bpia 2024 Annual Meeting

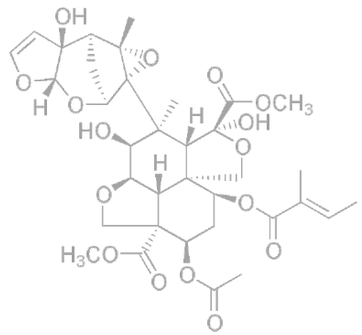
(Plant-based) Biopesticides

The “back to nature” approach is on the rise

Pedro FS Toledo

Plant-based biopesticides

Phytochemical defense traits of plants



- Evolutive pressure from herbivores, pathogens and competition with nearby plants.

Insect control

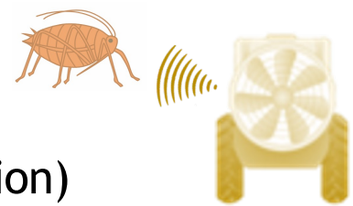
Disease control

Weed control

A plethora of biological activities

Plant-based phytocomplexes

Insecticidal blend of chemistries (many properties)



- **Toxic**

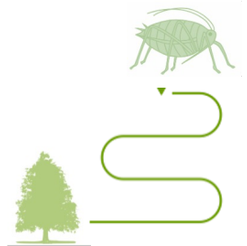
  Kill or sublethally affect (multiple modes of action)

- **Alter behavior**

  Deterrence/irritability (e.g., prevention of feeding or oviposition)

  Repellence (moving away from a stimulus)

  Confusion (to trap/lure – attract and kill - push and pull)



As a result: enormous diversity of bioactive plant secondary metabolites has been identified and prospected for pest control

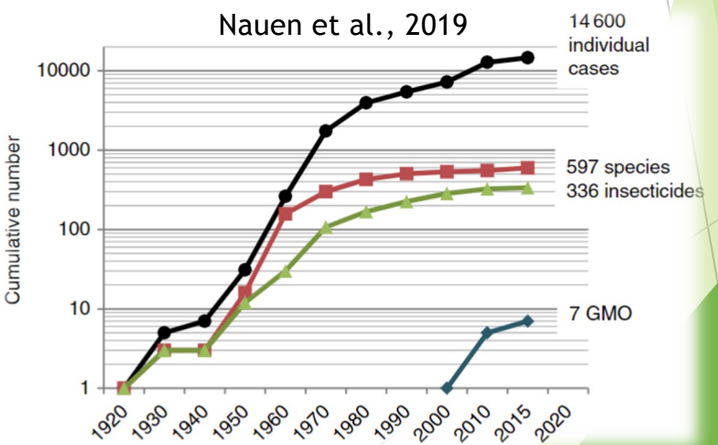
Eco-friendlier properties

Promise to mitigate pitfalls of currently-used methods

- Environmental safety and human health
  - Faster degradation (less residues)
  - Lower impacts to non-target organisms (conservation)

- Provide sustained control (e.g., managing resistance/failure)
  - Diverse (and multi) in modes of action

