


## SHORT REPORT

## An Early Holocene case of congenital syphilis in South America

Rodrigo Oliveira<sup>1,2</sup>  | André Strauss<sup>1,3</sup> | Rui Murrieta<sup>1</sup> | Claudio Castro<sup>4</sup> | Antônio Matioli<sup>4</sup><sup>1</sup>Departamento de Genética e Biologia Evolutiva, Universidade de São Paulo, São Paulo, SP, Brazil<sup>2</sup>Disciplina de Periodontia, Departamento de Semiologia, Universidade de São Paulo, São Paulo, SP, Brazil<sup>3</sup>Museu de Arqueologia e Etnologia, Universidade de São Paulo, São Paulo, SP, Brazil<sup>4</sup>Serviço de Diagnóstico por Imagem do Hospital Universitário, Universidade de São Paulo, São Paulo, SP, Brazil

## Correspondence

Rodrigo Oliveira, Departamento de Genética e Biologia Evolutiva, Universidade de São Paulo, Rua do Matão 277, Cidade Universitária, São Paulo, SP, Brazil.  
Email: [eliaso@alumni.usp.br](mailto:eliaso@alumni.usp.br)

## Funding information

FAPESP, Grant/Award Number: 2017/16451-2

## Abstract

Over millennia, treponematoses have been present in the American continent. The search for the oldest case and the description of the pathological characteristics are fundamental to understanding the evolutionary history of treponemal diseases, as well as the evolution of the humans who contracted them. A child with a minimum age of 9400 years before present exhumed at “Lapa do Santo” cave, Brazil, presents characteristic lesions of congenital syphilis. This well-preserved skeleton with dental and bone pathological evidence is the oldest syphilitic case of America and reinforces the presence of syphilis, at least 10,000 years ago, in the continent.

## KEYWORDS

congenital syphilis, Lagoa Santa, Lapa do Santo, paleopathology, treponematoses

## 1 | INTRODUCTION

The resurgence of syphilis in recent decades, even after its almost disappearance in the 20th century, is directly associated with the behavior of modern humans but highlighted the resistance and the adaptability of this treponematoses (Centers for Disease Control and Prevention [CDCP], 2009). Genetic data of *Treponema pallidum* sp. extracted from archaeological material reinforces the global distribution and the antiquity of syphilis, but it is unable to specify the origin (Majander et al., 2020). Skeletons are used to calculate the emergence of a common ancestor of human treponematoses and so the search for the oldest pathological human remains is fundamental for the understanding of the emergence and the evolution of this disease (de Melo et al., 2010).

There are three treponematoses with bone lesions (yaws, bejel, and syphilis), but only syphilis (*T. pallidum subsp. pallidum*) is present throughout the planet and differs from other treponematoses by contagion, and it is classified as either acquired syphilis or congenital syphilis (CS) (Perine et al., 1984). CS has the highest mortality rate among treponematoses causing abortions, stillbirths, or victimizing

the infected in the first years of life. The appearance of bone and dental lesions in early CS occurs at up to 2 years of age while in late CS, it occurs after 2 years of age (Perine et al., 1984). The bone signs of CS are frontal bossing, saber-tibia, saddle nose, metaphysis resorptions in long bones, and polyostotic periosteal reaction, among others (Katz, 2012). The most common dental lesions of CS are notched incisors (Hutchinson's teeth), molars with multiple cusps (Mulberry's molars), severe tooth dysplasia, conoid teeth, and microdontia (Freiman et al., 2009).

Treponematoses have always been present in the American continent, and 107 archaeological cases of treponematoses have been described in North America between 7900 and 3500 years before present (BP) (Cook & Powell, 2005). Guatemala and Dominican Republic present the few precontact archaeological cases (prior to 1492 CE) in Central America (Cook & Powell, 2005). In South America, nonspecific cases of treponematoses over 8000 years-old were found in Chile and Peru, whereas the oldest syphilitic case on the continent was exhumed in “Aguazuque,” Colombia (5030 ± 40 yBP) (de Melo et al., 2010). On the east coast, the oldest case of treponematoses was found in “Piaçaguera” (6342

$\pm 34$  yBP) while the most recent case was in “Praia da Tapera” ( $425 \pm 70$  yBP), evidencing the presence of treponematoses in Brazilian shell middens (*sambaquis*) for, at least, 5500 years (Filippini et al., 2019). Treponematoses in adults are relatively well represented in the archaeological record, but CS is quite rare before contact in the Americas, with only two cases described at this moment (Cook & Powell, 2005; Filippini et al., 2019).

