



Subterranean Effects of the Termite *Constrictotermes cyphergaster* on Soil Fungal Abundance in the Brazilian Caatinga

Mário Herculano de Oliveira^{1*}, Maria Lacerda², Derick Lira³, Érica Olandini Lambais⁴, Maria Avany Bezerra-Gusmão⁵ and José João Lelis Leal de Souza⁶

¹Programa de Pós-Graduação em Ecologia e Conservação, Universidade Estadual da Paraíba, 58429-500, Campina Grande, Paraíba, Brazil

ORCID: <https://orcid.org/0000-0002-7015-4350>

²Programa de Pós-Graduação em Entomologia, Universidade Federal de Viçosa, 36570-900, Viçosa, Minas Gerais, Brazil

ORCID: <https://orcid.org/0000-0001-8523-6896>

³Programa de Pós-Graduação em Entomologia, Universidade Federal Rural de Pernambuco, 52171-900, Recife, Pernambuco, Brazil.

ORCID: <https://orcid.org/0000-0001-6218-6988>

⁴Instituto Nacional do Semiárido

ORCID: <https://orcid.org/0000-0001-8239-0337>

⁵Programa de Pós-Graduação em Ecologia e Conservação, Universidade Estadual da Paraíba, 58429-500, Campina Grande, Paraíba, Brazil

ORCID: <https://orcid.org/0000-0002-1227-3167>

⁶Departamento de Solos, Universidade Federal de Viçosa, Minas Gerais, Brazil

ORCID: <https://orcid.org/0000-0003-4670-6626>

Received: April 09, 2026 Accepted: July 07, 2026



Editor-in-Chief
Praveen Kumar

Editors (India)

Anita Pandey
Hema Yadav
Neena Singla
Ritu Mawar
Sanjana Reddy
Surendra Poonia
R.K. Solanki
P.S. Khapte

Editors (International)

M. Faci, Algeria
M. Janmohammadi, Iran

*Correspondence

Mário Herculano de Oliveira
mariohecules@hotmail.com

Citation

Oliveira, M.H. de, Lacerda, M., Lira, D., Lambais, É.O., Bezerra-Gusmão, M.A. and Souza, J.J.L.L. de. 2026. Subterranean effects of the termite *Constrictotermes cyphergaster* on soil fungal abundance in the Brazilian Caatinga. *Annals of Arid Zone* 65(3): 319-326

<https://doi.org/10.56093/aaz.v65i3.177899>

<https://epubs.icar.org.in/index.php/AAZ/article/view/177899>

Abstract: Termites are key ecosystem engineers whose nesting activities influence soil structure, nutrient dynamics, and microbial communities, particularly in resource-limited environments. In semiarid ecosystems, where soils are typically low in organic carbon, termite-induced modifications may help sustain belowground biological activity. *Constrictotermes cyphergaster* is a widespread arboreal termite in the Brazilian Caatinga whose nests maintain consistent subterranean connections with the soil, yet the microbial implications of these structures remain poorly understood. In this study, we assessed fungal abundance in soils associated with the nesting system of *C. cyphergaster* at two semiarid sites with contrasting precipitation regimes and soil classes. Soil samples were collected from beneath arboreal nests, from termite-built hypogeous constructions, and from surrounding soils, and fungal density was quantified using colony-forming units. Fungal abundance differed significantly among sampling points at both sites, with higher densities consistently observed in soils influenced by termite structures compared to surrounding soils. These

results suggest that the nesting system of *C. cyphergaster* creates localized conditions that favor fungal proliferation. Our findings highlight the ecological importance of arboreal termites with subterranean connections in structuring soil microbial communities and emphasize their potential role in maintaining soil functioning in semiarid landscapes.

Key words: Ecosystem engineering, termites, soil fungi, semiarid ecosystems, caatinga.

Termites are widely recognized as ecosystem engineers whose profoundly affects soil structure, chemistry, and biological functioning, particularly in nutrient-limited environments (Adamson, 1943; Lee and Wood, 1971; Jouquet *et al.*, 2016). Through the construction of nests, galleries, and subterranean structures, termites redistribute organic matter and minerals, modify soil porosity, and generate spatial heterogeneity that can persist long after colony abandonment (Chen *et al.*, 2021). These modifications often translate into localized hotspots of biological activity, with cascading effects on soil food webs and ecosystem processes (Chen *et al.*, 2018; Baker *et al.*, 2020; Davies *et al.*, 2024).

