Archaeofauna 17 (2008): 21-34

The Use of Molluscs in the Precolumbian Amerindian Lesser Antilles: Human, Animal, and Environmental Parameters (with an emphasis on metrics)

NATHALIE SERRAND
INRAP, rue des Gommiers Blancs, Parnasse, 97120 St-Claude, Guadeloupe
UMR 5197 CNRS/MNHN, USM303, Muséum national d´Histoire Naturelle, Paris, France
nathalie.serrand@inrap.fr

(Received *21 October 2006*; Revised *7 January 2008*; Accepted *23 January 2008*)

ABSTRACT: The diverse use of molluscs in the pre-Columbian Amerindian Lesser Antilles is outlined based on data from twenty-seven sites and case studies from the Preceramic through to the Ceramic Ages (ca. 1000 BC - AD 1200). Clear variations in the role of molluscs through time reflect as yet little understood economic and cultural evolutions of Amerindian island societies, but they likely relate to interacting factors such as local and large-scale animal population dynamics, ecology, and paleoenvironmental processes. Articulating all dimensions based on rather imperfect archaeological records, unsuitable ecological data, and the vast field of human cultural facts, is a challenge for archaeomalacology. The use of metrics recorded on archaeologically-recovered species is particularly discussed here as a case study. It illuminates the parameters and pitfalls that need to be taken into account before building anthropogenic or paleoecological interpretations.

KEYWORDS: MOLLUSCS, PRE-COLUMBIAN AMERINDIAN LESSER ANTILLES, CONSUMPTION, INDUSTRY, METRICS, ECOLOGY

RESUMEN: La diversificada explotación de moluscos en las Antillas menores precolombinas queda sintetizada a través de datos procedentes de 27 yacimientos y muestras que discurren desde el Precerámico hasta el Cerámico (ca. 1000 a.C. - 1200 d.C.). Las patentes variaciones que desempeñaron los moluscos en distintos momentos reflejarían una evolución económica y cultural de las sociedades amerindias isleñas que, hoy por hoy, es mal comprendida, aunque seguramente implicarían la interactuación de una amplia serie de factores entre los que incluimos la propia dinámica de las poblaciones, tanto a escala local como regional, y procesos que afectarían a la ecología y al paleoambiente. Integrar todos estos fenómenos sobre la base de registros arqueológicos incompletos, datos ecológicos inadecuados y una enorme variedad de factores de origen antrópico, es un reto para la arqueomalacología. Se valora aquí, en concreto, el uso de la biometría realizada sobre especies arqueológicas a modo de botón de muestra. Ello ilustra los parámetros y limitaciones que uno tiene que tener en cuenta antes de intentar realizar interpretaciones antropogénicas y paleoambientales.

PALABRAS CLAVE: MOLUSCOS, AMERINDIOS PRECOLOMBINOS, ANTILLAS MENORES, CONSUMO, INDUSTRIA, BIOMETRÍA, ECOLOGÍA

INTRODUCTION

The pre-Columbian Amerindian societies of the West Indies used molluscs in various ways which are of interest to the field of archaeomalacology. A good number of assemblages witness to the diverse roles these organisms played from the Preceramic up to the Late Ceramic Ages (ca. 1000 BC-AD 1200). Molluscs were simultaneously an important food resource, a raw material for tools and ornaments, and trade items integrated within the mobility and spatial occupation strategies.

In a complementary role to marine fish, molluscs occupied an important place in the subsistence economies of the pre-Columbian societies, especially in the small islands of the Lesser Antilles characterised by a limited set of terrestrial animal resources. Yet, this role fluctuated through time and these variations remain to be fully understood. While some relate to economic, cultural, and social processes, they also likely imply other dynamic factors. It is clear that local, seasonal and large-scale animal population dynamics and ecology, and paleoenvironmental processes (e.g. local modifications of littoral environments, sea-level fluctuations), interacted with the human activities (e.g. susceptibility to stock depletion).

It is thus challenging for archaeomalacology to investigate from the basis of the rather imperfect archaeological records, incomplete and sometimes unsuitable ecological data, and the vast field of human cultural facts and social processes. This challenge is compounded in the West Indies, where the set of raw archaeological and ecological information, although extensive, is still often incomplete. The use of metrics on archaeological specimens is discussed here as an example of the difficulty of building anthropogenic or paleoecological interpretations.

THE EXPLOITATION OF MOLLUSCS IN THE PRE-COLUMBIAN AMERINDIAN LESSER ANTILLES: GENERAL TRENDS

The Caribbean islands (Figure 1) were first settled by mobile navigators, hunters and gatherers known as Preceramic peoples. Coming either from South or Central America, they were present in some of the Greater and Lesser Antilles islands, and in Trinidad starting around the 6th millennium BC. Around 500 BC, more sedentary groups of potters and horticulturists (Saladoid series) came from the Venezuelan and Guyanese coasts. Initiating the Ceramic Age, they initially occupied the Lesser Antilles only as far north as the eastern tip of Hispaniola (Figure1). Between the 7th and 9th centuries AD, multiple lines of evidence point to a regional diversification in ceramic styles, population movements, colonization of the entire West Indies (Figure 1), and an increase in cultural and social complexity. This post-Saladoid period of the Ceramic Age (Ostionoid, Troumassoid, and Suazoid series) lasted until the European arrival (Contact period after 1492) (Rouse & Cruxent, 1963; Rouse, 1992; Keegan, 1994, 2000).

The evidence for Caribbean pre-Columbian Amerindian subsistence economies implies various combinations of hunting, fishing and collecting of terrestrial and marine plants and animals (Wing & Wing, 1995; deFrance *et al.*, 1996). Those came in addition to horticulture which was more or less developed in the Preceramic Age economies (Pagan & Rodríguez, 2007) and likely became a staple during the Ceramic Age. In the Lesser Antilles, the set of terrestrial animal resources being rather limited (reptiles, birds, small mammals, crabs), molluscs had their role in the subsistence in complement to marine fish. Moreover, they were an important raw material for a variety of tool and ornamental productions, as well as valued trade items (Serrand, 2002).

During the Preceramic period, marine molluscs make up the majority of faunal remains in the coastal sites of the Lesser Antilles (see Armstrong, 1978; Lundberg, 1989; Brokke, 1999). They were most often collected intensively with a few productive, large-sized species targeted; quite often bivalves available in shallow biotopes. Two recently excavated Preceramic coastal sites in St Martin, Orient Bay (800-400 BC; Bonnissent *et al.*, 2002, 2003) and Etang Rouge (Bonnissent *et al.*, 2005), confirm patterns of occupation and resource exploitation largely centred on molluscs (Serrand, 2005a; Serrand & Bonnissent, 2005; Figure 2a, b). Shellfish predominate at both sites (Figure 2a): in Etang Rouge, a large bivalve, *Arca zebra,* was intensively targeted (MNI = 4889, 93%). In Orient Bay, five species (MNI = 3819, 84%) – including the large Queen Conch *Strombus gigas* and West Indian topshell *Cittarium pica* – were collected in a pragmatic way with the most accessible specimens targeted in the shallow sea grass beds and intertidal rocky shores. Both sites

