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Integrating electroantennography and *in silico* odorant receptor binding: Sustained-release oviposition deterrence of *Piper nigrum* essential oil-loaded nanoemulsions against *Corcyra cephalonica*.

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INTRODUCTION

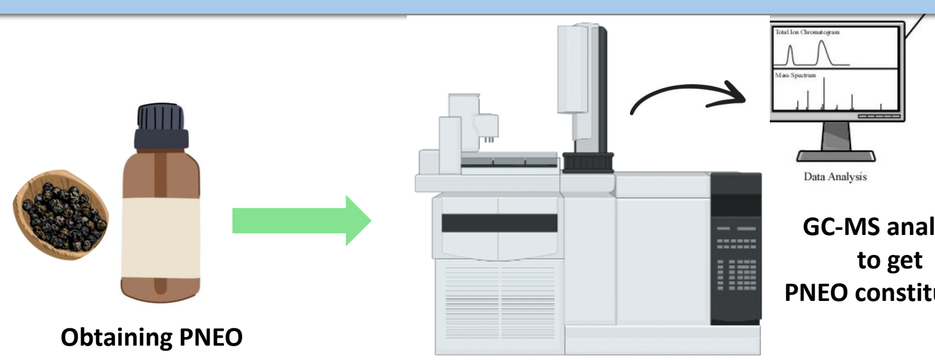
BACKGROUND

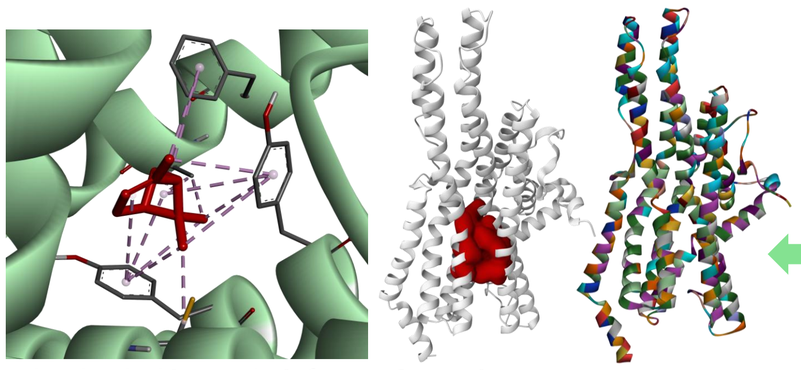
- **Global pest & problem:** *Corcyra cephalonica* is a stored grain pest. The current use of synthetic insecticides is facing insecticide resistance and increased environmental concerns.
- **Promising alternative:** *Piper nigrum* (black pepper) essential oil (PNEO) is a bioactive, eco-friendly candidate for insect management.
- **Key limitation:** PNEO's high volatility leads to rapid loss of potency, restricting practical use.
- **Technological solution:** PNEO nanoemulsions (PNNEs) allow for encapsulation of PNEO, leading to prolongation of PNEO's bioactivity.
- **Targeted strategy:** Oviposition deterrence (OD) - preventing egg-laying - is a critical behavioural control method driven by olfaction.
- **Integrated, novel approach:** Combining NE formulation with electroantennography (EAG) and *in silico* molecular docking to develop and mechanistically explain a sustained-release deterrent is an innovative and underexplored research avenue.

OBJECTIVES

- To formulate and characterize PNNEs and assess the antennal sensitivity of *C. cephalonica* to both the PNEO and PNNEs using EAG.
- To correlate EAG responses against PNEO and PNNEs' acute vs. sustained OD activity against *C. cephalonica*.
- To investigate the molecular mechanism of olfaction disruption via in silico docking of key PNEO constituents with a target *C. cephalonica* odorant receptor.

