# Microgravity effect on entomopathogenic nematodes' ability to find and kill insects

Dr. Fatma Kaplan, Pheronym
Dr. David Shapiro-Ilan, USDA
Dr. Edith Sampson, UF

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# Without pest control,
# Farmers would lose 30 - 80% of their crops



A 12% annual global crop loss, worth ~$157 Billion, is just due to plant parasitic nematodes.

*Chapter in Integrated Pest Management Reviews ( 2014) In book: Integrated Pest Management: Pesticide Problems, 3:201-225, Research and Markets*: Nematicides Market - Global Opportunity Analysis and Industry Forecast (2018-2023); *Research and Markets:* Global Nematicides Market 2017-2021*; Singh etal (2015)* Nematodes: A Threat to Sustainability of Agriculture. Procedia Environmental Sciences 29, 215-216

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# Nematodes

## The most abundant animals on earth!



- Live everywhere
- Parasitize nearly everything
- Stay dormant decades
- Difficult to control

~1020 trillion nematodes (2000/$m^2$) estimated on earth

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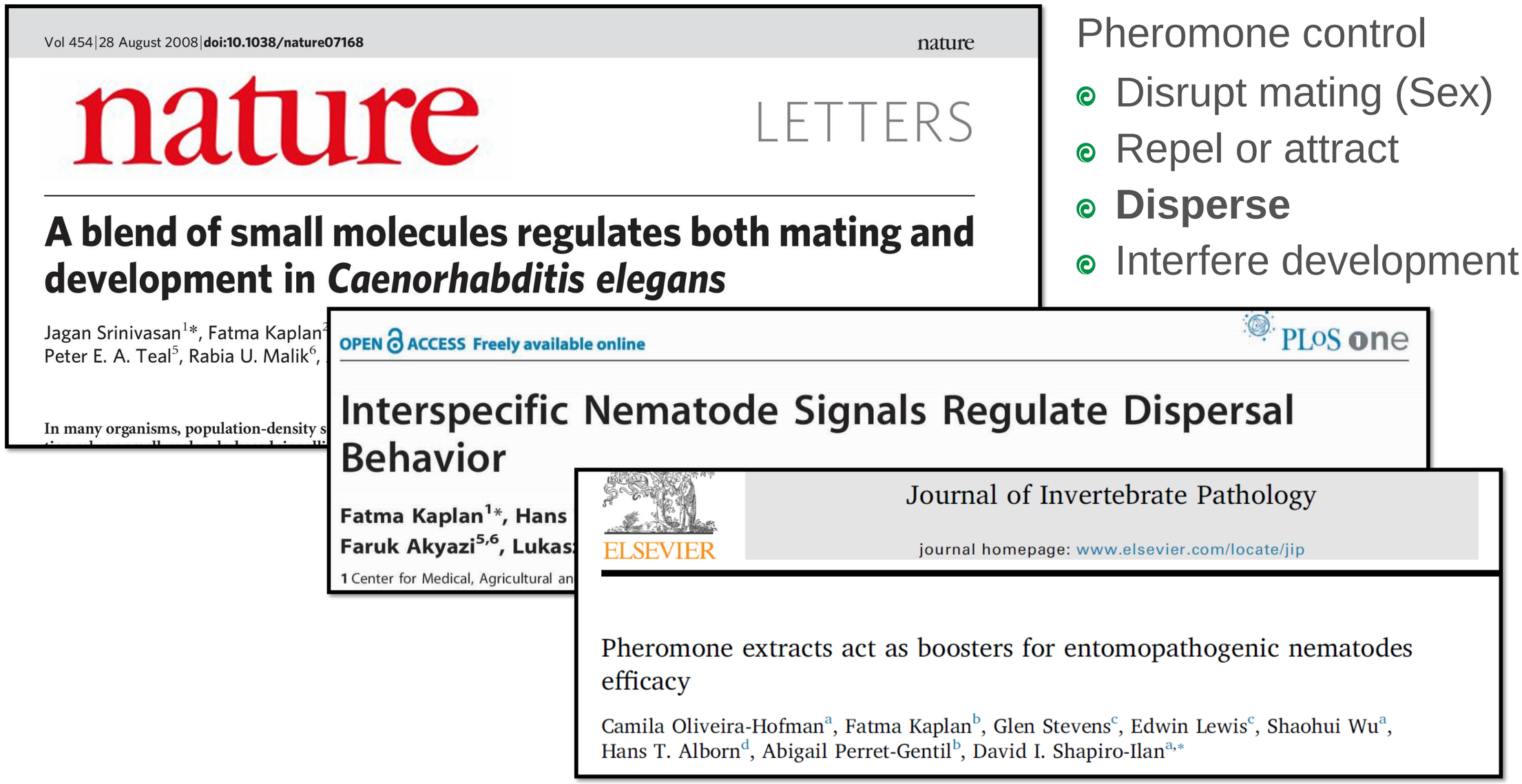
# Nematode pheromones



