Tropentag 2025
September 10-12, 2025
Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the University of Bonn, Bonn, Germany

Ecological characterisation of indigenous entomopathogenic nematodes against *Spodoptera frugiperda* in Nigeria

Christopher Tobe Okolo[ac], Abiodun Claudius-Cole[d], Florian Grundler[b] and Christian Borgemeister[a]

a University of Bonn, Center for Development Research (ZEF), Germany Email: cokolo@uni-bonn.de
b University of Bonn, Institute of Crop Science and Resource Conservation (INRES), Germany
c Ahmadu Bello University, Department of Crop Protection, Nigeria
d University of Ibadan, Crop Protection and Environmental Biology, Nigeria

Abstract
The effective deployment of entomopathogenic nematodes (EPNs) for biological pest control relies on their ecological resilience and consistent performance under local agroecological conditions. This study evaluated six indigenous EPN isolates from Nigeria for their ecological traits against the fall armyworm (FAW), *Spodoptera frugiperda*. The isolates included *Heterorhabditis bacteriophora* (Ib-CRIN68), *Steinernema carpocapsae* (Ib-IART45, Ib-ITUC102), *Steinernema nepalense* (Ib-HORT), *Steinernema feltiae* (Za-SAM), and *Oscheius myriophilus* (Ib-FRIN32). Laboratory bioassays were conducted to assess performance under temperature variation, moisture stress, oxygen limitation, oxidative stress, and foraging behaviour. Results revealed significant inter-isolate differences, with *H. bacteriophora*, *S. nepalense*, and *S. carpocapsae* exhibiting superior ecological fitness. The findings highlight the importance of ecological screening for selecting robust EPN candidates suitable for pest management programmes in sub-Saharan Africa.

Keywords: Entomopathogenic nematodes, ecological tolerance, biological control, fall armyworm, abiotic stress, Nigeria.

Introduction

The fall armyworm (*Spodoptera frugiperda*), a highly invasive and polyphagous lepidopteran pest, has become a major threat to maize production across Africa since its introduction in 2016 (Goergen et al., 2016). In Nigeria, the pest has caused significant yield losses for smallholder farmers, who predominantly rely on synthetic insecticides for control (Nwadike et al., 2021). However, chemical-based pest management is not only unsustainable but also contributes to resistance development, environmental pollution, and non-target effects. Biological control using entomopathogenic nematodes (EPNs) represents a promising alternative due to their ability to actively locate and kill insect hosts through symbiotic bacteria (van Lenteren et al., 2018). Despite the demonstrated laboratory virulence of several EPN isolates, their field efficacy can be constrained by environmental stresses such as temperature extremes, desiccation, low oxygen, and oxidative stress (Levy et al., 2020; Mukuka, Strauch, & Ehlers, 2010). Therefore, assessing ecological traits is essential for identifying robust isolates capable of withstanding harsh field conditions. This study investigates the ecological performance of six indigenous EPN isolates from Nigeria to inform their suitability for integrated pest management (IPM) programmes targeting FAW.

Material and Methods

EPN Isolates

Six previously identified and characterised EPN isolates were used: *Heterorhabditis bacteriophora* (Ib-CRIN68), *Steinernema carpocapsae* (Ib-IART45, Ib-ITUC102), *Steinernema nepalease* (Ib-HORT), *Steinernema feltiae* (Za-SAM), and *Oscheius myriophilus* (Ib-FRIN32). Identification was based on morphological and molecular criteria including ITS, COI, and D2–D3 rDNA sequences.

