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ORIGINAL ARTICLE

The forest people: landscape and firewood use in the Araruama region, southeastern Brazil, during the late Holocene

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Abstract The site of Morro Grande, situated in the Araruama region, southeastern Brazil (22°47′07″S, 42°21′49″W), is in the Atlantic rainforest phytogeographical domain. It is attributed to proto-Tupinambá agriculturalist and ceramicist populations, recognized by their typical polychrome ceramics. Four periods of occupation were identified at this site: (1) 3,220–2,840 cal B.P.; (2) 3,000–2,150 cal B.P.; (3) 1,820–1,390 cal B.P.; and (4) c. 750 cal. B.P. Analysis of 3,908 charcoal fragments from the three earlier periods has allowed the identification of 78 taxa and 29 plant families. This work demonstrates the permanence of the Atlantic rainforest in the region between 3,220 and 1,390 cal B.P., confirming previous palaeoenvironmental studies in southeastern and southern Brazil. The existence of mature forests is demonstrated; however, firewood was collected mainly from secondary vegetation, probably in the area surrounding the settlement or from cultivated land. These results provide further evidence of human influence on Neotropical rainforests. Creation of secondary environments, however, did not result in irreversible damage to local biodiversity, since the forest tended to regenerate after the clearings were abandoned. Analysis of charcoal concentrated in features allowed the identification of ritual funerary hearths, as well as of a probable specialized feature for firing ceramics. This evidence affords new perspectives for the archaeological interpretation of the funerary ritual and way of life of proto-Tupinambá people.

Keywords Landscape · Archaeology · Rainforest · Neotropics · Charcoal · Tupiguarani

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Introduction

The Brazilian coast was occupied, until the 16th century A.D., by two branches of agriculturalist and ceramicist populations within the Tupi linguistic stock, which encompasses different related languages spread throughout eastern South America (Noelli 1998). The historical Guarani (southern Brazil, northern Argentina, Uruguay, Paraguay) and Tupinambá (northeastern, central and southeastern Brazilian coast) produced typical polychrome ceramics. The southern Guarani, who were maize cultivators, produced mainly plastic decorated ceramics, while the northern Tupinambá, who were manioc cultivators, produced beautifully painted ceramics in red, black, and white. Vessel morphology is also a defining element of cultural identities for these groups; different vessel shapes are associated with diverse food items or processing techniques such as toasting manioc, boiling maize, beer-making festivities and so forth.

Brazilian archaeologists usually associate polychrome ceramics from pre-colonial sites with Tupian language speakers (Prous 1992; Heckenberger 1998) on the basis of historic descriptions of the material culture and funerary ritual of Tupinambá and Guarani people, which are similar to what is found in archaeological sites. Since this attribution is not straightforward, as linguistic manifestations cannot be directly related to the archaeological record, historically-known groups are usually named "Tupi-Guarani" and their putative ceramic correlates as "Tupiguarani" (Prous 1992).

An intense Tupiguarani occupation, probably the ancestors of the Tupinambá, is recorded in Rio de Janeiro State (southeastern Brazil), both in the coastal plain and in the "Serra do Mar" lower elevations (Buarque 1999). Many of the 264 so far recorded archaeological sites are situated in the Araruama region, where more than two thousand years of occupation have been ascertained (Fig. 1; Buarque et al. 2003; Scheel-Ybert et al. 2008).

The archaeological record provides evidence of a relatively unchanged mortuary pattern since the earliest occupation until contact with Europeans in the 16th century (Buarque et al. 2003). Dead members of the community were buried in funerary urns inside the settlements. Outside the settlements, specific elaborated decoration patterns in ceramics are interpreted as evidence of cannibal feasts of enemies (Buarque 2010).

Anthracological (charcoal) analysis at the Morro Grande site seeks to provide the first direct palaeoenvironmental reconstruction of a Tupiguarani site, along with palaeoethnobotanical information on the mortuary ritual and everyday life of these people.

Study area

The Morro Grande site is located in the southeastern coastal plain of Rio de Janeiro State, in the Araruama region (22°47′07″S, 42°21′49″W) (Fig. 1). It is within the urban area of Morro Grande, above the higher parts of the village. The environment, surrounded by rivers and lakes, is nowadays completely deforested. The archaeological area comprises c. 9 ha. Although the surface layer of the site was partially destroyed by urbanization, many intact archaeological features and well preserved ceramics were found. These remains were related to a proto-Tupinambá settlement (Buarque 2010).

The Brazilian coast is the domain of the Atlantic rainforest (dense ombrophilous forest), considered as one of the global biodiversity hotspots for conservation priorities (Myers et al. 2000). It is the second largest neotropical rainforest, only second to Amazonia. Because of intensive clearance, it is estimated that only 7 % of the original forest remains at present, mostly in isolated remnants scattered throughout a landscape dominated by agriculture. However, different facies of this forest once extended almost continuously from northeastern Brazil to the south (Fig. 1). They occupied the crystalline coastal plains, foothills and slopes of the coastal mountain chains up to 2,000 m a.s.l. This vegetation is associated with the high precipitation characteristic of the area of contact between oceanic air masses and the slopes (Ferri 1980). Rainfall is similar in both the Atlantic and the Amazonian Forest phytogeographical zones, but their temperature regimes differ (Rizzini 1979). Physiognomic characteristics of both forests are quite similar, but floristic similarity is low between them (Oliveira-Filho and Fontes 2000). Atlantic rainforest is more stratified, with more than two tree layers, the higher one reaching over 30 m high (Ferri 1980); the understory, dark and humid, has numerous epiphytes, lianas and a dense shrubby-herbaceous layer. The limits and classifications of this forest are still a subject of great discussion (Oliveira-Filho and Fontes 2000), but most

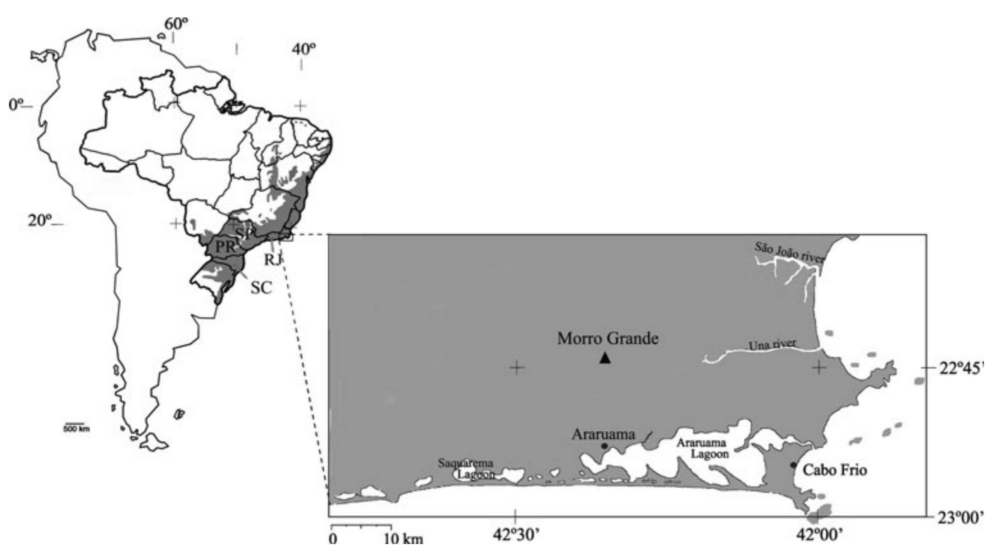


Fig. 1 Study area. Map of Brazil showing political divisions, with indication of the states mentioned in the text (*RJ* Rio de Janeiro; *SP* São Paulo; *PR* Paraná; *SC* Santa Catarina), and the postulated distribution of the Atlantic rainforest primitive phytogeographical domain (*in grey*). In detail, location of the Morro Grande site in southeastern Rio de Janeiro State

researchers agree that altitude determines at least three forest facies: slope forests, high-altitude (montane and submontane) forests and coastal plain forests (Joly et al. 1991). The lower altitude formations, occurring over the crystalline coastal plains, are floristically similar to the higher altitude facies, but due to greater restriction of water supply, the trees are smaller and the forest less dense (Rizzini 1979). Altitude gradient influences the composition and richness of the plant communities as well. Low altitude forests have high diversity and dominance of Fabaceae, Euphorbiaceae, Rubiaceae, Lauraceae, Moraceae, Myrtaceae, Annonaceae and Sapotaceae taxa (Vaz 1992; Carvalho et al. 2008). Increasing altitude is related to higher abundance of Asteraceae, Melastomataceae and Solanaceae, while there is reduction in Fabaceae (Oliveira-Filho and Fontes 2000).

