Anthracological reference collection of palms of the Atlantic Forest (*sensu stricto*) of southern Brazil

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ABSTRACT

Comparative or taphonomic methods that help interpret and identify macro- and microbotanical remains based on reference collections have contributed significantly to expanding Brazilian archaeobotanical and archeological field methods. The present work had the objective of creating a carbonized carpological reference collection that emphasizes fruits from the family Arecaceae that occur in the Atlantic Forest (sensu stricto) of southern Brazil. To create the reference collection, six palm species native to the Atlantic Forest were selected that are widely distributed, occur on the coast of northeastern Santa Catarina and are found at innumerous archeological sites with the sambaqui typology. The selected species were Attalea dubia (Mart.) Burret, Bactris setosa Mart., Butia catarinensis Noblick and Lorenzi, Euterpe edulis Mart., Geonoma schottiana Mart. and Syagrus romanzoffiana (Cham.) Glassman. To conduct the taphonomic tests, 10 fresh fruits (with the pericarp) of each species were selected and submitted to combustion in a muffle furnace set at 400°C and 600°C for 30, 45 and 60 minutes. Ten manually depulped fruits of each species were submitted to the same treatment. The results demonstrated different rates of fragmentation among the carbonized fruits of the selected palm species. The fruits of A. dubia were notable for their well-preserved morphological structures and became completely carbonized after six hours at 600°C in the furnace. Similar results were also found for the fruits S. romanzoffiana.

Keywords: Cultural heritage; Archaeobotany; Anthracology; Reference collection; Sambaquis

INTRODUCTION

Archaeology, like other sciences, requires samples and knowledge about the study subject (Scheel-Ybert *et al*., 2005-2006). In this field, more specifically archaeobotany, this information is obtained using comparative and taphonomic methods to help interpret and identify macro- and microbotanical remains by comparing material from the past with reference collections (Scheel-Ybert *et al*., 2006). Thus, samples of material from the present that have been identified and systematically cataloged are important to make direct comparisons between past (unknown taxon) and present material to infer the taxonomic identity (Scheel-Ybert et al., 2006). However, it is important to consider the type of material being compared. For example, plant charcoal from archeological matrices requires reference samples in a similar state, since taphonomic processes (i.e., of fossilization and/or preservation) imply there have been innumerous changes to the original condition (Thery-Parisot et al., 2010).

Since charcoal (carbonized wood) is the most representative macrobotanical remain in archeological sites (Scheel-Ybert, 2004), where it is encountered in large quantities (Scheel-Ybert et al., 2006), and because it provides a fairly reliable way to reconstitute the local woody vegetation (Schell-Ybert, 2002), its frequency makes it possible to advance methodological techniques that result in better interpretations, forms of recovery and taxonomic identifications (Pearsall, 2000; Scheel-Ybert, 1996, 2002, 2004; Scheel-Ybert et al., 2005-2006; Melo Júnior, 2009; Silva et al., 2016). Further, this results in important discussions related to taphonomic processes (Théry-Parisot et al., 2010).

In addition to charcoal, other typologies of plant remnants of archeological significance are present at different sites in Brazil. Among these are the following: wooden stakes *in natura*, as recovered in the rock shelter in Santa Elina, Jangada – MG (Ceccantini, 2001) and in the Cubatão I sambaqui in Joinville – SC (Melo Jr. et al., 2016); carbonized fruits, as found in the rock shelter of Lapa das Boleiras in Lagoa Santa - MG (Nakamura et al.,2010); starch grains (Wesolowski et al., 2007); and braided fibers (Peixe, Melo Jr. and Bandeira, 2007). Thus, macrobotanical remains are always present in archeological contexts, preserved by desiccation, carbonization or specific conditions, such as submersion (Peixe et al., 2007; Melo Júnior et al., 2016), making them a viable alternative to subsidize archaeobotanical works.