Vol 454|28 August 2008|doi:10.1038/nature07168

nature

LETTERS

**A blend of small molecules regulates both mating and development in *Caenorhabditis elegans***

Jagan Srinivasan[1]*, Fatma Kaplan[2]
Peter E. A. Teal[5], Rabia U. Malik[6],

In many organisms, population-density s

OPEN ACCESS Freely available online

PLoS one

**Interspecific Nematode Signals Regulate Dispersal Behavior**

**Fatma Kaplan[1]*, Hans**
**Faruk Akyazi[5,6], Lukas**

1 Center for Medical, Agricultural an

ELSEVIER

Journal of Invertebrate Pathology

journal homepage: www.elsevier.com/locate/jip

Pheromone extracts act as boosters for entomopathogenic nematodes efficacy

Camila Oliveira-Hofman[a], Fatma Kaplan[b], Glen Stevens[c], Edwin Lewis[c], Shaohui Wu[a], Hans T. Alborn[d], Abigail Perret-Gentil[b], David I. Shapiro-Ilan[a,*]

Pheromone control

- Disrupt mating (Sex)
- Repel or attract
- **Disperse**
- Interfere development

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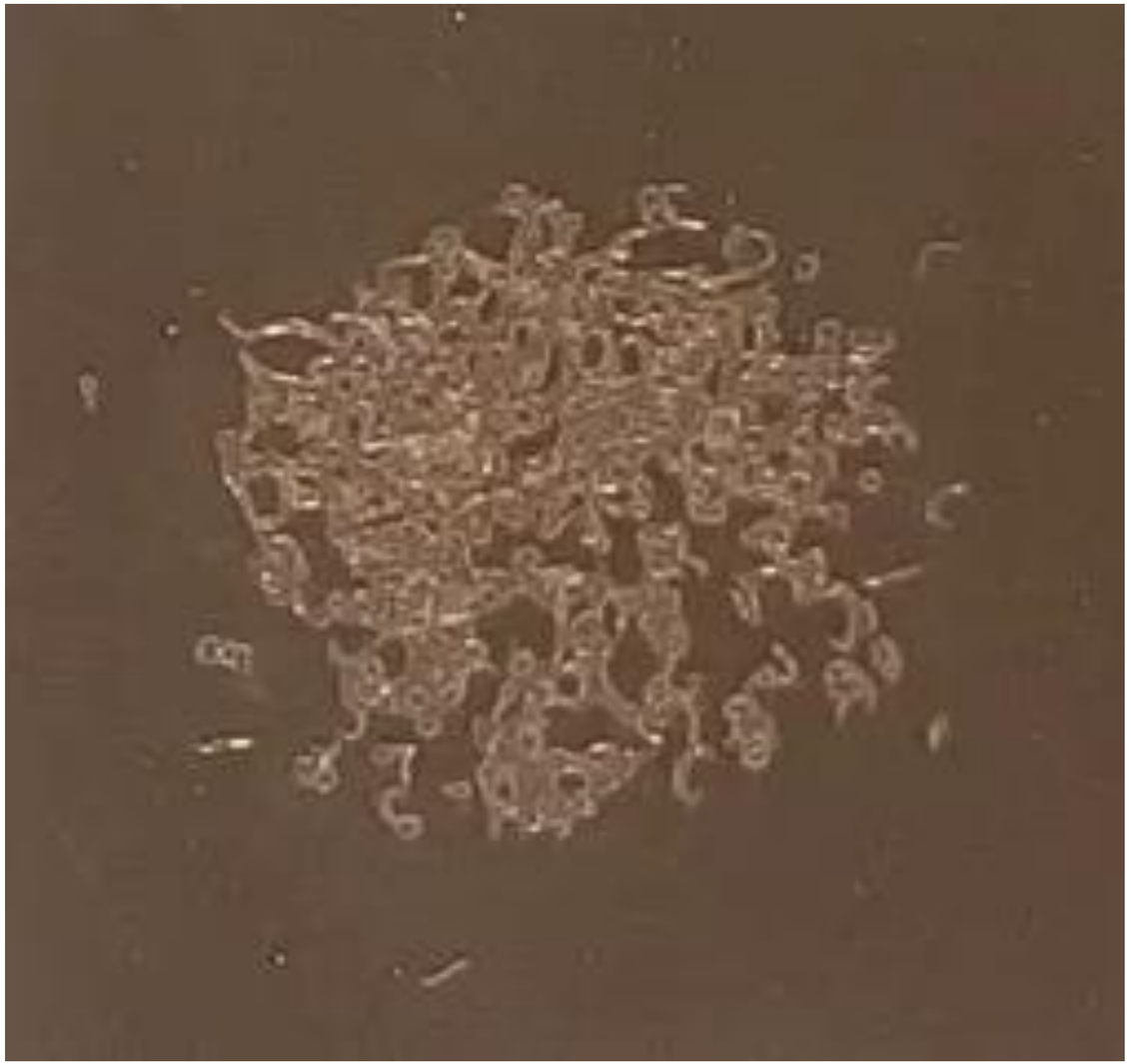
# Pheromone stimulate dispersal behavior