The presence of the treponematoses (yaws, bejel, and syphilis) in America thousands of years before contact is evident and the absence of bejel in South and Central America reinforces the theory of treponematoses dispersion according to the latitude and climate (Filippini et al., 2019). The discrepancy between the number of cases of yaws and syphilis in the American archaeological record could be explained by its pathological characteristics, because bone lesions occur in 33% of yaws infected whereas 1% to 5% of syphilitics have their bones affected (Hackett, 1976; Ortner, 2003). The rarity of cases of CS in the archaeological literature could be explained by the fragility of infant skeletons, the high infant mortality rate, and the peculiar characteristics of syphilis, not to mention the asymptomatic cases (*syphilis congenita tarda*) (Ortner, 2003; Roberts & Manchester, 2005). A syphilitic mother loses her child in 39% of pregnancies, and when the children manage to survive, up to 77% of them are born uncontaminated (Arnold & Ford-Jones, 2000). In 1933, only 4.2% of the autopsies at Johns Hopkins Hospital were diagnosed with CS; however, only 0.04% were syphilitic children over 4 years of age (Ortner, 2003). Such reasons are sufficient to explain why the oldest record of syphilis in adults in America dated to 5300 BP while the oldest case of CS is almost four millennia later (de Melo et al., 2010). Due to the impossibility of discussing the congenital forms of yaws or bejel in B20, we assumed *T. pallidum pallidum* as being the only pathogen responsible for transplacental transmission (Stodder, 2005; Wicher et al., 2000).

## 2 | MATERIALS AND METHODS

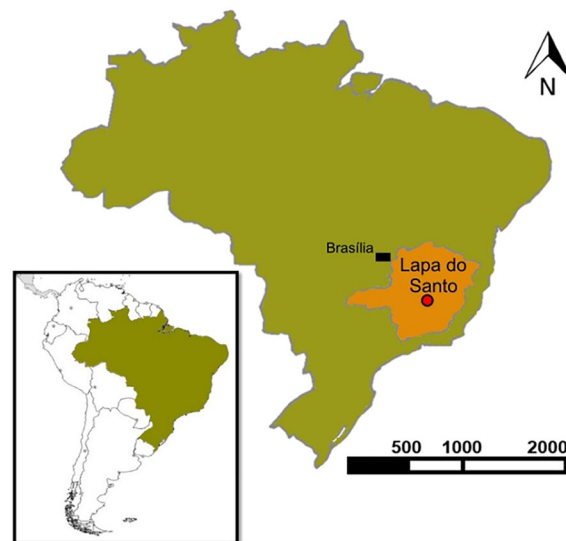
### 2.1 | The syphilitic child of Lapa do Santo site

A 4-year-old subadult named Burial XX (B20) who lived during the Early Holocene was exhumed in Lapa do Santo site, Minas Gerais, Brazil (Figure 1).

B20's skeleton was almost complete, and it was well preserved as many others skeletons of that site. B20 was buried in lateral position, without ritual manipulations as cuts, pigments, or fire modifications (Figure 2).

The observation of macroscopic marks and the imaging exams (X-rays and CT scan) were used in this study to analyze the health condition of this child (see Supporting Information S1 for more details of “Materials and Methods”).

B20 presents some bone lesions and several dental modifications that characterize CS. The bone alterations are present in its left femur, left ulna, and most of them are in his skull.