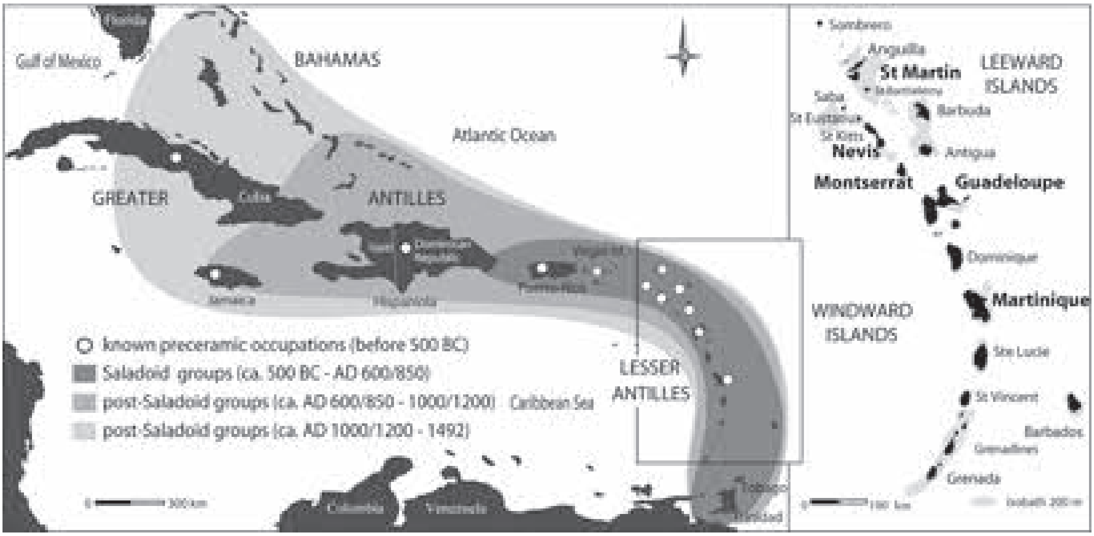

FIGURE 1

Simplified major pre-Columbian phases in the West Indies (after Hofman 1993, fig. 94); close-up of the Lesser Antilles – in bold: islands mentioned in the text.

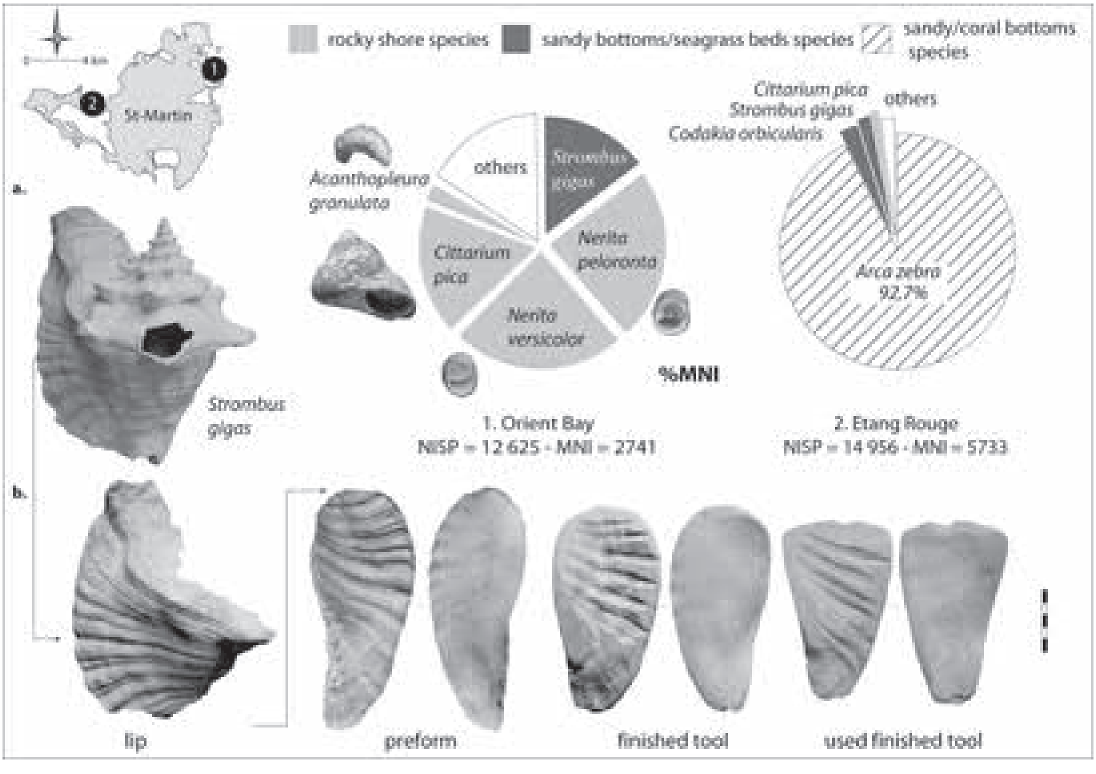

FIGURE 2

(a) Proportions of individuals (% MNI) of the major species in the Preceramic sites of Orient Bay and Etang Rouge in Saint-Martin (Northern Lesser Antilles); (b) Production stages of tools made of the lip of *Strombus gigas* in Orient Bay.

contain evidence testifying to the cooking of large amounts of these molluscs on the spot, in structures composed of heated rocks (Bonnissent *et al.*, 2002, 2003). In Orient Bay, moreover, lips of mature conchs were used for the intensive production of standardized adze tools (Figure 2b). This industry, maybe related to the manufacture of wooden canoes, continued throughout the punctuated occupation of the site. Access to *Strombus gigas* populations, providing raw materials for tools, thus likely played a major role in the location of the Orient Bay specialized site, while subsistence motives were probably more important in terms of Etang Rouge. In both cases, nearby dense populations of a few large species of molluscs, which were intensively exploited, appear to have motivated series of short-term, repeated occupations.

As Orient Bay and Etang Rouge, other Preceramic sites of the Lesser Antilles reveal specialized economic strategies centred on different zones of the landscape, with coastal economies being centred on molluscs while terrestrial resources are targeted in inland sites (Hofman & Hoogland, 2003). These lines of evidence suggest that the distribution of resources played an important role in the groups' mobility and, hence, spatial occupation patterns of that period. These were probably based on the cyclic exploitation of complementary resources for social facets such as industry and subsistence, within a network of specialized sites. Molluscs played an important role within these systems as witnessed by the coastal sites.

During the following Ceramic Age, the Amerindian groups of the Saladoid and subsequent post-Saladoid series were largely sedentary and relied on horticulture. While still a component of the subsistence economy, molluscs probably played a less significant role. This fact is reflected in the less diffuse mobility and spatial occupation strategies.

For the very early (Huecan/Cedrosan) Saladoid period (ca. 500 BC-AD 400), several sites of the Lesser Antilles studied by the author – Radio Antilles and Trants (Petersen, 1996) in Montserrat, Hope Estate in St Martin (Bonnissent & Henocq, 1999), and Cathédrale and Gare Maritime de Basse–Terre in Guadeloupe (Bonnissent *et al.*, 2004, Romon *et al.*, 2006) – show similar exploitation patterns of molluscs and more generally invertebrates (Serrand, 2002, 2004). Land invertebrates play an important role: either crabs as in Hope Estate, Trants and Radio Antilles, or freshwater snails such as *Neritina virginea* in Cathédrale and Gare Maritime de Basse-Terre. As for marine molluscs (Figure 3a), bivalves were rarely exploited and the gathering focused mostly on gastropods, apparently collected at random in the productive ecological zones of the rocky shore and sea grass areas. While the most productive species of these ecotones (i.e. *Cittarium pica, Strombus gigas*) were collected in good numbers, there is little to suggest they were necessarily targeted. As these sites witness, the importance of land invertebrates (crabs / snails) decreases through time in favour of the marine gastropods from rocky shores (notably nerites and *Cittarium pica*) and sea grass beds (conchs, star and turban shells). In parallel, during that period, the shell industry is well developed and diversified with artefacts mostly related to the ornamental field but rather standardized from one site to the other: there is a clear homogeneous common background.

The later phases of the Ceramic period witness changes in the exploitation of invertebrates. Several sites in Martinique, spanning from the late Saladoid to Suazoid series, give particular insights into this evolution (Serrand, 2007) (Figure 3b). Gathering at the coastal site of Dizac (ca. AD 450-700), while including various mollusc species from several environments (sandy bottoms, sea grass beds, rocky zones), initially focused on a small bivalve, *Donax denticulatus* (West-Indian donax). Targeted on the nearby sandy splash zone, it remains important throughout the occupation (30 to 50% MNI) but with a clear decrease in numbers through time. In parallel, other more distant and varied environments (sea grass beds, sandy bottoms, rocky shores, and mangrove) and species, including mostly bivalves, are progressively included. These variations go along with changes in the metrics of *Donax* (see second part of the paper). The importance of the small bivalve in this site initiates a trend which becomes more noticeable through time as in the three later coastal sites of Martinique: in Les Salines (5-8th and 12-13th centuries AD, Saladoid/Troumassoid series), Trabaud (11-13th c. AD, late Troumassoid/early Suazoid series), and Macabou (12-15th c. AD, Suazoid series), the exploitation is almost entirely focused on dense bivalve beds (over 70% MNI), easy to collect in large quantities, on sandy and muddy bottoms present near the sites (Figure 3b).

