***Short communication***

**UNIQUENESS OF ASSOCIATION OF FERN AND INSECT IN THE FIELD**

**Abstract-**

Initial analysis of fern–insect herbivore interactions ﬁrst appeared in the 1970–1980s. The ferns were actually the primary food supply for the herbivorous sauropods during the Mesozoic epoch. Given their ability to contain a large amount of energy in a tiny packaging, fern spores have been shown to be rich in lipids. The presence of simple phenolics, which can be regarded as one of the primary causes of repulsion, makes insect phytophagy on ferns a rare occurrence.Unlike angiosperms, ferns contain special chemicals. The level of specialisation of insects that currently feed on ferns is well illustrated by Porto et al. The study on insects found feeding on ferns conducted in the field is presented in the publication. The study found that the number of different insects such as Beetle, Flea beetle, Saw fly, bugs and mealybug infested different ferns. Despite the increased toxicity, some insects, such as snails and grasshoppers, can consume mature ferns on a daily basis. Further study has to be carried out to find how these insects affect the growth and metabolism of the ferns. Fern-insect interactions can be explained by their evolutionary ties. Only four Lepidopteran families exhibit the rare phenomena known as fern-spore-feeding (FSF). Fern proteins regulate insects that are resistant to Bt insecticidal proteins, indicating different methods and/or areas of action and perhaps providing a novel method of managing insect pests.

**KEYWORDS**: Insects, Ferns, interaction, phytophagy, angiosperms, Fern-spore-feeding, Bt insectidal proteins

**Introduction**

Ferns (*Pteridophyta*, including both *Lycopodiophyta* and *Polypodiophyta* in the broad sense) are the second largest group of vascular plants, just after angiosperms ([Dai et al. 2020](https://pmc.ncbi.nlm.nih.gov/articles/PMC8016819/#B6425121)).The first known ferns are thought to have appeared at least 423 million years ago (Ma).

(Nitta *et al*., [2022](file:///C%3A%5CUsers%5CHP%5CDownloads%5CInsect%20-Fern%20association.docx#nph20361-bib-0014)).Interactions between ferns and insect herbivores were initially examined in the 1970s and 1980s (Cooper-Driver, 1978). The majority of the primary herbivore feeding strategies had evolved by the end of the Pennsylvanian, approximately 300 Ma, to include chewing, sucking and piercing, boring, galling, and spore ingestion. Previously, only insects with sucking and piercing mouthparts could devour ferns and fern relatives(Labandeira, [2002](file:///C%3A%5CUsers%5CHP%5CDownloads%5CInsect%20-Fern%20association.docx#nph20361-bib-0011)). Plant-animal interaction is often observed chronologically with the evolution of different groups of plants and animals. However, animals generally do not like ferns. The presence of simple phenolics, which can be regarded as one of the primary causes of repulsion, makes insect phytophagy on ferns a rare occurrence. As it was noticed that damage of different parts of plants of ferns and fern allies by various insects disclosed that soon after the appearance of the land flora, the terrestrial vegetation was attacked by different insects. In recent years different cases of interaction between insects and extant ferns and fern allies have been reported. The level of specialisation of insects that currently feed on ferns is well illustrated by Porto et al. (Fuentes-Jacques et al., 2022). Fern-insect interactions can be explained by their evolutionary ties. Insect orders belonging to the Endopterygota clade tended to interact with similar fern species, which may be due to the inheritance of Endopterygota ancestors due to phylogenetic niche conservationism. In an ecological setting, fern specialisation developed in response to climate stability, precipitation, and temperature. The evolutionary grouping of the fern species in understanding the regional variety of insect-fern interactions that environment may be a key factor.( Robert J. Marquis et.al. 2024).

In this communication, some observations of fern and insect has been reported to understand whether the fern-interaction could help us to understand their effect on Ferns as well as on the environment.

**MATERIAL AND METHODS-**

During a fern collection tour along the Dehradun district from 2008-2011, the authors on careful observations noticed some larvae are actively feeding on the undersurface of the lamina of these ferns and some of the insects were noticed on the upper surface as well as on the undersurface of the leaves. Apart from that study was done consulting the herbarium from BSI, Dehradun and literature survey was also done for further studies such as Stegelmeier, BL.2014, Patra B and Bera S, 2007, Walker, 2010.