One of the most consistent consequences of termite engineering is the enrichment of soil organic matter associated with their constructions (Sheikh and Kayani, 1982; Brossard *et al.*, 2007; Joseph *et al.*, 2013). Soil organic matter represents the primary reservoir of carbon and nitrogen for soil microorganisms, underpinning microbial metabolism, growth, and enzymatic activity (Hu *et al.*, 2020; Sokol *et al.*, 2022). In systems with low baseline carbon, even modest increases in organic inputs may enhance microbial biomass and activity, thereby influencing nutrient cycling and decomposition dynamics (Gunapala and Scow, 1998; Bach and Hofmockel, 2015; Soong *et al.*, 2018). Experimental and observational studies have demonstrated higher microbial biomass in termite mounds relative to surrounding soils (Fall *et al.*, 2004; López-Hernández, 2001; Pinheiro *et al.*, 2013; Baker *et al.*, 2020), as well as in soils influenced by hypogeous termite constructions compared to termite-free areas (Yan *et al.*, 2021; Chen *et al.*, 2023).

Soil microbial communities, particularly bacteria and fungi, are central to terrestrial ecosystem functioning. They mediate organic

matter decomposition, regulate nutrient availability, and link aboveground and belowground compartments through complex trophic and biogeochemical pathways (Van der Heijden *et al.*, 2008; Bardgett and Van der Putten, 2014). While bacteria are key drivers of nitrogen cycling processes (Yang *et al.*, 2021), fungi often dominate carbon turnover, especially under conditions of environmental stress or low nutrient availability (Fontaine *et al.*, 2011; Fabian *et al.*, 2017). Fungal communities exhibit remarkable physiological plasticity, enabling efficient decomposition of plant material and the establishment of symbiotic interactions that facilitate carbon capture and translocation within soils (Clemmensen *et al.*, 2013). Consequently, shifts in fungal abundance can signal meaningful changes in soil functional capacity.

In semiarid ecosystems, these processes are particularly essential. Soils in drylands are typically characterized by low organic carbon content, high spatial heterogeneity, and strong exposure to climatic extremes (Lal, 2004; Plaza *et al.*, 2018; Chen *et al.*, 2022), making them highly sensitive to biotic drivers of soil functioning. In the Brazilian semiarid region, soils are predominantly classified as Yermic Eutric Leptosols according to the WRB system (IUSS, 2022), corresponding to Neossolos under the Brazilian Soil Classification System (Santos *et al.*, 2018).

Biological inputs from ecosystem engineers, such as termites, are decisive for maintaining soil microbial activity and ecosystem resilience in soils with low carbon stocks (Enagbonma *et al.*, 2021; Araújo-Filho *et al.*, 2022).

The *Constrictotermes cyphergaster* (Silvestri, 1901) (Termitidae: Nasutitermitinae) is a widespread termite species in the Brazilian semiarid that constructs conspicuous arboreal nests throughout the Caatinga biome (Vasconcellos *et al.*, 2007; Bezerra-Gusmão *et al.*, 2011). Although these nests are built aboveground, they maintain a consistent, well-defined physical connection with the soil through galleries and subterranean structures (Oliveira *et al.*, 2022; de Oliveira *et al.*, 2026a; de Oliveira *et al.*, 2026b). Recent field observations suggest that these hypogeous constructions function as integral components of the nesting system, potentially modifying soil conditions

beneath and around arboreal nests. Despite growing interest in termite–soil interactions, the influence of arboreal termite species with subterranean connections on soil microbial communities remains poorly explored.

In this study, we evaluated whether the nesting system of *C. cyphergaster* affects fungal abundance in soils of the Caatinga semiarid region. We hypothesized that the subterranean constructions associated with arboreal nests enhance fungal density by locally modifying soil conditions, particularly through organic matter inputs and microclimatic buffering. Given the low carbon content of semiarid soils, even localized termite-induced alterations may have ecologically meaningful consequences for microbial communities and, by extension, soil functioning.