Curating charcoal from archeological excavations reveals a substantial fraction of carbonized fruits, including those noted by Schell-Ybert (2001) as fragments of *coquinhos* (palm fruits). A study conducted at an archeological site on the central-south coast of Brazil, occupied by fisher-gatherer populations, reported the presence of these carbonized fruits (Lima, 1999, 2000). An assemblage of carbonized botanical remains recovered from the Hatahara site, in central Amazonia, also includes many fruits and seeds, notably palm fruits "*coquinhos*" (Caromano, 2010). When it comes specifically to sites of the sambaqui typology, although there is constant mention of the presence of palm fruits "*coquinhos*" in the archeological sedimentary matrix, associated or not with structures of combustion, taxonomic information about these remains are scarce and there is only one old association with the species *Syagrus romanzoffiana* (Arecaceae) (Beck, 1972).

This important gap in the knowledge about the lifestyle of sambaqui populations and their food habits can result from the following: a) greater emphasis on wood charcoal, making other plant remains, such as carbonized seeds and fruits, less representative; b) lack of field protocols that allow the full recovery of this type of plant remain; or c) lack of reference collections that allow for reliable interpretations and taxonomic identifications.

Nevertheless, there have been advances in the area, such as computerized databases (Scheel-Ybert et al., 2006) and an anthracological atlas (Scheel-Ybert and Gonçalves, 2017). Plant anatomy studies that used reference collections imply the collections are the best way to recognize different species manipulated by past populations, are essential for archeological studies, and serve as a safe comparative basis for other carbonized plant remains (Oliveira and Melo Júnior, 2017). Moreover, the megadiversity of the flora of tropical countries, where in Brazil alone there is an estimated 49.5 thousand plant species or 14% of the worldwide plant diversity (Peixoto and Morim, 2003), means there are gaps in reference collections. Among the 28 wood collections (xylotheque) in Brazil (Melo Júnior et al., 2014), only 4 have safeguarded material of archaeobotanical interest (Melo Júnior et al., 2014; Scheel-Ybert, 2016b). This scarcity reinforces the need to fill these gaps by developing works that support archaeobotanical research.

Thus, the present work had the objective of creating a carbonized carpological reference collection that emphasizes fruits of the family Arecaceae distributed in the Atlantic Forest (*sensu stricto*) of southern Brazil.

MATERIAL AND METHODS

Species selection

To create the reference collection, six species of Arecaceae were selected that are native to Brazil, have wide distributions in the Atlantic Forest *sensu stricto*, and occur on the coast of northeastern Santa Catarina, where there are innumerous archeological sites of the sambaqui typology. The species are the following: *Attalea dubia* (Mart.) Burret, *Bactris setosa* Mart., *Butia catarinensis* Noblick and Lorenzi, *Euterpe edulis* Mart., *Geonoma schottiana* Mart. and *Syagrus romanzoffiana* (Cham.) Glassman.

The material was collected and treated following standard techniques used in floristics (Fidalgo and Bononi 1989). The botanical material was herborized, identified and archived in the herbarium at the Universidade de Joinville (JOI). The species were identified using specialized literature, comparative morphology and consulting herbaria. To confirm the names of the species and their authors, the Lista de Espécies da Flora do Brasil (BFG, 2015) was used.

Taphonomic Tests

To conduct the taphonomic tests, 10 fresh fruits (with the pericarp) of each species were selected, which were submitted to combustion in a muffle furnace set at 400°C and 600°C, for 30, 45 and 60 minutes, based on a method adapted from Pearsall (2000). Ten manually depulped fruits of each species were submitted to the same treatment. To understand the complete carbonization time, the fruits that were not carbonized after 60 minutes were submitted to longer periods in the muffle furnace (maximum of 6 hours). The carbonized fruits were placed in plastic ziplock bags and labeled with the name of the species, time and burning temperature. The carbonized material was photographed using a Zeis binocular stereomicroscope. All material was incorporated into the anthracological reference collection of the Xiloteca JOIw at the Universidade da Região de Joinville - UNIVILLE.

RESULTS AND DISCUSSION

The taphonomic experiment revealed different rates of fragmentation among the carbonized fruits of the selected palm species in this study, in addition to the formation or non-formation of ash from the burning (table 1).