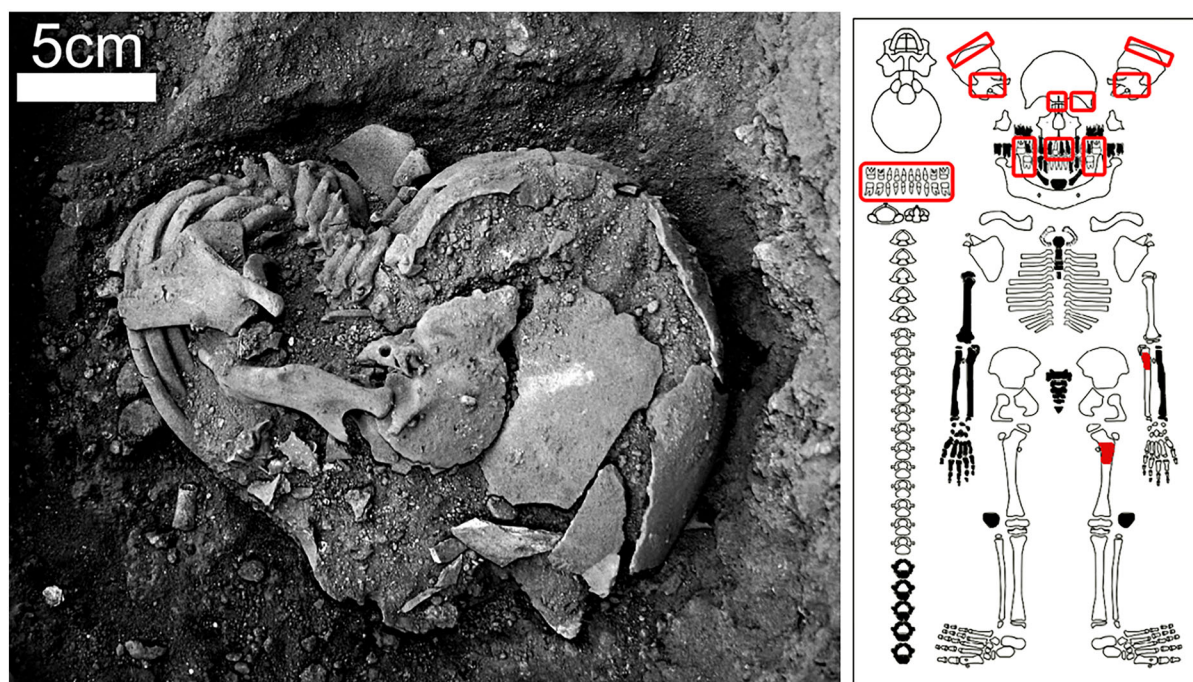
**FIGURE 1** Location of the archaeological site of Lapa do Santo, Matozinhos, MG, Brazil [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/oa.3180)]

## 3 | RESULTS AND DISCUSSION

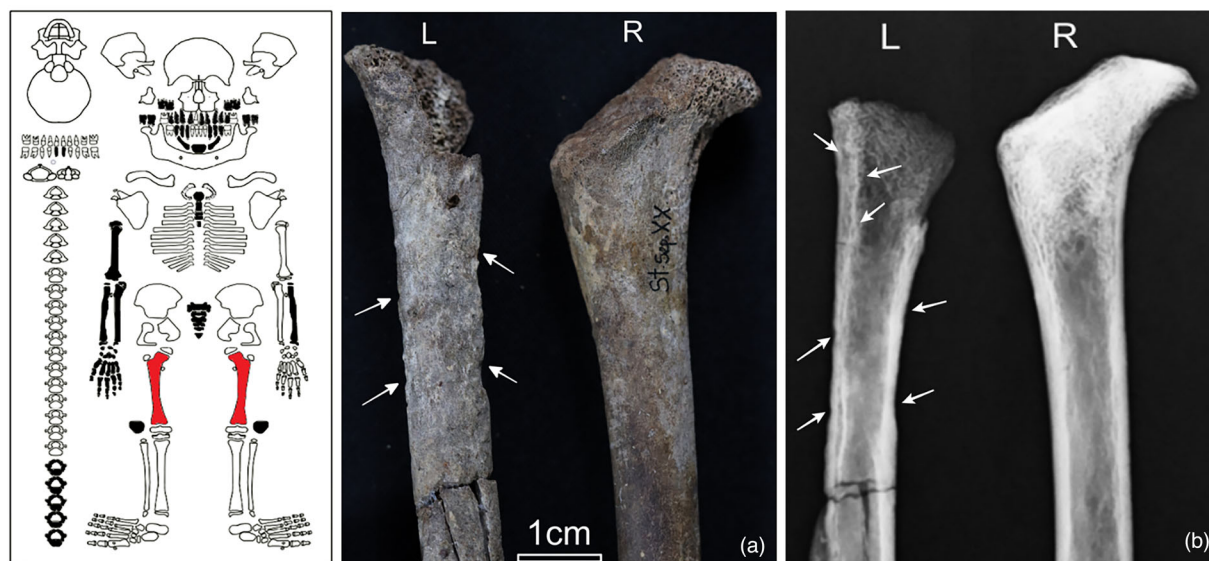
“Lapa do Santo” is one of the most important sites of the Early Holocene in America with well-preserved human remains, accurate excavation process, and detailed dating program of the site's occupation, characteristics that ensure a minimum age of 9.49 KyBP for B20 (Strauss et al., 2016) (see Supporting Information S4 for more details). None of the 195 archaeological skeletons of the Lagoa Santa region show signs of nutritional deficiencies or hormonal changes; however, B20 presents an important delay in its growth without features such as arched lower limbs that characterizes rickets (Da-Gloria & Oliveira, 2017; Petje et al., 2008). Lesions in the roof of the orbital cavity (*cribra orbitalia*) are not necessarily related to treponematoses but reinforce a case of nutritional deprivation or infection (Erdal, 2006) (see Supporting Information S6 for complementary images). Treponematoses can affect the pituitary gland and cause nanism or growth retardation as we observed in B20, who died at the age of four but with a stature of a 1.5- to 2.0-year-old child (Gardiner-Hill, 1937; Sharma et al., 2005; Strauss et al., 2016).

