

Iniciação Científica

Occurrence and characterization of insect galls in two areas of tropical dry forest (caatinga) in São Francisco River Natural Monument, Brazil

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Abstract. The caatinga vegetation is an important natural laboratory for the study of how plants and gall-inducing insects interact in highly variable and stressful moisture regimes. Despite this, only five gall inventories have been conducted and its richness of inducing insects and host plants has been little known. To contribute to our knowledge of galls from caatinga habitats, we registered and characterized the macroscopic aspects of the galls, then identified the plant hosts and their associated fauna in two areas of caatinga in São Francisco River Natural Monument (MONA). Nineteen morphotypes of galls were recorded on 13 plant belonging to nine genera and seven host plant families. Of the total number of galls recorded, most occurred in the rainy season ($n=13$). Most of the galls are globoid ($n=10$), pilose ($n=10$), green ($n=15$), and isolated ($n=12$). Most of the gall-inducing insect species found belonged to Diptera (Cecidomyiidae). All morphotypes recorded in this study are the first ones recorded of galls and their host plants in MONA. We also recorded, for the first time, the occurrence of galls in the floral buds of *Cnidoscolus obtusifolius* Pohl ex Baill. (Euphorbiaceae), demonstrating the importance of conducting studies in areas not yet sampled in the Caatinga biome. It is expected that this study will stimulate future investigations, helping in the protection and conservation of this conservation area and consequently increasing our knowledge about its biodiversity.

Keywords: Cecidomyiidae; Dry tropical forest; Euphorbiaceae s.s.; Northeastern Brazil.

Ocorrência e caracterização das galhas de insetos em duas áreas de floresta tropical seca (caatinga) no Monumento Natural do Rio São Francisco, Brasil

Resumo. A vegetação de caatinga é um importante laboratório natural para o estudo de como as plantas e insetos galhadores interagem em regimes de umidade altamente variáveis e estressantes. Apesar disso, apenas cinco inventários de galhas foram realizados e sua riqueza de insetos indutores e plantas hospedeiras é pouco conhecida. Para contribuir com o nosso conhecimento sobre galhas de habitats de caatinga, registramos e caracterizamos os aspectos macroscópicos das galhas, em seguida identificamos as plantas hospedeiras e sua fauna associada em duas áreas de caatinga no Monumento Natural do Rio São Francisco (MONA). Dezenove morfotipos de galhas foram registrados em 13 plantas pertencentes a nove gêneros e sete famílias de plantas hospedeiras. Do total de galhas registradas, a maioria ocorreu na estação chuvosa ($n=13$). A maioria das galhas são globoides ($n=10$), pilosas ($n=10$), verdes ($n=15$) e isoladas ($n=12$). A maioria das espécies de insetos indutores de galhas encontradas pertencem a Diptera (Cecidomyiidae). Todos os morfotipos registrados neste estudo são os primeiros registrados de galhas e suas plantas hospedeiras no MONA. Também registramos, pela primeira vez, a ocorrência de galhas nos botões florais de *Cnidoscolus obtusifolius* Pohl ex Baill. (Euphorbiaceae), demonstrando a importância da realização de estudos em áreas ainda não amostradas no bioma Caatinga. Espera-se que este estudo estimule futuras investigações, auxiliando na proteção e conservação desta área de preservação e consequentemente aumentando nosso conhecimento sobre sua biodiversidade.

Palavras-chave: Cecidomyiidae; Euphorbiaceae s.s.; Floresta tropical seca; Nordeste do Brasil.

Caatinga vegetation is considered the largest continuous nucleus of seasonally dry tropical forests and woodlands in the Americas (QUEIROZ et al., 2017). It is very heterogeneous, mainly due to local variations in climate and soil, and it is characterized by a mosaic of xerophytic, deciduous, semiarid thorn scrub and forest that covers about 735,000 km² of the Semiarid Region or Caatinga Domain (VELLOSO et al., 2002).