**RESULT AND DISCUSSION-**

Some of the interesting aspects also came out during the field study such as insect and fern relationship and also by herbarium consultations-

 (a) Beetle infestation on *Christella dentata* (Forssk.) Brown (FIG-2) and *Drynaria propniqua* (Wall. ex Mett.) (FIG-1)

 (b) *Adiantum lunulatum* Burm. infested by larvae of Beetle.

(c) *Lygodium japonicum* (Thumb.) Sw. common insect found in association are: Flea beetle, Saw fly

(d) *Pteridium revolutum* (Bl.) Nakai (FIG-4) and *Pteris vittata* L. infested by bugs

(e) *Pyrrosia costata* (C. Presl ex Bedd.) Tagawa & K. Iwats. Shield bug are found in association

(f) The caterpillars feed on *Osmunda regalis* L.

 (g) On the underside of a frond of Silver Fern an adult female Silver fern mealybug, *Crisiococcus* sp. (FIG-3)



**FIG-1 :** *Drynaria propniqua* (Wall. ex Mett.)



 **FIG-2 :** Beetle infestation on *Christella dentata* (Forssk.) Brown



**FIG-3 :** On the underside of a frond of Silver Fern an adult female Silver fern mealybug, *Crisiococcus* sp.



**FIG-4 :** *Pteridium revolutum* (Bl.) Nakai

Insects and ferns have a complicated relationship that includes both positive and negative interactions.

Ferns' chemical defences against herbivores remain unclear. Unlike angiosperms, ferns contain special chemicals. (Wei et al., 2023). Despite the increased toxicity, some insects, such as snails and grasshoppers, can consume mature ferns on a daily basis. The primary dietary source for herbivorous sauropods during the Mesozoic era was ferns. Fern herbivores may be insect species that specialise in ferns or generalist insects that are generally found in insect orders Coleoptera, Hemiptera, and Lepidoptera. Strong mutualistic relationships exist between ants and *Microgramma* subgenus *Solanopteris* in the New World and *Lecanopteris* in the tropical regions of the Old World; a third, more facultative association has just been reported for *Antrophyum* in Costa Rica. Only four Lepidopteran families exhibit the rare phenomena known as fern-spore-feeding (FSF). The most specialised family, Stathmopodidae, contains FSF species, and its subfamily, Cuprininae, is exclusively devoted to FSF.( [Zong-Yu Shen](https://pubmed.ncbi.nlm.nih.gov/?term=Shen+ZY&cauthor_id=38395320), [Takeshi Terada](https://pubmed.ncbi.nlm.nih.gov/?term=Terada+T&cauthor_id=38395320), [Jean-François Landry](https://pubmed.ncbi.nlm.nih.gov/?term=Landry+JF&cauthor_id=38395320), [Robert J B Hoare](https://pubmed.ncbi.nlm.nih.gov/?term=Hoare+RJB&cauthor_id=38395320), [Li-Yaung Kuo](https://pubmed.ncbi.nlm.nih.gov/?term=Kuo+LY&cauthor_id=38395320), [Ming-Hsun Chou](https://pubmed.ncbi.nlm.nih.gov/?term=Chou+MH&cauthor_id=38395320), [Yu-Feng Hsu](https://pubmed.ncbi.nlm.nih.gov/?term=Hsu+YF&cauthor_id=38395320), [Jen-Pan Huang](https://pubmed.ncbi.nlm.nih.gov/?term=Huang+JP&cauthor_id=38395320),2024)

 Insect orders that are part of the Endopterygota clade tend to interact with similar fern species. Indicating that insects in this clade have similar diets which might be a result of the inheritance of Endopterygota ancestors due to phyloge-netic niche conservationism. (Gabriela Fraga Porto, Diego V. Anjos, Pedro Luna Kleber Del-Claro,2024)