Leishmaniasis and leprosy (*Mycobacterium leprae*) are pathologies capable of producing bone lesions analogous to those observed in syphilis in adults; however, both do not affect the teeth as we observed in this child (Costa et al., 2009; Gaul et al., 2015; Sivapathasundharam & Gururaj, 2012). The macroscopic modifications in the left femur and left ulna of B20 have nonspecific characteristics and could be taphonomy or pathology. Radiographic images of the left femur and left ulna of the child present great similarity in location and its characteristics with syphilitic osteoclastic lesions observed in clinical cases (Figure 3) (Erdal, 2006; Gaskell, 1951).

The suture among parietals is early fused (*Sagittal Synostosis*). The *Sagittal Synostosis* of B20 may have been caused by genetic alterations, birth trauma, metabolic diseases, or intrauterine infections like



**FIGURE 2** Burial XX of “Lapa do Santo”: photo of B20 exhumation and drawing of a skeleton showing the missing bones (black) and bones with alterations (red). Subadult skeleton form adapted from Roksandic (2003): [http://intarch.ac.uk/journal/issue13/roksandic\\_index.html](http://intarch.ac.uk/journal/issue13/roksandic_index.html) (see Supporting Information S1, S2, S3, and S4 for more details) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



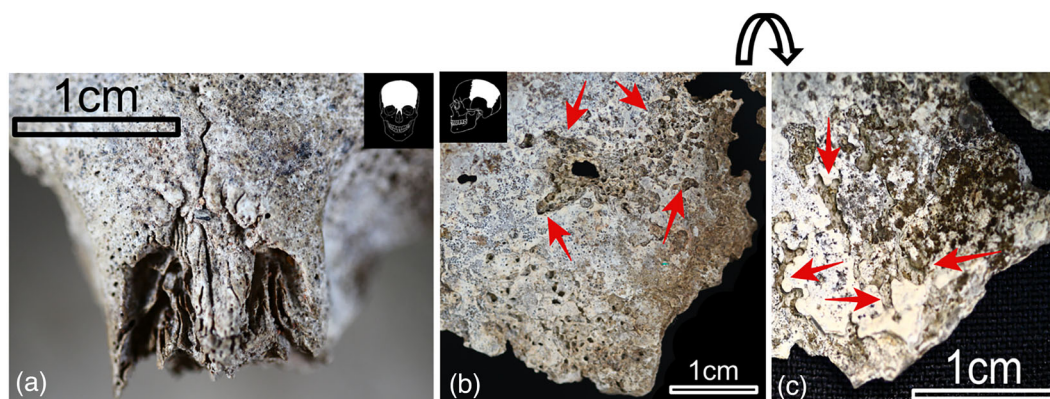
**FIGURE 3** Long bones of B20 (left). Photo (a) and X-rays (b) of the metaphyses and diaphyses of the femurs. White arrows indicate pathological change to the left femoral shaft (see Supporting Information S5 for further images). [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

CS, which we believe is what happened in B20 case (Hahn & Jane, 1978; Johnson & Wilkie, 2011) (see Supporting Information S6 for more details).

Changes in the external surface of the frontal, parietals, and temporals are compatible with syphilitic lesions (*caries sicca*) in the early stages of its development (Hackett, 1976) (Figure 4). We can consider

