Global Forum on Biological Control and Training Workshop on Biological Control

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Studies on non-target effects of biopesticides

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Introduction

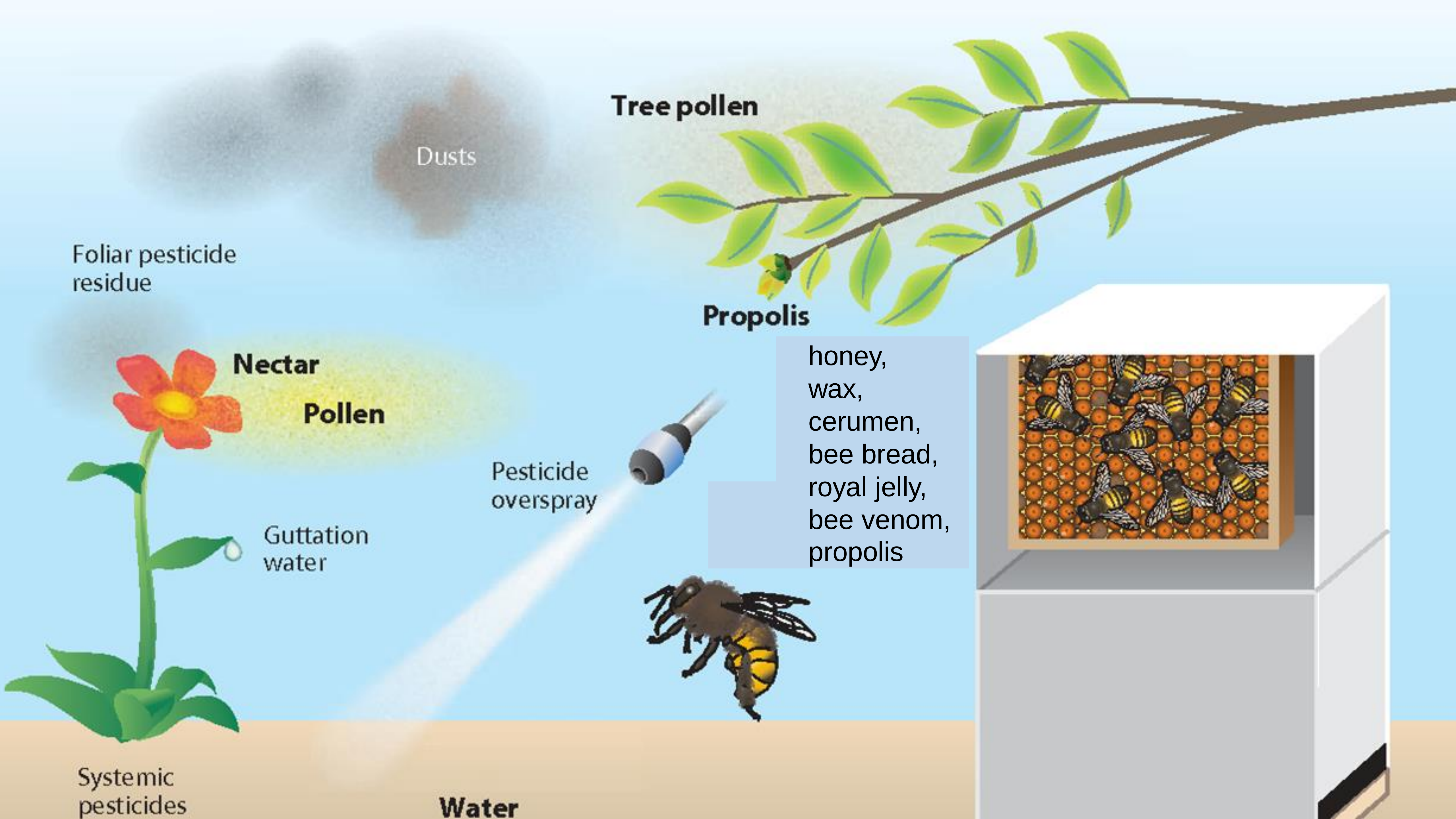
- Agriculture partly depends on the beneficial services offered by nature:

  - Over 75% of flowering crops depend on insect pollinators.
  - Some pollinators (bees) provide hive products such as honey, wax, cerumen, bee bread, royal jelly, bee venom, and propolis.

  - Natural enemies (parasitoids and predators) reduce pest populations.

  - Soil invertebrates improve fertility.

Chemical insecticides constitute the key drivers to the alarming global decline of pollinators.


Tree pollen
Dusts
Foliar pesticide residue
Propolis
Nectar
Pollen
honey,
wax,
cerumen,
bee bread,
royal jelly,
bee venom,
propolis
Pesticide overspray
Guttation water
Systemic pesticides
Water

Do maize plants require insect pollination?