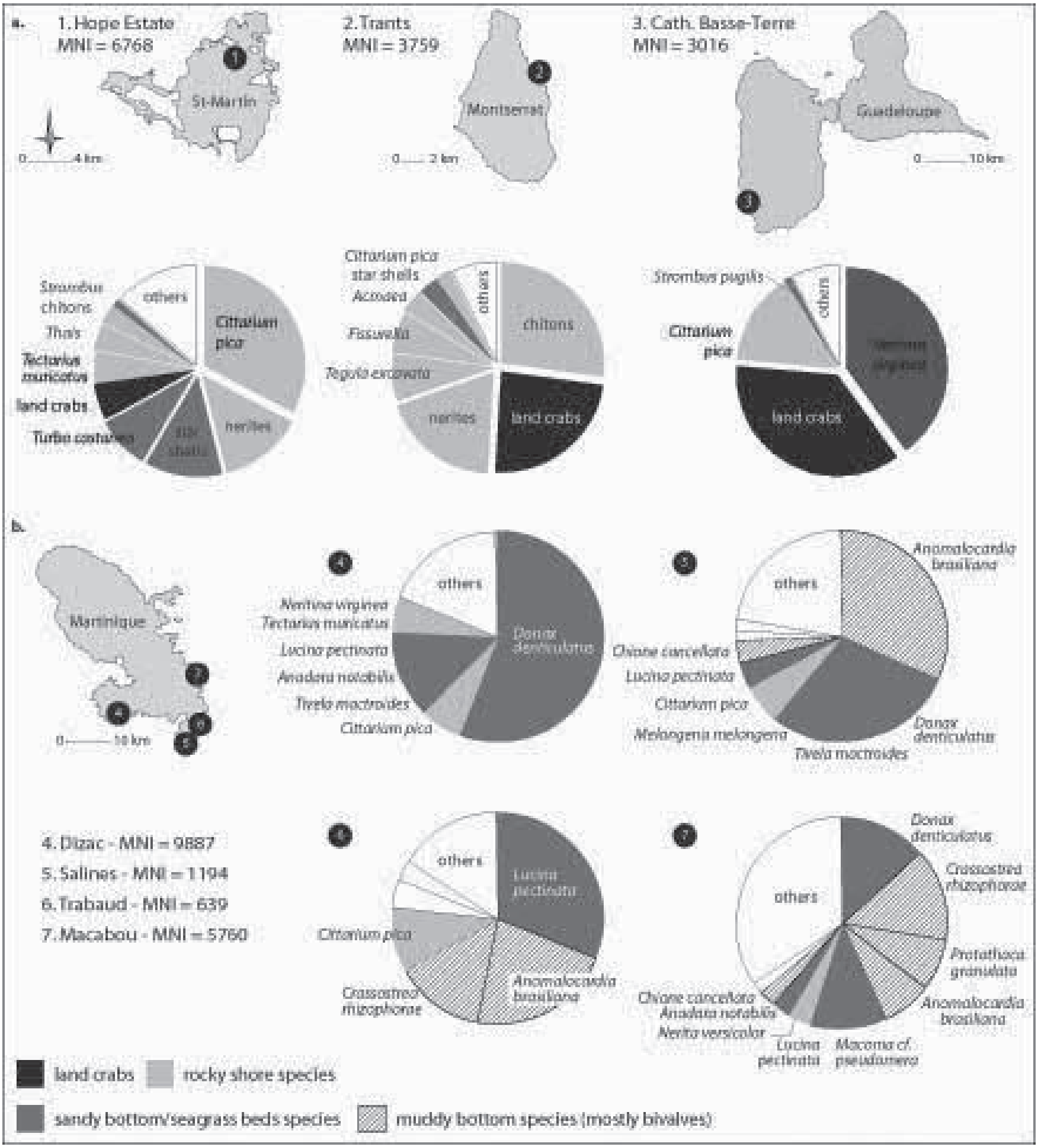

FIGURE 3

Representation of the major species in: (a) three early cedrosan Saladoid sites of in Saint-Martin, Montserrat and Guadeloupe; (b) four late Saladoid to post-Saladoid sites of Martinique – see text for dates.

Although not systematic, the pattern through time is rather clear: most late Saladoid to post-Saladoid period sites studied by the author in the Lesser Antilles are also characterized by the importance of bivalves (e.g. Sulphur Ghaut in Nevis and Bas-de-la-Source in Guadeloupe where *D. denticulatus* accounts for respectively 88 and 53% MNI; Serrand, 2002, 2005b). While situations may be more varied in the Greater Antilles and the Bahamas given the higher diversity of land resources, a few sites currently under study also include a sizeable bivalve component (e.g. Paso del Indio in Puerto Rico, where *Anomalocardia brasiliana* accounts for 22% MNI; three late post-Saladoid sites in Middle Caicos, Bahamas, where bivalves account for between 40 and 80% MNI; Serrand, unpubl.).

The higher contribution of bivalves is thus clearly marked in a large number of late Saladoid and post-Saladoid sites. Although bivalves contribute little in terms of meat (compared with fish, mammals or large gastropods), these gregarious species have the advantage of being concentrated in dense beds and easy to collect in large quantities. They were favoured for some reason by most sites' inhabitants of this period and this overall pattern in the Lesser Antilles contrasts with that of the former early Saladoid period. Indeed, it has been shown that land invertebrates and gastropods of the rocky shores and sea grass beds dominated while bivalves were rare (Serrand, 2002). In opposition, in most late Saladoid and post-Saladoid sites, the exploitation of land invertebrates is universally small, with a few local exceptions [e.g. Pointe du Helleux in Guadeloupe, Grouard (2001)], while that of bivalves increases or is dominant (Figure 4). This trend appears at a time when former unsettled islands are colonized and settlement processes intensify in the formerly occupied islands. In Martinique, for example, there is an increase in the number and diversity of post-Saladoid sites; they are located in a greater variety of locations and often functionally specialized (Bérard, 2004; Bérard *et al*., 2005). The increasing integration of bivalves –species available in larger quantities and densities – during the post–Saladoid period may thus parallel and reflect an intensification of resource exploitation. The precise relationships between this trend and the new settlement patterns are unclear but the predilection for dense available resources is overall consistent with the apparent process of settlement intensification. Nevertheless, again, data from the Greater Antilles should be included to widen this picture.