But chemistry **origin** does not necessarily assure desirable characteristics



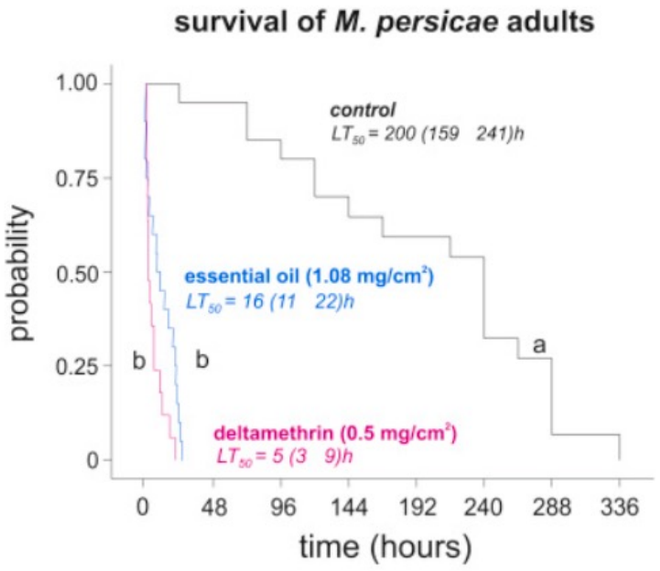
Research topics: Selectivity

compatibility with non-target organisms within agroecosystems

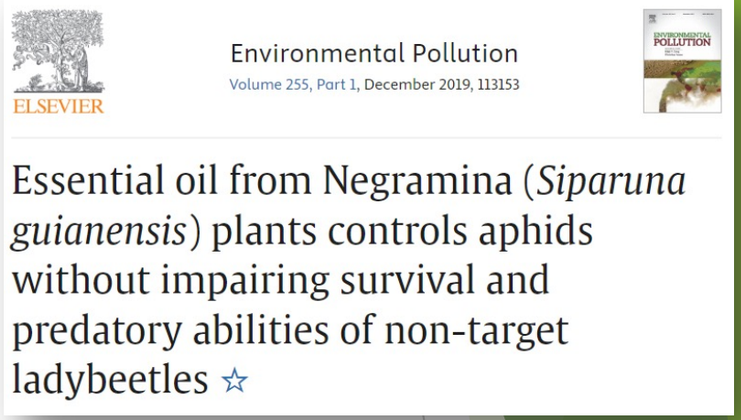
Lethal effects and potential disruptions of ecological services and ecosystem functioning

Negramina

major components: β-myrcene and 2-undecanone

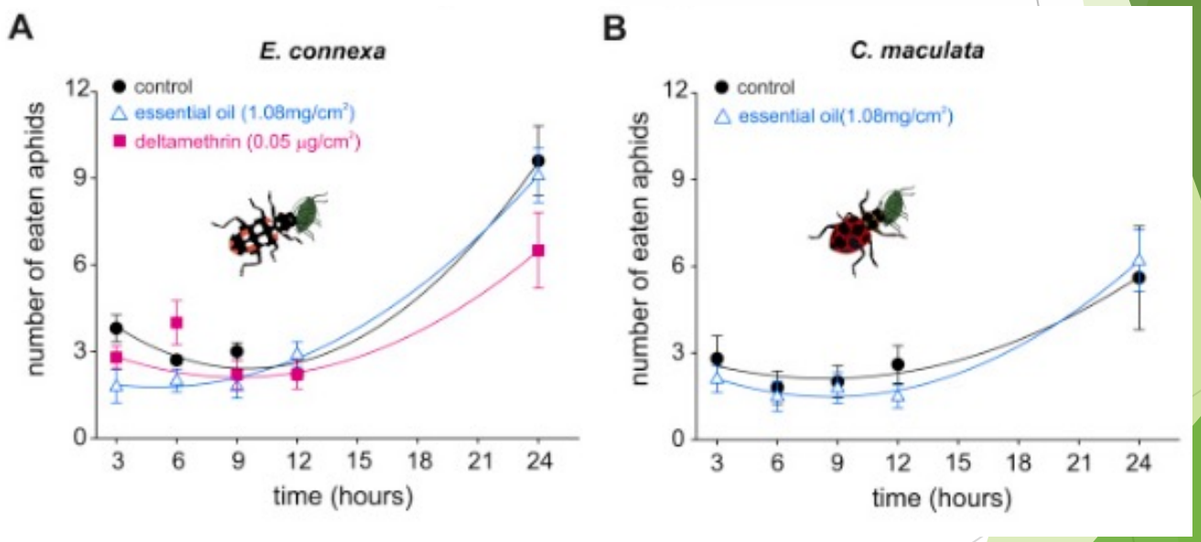


Toxic and repellent against *Myzus persicae*



Environmental Pollution
Volume 255, Part 1, December 2019, 113153

Essential oil from Negramina (*Siparuna guianensis*) plants controls aphids without impairing survival and predatory abilities of non-target ladybeetles ☆

