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Agrochemical pollution is a key driver of global insect declines, calling for increased scrutiny in regulatory assessments. Current environmental risk assessments (ERAs) for pollinating bees primarily rely on the western honeybee (*Apis mellifera*) as a surrogate species. However, bees can vary significantly in their sensitivity to agrochemicals due to differences in life-history, body size, feeding behavior, and detoxification capacity; this raises concerns about the extrapolation of *A. mellifera* data to other species. Here we show that *A. mellifera*-centric environmental risk assessments likely underestimate risks to other eusocial bee species. Following standard protocols (OECD 245), newly emerged workers from three eusocial bee species (two honeybee and one stingless bee species) were chronically exposed to increasing concentrations (0–1,000 ng g⁻¹) of a neonicotinoid for 15 days to determine median lethal daily dose (LDD) values based on sucrose consumption and mortality. Our results reveal significant time-dependent interspecies differences – *A. mellifera* (82 ± 25) revealed the highest and *Tetragonula laeviceps* (5 ± 1) the lowest LDD at day 10, whereas *Apis cerana* displayed the greatest tolerance (10 ± 1) compared to *A. mellifera* (3.8 ± 2.3) and *T. laeviceps* (3.3 ± 0.6) at day 15 (median LDD [ng g⁻¹ d]). While bee size and consumption are significant predictors of agrochemical susceptibility, they do not fully explain our findings, suggesting that other mechanisms regulate agrochemical sensitivity across species (e.g., detoxification abilities or life-history). Our findings underscore the urgent need to improve agrochemical regulatory standards to mitigate environmental risks of chemicals and thereby safeguard insect biodiversity.

Chronic exposure unravels varying susceptibility across three eusocial bee species

Symposium – Bee Health: Effects of Pesticides 2

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u^b Collaborators



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Widespread agrochemical pollution is a key driver of global biodiversity decline

(e.g., Goulson et al., 2015; Wagner et al., 2021)

Increasing evidence indicating agrochemicals can cause declines of wild and losses of managed bees

(Carreck & Neumann, 2010; Potts et al., 2010)

Eusocial species (e.g., honeybees or stingless bees) are perennially active and likely face chronic pesticide exposure

(Potts et al., 2010; Goulson et al., 2015)



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Agrochemical susceptibility

Indeed, low levels of agrochemical exposure via pollen and nectar consumed by bees can impose detrimental effects (*Siviter et al., 2018; Dicks et al., 2021*):



Increased mortality
(e.g., *Tosi et al., 2017*)



Impaired behaviour
(e.g., *Tosi et al., 2017*)



Reduced queen health
(e.g., *Williams et al., 2015*)

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Major knowledge gaps regarding the underlying mechanisms explaining differential agrochemical impact (i.e., susceptibility) (*Lundin et al., 2015*)

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Agrochemical susceptibility

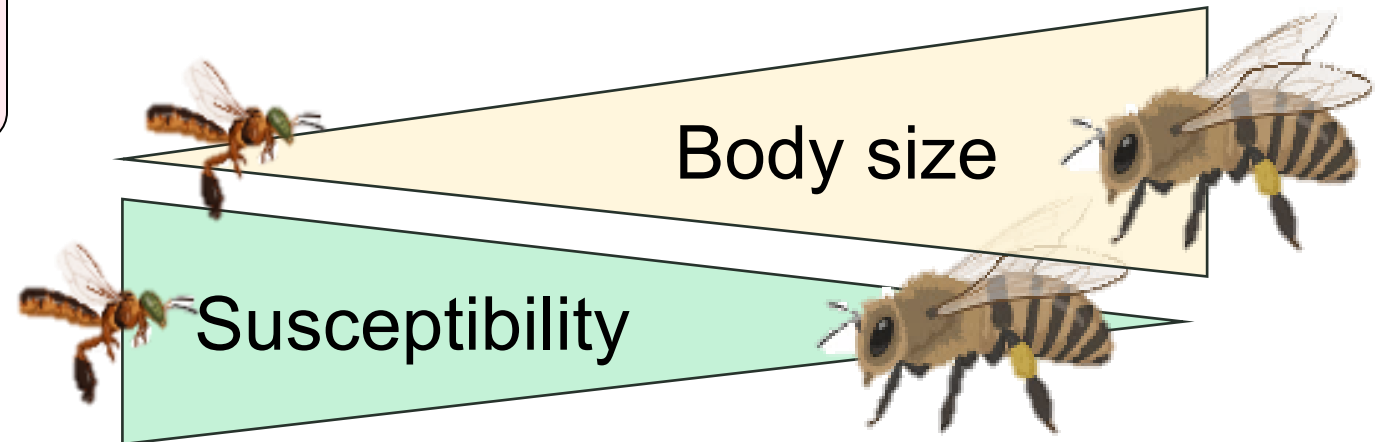
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Major knowledge gaps regarding the underlying mechanisms explaining differential agrochemical impact (i.e., susceptibility) (*Lundin et al., 2015*)

Body size

(e.g., *Arena & Sgolastra, 2014; Schmolke et al., 2021*)

- Smaller bees have higher mass-specific metabolic rates, leading to greater consumption, and consequently increased exposure (*Mobley & Gegear, 2018*)



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Colony size

(*Straub et al., 2015*)

➤ Buffering capacity of workers



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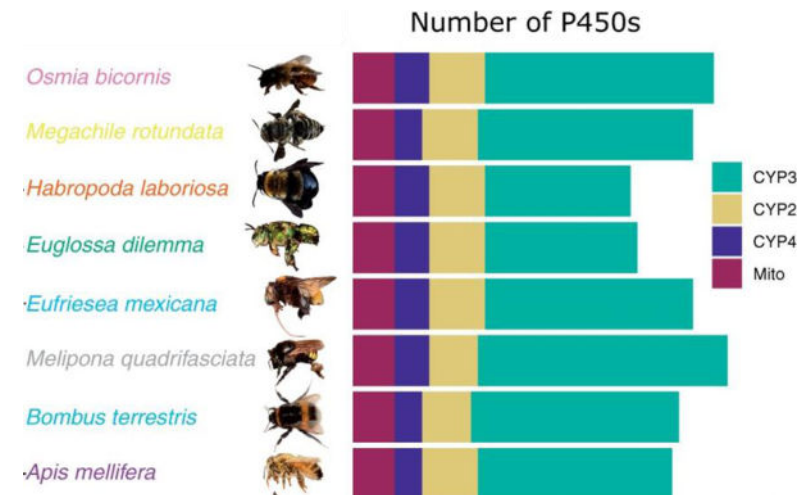
(e.g., *Arena & Sgolastra, 2014; Schmolke et al., 2021*)

Colony size

(*Straub et al., 2015*)

Detoxification abilities

(*Beadle et al., 2019; Han et al., 2025*)



- More cytochrome P450s likely enhance the ability to detoxify xenobiotics (*Darragh et al., 2021*)

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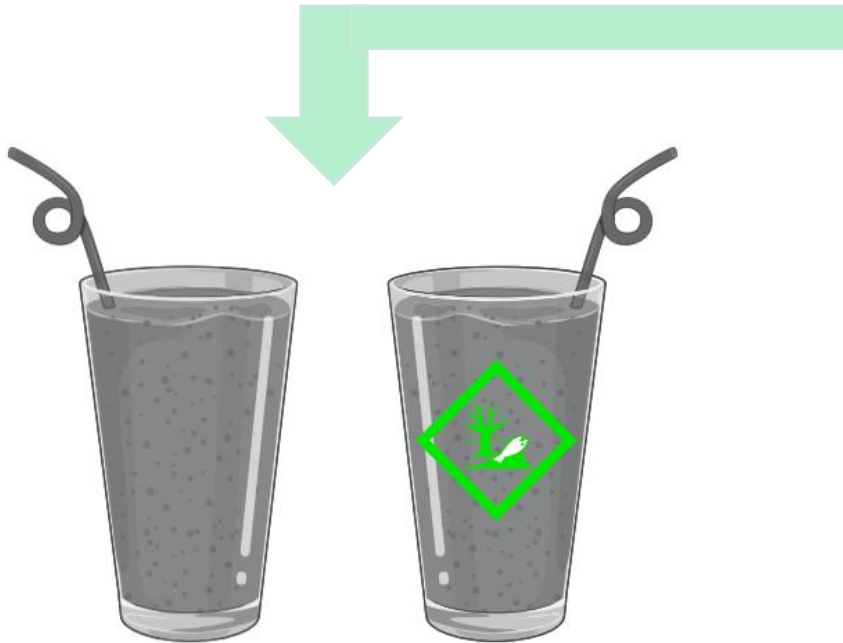
- Strong focus on *Apis mellifera*; despite data suggesting other eusocial species may be far more susceptible (*Barbosa et al., 2015; Li et al., 2017; Grüter et al., 2020*)

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Study objective

Investigate how **agrochemical susceptibility varies** across three managed eusocial bee species of Thailand under laboratory conditions:

Exposure (i.e., consumption)