The Atlantic rainforest is characterized by a remarkably high floristic diversity and endemism, suggesting a very ancient and original evolution (Walter 1994). The wide range of temperature and topography also contributes to the high biodiversity of the forest. Endemism in trees is particularly high, with approximately 54 % being restricted to the region, compared to about 30 % for higher plants in general (Mori et al. 1981).

Species richness in low altitude Atlantic ombrophilous forests from the São João river basin (around 22°25′S–42°15′O), in the same drainage basin as the site studied here, varied between 98 and 250 species, for areas of 0.4–1.2 ha (Carvalho et al. 2008). Other low altitude forests from Rio de Janeiro State show between 90 and 169 species (Guedes 1988; Farág 1999; Neves 2001; Peixoto et al. 2004). Higher altitude forests (slope forests, montane and sub-montane facies) showed between 118 and 210 species (Guedes-Bruni et al. 1997; Guedes-Bruni 1998; Oliveira 1999; Kurtz and Araujo 2000; Moreno et al. 2003; Pardo et al. 2007). The great variation in species numbers is due to differences in the sampled areas, methods and inclusion criteria of the plants (especially minimum diameter at breast height, which usually varies between 2.5 and 5 cm).

In spite of the great ecological importance of these forests, palaeoenvironmental records are still relatively rare. The Brazilian territory experienced important climatic changes during the late Quaternary. The climate during the late Pleistocene and early Holocene was conspicuously cooler and drier than today, with more open vegetation at all studied sites (Behling 1997a; Ledru et al. 2005; Behling et al. 2007; Saia et al. 2008). The change towards a wetter climate occurred between 12,000 and 4,400 cal B.P., depending on the region (Ybert et al. 2003). Due to its widespread distribution, the Atlantic rainforest underwent considerable differences in the timing of forest expansion or contraction at different latitudes (Ledru et al. 2005).

Previous studies in the Atlantic rainforest area are markedly concentrated in the coastal region of São Paulo State (southeastern Brazil) (Fig. 1). North of this area, in Serra da Bocaina, between São Paulo and Rio de Janeiro States, the advance of the rainforest is recorded from c. 4,500 years B.P. onward, attributed to very wet climatic conditions (Behling et al. 2007). In northern São Paulo State, pollen analyses indicate a progressive moisture increase during the late Holocene, with expansion of the forest to its present potential distribution by 3000 (Behling 1997a) or 3,500 B.P. (Garcia et al. 2004). In the centre of the state, full development of the rainforest is suggested after 9,000 B.P., with a floristic composition similar to the present one. Two forest regressions are suggested, between 6,000 and 4,000 B.P. and during the past millennium (Ledru et al. 2005, 2009). To the south, stable carbon isotopes and pollen analysis showed continuous forest expansion, associated with a wetter and warmer climate, from c. 19,000 B.P. to the present (Saia et al. 2008; Pessenda et al. 2009). Pollen and diatom analyses in the southern coastal plain revealed some climatic and sea-level oscillations during the last 5,000 years, but no drastic changes were recorded in the vegetation, as forest formations remained dominant (Ybert et al. 2003).

Other related studies are from southern Brazil. Pollen data indicate a very similar vegetation and climate history in Paraná and Santa Catarina states (Behling 1995, 1997b). Atlantic rainforest elements appeared by the end of the late Pleistocene; the forest increased during the Holocene; rapid expansion of tropical taxa related to warmer climate and higher annual precipitation took place after c. 7,000 years B.P. Palaeoenvironmental reconstructions associated with prehistoric populations are rare. In southeastern Rio de Janeiro State, near to the site reported here, as well as on the southern coast of Santa Catarina State, anthracological analyses of several shell mound sites have demonstrated the permanence of restinga vegetation and coastal plain Atlantic forests between c. 6,200 and 1,200 cal B.P. (Scheel-Ybert 2000, 2001a, 2001b; Scheel-Ybert and Dias 2007; Scheel-Ybert et al. 2009b). The restinga ecosystem, characteristic of the Brazilian coast and related to the Atlantic Forest biome, is associated with sandy beach ridges. This complex ecosystem includes different vegetation types, from sparse open plant communities, herbaceous and scrub formations (open restinga) to dense evergreen forest (restinga forest). Each of these vegetation types occupies a well-defined relief configuration, producing zonation of the ecosystem. Low areas between the beach ridges and dune slacks support marshy vegetation. Scrub communities usually grow inland on the external sand barrier, on dunes or in low areas. The remnant restinga forests, growing on the innermost sand barrier, are c. 8 m high with emergent trees that reach 15–25 m, a dense understory and many epiphytes (Araujo and Henriques 1984).

Materials and methods

Archaeological excavations over several seasons of fieldwork, performed according to natural stratigraphic levels, identified five layers in different loci. The occupation level is 0.6 m in thickness and lies upon a sandy substratum. Most archaeological artefacts (ceremonial and daily-use vessels, upper portions of urns) occur between 0.2 and 0.5 m of depth, in a grey layer with black lenses (archaeological hearths). Below this depth, within clayey sediments and quartz beds down to 1.2 m, remains are restricted to funerary urns that are generally well preserved (Fig. 2).

Each archaeological locus comprises a funerary area, with the presence of a funerary urn surrounded by painted vessels, the latter probably used for food offerings, and generally a domestic area. In the funerary area, pottery pieces had painted decoration, frequently with elaborate motifs such as skeletal or visceral patterns that suggest they were made especially for the mortuary ritual (Buarque 2010). Further from the funerary urn and spatially isolated from the funerary area, features in a domestic context are associated with fragments of utilitarian, non-decorated or plastic decorated ceramics (Fig. 3).

Four periods of occupation were identified at this site: the first period dates to 2,920 ± 70 B.P. (3,220–2,840 cal B.P., Gif-11045) and is associated with an utilitarian combustion feature in the first archaeological layer of Locus 2; a second period dates to 2,600 ± 160 B.P. (3,000–2,150 cal B.P., Plid-0688) and consists of a settlement area within which a funerary ritual was performed (Locus 2); a third period is dated to 1,740 ± 90 B.P. (1,820–1,390 cal B.P., Beta-84333) and is associated with a further occupation of Locus 2 and with dispersed charcoal fallen inside the funerary urn; finally, a fourth period is dated to 315 ± 50 (TL, MGU) and 510 ± 160 B.P. (750-0 cal B.P., Plid-0686) and is associated with an urn of quite different cultural characteristics in Locus 11. The latter is possibly related to a reoccupation of the area by people of Guarani affiliation (Buarque 2009). Only samples from the three earlier periods were available for anthracological analysis.