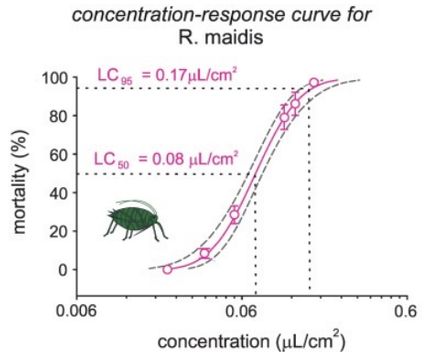


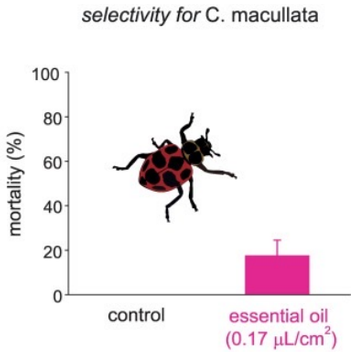
Besides not killing ladybeetles: conserved their predatory abilities

Toledo et al., 2019

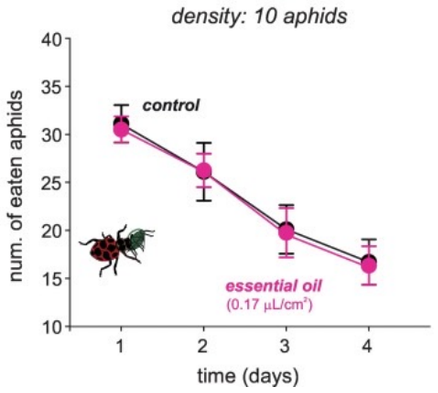
Clove

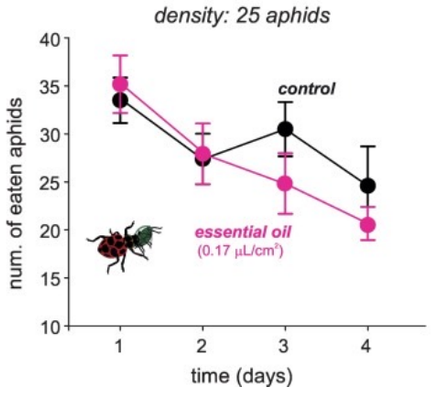
major components: Eugenol and ß-caryophyllene



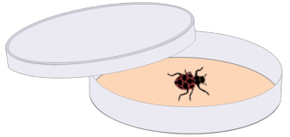


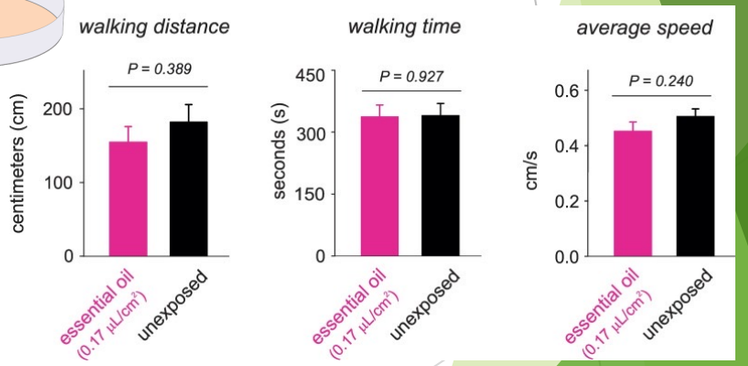
80% ladybeetle species survived concentration that kills aphids





Predatory abilities of survivors on aphids (not affected)





Did not affect locomotion

ELSEVIER

Science of The Total Environment

Volume 718, 20 May 2020, 137328

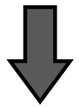
Disentangling the ecotoxicological selectivity of clove essential oil against aphids and non-target ladybeetles

Pedro F.S. Toledo [a 1], Luis O. Viteri Jumbo [a 1], Sarah M. Rezende [a], Khalid Haddi [a b], Bruno A. Silva [c], Tarcísio S. Mello [c], Terezinha M.C. Della Lucia [d], Raimundo W.S. Aguiar [e], Guy Smagghe [f], Eugenio E. Oliveira [a g]

Toledo et al., 2020

Research topics: Mode of action

What are the molecular targets of EOs?