- Bees foraging on maize, other flowering crops (legumes, sunflowers) and wildflowers (weeds) on, and around maize field may be exposed to several chemical insecticides sprayed on fields (Fernandez-Cornejo et al. 2014; Long and Krupke 2016).
- To protect pollinators, biopesticides based on entomopathogenic fungi (EPF) can be used as alternatives to chemical insecticides.

Biopesticides developed at icipe

Ecotoxicological test of biopesticides

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- Ecotoxicological dossiers are available for registered biopesticides.
- Ecotoxicological dossiers are based on Organisation for Economic Co-operation and Development (OECD,1998) guidelines to test suboptimal doses (<10^7 conidia/mL) through oral exposure in short bioassays (<96 hr) with honeybees.
- Stingless bees have never been used as test insects.
- Long (10-days) bioassays with honeybees and stingless bees can result in variable toxicity levels depending on EPF isolates.
- International Organization of Biological Control (IOBC) classification:
  - ❖Class 1: harmless (<25%),
  - ❖Class 2: slightly harmful (25%-50%),
  - ❖Class 3: moderately harmful (51%-75%),
  - ❖Class 4: harmful (>75%)

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Selected biopesticides screened for non-target effect on pollinators (honeybees and stingless bees)

Biopesticide isolate name	Trade Name	Target pests
Metarhizium anisopliae ICIPE 7	Detain	Fall armyworm
Metarhizium anisopliae ICIPE 78	Achieve, Mazao achieve	Fall armyworm, Spider mites,
Metarhizium anisopliae ICIPE 20	-	Tuta absoluta, Fall armyworm, leafminers
Metarhizium anisopliae ICIPE 62	Mazao supreme	Aphids
Metarhizium anisopliae ICIPE 69	Campaign	Thrips, whiteflies, leafminers
Beauveria bassiana ICIPE 284	-	Fall armyworm

Akutse et al., 2020

Objectives of the study

Effect biopesticides on survival of bees in lab

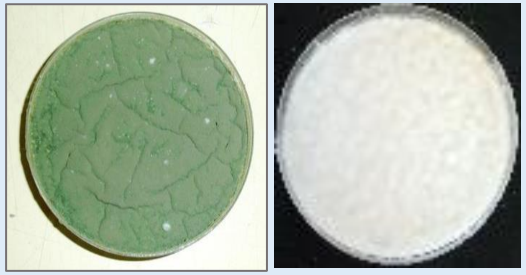
Modelling performance of the biopesticides in bee colonies simulated temperatures.

Effect of biopesticides on bee pollination behaviour and crop productivity in semi-field trials

Effect of biopesticides on survival of bees

Honeybees
Apis mellifera

Stingless bees
Meliponula ferruginea



Fungal isolates

Spray tower

- Applying 10^8 conidia/mL or water on filter paper.
- Exposure of 25-30 bees/cage in four replicates.