Charcoal from hearths was systematically collected for anthracological analysis and radiocarbon dating. Not all identified features provided charcoal, probably because of post-depositional and preservation issues. A large sample of charcoal dispersed in the soil and concentrated in hearths or other features was collected in Locus 2. All the

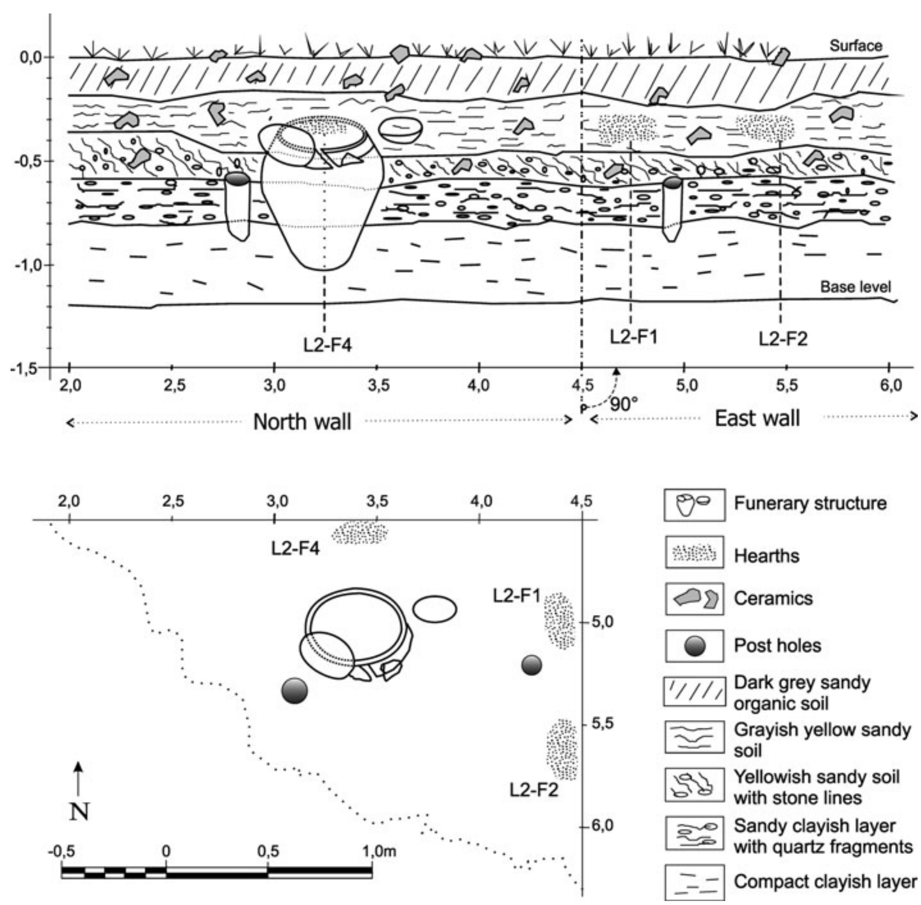


Fig. 2 Morro Grande archaeological site. Schematic stratigraphic profile of Locus 2 north and east walls, and partial surface plan of the same area (adapted from Scheel-Ybert et al. 2008)

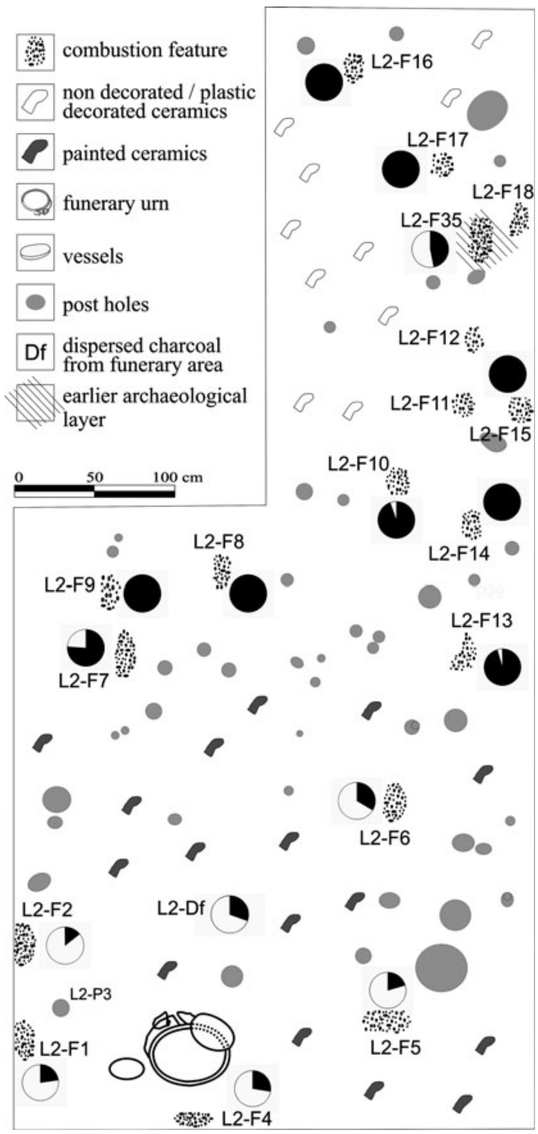


Fig. 3 Excavation plan of Locus 2. Hearths L2-F1 to L2-F7, situated in the funerary area, contained high proportions of bark and are interpreted as elements of the mortuary ritual. Hearths L2-F10 to L2-F17, situated in the domestic area, contained few or no bark fragments and are interpreted as household features. Feature L2-F35 is situated stratigraphically below the other features represented, in an earlier occupation, and is interpreted as an utilitarian feature. Pie charts besides each feature represent the bark proportion (*white*) in relation to wood fragments (*black*)

sediments removed from this excavation area were dry- or water-sieved and charcoal pieces were picked out with forceps.

Charcoal identification was performed with reflected light brightfield/darkfield microscopes, along fresh hand-broken surfaces. Identifications were helped by a computerized key for wood determination associated with a database of anatomical characters for Brazilian taxa (Scheel-Ybert et al. 2006), and by comparison with a reference collection of carbonized wood and with the specialized literature. SEM micrographs were obtained from gold-sputter-coated charcoal samples using a Jeol EVO 040 at the Instituto de Pesquisas Jardim Botanico do Rio de Janeiro.

Table 1 Absolute results of the anthracological analyses. Nt, Total number of analyzed charcoal pieces; Ni, Number of identified wood charcoal pieces. Bark percentages, and number of taxa (Nsp) for each of the analysed samples

Sample	Nt	Ni	Bark	%bark	Nsp
Dispersed charcoal					
L2-level 1	114	70	8	7 %	20
L2-level 2	223	197	5	2 %	27
L2-level 3	305	282	6	2 %	35
L2-Urn	374	224	6	2 %	27
L2-Vessel	12	6	0	0 %	2
L2-Df	836	209	580	69 %	25
L1-Vessel	29	26	2	7 %	12
L12-Urn	55	49	1	2 %	12
Concentrated charcoal (features)					
L1-F1	39	28	0	0 %	6
L2-F1	422	83	326	77 %	11
L2-F2	118	17	100	85 %	4
L2-F4	138	35	100	72 %	6
L2-F5	475	65	378	80 %	16
L2-F6	71	20	40	56 %	4
L2-F7	30	22	7	23 %	5
L2-F8	1	1	0	0 %	1
L2-F9	3	1	0	0 %	1
L2-F10	78	71	4	5 %	6
L2-F13	107	84	4	4 %	10
L2-F14	12	6	0	0 %	1
L2-F15	2	1	0	0 %	1
L2-F16	35	35	0	0 %	2
L2-F17	4	4	0	0 %	2
L2-F35	416	135	221	53 %	12
L4-F1	9	9	2	22 %	6

Charcoal diagrams were plotted using program C2 Data Analysis (Juggins 2007). Diagrams were constructed with the relative frequencies of the different taxa calculated on the basis of the number of identified fragments, indeterminate pieces included (Ni). The total number of fragments analyzed (Nt) comprises the Ni plus non-identifiable pieces, for example, knots, bark, tiny stems, poorly-preserved fragments. Statistical analyses and ecological measures, especially Shannon diversity index, were calculated using the computing environment (R Development Core Team 2007).