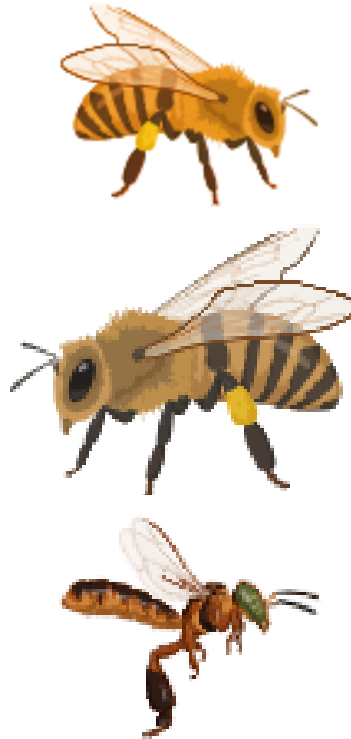
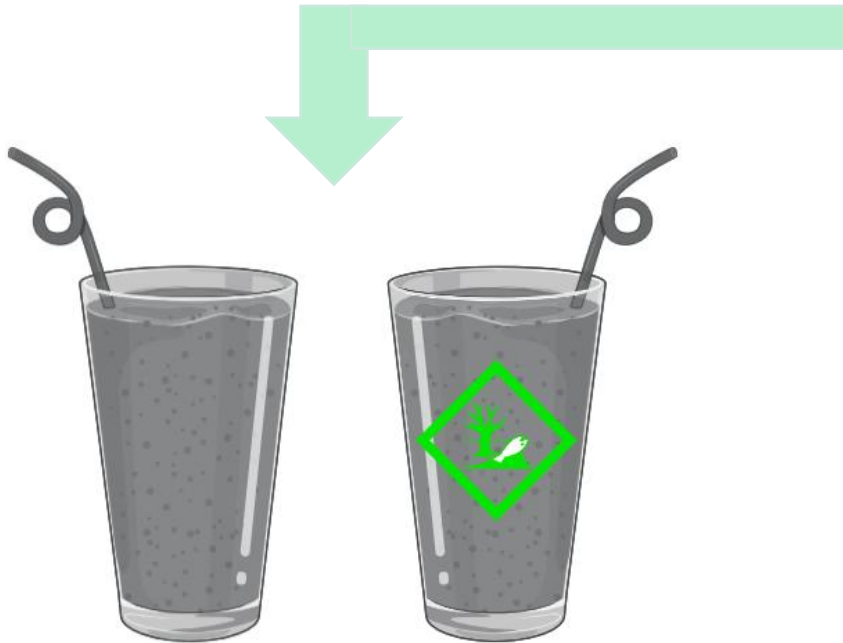


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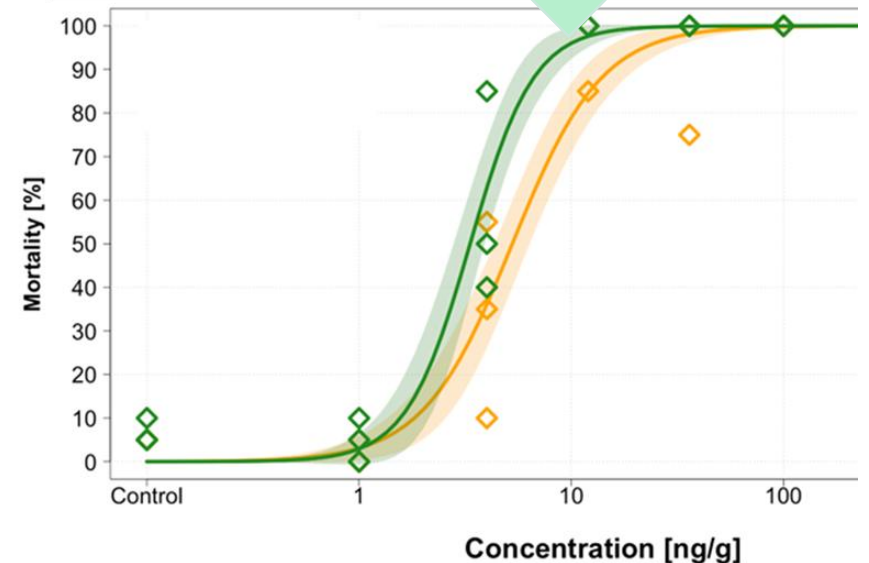
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Investigate how **agrochemical susceptibility varies** across three managed eusocial bee species of Thailand under laboratory conditions:

Exposure (i.e., consumption)



Survival (i.e., Lethal Daily Dosage $_{50}$)



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Methods

Followed standard laboratory chronic toxicity protocols (OECD 245)

Bee species: *Apis mellifera*, *Apis cerana*, *Tetragonula laeviceps*

Species	Body mass [mg]	Colony size [# workers)	References
<i>Apis mellifera</i>	99.45 ± 0.75	3'000 – 55'0000	Sharma et al., 2005; Schmickl & Crailsheim, 2007; Straub et al., 2016
<i>Apis cerana</i>	73.95 ± 0.55	2'000 – 34'0000	Ruttner, 1988; Inoue et al., 1990; Yue et al., 2017
<i>Tetragonula laeviceps</i>	2.76 ± 1.01	500 – 2'800	Pangestika et al., 2017; Chinh et al., 2005

➤ **Sample sizes:** $N = 800$ per *Apis* spp.; $N = 480$ for *T. laeviceps*

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Methods

Followed standard laboratory chronic toxicity protocols (OECD 245)

Bee species: *Apis mellifera*, *Apis cerana*, *Tetragonula laeviceps*

Chemical test substance:
Thiamethoxam (active ingredient)

- Widely used in Thai crop production and frequently detected in residue analyses (FAO, 2022; Nimako et al., 2025)
- Bees exposed to an increasing range of concentrations (0 – 1'000 ng mL⁻¹)



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Methods

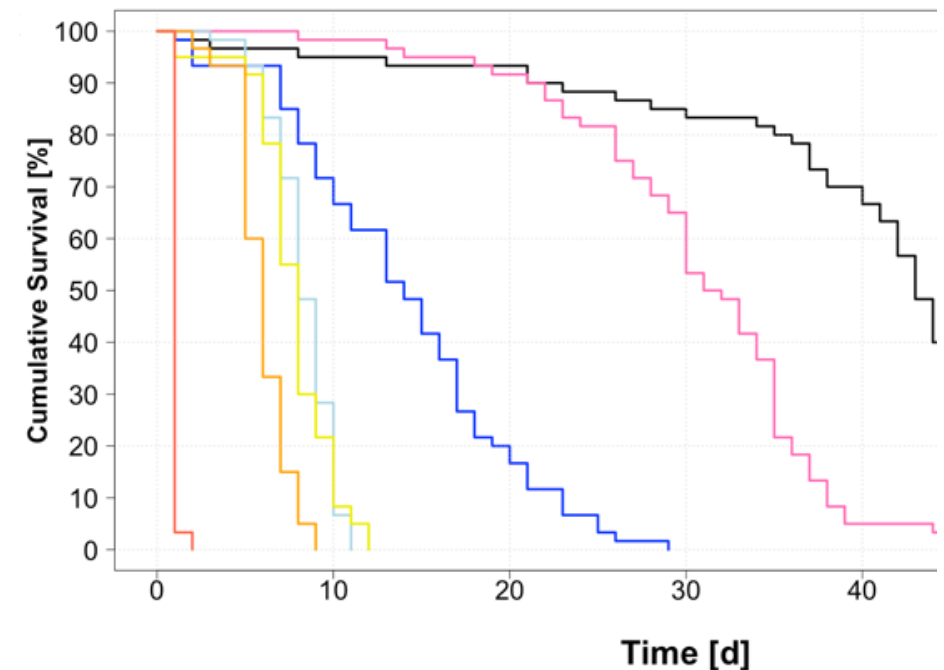
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Endpoint measures:

➤ Survival [%]



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Methods

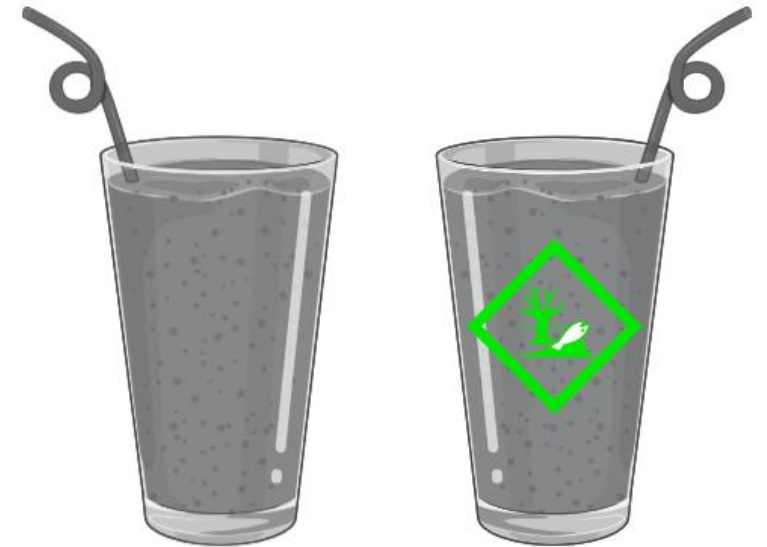
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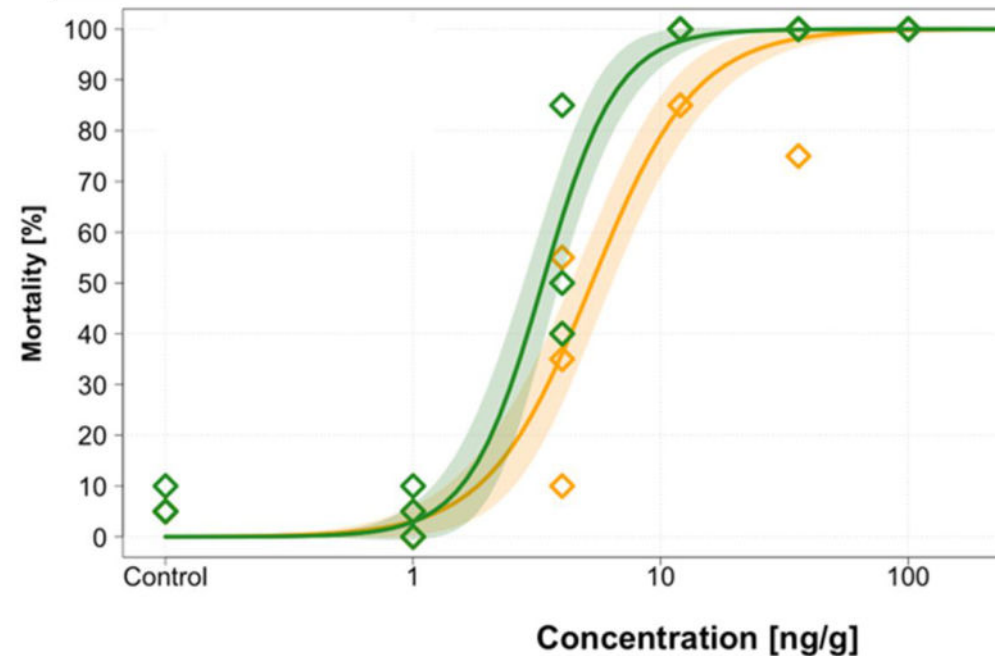
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Endpoint measures:

- Survival [%]
- Daily consumption [mL d^{-1}] & exposure [ng d^{-1}]
- Lethal Day Dosage 50 (LDD_{50})

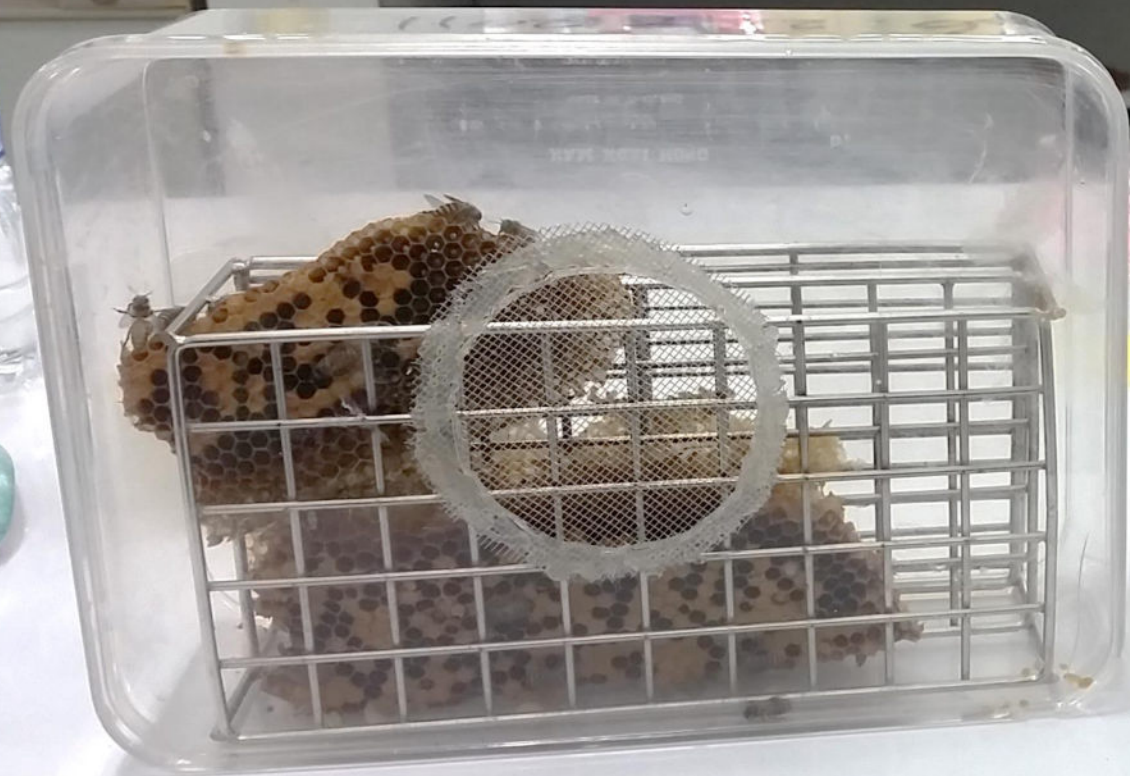


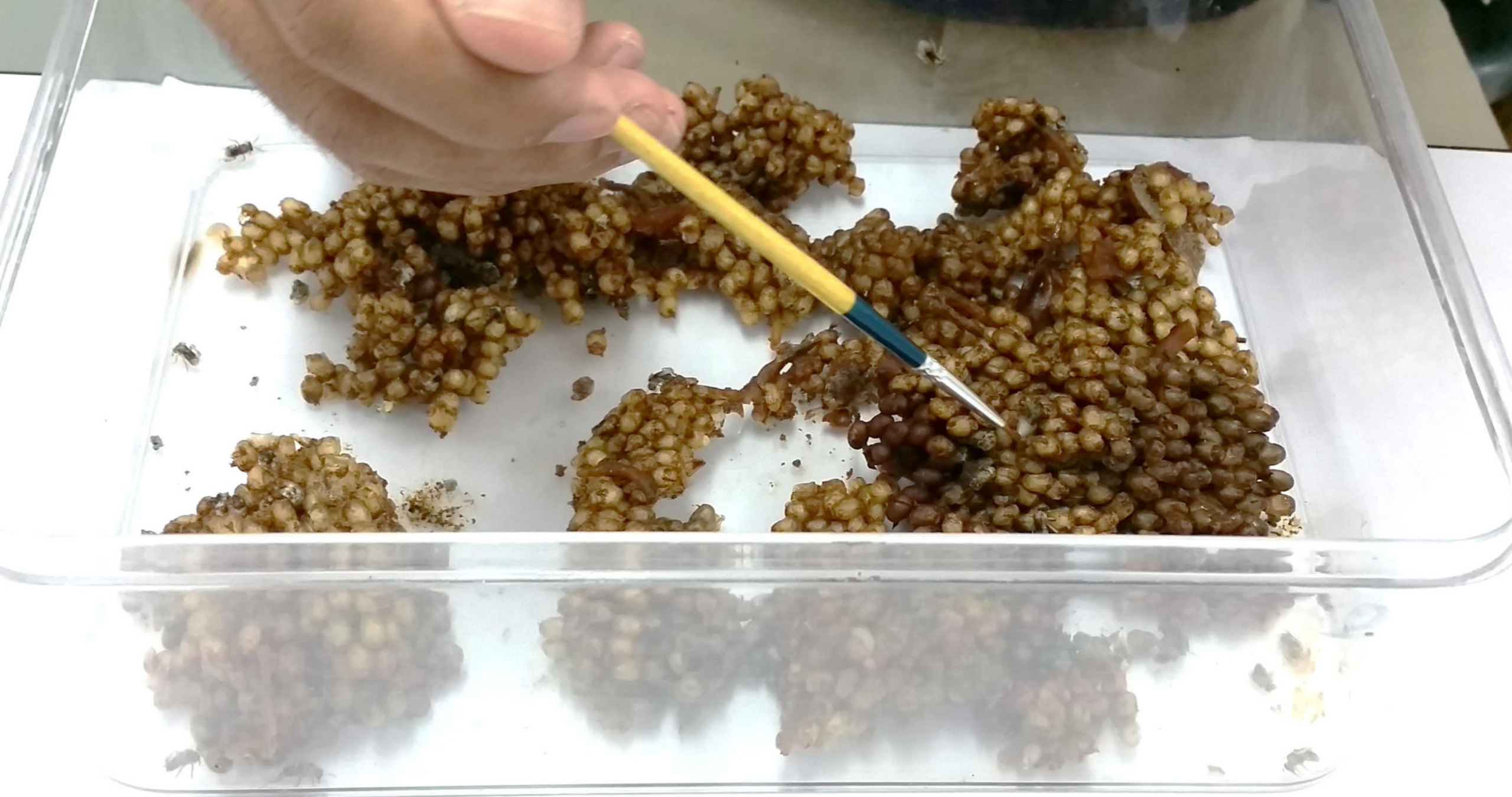














Date	26.10.2016	26.10.2016	27.10.2016
Treatment	Mass 5 or 4	Mass 0	Mass 1
TE1-1	10.2185		
TE1-2	10.2185		
TE1-3	10.1628		