Fieldwork was conducted at two Caatinga forest sites in northeastern Brazil, selected to represent contrasting precipitation regimes and soil classes within the semiarid region. Site 1 was located in the municipality of Campina Grande (−7.2800, −35.9760), characterized by a Dystric Gleysol formed from gneiss weathering and an average annual precipitation of approximately 800 mm. Site 2 was located in the municipality of Cabaceiras (−7.3736, −36.2804), where an Eutric Regosol formed from gneiss weathering occurs under markedly drier conditions, with an average annual precipitation of approximately 400 mm. At each site, three arboreal nests of *C. cyphergaster* were selected, with nests spaced at least 20 m apart to ensure independence.

For each nest, soil samples were collected from three distinct sampling points: (i) soil directly beneath the arboreal nest (“below nest soil”), sampled from the upper 8 cm of the soil surface; (ii) hypogeous construction, consisting of soil material taken directly from the subterranean structure built by termites; and (iii) surrounding soil, sampled at a distance of 1.5 m from the nest base at a depth of 8 cm. Standardized collection protocols were applied across sites to minimize sampling bias, and all samples were stored under controlled conditions prior to laboratory analyses.

Fungal abundance was quantified using culture-based methods, with colony-forming units (CFUs) used as a proxy for fungal density. Ten grams of soil from each sample were suspended in 90 ml of 0.9% saline solution and

agitated for 15 minutes, then serially decimal diluted from 10^{-1} to 10^{-4} . Aliquots of 0.1 ml from each dilution were plated onto Martin medium supplemented with streptomycin sulfate (Menzies, 1965). Plates were prepared in triplicate and incubated at 25°C for 96 hours. Colonies were counted on plates containing between 30 and 300 CFUs. Differences in fungal abundance among sampling points were analyzed using generalized linear models with a negative binomial error distribution to account for overdispersion in count data. Separate models were fitted for each site, with significance assessed via analysis of deviance and post hoc comparisons performed using Tukey-adjusted contrasts based on estimated marginal means (Lenth, 2023). All analyses were conducted in R (R Core Team, 2022).

Fungal abundance differed significantly among sampling points at both sites, indicating a consistent influence of termite-associated structures on soil fungal density (Site 1: $X^2=7.46$, $df = 2$, $P=0.024$; Site 2: $X^2=6.07$, $df = 2$, $P=0.048$; Fig. 1).

At Site 1, CFU counts were significantly higher within the hypogeous constructions compared to the surrounding soil ($Z = 2.74$, $P = 0.016$), while soils beneath nests exhibited intermediate values that did not differ statistically from the other sampling points. At Site 2, fungal abundance was significantly higher in the “below nest soil” compared to surrounding soils ($Z = 2.40$, $P = 0.044$), whereas hypogeous constructions did not differ significantly from either category. Despite site-specific differences in the spatial expression of this effect, both locations showed elevated fungal density in soils influenced by termite nesting systems relative to adjacent, termite-unaffected soils.

These findings support the hypothesis that the nesting system of *C. cyphergaster* enhances fungal abundance in semiarid soils, even under contrasting precipitation regimes and soil classes. The observed patterns are consistent with the notion that termite constructions function as localized zones of improved habitat quality for microorganisms (Chouvenc *et al.*, 2011; Li and Greening, 2022), particularly in environments characterized by low organic carbon availability. By adding organic inputs and creating buffered microhabitats with less