In this paper we present the complete anthracological results from the Morro Grande site, including palaeoenvironmental data from dispersed charcoal and

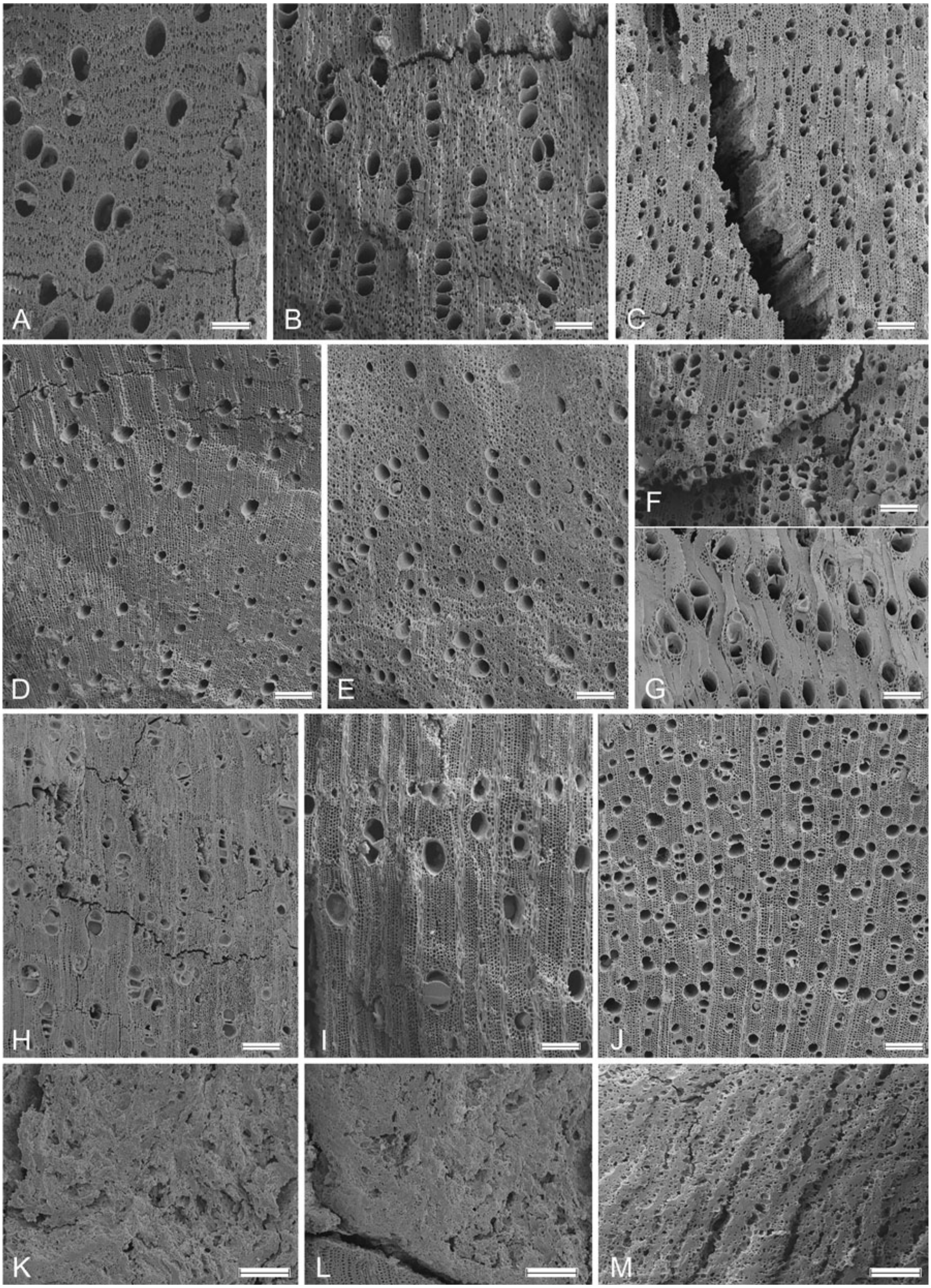
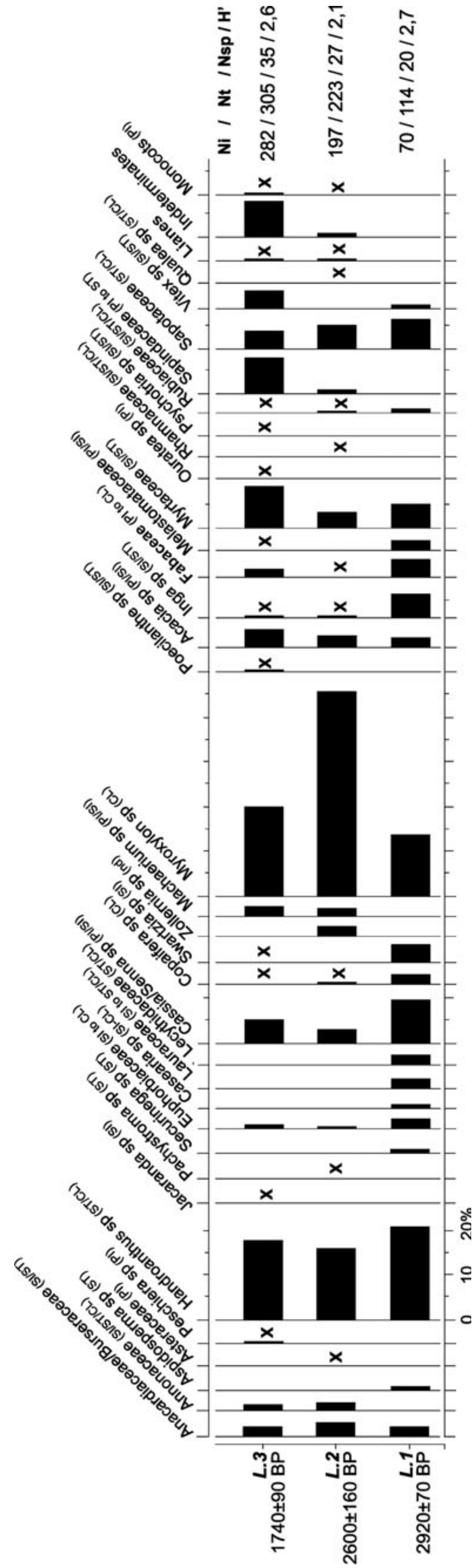


Fig. 4 Transverse sections of some of the taxa identified in scanning electron microscopy. **a**, Chrysobalanaceae (L2-F1); **b**, Sapotaceae (L2-F2); **c**, *Psychotria* sp. (dispersed charcoal, level 3); **d**, *Machaerium* (L2-F2); **e**, Myrtaceae (L2-F7); **f**, *Handroanthus* sp. (L2-F1); **g**, *Myroxylon* sp. (L2-F9); **h**, *Bauhinia* sp. (L2-F35); **i**, *Copaifera* sp. (L2-F1); **j**, Anacardiaceae (dispersed charcoal, level 3); **k**, **l**, **m**, dicotyledonous bark (L2-F35, L2-Df, L2-F2). *Bars* = 200 µm

Fig. 5 Morro Grande anthracological diagram, based on dispersed ▶ charcoal from Locus 2. Codes after the taxonomic names stand for their classification in ecological groups (*PI* pioneer; *SI* early secondary; *ST* late secondary; *CL* climax). Ni, Number of identified wood charcoal pieces; Nt, Total number of analysed charcoal pieces; Nsp, Number of species in each sample; H', Shannon diversity index



palaeoethnobotanical data from funerary hearths. The latter, already partially published and thoroughly discussed (Beauclair et al. 2009), are presented together with some further analyses, to allow comparison between the datasets.