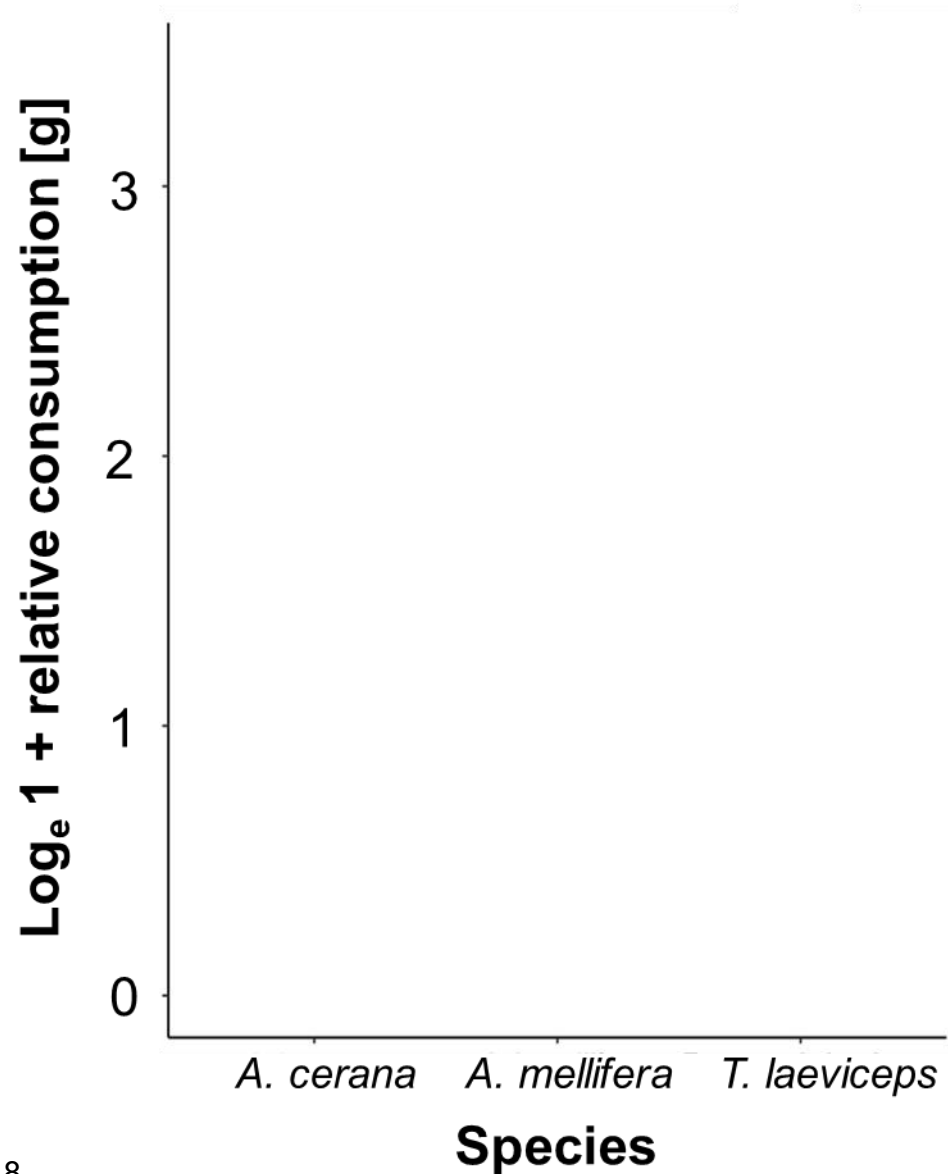
Date	26.10.2016	27.10.2016
Treatment	Mass 5	Mass 1
CE-1	10.8352	
CE-2		
CE-3		
CE-4		

Date	26.10.16	27.10.16
Treatment	Mass 2	Mass 3
CC-1	10.7263	
CC-2	10.6347	
CC-3	10.7530	
CC-4		

Date	26.10.16	27.10.16
Treatment	Mass 3	Mass 4
C1-4	10.6571	
C4-4	10.5500	
C12-2	10.4000	

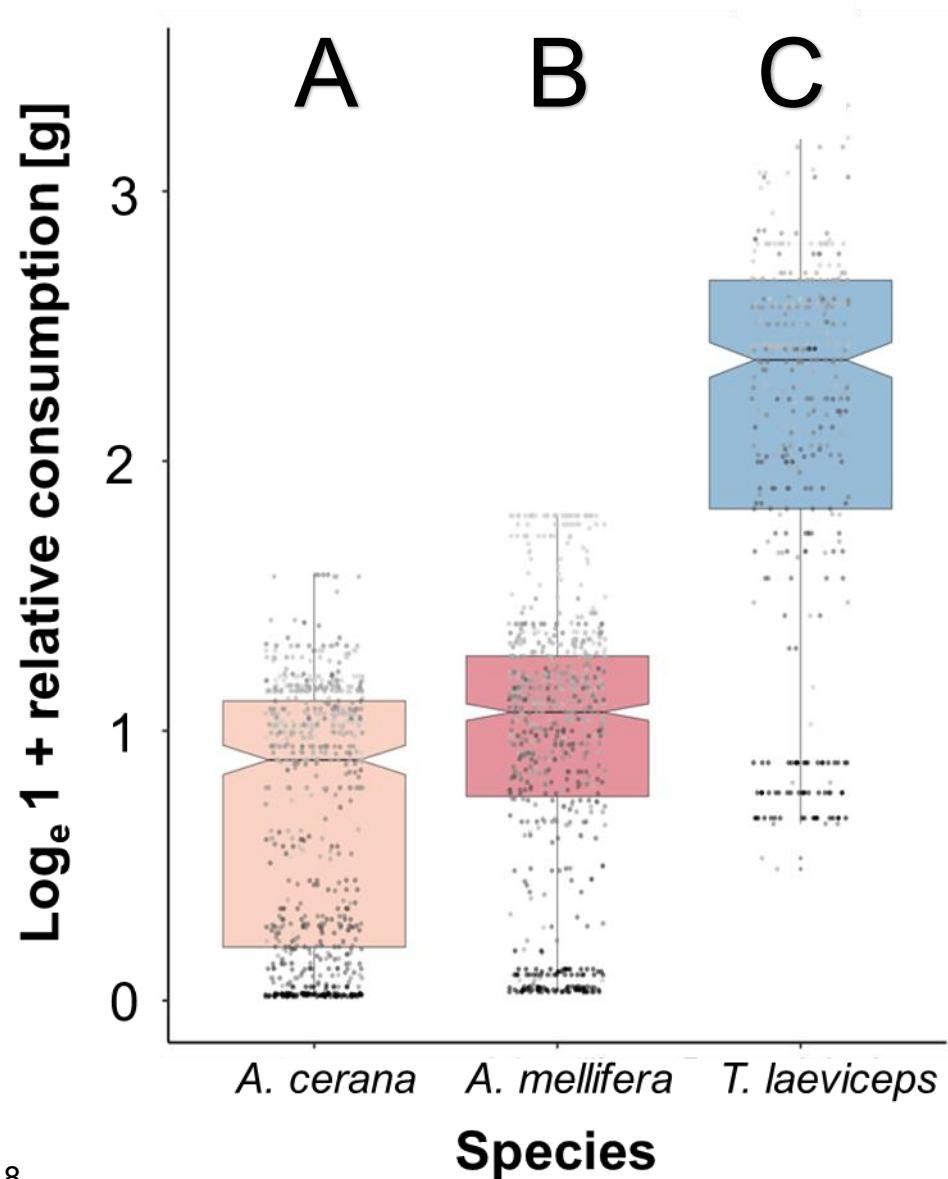
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Results: Consumption & exposure