ANIMAL POPULATION DYNAMICS, PALEOENVIRONMENTAL PROCESSES, AND HUMAN ACTIVITIES: A CHALLENGING MIX FOR CARIBBEAN ARCHAEOMALACOLOGY

Trends appear through time in the use of molluscs by the Pre-Columbian Amerindian societies of the Lesser Antilles. They likely reflect a combination of local and large-scale social and economic strategies, patterns and evolutions, animal population dynamics and ecology (seasonal variations, susceptibility to stock depletion), and paleoenvi-

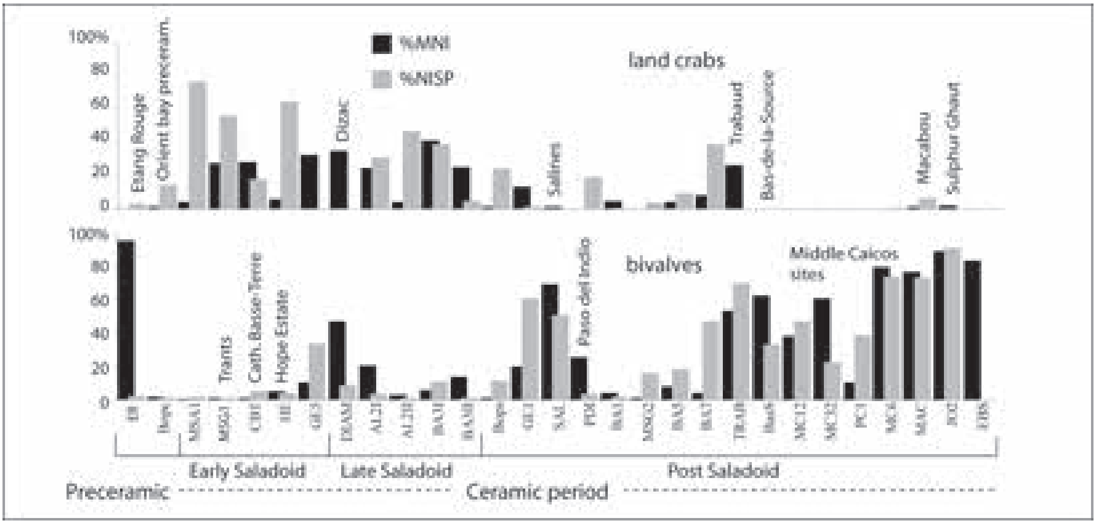

FIGURE 4

Variation of the % MNI and % NISP of land crabs and bivalves in several sites of the West Indies across the Preceramic and ceramic periods.

ronmental processes (sea-level fluctuations, local modifications of littoral environments).

It is not the aim of this paper to explore all of these possible aspects and their interactions – as yet mostly uncontrolled in the Caribbean – but to present a few cases which demonstrate the need for caution when interpreting data. One restricted aspect – metrics – is used as a means of approaching and discussing possible multi-scale parameters that should be taken into account before building anthropogenic or paleoecological interpretations.

In the Caribbean, assessing the value of metric data recorded on archaeological specimens and comparing them are difficult tasks. Indeed, data on the ecology and growth patterns are available for only a few economically important species (e.g. the conch *Strombus gigas*) and incomplete or absent for many others. This adds to the difficulty of using incomplete archaeological records where assessing the time range of the various deposits (site and inter-site levels) is not always easy. Such difficulties are exposed in the following two examples.

As has been seen before (see above), the shell assemblage of the late Saladoid site of Dizac in Martinique is dominated by the small bivalve *Donax denticulatus*, which is the main species at least in terms of gathering time investment. Initially targeted, it remains important throughout the occupation (30 to 50% MNI). Nevertheless, this species importance slightly decreases in time in favour of other species which are progressively incorporated. Changes occur along in the mean length of *Donax* individuals and in the structure of the collected archaeological population(s). Initially, *Donax* is heavily exploited, the individual mean length is high and steady and the population balanced. In the following part of the sequence, the quantity of *Donax* fluctuates and decreases and both the mean individual length and the population structure reveal episodes of decline and signs of imbalance (Figure 5). One would be tempted to

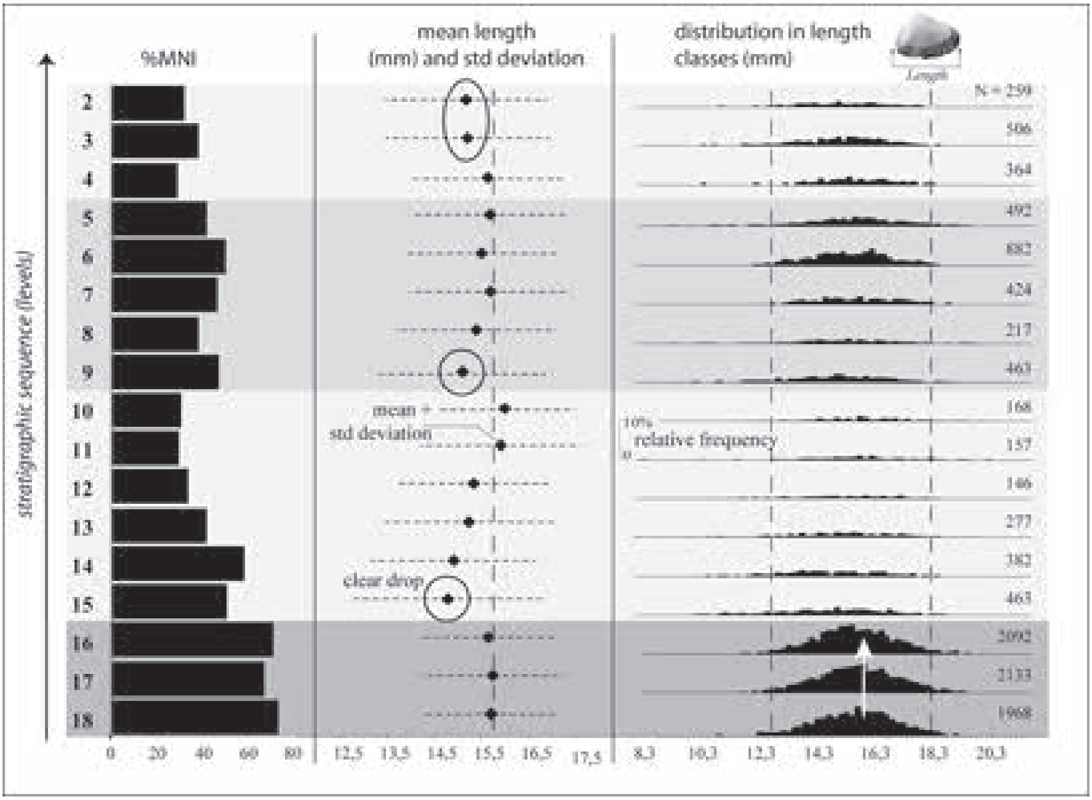

FIGURE 5

Relative frequencies of individuals (% MNI), mean length (mm) and distribution in length classes (mm) of *Donax denticulatus* individuals on the stratigraphic sequence of Dizac.

conclude that these trends reflect the impact of the initial intensive exploitation leading to an imbalance of the bivalve beds hence their lesser exploitation at the end of the occupation. But several factors and unknowns make it more complex and should be taken into account.

From an archaeological point of view, the excavated portion of the site is a dump area formed by the accumulation of several episodes of discard and does not correspond easily with stratified occupation levels. Thus the temporal aspects of the dump are ambiguous. Moreover, the archaeological material does not allow specification of the occupation pattern of the site, such as classification as permanent occupation, specialized activity site, or other function. Thus, estimating the exact value of the analyzed samples is hard in that there are few stratigraphic indicators to isolate episodes of mixing and separate discard events clear through time. It is consequently hard to assess what is the temporal range of the metric trends. What remains is that they nevertheless go along with clear modifications in the species proportions and these proportions appear to define coherent phases (Figure 5).

From the anthropogenic point of view, the collecting modes are unknown. They may have fluctuated during the occupation, depending upon the season, the groups of gatherers, or another variable/mix of variables: the gathering could be, always or sometimes, targeted or random with even the smallest specimens kept, or with a sorting of only the specimens of decent size. It could be conducted across the whole beach or only in some parts, and hence focused on specific local beds. In short, the variations could simply reflect varying events and modes of collecting through time depending on fluctuating mix of variables rather than the tangible impact of a constant and continuing mode of collecting.

From the ecological point of view (Figure 6), there are several contributions about the ecology, growth, and reproduction of *Donax denticulatus* (Etechevers, 1975; Marcano *et al.*, 2004). They show great variation of data between different populations and localities. For example, Vélez (1985) and Vélez *et al.* (1985) state for *Donax* in Venezuela a life expectancy of 13 to 16 months, length variation (beyond the spat stage) of 4 and 24 mm, and a major reproductive season between July and December. On another hand, Wade (1967, 1968) indicates great variations in the densities and length frequencies between populations from different localities of Jamaica.