Biological activities usually attributed to major compounds

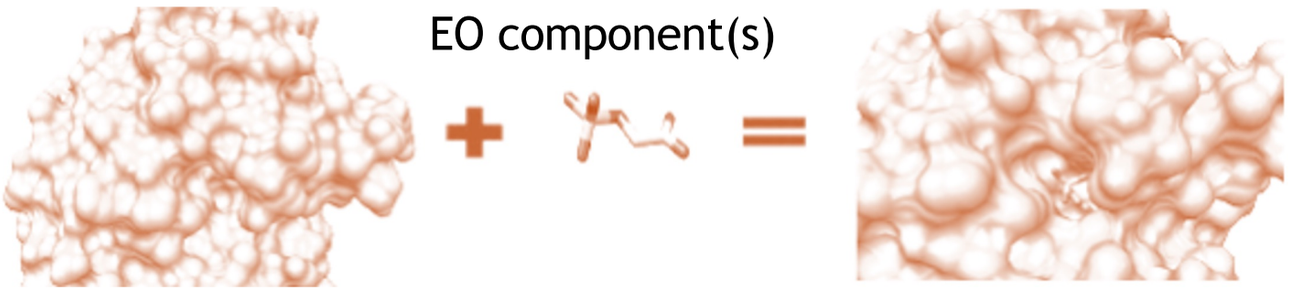
Cab be difficult to pinpoint
synergism is possible within complex blends

“Accelerating” discoveries

Computational methods to fast-forward

- Using a rational approach commonly used in drug design (initial screening)