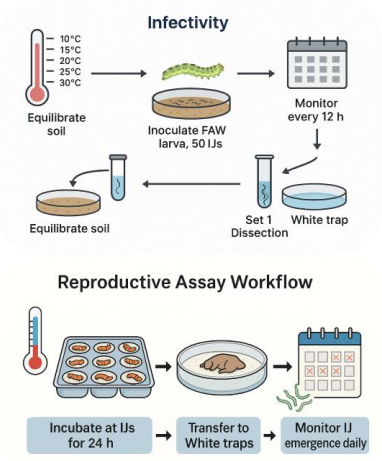
Ecological Bioassays

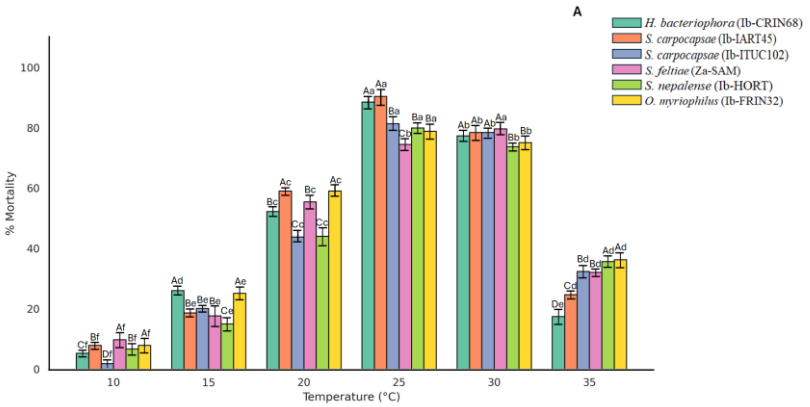
Five bioassays were conducted to simulate relevant ecological stress conditions. Temperature tolerance assay evaluated the infectivity and reproductive potential of the infective juveniles at 10, 15, 25, 30, and 35°C using last-instar *Galleria mellonella* larvae as hosts. Desiccation tolerance was simulated using PEG 6000 at -1.5 MPa to induce water stress. IJ survival was monitored after 24 h. For oxidative stress assay IJs were exposed to hydrogen peroxide (H_2O_2) solutions (0.5%, 1.0%, and 1.5%) for 4 h; viability was recorded post-exposure. IJs was exposed to anoxic conditions in airtight chambers to assess their survival under limited oxygen. Survival was assessed at 24, 48, and 72 hours. The host-finding efficiency of IJs was evaluated using vertical soil columns with *Galleria* larvae placed at varying depths (2 cm, 5 cm, 10 cm), under sand and loam substrates. All experiments were conducted with three biological replicates and repeated to ensure consistency. Data were analysed using ANOVA with post hoc Tukey's tests ($p < 0.05$).

Results and Discussion

Temperature Tolerance

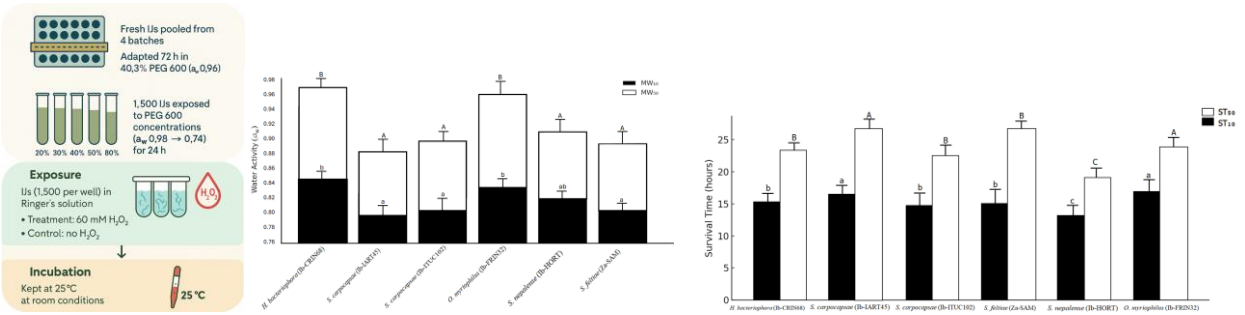
All isolates demonstrated optimum infectivity and reproduction between 25°C and 30°C, consistent with tropical soil conditions. At 10°C and 35°C, both infectivity and emergence declined sharply, suggesting thermal stress susceptibility. *S. carpocapsae* isolates showed the steepest decline at higher temperatures, whereas *H. bacteriophora* showed relatively better tolerance.





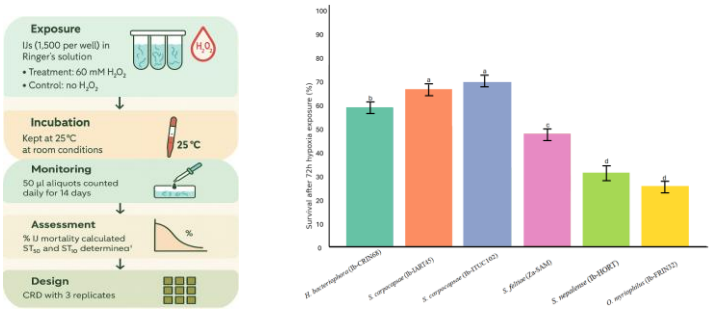
Desiccation and Oxidative Stress

Survival under PEG-induced desiccation was highest in *H. bacteriophora* and *S. nepalense*, which retained >70% viability. These isolates also showed greater oxidative stress resistance, surviving >60% at 1.0% H_2O_2. In contrast, *O. myriophilus* and *S. feltiae* showed poor performance under both stress conditions.