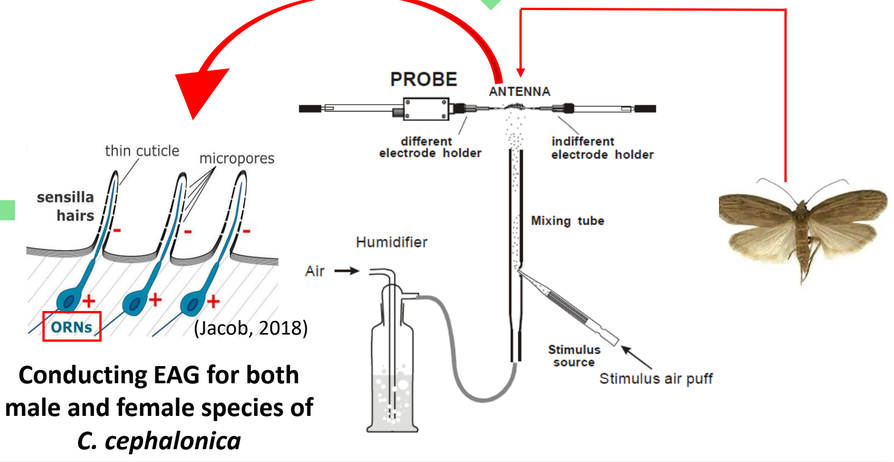
WORKFLOW





Molecular docking analysis for PNEO constituents
Right: Selecting the potential Odorant Receptor (UniProt-Q9V9I2)
Middle: Selecting the potential binding pocket of the receptor
Left: Docked complex analysis

Conducting OD assays for five days of time



Conducting EAG for both male and female species of *C. cephalonica*

RESULTS & DISCUSSION

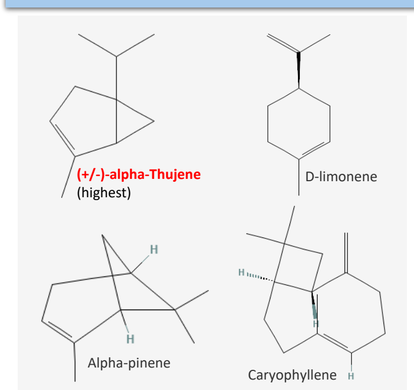


Fig 01: PNEO constituents with high area percentages

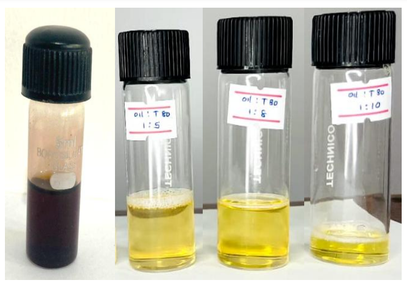


Fig 02: PNEO and PNNEs (1:5, 1:8 & 1:10 from left to right)

Table 01:Droplet size, PDI and Zeta Potential of PNNEs

PNEO : Tween 80 Ratio	Droplet Size (nm)	PDI	Zeta potential (mV)
1:5	11.66	0.210	-10.65
1:8	10.5	0.153	-17.87
1:10	9.58	0.130	-11.27

Tween 80 ratio ↑ Droplet size ↓

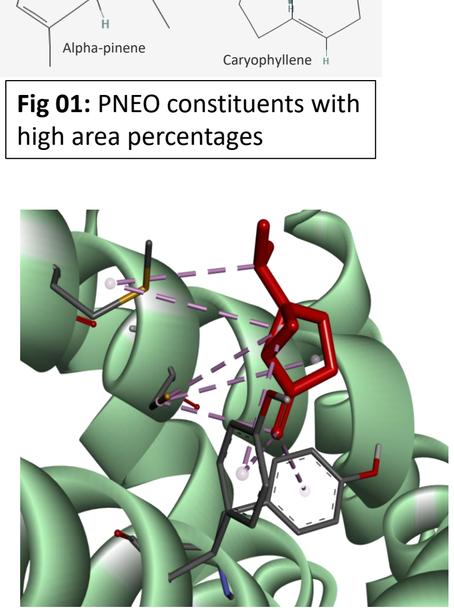


Fig 05: van der Waals and hydrophobic interactions of PNEO constituents, showcasing higher binding affinities with odorant receptor