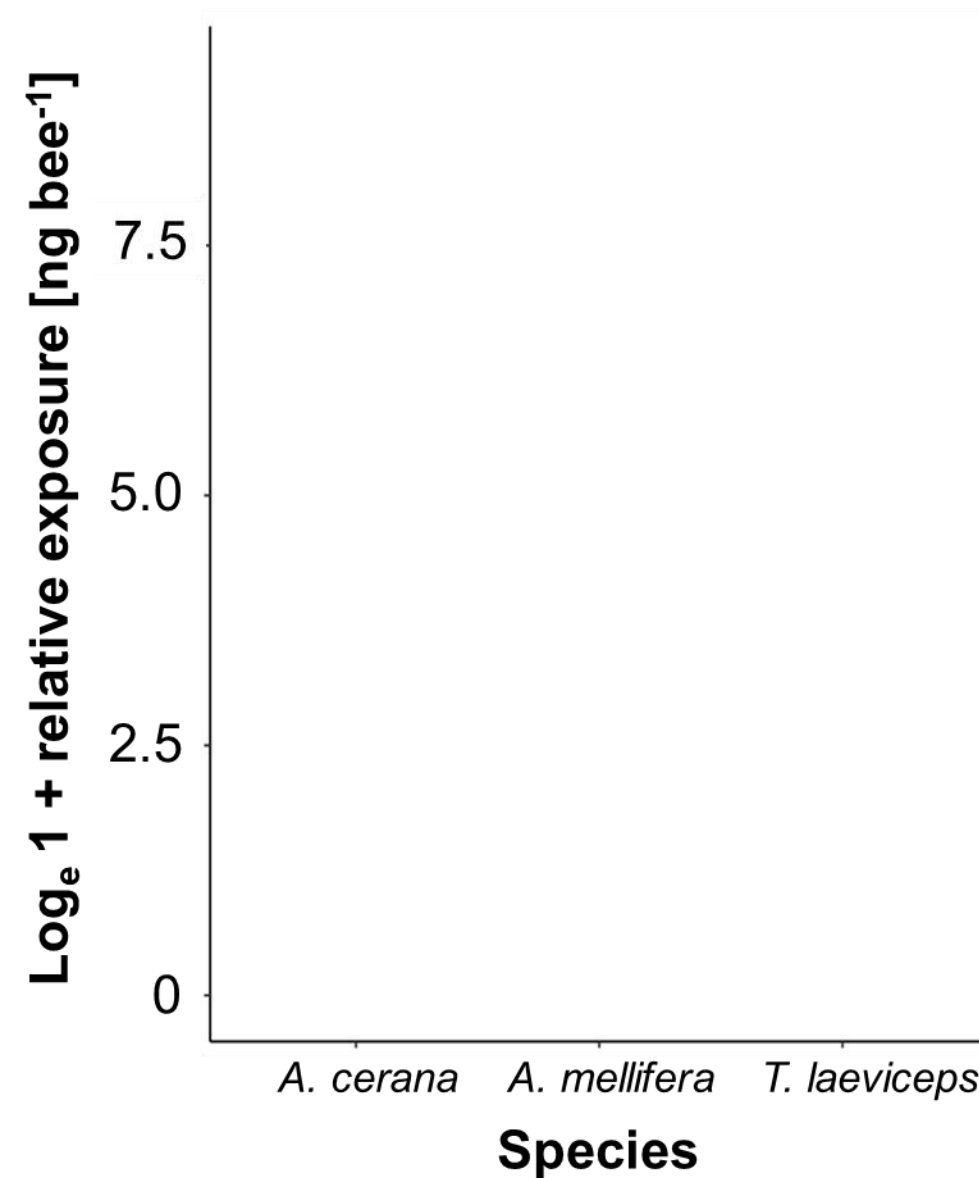
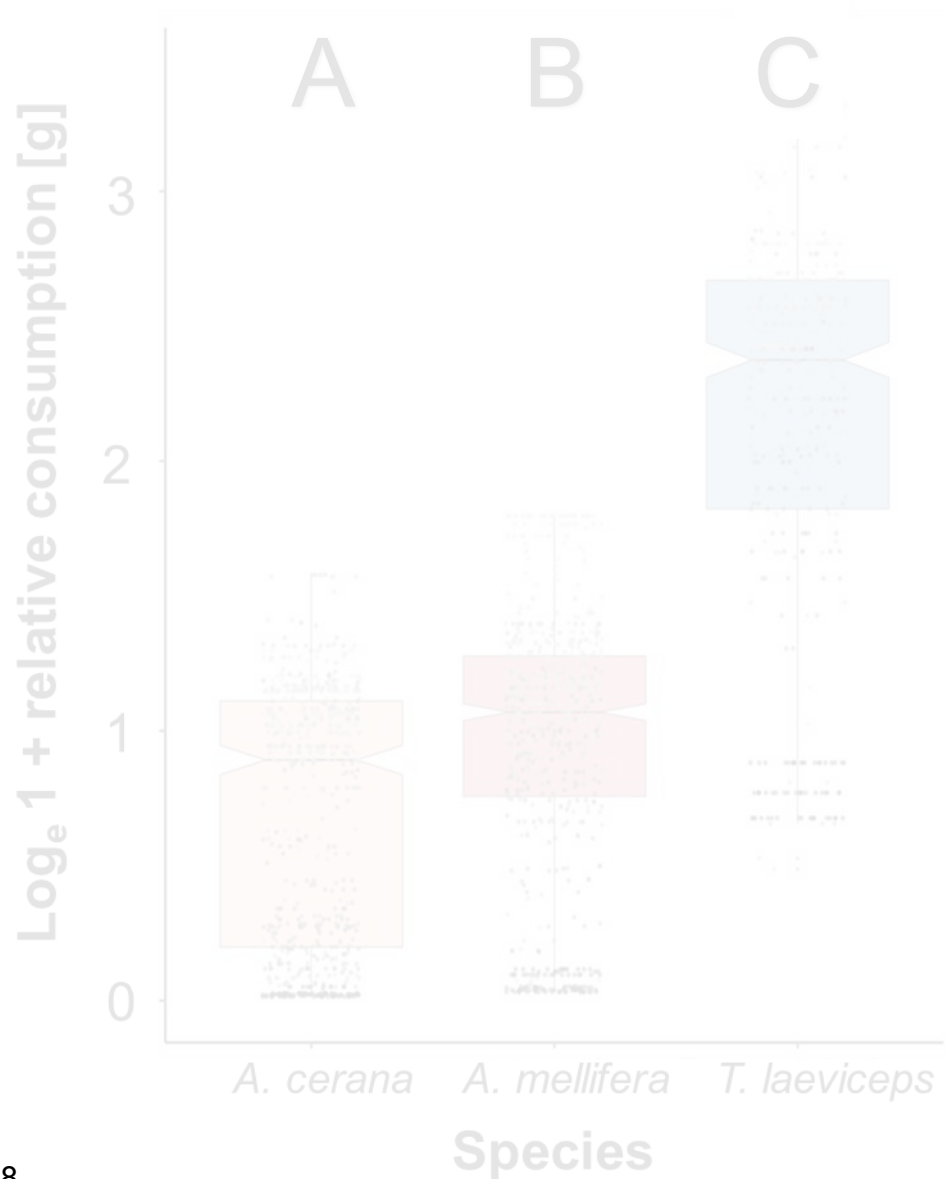
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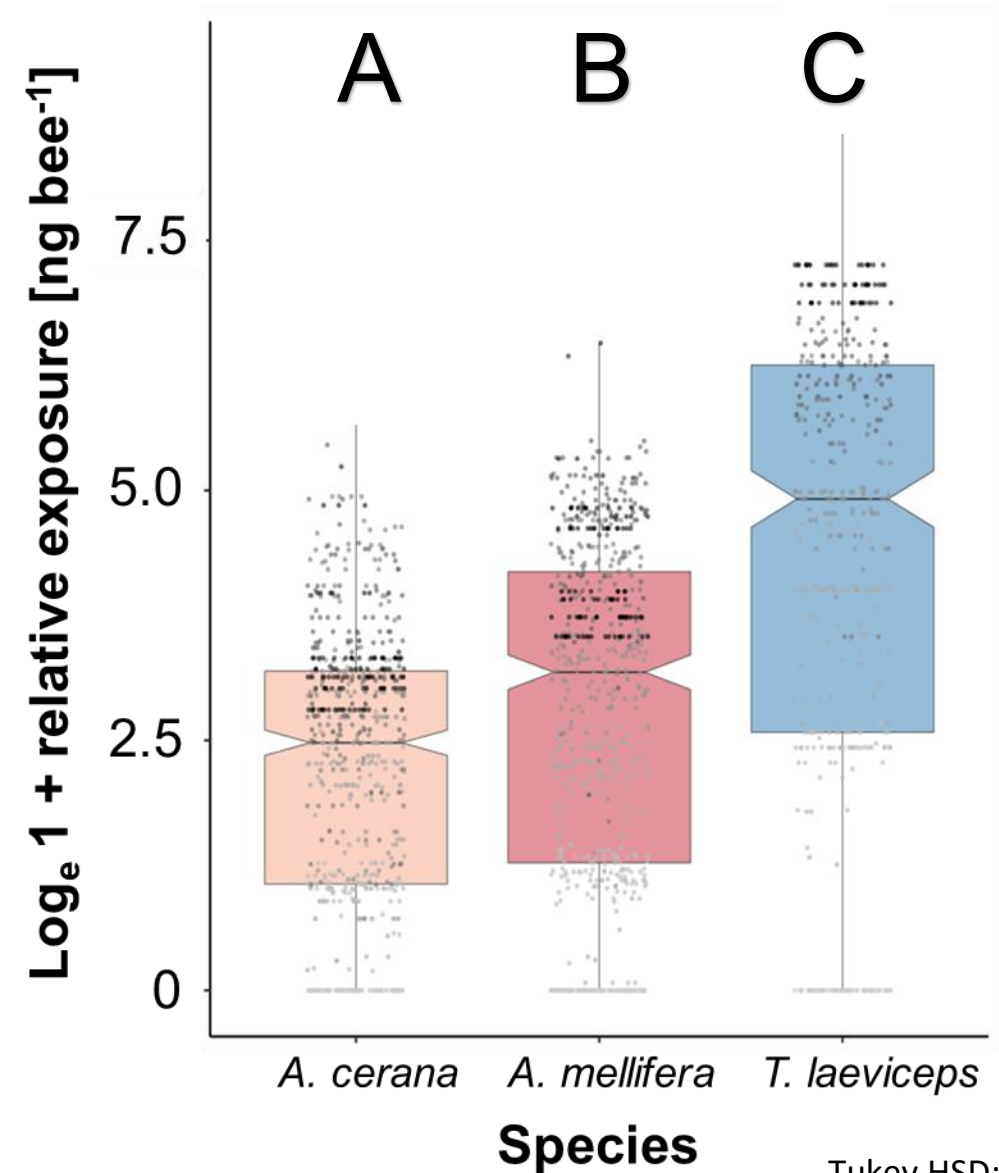