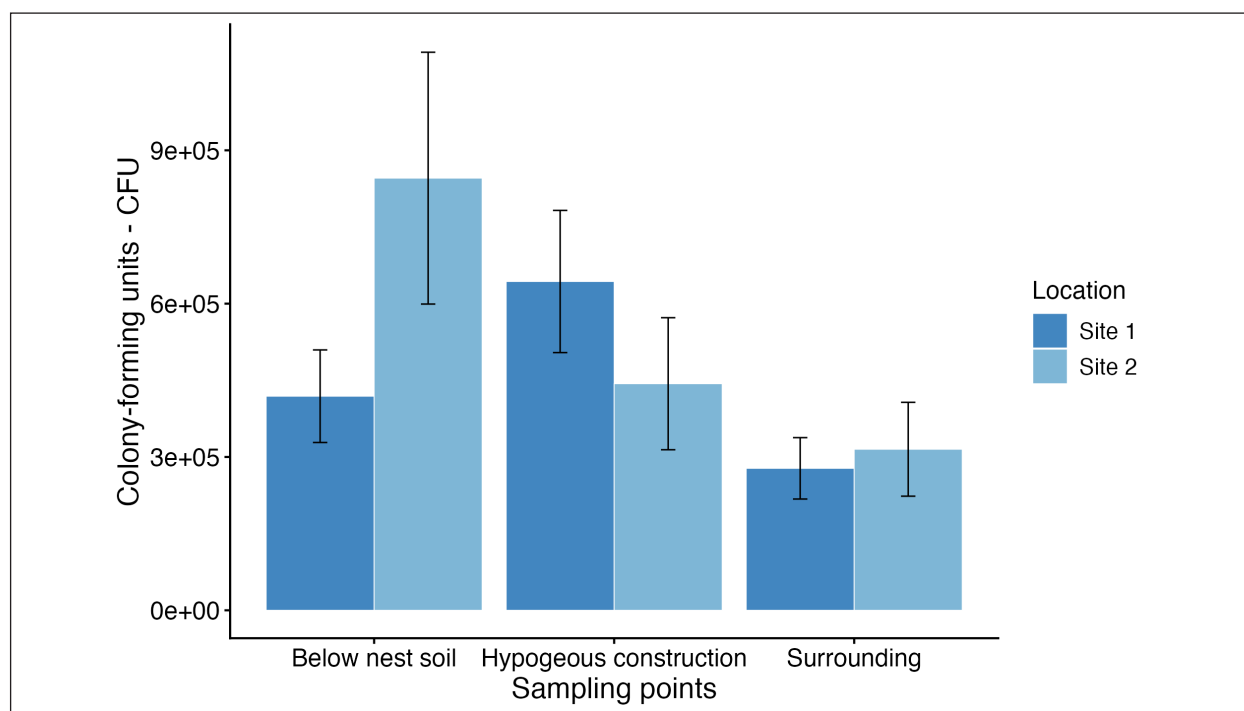


Fig. 1. Colony-forming units (CFU) of soil fungi at three sampling points associated with *Constrictotermes cyphergaster* nests: soil directly beneath the arboreal nest (Below nest soil), termite-built hypogeous construction (Hypogeous construction), and surrounding soil (Surrounding). Data are shown for two Caatinga sites, Site 1 (Campina Grande; light-grey rectangles) and Site 2 (Cabaceiras; dark-grey rectangles). Bars represent mean values, and vertical lines indicate the standard error of the mean.

stressful and more stable temperature and moisture conditions (Aiki *et al.*, 2019; Joseph *et al.*, 2016), termite structures mitigate some of the abiotic constraints that limit fungal growth in exposed semiarid soils (Bonachela *et al.*, 2015). Excessive solar radiation and associated increases in temperature and water loss can negatively affect fungal diversity and enzymatic activity (Braga *et al.*, 2015; de Oliveira *et al.*, 2020; Misiak *et al.*, 2020), including amylase production (Pasin *et al.*, 2022), suggesting that microclimatic regulation by termites may play a complementary role alongside organic matter enrichment.

From a broader ecological perspective, the role of arboreal termites linked to hypogeous structures expands the concept of ecosystem engineering beyond conspicuous mounds, encompassing subtler, yet functionally significant, modifications of the soil. In semiarid landscapes increasingly affected by land-use change, human pressure, and desertification processes (Zhao *et al.*, 2005; Moreno-de Las Heras *et al.*, 2011; IPCC, 2019; Franca Rocha *et al.*, 2024), such biogenic structures may represent notable stabilizing elements that sustain soil microbial activity and associated

ecosystem functions. Although based on a limited sampling design, this study highlights the ecological relevance of *C. cyphergaster* nesting systems as drivers of belowground biological organization in the Caatinga. Future studies integrating molecular approaches, functional assays, and larger spatial scales will be essential to elucidate the role of arboreal termites in shaping soil microbial diversity and functioning in dryland ecosystems.

Acknowledgement

This study was partially supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES, Brazil; Finance Code 001) through scholarships awarded to M. H. Oliveira, M. Lacerda, and D. Lira. Additional funding was provided by the Long-Term Ecological Research Program (PELD) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) under the CNPq/CONFAP-FAPs/PELD Call No. 23/2024 (grant No. 445968/2024-9), as well as by the Water Resources Fund (CT-Hidro) through the CNPq/MCTI/FNDCT/CT-Hidro Call No. 63/2022 (grant No. 409348/2022-8).