Results

Charcoal samples from various contexts in different loci of the Morro Grande site were analysed. Charcoal pieces dispersed in the sediments and those concentrated in hearths and other features provide different kinds of results. From the 3,908 charcoal pieces analysed (Table 1), 1,112 pieces of dispersed charcoal from domestic contexts were used for palaeoenvironmental interpretation, and 1,960 pieces from features, as well as 836 fragments of dispersed charcoal from a funerary area, provided palaeoethnobotanical evidence. Most of the samples come from Locus 2, the more extensively excavated one (Figs. 2, 3).

Fifty-four taxa from 29 plant families were identified, along with 24 indeterminate taxa (Fig. 4). Dispersed charcoal resulted in 51 taxa in 26 families and 20 indeterminate (Figs. 5, 6); concentrated charcoal had 28 taxa in 15 families and 4 indeterminate (Fig. 7). All identified *taxa* are common in the Brazilian Atlantic rainforest, except for *Laguncularia racemosa* (identified in L1-F1 (Fig. 7), typical of the mangrove forest.

Taxa composition in Locus 2 dispersed charcoal demonstrates the permanence of the Atlantic rainforest in the region throughout the analysed period, between 3,220–2,840 and 1,820–1,390 cal B.P. (Fig. 5). Taxonomic richness increases, along with sample size, from earlier to later archaeological levels, with 20 taxa in 114 charcoal pieces in level 1; 27 taxa in 223 fragments in level 2; and 35 taxa in 305 fragments in level 3. Shannon diversity indices (H') are relatively low, 2.7–2.1–2.6, respectively. There is a high proportion of taxa of early successional stages in all archaeological levels, although taxa of late ecological successional stages are also recorded (Fig. 8). An increase in the proportion of early successional taxa in the third archaeological level (L2-l.3, 1,820–1,390 cal B.P.) points to possible opening of the local vegetation after c. cal. 2,000 B.P.

A funerary area in Locus 2 archaeological level 2, dated to 3,000–2,150 cal B.P., showed ceremonial hearths encircling a funerary urn and associated ceramic vessels (Fig. 3). Several postholes were identified in this area. One of these provided remains of a carbonized post (L2-P3), which was identified as wood of Lauraceae. Obviously, this cannot be taken as an indication of species selection. However, it is remarkable that the Lauraceae family produces many timbers which are, still at the present time, greatly appreciated for their durability and resistance. Interestingly, the use of this kind of timber for funerary posts has been reported for shell mound builders in Santa Catarina State, dated to c. 2,500 B.P. (Bianchini et al. 2007).

Funerary hearths closer to the urn (L2-F1, L2-F2, L2-F4, L2-F5) consisted of more than 70 % dicotyledonous bark remains; L2-F6 contained 56 % bark (Figs. 3, 7; Table 1). Hearth L2-F7, which was not previously considered as a funerary hearth, also had a high proportion of bark (24 %), suggesting that it might be part of the mortuary setting as well. The sample of dispersed charcoal from the funerary area (L2-Df), composed of five sub-samples collected around the funerary urn, show 69 % bark. It was therefore analyzed along with the funerary features (Fig. 7).

The other hearths analyzed at the same archaeological level in Locus 2 come from a domestic context. They had only a small percentage of bark, or none at all, conforming to what is normally found in anthracological samples. Hearths L2-F10, L2-F13 and L2-F16 provided samples of 35–107 charcoal pieces, with 2–10 species (Fig. 7). Hearths L2-F8, L2-F9, L2-F14 and L2-F15 provided extremely poor samples composed only of Lecythidaceae (L2-F8), *Myroxylon* sp. (L2-F9, L2-F15), a non-identified liana (L2-F14) and *Myroxylon* sp./Sapotaceae (L2-F17). Hearths L2-F11, L2-F12 and L2-F18 did not provide any analyzable charcoal piece. Unfortunately, the small number of fragments available from most of these hearths compromises their representativity.

A positive linear correlation (0.7361) was verified between species richness and number of charcoal pieces analyzed in funerary and domestic hearths, confirming that taxonomic diversity tends to increase in larger samples. Larger samples obviously increase representativity. However, in every case, all available fragments were analyzed.

Funerary hearths from Loci 1 to 4 were also analyzed. A relatively high percentage of bark (22 %) was present in sample L4-F1, while L1-F1 had no bark remains (Fig. 7). Due to the extremely small number of charcoal pieces analyzed, though, no conclusion can be drawn from these results.

Samples from inside the funerary urns and vessels, collected during the excavation, were analyzed separately (Fig. 6). Although circumscribed, these samples cannot be considered as concentrated charcoal, as they do not come from combustion features, but from dispersed charcoal in the sediments deposited around or inside the artefacts. Charcoal from vessels might be related to the funerary context, but charcoal from inside funerary urns certainly

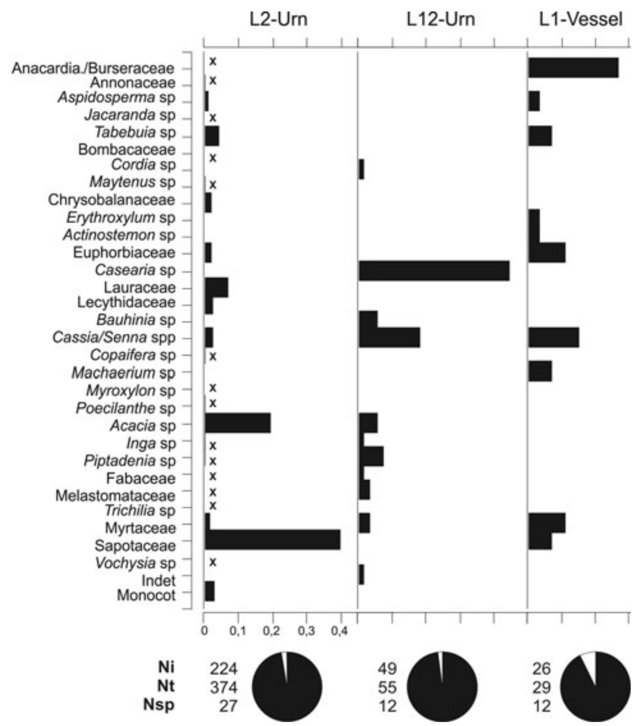


Fig. 6 Results of the anthracological analysis of samples collected inside urns and vessels from the Morro Grande site. Pie charts represent the bark proportion (*white*) in relation to wood fragments (*black*)

came along with the sediments deposited subsequently, which fell into the urn at a later time, after its lid was broken (lid fragments were found interspersed with sediments inside the urns).

Charcoal from vessels was collected in Loci 1 and 2 (Fig. 6; Table 1). The first sample presents a rather high diversity (12 taxa in 29 charcoal pieces), along with 7 % bark. The second sample, which was very small, consisted only of *Cassia* sp. and one Sapotaceae fragment, with no bark.

The charcoal sample retrieved inside the Locus 2 funerary urn, dated to 1,820–1,390 cal B.P. and associated with archaeological level 3, had a relatively high taxonomic diversity. Twenty-five wood taxa in 16 families were identified (Fig. 6), with a predominance of Sapotaceae, Fabaceae (8 taxa, mainly *Acacia* sp.), Lauraceae and Bignoniaceae (*Handroanthus* sp.). Two taxa remained indeterminate. The Shannon index (H') of 2.2 is of the same order as that found for dispersed charcoal. This sample contained only 1.6 % bark. Taxonomic diversity and low bark content are compatible with dispersed charcoal from a domestic context.