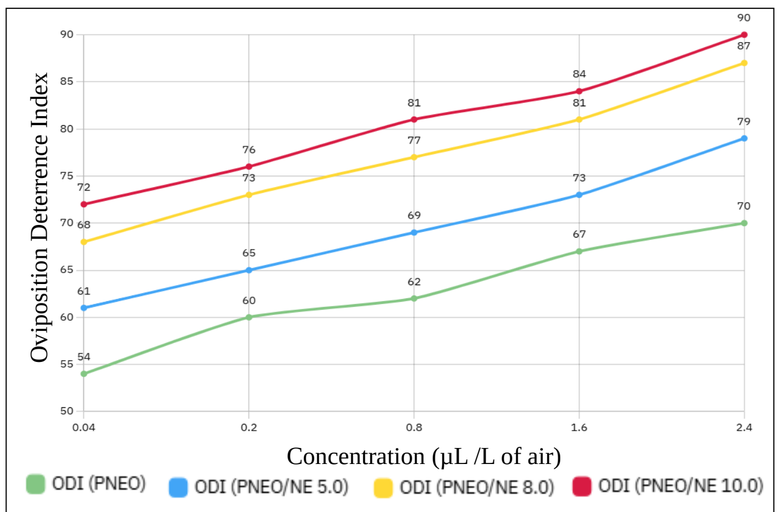


Figure 04: Oviposition Deterrence Index **(ODI)** for PNEO and PNNEs against *C. cephalonica* adults (1F:2M) at 120 hours. Values are expressed as mean ± SD (n=5)

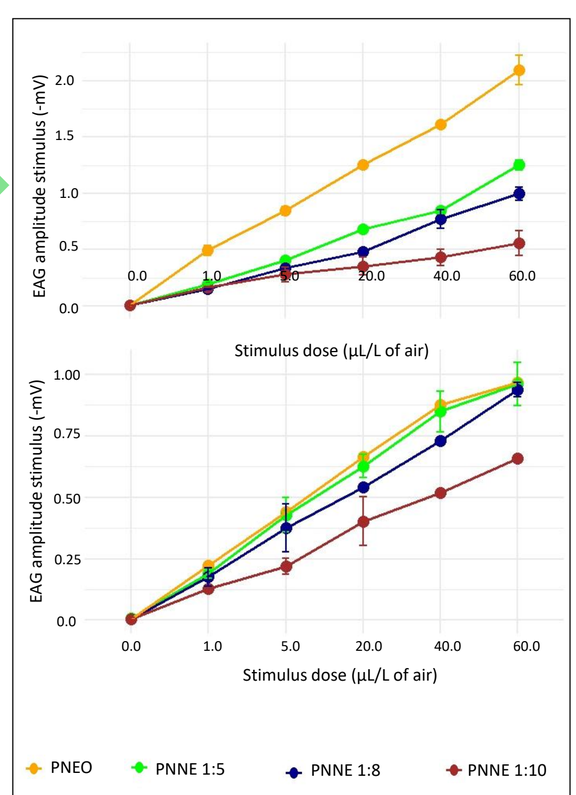


Figure 03: Mean EAG responses for PNEO and PNEO/NEs against *C. cephalonica* adult females (top) and adult males (bottom). Values are expressed as mean ± SD (n=5)

CONCLUSIONS

Particle size of PNEO > PNEO/NE 1:5 > PNEO/NE 1:8 > PNEO/NE 1:10

Rapid Volatilization ↓ Immediate Antennal Response ↓ Behavioural and Toxic Effects Over Time ↑ ODI ↑

***In silico* docking analysis indicated that PNEO constituents bind with the odorant receptor to facilitate olfactory disruption**

References
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Rahma, H., Priani, S. E., Fakih, T. M., Suarantika, F., Patricia, V. M., Laksono, B. T., & Subekti, P. I. (2025). *Nanoemulsion-based delivery system of tamanu (Calophyllum inophyllum L .) oil : Formulation , characterization , and antibacterial activity*. 1–11. https://doi.org/10.3897/pharmacia.72.e153246