Molecular docking - describe the interactions between receptor and ligand

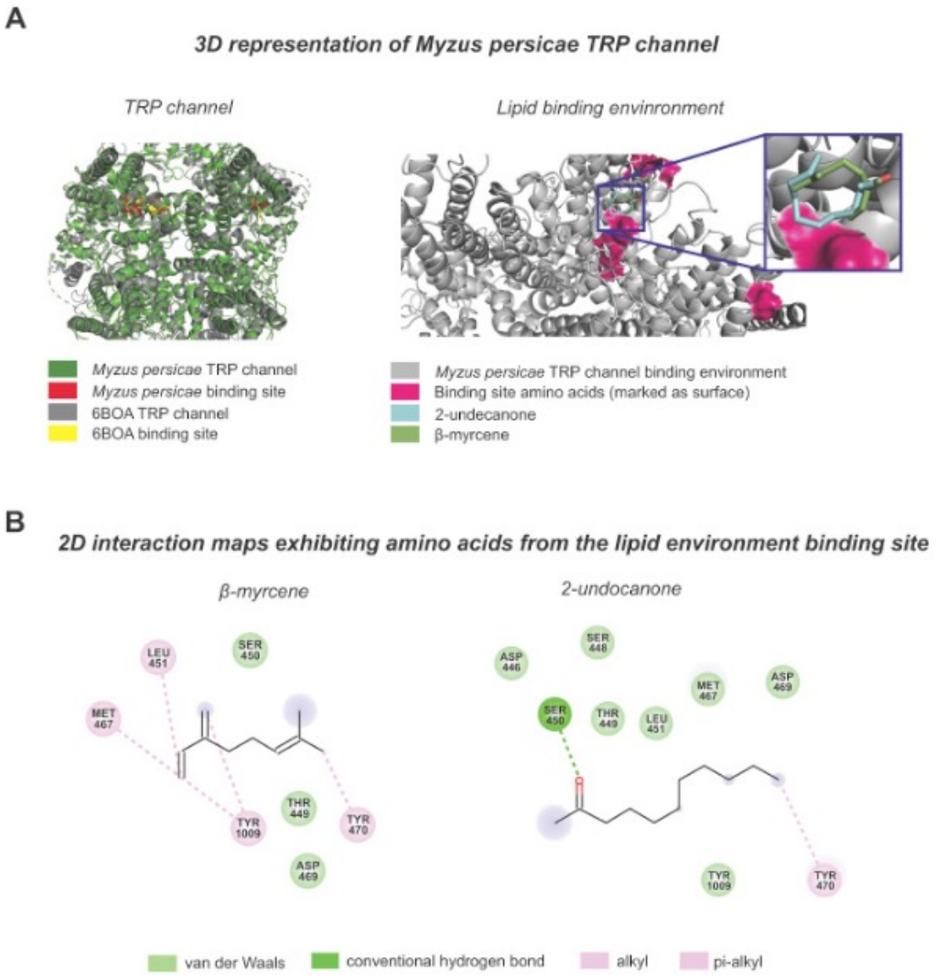


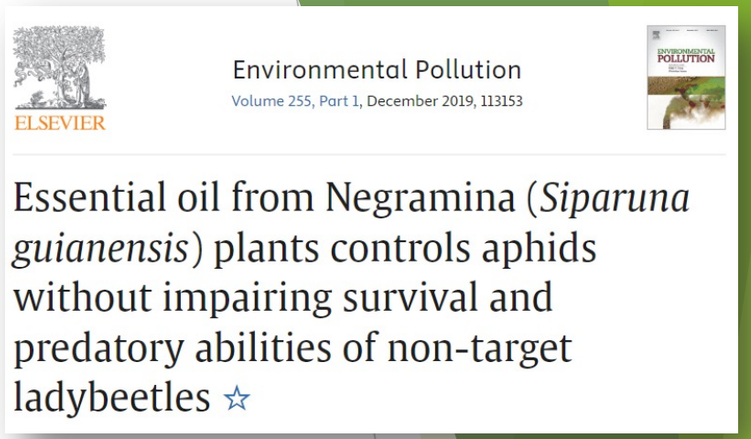
potential common target
(e.g., receptors)

in sillico docking
(reveals affinity in the interaction)

Negramina: in sillico

major components: ß-myrcene and 2-undecanone





Major compounds of the essential oil **selectively** bound only to *M. persicae* TRP channels

Toledo et al., 2019

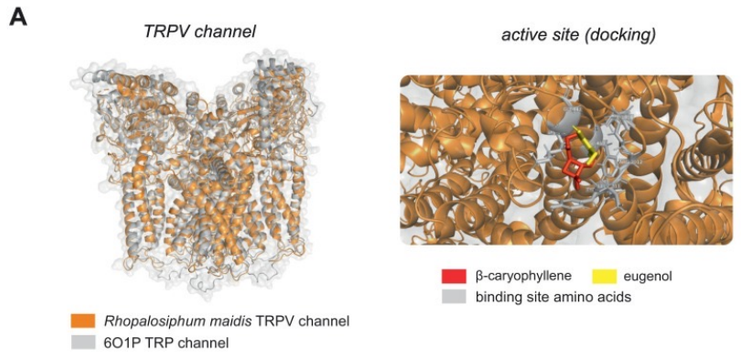
Clove: in sillico

major components: Eugenol and ß-caryophyllene

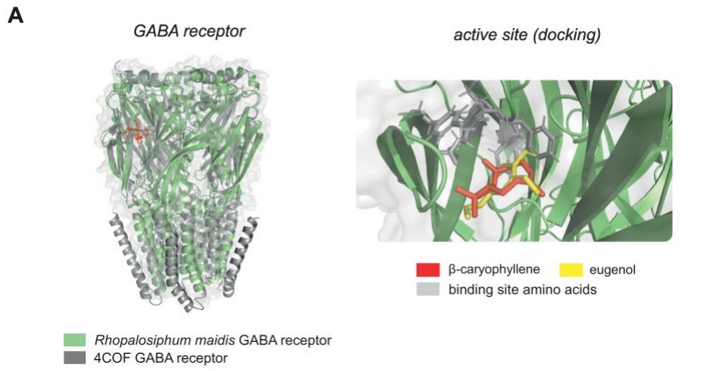
Science of The Total Environment
Volume 718, 20 May 2020, 137328
ELSEVIER

Disentangling the ecotoxicological selectivity of clove essential oil against aphids and non-target ladybeetles

***clove essential oil binds only to TRP channels* of Rhopalosiphum maidis**



***clove essential oil binds only to GABA receptors of* Rhopalosiphum maidis**



Interacted with aphid's transient receptor potential (TRP) channels and γ-aminobutyric acid (GABA) receptors (**but not ladybeetle-related**).