The charcoal sample retrieved inside a funerary urn in Locus 12 provided similar results, although with fewer taxa (Fig. 6). In both cases, this intrusive material does not appear to be related to natural events, such as possible natural fires occurring over the abandoned site. Natural fire samples are taxonomically much less diverse than archaeological ones, particularly in the tropics (Scheel-Ybert et al. 2003; Scheel-Ybert 2004). Charcoal retrieved inside the urns is certainly of human origin, corroborating the hypothesis of site reoccupation along the time. Archaeological data support this hypothesis, as there is evidence of changes in the material culture, especially ceramic morphology and decoration (Buarque 2009).

In addition, a feature from Locus 2 first archaeological layer (L2-F35), dated to 3,220–2,840 cal B.P., was analyzed (Fig. 3). This sample also revealed an extremely high proportion of bark; wood taxa represent less than 50 % of the fragments, with a clear dominance of *Copaifera* sp. (79 % of the wood charcoal). Minor taxa identified were Anacardiaceae/Burseraceae, Chrysobalanaceae, *Croton* sp., *Bauhinia* sp., *Cassia/Senna* sp., *Dalbergia* sp., *Machaerium* sp., *Myroxylon* sp., Fabaceae and *Qualea* sp. This feature is clearly not in a ritual context, and was therefore associated with a utilitarian specialized hearth.

Several techniques of multivariate statistics were applied to the anthracological results, such as correspondence analysis, principal component analysis, detrended correspondence analysis, non-metric multidimensional scaling and cluster analyses. In all methods, samples from funerary hearths and the utilitarian specialized hearth are grouped together, as opposed to the dispersed charcoal samples (Fig. 9). The first assemblage is characterized by high proportions of dicotyledonous bark. The sample of dispersed charcoal from Locus 2 funerary area (Df) is grouped with the funerary hearths. Hearth L2-F7 sample is in a somewhat intermediate position between the two groups, which may be explained by its moderate bark content. The sample from inside the Locus 2 urn clusters with the dispersed charcoal samples, reinforcing its association with archaeological level 3. Depending on the analysis, domestic hearths may group with the dispersed charcoal samples. However, poverty and over-representation of few taxa in these samples generally make them behave as outliers.

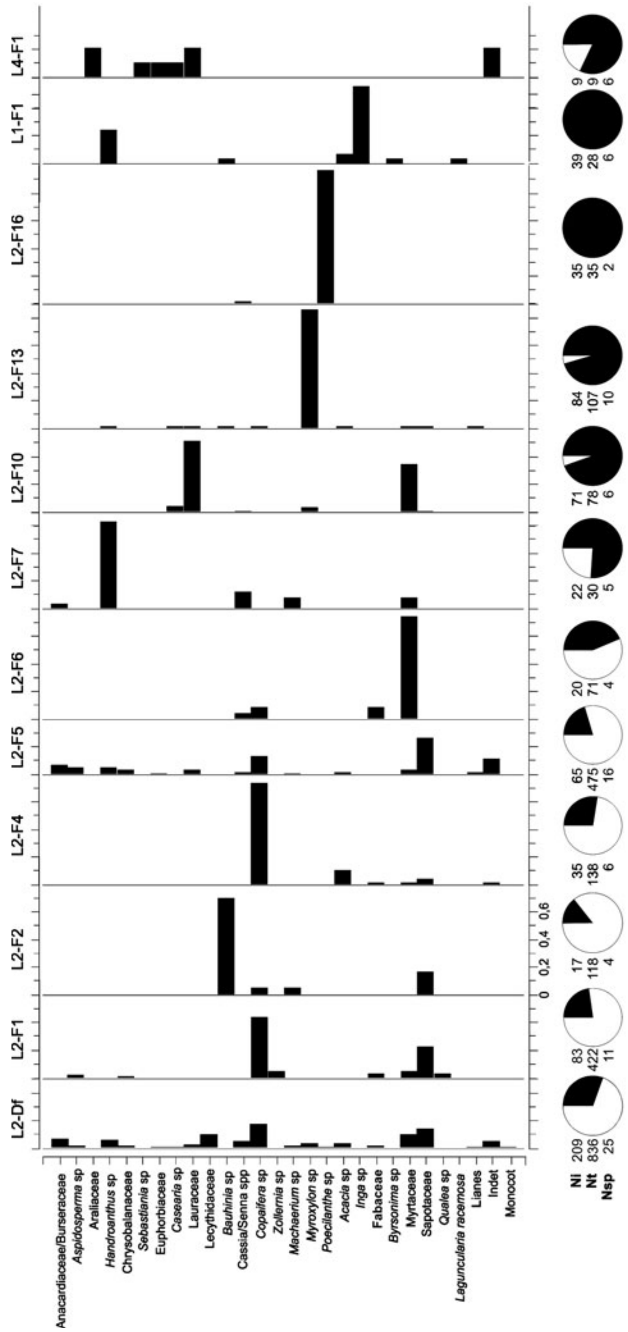


Fig. 7 Results of the anthracological analysis of Morro Grande hearths and features. F, combustion feature; L, Locus; Df, dispersed charcoal from Locus 2 funerary area. Pie charts represent the bark proportion (*white*) in relation to wood fragments (*black*). Ni, Number of identified wood charcoal pieces; Nt, Total number of analysed charcoal pieces; Nsp, Number of species in each sample

Discussion

Most of the analysed hearths show very low diversity, with both low taxonomic richness and a strong predominance of one or a few taxa (Fig. 7). This is expected from short-term deposits—combustion features that have had a short period of use or ones that have been cleaned before the last use (Chabal 1997). In both cases, they represent a single firing event that was fed with logs or branches from only a few trees or shrubs. Several of these features also had a very low number of charcoal fragments, which is probably due to post-depositional and preservation factors.

Funerary hearths, as well as feature L2-F35, showed exceptionally high frequencies of dicotyledonous bark. The prevalence of some bark fragments is usual, either in a

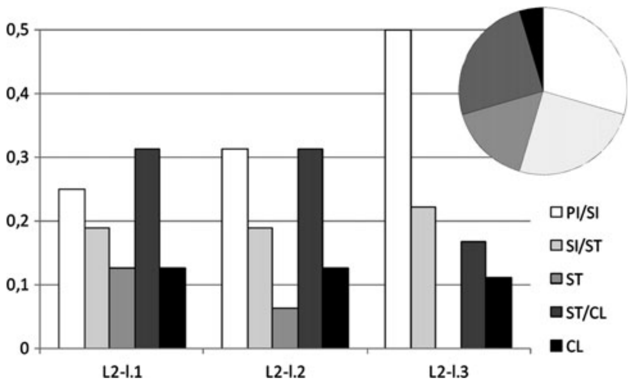


Fig. 8 Histograms showing distribution of taxa in ecological groups for dispersed charcoal from Morro Grande Locus 2, in frequency of the number of taxa at each archaeological level (classification mainly according to Oliveira 2002; Peixoto et al. 2004; Santos 2009). Pie chart represents the distribution of ecological groups in all analyzed samples (dispersed and concentrated charcoal). (*PI* pioneer; *SI* early secondary; *ST* late secondary; *CL* climax)

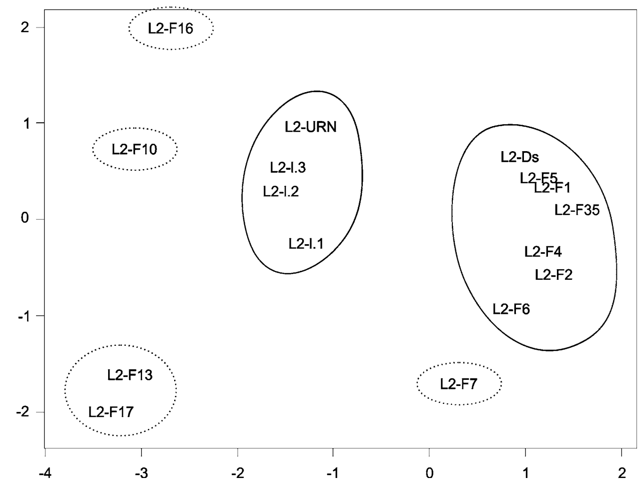


Fig. 9 Non-metric multidimensional scaling (metaMDS, Bray-Curtis distance) for Morro Grande Locus 2 charcoal samples

natural or in an archaeological context, because the bark is not usually taken off when wood is burnt. High proportions of bark, however, do not occur in natural contexts, as plants always consist of much more wood than bark. It is clear, in the present situation, that this material was intentionally selected for fuel.