The vegetation heterogeneity of the caatinga and the particularities of some of its ecosystems - a situation that promotes insect-plant interactions - suggest the possibility

that there is a richness of galls associated with caatinga plants. Despite this, little attention has been given to studying the richness of its galls and the distribution patterns of its gall-inducing insects. The extent of this neglect is evident on examination of the number of studies realized in the Caatinga Domain, only five gall inventories were published for the Caatinga. Based on information available in the literature, Cintra et al. (2021) estimated the occurrence of 100 host plant species and 156 morphospecies of gall-inducing insects for the caatinga.

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Considering that the caatinga is an important natural laboratory for the study of how plants and gall-inducing insects interact in highly variable and stressful moisture regimes and few efforts have been made to study galling insects in the caatinga, we conducted an inventory of the richness of galling insects in caatinga areas of the São Francisco River Natural Monument (MONA), aiming to reduce the gap in our knowledge about the interactions between galling insects and their host plants in Caatinga environments and to support ecological and biological studies in this protected area.

The study was carried out in two localities of open shrub caatinga at MONA (Figures 1S and 2S), located in the municipalities of Canindé do São Francisco, Sergipe: Eco Fazenda Mundo Novo (MN) (9° 34' 17" S and 37° 59' 23" W; 243.7 m altitude); and Paulo Afonso, Bahia: Povoado Rio do Sal (RS) (9° 27' 3780" S and 38° 9' 82" W; 207.8 m altitude). The region's climate is semi-arid, with scarce precipitation and dry periods that extend for 10 months. The rainy season extends from May to June, with an annual average of 500 to 700 mm. The local temperature does not show great variations, with annual averages of 25 °C (INPE, 2001).

The caatinga vegetation was examined during 10 months, between August 2019 to March 2020 and August and September 2021, adopting the random walking for sampling. The galls and the host plants were collected once a month along pre-existing trails. All plant architectural types were inspected. Each gall morphotype was photographed, collected, and stored in plastic bags for removal to the laboratory. Then external morphological characteristics were described, including color, shape, pilosity and organ of occurrence. The plants were identified by consulting the taxonomic literature and contacting botanical specialists. The conservation status of the plant species was verified Flora e Funga do Brasil and was based on categories proposed by IUCN (2022). The identifications of the insect species was undertaken by comparisons with the morphotypes of known gall-inducing insects and host plants previously identified in Caatinga field environments.

A total of 19 gall morphotypes were found on 13 host plant species belonging to nine genera and seven families (Figure 1; Table 1S). Of the total number of galls, five were collected in RS and 14 in MN. There was a predominance of galls in the rainy season ($n=13$) when compared to the dry season ($n=2$). Of the morphotypes found, the globoid galls induced on the flower buds of *Cnidoscolus obtusifolius* Pohl ex Baill. (Euphorbiaceae s.s.) are recorded here for the first time for Brazil.

The plant families that hosted the greatest richness of gall morphologies were Euphorbiaceae and Fabaceae (with nine and four, respectively); those same families demonstrated the greatest numbers of host species (six and two, respectively) (Table 1S). The plant genera with the greatest numbers of galls were *Croton* L. ($n=4$ species and $n=5$ gall morphotypes) and *Cnidoscolus* Pohl ($n=2$ species and $n=4$ gall morphotypes), both belong to Euphorbiaceae s.s. The super-host species was *C. obtusifolius* ($n=3$ gall morphotypes). The gall morphotypes of this species were induced on leaves and floral buds, with globoid shape.

All of the host plants of insect galls in the study area are native to Brazil and have already been recorded as hosts of galls in other caatinga environments, six of them endemic to that country [*Cenostigma pyramidale* (Tul.) Gagnon & G.P. Lewis, *Cnidoscolus obtusifolius*, *Cnidoscolus quercifolius* Pohl, *Croton adamantinus* Müll. Arg., *Croton triangularis* Müll. Arg., and *Neocalyptrocalyx longifolium* (Mart.) Cornejo & Iltis]. Concerning IUNC (2022) conservation categories, plant species were classified into Not Evaluated (NE) ($n=10$) and Near Threatened (NT) ($n=1$).

