The people of Jabuticabeira II: reconstruction of the way of life in a Brazilian shellmound

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Abstract

Sambaquis are huge shellmounds built along almost the entire Brazilian coast between 8000 and 600 years ago. In the present article, 14 osteological markers from 89 individuals excavated at the Sambaqui Jabuticabeira II (2890±55/2186±60 BP) are analyzed in order to reconstruct the population’s health status and way of life. The present palaeopathological findings (such as lower frequency of degenerative joint diseases in legs, as compared to arms, and the rarity of traumas) together with archaeological findings support the idea of nearby resource abundance and infrequent interpersonal competition. The presence of auditory exostoses mainly in males corroborates previous findings indicating the importance of marine resources. The low caries frequency and the high degrees of dental wear point to a diet poor in cariogenic food, and rich in abrasives such as sand, shell fragments and phytoliths. This suggests a broader diet, based on marine protein as well as plants, than previously thought. The etiology of cribra orbitalia could be explained by gastrointestinal parasites or other sources of physiological stress. These parasites, in turn, could have led to higher frequencies of infectious diseases, either by the debilitation of the immune system or by the direct contact with infectious agents. Despite the periods of illness various individuals experienced, the daily life among the builders of the Sambaqui Jabuticabeira II seems...
to have been relatively easy due to the abundance and predictability of resources and the paucity of violent traumas.

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**Introduction**

Sambaquis are archaeological sites associated with populations that intensely colonized the entire Brazilian coast, specially the Southern regions. The name given to these sites originates from the tupi words “tamba” (mollusk) and “ki” (accumulation), thus meaning “shellmound” (Prous 1991).

These coastal populations lived from 8000 to 600 years ago (Lima et al 2001). This long period of time and large area of occupation, associated with the huge size of many of these sites, suggests that these populations were very well adapted to the coastal environment. Because of their use for the extraction of lime, the Portuguese colonists knew the Sambaquis already in the 16th century. But these sites have only been scientifically studied since the 19th century (Lacerda 1885). Although about 1000 of these sites have been catalogued and partially analyzed until the present, there are only a few reports published in international journals (Gaspar 1998).
In early Sambaqui studies, two main ideas about their origin predominated. One of these interpreted Sambaquis as natural structures formed by sea level decline (Ilhering 1907). The other one stated that they were artificially formed by the accumulation of food remains left over by prehistoric populations (Bigarella 1951). However, the fact that some of the Brazilian Sambaquis are so huge (some sites measure 30 m in height and several hundred meters in diameter) suggests that they were not incidental structures, but rather the result of the intention to form a well-visible construction (Gaspar & De Blasis 1992).

The presence of beautiful bone and lithic artifacts in the Sambaquis, along with findings of recent zooarchaeological and stable isotope studies indicate that the subsistence of these peoples was mainly based on fishing and gathering of molluscs (Figuti 1992, 1993, 1994, 1999; Kneip 1994; De Masi 1999). This latter process would have been the activity that led to the construction of the Sambaquis (De Blasis et al 1998).

The occurrence of pottery in Sambaquis, although used to define pre-ceramic and ceramic periods (Beck 1974), is limited to a few pieces usually scattered around the surface of the site, without any other cultural change and no burial associations. These ceramic fragments might represent occasional trade with surrounding groups (Gaspar 1996), and appear to indicate that pottery did not play a significant role in their cooking technology, nor that pottery can be safely associated with high caries indices (Fish et al 2000; Wesolowski 2000).

Although there are hypotheses that propose the existence of two or three morphologically distinct populations within the Sambaqui culture (Imbelloni 1956/1958; Neves 1988) some authors favor the occurrence of a morphological unity of these groups (Mello e Alvim & Seyferth 1968/1969, 1971). However, more detailed comparative morphological studies are necessary to test these hypotheses.