Incubators

Honeybees

Stingless bees

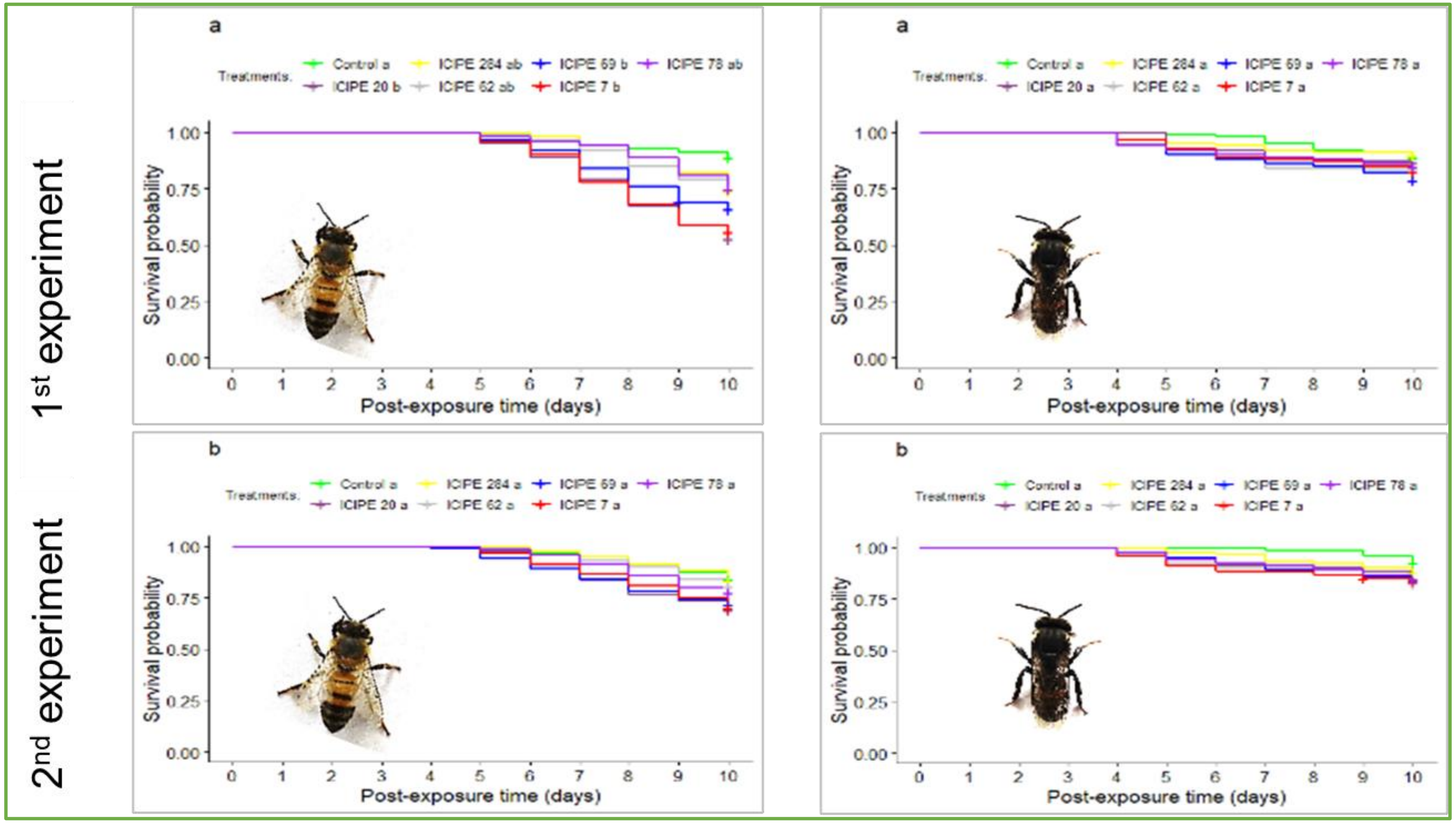
10-days survival bioassays

Results

Kaplan-Meier survival curves of fungus-exposed bees

Honeybees

Stingless bees



The tested isolates were moderately and nontoxic to bees according to the International Organization of Biological Control (IOBC) classification

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Research

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Biological and Microbial Control

Susceptibility of the Western Honey Bee *Apis mellifera* and the African Stingless Bee *Meliponula ferruginea* (Hymenoptera: Apidae) to the Entomopathogenic Fungi *Metarhizium anisopliae* and *Beauveria bassiana*

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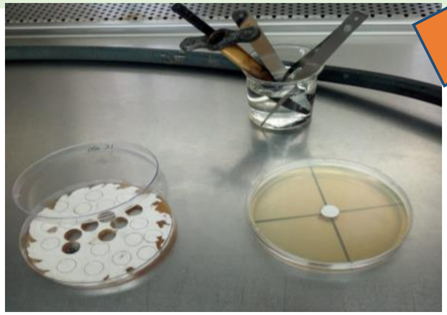
Modelling the performance of the biopesticide isolates under bee colonies' temperatures

Conidial germination

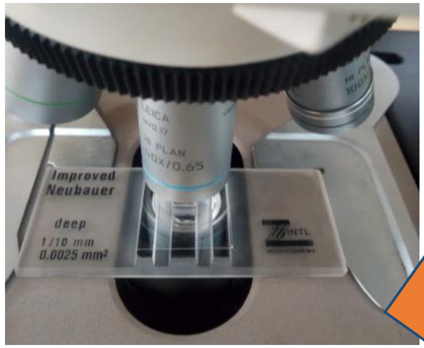
Fungal suspension (10^6 conidia/mL)

Mycelial growth

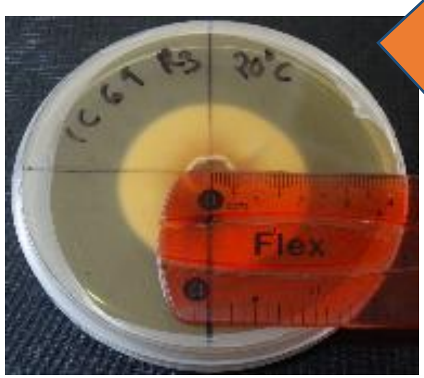


Mycelial mat

Incubation at 12, 16, 20, 24, 28, 32, 36°C



Observation of conidial germ tubes



Measurement of radial growth

Model selection

Eight models from literature

Model validation

Output

Model comparison

- Goodness-of-fit
- Adjusted R-squared

Thermal requirements for isolates:
Tmin (°C), Topt (°C), Tmax (°C), Pmax (%germination, mm/day)