Toledo et al., 2020

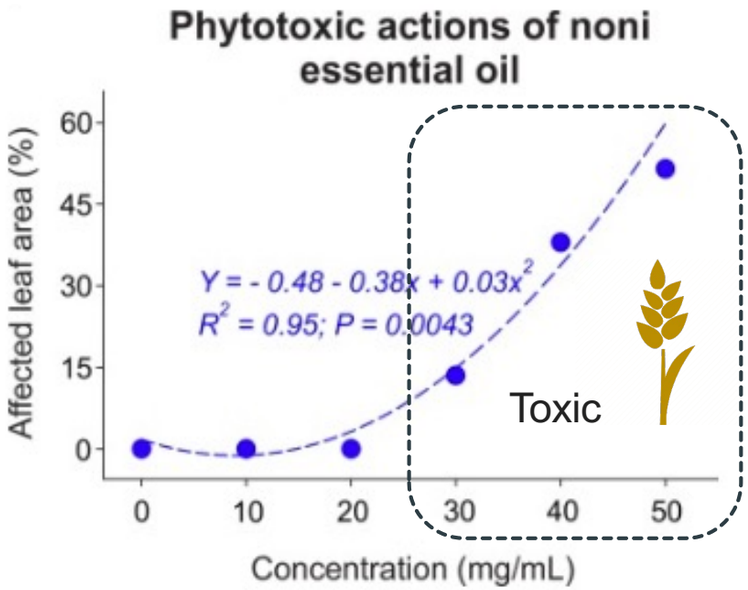
Research topics: +Compatibility

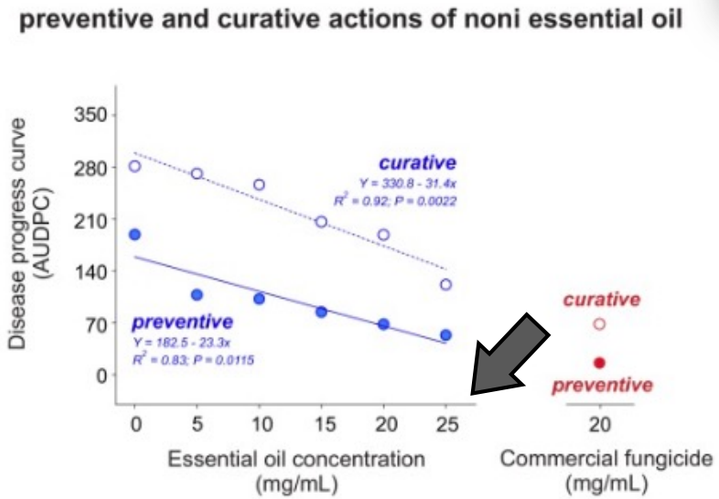
Phytotoxicity-related barriers

Chemistries should not harm crop of interest or other non-target plants

Noni: Phytotoxicity

Can be a major drawback





Preventive application reduced 71.2% of the disease severity.

Industrial Crops and Products
Volume 170, 15 October 2021, 113728

Essential oil of Noni, *Morinda citrifolia* L., fruits controls the rice stem-rot disease without detrimentally affect beneficial fungi and ladybeetles