It is thus hard to find a good present-day sample as a comparison basis for our incomplete archaeological data, and to go (for now at least) beyond the assessment of fluctuations«probably» related to some impact of the collection but possibly combined with the marked seasonal fluctuations of the *Donax* populations and of the gathering activity itself. Further mixture analysis (based on the method of maximum likelihood) will be tested, using bootstrap and kernel methods (Monchot & Léchelle, 2002) to help identify the various components of the samples and study the distributions better than is possible with histograms.

The second case deals with data on the West Indian topshell *Cittarium pica* through time on the island of Saint-Martin at the Orient Bay Preceramic site, the Hope Estate early Saladoid site, and the Orient Bay post-Saladoid site (see above). The first and last sites, almost 1000 years apart, are in the same coastal location, thus making the comparison especially interesting. *C. pica* accounts for between 25 and 50% of the MNI in the three sites (Figure 7). Metrics are presented according to the width [measured across the widest dimension of the shell base; Debrot (1990b)]. In the Orient Bay Preceramic site [800-400 BC; Bonnissent *et al.* (2003)] (Figure 7), a likely punctuated occupation with no apparent stratigraphy, the sample of measured specimens is considered as a whole (n = 115[1]). It comprises mostly medium-sized individuals supplemented by a smaller proportion of large specimens. At Hope Estate, a long-term occupation with stratified deposits [500 BC-AD 700; Bonnissent & Henocq (1999)], small individuals dominate in the total sample (n = 398[2]) and in most stratigraphic levels[3]. All other classes are nevertheless also represented but in low proportions. Finally, in the Orient Bay post-Saladoid site [8-10th c. AD; Bonnissent *et al.* (2002)], a likely one-time occupation with no apparent stratigraphy, the population sample (n = 1135) is balanced with a few juveniles, a sizeable portion of young to medi-

---

[1] The small number is due to high fragmentation. Nevertheless, the fragments (n = 1255), sorted into growth classes, mostly belong as well to small-to-medium and medium (78%) sized individuals.

[2] Again, the small number is due to high fragmentation. Unfortunately, no assessment of the fragments' growth stages was conducted and fragmentation could bias the width-frequencies.

[3] No significant difference between the levels could be detected.

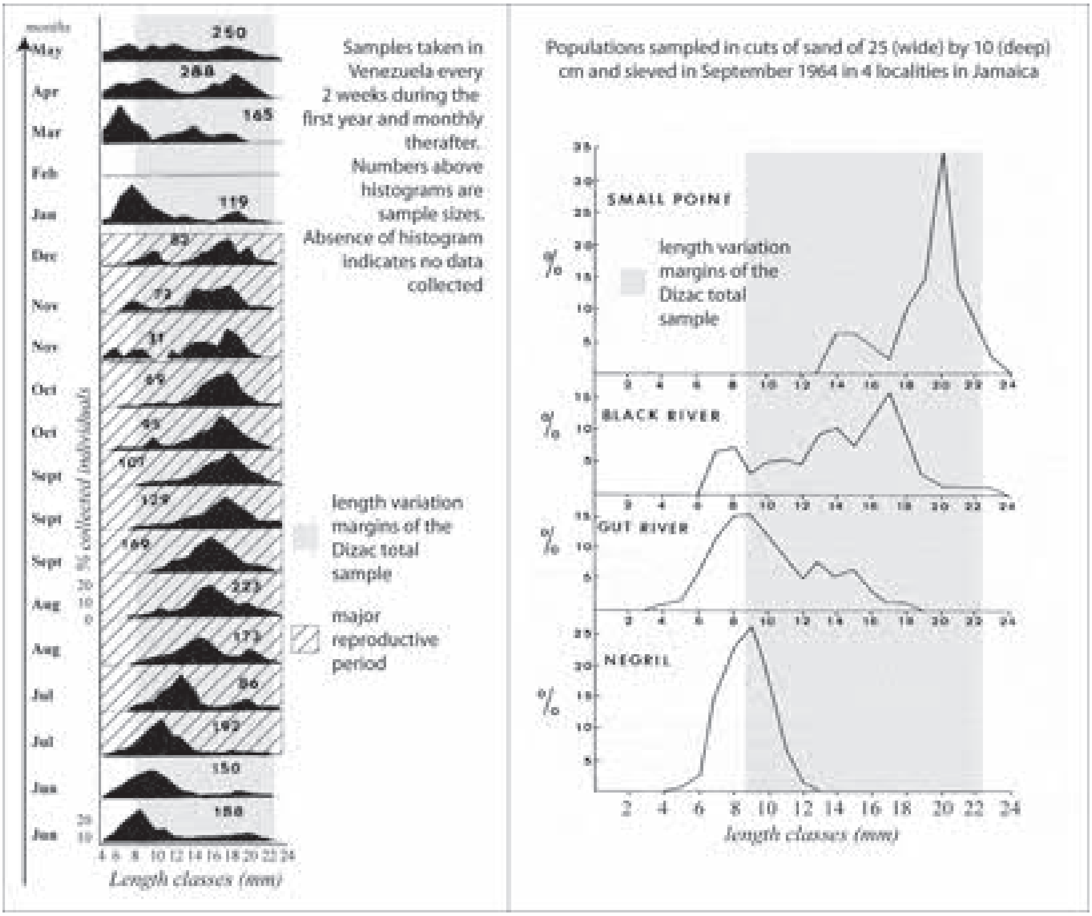

FIGURE 6

(a) Excerpt from Velez *et al*. (1985: fig. 1) – Length-frequency histograms for *D. denticulatus* 1974-1976; (b) Excerpt from Wade (1967: fig. 7) – Length-frequency graphs for samples of four populations of *D. denticulatus* in Jamaica.

um-sized specimens and some large-sized individuals.

A few studies (Randall, 1964; Debrot, 1990a, b; Bell, 1992), and present-day data (Schmidt *et al*., 2002) (Figure 8) show interesting differences in width-frequency distributions of *Cittarium pica* individuals at both human exploited and non-exploited sites in Costa Rica[4]. The absence of the large size classes at the exploited sites and the balanced distribution at the unexploited one nicely echo those at respectively the Hope Estate and post-Saladoid Orient Bay sites (Figure 7). Nevertheless, again, one needs to look at various factors before pretending to understand these data, in particular, the archaeological and anthropogenic variables suggested by the samples, basic site data and potential exploitation patterns.

As seen above, in the episodically-frequented Preceramic Orient Bay site, the shell industry and the access to raw materials seem to have been the determining factor in the choice of location and settlement strategies. The gathering of molluscs for food was very likely a secondary focus and was organized accordingly. Utilising a ‘pragmatic’

---

[4] To note that the width variation margins recorded in Schmidt *et al.* 2002 in Costa Rica in both exploited and non-exploited sites are smaller than those recorded in our archaeological samples.