The fruits of *A. dubia* are larger (6.0-8.5 cm) compared to the other species (Lorenzi et al., 2010), had morphological structures that remained well preserved, and completely carbonized after six hours at 600°C in the muffle furnace. The fruits of *B. setosa* remained well preserved at both temperatures but exhibited excessive friability when handled. The seeds of the fruits with and without pulp stayed intact and the entire pericarp turned into ash. The fruits of *B. catarinense* partially fragmented at both temperatures and all burning periods in the muffle furnace; 100% fragmented after an hour of burning. The fruits of *E. edulis* presented similar characteristics regarding the reduction of the pericarp and well-preserved seeds. The fruits of *G. schottiana* exhibited 100% fragmentation at 600ºC for all periods. This friability might be related to their small size (1 cm diameter according to Lorenzi et al., 2010). The fruits of *S. romanzoffiana* presented the same characteristic as *A. dubia*, completely carbonizing after six hours in the muffle furnace at 600°C.

Anthracological studies support that under natural depositional conditions the distinct characteristics of each taxon in combination with environmental processes, such as bioturbation caused by roots and animals, or the same post-depositional processes, can influence the fragmentation process of carbonized macrobotanical remains (Thery-Parisot et al. 2010; Scheel-Ybert, 2003; Santana and Carvalho, 2013).

Table 1 – Description of the carbonization processes (taphonomy) with burning period, fragmentation rate and ash formation for palm fruits of the Atlantic Forest *sensu stricto* in southern Brazil. Legend: (+) present; (-) absent.

Species	Type	Temperature	Time (min)	Fragmentation (%)	Ash
Attalea dubia	fresh	400°C	30	0	-
			45	0	-
			60	0	-
	without pericarp	400°C	30	0	-
			45	0	-
			60	0	-
	fresh	600°C	30	0	-
			45	0	-
			60	0	-
	without pericarp	600°C	30	0	-
			45	0	-
			60	0	-
Bactris setosa	fresh	400°C	30	0	+
			45	10	+
			60	10	+
	without pericarp	400°C	30	0	+
			45	0	+
			60	30	+
	fresh	600°C	30	0	+
			45	0	+
			60	20	+

	without pericarp	600°C	30	10	+
			45	20	+
			60	30	+
Butia catarinensis	fresh	400°C	30	80	+
			45	80	+
			60	100	+
	without pericarp	400°C	30	80	+
			45	80	+
			60	100	+
	fresh	600°C	30	80	+
			45	90	+
			60	100	+
	without pericarp	600°C	30	60	+
			45	80	+
			60	100	+
Euterpe edulis	fresh	400°C	30	0	+
			45	0	+
			60	0	+
	without pericarp	400°C	30	0	+
			45	0	+
			60	0	+
	fresh	600°C	30	0	+
			45	0	+
			60	0	+
	without pericarp	600°C	30	0	+
			45	0	+
			60	0	+
Geonoma schottiana	fresh	400°C	30	70	+
			45	80	+
			60	80	+
	without pericarp	400°C	30	70	+
			45	100	+
			60	100	+
	fresh	600°C	30	100	+
			45	100	+
			60	100	+
		600°C	30	100	+

	without pericarp		45	100	+
			60	100	+
Syagrus romanzoffiana	fresh	400°C	30	0	-
			45	0	-
			60	0	-
	without pericarp	400°C	30	0	-
			45	0	-
			60	0	-
	fresh	600°C	30	0	-
			45	0	-
			60	0	+
	without pericarp	600°C	30	0	-
			45	0	-
			60	0	+

Figures 1 to 6 illustrate the carbonized fruits and seeds of the six species and highlight morphological characteristics for taxonomic diagnosis.