Apart from craniometrical studies, most of the research carried out on skeletal remains is concentrated on the description of oral pathologies (Salles Cunha 1959, 1963a, b; Araujo 1969, 1970; Wesolowski 2000; Neves & Wesolowski 2002), as well as cribra orbitalia and porotic hyperostosis (Mello e Alvim et al 1991; Mello e Alvim & Gomes JC de 1992) in single Sambaquis.

Recently, archaeological excavations in the Sambaquis have been more systematic, and permit the meaningful analysis of population history at specific Sambaquis sites. The present article focuses on the description of the health status of 89 individuals buried in the shellmound Jabuticabeira II based on an assessment of 14 osteological markers.

**Archaeological context of Sambaqui Jabuticabeira II**

The material reported in this article was excavated from a Sambaqui called Jabuticabeira II. The excavation of this site is part of a multidisciplinary project called “Settlement patterns and formation of Sambaquis from the Santa Catarina state”. Its main objective is the systematic approach of a whole series of Sambaquis, localized around the lake Camacho (Fig. 1), at the southern coast of Brazil, in order
to obtain understand their construction processes (Gaspar et al 1999; Fish et al 2000).

Besides Jabuticabeira II, there are 22 Sambaquis built between 2000 and 4000 years ago (Fish et al 2000) that are scattered around this lake. In the past this group of Sambaquis was significantly closer to the coast, due to the decrease in sea level that began 5100 BP (Bissa et al 2000). Thirty-nine radiocarbon dates for Jabuticabeira II indicate that it was constructed between $2890 \pm 55$ and $2186 \pm 60$ BP (Laboratory of Isotope Chemistry, Department of Geosciences, University of Arizona) or over a period of about 700 years (Fish et al 2000). What remained of this site after mining activities measures approximately 400 m (NW–SE) by 250 m by 6 m height.

The osteological material from Jabuticabeira II derives from profiles as well as traditional horizontal excavations, which reveal a long and continuous depositional history involving recurrent burial and mortuary activities and the lack of habitation structures. The high number and great density of burials, each of which is often covered over by a layer of sand and shells, suggest that the utilization of this Sambaqui as cemetery was linked to its construction process (Fish et al 2000).

The burials are distributed over most of the locations excavated, and are accompanied, in the majority of cases, by hearths, post-holes, as well as lithic
artifacts, beads, some evidence of food (mainly fish), red pigment and different ways of interment indicating elaborate funeral rituals (Edwards et al. 2001). Based on the ratio of burials per cubic meter, Fish et al. (2000) estimated an astonishing number of approximately 40,000 persons that must have been buried during the construction of Jabuticabeira II. Even if this is an overestimate, it suggests a large number of people living nearby the Sambaqui, sharing a common social identity and getting together for the construction of this mortuary monument.

**Material and methods**

The material described here consists of the remains of a minimum number of 89 individuals excavated from the site Jabuticabeira II during three field campaigns in 1997, 1998 and 1999. The state of conservation of some of the individuals is far from being ideal. In many cases there are only a few skeletal elements. The curation was carried out in the laboratory supervised by one of us (SE) according to internationally accepted criteria.

The minimum number of individuals (MNI) was estimated according to White (1991). The age at death of the juveniles was based on the degree of epiphysial closure (Brothwell 1981), on tooth formation and eruption (Ubelaker 1989) and on the size of the long bones (Johnston 1962). The adult individuals were sexed based on pelvic and cranial morphology (Buikstra & Ubelaker 1994), and their age at death was estimated based on the morphology of the pubic symphysis (Brooks & Suchey 1990) or on the degree of cranial suture closure in cases where the pelvis was absent (Meindl & Lovejoy 1985). If neither was possible, the individuals were simply classified as adults.

The estimation of adult stature was carried out based on the maximal length of complete long bones and on regression formulae for prehistoric Amerindian populations (Sciulli & Giesen 1993).