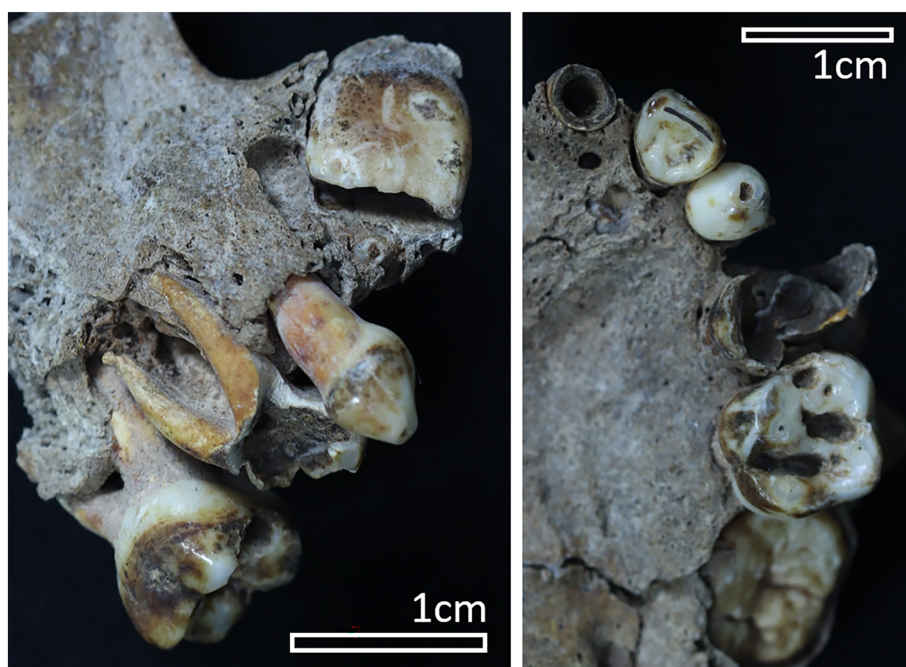
them as Porotic Hyperostosis, but they would also be compatible with a nonspecific infectious process, and syphilis is a hypothesis. These modifications happened in areas commonly affected by syphilis and, although we are conservative and consider them as taphonomic alterations, the chemical and morphological modifications present in infected bones help explain these *postmortem* “lesions” (Fernández-





**FIGURE 4** Cranial lesions of B20. The destruction of the nasal bones and the lesion on the frontonasal suture (a). Destructive changes to the external (b) and internal (c) cortex of left parietal bone compatible with treponemal bone resorption (red arrows). See Supporting Information S6 for more details. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/oa.3180)]

**FIGURE 5** Upper deciduous teeth presenting many dental caries and morphological alterations like microdontia (conoid teeth) and hypoplasia. The right permanent incisor (I1) shows a denticulated incisal edge. (see Supporting Information S7 for supplementary images and information). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/oa.3180)]



López, 2006; Ortner, 2003; Roberts & Manchester, 2005) (see Supporting Information about taphonomy on Supporting Information S4).

In the endocranial view, we observed in both temporals some lesions suggestive of osteomyelitic fistula. These injuries “fistula-like” in B20 suggested a typical chronic osteomyelitis, lesions found in temporal bones in CS (Hughes & Rutherford, 1986).

On the forehead, the frontonasal suture of B20 shows anatomical alterations analogous to that of syphilis lesions, and the left orbit roof presents a typical aspect of *cribra orbitalia* (Hackett, 1976) (see Supporting Information S6 for supplementary information).

The lesion observed in the frontonasal suture and the absence of B20's nasal bones are compatible with the *saddle nose* (Horodniceanu et al., 1978) (Figure 4). The lesions of CS in the nasal region, the orbital cavity, and long bones described in the literature are analogous

to lesions of B20 (Hackett, 1976; Horodniceanu et al., 1978; Ortner, 2003).

All deciduous teeth present generalized enamel hypoplasia (except 72 and 82), and 16 of the 18 deciduous teeth are decayed (see Supporting Information S1 and S7 for supplementary information and images) (Oliveira, 2014; Oliveira & Neves, 2015). The teeth lesions strongly suggest syphilis on B20. Most teeth present caries (88.89%), and this prevalence is 16 times higher than “Lapa do Santo” skeletons (5.5%) and 24 times higher than hunter-gatherers (3.58%) (Da-Gloria & Oliveira, 2017). The high prevalence of caries caused by generalized enamel hypoplasia observed in B20 is compatible with CS (Ortner, 2003). Dental lesions of B20 are identical to a 6-year-old child from Virginia with CS (Virginia—NMNH 379177) (Figure 5) (Ortner, 2003).

Morphological alterations are present in many teeth of deciduous and permanent dentition. Conoid canines observed in B20 show the aggressiveness of the infection during his intrauterine life (Freiman et al., 2009). The permanent right central incisor shows a slight but clear modification on its incisal edge (notch), differing from the lobes that are common in incisors (Figure 5) (Gaul et al., 2015; Ioannou et al., 2018). All first permanent molars of B20 show small and multiple cusps and some punctual enamel alterations. These teeth are not traditional *Mulberry molars* (syphilitic lesion), but they seem to be a mild form of them (Erdal, 2006; Freiman et al., 2009; Gaul et al., 2015).

Fluorosis, amelogenesis imperfecta, and rickets are diseases that could present similar alterations on the enamel surface (hypoplasia), but these diseases do not produce morphological modifications like conoid canines or multiple cusps molars like B20 (Baker et al., 2020; Ioannou et al., 2016). Mercury was largely used to treat many diseases including syphilis after 19th century. The mercury intoxication causes enamel and dentine damages, and it changes aggressively the morphology and the color of teeth, something that we did not observe in B20 (Ioannou et al., 2016).

