



## First record of galls in the tree fern *Cyathea phalerata* (Cyatheaceae) from a Tropical Rainforest in Brazil

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Galls are abnormal, morphogenetically modified plant tissues that were induced by insects (Raman, 2007), and occur especially on angiosperms (e.g. Santos et al., 2011; Maia and Silva, 2016). Comparatively few galls have been reported on ferns (e.g., Houard, 1933; Kraus et al., 1993; Balick et al., 1978; Maia and Santos, 2015), although ferns are the second largest group of vascular plants and are especially abundant in tropical forest understories (Sharpe et al., 2010). Consequently, ferns might have been underestimated as host plants of gall-inducing insects, due to the lack of adequate sampling (Mehlreter, 2010).

The galling insects are highly specific to their host plants (Shorthouse and Rohfritsch, 1992; Price et al., 1998), because oviposition and/or larval feeding are capable of inducing specific morphogenetic changes only in the tissues of their specific host plants (Mani, 1992). Because of this high specificity, the discovery of new galls is often accompanied by the recognition of new gall-inducing insect species, as well (e.g. Maia and Santos, 2011; Maia and Araújo, 2016). Moreover, the geographical range of fern-insect interactions can provide further insights into their biology and evolutionary origins, especially in the high diverse Neotropics (Fernandes et al., 2011; Santos et al., 2012).

In this study, we report galls on the Brazilian tree fern *Cyathea phalerata* Mart. (Cyatheaceae) for the first time. In addition, we present morphological characteristics and some field observations.

The study was performed in a remnant of the Atlantic Forest, located in the municipality of Bonito, Pernambuco State, northeastern Brazil (08°29'56"S, 35°41'43"W; 680 m a.s.l.). The forest fragment is less than 50 ha in size and surrounded by a road and open areas, with other forest remnants nearby. The climate is tropical with a rainy season during autumn and winter. Average annual temperatures are 22.1 °C and mean annual rainfall is

approximately 1,200 mm. A voucher of *C. phalerata* was deposited at the herbarium of the Universidade Federal de Pernambuco (UFP, n° 81.373). The identification of the specimen followed Weigand and Lehnert (2016).

During fieldwork from May to June 2015, leaves (croziers, sterile and fertile) of *C. phalerata* were collected and examined for the presence of galls. Descriptions of gall morphology (color, shape, number of larval chambers, pubescence and distribution) follow Isaias et al. (2014). The quantification of galls per pinnule was made from 20 samples, which were obtained from 12 plant individuals at the study site. Leaves were composed of 10-16 pinnae with 40-50 pinnules (leaflets) each, and measured 150-220 cm in length.

Galls were present on completely expanded sterile and fertile leaves of eight plants, but absent in croziers and young, still expanding leaves. Leaf galls of *C. phalerata* were induced on the upper surface of leaves and may superpose the sori. The galls were glabrous and green, but often black at later developmental stages. Galls were globose and contained one larval chamber with a solitary larva. The exit hole is on the lower surface of the leaf. Galls occurred individually or in groups. The average number of galls was  $10.93 \pm 6.39$  per leaflet and could be in different developmental stages. Galls might occur near the midvein of the leaflet, extended to the marginal incision between two leaflets (Figure 1), and were induced by a new genus of Cecidomyiidae (Diptera), which belongs to the tribe Cecidomyiini (*paper in preparation*).

The gall of *C. phalerata* represents a new record on tree ferns and the third for genus, previously recorded in *Cyathea squamata* (Klotzsch) Domin (Houard, 1933) and *Cyathea* sp. (Maia et al., 2008). We presume that increasing sampling efforts in the tropics may reveal if the number of galls on ferns has been underestimated. In a revision from Costa Rica, Hanson and Gómez-Laurito (2005) reported



**Figure 1.** Leaf galls induced by Cecidomyiidae in the tree fern *Cyathea phalerata* Mart. (Cyatheaceae) from a Tropical Rainforest in Brazil. Galls situated near the vein and between two leaf segments, contained one larval chamber.

17 species of gall insects on ferns, which doubled the number that has been previously recorded worldwide (Balick et al., 1978). If the ratio of 17 gall-forming insects on 1,200 fern species (1:70.6) and 950 gall-formers on 9,000 angiosperm species (1:9.5) for Costa Rica is representative for the world, ferns would have just seven times fewer galls than angiosperms, but there would be still ca. 140 new gall-inducing species to be discovered for the currently 12,000 fern species worldwide (Mehlreter, 2010). Finally, we emphasize the need for a greater sampling effort of fern galls in the Neotropics to study their phylogenetic distribution and diversity on ferns.

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