The highest number of galls were found on shrubs ($n=5$) and subshrubs ($n=5$). Gall morphotypes were induced on leaves (adaxial or/and abaxial surface) ($n=14$), stems ($n=4$) or buds

($n=1$). Generally, the galls occur isolated ($n=12$) and have trichomes ($n=12$), and can be globoid ($n=10$), lenticular ($n=6$) or fusiform ($n=3$). In relation to their colors, galls are green ($n=15$) or brown ($n=4$) (Table 1S).

The gall-inducing insects that could be identified belong to the orders Diptera (Cecidomyiidae) (Table 1S). In addition to the gall-inducing insects, other inhabitants belong to Acari composing the associated fauna of foliar gall induced on *Cnidoscolus quercifolius* and Acari and Thysanoptera were found in stem galls of *Cenostigma pyramidale* (Tul.) Gagnon & G.P. Lewis (Fabaceae).

The richness of galling insects in the study area was greater than that found in other inventories of caatinga (Table 2S). Studies conducted in caatinga environments of the Northeastern region, adopting different sampling efforts, revealed a richness of 12 to 64 distinct morphotypes of gall induced on three to 18 host plant species (SANTOS et al., 2011; CARVALHO-FERNANDES et al., 2012; ALCÂNTARA et al., 2017; BRITO et al., 2018; SANTOS-SILVA et al., 2022). The number of gall morphotypes of caatinga vegetation is lower when compared to other vegetations studied. It can be explained by an under-sampling of the number of gall inventories, low diversity of flowering plant in comparison to other Brazilian vegetation and the semi-arid aspect of caatinga which is characterized by low rainfall and humidity, drought and high temperatures, with the prevalence of deciduous plants that show themselves as impacting aspects for the development of the galling insects (CINTRA et al., 2021).

Euphorbiaceae s.s. and Fabaceae are reported here as super-host families. These host families are the top 10 richest angiosperm families in Brazil, with Fabaceae occupying first position (3,033 species) and Euphorbiaceae ninth (973) (BFG, 2021). Our results add evidence to the hypothesis plant diversity argues that families with the highest number of plant species in Brazil have proportionally the highest number of gall-forming species (FERNANDES, 1992; SANTOS-SILVA et al., 2020). In addition, they reinforce the importance these families for the conservation of galling insects in the different phytophysiognomies in Brazil.

A higher incidence of galls was observed in the rainy season, similar to the other gall inventory areas of caatinga vegetation of the Bahia state (BRITO et al., 2018; SANTOS-SILVA et al., 2022). The predominance of galls in the rainy season can be explained by the greater availability of leaves, since this is the preferred organ for inducing galls because it contains a greater amount of meristematic tissues (ABRAHAMSON et al., 1997). Moreover, the water availability along the rainy season allows nutritional resources that favor the development of the gall due to the allocation of photoassimilates, indicating a important window of opportunity for galling insects and a phenological strategies in host plant-galling insect system (NOGUEIRA et al., 2022).

The highest number of galls was found on shrubs and subshrubs, providing evidence for the hypothesis that plants that have a higher structural complexity would host a higher richness of gall-inducing insects, given that this complexity entails greater anatomical and chemical variation, offering a higher number of microhabitats to herbivorous insects (FERNANDES and PRICE, 1988).

Leaves comprised the organ with the greatest richness and diversity of galls, followed by stems. All plant organs are susceptible to gall induction by insects, but the leaves are the most vulnerable. It may be explained by evolution of the galler life habit that commences during the Middle Devonian on cryptogam hosts. The process presumably spread to diminutive vascular plants such as fern relatives and the earliest arborescent plants. There is evidence that spore-bearing plants possessed galls along their vegetative and reproductive axes, but not on foliage. During the Permian, leaves of seed plants became the organs that were subject to gall insect attack. Since then most of the gall interactions have been with seed plants,