 The susceptibility of fern-insect interactions is another illustration of how distinctive ecological interactions may be lost before the different fern species are recorded. For both ferns and insects, targeted sampling of interactions conducted in an aphylogenetic framework appears to be the most fruitful. Comparing fern clades that originated before with those that evolved after the emergence of angiosperms might also be instructive. If and how fern chemistry differs from flowering plant chemistry, as well as how these substances contribute to the structuring of fern herbivore assemblages and the damage they do, can be determined once such data are accessible. The effects of plant size, deciduousness, the great variation of leaf form and size, and environment between species of ferns. It has been demonstrated that these elements affect herbivore damage in angiosperms (Chaves et al., 2025). According to Porto et al., because these relationships are the most specialised and least investigated, research and conservation efforts should concentrate on tropical ferns and their insect partners. The restricted climatic niches of low-to-mid elevation tropical forests are expected to make fern–insect interactions the most vulnerable to climate change (Grinder & Wiens, 2023). The susceptibility of fern-insect interactions is another illustration of how distinctive ecological interactions may be lost before the species of fern are recorded. Since ferns generate a number of highly efficient defensive compounds, such as substances that imitate insect growth hormones and obstruct caterpillar and other insect growth, they are immune to many insect pests. However, the caterpillar of the Florida fern may overcome these defences and can seriously defoliate Boston ferns and other fern species.( Romulo Cenci, Rodrigo Scalise Horodyski,2022).Fern proteins regulate insects that are resistant to Bt insecticidal proteins, indicating different methods and/or areas of action and perhaps providing a novel method of managing insect pests.( Jun-Zhi Wei; Amy Lum; Eric Schepers; Lu Liu; Ross T. Weston; Bruce S. McGinness; Matthew J. Heckert; Weiping Xie; Adane Kassa; Denny Bruck et al.,2023). Steroidal compounds which are closely related structurally to ecdysone are grouped as ecdysteroids. Ecdysteroids identified in plants and animals are named phytoecdysteroids and zooecdysteroids, respectively. Phytoecdysteroids are distributed in a large number of land plants (6%). Phytoecdysteroids have been recorded from 27 families of pteridophytes. Ecdysteroids are not found in all fern families, but in Polypodiaceae; it is very common. Ferns likes *Pteridium aquilinum*, *Polypodium vulgare*, *Schizaea dichotoma*, *Cheilanthes farinosa*, *Cheilanthes tenuifolia*, *Microsorum scolopendria*, *Adiantum pedatum*, *Dryopteris nipponensis*, *Adiantum raddianum*, *Asplenium aethiopicum*, *Cyclosorus interruptus*, *Dicranopteris linearis*, *Diplazium polypodioides* etc. more commonly synthesize Ecdysteroids. One major drawback is that some plants' phytoecdysteroids might discourage beneficial insects and other insect predators that are not suited.One major drawback is that some plants' phytoecdysteroids might discourage beneficial insects and other insect predators that are not suited.(Sahayaraj, K. 2022).

**Declarations**

Ethical Approval is not applicable for this work.

**Data availability statements**

Data source and support are not used for this work.