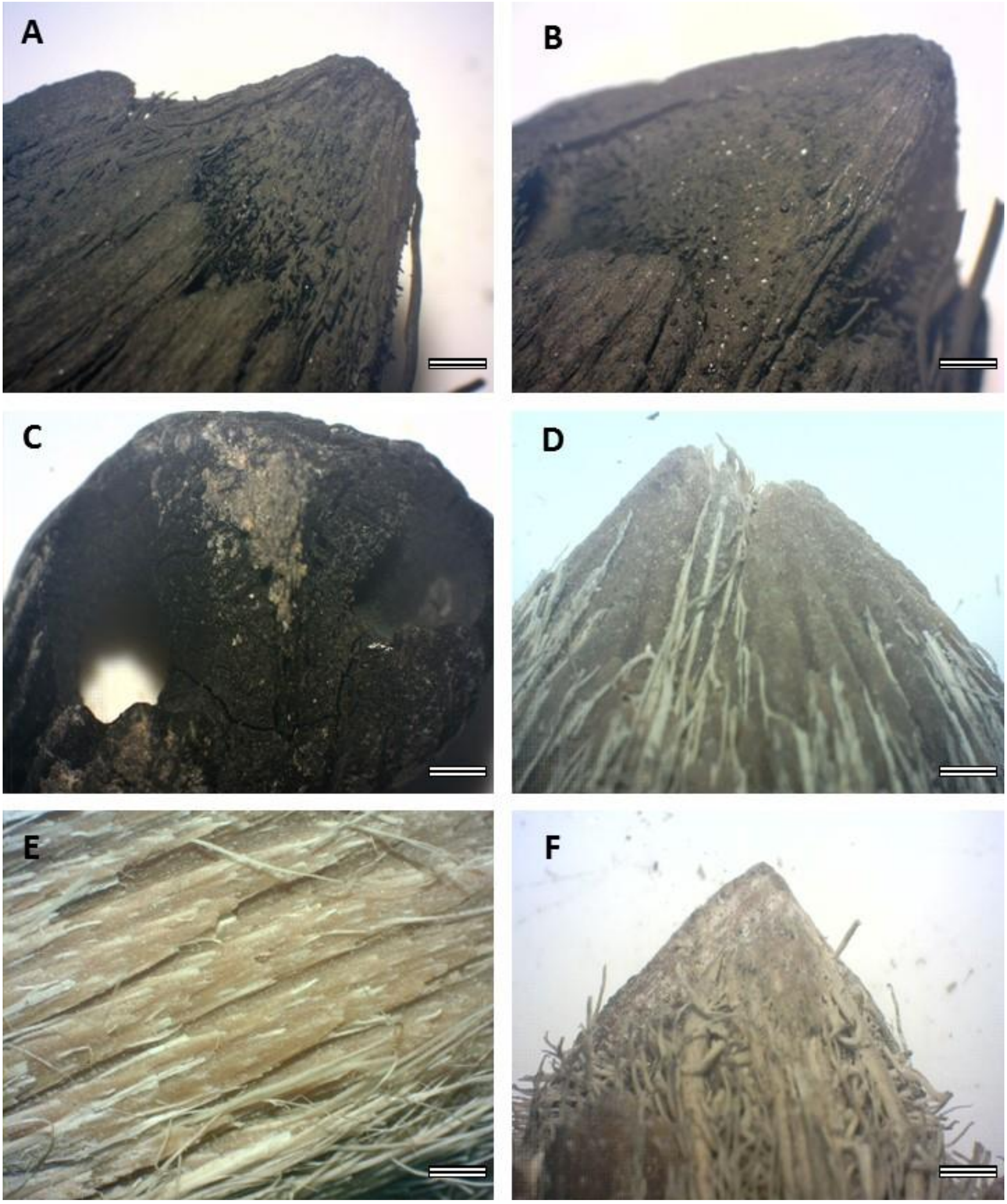

Figure 1 – Taphonomic process of the seeds of *Attalea dubia* from the Atlantic Forest *sensu stricto* in southern Brazil. A – C: carbonized seed, detail of germination pore; D – F: non-carbonized seeds, detail of endocarp and endocarp fibers. Scale bar = 10 mm.