Declaration of Competing Interest

The authors declare no conflicts of interest related to the research or the manuscript.

Data availability

Data will be made available on request.

AI Statements

AI-assisted tools were used for spell-checking and grammatical refinement.

References

- Adamson, A.M. 1943. Termites and the fertility of soils. *Tropical Agriculture* 20: 107-112.
- Aiki, I.P., Pirk, C.W.W. and Yusuf, A.A. 2019. Thermal regulatory mechanisms of termites from two different savannah ecosystems. *Journal of Thermal Biology* 85: 102418. doi:10.1016/j.jtherbio.2019.102418
- Araujo, H. F. P., Garda, A. A., Silva, W. A. G.; Nascimento, N. F. F., Mariano, E. F.; Silva, J. M. C. The Caatinga region is a system and not an aggregate. *Journal of Arid Environments*, v. 203 (2022), 104778, 2022. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0140196322000738>. doi:10.1016/j.jaridenv.2022.104778.
- Bach, E.M. and Hofmockel, K.S. 2015. Coupled carbon and nitrogen inputs increase microbial biomass and activity in prairie bioenergy systems. *Ecosystems* 18: 417-427. doi:10.1007/s10021-014-9835-8
- Bardgett, R.D. and van der Putten, W.H. 2014. Belowground biodiversity and ecosystem functioning. *Nature* 515: 505-511. doi:10.1038/nature13855
- Baker, C.C.M., Castillo Vardaro, J.A., Doak, D.F., et al. 2020. Spatial patterning of soil microbial communities created by fungus-farming termites. *Molecular Ecology* 29: 4487-4501. doi:10.1111/mec.15585
- Bezerra-Gusmão, M.A., Barbosa, J.R.C., Barbosa, M.R. de V., et al. 2011. Are nests of *Constrictotermes cyphergaster* (Isoptera, Termitidae) important in the C cycle in the driest area of semiarid caatinga in northeast Brazil? *Applied Soil Ecology* 47: 1-5. doi:10.1016/j.apsoil.2010.11.003
- Bonachela, J.A., Pringle, R.M., Sheffer, E., et al. 2015. Termite mounds can increase the robustness of dryland ecosystems to climatic change. *Science* (1979) 347: 651-655. doi:10.1126/science.1261487
- Braga, G.U., Rangel, D.E., Fernandes, É.K., et al. 2015. Molecular and physiological effects of environmental UV radiation on fungal conidia. *Current Genetics* 61: 405-425.
- Brossard, M., López-Hernández, D., Lepage, M. and Leprun, J.C. 2007. Nutrient storage in soils and nests of mound-building *Trinervitermes* termites in Central Burkina Faso: Consequences for soil fertility. *Biology and Fertility of Soils* 43: 437-447. doi:10.1007/s00374-006-0121-6
- Chen, C., Liu, W., Wu, J. and Jiang, X. 2018. Spatio-temporal variations of carbon and nitrogen in biogenic structures of two fungus-growing termites (*M. annandalei* and *O. yunnanensis*) in the Xishuangbanna region. *Soil Biology and Biochemistry* 117: 125-134. doi:10.1016/j.soilbio.2017.11.018
- Chen, C., Singh, A.K., Yang, B., et al. 2023. Effect of termite mounds on soil microbial communities and microbial processes: Implications for soil carbon and nitrogen cycling. *Geoderma* 431. doi:10.1016/j.geoderma.2023.116368
- Chen, C., Zou, X., Wu, J., et al. 2021. Accumulation and spatial homogeneity of nutrients within termite (*Odontotermes yunnanensis*) mounds in the Xishuangbanna region, SW China. *Catena* (Amst) 198: doi:10.1016/j.catena.2020.105057
- Chen, Y., Zhang, S., Wang, Y. 2022. Distribution characteristics and drivers of soil carbon and nitrogen in the drylands of central Asia. *Land (Basel)* 11: doi:10.3390/land11101723
- Chouvenc, T., Elliott, M.L., Su, N-Y. 2011. Rich Microbial Community Associated with the Nest Material of *Reticulitermes flavipes* (Isoptera: Rhinotermitidae). *Florida Entomologist* 94: 115-116. doi:10.1653/024.094.0117
- Clemmensen, K.E., Bahr, A., Ovaskainen, O., Dahlberg, A., Ekblad, A., Wallander, H., Stenlid, J., Finlay, R.D., Wardle, D.A. and Lindahl, B.D. 2013. Roots and associated fungi drive long-term carbon sequestration in boreal forest. *Science* 339(6127): 1615-1618. doi:10.1126/science.1231923
- Davies, A.B., Levick, S.R., van Rensburg, B.J., et al 2024. Context-dependent directional effects of termite mounds on soil nutrients, vegetation communities, and mammalian foraging. *Ecosphere* 15: doi:10.1002/ecs2.4978
- de Oliveira, M.H., Lacerda, M., Lira, D. et al. 2026a. Hidden chambers, visible impacts: hypogeal construction and soil modification by *Constrictotermes cyphergaster* (Termitidae: Nasutitermitinae). *Insectes Sociaux* doi:10.1007/s00040-026-01126-5