The diagnosis of oral and general palaeopathology followed acknowledged criteria (see below) and was carried out macroscopically, since this is the only method that allows comparisons with reports on other Sambaquis. Due to the fragmentary character of the sample, not all individuals were included in every analysis. Therefore we used the frequency of pathologies per tooth, socket or anatomical unit. For oral pathology analyses, only individuals presenting more than 50% of teeth or sockets were included for the estimation of frequency per person, whereas all teeth/sockets available were considered for prevalence per tooth/socket. Periodontal disease and dental calculus were recorded as present or absent. Molar dental wear was analyzed according to Brothwell (1981) and anterior dental wear according to Smith (1984). Palaeopathological analyses were performed on the criteria established by Ortner & Putschar (1981) and Außerheide & Rodriguez-Martín (1998), and recorded as present or absent per anatomical unit. The oral, cranial and postcranial pathologies were evaluated quantitatively, whereas qualitative evaluations were carried out for infectious disease only.
Statistical analyses were performed on the SPSS program for Windows in order to obtain the degree of significance in $\chi^2$ tests aimed at verifying the differential frequency of certain traits in subgroups of the population.

Results

Sex and age at death

The estimation of the MNI yielded a total of 89 persons. The distribution of the age at death is shown in Table 1. Due to their incompleteness (76.4% of all individuals had less than 50% of all bones) many of the adult skeletons (simply referred to as Adults in Table 1) lack a more precise age determination. That is why the sample of adults was not divided into age categories when analyzed. The same problem of incompleteness prevented sex determination in 63% of the adults.

Stature

The average stature of the population from Jabuticabeira II is 1.51 m. The mean stature of males ($n = 6$) was estimated to be 1.56 m ($s = 0.074$, $\sigma = 0.067$), whereas that of females ($n = 5$) was 1.46 m ($s = 0.042$; $\sigma = 0.039$).

Oral pathologies

The distribution of age at death of the 24 individuals included in the oral pathology analyses (Table 2) consists of one adolescent (4.2%), two young adults (8.3%), nine middle adults (37.5%), one old adult (4.2%) and 11 adults (45.8%). As shown in Table 2, periodontal disease was observed in the great majority of the individuals, and in two-thirds of the teeth. Abscessing was present in almost half of the population, but affected only a small number of alveoli per individual. A similar pattern was observed for antemortem tooth loss: one-third of the population was

<table>
<thead>
<tr>
<th>Age class</th>
<th>Age-at-death (years)</th>
<th>N</th>
<th>%</th>
<th>N females</th>
<th>N males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juveniles</td>
<td>0–20</td>
<td>26</td>
<td>29.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Young adults</td>
<td>21–35</td>
<td>10</td>
<td>11.2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Middle adults</td>
<td>36–49</td>
<td>11</td>
<td>12.4</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Old adults</td>
<td>&gt; 50</td>
<td>1</td>
<td>1.1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Adults</td>
<td>&gt; 21</td>
<td>41</td>
<td>46.1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>—</td>
<td>89</td>
<td>100.0</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 1. Age at death and sex distribution in Jabuticabeira II
affected, but one individual presented an edentulous mandibula, whereas the rest of the affected persons lost only very few teeth. Finally, a low caries incidence was found in this population (4.2% of individuals and 0.44% of teeth affected), in which only one adult individual presented the two (occlusal molar) caries lesions found in this sample. All adults presented a pronounced dental wear. The mean degree of dental wear for incisors, canines and premolars is $x = 4.763$ (following Smith 1984) and $x = 3.649$ for molars (following Brothwell 1981).

No evidence of the use of teeth as tools was found in this sample. All individuals were affected with dental calculus. However, only very few presented them intact (two out of 23 available individuals), and in these cases the calculus was remarkably extensive, reaching the maximum degrees in Brothwell’s classification (1981). Due to the small sample size, statistical analyses of dental pathologies were not carried out.