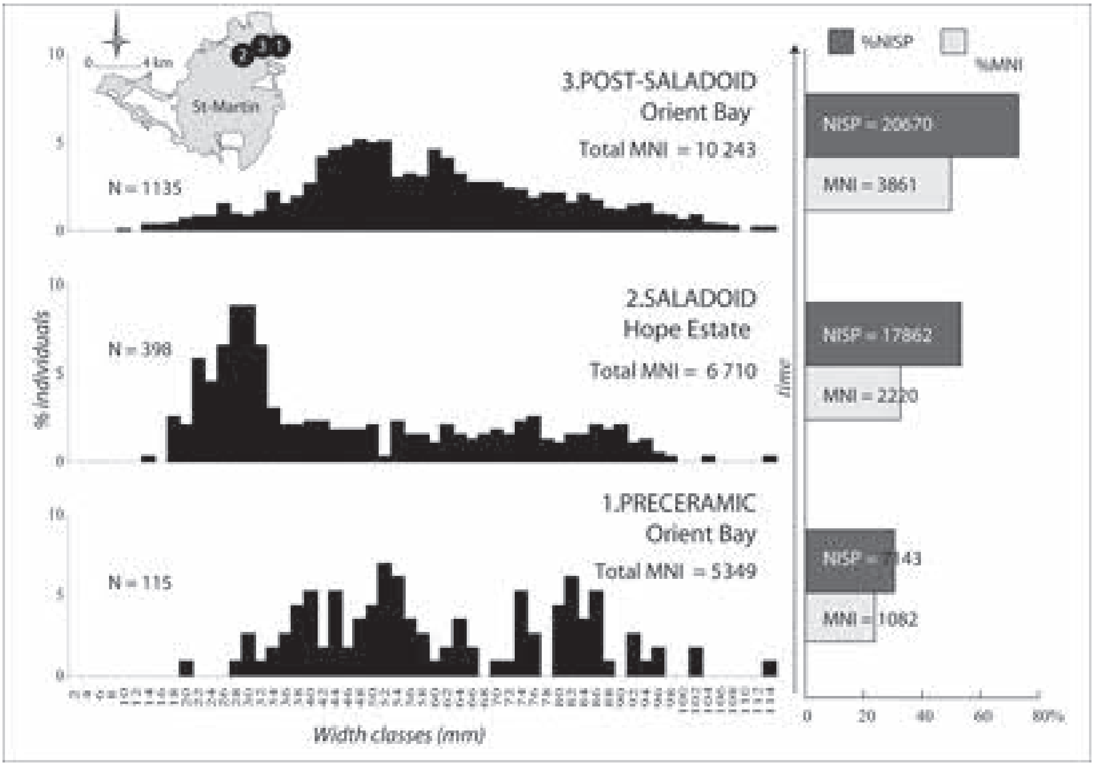

FIGURE 7

Distribution in width classes (mm) of *Cittarium pica* individuals and relative frequencies of individuals (% MNI) in the three sites of preceramic Orient Bay, Saladoid Hope Estate and post–Saladoid Orient Bay – see text for dates.

strategy, inhabitants took advantage of species and individuals easily available in the nearby shallow, productive enough, environments. This is the case for the medium-sized individuals of *C. pica,* which are easily found in the upper levels of the rocky intertidal, and thus were probably favoured by the occupants for the ease of their collecting, although more mature specimens were available as well (a few are represented in the archaeological sample[5]).

The Saladoid Hope Estate site is a long-term occupation village located about 2 km distant heading inland, up in the mountains. This site yielded evidence of differential transportation of shells with regard to the larger species, *Strombus gigas* (Serrand, 2002), and it is possible that it was also the case for *C. pica*. Most of the largest shells may have been discarded after meat extraction at the collecting site(s) and only their flesh and smaller individuals – for which the extraction on the spot may be less cost-effective then the transportation (Bettinger & Malhi, 1997) – were brought to the site. The high proportion of small individuals in the sample may therefore not reflect the state of the collected natural population or the targeting of the collecting but mostly transportation or consumption strategies related to the management of distances and costs.

Finally, in the post-Saladoid Orient Bay site, a likely one-time occupation, *Cittarium pica* appears to have been the major mollusc exploited for food (>54% MNI). Local populations were intensively exploited including specimens of all size classes. The archaeological population structure is balanced, and close to that of a natural one.

---

[5] To note, as underlined by K. Szabo, the lack of focus on larger, less accessible specimens probably heightened the population's ability to recruit and replenish their stocks.

Nevertheless, the occupation/exploitation duration is unknown. What appears as a one mid-term event of exploitation may be the result of several accumulated events. Despite this, it is clear that the West Indian top shell was the sole exploited mollusc resource and all specimens were integrated (and likely brought back to the site).

Again, thus, before metrics can be used to discuss potential changes in the local populations of one species through time, and related to possible human impacts, all combined potential parameters must be examined, here especially the clues about the exploitation patterns.

DISCUSSION AND CONCLUSION

Of all the various approaches that can be used to investigate the nature of archaeomalacological samples, one must take particular care with metric information. As the sketchy presentation of the varied uses of molluscs showed, their exploitation by the Amerindian pre-Columbian populations was obviously part of larger and complex strategies of territorial occupation, mobility, economic cycles and networks, most of which are still mostly unknown. Therefore, as demonstrated through the three sites in Saint-Martin, no matter how good the metric records, it is crucial to put them back into anthropic frames (settlement patterns, resources exploitation strategies, mobility, networks of specialized sites, etc.) to avoid certain pitfalls. On another hand, such metrics clearly cannot be properly addressed if precise ecological and biological data are not available, or, even better, present-day analogues. Unfortunately, such analogues are generally lacking in the Lesser Antilles. Finally, it is also necessary to put into practice adapted tools for analyzing data under discussion (e.g. mixture analysis; Monchot & Léchelle, 2002). In short, several levels of parameters need to be included in any interpretative approach given the complexity of human social behaviours and the various unknowns and imperfections of the archaeological record, ecological data and paleoenvironmental field.

In this last regard, it is becoming clear in the West Indies that local and large scale, short- and long-term environmental changes probably played a role in some of the socio-economic options that the Amerindian populations adopted through time. A few paleoenvironmental studies conducted in Puerto Rico, Haiti and St Thomas suggest wet /

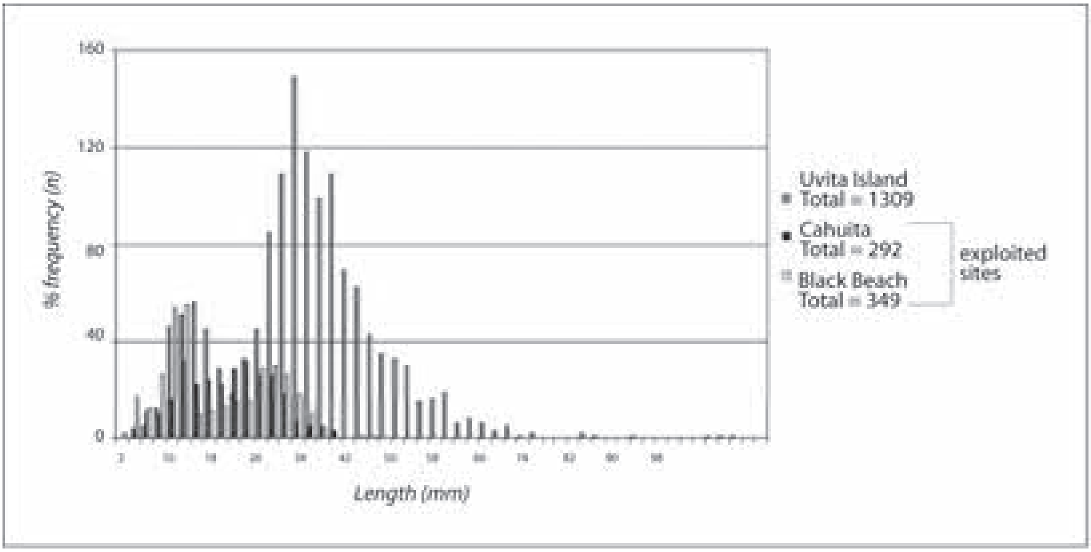

FIGURE 8

Excerpt from Schmidt *et al*. (2002: fig. 2) – length-frequency distributions of *Cittarium pica* at the three sampling sites on the Caribbean coast of Costa Rica 2000-2001 – what is called«length» is described by the author as the width defined in Debrot 1990b (Schmidt *et al*., 2002: 1081) which is the measure used for our archaeological samples; frequencies are not relative.

dry alternations (Higuera-Gundy, 1991; Hoddell *et al*., 1991; Curtis & Hoddell, 1993; Burney *et al*., 1994). Such climatic alternations are evidenced for the Lesser Antilles as well, although with local variation. In the Guadeloupean site of Anse à la Gourde (Beets *et al*., 2006), data are available for the 6th and 13th centuries AD and, on the island of Saint-Martin, during the last four millennia (Bertran *et al*., 2004; Bonnissent *et al*., 2007). Relative synchronicities appear at Anse à la Gourde and in Saint-Martin between the major occupation events and cultural phases (in Saint-Martin, especially the Saladoid and post-Saladoid periods) and the various climatic alternations. These data illuminate paleoenvironmental variability and its potential role, along with other parameters (cultural, demographic, socio-political), within the economic, occupation and mobility patterns on local and larger scales (site, coastal area, part of an island, cultural phases, etc.). And, clearly these climatic alternations, sea-level fluctuations (Lighty *et al*., 1982; Digerfeldt & Hendry, 1987) and cyclical tropical disturbances had a local impact (modification, transgression and regression of ecosystems) on the resources, their richness and availability and probably impacted some of the Amerindian exploitation strategies. This largely unexplored aspect cannot be ignored and should be explored further. It is especially interesting to raise the matter when addressing the increasing role of bivalves (see Keegan *et al*., 2003) which becomes noticeable with the late Saladoid period and later, in a time of intensification of social and demographic processes and likely climatic transition to a dryer phase (Bonnissent *et al*., 2007).