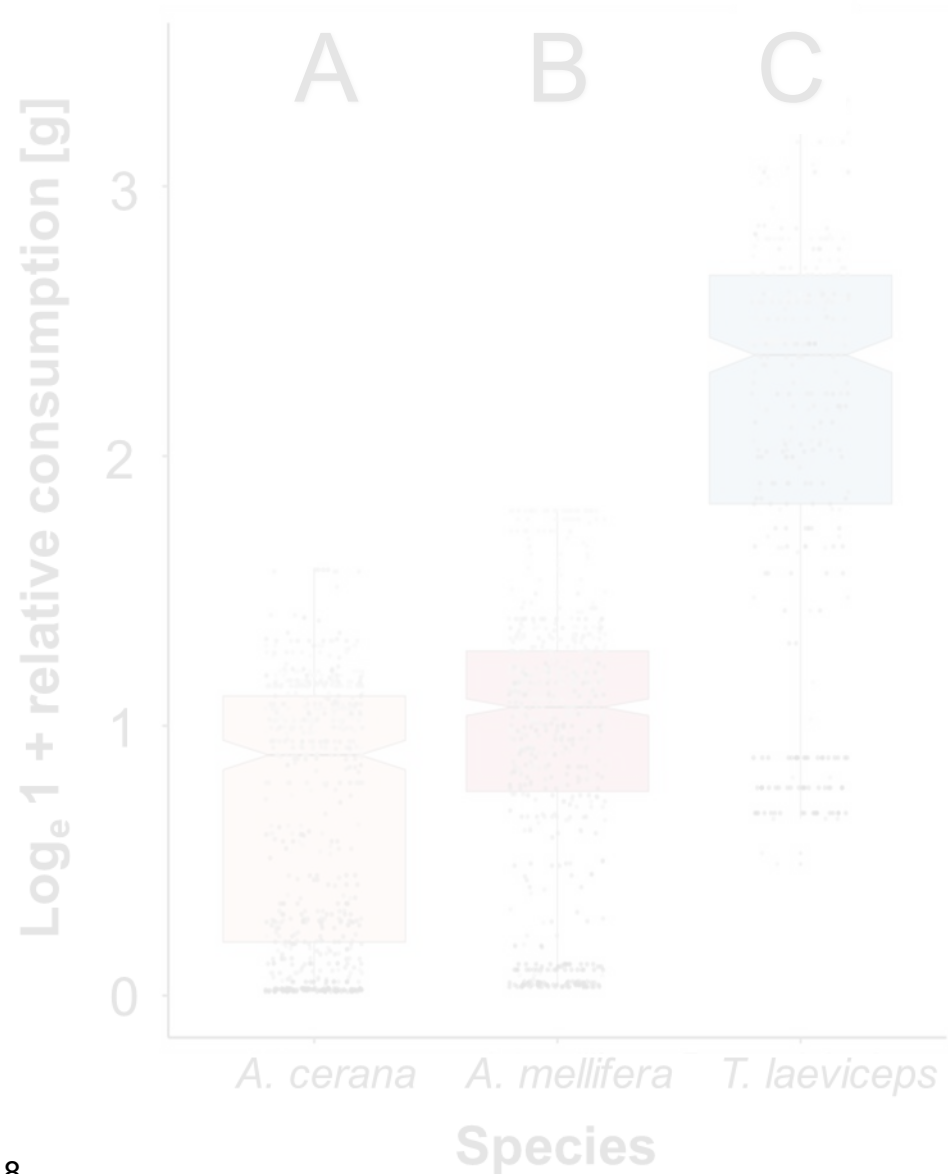
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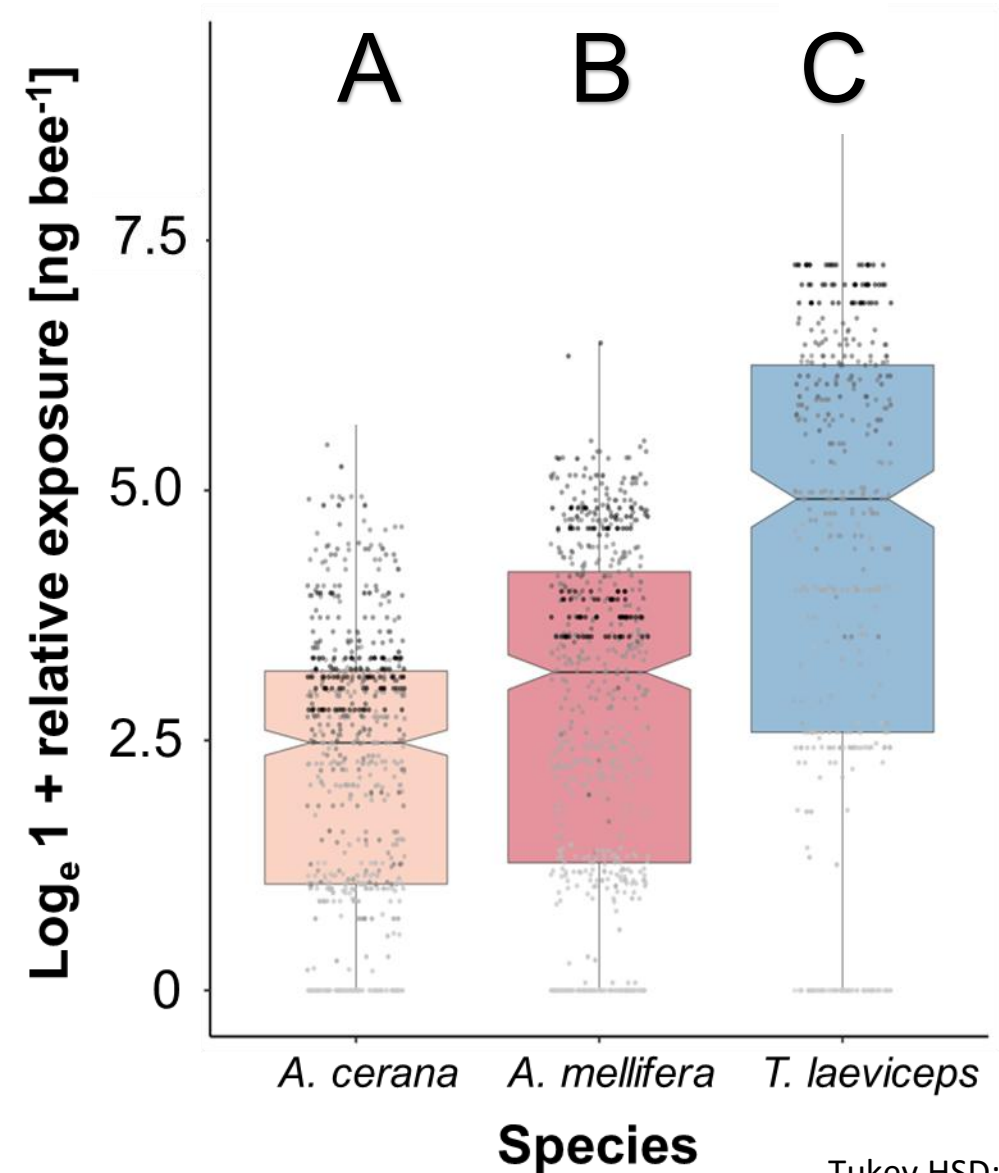
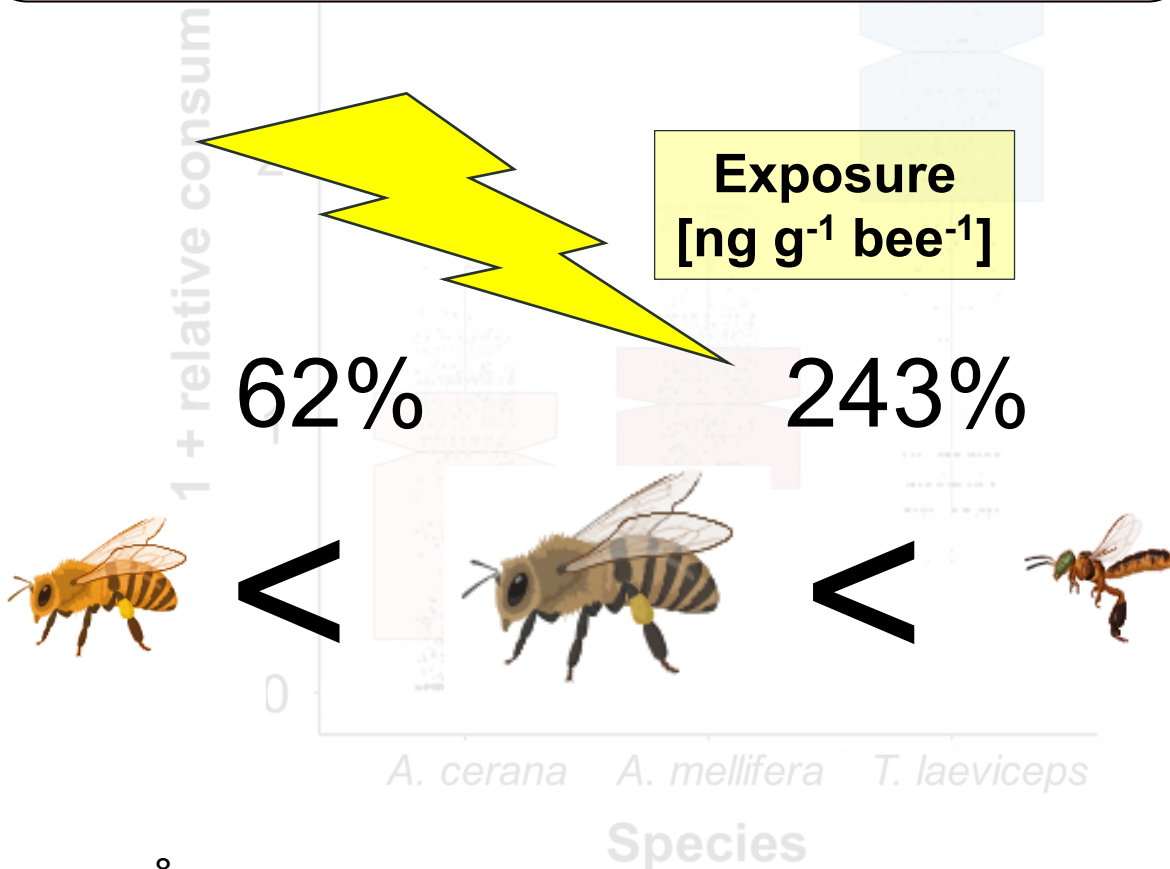