**Auditory exostoses**

Auditory exostoses was observed in four adult males and one adult female (out of nine males, seven females and five adults of undetermined sex with at least one meatus preserved), leading to a figure of 23.8%. In males, in two cases the exostosis was observed in both meati and with symmetric grades of severity, but in one case, the right meatus was more affected than the left one. The female had just one meatus affected. Six out of 34 (17.7%) meati presented auditory exostoses.

**Cribra orbitalia**

The occurrence of cribra orbitalia was verified in five individuals in a total of 17 eligible crania (eight females, six males, one non-sexed adult and two juveniles with at least one preserved orbit), yielding a figure of 29.4%. Four of these lesions were healed and belonged to adult females; one was still active at the time of death and belonged to a three-year-old child. Eight among 27 orbits (29.6%) showed evidence of cribra orbitalia.

Table 2. Frequency distribution of oral pathologies in Jabuticabeira II

<table>
<thead>
<tr>
<th>Oral Markers</th>
<th>N Available Individuals</th>
<th>N Affected Individuals</th>
<th>Frequency of Affected Individuals (%)</th>
<th>N Available Teeth or Sockets</th>
<th>N Affected Teeth or Sockets</th>
<th>Frequency of Affected Teeth or Sockets (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peridontal disease</td>
<td>21</td>
<td>19</td>
<td>90.5</td>
<td>336</td>
<td>222</td>
<td>66.07</td>
</tr>
<tr>
<td>abscesses</td>
<td>16</td>
<td>7</td>
<td>43.7</td>
<td>336</td>
<td>12</td>
<td>3.57</td>
</tr>
<tr>
<td>AMTL</td>
<td>16</td>
<td>6</td>
<td>37.5</td>
<td>359</td>
<td>23</td>
<td>6.41</td>
</tr>
<tr>
<td>Caries</td>
<td>24</td>
<td>1</td>
<td>4.2</td>
<td>452</td>
<td>2</td>
<td>0.44</td>
</tr>
</tbody>
</table>
Infectious diseases

The distribution of infectious diseases, considered here as periostitis and osteomyelitis, is given in Table 3. The bone significantly most often affected was the tibia (37%) \((\chi^2 = 11.24; p < 0.01)\), whereas the rib was the bone with the lowest frequency observed. All infections matched the diagnostic criteria of periostitis, except a distal humerus with osteomyelitis and the case of a pair of tibiae and one fibula with gummatous lesions (Fig. 2) that belonged to an adult of undetermined sex. The right tibia was more affected than the left one, the former being a typical saber shin tibia. The X-ray of both tibiae showed a slight reduction of the diameter of the medullary cavity (Fig. 3).

Table 3. Frequency distribution of periostitis and osteomyelitis per anatomical unit in Jabuticabeira II

<table>
<thead>
<tr>
<th>Bone</th>
<th>N available bones</th>
<th>N affected bones</th>
<th>Affected bones (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clavicula</td>
<td>43</td>
<td>4</td>
<td>9.30</td>
</tr>
<tr>
<td>Scapula</td>
<td>45</td>
<td>4</td>
<td>8.89</td>
</tr>
<tr>
<td>Humerus</td>
<td>61</td>
<td>6</td>
<td>9.84</td>
</tr>
<tr>
<td>Radius</td>
<td>56</td>
<td>8</td>
<td>14.29</td>
</tr>
<tr>
<td>Ulna</td>
<td>56</td>
<td>5</td>
<td>8.93</td>
</tr>
<tr>
<td>Femur</td>
<td>55</td>
<td>9</td>
<td>16.36</td>
</tr>
<tr>
<td>Tibia</td>
<td>49</td>
<td>18</td>
<td>36.73</td>
</tr>
<tr>
<td>Fibula</td>
<td>38</td>
<td>4</td>
<td>10.53</td>
</tr>
<tr>
<td>Long bone (fragment)</td>
<td>30</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Rib</td>
<td>34</td>
<td>1</td>
<td>2.94</td>
</tr>
</tbody>
</table>