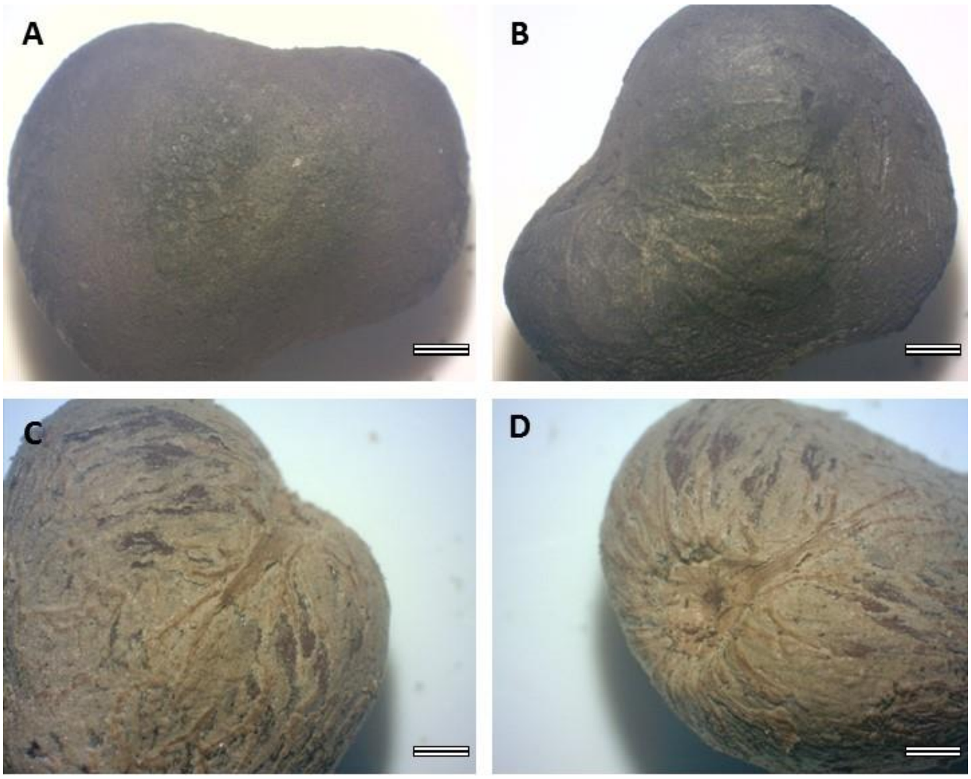

Figure 2 - Taphonomic process of the seeds of *Bactris setosa* from the Atlantic Forest *sensu stricto* in southern Brazil. A and B: carbonized seed; C and D: non-carbonized seed, detail of hilum and raphe. Scale bar = 10 mm.

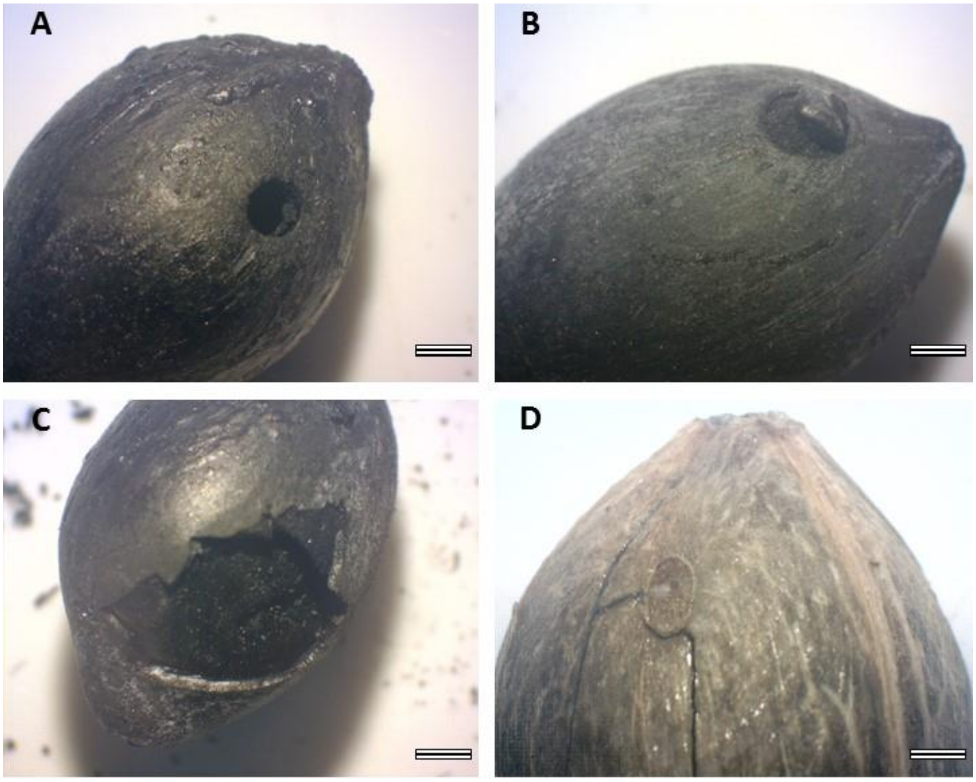

Figure 3 - Taphonomic process of the seeds of *Butia catarinenses* from the Atlantic Forest *sensu stricto* in southern Brazil. A – C: carbonized seed, detail of hilum. D: non-carbonized seed and detail of germination pore. Scale bar = 10 mm.