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# Pheronym controls all nematodes with pheromones

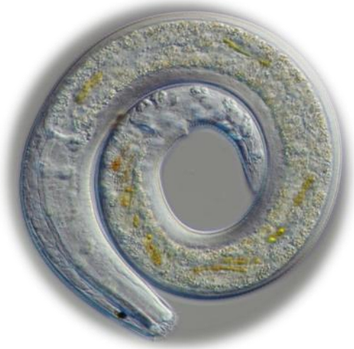
## Bad Nematodes

Infect plant root

**PheroCoat**

Repels nematodes
from plants

Nematode
Microscopic round worm



## Good Nematodes

Infect insect

**Nemastim**

Directs nematodes
toward insect pests



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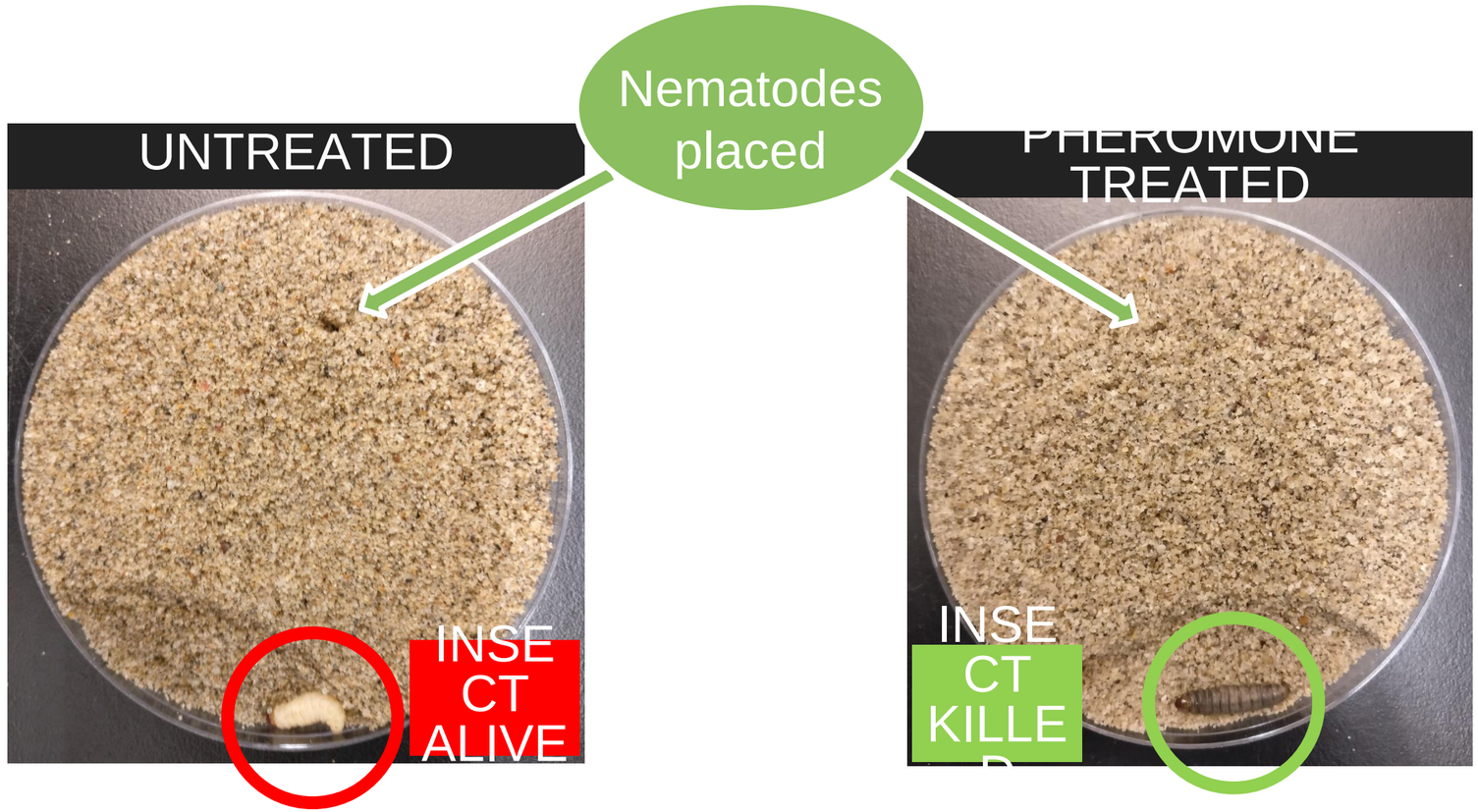
# With pheromone treatment, EPNs disperse and encounter insects

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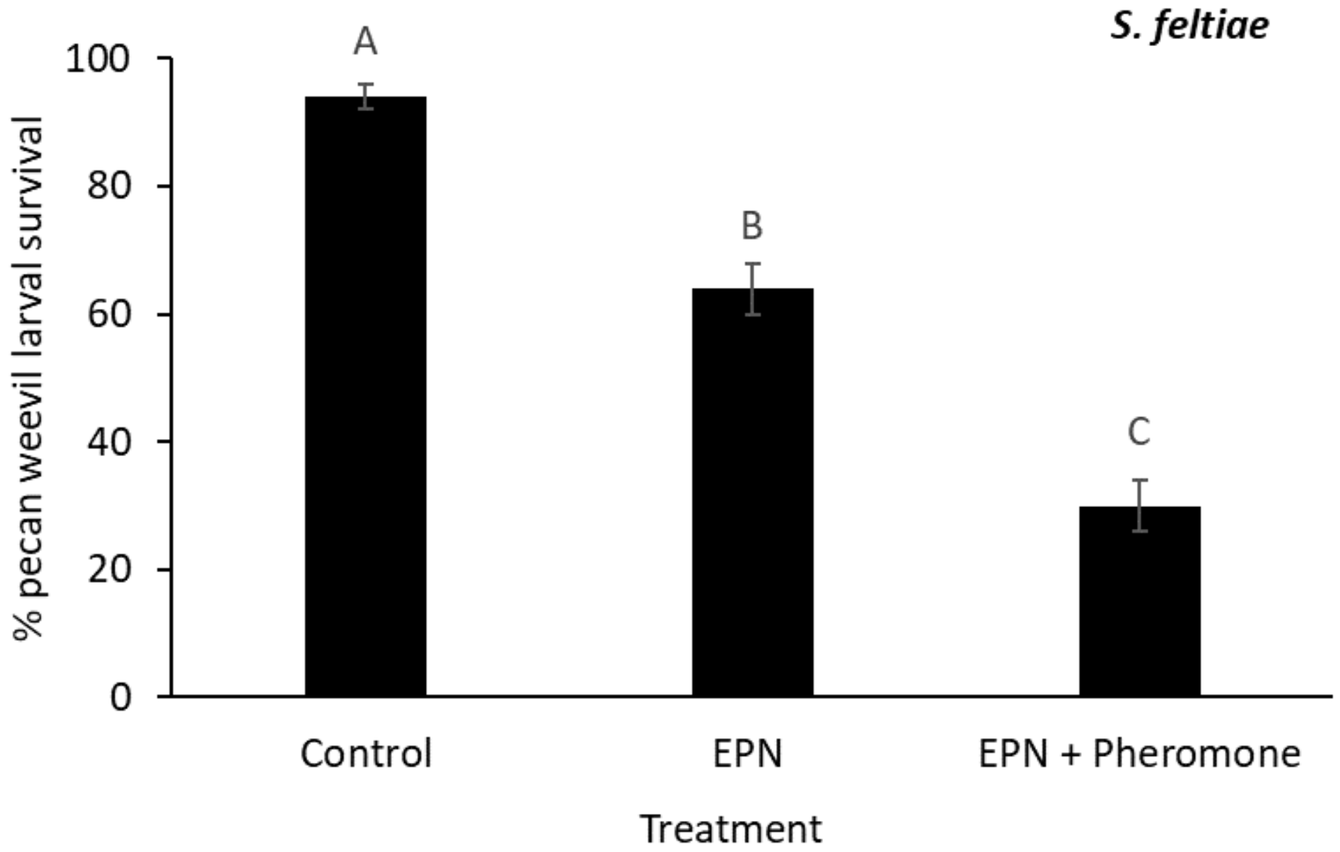
# Improved efficacy for controlling pecan weevil