But opportunities to the design of herbicides

Osorio et al., 2021

Research points: Delivery

low solubility, low bioavailability, and high volatility

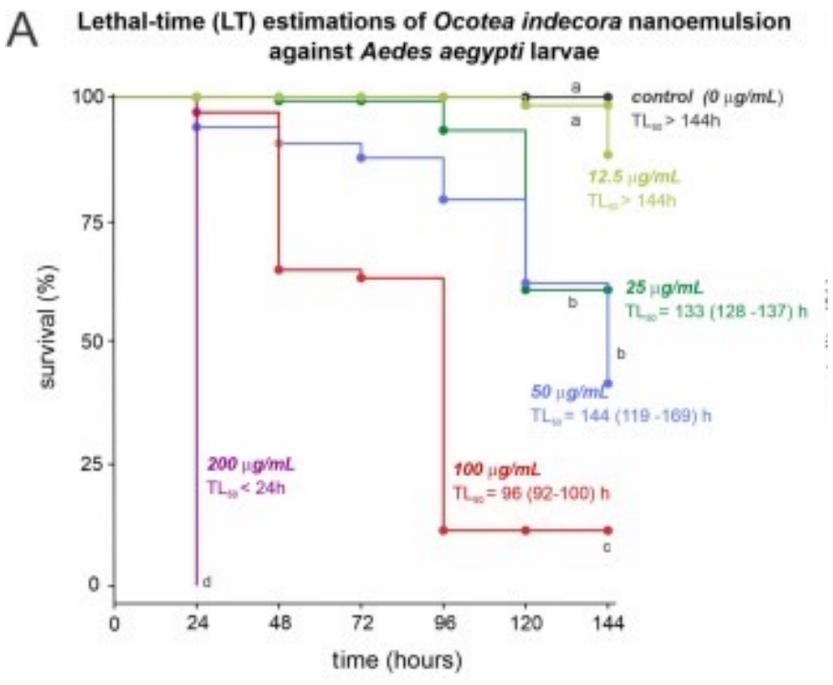
May need/benefit from special delivery methods
(e.g., nanoencapsulation)

Ocotea indecora

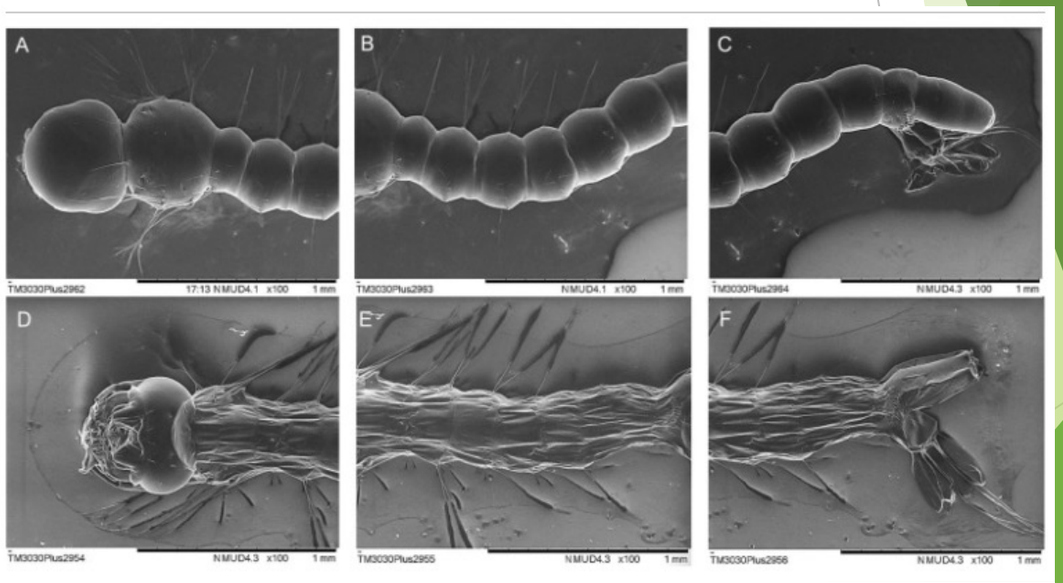
Optimized Nanoemulsion (mosquito control)
Major compound: Sesquirosefuran

Industrial Crops and Products
Volume 192, February 2023, 116031

Nanoemulsion of *Ocotea indecora* (Shott) Mez essential oil: Larvicidal effects against *Aedes aegypti*



Larvicidal effect
against *Aedes aegypti* larvae.