Tukey HSD; $P < 0.001$

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Results: Consumption & exposure

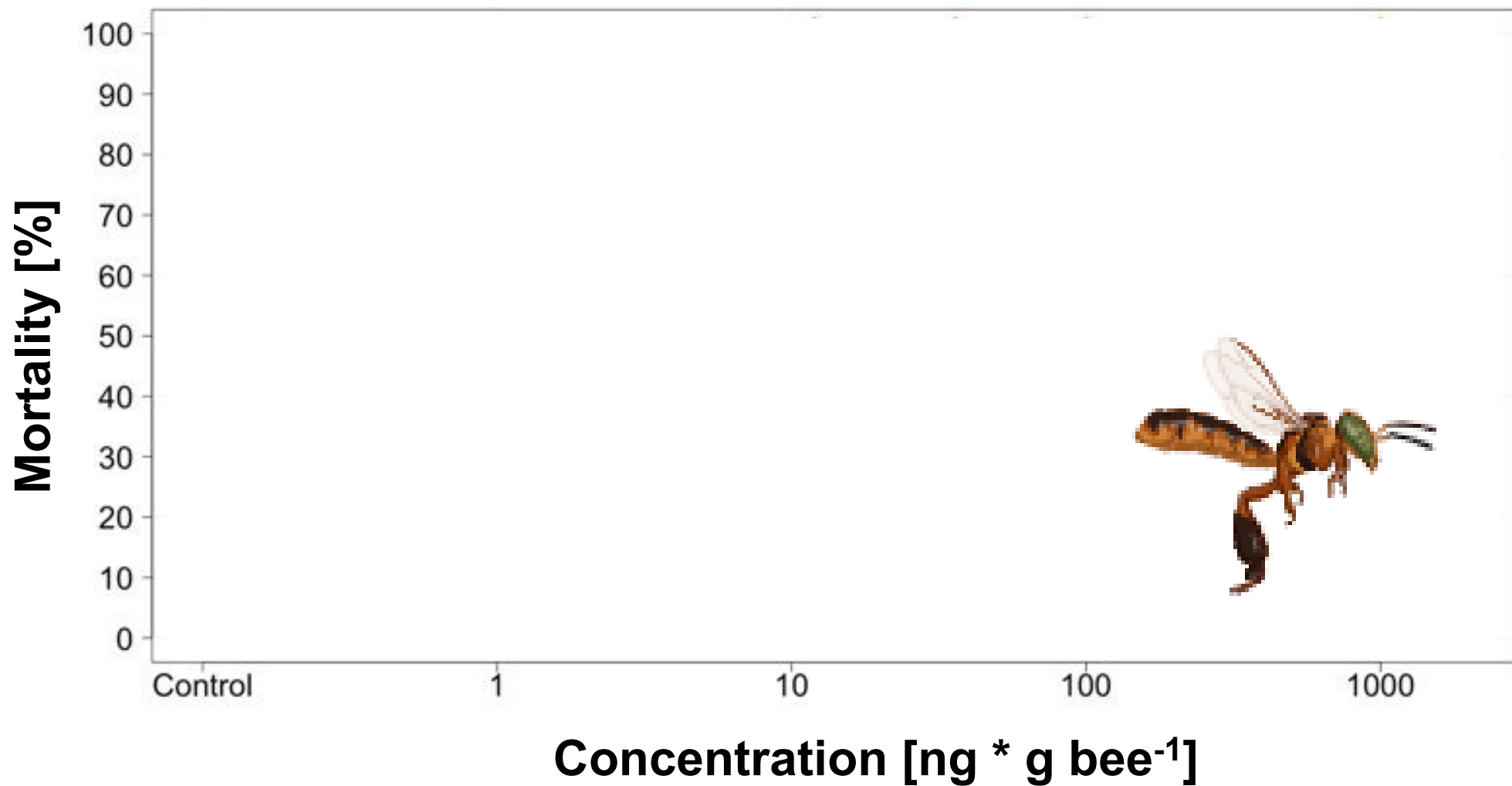
We can confirm species-specific exposure scenarios due to varying consumption
(e.g., Thompson, 2001; Heard et al., 2017; Lourencetti et al., 2023)



Tukey HSD; $P < 0.001$

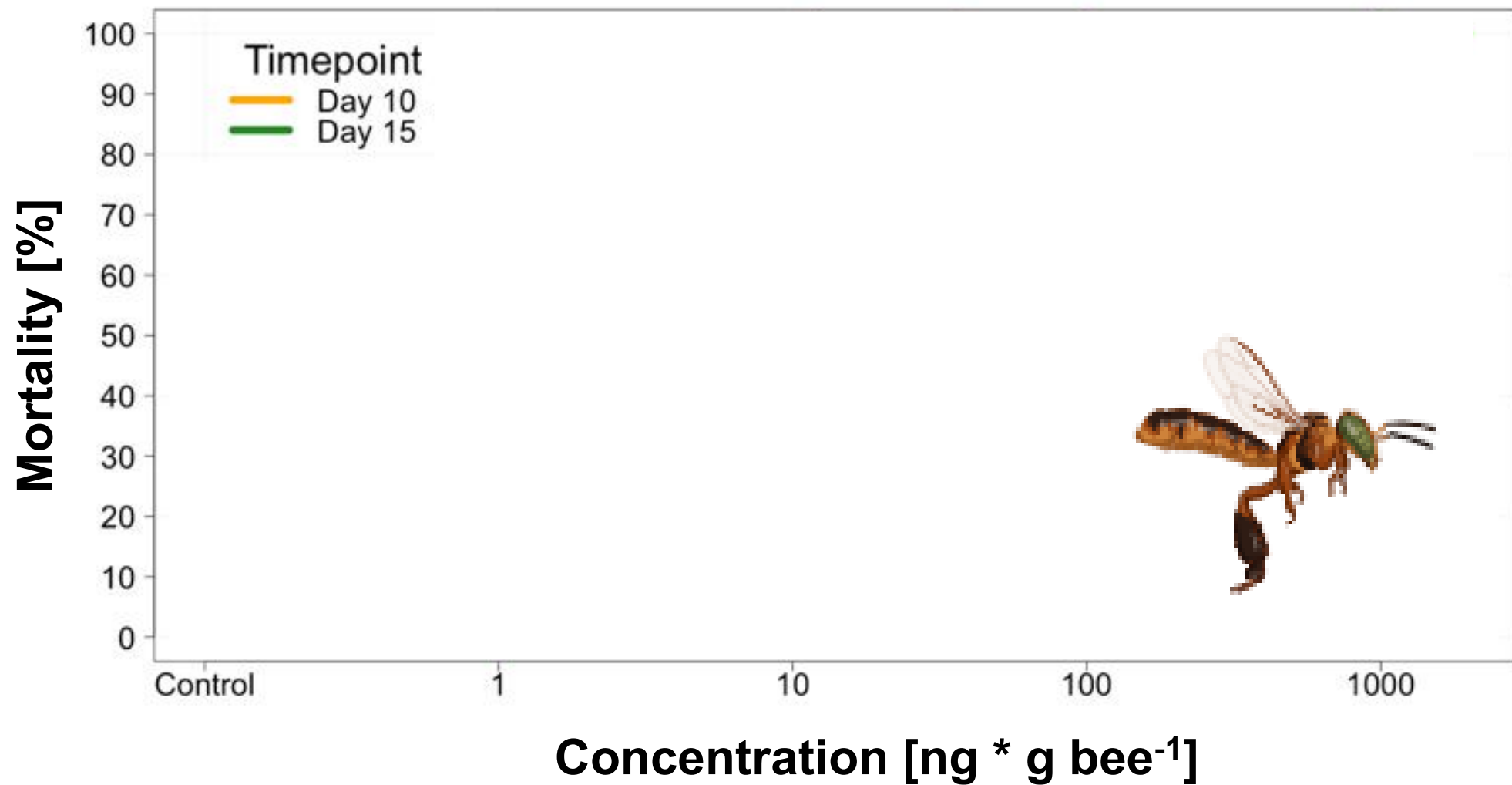
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Results: Lethal Daily Dosage₅₀



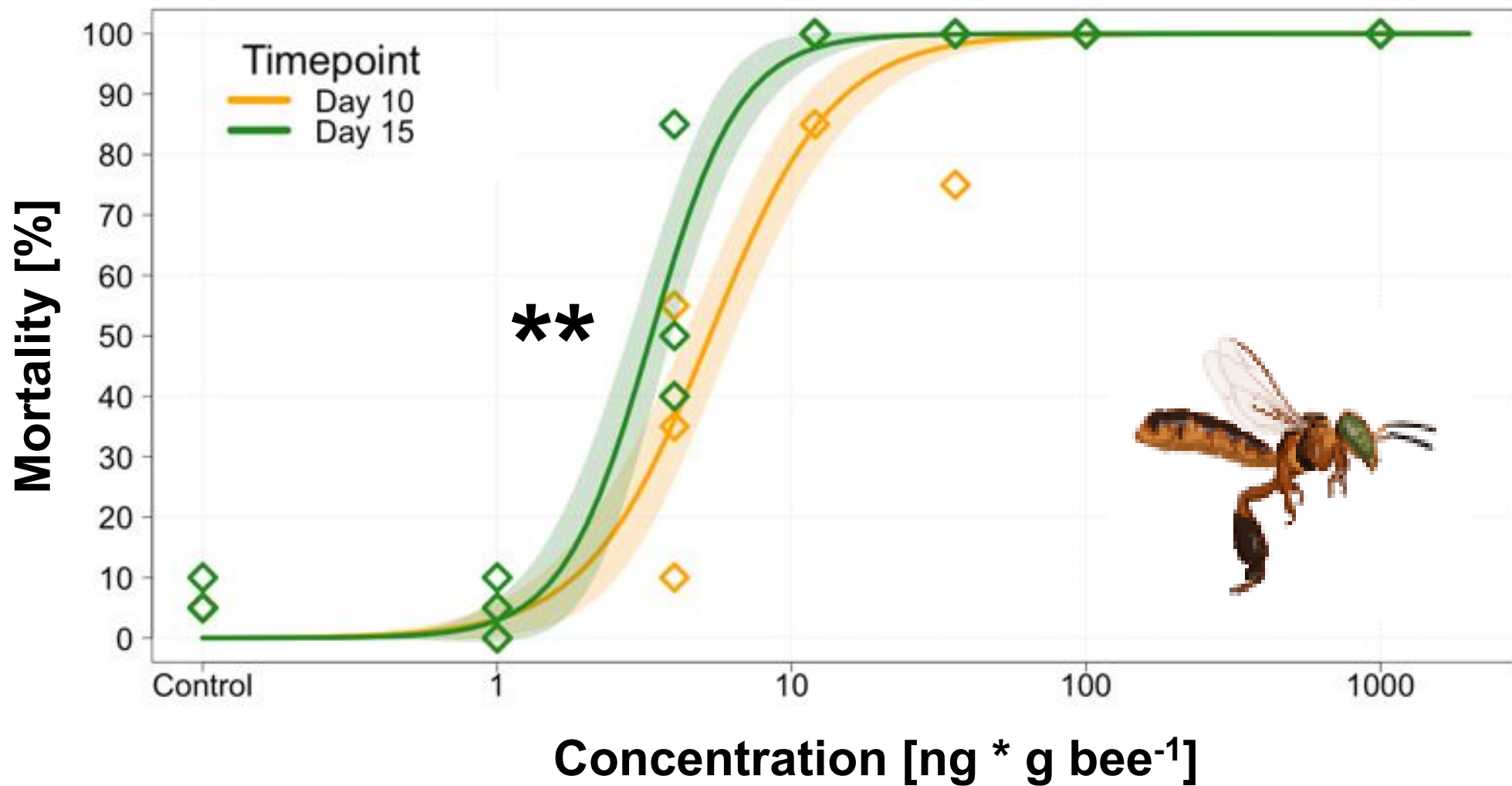
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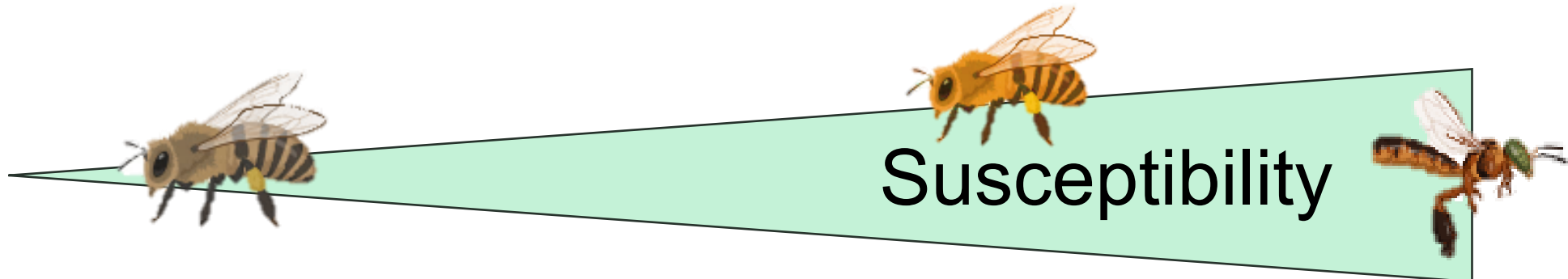
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Time point	Day 10	
Species	LDD_{50} (ng * g bee ⁻¹)	± 95% CI
<i>Apis cerana</i>	20.15	4.41
<i>Apis mellifera</i>	82.8	25.74
<i>Tetragonula laeviceps</i>	5.28	1.01