As previously discussed by Beauclair et al. (2009), in modern society tree bark is generally an unwanted residue of the wood industry (Harkin and Rowe 1970). It is seldom used as fuel and, if so, it is done mainly in order to avoid waste (Baughman et al. 1990; Núñez-Regueira et al. 2005). This is due to its high moisture content—energy is needed to evaporate water, and consequently the energy balance may be unfavourable. The calorific content of dry bark, however, is similar, and frequently higher, than that of dry wood (Ince 1979).

On the other hand, Staden (1927) reported that bark was used by Tupinambá women to fire ceramics. The vessels were placed upon stones and covered with dry bark, which was fired. The pottery was then heated until it was fired.

At present, bark is among the most appreciated fuels for modern potters, because of its high and instantaneous heat, being used even when wood is abundant (Thompson 1994). Use of bark to fire ceramics is also reported for several Brazilian (Lima 1986) and North American natives (Curtis 1926; Sheppard 1968). The arrangement of the bark, covering ceramics in order to preserve the heat and produce uniform firing, is frequently emphasized (Sheppard 1968; Lima 1986), precisely in the same way described for historic Tupinambá (Staden 1927).

Using ethnological and modern observations to explain archaeological contexts is hazardous, as recent preferences and uses cannot be directly transferred to past cultural settings, even if they are observed among native populations and most especially when such a large time span is considered. Human agents might have behaved differently at different places and times. However, analogies may be useful in indicating possibilities for the understanding of past cultural practices.

On this hypothetical basis, we suggest that the utilitarian feature L2-F35 might have been a specialized feature for firing ceramics. It is situated in the earlier archaeological level of this site (3,220–2,840 cal B.P.), below the domestic area identified in Locus 2 (3,000–2,150 cal B.P.). Firing ceramics is an activity that does not belong to a habitation space like the one identified in the subsequent level. That, along with other archaeological evidence, points to the fact that Tupiguarani people have repeatedly occupied the same area, but that they have not established their habitations always in the same place. The village and various spaces and activities related to everyday life were probably differently distributed in the landscape during each occupation period.

All the other bark hearths, however, are associated with a ritual context, situated inside the village, in archaeological level 2 of Locus 2 (3,000–2,150 cal B.P.). It is expected that funerary rituals occurred inside or near the occupied area, according to some Tupiguarani cultural patterns (Staden 1979, p. 100; Prous 2011, p. 40).

Fire was extremely important to Tupinambá people, both in everyday and in ritual activities, and its vestiges are expected at both contexts. The presence of hearths and fire has been repeatedly related to Tupi-Guarani funerary rituals, probably being one of the most constant elements in these ceremonies (Ribeiro 2002). Fire was a constant in these societies' social activities, performing an essential role in Tupinambá funerary rituals (Sousa 1938; Staden 1979; Cardim 1980; Léry 1994; Ribeiro 2002; Thevet 2006; Buarque 2010). In historical reports as well as in archaeological sites, hearths frequently surrounded the urns. Their function was presumably to warm the dead (Sousa 1938) and/or to frighten away the evil spirits (Thevet 1575, 1944; Léry 1994).

Archaeological and ethnographic evidence indicates that in Tupian funerals, as well as in other domains, economic processes and cultural-symbolic aspects were dialectically related, feeding off each other. Rituals can parallel everyday activities, and therefore the use of a material in day to day activities does not prevent it from having a ritual role (Morehart et al. 2005). Based on this premise, Beauclair et al. (2009) suggested a possible explanation for the presence of bark hearths in a funerary context. These authors proposed that it might be a symbolic parallel with the everyday: the potency and power of transformation of bark as a fuel would be regarded at a spiritual level, achieving the transformation of the body soul in the revered soul of an ancestor.

Tupiguarani ceramists are usually considered to have been "Forest People". Almost all the known settlements are situated in areas of warm rain forests, close to navigable rivers. The rare records outside these regions are sparse and probably late (Prous 2011). When these groups first left their land of origin in Amazonia, (Noelli 1998; Heckenberger et al. 1998), they were probably already used to intensive agriculture (Brochado 1984). Southeastern Brazilian historical groups cultivated manioc and practised horticulture, plant gathering, fishing, and, to a lesser extent, hunting and mollusc gathering (Prous 1992).

Anthracological results corroborate the association of the prehistoric groups with the Atlantic rainforest, as the analysis of dispersed charcoal in the Morro Grande site has demonstrated the permanence of this forest in the region between 3,220 and 1,390 cal B.P. The high proportion of taxa of early successional stages suggests the existence of secondary vegetation around the site, which is coherent with an environment affected by people. Concurrently, a considerable proportion of taxa of late ecological successional stages show the existence of mature forests. These results corroborate previous palaeoenvironmental studies in southeastern Brazil that postulated forest expansion in the mid Holocene (Behling 1997a; Ybert et al. 2003; Ledru et al. 2005; Behling et al. 2007).

Fabaceae taxa are clearly dominant in the anthracological record, such as *Bauhinia* sp., *Cassia* spp., *Copaifera* sp., *Swartzia* sp., *Zollernia* sp., *Dalbergia* sp., *Machaerium* sp., *Myroxylon* sp., *Poecilanthe* sp., *Acacia* sp., *Inga* sp. and three indeterminate taxa. This family is still, at present, frequently dominant in the Atlantic rainforest, both in number of species and in number of individuals, especially in low altitude facies (Vaz 1992). Bignoniaceae (especially *Handroanthus* sp.), Myrtaceae and Sapotaceae are also well represented in frequency, while the Euphorbiaceae are distinguished by a relatively high species diversity, with *Croton* sp., *Pachystroma* sp., *Securinega* sp. and one indeterminate taxon. These results are compatible with the structure of lowland Atlantic rainforests verified in botanical studies (cf. Vaz 1992; Oliveira-Filho and Fontes 2000; Peixoto et al. 2004; Carvalho et al. 2008).

The presence of *Laguncularia racemosa* in Locus 1 points to the occurrence of mangrove in the area as well. Although this material has not been dated, stratigraphy, material culture and arrangements of the funerary structure suggest that it was contemporary with one of the earlier periods of site occupation, probably between 3,220 and 1,390 cal B.P. The most probable source of this vegetation type is the margins of the Araruama lagoon, presently some 10 km from the site, but mangrove elements could also have come from the rivers Una or São João, presently located some 30/40 km from the site (Fig. 1). It must be considered that during the period considered, the sea level was 1–3 m higher than at present (Angulo et al. 2006) and water bodies were therefore closer to the site. Anyway, Tupiguarani people were excellent canoeists (Staden 1979), so it is not unlikely that some timber could have come from farther away from the site, especially in the case of useful or interesting taxa.