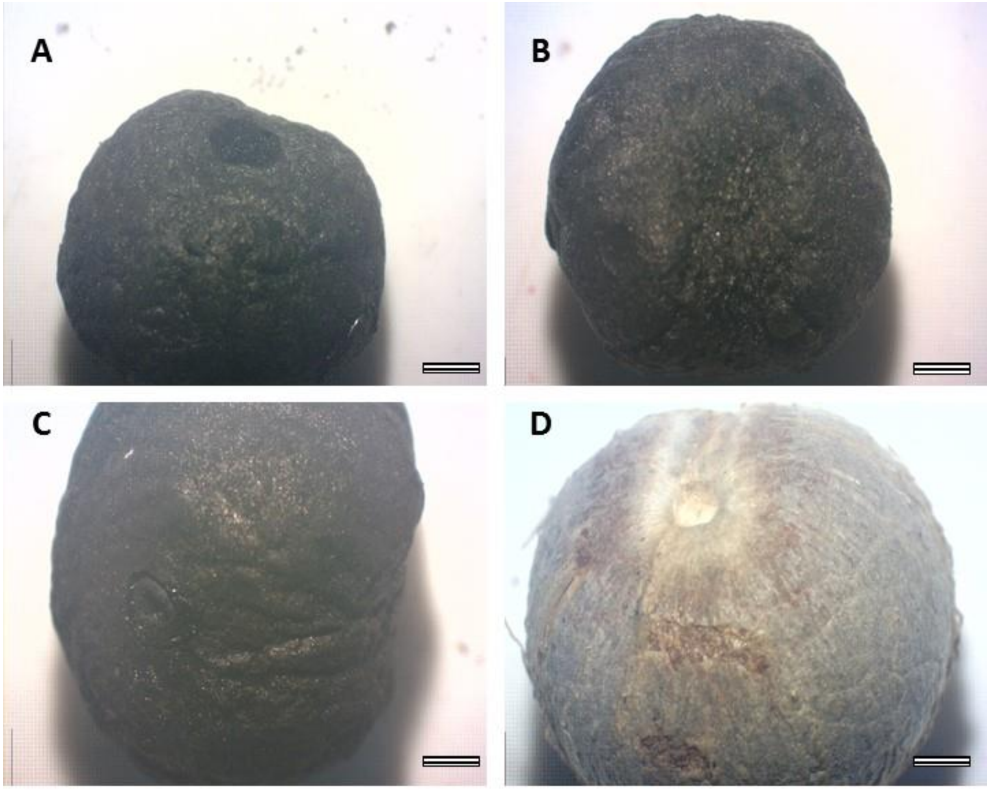

Figure 4 - Taphonomic process of the seeds of *Euterpe edulis* from the Atlantic Forest *sensu stricto* in southern Brazil. A – C: carbonized seeds, details of hilum, raphe and micropyle; D: non-carbonized seed, details of the hilum and raphe. Scale bar = 10mm.