Unlike the Virginia–USA site (925 CE), “Lapa do Santo” does not present any case of syphilis among the adults (Da-Gloria & Oliveira, 2017; Ortner, 2003). However, there are two reports of treponematoses in the “Lagoa Santa” region. A woman (SR1-SepVIIa) exhumed in “Santana do Riacho”, a contemporary site about 60 km from “Lapa do Santo,” confirmed the presence of treponematoses in the region during the Early Holocene (Da-Gloria & Oliveira, 2017).

The limitations of our study are based on (i) the lack of cases of CS described in the archaeological literature, despite the enormous number of cases described in the medical literature; (ii) the absence of collagen made impossible to define its radiocarbon dates. The minimum age proposed by us is based on the archaeological context in which B20 is inserted.

## 4 | CONCLUSION

The CS of B20 from “Lapa do Santo” ratified the presence of syphilis in America millennia before 1492 CE, being the oldest case of CS described until now. This case reinforces the importance of new analyses in archaeological skeletons even when biochemical analyses failed, looking for the treponematoses carriers that circulated on the American continent between the Late Pleistocene and the Early Holocene.

## ACKNOWLEDGMENTS

The authors would like to thank editor Dr. Piers Mitchell and the IJO referees for the improvement to the seminal manuscript. The authors also thank Dr. Walter Neves, Dr. Maria Okumura, Dr. Pedro da Glória, Dr. Sheila Souza, Lavinia Elias, Waldiane Cossermelli, Max Cezário, and the entire team of the “Department of Clinical Imaging” from

HU/USP. André Strauss is grateful for the financial support of FAPESP (2017/16451-2).

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## DATA AVAILABILITY STATEMENT

In accordance with the “DFG Guidelines on the Handling of Research Data”, we will make all data (photos, Xrays images, and TC scan images on TIFF or JPEG format) available upon request for every reader of International Journal of Osteoarchaeology. The data set will be archived for at least 10 years after publication.

## ORCID

Rodrigo Oliveira  <https://orcid.org/0000-0003-3770-7774>

## REFERENCES

- Abelenda, A. M., Semple, K. T., Lag-Brotons, A. J., Herbert, B. M. J., Aggidis, G., & Aiouache, F. (2022). Strategies for the production of a stable blended fertilizer of anaerobic digestates and wood ashes. *Nature-Based Solutions*, 2, 100014. <https://doi.org/10.1016/j.nbsj.2022.100014>
- Arnold, S. R., & Ford-Jones, E. L. (2000). Congenital syphilis: A guide to diagnosis and management. *Paediatric Child Health*, 5(8), 463–469. <https://doi.org/10.1093/pch/5.8.463>
- Baker, B. J., Crane-Kramer, G., Dee, M. W., Gregoricka, L. A., Henneberg, M., Lee, C., Lukehart, S. A., Mabey, D. C., Roberts, C. A., Stodder, A. L. W., Stone, A. C., & Winingear, S. (2020). Advancing the understanding of treponemal disease in the past and present. *American Journal of Physical Anthropology*, 171, 5–41. <https://doi.org/10.1002/ajpa.23988>
- Centers for Disease Control and Prevention. (2009). *Sexually Transmitted Disease Surveillance*, 2008. U.S. Department of Health and Human Services.
- Cook, D., & Powell, M. (2005). Piecing the puzzle together. In M. Powell & D. Cook (Eds.), *The myth of syphilis* (pp. 442–479). University Press of Florida.
- Costa, M. A., Matheson, C., Iachetta, L., Llagostera, A., & Appenzeller, O. (2009). Ancient leishmaniasis in a highland desert of Northern Chile. *PLoS ONE*, 4(9), e6983. <https://doi.org/10.1371/journal.pone.0006983>
- Da-Gloria, P., & Oliveira, R. E. (2017). History of the research into health and lifestyle in Lagoa Santa. In P. Da-Gloria, W. Neves, & M. Hubbe (Eds.), *Archaeological and paleontological research in Lagoa Santa* (pp. 253–274). Springer. [https://doi.org/10.1007/978-3-319-57466-0\\_12](https://doi.org/10.1007/978-3-319-57466-0_12)
- de Melo, F. L., de Mello, J. C. M., Fraga, A. M., Nunes, K., & Eggers, S. (2010). Syphilis at the crossroad of phylogenetics and paleopathology. *PLoS Neglected Tropical Diseases*, 4(1), e575. <https://doi.org/10.1371/journal.pntd.0000575>
- Erdal, Y. S. (2006). A pre-Columbian case of congenital syphilis from Anatolia (Nicaea, 13th century AD). *International Journal of Osteoarchaeology*, 16(1), 16–33. <https://doi.org/10.1002/oa.802>
- Fernández-López, S. R. (2006). Taphonomic alteration and evolutionary taphonomy. *Journal of Taphonomy*, 4(3), 111–142.
- Filippini, J., Pezo-Lanfranco, L., & Eggers, S. (2019). Estudio Regional Sistemático De Treponematoses En Conchales (Sambaquis) Precolombinos De Brasil. *Chungará (Arica)*, 51(3), 403–425. <https://doi.org/10.4067/S0717-73562019005000301>
- Freiman, A., Borsuk, D., Barankin, B., Sperber, G. H., & Krafchik, B. (2009). Dental manifestations of dermatologic conditions. *Journal of the*