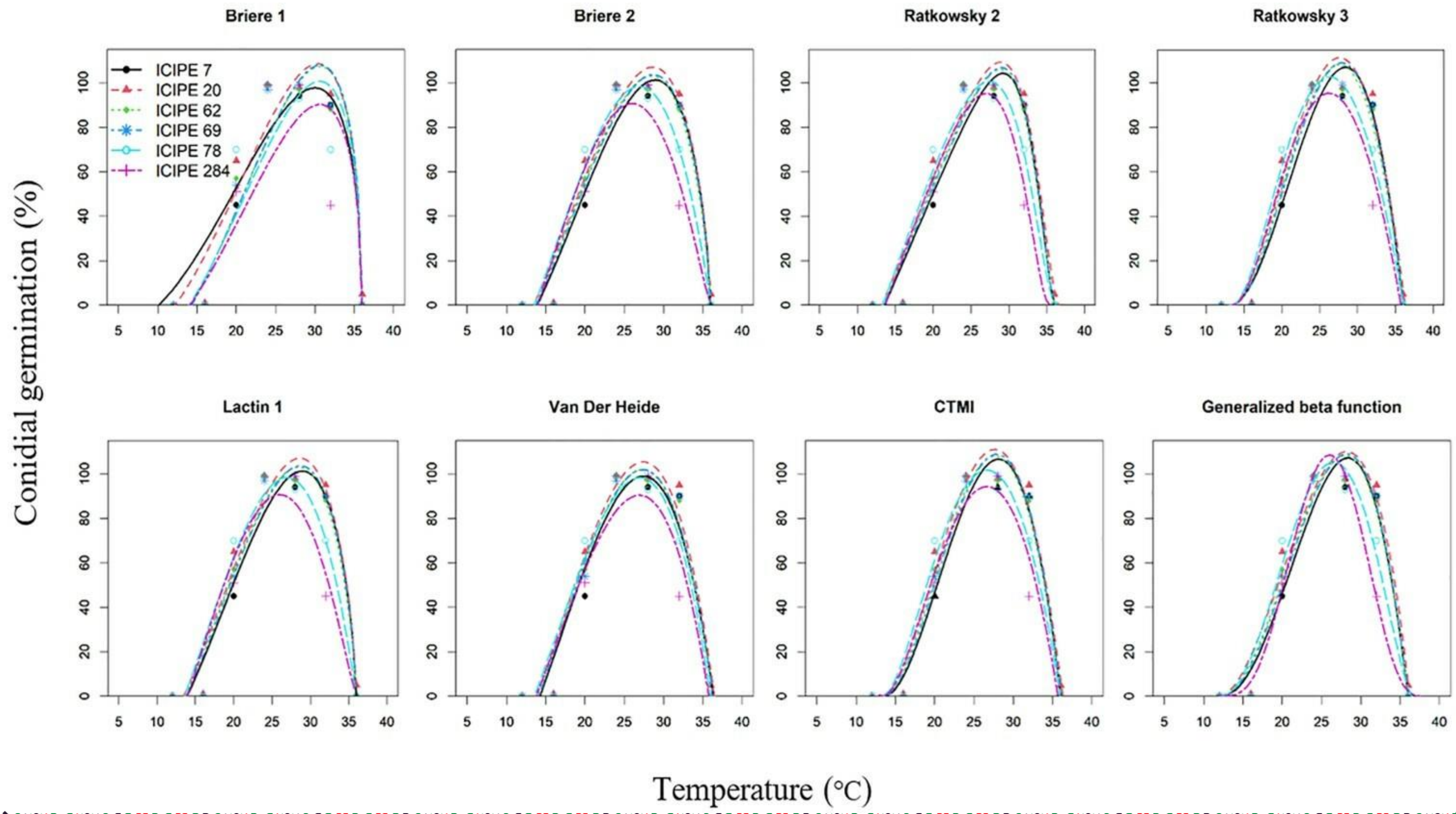
Temperature dependent models tested

Model tested

1. Briere 1
2. Briere 2
3. Ratkowsky 2
4. Ratkowsky 3
5. Lactin 1
6. Van Der Heide
7. CTMI (Cardinal temperature model with Inflection)
8. Generalized beta function