Fig. 2. Saber Shin tibia from one adult individual.
An interesting palaeopathological finding refers to a double burial of a six-month old infant and a three-year-old child. Both were buried together in an undoubtedly secondary burial, with many beads and a carved shell positioned near their heads. Although the bones were very fragile (due to their tiny size, their pathologies and the very bad weather conditions during the excavation), both skeletons were more than 50% complete and well preserved. All their long bones presented about 2mm thick detachable new bone formation (periostitis) on both, metaphysis and diaphysis (Fig. 4). The X-ray of these bones revealed no alteration in the medulary cavity (Fig. 5). The older child presented active cribra orbitalia.

**Fig. 3.** X-ray of the pathological tibiae shown on Fig. 2 (on the left and in the middle) in comparison with a normal one (on the right).
Among the adults ($n = 34$ individuals), almost all ($n = 33$) were affected by degenerative joint disease. It must be kept in mind that due to the small sample size only presence and absence of DJD was considered. Nevertheless, it was possible to

**Degenerative joint disease (DJD)**

Among the adults ($n = 34$ individuals), almost all ($n = 33$) were affected by degenerative joint disease. It must be kept in mind that due to the small sample size only presence and absence of DJD was considered. Nevertheless, it was possible to
observe that the degenerative changes affected both men and women equally, but the
distribution of bones affected (Table 4) shows that the upper limbs (37% of them
arthritic) were significantly \( (\chi^2 = 21.77; p < 0.01) \) more affected than the lower ones
(16% of them arthritic). Despite the high prevalence of DJD, no eburnation was
observed.

Degenerative joint changes were also observed in the vertebral column. However,
since none of the spines were complete and all of the vertebrae were badly damaged,
no attempt could be made to analyse the differential degree of articular changes in
the cervical, thoracic and lumbar segments. Degenerative joint disease was found in

<table>
<thead>
<tr>
<th>Bone</th>
<th>( N ) available bones</th>
<th>( N ) affected bones</th>
<th>Affected bones (%)</th>
<th>Affected joints (%)</th>
<th>Upper limbs and lower limbs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sternal end of clavicula</td>
<td>14</td>
<td>11</td>
<td>78.57</td>
<td>78.57</td>
<td>—</td>
</tr>
<tr>
<td>Acromial end of clavicula</td>
<td>14</td>
<td>10</td>
<td>71.43</td>
<td>47.17</td>
<td>88/147 = 59.86</td>
</tr>
<tr>
<td>Scapula</td>
<td>18</td>
<td>12</td>
<td>66.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal humerus</td>
<td>21</td>
<td>3</td>
<td>14.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal humerus</td>
<td>29</td>
<td>17</td>
<td>58.62</td>
<td>59.46</td>
<td></td>
</tr>
<tr>
<td>Radius/ulna</td>
<td>21</td>
<td>13</td>
<td>61.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal ulna</td>
<td>24</td>
<td>14</td>
<td>58.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal radius</td>
<td>18</td>
<td>3</td>
<td>16.67</td>
<td>20.37</td>
<td></td>
</tr>
<tr>
<td>Distal ulna</td>
<td>14</td>
<td>5</td>
<td>35.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpii</td>
<td>22</td>
<td>3</td>
<td>13.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metacarpii</td>
<td>27</td>
<td>3</td>
<td>11.11</td>
<td>14.81</td>
<td></td>
</tr>
<tr>
<td>Phalanges (hand)</td>
<td>27</td>
<td>5</td>
<td>18.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetabulum</td>
<td>11</td>
<td>1</td>
<td>9.09</td>
<td>6.67</td>
<td>26/165 = 15.76</td>
</tr>
<tr>
<td>Proximal femur</td>
<td>19</td>
<td>1</td>
<td>5.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal femur</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>18.92</td>
<td></td>
</tr>
<tr>
<td>Patella</td>
<td>20</td>
<td>7</td>
<td>35.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal tibia</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal fibula</td>
<td>10</td>
<td>2</td>
<td>20.00</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Distal tibia</td>
<td>14</td>
<td>1</td>
<td>7.41</td>
<td>17.65</td>
<td></td>
</tr>
<tr>
<td>Distal fibula</td>
<td>13</td>
<td>2</td>
<td>15.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tarsii</td>
<td>24</td>
<td>6</td>
<td>25.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metatarsii</td>
<td>16</td>
<td>3</td>
<td>18.75</td>
<td>16.22</td>
<td></td>
</tr>
<tr>
<td>Phalanges (foot)</td>
<td>21</td>
<td>3</td>
<td>14.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertebrae</td>
<td>531</td>
<td>220</td>
<td>41.44</td>
<td>41.43</td>
<td>—</td>
</tr>
</tbody>
</table>

