



RESEARCH COMMUNICATION

A new frontier in mycophagy: *Forficula auricularia* on *Podosphaera fusca*

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Received: 04 November 2025; Accepted: 15 March 2025; Available online: Version 1.0: 20 April 2026

Cite this article: Lham D, Nitika S, Anjana T, Shailja S, Puneet K, Deeksha MG, Suman S, Neha P, Niraj G. A new frontier in mycophagy: *Forficula auricularia* on *Podosphaera fusca*. Plant Science Today. 2026; 13(sp2): 1-3. <https://doi.org/10.14719/pst.12582>

Abstract

Powdery mildew, caused by the fungus *Podosphaera fusca*, poses a significant threat to global cucurbit cultivation. This report presents a noteworthy observation with potential implications for managing the prevalent biotic stress in cucumber crops. Our research unveils the active feeding behaviour of the earwig species *Forficula auricularia* on *P. fusca*, highlighting its potential as a promising natural biocontrol agent. Molecular identification techniques, resulting in accession number OQ102947, unequivocally confirmed the species as *F. auricularia*. While this discovery is promising, further studies are crucial to evaluate the biological control efficiency of *F. auricularia* against *P. fusca* in cucurbit crops.

Keywords: biocontrol; cucumber; earwig; cucurbit; powdery mildew

Introduction

Earwigs, classified under the order Dermaptera, are globally distributed insects recognised for their distinctive pincer-like appendages and nocturnal behaviour, intriguing entomologists and observers worldwide (1). Earwigs are generally omnivorous, feeding on insects, plant material and decaying organic matter. Certain earwig species display a distinct preference for fungi, actively feeding on spores, mycelium and other fungal structures (2). Their consumption of fungi can impact fungal populations, necessitating an understanding of targeted species and their ecological roles. This fungivorous behaviour holds implications for both insect ecology and the dynamics of fungal communities within ecosystems (3).

In this study, an earwig species was observed feeding on cucurbit powdery mildew, a prevalent and damaging disease of cucurbit crops, primarily caused by the fungus *Podosphaera fusca*. This pathogen poses a significant threat to squash, melons and cucumbers, presenting as white powdery spots on leaves, stems, and fruits (4). The distinctive biology of powdery mildew fungi, featuring external hyphal mat formation and haustorium as the sole nutrient acquisition structure penetrating the host's cuticle, offers potential for arthropods to serve as biological control agents (5).

Despite fungivory being a fundamental trait in numerous insect species, especially concerning powdery mildew, its potential as a strategy for biological control remains relatively underexplored (6). This study molecularly identifies the earwig species linked to cucurbit powdery mildew, aiming to explore fungivorous arthropods, particularly earwigs, as potential alternatives for more effective control of destructive powdery mildew pathogens in cucurbit crops.

Materials and Methods

In August 2023, during a field visit to Salooni village (32.7216° N, 76.0515° E), Himachal Pradesh, India, earwigs feeding on cucumber powdery mildew were observed. Collected specimens were sorted and preserved in 70 % ethanol for molecular identification. DNA isolation was carried out using the cetyltrimethylammonium bromide (CTAB) method (7).

Genomic DNA was extracted from hindleg samples following the CTAB protocol. Samples were homogenised in 0.85 % NaCl, centrifuged and the resulting pellet was lysed in TE buffer containing SDS, lysozyme and Proteinase K. After incubation, NaCl and CTAB

were added, followed by purification with chloroform:isoamyl alcohol (24:1). DNA was precipitated with isopropanol, washed with 70 % ethanol, air-dried and dissolved in TE buffer. DNA concentration and purity were determined by measuring absorbance at 260/280 nm using a NanoDrop™ 2000/2000c spectrophotometer (Thermo Scientific) and integrity was confirmed by electrophoresis on a 0.8 % agarose gel.

The mitochondrial COI (MtCO1) region was amplified using universal primers LCO and HCO in a 25 µL polymerase chain reaction (PCR) containing genomic DNA, master mix, primers and nuclease-free water. The PCR program included an initial denaturation at 94 °C, followed by 35 cycles of denaturation (94 °C), annealing (52 °C) and extension, with a final extension at 72 °C. Amplified products were resolved on a 1.2 % agarose gel using a 1 kb DNA ladder and visualised under a gel documentation system. Verified amplicons were purified and subjected to bidirectional sequencing.

Results and Discussion

Analysis of the mitochondrial COI (MtCOI) sequences revealed fragments of 657 bp, which were used for subsequent molecular analyses. BLASTn comparison against the NCBI database showed 100 % sequence identity with *Forficula auricularia*. The sequences were deposited in GenBank under accession number OQ102947. Sequence alignment and preliminary analyses were performed using BioEdit. Phylogenetic analysis was conducted in MEGA X using the neighbor-joining (NJ) method with 1000 bootstrap replicates to assess branch support (Fig. 1). The phylogenetic tree was constructed using 10 reference sequences retrieved from GenBank. In the resulting topology, OQ102947 clustered with the reference sequence MH853424 with strong bootstrap support, confirming its taxonomic identity as *F. auricularia*.