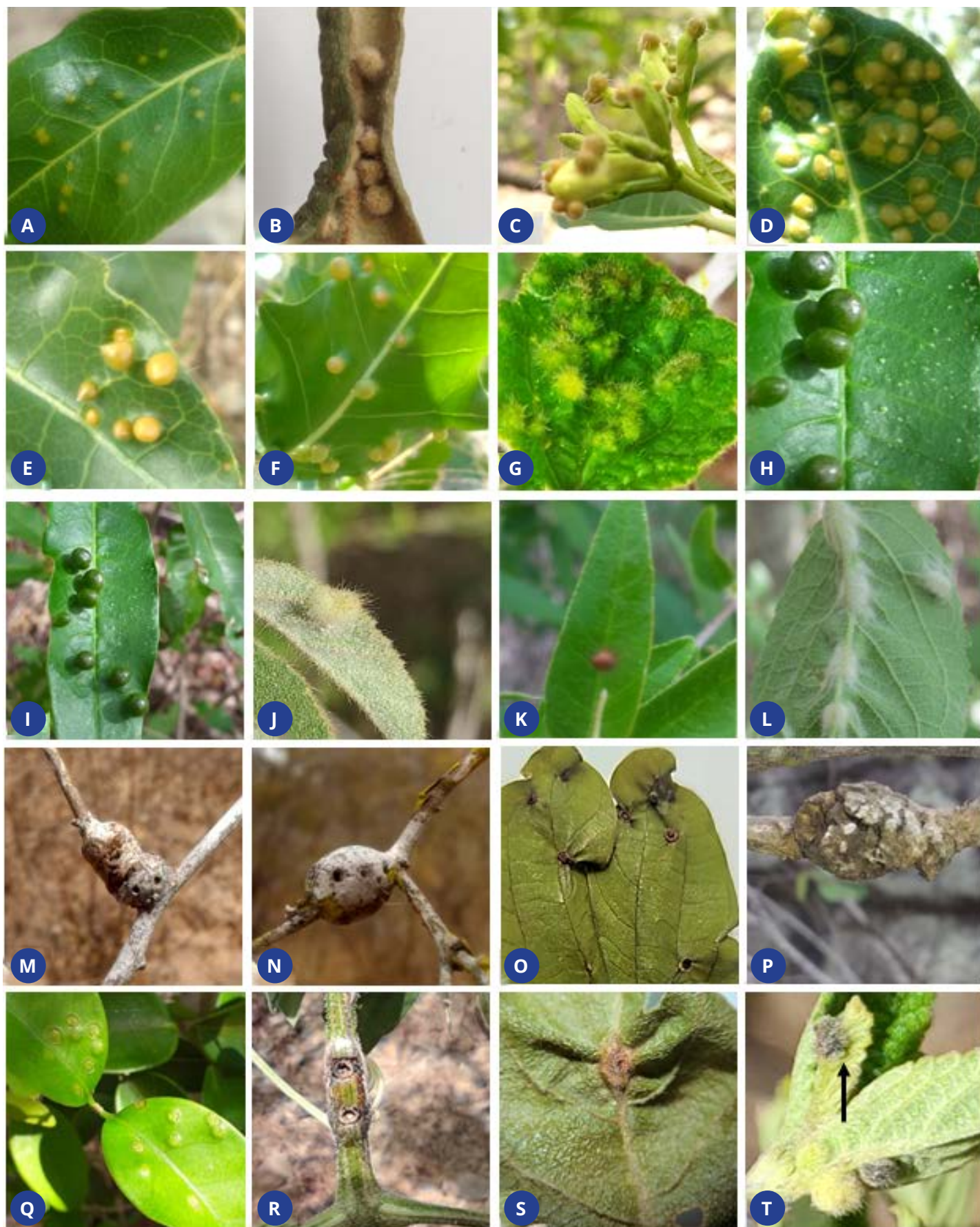


Figure 1. Insect gall in two areas of caatinga in São Francisco River Natural Monument, Brazil. **A.** *Handroanthus impetiginosus* (Mart. ex DC.) Mattos; **B.** *Neocalyptrocalyx longifolium* (Mart.) Cornejo & Iltis; **C-E.** *Cnidoscopus obtusifolius* Pohl ex Baill.; **F.** *Cnidoscopus quercifolius* Pohl; **g** *Croton adamantinus* Müll.Arg.; **H-i.** *Croton argyrophyllus* Kunth; **J-K.** *Croton heliotropifolius* Kunth; **L.** *Croton triangularis* Müll.Arg.; **M-N.** *Cenostigma pyramidale* (Tul.) E. Gagnon & G.P. Lewis; **O-P.** *Bauhinia cheilantha* (Bong.) Steud.; **Q.** *Eugenia* sp.; **R-S.** *Serjania glabrata* Kunth; **T.** *Lippia grata* Schauer. Photos: Geissy Anny Melo.

resulting in leaf gall (LABANDEIRA 2021).

The predominance of globoid galls on leaf galls has been reported in other Brazilian ecosystems. The galls have three-dimensional growth and are variously shaped. However,

the globoid format is believed to be the most common gall morphotype (ISAIAS et al., 2013).

Pilose galls were more common among the inventoried morphotypes, occurring with more frequency on the leaves. The

trichomes are commonly present on plants in arid or exposed environments. This is thought to be due to trichomes' ability to reflect sunlight and reduce water loss (ABDULRAHAMAN and OLADELE, 2011).

Due to the endemic distribution of the host plant species and to species-specific relationships with the galling insect-host plant, six species of galling insects may be endemic to Brazil, which reinforces the importance of São Francisco River Natural Monument in the conservation of galling insects and their host plants.

The Cecidomyiidae family is responsible for inducing most morphotypes, coinciding with the pattern observed in various Brazilian ecosystems. In Bahia state, this family is represented by 44 species of 28 genera; eighteen of the species were described between 1877 and 1922 and have never been re-collected (MAIA and SILVA, 2020).

It is concluded that our results can likewise aid in the planning and execution of conservation strategies for the host plants on which galling insects are totally dependent. This can stimulate future research in São Francisco River Natural Monument, consequently increasing our knowledge about its biodiversity.