USDA Agricultural Research Service

The trials conducted in the laboratory of Dr. David Shapiro-Ilan

Oliveira-Hofman et al. 2019. Pheromone extracts act as boosters for entomopathogenic nematodes efficacy J. Invertbr. Pathol. https://doi.org/10.1016/j.jip.2019.04.008

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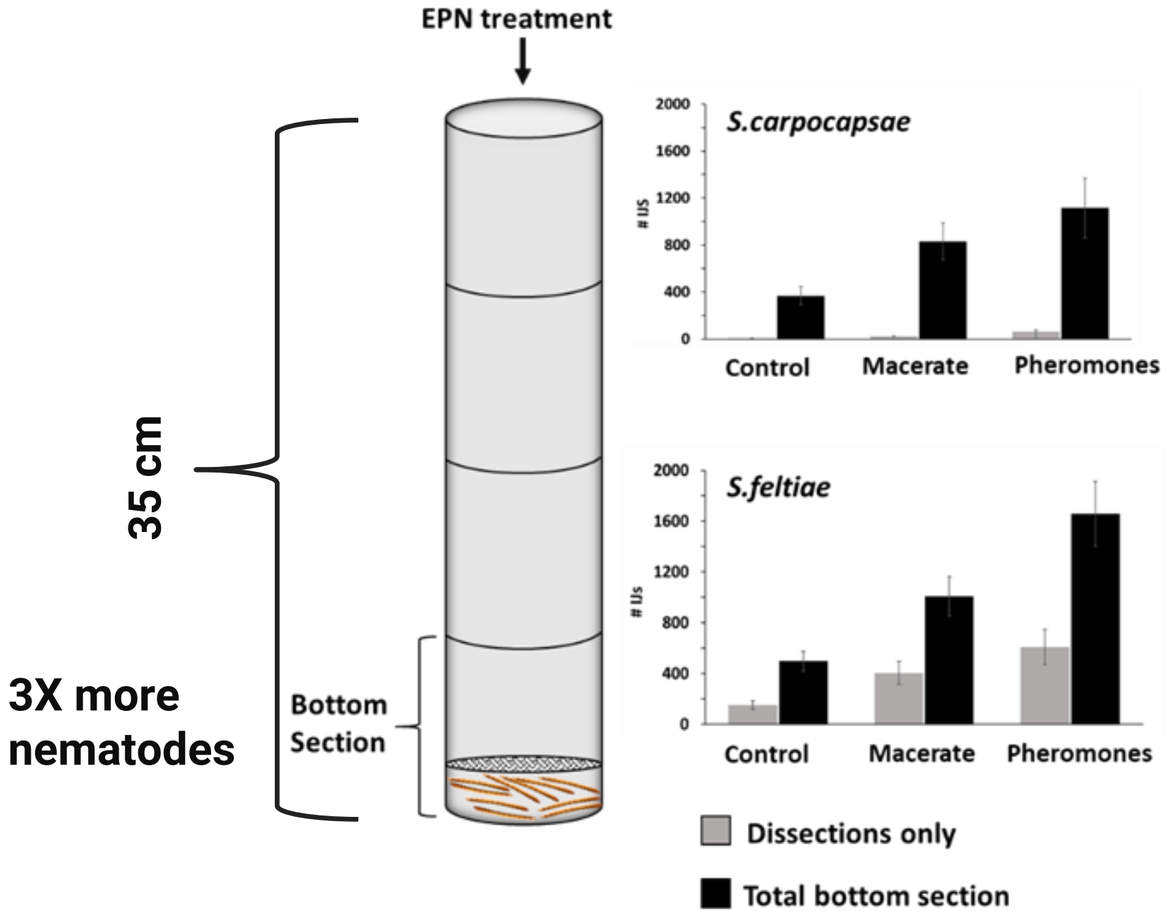
# With Nemastim treatment, more nematodes go further in the soil