- American Academy of Dermatology, 60(2), 289–298. <https://doi.org/10.1016/j.jaad.2008.09.056>
- Gardiner-Hill, H. (1937). Abnormalities of growth and development. *British Medical Journal*, 1, 1302–1308. <https://doi.org/10.1136/bmj.1.3990.1302>
- Gaskell, K. H. (1951). Radiology in syphilis. *British Journal of Venereal Diseases*, 27(2), 59–74. <https://doi.org/10.1136/sti.27.2.59>
- Gaul, J. S., Grossschmidt, K., Gusenbauer, C., & Kanz, F. (2015). A probable case of congenital syphilis from pre-Columbian Austria. *Anthropologischer Anzeiger*, 72(4), 451–472. <https://doi.org/10.1127/anthranz/2015/0504>
- Gordon, C. C., & Buikstra, J. E. (1981). Soil pH, bone preservation, and sampling bias at mortuary sites. *American Antiquity*, 46(3), 566–571. <https://doi.org/10.2307/280601>
- Guetti, N. C., Solari, A., & Silva, S. F. S. M. (2020). Determinação de pH em Sedimentos Associados aos Remanescentes Humanos do Sepultamento 2, Pedra do Cachorro, Buíque/PE, Brasil. *FUMDHAMentos*, 17(1), 87–97.
- Hackett, C. (1976). *Diagnostic criteria of syphilis, yaws and treponemal diseases in dry bones*. Elsevier.
- Hahn, J., & Jane, J. (1978). Craniosynostosis and related syndromes. *Cleveland Clinic Quarterly*, 45(2), 213–217. <https://doi.org/10.3949/ccjm.45.2.213>
- Horodniceanu, C., Grünebaum, M., Volovitz, B., & Nitzan, M. (1978). Unusual bone involvement in congenital syphilis mimicking the battered child syndrome. *Pediatric Radiology*, 7(4), 232–234. <https://doi.org/10.1007/BF02386714>
- Hughes, G. B., & Rutherford, I. (1986). Predictive value of serologic tests for syphilis in otology. *Annals of Otology, Rhinology & Laryngology*, 95(3), 250–259. <https://doi.org/10.1177/000348948609500308>
- Ioannou, S., Sassani, S., Henneberg, M., & Henneberg, R. J. (2016). Diagnosing congenital syphilis using Hutchinson's method: Differentiating between syphilitic, mercurial, and syphilitic-mercurial dental defects. *American Journal of Physical Anthropology*, 159, 617–629. <https://doi.org/10.1002/ajpa.22924>
- Ioannou, S., Henneberg, R. J., & Henneberg, M. (2018). Presence of dental signs of congenital syphilis in pre-modern specimens. *Archives of Oral Biology*, 85, 192–200. <https://doi.org/10.1016/j.archoralbio.2017.10.017>
- Johnson, D., & Wilkie, A. O. M. (2011). Craniosynostosis. *European Journal of Human Genetics*, 19(4), 369–376. <https://doi.org/10.1038/ejhg.2010.235>
- Katz, K. A. (2012). Syphilis. In L. Goldsmith, S. Katz, B. Gilchrist, A. Paller, D. Leffell, & K. Wolff (Eds.). *Fitzpatrick's dermatology in general medicine* (8th ed.) (pp. 2471–2492). The McGraw-Hill Medical.
- Luna, L. H., Aranda, C. M., & Santos, A. L. (2017). New method for sex prediction using the human non-adult auricular surface of the ilium in the collection of identified skeletons of the University of Coimbra. *International Journal of Osteoarchaeology*, 27, 898–911. <https://doi.org/10.1002/oa.2604>
- Majander, K., Pfrengle, S., Kocher, A., Neukamm, J., Plessis, L., Pladiaz, M., Arora, N., Akgul, G., Salo, K., Schats, R., Inskip, S., Oinonen, M., Valk, H., Malve, M., Kriiska, A., Onkamo, P., Gonzalez-Candelas, F., Kuhnert, D., Krause, J., & Schuenemann, V. J. (2020). Ancient bacterial genomes reveal a high diversity of *Treponema pallidum* strains in early modern Europe. *Current Biology*, 30(19), 3788–3803. <https://doi.org/10.1016/j.cub.2020.07.058>