References

- ABDULRAHAMAN, A. A.; OLADELE F. A. Response of trichomes to water stress in two species of *Jatropha*. **Insight Botany**, v.1, p. 15–21, 2011. DOI: <https://doi.org/10.5567/BOTANY-IK.2011.15.21>
- ABRAHAMSON, W. G.; WEIS, A. E. Evolutionary ecology across three trophic levels: goldenrods, gall makers and natural enemies. **Princeton University Press**, Princeton, 1997. DOI: <https://doi.org/10.12987/9780691209432>
- ALCÂNTARA, J. A.; SOUZA, E. B.; BRAGA, P. E. T. Ocorrência e caracterização de galhas em duas áreas do noroeste do Ceará, Brasil. **Natureza on line**, v.15, n. 1, p. 33–40, 2017.
- BFG - The Brazil Flora Group. **Brazilian Flora 2020: Leveraging the power of a collaborative scientific network**. *Taxon*, v. 71, p. 178–198, 2021. DOI: <https://doi.org/10.1002/tax.12640>
- BRITO, G. P.; COSTA, E. C.; CARVALHO-FERNANDES, S. P.; SANTOS-SILVA, J. (2018) Riqueza de galhas de insetos em áreas de Caatinga com diferentes graus de antropização do Estado a Bahia, Brasil. **Iheringia, série Zoologia**, v. 108, 2018. DOI: <https://doi.org/10.1590/1678-4766e2018003>
- CARVALHO-FERNANDES, S. P.; ALMEIDA-CORTEZ, J. S.; FERREIRA, A. L. N. Riqueza de galhas entomógenas em áreas antropizadas e preservadas de Caatinga. **Revista Árvore**, v. 36, n. 2, p.269–277, 2012. DOI: <https://doi.org/10.1590/S0100-67622012000200008>.
- FERNANDES, G. W. Plant age and size effects on insular gall-forming species richness. **Global Ecology and Biogeography Lett**, v. 2, n. 3, p. 71–74, 1992. DOI: <https://doi.org/10.2307/2997508>
- FERNANDES, G. W.; PRICE, P. W. Biogeographical gradients in galling species richness: test of hypotheses. **Oecologia**, v. 76, v. 2, p. 161–167, 1988. DOI: <https://doi.org/10.1007/BF00379948>
- INPE- Boletim meteorológico. 3:25, **A estiagem durante o verão e outono de 2001 no Brasil e as características Atm. Associadas**. Disponível em: <<http://energia1.cptec.inpe.br/anomalias/pt>>. Acesso em: 02 maio 2022.
- ISAIAS, R. M. S.; CARNEIRO, R. G. S.; OLIVEIRA, D. C.; SANTOS, J. C. Illustrated and annotated checklist of Brazilian Gall Morphotypes. **Neotropical Entomology**, v. 42, n. 3, p. 230–239, 2013. DOI: <https://doi.org/10.1007/s13744-013-0115-7>.
- LABANDEIRA, C. C. Ecology and evolution of gall-inducing Arthropods: The Pattern From the Terrestrial Fossil Record. **Frontiers Ecologia Evolução**, v. 9, p. 1-30, 2021. DOI: <https://doi.org/10.3389/fevo.2021.632449>
- MAIA, V. C.; SILVA, B.G. Checklist of the gall midges (Diptera, Cecidomyiidae) in the state of Bahia (Northeastern Brazil) / Lista dos Cecidomyiidae (Diptera) no estado da Bahia (Nordeste do Brasil). **Brazilian Journal of Animal and Environmental Research** v. 3, n. 4, p. 3991–4013, 2020. DOI: <https://doi.org/10.34188/bjaerv3n4-096>
- NOGUEIRA, R. M.; COSTA, E.C.; SANTOS-SILVA, J.; ISAIAS, R. M. S. Phenological trick and cell wall bricks toward adaptive strategies of *Mimosa tenuiflora-Lopesia mimosae* interaction in Caatinga environment. **Flora**, v. 294, 2022. DOI: <https://doi.org/10.1016/j.flora.2022.152121>
- OLIVEIRA, J. C.; MAIA, V. C. Ocorrência e caracterização de galhas de insetos na restinga de Grumari (Rio de Janeiro, RJ, Brasil). **Arquivos de Museu Nacional**, v. 63, n. 4, p. 669–675, 2005.
- QUEIROZ, L. P.; CARDOSO, D.; FERNANDES, M. F.; MORO, M. Diversity and evolution of flowering plants of the Caatinga domain. In: Silva JC, Leal I, Tabarelli M (eds), *Caatinga: the Largest Tropical Dry Forest Region in South America*. Springer, Cham, pp. 23–63, 2017. DOI: https://doi.org/10.1007/978-3-319-68339-3_2
- SANTOS, J. C.; ALMEIDA-CORTEZ, J. S.; FERNANDES, G. W. Richness of gallinducing insects in the tropical dry forest (Caatinga) of Pernambuco. **Revista Brasileira Entomologia**, v. 55, n. 1, p. 45–54, 2011. DOI: <https://doi.org/10.1590/S0085-56262011000100009>
- SANTOS-SILVA, J.; ARAÚJO, T. J. Are Fabaceae the principal superhosts of galls in Brazil? An **Academia Brasileira de Ciências**, v. 92, n. 2, p. 1-15, 2020. DOI: <https://doi.org/10.1590/0001-3765202020181115>
- SANTOS-SILVA, J.; SANTOS, G. A. B.; SANTOS, J. C. Soils and seasonality influence the richness of gall-inducing insects and their host plants in a tropical dry forest. **Journal of Arid Environments**, v. 196, n. 1, p. 1-11, 2022. DOI: <https://doi.org/10.1016/j.jaridenv.2021.104651>
- VELLOSO, A. L.; SAMPAIO, E. V. S.; PAREYN, F. G. C. (Eds.). *Ecorregiões propostas para o bioma Caatinga*. 1ª ed. APNE - Associação Plantas do Nordeste. **The Nature Conservancy do Brasil**, v. 1, p. 76. 2002.