ACKNOWLEDGEMENTS

My sincere thanks go to Katherine Szabo for her kind and most efficient editing of the manuscript and improvement of its clarity. I am thankful to all persons and institutions that contributed to the various aspects of this ongoing research: the Regional Services for Archaeology in Martinique and Guadeloupe and their curators; the National Institute for Research in Salvage Archaeology (INRAP) in Guadeloupe and D. Bonnissent; the Ouacabou Association in Martinique and B. Bérard; the Hope Estate Association for Archaeology in St Martin and C. Henocq; the Florida Museum of Natural History in Gainesville and W.F. Keegan, E.S. Wing, and I. Quitmyer; D.R. Watters of the Carnegie Museum of Natural History in Pittsburgh; and J. B. Petersen, sadly gone, of the Vermont University.

REFERENCES

ARMSTRONG, D.V. 1978: Archaic Shellfish Gatherers of St Kitts, Leeward Islands: a Case Study in Subsistence and Settlement Patterns. Unpublished Master's Thesis, Dept. of Anthropology, UCLA.

BEETS C.J.; TROELSTRA, S.R.; GROOTES, P.M.; NADEAU, M.J.; VAN DER BORG, K.; DE JONG, A.F.M.; HOFMAN, C.L. & HOOGLAND, M. L. P. 2006: Climate and pre-Columbian settlement at Anse à la Gourde, Guadeloupe, northeastern Caribbean. *Geoarchaeology* 21(3): 271-280.

BELL, L.J. 1992: Reproduction and larval development of the West Indian topshell, *Cittarium pica* (Trochidae), in the Bahamas. *Bulletin of Marine Science* 51: 250-266.

BÉRARD, B. 2004: *Les premières occupations agricoles de l'arc antillais, migration et insularité. Le cas de l'occupation Saladoïde ancienne de la Martinique*. BAR S1299, Monographs in American Archaeology 15. Paris.

BÉRARD, B.; GROUARD, S. & SERRAND, N. 2005: L'occupation post-saladoïde du sud de la Martinique, une approche de l'idée de territoire. *Communication présentée au 21st International Congress of the Association for Caribbean Archaeology*, Port of Spain, Trinidad, 24-30 juillet 2005, International Association for Caribbean Archaeology.

BERTRAN, P.; BONNISSENT, D.; GALOP, D.; IMBERT, D.; LOZOUET, P.; SERRAND, N. & STOUVENOT, C. 2004: Paléoclimat des Petites Antilles depuis 4000 ans BP: l'enregistrement de la lagune de Grand-Case à Saint-Martin. *Comptes Rendus Géoscience* 336: 1501-1510.

BETTINGER, R.L. & MALHI, R. 1997: Central place foraging models of acorn and mussel processing. *Journal of Archaeological Science* 24: 887-899.

BONNISSENT, D. & HENOCQ, C. 1999: Saint-Martin, Hope Estate. *Bilan Scientifique 1998*: 40-41. Service Régional de l'Archéologie, Direction Régionale des Affaires Culturelles, Ministère de la Culture, Direction du Patrimoine, Sous-Direction de l'Archéologie.

BONNISSENT, D.; BERTRAN, P.; CHANCEREL, A.; GROUARD, S.; ROMON, T.; SERRAND, N; STOUVENOT, C. & TARDY, C. 2002: *Les sites de la Baie Orientale. Occupations précéramiques et post-Saladoïde, Saint-Martin, Guadeloupe, Petites Antilles*. Document

Final de Synthèse auprès du Service Régional d'Archéologie de Guadeloupe.

BONNISSENT, D.; BERTRAN, P.; CHANCEREL, A. & ROMON, T. 2003: Le gisement précéramique de la Baie Orientale à Saint-Martin (Petites Antilles). Résultats préliminaires. In: Alofs, L. & Dijkhoff, R.A.C.F. (eds.): *Proceedings of the 19th International Congress for Caribbean Archaeology*: 78-88. Vol. 9. Publication of the Museo Arqueologico Aruba, Aruba.

BONNISSENT, D.; ROMON, T.; BERTRAN, P. & SERRAND, N. 2004: *Le site de la Cathédrale de Basse-Terre, Guadeloupe*. Rapport au Service Régional de l'Archéologie de Guadeloupe.

BONNISSENT, D.; BERTRAN, P.; FOUERE, P. & SERRAND, N. 2005: *Cultures précolombiennes des Petites Antilles. Les occupations précéramiques de l'Etang Rouge 1. Baie Rouge, Les Terres Basses, Ile de St-Martin, Région Guadeloupe*. Document Final de Synthèse auprès du Service Régional d'Archéologie de Guadeloupe.

BONNISSENT, D.; BERTRAN, P.; GALOP, D.; IMBERT, D. & STOUVENOT, C. 2007: Chronologie des occupations précolombiennes de l'île Saint-Martin (Petites Antilles) et relations avec les paléoenvironnements. In: University of the West Indies, School of Continuing Studies, St Augustine (ed.): *Proceedings of the XXI Congress of the International Association for Caribbean Archaeology*: 20-30. Port of Spain, Trinidad.

BROKKE, A.J. 1999: Part one: Norman Estate. Shell. In: Hofman, C.L. & Hoogland, M.L.P. (eds.): *Archaeological Investigations on St. Martin (Lesser Antilles). The Sites of Norman Estate, Anse des Pères and Hope Estate with a contribution to the 'La Hueca problem'*: 47-50. Leiden University Archaeological Studies, Faculty of Archaeology, Leiden.

BURNEY, D.A.; PIGOTT BURNEY, L. & MCHEE, R.D.E. 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.

CURTIS, J.H. & HODDELL, D.A. 1993: An isotopic and trace element study of ostracods from Lake Miragoane, Haiti: a 10500 year record of palaeosalinity and palaeotemperature changes in the Caribbean. In: Swart, P.K.; Lohmann, K.C.; Mckenzie, J. & Savin, S. (eds.): *Climate change in the continental isotopic record*: 135-152. American Geophysical Union. Geophysical Monograph Number 78.

DEBROT, A.O. 1990a: Temporal aspects of population dynamics and dispersal behavior of the West Indian topshell, *Cittarium pica* (L.), at selected sites in the Exuma Cays, Bahamas. *Bulletin of Marine Science* 47(2): 431-447.

DEBROT, A.O. 1990b: Survival, growth, and fecundity of the West Indian topshell *Cittarium pica* (Linnaeus), in various rocky intertidal habitats of the Exuma Cays, Bahamas. *Veliger* 33: 363-371.

DEFRANCE, S.D.; KEEGAN, W.F. & NEWSOM, L.A. 1996: The archaeobotanical, bone isotope, and zooarchaeological records from Caribbean sites in comparative perspective. In: Reitz, E.J.; Newsom, L.A. & Scudder, S. (eds.): *Case Studies in Environmental Archaeology*: 289-304. Plenum Press, New York.

DIGERFELDT, G. & HENDRY, M.D. 1987: An 8000 year Holocene sea-level record from Jamaica: implications for interpretation of Caribbean reef and coastal history. *Coral Reefs* 5: 165-169.