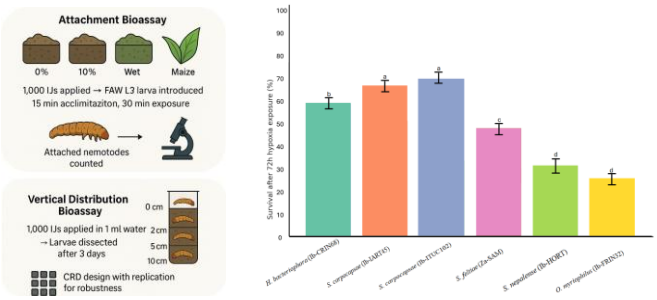
Oxygen Limitation

Moderate tolerance to hypoxia was observed across all isolates. However, *H. bacteriophora* and *S. nepalease* again stood out, maintaining over 50% survival after 72 h in anoxic conditions. This trait is important for EPN survival in waterlogged or compacted soils common in sub-Saharan farming systems.



Foraging Behaviour

The ability to locate hosts under varied soil conditions is critical for EPN success. *S. carpocapsae* isolates exhibited superior host-finding ability at shallow depths in dry, sandy soils, aligning with their ambusher foraging strategy. Other isolates performed moderately across different substrates but were less effective in deeper or moist loam conditions. These results affirm that ecological performance is isolate-specific and not uniform across genera or species. The superior adaptability of *H. bacteriophora* and *S. nepalense* makes them prime candidates for deployment in fluctuating field environments.



Conclusions and Outlook

This study provides crucial insights into the ecological robustness of six indigenous EPN isolates from Nigeria. Significant differences in temperature, desiccation, oxidative, and oxygen stress responses suggest that only a subset of these isolates possess the ecological fitness necessary for consistent field performance. *H. bacteriophora* and *S. nepalense* demonstrated strong resilience across multiple stress factors, while *S. carpocapsae* showed superior foraging ability. Future work should focus on field validation across agroecological zones, formulation development to enhance shelf-life, and integration into IPM frameworks for sustainable FAW control. The ecological screening framework presented here can support selection pipelines for EPNs in sub-Saharan Africa.

References

Goergen, G., Kumar, P. L., Sankung, S. B., Togola, A., & Tamò, M. (2016). First report of outbreaks of the fall armyworm spodoptera frugiperda (J. E. Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PLoS ONE*, *11*(10). https://doi.org/10.1371/journal.pone.0165632.

Kaya, H. K., & Gaugler, R. (1993). Entomopathogenic nematodes. *Annual Review of Entomology*, 38(1), 181–206.

Laznik, Ž., Tóth, T., & Vidrih, M. (2011). Control of the Colorado potato beetle (*Leptinotarsa decemlineata*) with the entomopathogenic nematodes *Steinernema feltiae* and *Heterorhabditis bacteriophora*. *Zemdirbyste-Agriculture*, 98(4), 425–432.

Levy, N., Faigenboim, A., Salame, L., Molina, C., Ehlers, R. U., Glazer, I., & Ment, D. (2020). Characterization of the phenotypic and genotypic tolerance to abiotic stresses of natural populations of Heterorhabditis bacteriophora. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-67097-0.

Mukuka, J., Strauch, O., & Ehlers, R. U. (2010). Variability in desiccation tolerance among different strains of the entomopathogenic nematode Heterorhabditis bacteriophora. *Nematology*, *12*(5), 711–720. https://doi.org/10.1163/138855409X12607871174454.

Nwadike, C., Joshua, V. I., Doka, P. J. S., Ajaj, R., Hashidu, U. A., Gwary-Moda, S., . . . Moda, H. M. (2021). Occupational Safety Knowledge, Attitude, and Practice among Farmers in Northern Nigeria during Pesticide Application—A Case Study. *Sustainability, 13*(18), 10107-10107. doi:10.3390/SU131810107.

Shapiro-Ilan, D. I., Hazir, S., & Glazer, I. (2017). Basic and applied research: Entomopathogenic nematodes. In Lacey, L. A. (Ed.), *Microbial Control of Insect and Mite Pests* (pp. 91–105). Academic Press.

van Lenteren, J. C., Bolckmans, K., Köhl, J., Ravensberg, W. J., & Urbaneja, A. (2018). Biological control using invertebrates and microorganisms: plenty of new opportunities. *BioControl, 63*(1), 39-59. doi:10.1007/s10526-017-9801-4.