- Oliveira, R. E. (2014). *Prevalência de patologias orais em los oasis de San Pedro de Atacama*. Publicia - OmniScriptum GmbH & CO - Saabücken.
- Oliveira, R. E., Da-Glória, P., & Neves, W. A. (2018). A Percepção do Meio por Parte da População Atual de Lagoa Santa e suas Implicações para a Arqueologia Regional. *Revista de Arqueologia*, 31(1), 104–130. <https://doi.org/10.24885/sab.v31i1.537>
- Oliveira, R. E., & Neves, W. A. (2015). Oral health in prehistoric San Pedro de Atacama oases, Northern Chile. *HOMO Journal of Comparative Human Biology*, 66(6), 492–507. <https://doi.org/10.1016/j.jchb.2015.05.001>
- Ortner, D. (2003). Infectious diseases: Treponematoses and other bacterial infectious diseases. In D. Ortner (Ed.). *Identification of pathological conditions in human skeletal remains* (2nd ed.) (pp. 273–324). Academic Press. <https://doi.org/10.1016/B978-012528628-2/50048-X>
- Perine, P. L., Hopkins, D. R., John, R. K. S., Niemei, P. L. A., Causse, G., & Antal, G. M. (1984). *Handbook of endemic treponematoses: Yaws, endemic syphilis and pinta* (p. 106p). World Health Organization.
- Petje, G., Meizer, R., Radler, C., Aigner, N., & Grill, F. (2008). Deformity correction in children with hereditary hypophosphatemic rickets. *Clinical Orthopaedics and Related Research*, 466(12), 3078–3085. <https://doi.org/10.1007/s11999-008-0547-2>
- Roberts, C., & Manchester, K. (2005). Infectious disease. In C. Roberts & K. Manchester (Eds.). *The archaeology of disease* (3rd ed.) (pp. 164–220). Cornell University Press.
- Roksandic, M. (2003). New standardised visual forms for recording the presence of human skeletal elements in archaeological and forensic contexts. *Internet Archaeology*, 13, 26. [http://intarch.ac.uk/journal/issue13/roksandic\\_index.html](http://intarch.ac.uk/journal/issue13/roksandic_index.html)
- Sharma, M., Solanki, R., Gupta, A., & Shah, A. (2005). Different radiological presentations of congenital syphilis: Four cases. *Indian Journal of Radiology and Imaging*, 15(1), 53. <https://doi.org/10.4103/0971-3026.28745>
- Sivapathasundharam, B., & Gururaj, N. (2012). Bacterial infections of the oral cavity. In B. Sivapathasundharam & R. Rajendran (Eds.). *Shafers textbook of oral pathology* (7th ed.) (pp. 317–338). Elsevier.
- Stodder, A. (2005). Treponemal infection in the prehistoric Southwest. In M. Powell & D. Cook (Eds.). *The myth of syphilis* (pp. 227–280). University Press of Florida.
- Strauss, A., Oliveira, R. E., Villagran, X. S., Bernardo, D. V., Salazar-García, D. C., Bissaro, M. C., Pugliese, F., Hermenegildo, T., Santos, R., Barioni, A., Oliveira, E. C., Sousa, J. C. M., Jaouen, K., Ernani, M., Hubbe, M., Inglez, M., Grato, M., Rockwell, H., Machado, M., ... Neves, W. (2016). Early Holocene ritual complexity in South America: The archaeological record of Lapa do Santo (east-central Brazil). *Antiquity*, 90(354), 1454–1473. <https://doi.org/10.15184/aqy.2016.220>
- Wicher, K., Wicher, V., Abbruscato, F., & Baughn, R. E. (2000). *Treponema pallidum* subsp. *pertenue* displays pathogenic properties different from those of *T. pallidum* subsp. *pallidum*. *Infection and Immunity*, 68(6), 3219–3225. <https://doi.org/10.1128/IAI.68.6.3219-3225.2000>

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Oliveira, R., Strauss, A., Murrieta, R., Castro, C., & Matioli, A. (2023). An Early Holocene case of congenital syphilis in South America. *International Journal of Osteoarchaeology*, 33(1), 164–169. <https://doi.org/10.1002/oa.3180>