USDA Agricultural Research Service

**The trials conducted in the laboratory of Dr. David Shapiro-Ilan**

Provide more coverage in the soil and can enhance others' products

Oliveira-Hofman et al. 2019. Pheromone extracts act as boosters for entomopathogenic nematodes efficacy J. Invertbr. Pathol. https://doi.org/10.1016/j.jip.2019.04.008

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# Bee friendly insect control solution with good nematodes

One product 2 beneficial nematodes controlling 25 insect pests

Nemastim™ → *S. feltiae* → **Thrips,** fungus gnats; **pecan weevil,** armyworms, banana root borer, shore flies, sweetpotato weevil, leafminers, **codling moth**, corn earworm, **borers, citrus root weevil**

Nemastim™ → *S. carpocapsae* → artichoke plume moth, **banana moth**, black cutworm, mole crickets, **corn rootworm**, billbug, **black vine weevil**, cat flea, cranberry girdler, crane fly, iris borer, large pine weevil, **navel orangeworm**, scarab grubs

Nemastim makes nematodes
- move faster
- go deeper in the soil
- infect in 3X higher numbers
- 28% to 78% more effective

**Pecan weevil** targets


Pecan


Walnut

**Citrus root weevil** targets 270 plants


Citrus


Sugarcane


Potatoes


Strawberry

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# In line with NASA's mission to colonize the Moon and Mars

Open Agriculture. 2017; 2: 14–32

DE GRUYTER OPEN

**Review Article**

**Open Access**

Raymond M. Wheeler*

## Agriculture for Space: People and Places Paving the Way

DOI 10.1515/opag-2017-0002

Received December 14, 2016; accepted January 15, 2017

**Abstract:** Agricultural systems for space have been discussed since the works of Tsiolkovsky in the early 20th century. Central to the concept is the use of photosynthetic organisms and light to generate oxygen and food.

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BIOCONTROL IN SPACE • USDA • PHERONYM • ISS • NL

ASTRONEMATODE

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# Good nematodes are part of healthy soil ecosystem