**REFRENCES**

1. Cooper-Driver GA (1978). Insect-Fern associations Entomologia Experimentalis Et Applicata 24:310-316.
2. Chaves M, Garcıa-Robledo C, Carlsen MM, Vargas OR, Rojas-Gomez M,Marquis RJ (2025). Impact of biogeography, ecology, evolutionary history, and architectural traits on the structure of rolled-leaf beetle assemblages of Costa Rican Zingiberales. Biotropica 57. doi: 10.1111/btp.13402.
3. *Dai Xiaohua, Chen Chunfa, Li Zhongyang, Wang Xuexiong. Taxonomic, phylogenetic, and functional diversity of ferns at three differently disturbed sitesin Longnan County, China. Diversity. 2020;12(4):135.*
4. Fuentes-Jacques LJ, Hanson-Snortum P, Hernandez-Ortiz V, Dıaz-Castelazo C,Mehltreter K (2022). A global review and network analysis of phytophagous insect interactions with ferns and lycophytes. Plant Ecology 223: 27–40.
5. Gabriela Fraga Porto, Diego V. Anjos, Pedro Luna Kleber Del-Claro.2024. A global overview of insect–fern interactions and its ecological trends. New Phytologist.246
6. Grinder RM, Wiens JJ (2023). Niche width predicts extinction from climate change and vulnerability of tropical species. Global Change Biology 29: 618–630.
7. Jun-Zhi Wei; Amy Lum; Eric Schepers; Lu Liu; Ross T. Weston; Bruce S. McGinness; Matthew J. Heckert; Weiping Xie; Adane Kassa; Denny Bruck.2023.Novel insecticidal proteins from ferns resemble insecticidal proteins from Bacillus thuringiensis. Proceedings of the National Academy of Sciences. 10-31
8. Labandeira CC (2002). The history of associations between plants and animals. In:Herrera CM, Pellmyr O, eds. Plant–animal interactions, an evolutionary approach .Oxford, UK: Blackwell Scientiﬁc, 26–74
9. Nitta JH, Schuettpelz E, Ramırez-Barahona S, Iwasaki W (2022). An open and continuously updated fern tree of life. Frontiers in Plant Science 13: 909768
10. Patra B and Bera S 2007 Herbivore damage to ferns caused by a chrysomelid beetle from Lower Gangetic Plains of West Bengal, India American Fern Journal
11. Porto GF, Anjo DV, Luna P, Del-Claro K (2024). A global overview of insect–fern interactions and its ecological trends. New Phytologist. doi: 10.1111/nph.20229.
12. Robert J. Marquis.2024. On the uniqueness of fern–insect interactions, New Phytologist, 10.1111/nph.20361, 246, 2, (386-388).
13. Romulo Cenci, Rodrigo Scalise Horodyski.2022 Fern-Arthropod Interactions From The Modern Upland Southeast Atlantic Rainforest Reveals Arthropod Damage Insights To Fossil Plant-Insect Interactions. *Palaios* ; 37 (7): 349–367
14. Sahayaraj, K. (2022). Ferns, a Source of Phytoecdysones, and their Applications in Pestiferous Insect Management. In: Marimuthu, J., Fernández, H., Kumar, A., Thangaiah, S. (eds) Ferns. Springer.
15. Stegelmeier, BL (2014) *Overview of bracken fern poisoning*. Retrieved from: <http://www.merckmanuals.com/vet/toxicology/bracken_fern_poisoning/overview_of_bracken_fe>[rn\_poisoning.html#v11577387](file:///C%3A%5CUsers%5CHP%5CDownloads%5CInsect%20-Fern%20association.docx#v11577387).
16. Wei JZ, Lum A, Schepers E, Liu L, Weston RT, McGinness BS, Heckert MJ, Xie W, Kassa A, Bruck D *et al.* (2023). Novel insecticidal proteins from ferns resemble insecticidal proteins from Bacillus thuringiensis. Proceedings of the National Academy of Sciences, USA 120: e2306177120.
17. Walker, M (2010).  *A mouse that eats ferns like a dinosaur*. Retrieved from: <http://news.bbc.co.uk/earth/hi/earth_news/newsid_8523000/8523825.stm>.
18. [Zong-Yu Shen](https://pubmed.ncbi.nlm.nih.gov/?term=Shen+ZY&cauthor_id=38395320), [Takeshi Terada](https://pubmed.ncbi.nlm.nih.gov/?term=Terada+T&cauthor_id=38395320), [Jean-François Landry](https://pubmed.ncbi.nlm.nih.gov/?term=Landry+JF&cauthor_id=38395320), [Robert J B Hoare](https://pubmed.ncbi.nlm.nih.gov/?term=Hoare+RJB&cauthor_id=38395320), [Li-Yaung Kuo](https://pubmed.ncbi.nlm.nih.gov/?term=Kuo+LY&cauthor_id=38395320), [Ming-Hsun Chou](https://pubmed.ncbi.nlm.nih.gov/?term=Chou+MH&cauthor_id=38395320), [Yu-Feng Hsu](https://pubmed.ncbi.nlm.nih.gov/?term=Hsu+YF&cauthor_id=38395320), [Jen-Pan Huang](https://pubmed.ncbi.nlm.nih.gov/?term=Huang+JP&cauthor_id=38395320).2024.Systematics and evolutionary dynamics of insect-fern interactions in the specialized fern-spore feeding Cuprininae (Lepidoptera, Stathmopodidae). Mol Phylogenet Evol :194:108040.