The current study marks the initial documentation of *F. auricularia* (Dermaptera: Forficulidae) feeding on cucumber powdery mildew caused by *P. fusca* in India (Fig. 2). As an omnivorous earwig native to Europe, western Asia and North Africa, it has spread globally since the early 1900s, displaying a generalist feeding behaviour encompassing soft plant tissue, organic matter, invertebrates and fungi. In various ecosystems, it is notably recognised for its agricultural significance (7). While some studies have identified *F. auricularia* as a potential biocontrol agent against insect pests (8), its role as a biocontrol agent against fungi,

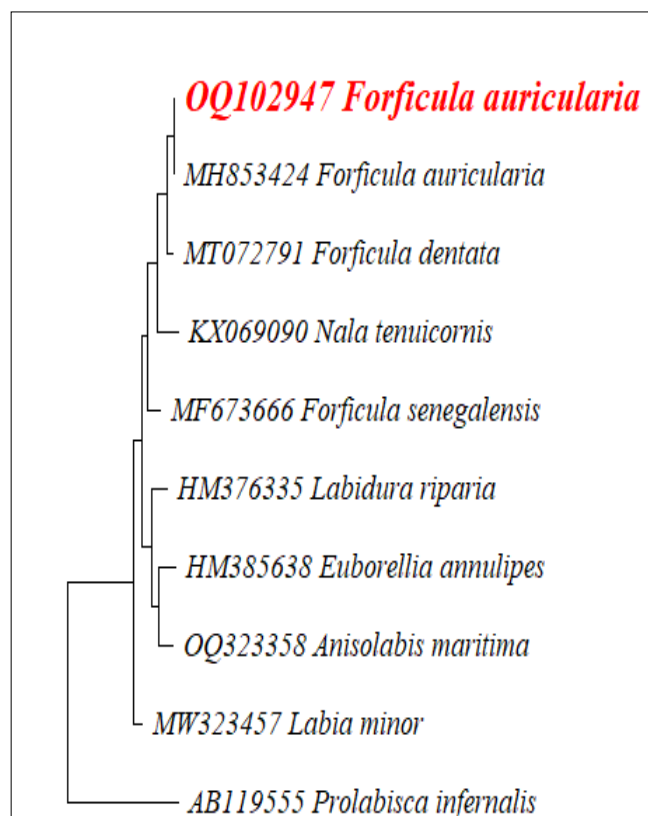


Fig. 1. Phylogenetic tree representing the molecular identification of *Forficula auricularia*.

particularly as a pest, remains unexplored in existing literature. This study serves as a foundation, documenting *F. auricularia* feeding on *P. fusca*. Although earlier literature has reported the ability of *F. auricularia* to consume fungi, there is a paucity of studies describing it as a fungivorous species. Additionally, several other dermapteran species have been documented with mycophagous habits (3). Similar to the present findings, a recent study reported the mycophagous behaviour of *Doru luteipes* on *Puccinia polyspora* uredospores, the causal agent of southern corn rust (2). Herbivorous insects feeding on plant-associated fungi derive direct nutritional benefits, including nitrogen, hydrolytic enzymes, choline, sterols and vitamin B from fungal tissues (9). Concerning powdery mildew fungi, larger arthropods, such as coccinellids from the tribe Halysziini, were reported to excel in powdery mildew removal and suppression (10, 11). Thus, the present study offers initial insights into the fungivorous



Fig. 2. Earwig engaged in powdery mildew consumption on cucumber plant.

behaviour of the earwig *F. auricularia*, feeding on *P. fusca*. This information can contribute to the development of biological control strategies for this fungus. Nevertheless, further investigations are needed to assess the biological control efficacy of *F. auricularia* against powdery mildew in cucurbit crops.

Conclusion

This study provides valuable insights into the fungivorous behaviour of *Forficula auricularia* on *Podosphaera fusca*, indicating that *F. auricularia* has the potential to serve as a biocontrol agent against *P. fusca*. These findings pave the way for future research and practical applications, highlighting the scope for developing eco-friendly strategies to manage *P. fusca* infestations in agricultural and horticultural ecosystems.

Acknowledgements

All authors gratefully acknowledge the Department of Entomology, CSK Himachal Pradesh Krishi Vishvavidyalaya (CSK HPKV), Palampur, for providing essential research facilities and continuous support throughout this study.

Authors' contributions

NG and NP collected the insect samples. NG and MGD carried out the molecular identification of the insect. NS, LD, AT, SS¹, PK and SS² were involved in manuscript review and editing. All authors read and approved the final manuscript [SS¹- Shailja Sharma and SS²- Suman Sanjta].

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process: The authors declare that the Perplexity AI tool was used solely for sentence rephrasing, grammatical correction and language refinement. The authors take full responsibility for all scientific content, interpretations, findings and conclusions. Prior to submission, the manuscript was carefully reviewed by the authors to ensure its accuracy, integrity and originality.

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Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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