specimen on left is 32.8 mm high.

If the animal were sucked out through the top, some of the internal whorl partitions would have to be broken, for the large foot could not fit in the small whorls left near the top of the shell. X-ray photographs of decapitated shells (Fig. 5) show clearly that the whorl partitions are never disturbed. The animal could not have been extracted through the apical hole.

If you take an intact shell with its animal inside and suck as hard as possible at the aperture, the animal cannot be extracted. But, when the apex is removed, a single hard suck upon the aperture will extract either the large foot of the animal or the entire body itself. Removal of the top breaks the vacuum inside the shell and facilitates the extraction of its contents. The entire process is really quite efficient: one strike, one suck, and the animal is removed. Several can be eaten in a minute (though I recommend *Cerion* only to the starving).

Somehow, I find it satisfying to think that the Meso-Indians of Curaçao discovered an important physical principle for such a practical procedure. This idea, so obvious to all of us who were raised in the pre pop-top age of the beer can industry, is by no means a self-evident principle.

2. *Variation and form of* Cerion uva. Any sample from a shell midden is, of course, strongly biased from a biometrical point of view. The probable bias, in these cases, is twofold: the selection of large individuals (for *Cerion* is not a large snail and much work must be expended for little nutrition), and the amalgamation of shells from several local populations.

Much has been made in the literature of the extreme intraspecific variability of land snail shells. This indeed is true, but it is usually of a particular kind (and this is rarely emphasized). The variation is interpopulational, i.e., the shells of any local population are not unusually variable, but differences among the means of local populations are often extreme. Thus, it is likely that our two biases will affect the mean of a midden sample in opposite ways: the selection of large shells will augment the mean, but the amalgamation of large individuals from several local populations will produce a midden mean smaller than the true mean of a local population with large shells.

The rise in variability from amalgamation of local populations can be gauged by comparing coefficients of variation (C.V.) (Simpson, Roe, and Lewontin, 1960: 89–95) of midden samples and modern local populations for the same character. Table 2 presents C.V.'s for shell height of the three midden samples and a mean value for 69 modern local populations (Gould, unpublished data for monograph in preparation; N = 20 for all samples, midden and modern; values for midden shells are estimates for actual height with decapitated apical whorls restored; all shells are adults with completed growth). All midden means are above the modern grand mean. Rooi Rincón and Tafelberg are within the span of modern C.V.'s (4.03 to 10.18), but, at 15.45, shells from Kintján are far more variable than those of any modern local population.

The striking feature of midden samples is the large size of some of their shells. Fortunately, *Cerion uva* is among the world's best known land snails from a biometrical point of view. Three major studies have been done in this century: by Baker in the early 1920's (Baker, 1924), by Hummelinck in the late 1930's (Hummelinck, 1940) and by myself during the past two years. Table 2 compares the heights of shells in midden and modern samples. Each modern study has uncovered a local population with greater mean height than the smallest midden sample, and one of Hummelinck's local populations exceeds the largest midden sample in mean height. Still, of course, the midden means are all well above

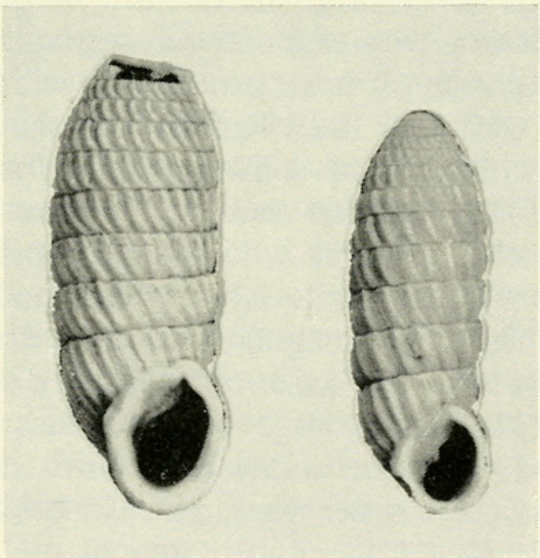

Figure 6. Comparison of largest shell heap (left, from Kintján, 34.3 mm high) *Cerion* and largest modern shell. Difference is much more striking in actual shells in which areal artifact of two dimensional representation is lost and judgment of size is made more properly by volume.

the grand mean of means for each modern study. However, as mentioned previously, the midden means are almost surely lower than the true means of local populations with large shells living at that time. A more appropriate comparison might be made using maximal size.

Among almost 12,000 modern snails from 248 local populations over 50 years, no snail greater than 30 mm in height has ever been found. (In only one of Hummelinck's local populations did any individuals exceed 29 mm; neither Baker nor Gould found any taller than 28.5 mm.) Yet snails exceeding 30 mm in height are very common in two of the three midden samples and, at 34.3 mm, the largest snail from Kintján dwarfs my modern "giant" (Fig. 6).