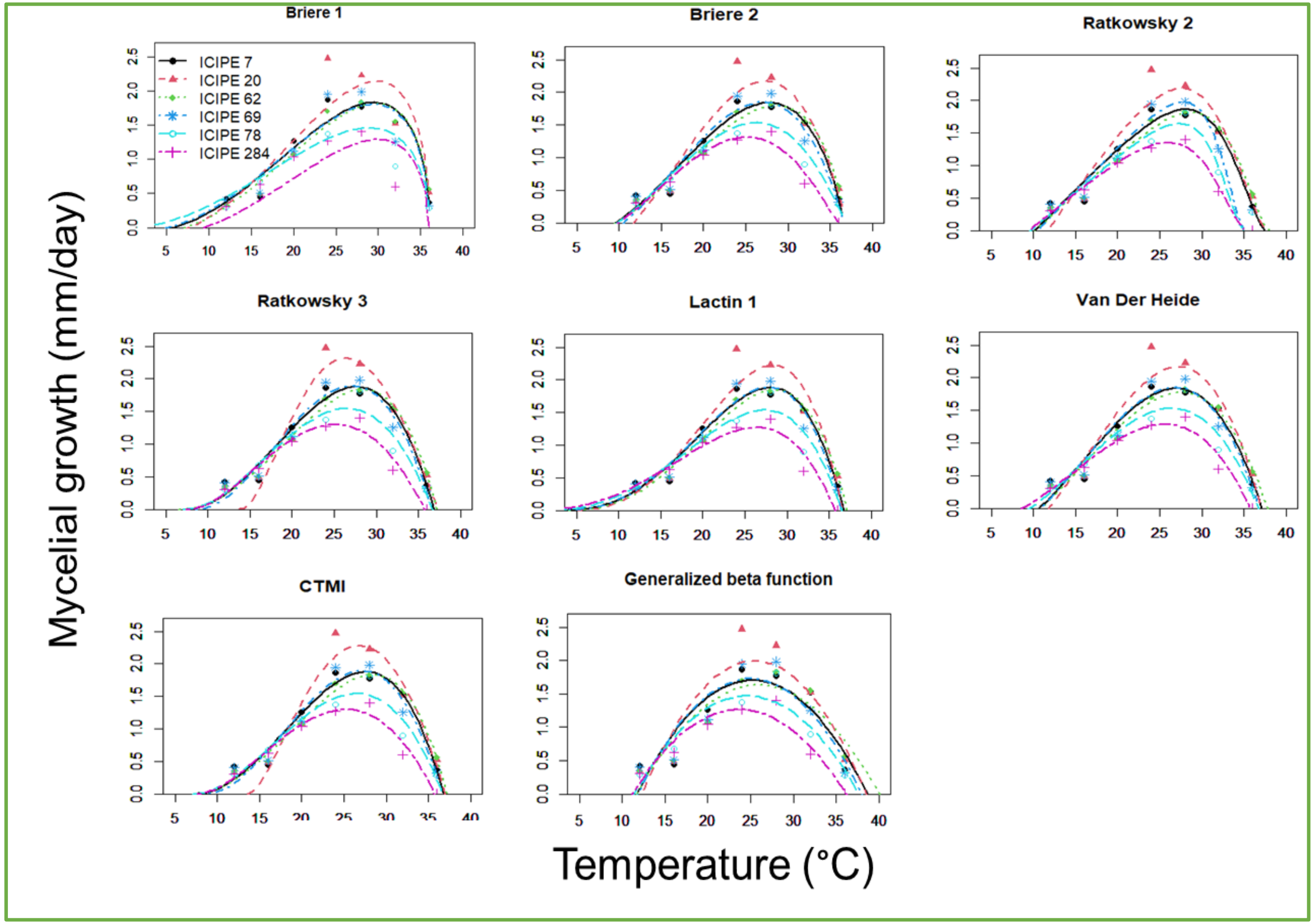
Results

Conidial germination curves by temperature-dependent models



Conidial germination started from 10–14°C and reached a peak at 25–30°C, followed by a precipitous decline reaching upper thresholds at 35–38°C.

Growth curves as predicted by 8 temperature-dependent models



Isolate	Tmin (°C)	Topt (°C)	Tmax (°C)	Pmax (mm/day)
ICIPE 7	7.4	27.6	36.8	1.89
ICIPE 20	13.5	26.8	37.0	2.28
ICIPE 62	3.7	28.4	37.2	1.85
ICIPE 69	8.7	27.1	36.6	1.89
ICIPE 78	7.3	26.5	36.7	1.54
ICIPE 284	9.5	25.9	35.4	1.36

Taylor & Francis

Biocontrol Science and Technology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cbst20

Suitable models to describe the effect of temperature on conidial germination and mycelial growth of *Metarhizium anisopliae* and *Beauveria bassiana*

Evanson R. Omuse, Saliou Niassy, John M. Wagacha, George O. Ong'amo, Abdelmutalab G. A. Azrag & Thomas Dubois

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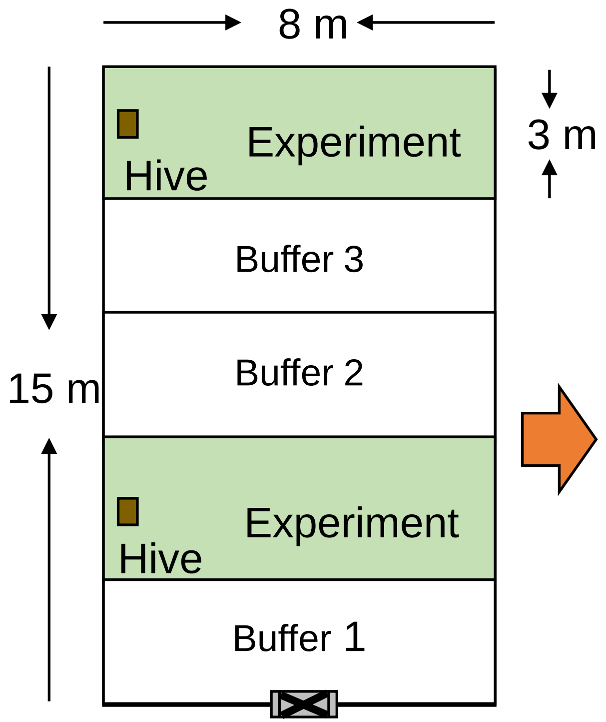
Effect of a biopesticide on survival, pollination behaviour and success of the stingless bee