- de Oliveira, M.H., Lacerda, M., Lira, D. *et al.* 2026b. From canopy to soil: subterranean galleries of arboreal termites amplify soil respiration and carbon dynamics in the Caatinga. *Journal of Arid Environments* 237: 105714.
doi:10.1016/j.jaridenv.2026.105714
- de Oliveira, T.B., de Lucas, R.C., Scarcella, A.S. de A., *et al.* 2020. Fungal communities differentially respond to warming and drought in tropical grassland soil. *Molecular Ecology* 29:1550-1559.
doi:10.1111/mec.15423
- Enagbonma, B.J., Amoo, A.E. and Babalola, O.O. 2021. Biopedturbation by Termites Affects Respiration Profiles of Microbial Communities from Termite Mound Soils. *Journal of Soil Science and Plant Nutrition* 21: 2115-2123.
doi:10.1007/s42729-021-00507-y
- Fabian, J., Zlatanovic, S., Mutz, M. and Premke, K. 2017. Fungal-bacterial dynamics and their contribution to terrigenous carbon turnover in relation to organic matter quality. *ISME Journal* 11: 415-425.
doi:10.1038/ismej.2016.131
- Fall, S., Nazaret, S., Chotte, J.L. and Brauman, A. 2004. bacterial density and community structure associated with aggregate size fractions of soil-feeding termite mounds. *Microbial Ecology* 48: 191-199.
doi:10.1007/s00248-003-1047-2
- Fontaine, S., Henault, C., Aamor, A., *et al.* 2011. Fungi mediate long term sequestration of carbon and nitrogen in soil through their priming effect. *Soil Biology and Biochemistry* 43: 86-96.
doi:10.1016/j.soilbio.2010.09.017
- Franca Rocha, W.J.S., Vasconcelos, R.N., Costa, D.P., *et al.* 2024. Towards Uncovering Three Decades of LULC in the Brazilian Drylands: Caatinga Biome Dynamics (1985-2019). *Land (Basel)* 13:
doi:10.3390/land13081250
- Gunapala, N. and Scow, K.M. 1998. Dynamics of soil microbial biomass and activity in conventional and organic farming systems. *Soil Biology and Biochemistry* 30: 805-816.
doi:10.1016/S0038-0717(97)00162-4
- Hu, Y., Zheng, Q., Noll, L., *et al.* 2020. Direct measurement of the in situ decomposition of microbial-derived soil organic matter. *Soil Biology and Biochemistry* 141: 107660.
doi:10.1016/j.soilbio.2019.107660
- IPCC (Intergovernmental Panel on Climate Change) 2019. Climate Change and Land (Special Report). <https://www.ipcc.ch/srccl/>
- IUSS, W.G.W. 2022. World Reference Base for Soil Resources. International soil classification system for naming soils and creating legends for soil maps., 4th edn. International Union of Soil Sciences, Vienna
- Joseph, G.S., Seymour, C.L., Coetzee, B.W.T., *et al.* 2016. Microclimates mitigate against hot temperatures in dryland ecosystems: termite mounds as an example. *Ecosphere* 7: e01509.
doi:10.1002/ecs2.1509
- Joseph, G.S., Seymour, C.L., Cumming, G.S., *et al.* 2013. Termite mounds as islands: Woody plant assemblages relative to termitarium size and soil properties. *Journal of Vegetation Science* 24: 702-711.
doi:10.1111/j.1654-1103.2012.01489.x
- Jouquet, P., Bottinelli, N., Shanbhag, R.R., *et al.* 2016. Termites: The neglected soil engineers of tropical soils. *Soil Science* 181:157-165.
doi:10.1097/SS.0000000000000119
- Lal, R. 2004. Carbon sequestration in dryland ecosystems. *Environmental Management* 33: 528-544.
doi:10.1007/s00267-003-9110-9
- Lee, K.E. and Wood, T. 1971. *Termites and Soils*. Academic Press., England
- Lenth, R.V. 2023. Emmeans: Estimated Marginal Means, aka Least-Squares Means (**incomplete**)
- Li, H. and Greening, C. 2022. Termite-engineered microbial communities of termite nest structures: a new dimension to the extended phenotype. *FEMS Microbiology Reviews* 46: fuac034.
doi:10.1093/femsre/fuac034
- López-Hernández, D. 2001. Nutrient dynamics (C, N and P) in termite mounds of *Nasutitermes ephratae* from savannas of the Orinoco Llanos (Venezuela). *Soil Biology and Biochemistry* 33: 747-753.
doi:10.1016/S0038-0717(00)00220-0
- Menzies, J.D. 1965. Fungi. In: *Methods of Soil Analysis* (Ed. C.A. Black), v.2, cap. 107, p. 1502-1505. Madison, WI. American Society of Agronomy.
- Misiak, M., Goodall-Copestake, W.P., Sparks, T.H., *et al.* 2020. Inhibitory effects of climate change on the growth and extracellular enzyme activities of a widespread Antarctic soil fungus. *Glob Chang Biol* 27.
- Moreno-de las Heras, Saco, P.M., Willgoose, G.R. and Tongway, D.J. 2011. Assessing landscape structure and pattern fragmentation in semiarid ecosystems using patch-size distributions. *Ecological Applications* 21(7): 2793-2805.
- Oliveira, M.H. d., Viana-Junior, A.B., Rolim, M. d. S.L., *et al.* 2022. The Impact of *Constrictotermes cyphergaster* (Termitidae: Nasutitermitinae) Termites on Semiarid Ecosystems in Brazil: A Review of Current Research. *Insects* 13:704