Affected insect cuticle

Machado et al., 2023

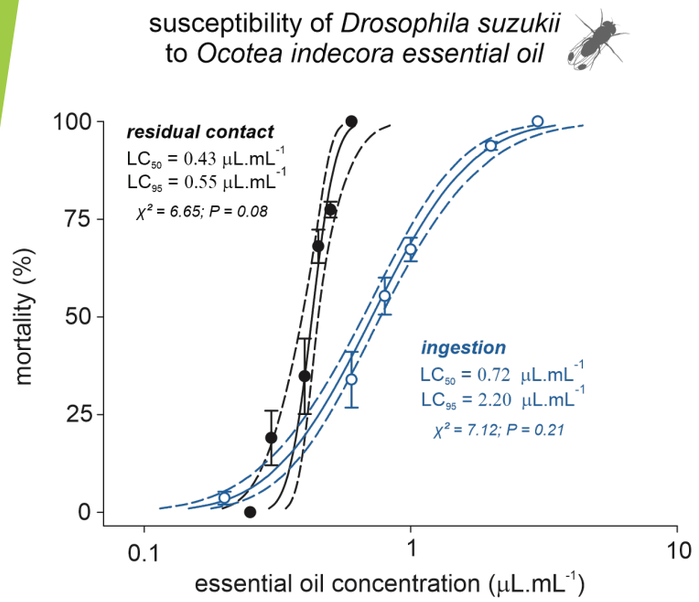
Ocotea indecora

Above-ground use in agriculture

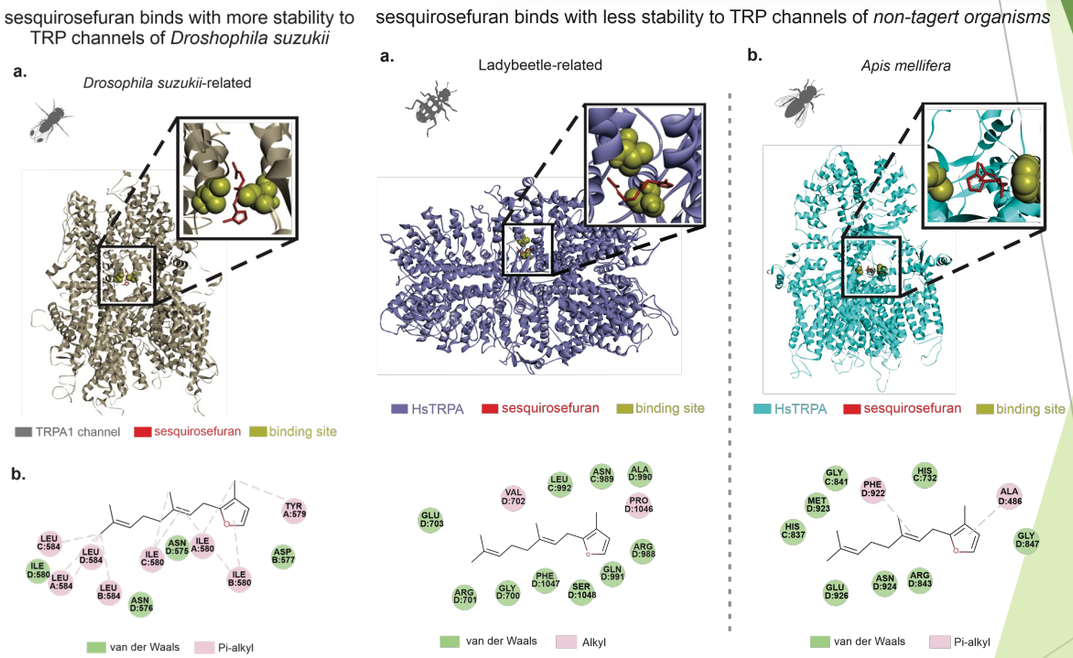
Home › Neotropical Entomology › Article

Potential of *Ocotea indecora* Essential Oil for Controlling *Drosophila suzukii*: Molecular Predictions for Toxicity and Selectivity to Beneficial Arthropods

Ecology and Management of D. Suzukii | Published: 03 January 2024



Insecticidal effect
against *Drosophila suzukii*
(two exposure pathways)



Bind to TRP channels of all insects
(**warrant evaluation of sublethal effects**)

Toledo et al., 2024

Final considerations

Current and near future (as uptake increases)

-Availability of the natural source

For “rare” oils: prices can be impractically high

- Issues with testing and regulatory approval

Standardized testing protocols (can they be imported from synthetic?)

- Famers perception of replacement (extension/advertising)

Additional tools to the toolbox: Proper use of the IPM package is key

Thank You!

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