Two separate factors can make a snail tall, and both operated to produce the large midden shells. First, a snail can increase in height simply by adding more whorls. Each of the decapitated shells of Figure 5 shows 11 whorls below the break; the complete shell would have had one or two more postprotoconch whorls. Modern shells with more than 10½ postprotoconch whorls are a great rarity (Baker and Hummelinck included protoconch whorls in their count, hence their larger figures). Secondly, a tall snail may have as many whorls as a smaller one, but simply have larger whorls. Protoconch size is a good measure of general whorl size (Gould, 1969). Only Rooi Rincón has enough complete shells to permit the calculation of mean protoconch width. At 1.67 mm, mean protoconch width for Rooi Rincón is at the top of the range of modern mean widths (1.41–1.69 mm for 69 samples, N = 20 for each sample). The midden shells grew more whorls than any modern sample and had larger whorls than most.

Why were the midden snails larger than modern snails? All three modern studies have demonstrated the extreme phenotypic plasticity of *Cerion uva.* Shell size of adults is a direct function of microenvironment; snails are large when habitats are moist, calm, and well vegetated. Curaçao today is an arid island. It receives only 17–22 inches of rain per year, most in brief downpours. It is hard to imagine a less hospitable area in the West Indies for pre-agricultural Meso-Indians. I do not know what they could have found, in this cactus-covered land, to supplement a diet of sea food. It is therefore tempting to think that the large midden shells indicate a wetter climate that might have supplied to Meso-Indians some of the tropical fruits that adorn most West Indian islands. Unfortunately, there is no other evidence for greater rainfall 4000 years ago. If Curaçao were much larger or higher than it is today, continental effects might lead to increased rainfall. But the eustatic rise of sea level has not been more than 10 feet during the past 4000 years (Redfield, 1967; Milliman and Emery, 1968) and the direction of tectonic movement has been upward (Weyl, 1966). Rouse and Cruxent (1936: 38) believe that temperatures and rainfall have not varied appreciably during the past 5000 years in Venezuela and surrounding areas.

If large size is not an immediate phenotypic response to local conditions more favorable than today's, then I suspect that the midden snails were programmed to be large, i.e., that the effect is mainly genetic. In this case they probably represent the relict populations of snails that had been genetically adapted to more favorable conditions during pluvial cycles of the previous glacial period. In any event, they served the Meso-Indians well; it would be hard to make a meal of modern *Cerion.*

There is an interesting postscript to the relationship of *Cerion* with Meso-Indians. There is considerable evidence for trade between the mainland and coastal islands, but it is all unidirectional. Rouse and Cruxent (1963: 45) found trade pottery from Venezuela in the Punta Gorda complex of the Manicuaroid Series on Cubagua. Du Ry (1960: 85) discovered that the oldest pottery of Aruba is finer in texture than later examples. He assumes that this first pottery was imported from northeastern Venezuela and that the later work is indigenous. In a nearly-forgotten work, Berry (1934) found *Cerion uva* in an Indian shell heap near Lake Valencia, Venezuela. Berry was not convinced that these shells were imported from the Dutch Leeward Islands. But his argument that *Cerion* might have once inhabited the shores of Lake Valencia can be discounted because this halophile would not survive so far inland. I also doubt that *Cerion* inhabited the coast of Venezuela, for it has never been recorded from shell heaps there. Since there is no evidence that *Cerion uva* ever lived elsewhere than the Dutch West Indies, I conclude that the Valencia specimens establish the reciprocity of transport between Venezuela and the islands.

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TABLE 1

Age of Shell Middens on Curaçao and Aruba

	Charcoal	Chama	Cittarium	Anadara	*Period*	*Island*
Rooi Rincón	3990±50-4490±60 (range of 5 dates)	4090±125	4705±160		Meso-Indian	Curaçao
Kintján		4150±140	3530±140		Meso-Indian	Curaçao
Tafelberg		3830±140	3665±140		Meso-Indian	Curaçao
Ceru Canashito		1685±115	815±105	1345±120	Neo-Indian	Aruba

TABLE 2

Size and Variability of *Cerion uva* in Indian Shell Middens and Modern Populations; in mm.

Sample or Study	*Height of Largest Specimen*	*Mean of Height*	*Largest Mean for Height*	*Smallest Mean for Height*	*C.V. for Height*	*Number of Specimens*	*Number of Samples*
Kintján	34.3	25.99			15.45	347	1
Rooi Rincón	31.7	26.30			8.74	129	1
Tafelberg	29.0	24.59			7.39	111	1
Baker, 1924	27.8		25.1	19.6		2,737	44
Hummelinck, 1940	29.5		26.4	19.4		6,540	66
Gould, unpublished	28.4		24.68	16.43	6.27*	2,622	138

* Mean value for 69 samples.

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