- Pasin, T.M., Moreira, E.A., Benassi, V.M., *et al.* 2022. Effects of Ultraviolet Exposure on the Tropical Fungi *Aspergillus carbonarius* and *Aspergillus japonicus*: Survival, Amylase Production, and Thermostability. *Tropical Conservation Science* 15: 19400829221092640.
doi:10.1177/19400829221092638
- Pinheiro, L.B.A., Pereira, M.G., Lima, E., *et al.* 2013. Atributos edáficos e de termiteiros de cupim-de-montículo (Isoptera: Termitidae) em pinheiral-RJ. *Floresta e Ambiente* 20: 510–520.
doi:10.4322/floram.2013.047
- Plaza, C., Zacccone, C., Sawicka, K., *et al.* 2018. Soil resources and element stocks in drylands to face global issues. *Scientific Reports* 8: 13788.
doi:10.1038/s41598-018-32229-0
- R Core Team 2022. R: A Language and Environment for Statistical Computing
- Santos, H.G. dos, Jacomine, P.K.T., Anjos, L.C. dos, *et al.* 2018. Sistema brasileiro de classificação de solos, 5th edn. Embrapa, Brasília
- Sheikh, K.H. and Kayani, S.A. 1982. Termite-affected soils in Pakistan. *Soil Biology and Biochemistry* 14(4):359–364.
doi:10.1016/0038-0717(82)90006-2
- Sokol, N.W., Slessarev, E., Marschmann, G.L., *et al.* 2022. Life and death in the soil microbiome: how ecological processes influence biogeochemistry. *Nature Reviews Microbiology* 20: 415–430.
doi:10.1038/s41579-022-00695-z
- Soong, J.L., Marañon-Jimenez, S., Cotrufo, M.F., *et al.* 2018. Soil microbial CNP and respiration responses to organic matter and nutrient additions: Evidence from a tropical soil incubation. *Soil Biology and Biochemistry* 122: 141–149.
doi:10.1016/j.soilbio.2018.04.011
- Van der Heijden, M.G., Bardgett, R.D. and van Straalen, N.M. 2008. The unseen majority: soil microbes as drivers of plant diversity and productivity in terrestrial ecosystems. *Ecology Letters* 11(3):296–310.
doi:10.1111/j.1461-0248.2007.01139.x
- Vasconcellos, A., Araújo, V.F.P., Moura, F.M.S. and Bandeira, A.G. 2007. Biomass and population structure of *Constrictotermes cyphergaster* (Silvestri) (Isoptera: termitidae) in the dry forest of caatinga, northeastern Brazil. *Neotropical Entomology* 36: 693–698.
doi:10.1590/S1519-566X2007000500009
- Yan, Z.Z., Chen, Q.L., Li, C.Y., *et al.* 2021. Termite mound formation reduces the abundance and diversity of soil resistomes. *Environmental Microbiology* 23: 7661–7670.
doi:10.1111/1462-2920.15631
- Yang, N., Zhang, C., Wang, L., *et al.* 2021. Nitrogen cycling processes and the role of multi-trophic microbiota in dam-induced river-reservoir systems. *Water Research* 206: 117730.
doi:10.1016/j.watres.2021.117730
- Zhao, W.Z., Xiao, H.L., Liu, Z.M. and Li, J. 2005. Soil degradation and restoration as affected by land use change in the semiarid Bashang area, northern China. *Catena (Amst)* 59: 173–186.
doi:10.1016/j.catena.2004.06.004