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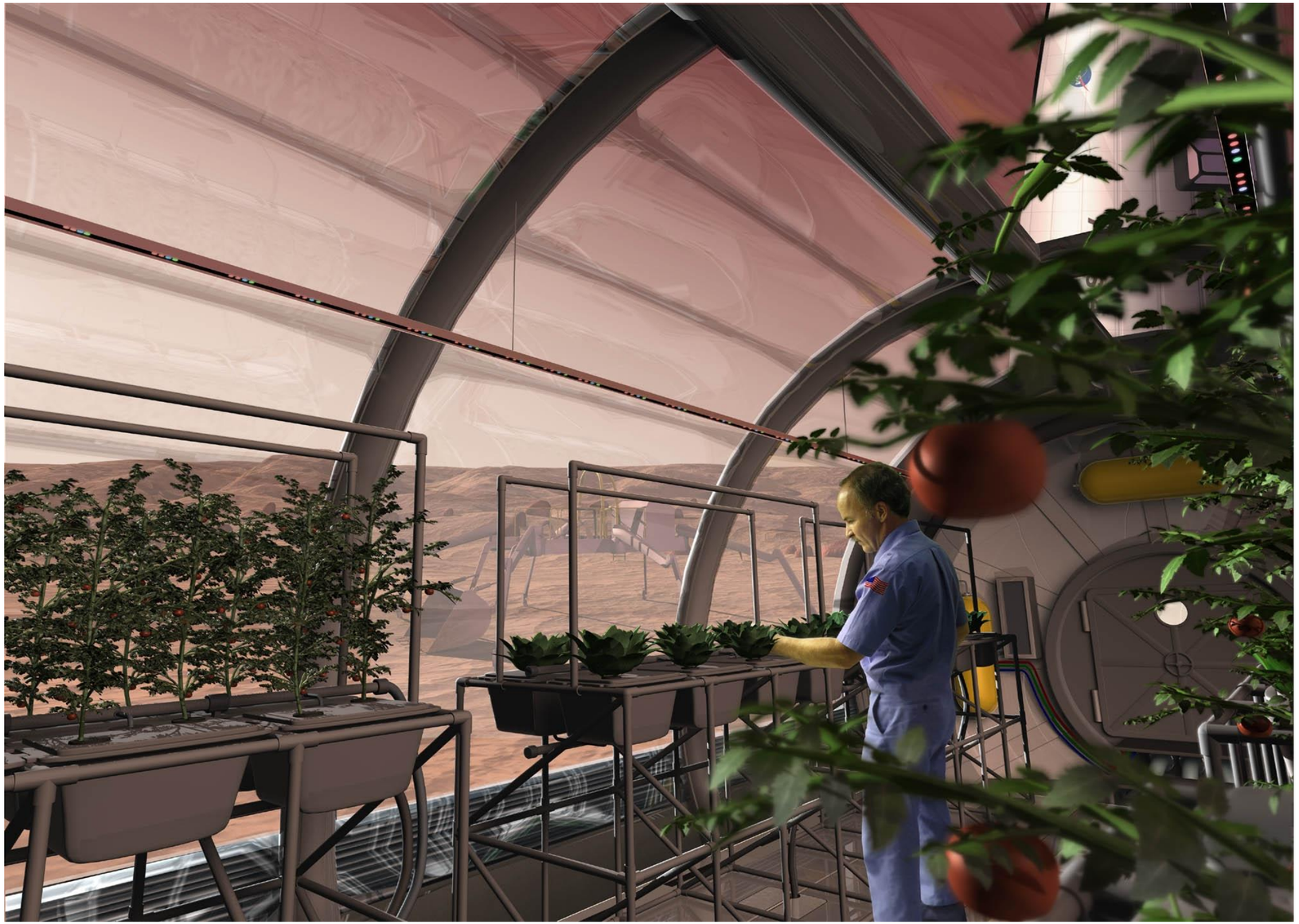
# One Tiny Step for a Nematode,
# One Big Step Toward Sustainable Agriculture in Space



https://www.ars.usda.gov/news-events/news/research-news/2019/starship-nematode/

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# Explore basic research questions


- How is pheromone production affected?
- Can EPNs find insects in microgravity?
- How does the insect immune system respond?
- Does space flight affect their infectivity?
- Would EPNs (reproduced in space) have the same microbiome?

- How does the space radiation affect nematode’s future progeny, life span, behavior, infectivity, etc?

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# Acknowledgement of funding and resources

## Funding

**Accelerator and Angel Investment**

SPACE FLORIDA

**USDA SBIR Phase I**

ISS U.S. NATIONAL LABORATORY

USDA NIFA

## Incubator and Cooperative Agreement

**CRADA**

USDA Agricultural Research Service

Greenhouse, orchards, lab and equipment

**Incubator**

HM•CLAUSE Life Science Innovation Center UCDAVIS

Shared lab space and equipment

*Leveraged grant funding, incubators and accelerators to build an investor-ready start-up*

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# AstroNematode
# Launched on December 5, 2019 on SpaceX Falcon 9 CRS-19, Returned on Jan 7, 2020

The 1st agriculture biocontrol experiment in space

For updates:

- Go to www.astronematode.com
- Follow @astronematode

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