Upper limbs: considered from acromial clavicula to phalanges of the hands. Lower limbs: considered from acetabulum to phalanges of the feet.
41.4% of the vertebral body facets (220 out of 531 facets affected) and in 22 out of 28 (78.6%) adult individuals (data not shown).

Trauma

Out of 14 adults (six males and eight females) only two of the females presented trauma, against three of the males. Moreover two out of seven adults (28.6%) of undetermined sex presented traumas. They were localized on one femur, two vertebrae, one ulna, one elbow and also on one skull. Most of them were not severe and presented no evidence of interpersonal violence. Furthermore they were in the process of healing at the time of death.

Discussion

Skeletal markers are among the most powerful tools used to reconstruct the biological features of ancient populations. A more complete reconstruction of their way of life can be made if there is an integration of the study of these markers with data obtained from other sources such as zooarchaeology, palaeobotany, material culture and settlement patterns. According to more recent studies, Sambaqui populations were fisher-gatherers (Figuti & Klöckler 1996), who used a wide variety of plants for food, fuel, artifact production and construction (Scheel-Ybert 1999) and engaged in elaborated mortuary rituals (Edwards et al 2001). They possibly shared a common identity with neighboring Sambaqui peoples and used their often huge mounds for purposes as diverse as habitation, cemetery and as a place for tool production (Gaspar 1998).

Sex and age at death

The data obtained from Jabuticabeira II revealed that approximately one-third of the buried individuals were juveniles. This high proportion of juveniles has been observed in most prehistoric cemeteries and in accordance with Waldron (1994), this indicates that burial rituals were not altering the natural demographic composition. This statement was corroborated by the fact that the sexes were evenly distributed and that the age at death of adults ranged from 21 to more than 50 years.

Stature

The average stature for the population of Jabuticabeira II (1.51m) and other Sambaquis (Mello e Alvim & Uchoá 1976; Kneip et al 1995; Mendonça de Souza 1995) is at the lower end of the range, especially for women, when compared with other prehistoric and extant Amerindian populations (Storto et al 1999).
Oral pathologies

The study of dental pathologies allows some inferences about the resources consumed by this coastal population. The high degree of dental wear detected on the occlusal surface of all studied teeth from Jabuticabeira II was exclusively due to masticatory stress. The high degree of dental wear in all Sambaqui populations studied, as already pointed out by many authors (Salles Cunha 1959, 1963a, b; Araujo 1969, 1970; Mendonça de Souza 1995; Wesolowski 2000), was probably caused by sand, tiny shellfish fragments and phytoliths (Reinhard et al 2001) present in the food consumed.

