

New species of ancient horsetail reveals relationship between plants, parasitoid insects about 300 million years ago

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Artistic reconstruction of the calamitalean sphenopsid *Annularia paisii* sp. nov. showing an insect-induced gall, *Paleogallus carpanularites* ichnosp. nov. Credit: Correia et al. 2020 (Artwork: Andrey Atuchin)

We have published an article describing a new calamitalean species named *Annularia paisii* with an insect gall about 303 million years old.

This new fossil species was discovered in the region of São Pedro da Cova, municipality of Gondomar, in the Douro Carboniferous Basin of the Upper Pennsylvanian of Portugal. Our study also includes a report of the worldwide record of arthropod herbivory on sphenophytes.

Evolutionary history of ecological interactions between terrestrial arthropods and vascular plants

The interactions between terrestrial arthropods and vascular plants encompass complex and intriguing terrestrial ecosystems that have persisted from Early Devonian times until today. These interactions are diverse, with multiple species of arthropods, mainly insects, and host plants interacting over a range of trophic levels through predation (i.e., herbivory), parasitism and pollination. The features, intensity and diversity of these interactions are mainly influenced by climatic and environmental conditions.

Galling represents the most biologically complex of all major arthropod–plant interactions, consisting of parasitic relationships characterized by the endophytic insect-induced plant tissue damage that can occur on all major plant organs. The insect-induced galling damage consists of atypically enlarged plant structures that are three-dimensional, conspicuous, generally of bilateral or radial symmetry and externally hardened. This offers to the encapsulated insect larvae a suitable microclimate, nutrition and protection from natural enemies. Insect galls usually affect plants only locally, but in some instances, can cause systemic effects.

Annularia paisii sp. nov. (holotype UP-MHNFCP-155167), from the São Pedro da Cova region, Douro Carboniferous Basin (DCB), northwestern Portugal.
Credit: Correia et al. 2020

Insect galls have a long evolutionary history, and the earliest fossil records of galls are known from the Pennsylvanian strata. These occurred on stems of arborescent ferns and calamitalean sphenopsids. Although insect galls have been well-documented in a wide range of host plant species, about 80% of extant galls occur on leaves. The Pennsylvanian-age galls are very poorly known because they are rarely found and only occasionally reported in the fossil record.

Ancient "horsetail" host shows insect gall preserved in situ

Horsetails are plants with a very old historical lineage, occurring in the fossil record from the Late Devonian to the present day, existing in abundance in Portugal. The new species *Annularia paisii* shows an insect gall induced by parasitoid insects (popularly known as galling insects), an a previously unknown ichnospecies that received a name *Paleogallus carpannularites*. This shows the existence of complex insect-plant relationships 303 million years ago, and reiterates the importance of the fossil record of the Portuguese Carboniferous. The patterns of herbivory of insects and other arthropods on horsetails are little known. In our paper, recently published in the *International Journal of Plant Sciences*, we addressed this subject, documenting 315 million years of sphenophyte herbivory relationships by arthropod.

Annularia paisii sp. nov. (paratype UP-MHNFCP-155168), from the São Pedro da Cova region, Douro Carboniferous Basin, northwestern Portugal. Credit: Correia et al. 2020

Structure of the insect-induced gall *Paleogallus carpanularites* ichnosp. nov. and its attachment to host *Annularia paisii* sp. nov. Credit: Correia et al. 2020

Interpretative view drawing of the holotype specimen of *Annularia paisii* sp. nov. and *Paleogallus carpanularites* ichnosp. nov. (UP-MHNFCP-155167). Credit: Correia et al. 2020

Ecological adaptation of *Annularia paisii*

The arrangement of the leaves of *Annularia paisii* appears anomalous for a species of *Annularia*. Its leaves are arranged in cup-shaped whorls, a typical characteristic of other calamitalean sphenopsid-like fossil genus *Asterophyllites*. Several explanations can account for this condition. The leaves of *Annularia paisii* were perhaps retracted into a cup shape during their burial. Alternatively, the cup shape could have been an induced feature resulting from their sensitivity to sunlight or an external tactile stimulus similar to the modern sensitive plant, *Mimosa pudica*. Another possibility is a physiological reaction from an herbivorous insect, such as a gall antagonism.

Annularia paisii is named in honor of the Portuguese paleobotanist João Pais (1949–2016) from Nova University in Lisbon (Portugal).

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More information: Pedro Correia et al. The History of Herbivory on Sphenophytes: A New Calamitalean with an Insect Gall from the Upper Pennsylvanian of Portugal and a Review of Arthropod Herbivory on an Ancient Lineage, *International Journal of Plant Sciences* (2020). [DOI: 10.1086/707105](https://doi.org/10.1086/707105)

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I am a PhD paleontologist and naturalist from Portugal. My research focus on Paleozoic paleobotany, paleoentomology, paleoclimate, paleogeography of Euramerica.

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