Cultivation of cucumber in screenhouses

Introduction of bee colonies and application of biopesticide (ICIPE 69) or distilled water (control)

Flight activity

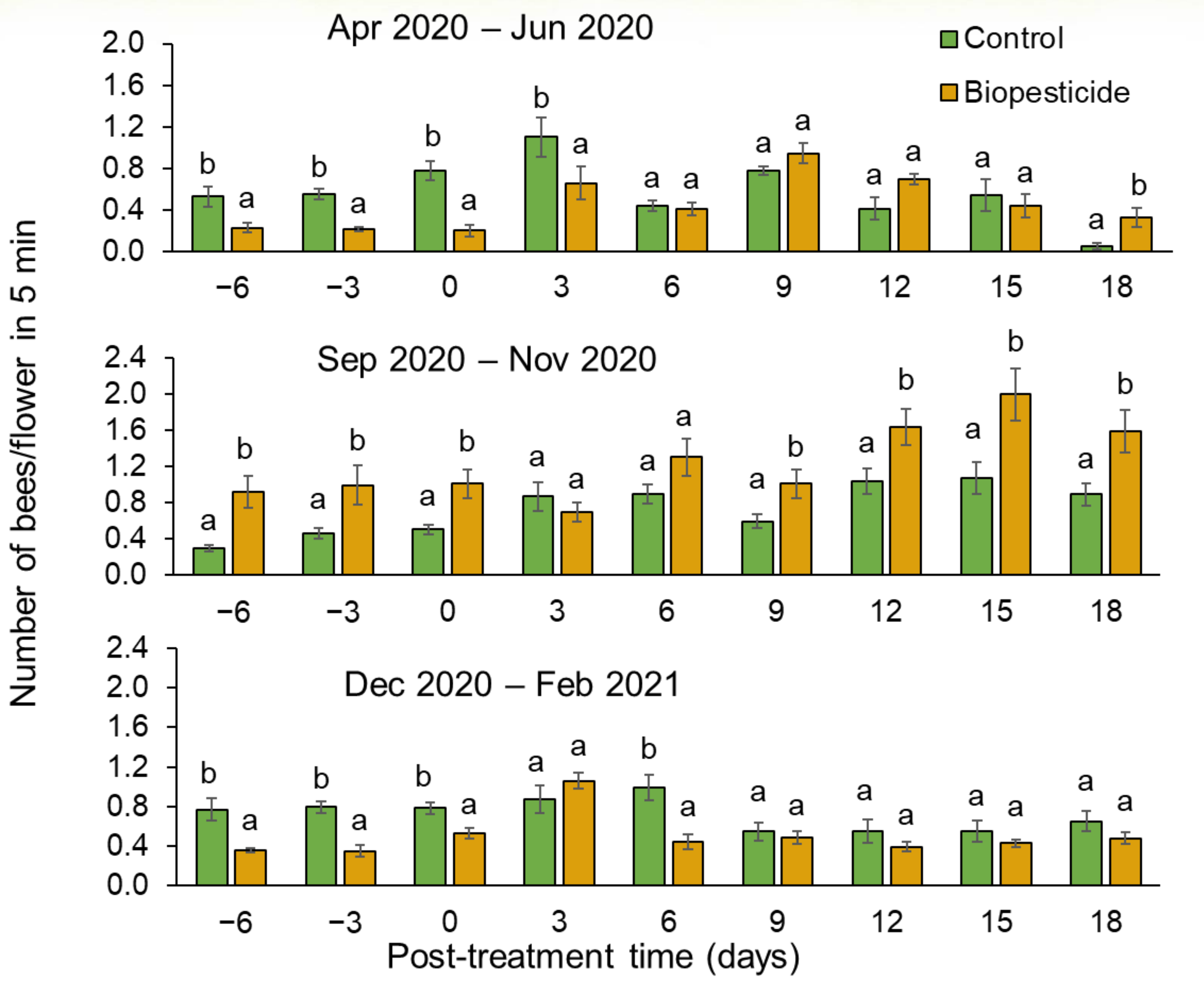
Foraging activity, survival

Fruit set, maturation and yield)