Dispersed charcoal samples in this site are characterized by relatively high taxon richness, indicating random gathering of firewood in a domestic context. However, the number of taxa in each archaeological level (20–35) is lower than that previously found in anthracological studies of shell mounds in the same region, situated in the restinga environment, which provided c. 30–50 taxa per level (Scheel-Ybert et al. 2009a).The total number of wood taxa recorded in this site (78) is also lower than in some previous anthracological studies (Scheel-Ybert 2000), as well as in phytosociological and floristic lists (90–169 for low altitude forests, according to Peixoto et al. 2004). Pollen studies in Atlantic forest areas in São Paulo State did not identify the same plant diversity either. Garcia et al. (2004) reported 106 pollen and spore types, of which 69 were associated with the Atlantic forest, but only 43 were related to woody taxa; Pessenda et al. (2009) recorded 158 palynomorphs (pollen, spores and algal taxa), of which 130 were from either arboreal and herbaceous angiosperms. In two studies from southern Brazil, Behling (1997a, b) recorded respectively 145 and 160 palynomorph types attributed to several ecological groups (grasslands, *Araucaria* forest, cloud forest, Atlantic rain forest, Andean forest, introduced taxa, aquatics, ferns, mosses, and algae). In each case, only 20 taxa originated from the Atlantic rain forest.

Similarly, Shannon diversity indices (2.1–2.7) are low compared to extant phytosociological studies in Atlantic forests. Lowland and slope forest inventories usually provide Shannon indices between 3.0 and 4.5 (Moreno et al. 2003; Peixoto et al. 2004), rarely around 2.5 (Peixoto et al. 2004). In spite of that, we still cannot speak of species selection. The high frequencies of *Myroxylon* sp. and *Handroanthus* sp. in all archaeological levels certainly contribute to lowering their diversity.

The high frequencies of *Myroxylon* sp. both in the dispersed charcoal (Fig. 5), as in some domestic hearths from Locus 2 are remarkable (Fig. 7). This genus comprises three species, only one of which (*M. peruiferum*) is reported in Rio de Janeiro State. All these species are characterized by producing highly valuable wood. Bark, wood and leaves of these plants are considered to be medicinal. Their trunks produce oils of high medicinal and economic importance, Peru and Tolu balsam (Sartori 2000). These plants are nowadays endangered due to over exploitation of their wood and balsam, which was responsible for a drastic reduction of their populations. Yet it is unlikely that they were ever predominant in the Atlantic Forest phytosociology. The prevalence of this taxon might therefore be explained by a particular economic exploitation of its wood.

The high frequencies of *Handroanthus* sp. (Figs. 5, 7) can also be explained in the same way, as this genus also comprises, among 24 species occurring in the Brazilian flora (half of which occur in Rio de Janeiro State), several with valuable wood and medicinal properties. However, an environmental explanation is also possible in this case, for *Handroanthus* sp. are frequently important elements of the dense ombrophilous forest (Oliveira-Filho et al. 2005).

The same considerations apply to *Copaifera* sp., which was frequent in the dispersed charcoal and especially in some funerary hearths (Figs. 5, 7) and in the probable utilitarian feature from Locus 2 first archaeological layer (L2-F35). This genus comprises 24 Brazilian species, three of which occur in Rio de Janeiro State; all of them produce valuable wood. All parts of the plant, particularly the trunk, produce an oil of multiple pharmacological applications: anti-inflammatory, analgesic, antimicrobial, antibacterial, anthelmintic, cicatrizant etc. Copaiba oil, as well as bark and seeds from these plants, was largely used in Tupiguarani traditional medicine. Several ethnographical reports state that indigenous practises for oil extraction were extremely ritualized (Veiga and Pinto 2002).

Given their properties, it is unlikely that any of these taxa were selected merely for firewood. If *Myroxylon*, *Handroanthus* and *Copaifera* species were exploited for their wood, as medicine, or for any other unknown reason, the wood waste remaining from these activities was probably used as firewood, raising their frequencies in the anthracological spectra.

Besides the prevalence of the former two taxa, moderate diversity in dispersed samples might be explained by limited anthracological sampling. A restricted site catchment area for firewood is also consistent with the present results. It is conceivable that these people were collecting at least most of the firewood in secondary vegetation as the result of human activity around the dwelling space or in previously cleared land, and not in the primary forest, similar to what was observed by Picornell et al. (2011) in Equatorial Guinea. Both the rather low diversity of charcoal samples and the high proportion of taxa of early successional stages support this hypothesis.

These results show that Tupiguarani people, who inhabited this area for almost three millennia, interacted with the natural vegetation, disturbing and transforming it in a number of ways. They adapted to the environment, but concomitantly adapted the environment to their necessities and signified it according to their beliefs, creating a landscape that changed though time and which was certainly very far from the ideal of a pristine Atlantic forest.

The establishment of sedentary or semi-sedentary villages, slash-and-burn cultivation, daily activities such as plant gathering, horticulture, exploitation of forest products, management, hunting, ritual activities such as cannibalism, funerals and ceremonial meetings, all interfere with the environment and shape the landscape, either as a physical reality and as social constructs.

The surroundings of the village, possibly including the paths interconnecting it with gardens, orchards, cultivation fields, rivers and exploited forests, was a space of domesticated secondary vegetation which, for its characteristics of closeness, structure and/or social significance, was probably preferred for firewood collection.

These results meet recent studies based upon historical ecology approaches that have been discussing human influence on forests and on the environment (Posey 1985; Denevan 1992; Fairhead and Leach 1995; Toledo and Molina 2007), many of them focusing on Amazonia (Balée 1989, 1994; Balée and Erickson 2006; Politis 1997, 2001; Rival 1998; Oliver 2008; Clement and Junqueira 2010). These authors agree that much, if not all of the biosphere has already been affected by human activity, which does not necessarily lead to degradation and extinction of taxa (Balée 1998). As long as we consider traditional societies and land use at non-industrial scales, human disturbance, local deforestation and creation of secondary environments do not result in irreversible damage to local biodiversity, due to the resilience of natural ecosystems and their ability to regenerate. On the other hand, human activities may actually increase natural biodiversity by forest management, planting or by encouraging the growth of an assemblage of useful plants in certain forest spots (Balée 1994; Rival 1998; Politis 2001; Oliver 2008). This increased biodiversity, however, may not be recorded in the charcoal assemblage, because useful plants are frequently spared when collecting firewood.

Conclusion

This work confirms the association of Tupiguarani people from southeastern Rio de Janeiro State with the Atlantic rainforest. In addition, it provides important evidence of special fuel selection for funerary hearths, and about wood use in daily activities. This evidence affords new perspectives for the archaeological interpretation of funerary rituals and of the way of life of Tupiguarani populations.

– The Brazilian Atlantic rainforest occurred in the Araruama region from c. 3,000 to 1,400 B.P. at least. The presence of mangrove in the region during at least part of this period is demonstrated.
– The existence of mature forests in the site catchment area is attested. Much of the firewood, however, was collected in secondary vegetation.
– It is proposed that the surroundings of the settlement consisted of an area of vegetation affected by people, which was probably preferred for firewood collection. Firewood collection was possibly also done in previously cleared land.
– A possible local opening of the vegetation after c. 2,000 B.P. is suggested, probably due to human activity.
– Lauraceae wood was used to make a post used in the funerary area.
– *Myroxylon*, *Handroanthus*, and *Copaifera* trees might have been used for their wood, as medicine, or for some other unknown reason.
– Bark was intentionally selected for fuel, either for daily activities or in funerary hearths. It is hypothesized that the former might have been a specialized use for firing ceramics, while in the latter bark was certainly used for symbolic reasons.
– Domestic hearths had only a small percentage of bark or none at all, conforming to what is normally found in anthracological samples. These hearths might have had a short period of use or they might have been cleaned out before their last use.
– Anthracological data, supported by archaeological evidence, suggests that Tupiguarani people repeatedly occupied the same area, but that the village and various spaces and activities related to daily life were probably differently distributed in the landscape during each occupation period.

This analysis of archaeological charcoal provides both palaeoenvironmental and cultural information. It is already largely acknowledged that the engagement of ancient people in transporting wood to the dwelling site does not invalidate past vegetation reconstructions. Concurrently, anthracological studies cannot underestimate the cultural significance of data, since important evidence on landscape, wood use, economic and social practices can frequently be deduced from the same samples.

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