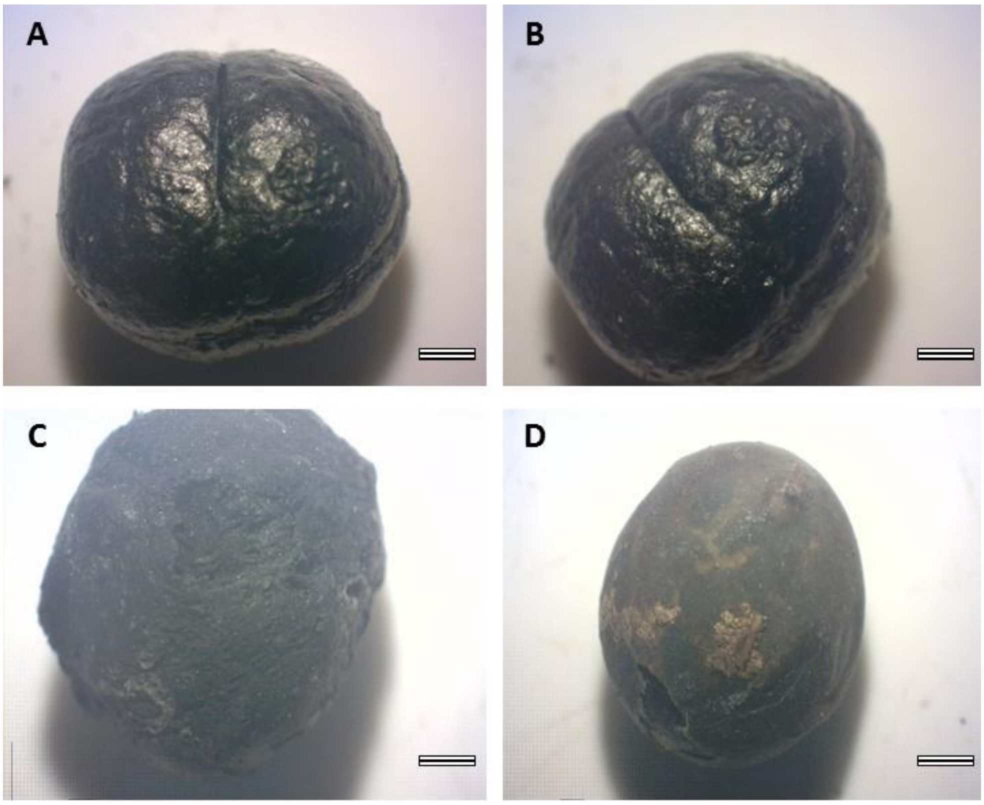

Figure 5 - Taphonomic process of the seeds of *Geonoma schottiana* from the Atlantic Forest *sensu stricto* in southern Brazil. A – C: carbonized seeds; D: non-carbonized fruit. Scale bar = 10mm.