Experiment was repeated three times in Apr 2020 – Jun 2020, Sep 2020 – Nov 2020, and Dec 2020 – Feb 2021

Results

Foraging activity



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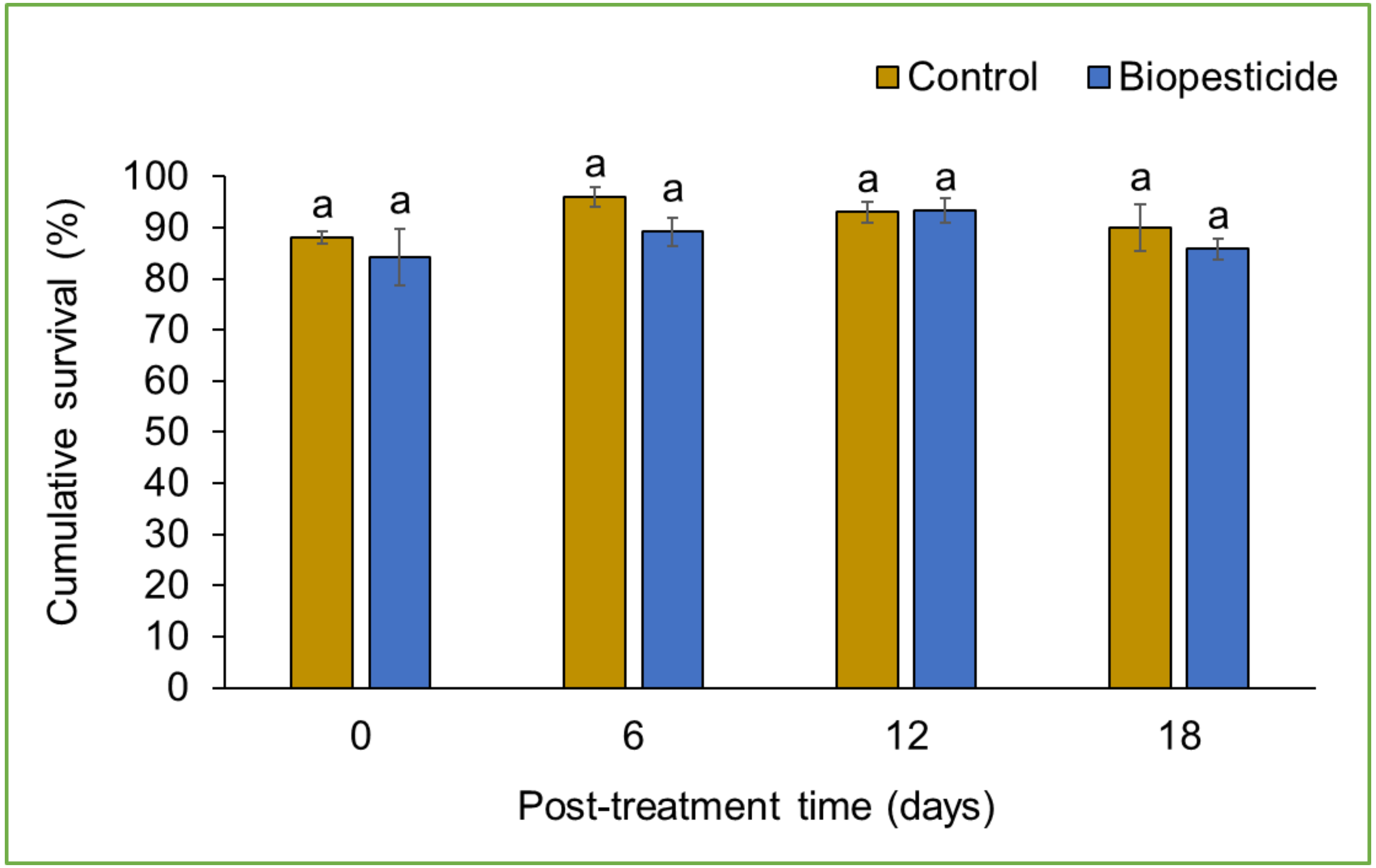
Survival of forager stingless bees



Fruit set and maturation (%)

Days	Fruit set (%)			Mature fruits (%)	
	Control	Biopesticide		Control	Biopesticide
−9 − −7	88 ± 2	89 ± 3		80 ± 4	80 ± 4
−6 − −4	94 ± 1	91 ± 2		88 ± 2	87 ± 2
−3 − −1	94 ± 1	89 ± 5		90 ± 2	87 ± 2
0 − 2	94 ± 2	96 ± 3		84 ± 5	88 ± 5
3 − 5	94 ± 1	92 ± 2		89 ± 2	88 ± 2
6 − 8	88 ± 1	86 ± 6		81 ± 2	76 ± 2

Fruit weight (g)