The large quantity of abrasive material present in the diet of the Jabuticabeira population possibly caused an increase in the frequency of periodontal disease (90.5% of the individuals and 66.07% of the sockets). High degrees of dental wear result in the loss of contact between adjacent teeth and irritation of nearby soft tissues, followed by inflammation and subsequent infection (Ortner & Putschar 1981; Alt et al 1998). However, this disease can also be the result of dental calculus (Brothwell 1981), a trait which affects all adults and that is extremely large in the Jabuticabeira II sample, when preserved. Only 4.2% of the individuals and 0.44% of the teeth were affected by caries. In spite of the fact that high degrees of dental wear reduce the substrate for occlusal caries, and this might account for the low frequency of caries (Maat & van der Velde 1987) observed in many Sambaqui populations (Salles Cunha 1959, 1963a, b; Araujo 1969, 1970; Mendonça de Souza 1995), the low frequency might also be related to a combination of the following factors: diet poor in cariogenic substances (Larsen 1997), low genetic predisposition to caries and cariostatic habits (Hillson 1996).

Coastal populations usually show high levels of dental wear and low frequencies of caries, calculus, abscesses and antemortem tooth loss (Littleton & Frohlich 1993). All of these features, except for high frequencies of dental calculus, were also observed in Jabuticabeira II and other Sambaquis (Salles Cunha 1963a; Mendonça de Souza 1995). A higher calculus frequency in other non-agricultural populations was reported to be due to the alkaline mouth environment caused by the ingestion of large quantities of fats and proteins (Pedersen 1947).

Auditory exostosis

Auditory exostosis can be interpreted as an indicator of sex specific activities in the Jabuticabeira II population. A higher frequency of auditory exostoses in men than women was observed in this and other Sambaqui populations (Mendonça de Souza 1995). This type of exostoses is reported to be caused by frequent dives in cool (Chaplin & Stewart 1998; Kennedy 1986) or salty water (Peixoto 1989) and may therefore be related to the people’s subsistence strategies. In several other populations, high frequencies of this trait are found in the sex which is responsible for the capture of aquatic resources (Kennedy 1986; Standen et al 1997). This might also be true for the Sambaqui people.
Cribra orbitalia

Once interpreted as one of the best palaeopathological markers, cribra orbitalia reached figures of almost 30% of orbits in Jabuticabeira II. Since it does not stand as a proxy for anaemia anymore, this relatively high percentage suggests that physiological stressors (Wapler et al 2004) must have affected them in probably different ways. According to the high prevalence of general infections (see below), the most parsimonious hypothesis on the origin of those stressors are parasitic infections.

Infectious diseases

Among all chronic diseases, only some result in bony changes. Periostitis and osteomyelitis do lead to bony changes but may be a consequence of several different causes, including metabolic disorders and infectious agents (Ortner & Putschar 1981). Periostitis is due to infections and inflammations of the periosteum (Mensforth et al 1978; Ortner & Putschar 1981; Goodman et al 1984) and might be due to local infection or systemic infection. Osteomyelitis is the result of the introduction of bacteria into the bone marrow either by direct infection through trauma, by extension from adjacent infections or by hematogeneous spread (Steinbock 1976; Ortner & Putschar 1981; Goodman et al 1984). Among the infectious agents, there are many different bacteria. One of them is *Treponema* sp., which besides venereal syphilis also causes pinta, yaws and endemic syphilis. These four diseases together are known as treponematoses.

The gummatous lesions found in the tibiae of one adult in Jabuticabeira II suggest treponematosis (Brothwell, personal communication). However, it is not possible to fully confirm this diagnosis because of the incompleteness of the skeleton, which also prevented us to apply criteria for differential diagnosis, such as those developed by Rothschild & Rothschild (1995).

The juvenile skeletal remains of the double secondary burial presenting severe systemic periostitis suggest four possible diagnoses. Since they presented the same type, distribution and severity of bone modifications, the same disease probably affected both of them. Possible diagnoses include congenital syphilis, yaws, scurvy or hematogenous osteomyelitis.