About the authors

Mário Herculano de Oliveira is a biologist and Ph.D. in Ecology and Conservation with over a decade of research experience in social insect behavior and ecology. Since 2013, his work has focused on termites and their ecological roles across Northeastern Brazil, particularly within the semi-arid biome. He is currently a Research Fellow at the Instituto Nacional do Semiárido (INSA), Brazil.

Maria Lacerda is a PhD candidate in Entomology at the Federal University of Viçosa (UFV), Brazil. Her research interests include termite ecology and behaviour, with a particular focus on macro- and microsymbiosis in social insects. Her current research examines the ecological and behavioural mechanisms underlying host-inquiline relationships in termites, particularly the factors that shape these associations.

Derick Lira is a PhD student in Entomology at the Federal Rural University of Pernambuco (UFRPE), Brazil. His research focuses on insect ecology and behavior, particularly ecological interactions and symbiotic associations between social insects and their associated organisms, as well as the role of termites in ecosystem functioning in semiarid environments.

Érica Olandini Lambais holds a Bachelor's degree in Science with a specialization in Biology from the Methodist University of Piracicaba (2006) and a Graduate Specialization in Bioecology and Conservation from the same institution (2010). She worked for seven years as a Laboratory Technician in Microbiology and Parasitology at the Methodist University of Piracicaba. She was a research fellow at the National Institute of the Semi-Arid (INSA), where she worked in the field of soil microbiology, focusing on soil microbial indicators, microbial diversity, and the bioprospecting of microorganisms from the Caatinga biome.

Maria Avany Bezerra-Gusmão holds a Ph.D. and an M.Sc. in Zoology from the Federal University of Paraíba (UFPB) and a Bachelor's Degree in Biological Sciences (Teacher Education Program) from the State University of Paraíba (UEPB). She is currently an Associate Professor (Class D) in the Department of Biology at UEPB, a Permanent Faculty Member of the Graduate Program in Ecology and Conservation (PPGEC/UEPB; CAPES rating: 5), and Coordinator of the Termite Ecology Laboratory (LET/UEPB). Her research focuses on the interactions between termites and their termitophiles, as well as the relationships between termites and their microbiome.

José João Lelis Leal de Souza holds a Bachelor's degree in Geography (2008), an M.Sc. (2010), and a Ph.D. (2013) in Agronomy (Soils and Plant Nutrition) from the Federal University of Viçosa (UFV), where he also completed a postdoctoral fellowship in 2015. His expertise encompasses periglacial, tropical, and equatorial soils, with research focused on surface geochemistry, particularly soil genesis and classification, soil geochemistry, and soil-plant interactions. He is currently the Coordinator of the Graduate Program in Soils and Plant Nutrition at UFV. He served as Director of the Eastern Regional Branch of the Brazilian Society of Soil Science (SBCS) from 2023 to 2025. He is Vice-Chair of the World Soil of the Year Working Group of the International Union of Soil Sciences (IUSS) for the 2024–2026 term. He also serves as Chair of the SBCS–SSSA Cooperation Working Group (2023–present) and is a member of the SBCS Discontinuities Working Group (2023–present).