ETECHEVERS, S.L. 1975: Notas ecológicas y evaluación de la población de chipichipi, *Donax denticulatus* (Linné, 1758) (Bivalvia - Donacidae), en la playa de la Restinga, Isla de Margarita, Venezuela. Mem. II Simp. Latinoam. Oceanogr. Biol. Universidad Oriente 1: 235-249.

GROUARD, S. 2001: Interprétations sur la présence des espèces de vertébrés et crustacés du site post-saladoïde de la Pointe du Helleux, Grande-Terre, Guadeloupe. In: Association Internationale d'Archéologie de la Caraïbe, Région Guadeloupe, Mission Archéologique (ed.): *Proceedings of the XVIII International Congress for Caribbean Archaeology*, St George's University campus, St George Grenada, 1999: 153-161.

HIGUERA-GUNDY, A. 1991: Antillean vegetational history and paleoclimate reconstructed from the palaeolimnological record of Lake Miragoane, Haiti. Ph.D. dissertation. University of Florida, Gainesville.

HODDELL, D.A.; CURTIS, J.H.; JONES, G.A.; HIGUERA-GUNDY, A.; BRENNER, M.; BINFORD, M.W. & DORSEY, K.T. 1991: Reconstruction of Caribbean climate change over the past 10,500 years. *Nature* 352: 790-793.

HOFMAN, C.L. 1993: In Search of the Native Population of Pre-Columbian Saba (400-1450 A.D.). Part one: Pottery Styles and their Interpretations. Unpublished Ph. D. dissertation. Leiden University, Leiden.

HOFMAN, C.L. & HOOGLAND, M.L.P. 2003: Plum Piece. Evidence for Archaic seasonal occupation on Saba, Northern Lesser Antilles around 3300 BP. *Journal of Caribbean Archaeology* 4: 12-27.

KEEGAN, W.F. 1994: West Indian Archaeology.1. Overview and Foragers. *Journal of Archaeological Research* 2(3): 255-284.

KEEGAN, W.F. 2000: West Indian Archaeology. 3. Ceramic Age. *Journal of Archaeological Research* 8(2): 135-167.

KEEGAN, W.F.; PORTELL, R.W. & SLAPCINSKY, J. 2003: Changes in invertebrate taxa at two pre-Columbian sites in southwestern Jamaica, AD 800-1500. *Journal of Archaeological Science* 30: 1607-1617.

Lighty, R.G.; Macintyre, I.G. & Stuckenrath, R. 1982: *Acropora palmata* reef framework: a reliable indicator of sea level in the Western Atlantic for the past 10 000 years. *Coral Reefs* 1: 125-130.

Lundberg, E.R. 1989: *Preceramic Procurement Patterns at Krum Bay, Virgin Islands*. Unpubl. Ph.D. dissertation. University of Illinois, Urbana-Champaign. University Microfilms, Ann Arbor.

Marcano, J.S.; Prieto, A.; Larez, A. & Salazar, H. 2004: Crecimiento de *Donax denticulatus* (Linné, 1758) (Bivalvia: Donacidae) en la ensenada La Guardia, isla de Margarita, Venezuela. *Zootecnia Tropical* 21: 12.

Monchot, H. & Léchelle, J. 2002: Statistical nonparametric methods for the study of fossil populations. *Paleobiology* 28: 55-69.

Pagán Jiménez, J.R. & Rodríguez Ramos, R. 2007: Sobre el origen de la agricultura en las Antillas. In: University of the West Indies, School of Continuing Studies, St Augustine (ed.): *Proceeding of the XXI° Congress of the International Association for Caribbean Archaeology*: 252-259. Port of Spain, Trinidad.

Petersen, J.B. 1996: Archaeology of Trants, Montserrat. Part 3. Chronological and settlement data. *Annals of Carnegie Museum* 65(4): 323-361.

Randall, H.A. 1964: A study of the growth and other aspects of the biology of the West Indian topshell *Cittarium pica* (Linnaeus). *Bulletin of Marine Science of the Gulf and Caribbean* 14(3): 424-443.

Romon, T.; Bertran, P.; Daussy, A.; Fouere, P.; Fouilloud, C.; Grouard, S.; Mestre, M.; Serrand, N. & Valette, C. 2006: Le site de la Gare Maritime de Basse-Terre, Guadeloupe. Rapport au service régional de l'Archéologie de Guadeloupe, Basse-Terre.

Rouse, I. & Cruxent, J. 1963: *Venezuelan Archaeology*. Caribbean Series 6. Yale University Press, New Haven.

Rouse, I. 1992: *The Taïnos: rise and decline of the people who greeted Columbus*. Yale University Press, New Haven.

Schmidt, S.; Wolff, M. & Vargas, J.A. 2002: Population ecology and fishery of *Cittarium pica* (Gastropoda: Trochidae) on the Caribbean coast of Costa Rica. *Revista de Biologia Tropical* 50: 1079-1090.

Serrand, N. 2002: *Exploitation des invertébrés marins et terrestres par les populations Saladoïdes et Post-Saladoïdes du Nord des Petites Antilles (ª 500 B.C.-1200 A.D.). Étude de cas et comparaisons*. Doctorat Université Paris I Panthéon-Sorbonne, Préhistoire-Ethnologie-Anthropologie, Paris.

Serrand, N. 2004: Les restes de mollusques du site de la Cathédrale de Basse-Terre, Guadeloupe. In: Bonnissent, D. *et al.* (eds.): *Le site de la Cathédrale de Basse-Terre, Guadeloupe*: 45-60. Rapport au Service Régional de l'Archéologie de Guadeloupe.

Serrand, N. 2005a: Exploitation des mollusques et crustacés sur le site Précéramique d'Etang Rouge, Saint-Martin, Guadeloupe. In: Bonnissent, D. *et al.* (eds.): *Cultures précolombiennes des Petites Antilles. Les occupations précéramiques de l'Etang Rouge 1. Baie Rouge, Les Terres Basses,Ile de St-Martin, Région Guadeloupe*: 106-132. DFS, Service Régional d'Archéologie de Guadeloupe.

Serrand, N. 2005b: La malacofaune du site post-Saladoïde de Bas-de-la-Source, Saint-Louis de Marie Galante, Guadeloupe. Rapport au Service Régional de l'Archéologie de Guadeloupe et à l'Association Ouacabou Martinique.

Serrand, N. 2007: L'exploitation des invertébrés durant l'occupation Céramique tardive du Sud de la Martinique: aperçu diachronique au travers des sites de Dizac, Salines, Trabaud et Macabou. In: *Proceedings of the 21st International Congress of the Association for Caribbean Archaeology*: 421-428. International Association for Caribbean Archaeology. Port of Spain, Trinidad.

Serrand, N. & Bonnissent, D. 2005: Pre-columbian Preceramic shellfish consumption and shell tool production: shell remains from Orient Bay, Saint-Martin, Northern Lesser Antilles. In: Bar-Yosef, D.E. (ed.): *Archaeomalacology: Molluscs in former environment of human behaviour*: 29-39. Proceedings of the 9th ICAZ Conference. Oxbow Books, Oxford.

Vélez Rojas, A. 1985: Reproductive biology of the tropical beach clam *Donax denticulatus* in Eastern Venezuela. *Caribbean Journal of Science* 21(3-4): 125-136.

Vélez Rojas, A.; Venables, B.J. & Fitzpatrick, L.C. 1985: Growth and reproduction of the tropical beach clam *Donax denticulatus* (Tellinidae) in Eastern Venezuela. *Caribbean Journal of Science* 21(1-2): 63-73.

Wade, B. 1967: Studies on the biology of the West Indian beach clam *Donax denticulatus* Linné. 1-Ecology. *Bulletin of Marine Science* 17: 149-174.

Wade, B. 1968: Studies on the biology of the West Indian beach clam *Donax denticulatus* Linné. 2- Life history. *Bulletin of Marine Science* 18: 876-901.

Wing, E.S. & Wing, S.R. 1995: Prehistoric Ceramic Age adaptation to varying diversity of animal resources along the West Indian archipelago. *Journal of Ethnobiology* 15(1): 119-148.