Congenital syphilis was excluded, despite the fact that deposition of subperiosteal bone on the shafts of long bones can be diagnostic of congenital syphilis (Ortner & Putschar 1981), because no other typical feature was found, such as the “saw-toothed” metaphysis or the pathognomonic dental lesions (Aufderheide & Rodriguez-Martin 1998).

The diagnosis of yaws was excluded due to the young age of the children (six months and three years old), since this disease usually affects the skeleton several years after the initial infection (Aufderheide & Rodriguez-Martín 1998; Buckley 2000).

Scurvy, the result of chronic vitamin C deficiency, was also ruled out. In scurvy, there is a new bone formation at the periosteum, and usually these changes are
bilateral, involve multiple bones, and in children affect mostly costochondral junctions and metaphyses (Ortner & Putschar 1981). Additionally, other osseous changes may be present due to scurvy such as bony growth on the jaws, orbits and along the lines of the temporalis muscle (Ortner 1984; Roberts 1987). Excluding metaphyseal periostitis, none of these features were observed in the two children. Furthermore, scurvy is unlikely to occur where fruits like guava and other Myrtacea seem to have been abundant (De Masi 1999) and at least the small child would probably still have been nursed with vitamin-rich milk from the mother.

Most cases of infection and hematogenous osteomyelitis in particular, are caused by bacteria such as *Staphylococcus aureus*. Besides causing mastitis and pneumonia, *S. aureus* is responsible for osteomyelitis, which, in pre-antibiotic times, would have led to septicemia with rapid and fatal outcomes. This bacterium can be found in a large range of environmental conditions and easily adapts to temperatures that range between 15 and 45°C, to environments with high degrees of salinity, as well as aerobic and anaerobic conditions (Todar 2004). Hematogeneous osteomyelitis caused by *S. aureus* seems to be the most plausible diagnosis of the disease which affected the two children because this diagnosis can be reached even with the lack of typical osteomyelitic features, since in children cloacae and sequestra are rarely observed and pus can exude directly through the periosteum (Ortner & Putschar 1981; Aufderheide & Rodríguez-Martín (1998)). Furthermore, the multiple bones affected in the two children are consistent with reports of several bones being affected in up to 40% of the juvenile cases (Bullough 1992).

Poor sanitary conditions such as those presumed for people living on shellmounds can account not only for hematogeneous osteomyelitis, but also for gastrointestinal infections that may lead to anemia or other sources of physiological stress (Wapler et al 2004) as is indicated by the cribra orbitalia observed in the older child (Buckley 2000).

**Degenerative joint diseases (DJD)**

The higher prevalence of DJD in the upper (60%) as compared to the lower limbs (16%) of the people from Jabuticabeira II has also been observed in other Sambaquis (Neves 1986) and was associated with activities like swimming, diving, rowing, throwing of fishing nets and carrying baskets full of seafood (Mendonça de Souza 1995). On the other hand, the minimal stress load observed in the lower limbs can be interpreted as indicating the short walking distances needed for resource procurement. This suggests both resource abundance and predictability.

**Trauma**

Besides its benign nature, the low frequency of traumas observed in Jabuticabeira II is not unexpected, since this has also been observed at other Sambaqui sites (Mendonça de Souza 1995; Lessa & Medeiros 2001). The broad temporal and geographic distribution of Sambaquis and especially the use of multiple concomitant neighboring sites sharing the same territory, suggest that the Sambaqui populations
may have been peaceful, showing little interpersonal violence. This is consistent with a high resource availability being shared by many peoples (Larsen 1997) and with the paleoenvironment of this region (Scheel-Ybert 1998).

**Conclusion**

These data support the idea of resource abundance, already indicated on the basis of the high number, density and size of the Sambaquis scattered around the lake Camacho (Fish et al. 2000). Despite the periods of illness various individuals experienced, the daily life among the Sambaqui dwellers from Jabuticabeira II seems to have been relatively easy due to the abundance and predictability of marine and plant resources and the rarity of traumas, be they violent or not.

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