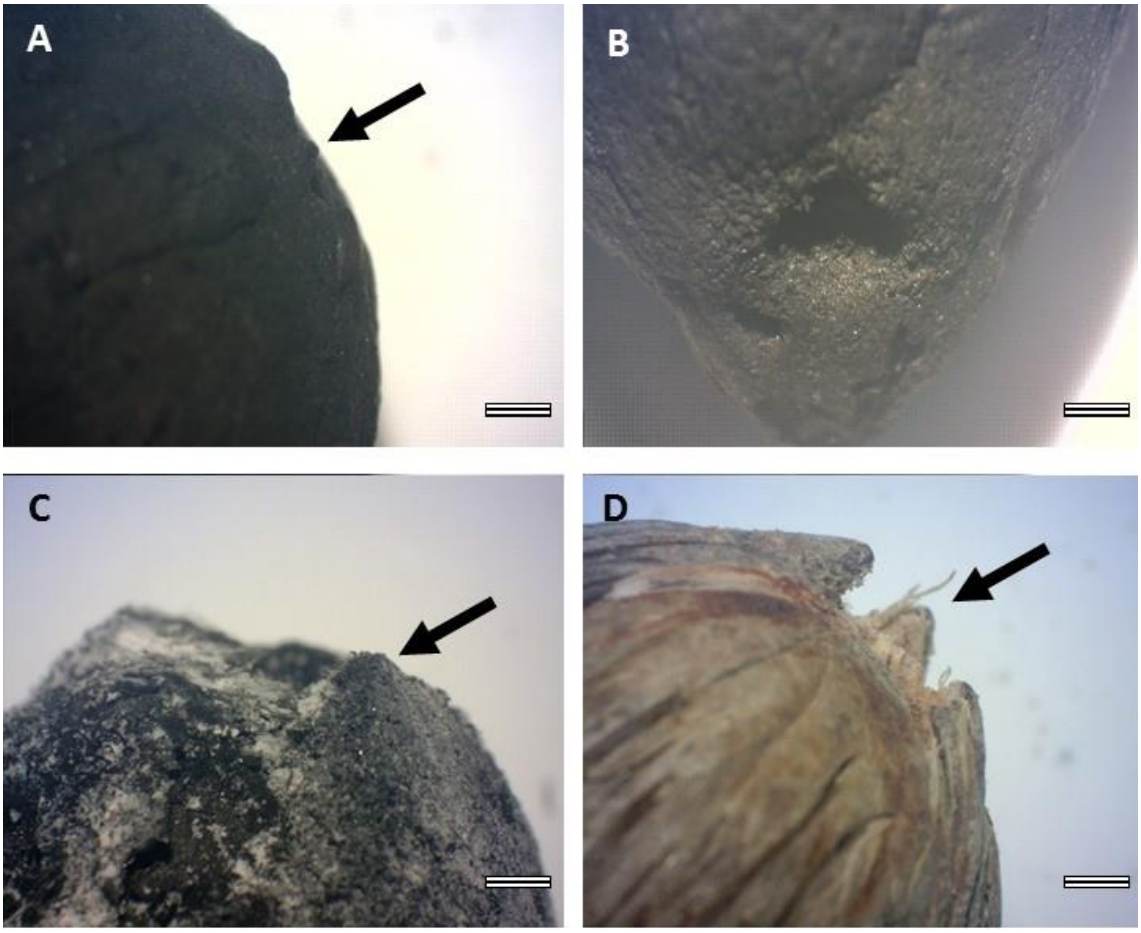

Figure 6 - Taphonomic process of the seeds of *Syagrus romanzoffiana* from the Atlantic Forest *sensu stricto* in southern Brazil. A and C: detail of the structure in the apical portion of a seed after carbonization (arrow); B: detail of the germination pore; D: detail of the structure in the apical portion of a non-carbonized seed (arrow). Scale bar = 10 mm.

In Brazil, archaeobotanical research is mainly focused on understanding the surrounding environment, type of relations established with the natural environment and diet of past societies that existed in the country (Scheel-Ybert, 2016a). Works developed at archeological sites with the sambaqui typology have become promising sources for archaeobotanical investigations (DeBlasis et al., 2007; Gaspar et al., 2013, Melo Júnior et al., 2016) and have led to the discovery of new sites (Bandeira et al., 2018). Although the study of these plant remains generally falls more into the field of archaeobotany than anthracology, the remains are generally preserved by carbonization and found in association with anthracological material (Scheel-Ybert, 2004). Actually, anthracology considers all carbonized macrobotanical remains preserved in the sediment and provides important archeological information (Scheel-Ybert et al., 2010).

Reports of macrobotanical remains of carbonized palm fruits "*coquinhos*" in archeological sites are common in the literature (Lima, 1999-2000; Scheel-Ybert and Solari, 2005). However, works that aim to identify these remains to the lowest taxonomic level and relate them (palm fruits "*coquinhos*") to the diet of past populations are scarce (Nakamura, Melo Jr. and Ceccantini, 2010). One of the oldest studies that reports the presence of palm fruits "*coquinhos*" in archeological sites suggests the exclusive consumption of *Syagrus romanzoffiana* (*jerivá*) by sambaqui populations on the coast of Santa Catarina, which is based on the presence of carbonized palm fruits "*coquinhos"* at different stratigraphic levels (Beck, 1972).

Dental plaque analyses note the presence of phytoliths of the family Arecaceae at different archeological sites in Brazil (Wesolowski et al., 2007; Boyadjian et al., 2016), reinforcing the presence and consumption of these resources by past populations. However, the suggestion of species, such as *S. romanzoffiana*, is often based on ethnographic literature (Levi-Strauss, 1987) and is not supported by reference collections or specific literature.

Anthracological studies can provide useful archeological results in Brazil, such as helping to describe the surroundings of living and gathering areas of past populations, as well as helping to explain paleoenvironmental and paleoclimatic variations. Specifically, the analysis of fruits and seeds provides paleoethnological and paleoethnobotanical information related to the diet of past populations and complements paleoecological research (Scheel-Ybert, 2004; Schell-Ybert et al., 2006). Thus, amplifying the methodological contribution through reference collections can guarantee more reliable identifications of taxa that represent the natural resources used by these populations.

CONCLUSION

Carbonized samples of palm fruits may facilitate the identification of the species of plant traces found in sambaqui archaeological sites. Reference collections used in plant morphology studies represent the best way to recognize the different species that were used by prehistoric populations, and thus are provide essential support to the research that pervades archeology.

ACKNOWLEDGMENT

Research Support Fund of the University of the Region of Joinville for the financial contribution to research.

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