Days	Apr 2020 – Jun 2020			Sep 2020 – Nov 2020			Dec 2020 – Feb 2021	
	Control	Biopesticide		Control	Biopesticide		Control	Biopesticide
−9 − −7	296 ± 15	257 ± 22		354 ± 13	358 ± 27		338 ± 15	371 ± 29
−6 − −4	289 ± 22	272 ± 22		366 ± 15	376 ± 21		363 ± 18	366 ± 21
−3 − −1	246 ± 22	234 ± 28		362 ± 36	359 ± 14		379 ± 42	372 ± 22
0 − 2	304 ± 21	242 ± 26		379 ± 19	353 ± 15		376 ± 24	380 ± 27
3 − 5	248 ± 20	253 ± 37		385 ± 83	336 ± 24		372 ± 22	378 ± 20
6 − 8	234 ± 24	196 ± 16		346 ± 31	311 ± 20		364 ± 20	376.± 27

Apidologie (2022) 53:28

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Original article

Check for updates

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A fungal-based pesticide does not harm pollination service provided by the African stingless bee *Meliponula ferruginea* on cucumber (*Cucumis sativus*)

Evanson R. Omuse[1,2], Saliou Niassy[1], Nkoba Kiatoko[1], H. Michael G. Lattorff[1], John M. Wagacha[2], Thomas Dubois[1]

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Conclusions

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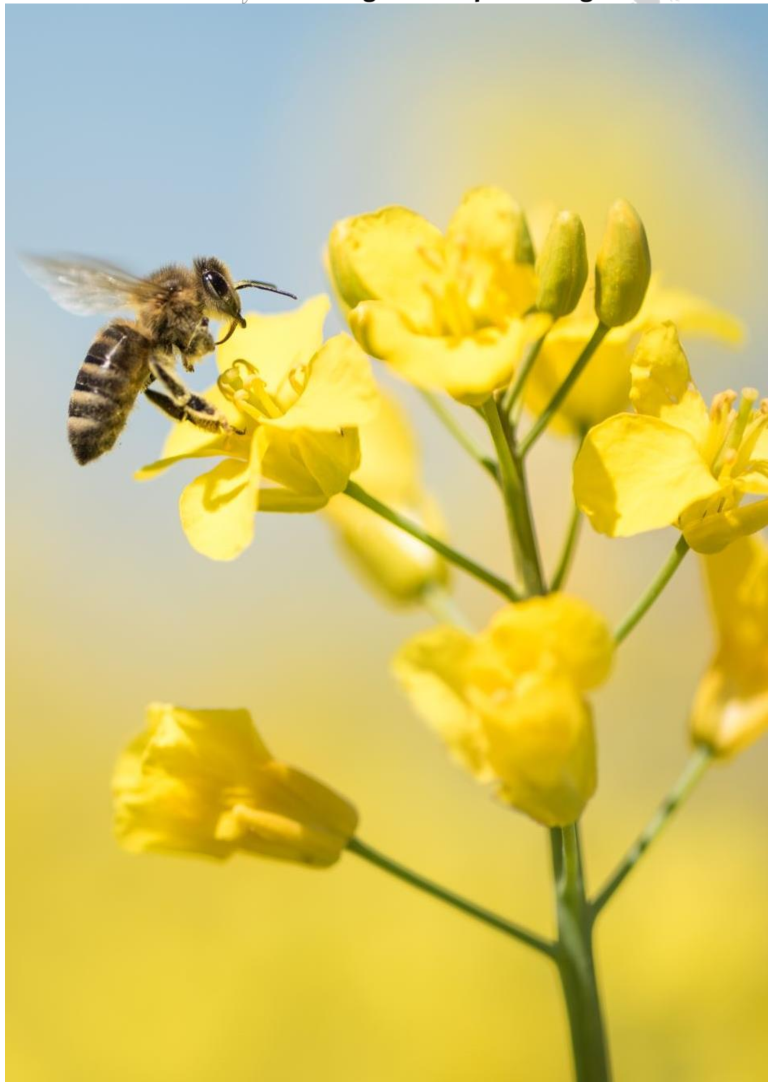
- Mortality due to biopesticides did not exceed 17.4% for honey bees or 11.0% for stingless bees.
- Biopesticides can germinate and grow optimally in beehive conditions.
- Biopesticide did not hamper bee pollination behaviour and success.
- The tested biopesticides can be safely used as to control insect pests in bee-resourced crop systems.
- The interactions of bee pollinators and biopesticides can also be limited by:
  1. careful timing of biopesticide application to avoid peak foraging periods.
  2. improving ‘lure and infect’ application techniques.



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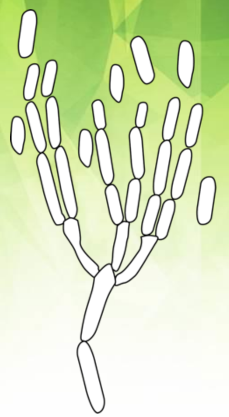

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