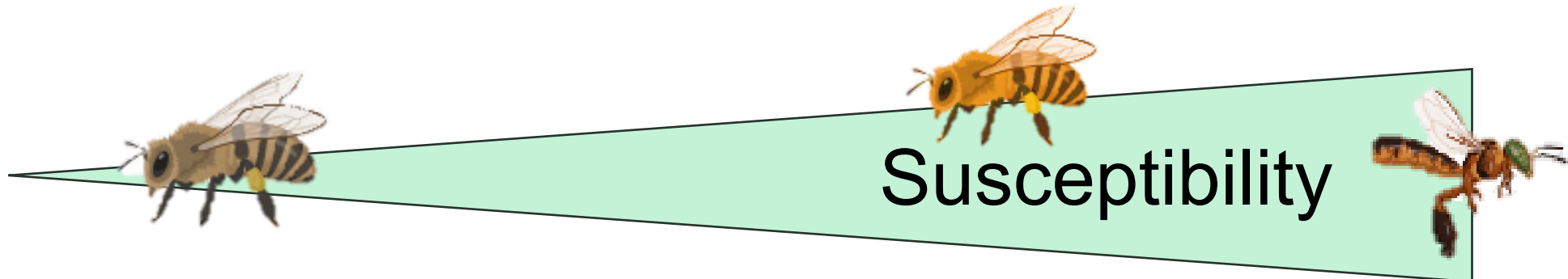


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Results: Lethal Daily Dosage ₅₀

Time point	Day 10	
Species	LDD_{50} (ng * g bee ⁻¹)	± 95% CI
<i>Apis cerana</i>	20.15	4.4
<i>Apis mellifera</i>	82.8	25.1
<i>Tetragonula laeviceps</i>	5.28	1.01

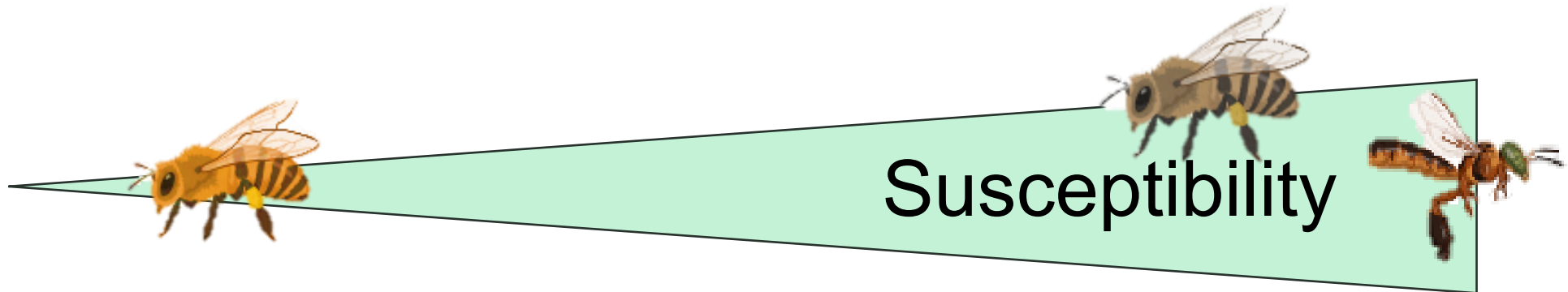
The 10x safety factor is not sufficient to ensure the protection of stingless bees
(e.g., Jacob et al., 2003; de Carvalho et al., 2024)



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Results: Lethal Daily Dosage $_{50}$

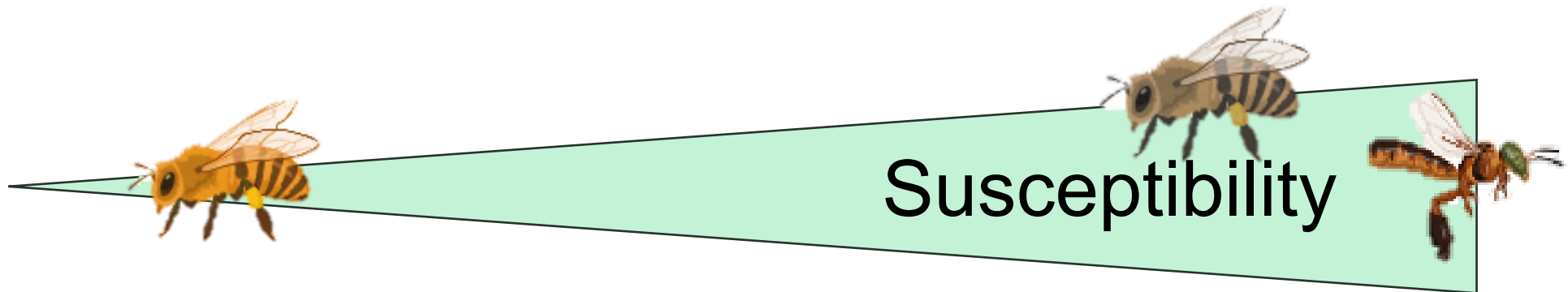
Time point	Day 10		Day 15	
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<i>Apis cerana</i>	20.15	4.41	10.04	2.47
<i>Apis mellifera</i>	82.8	25.74	3.75	2.27
<i>Tetragonula laeviceps</i>	5.28	1.01	3.34	0.56



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Results: Lethal Daily Dosage $_{50}$

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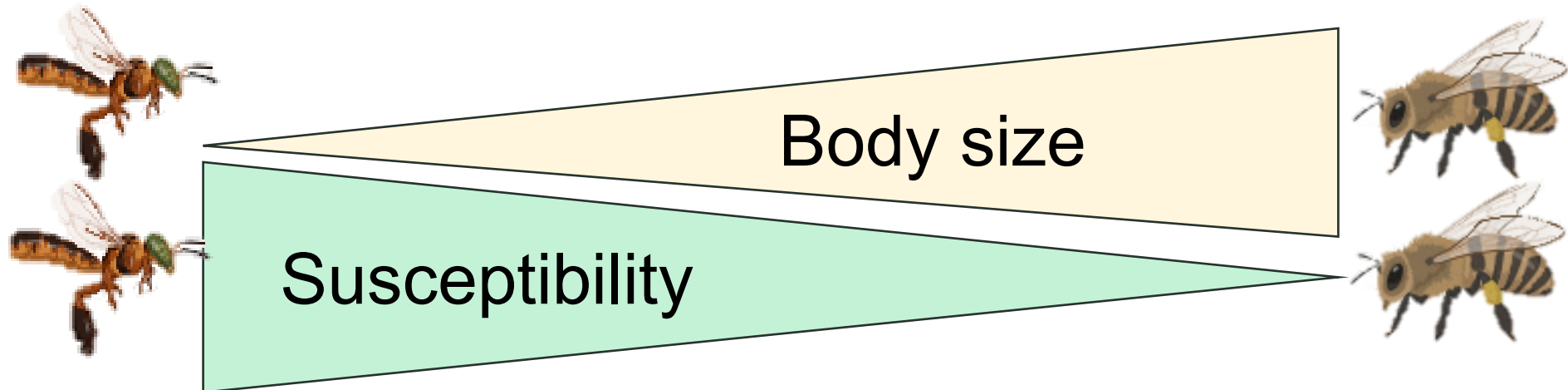
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Extending assessments beyond day 10 appear to be more robust, highlighting the need to account for time-reinforced toxicity (EFSA, 2023)

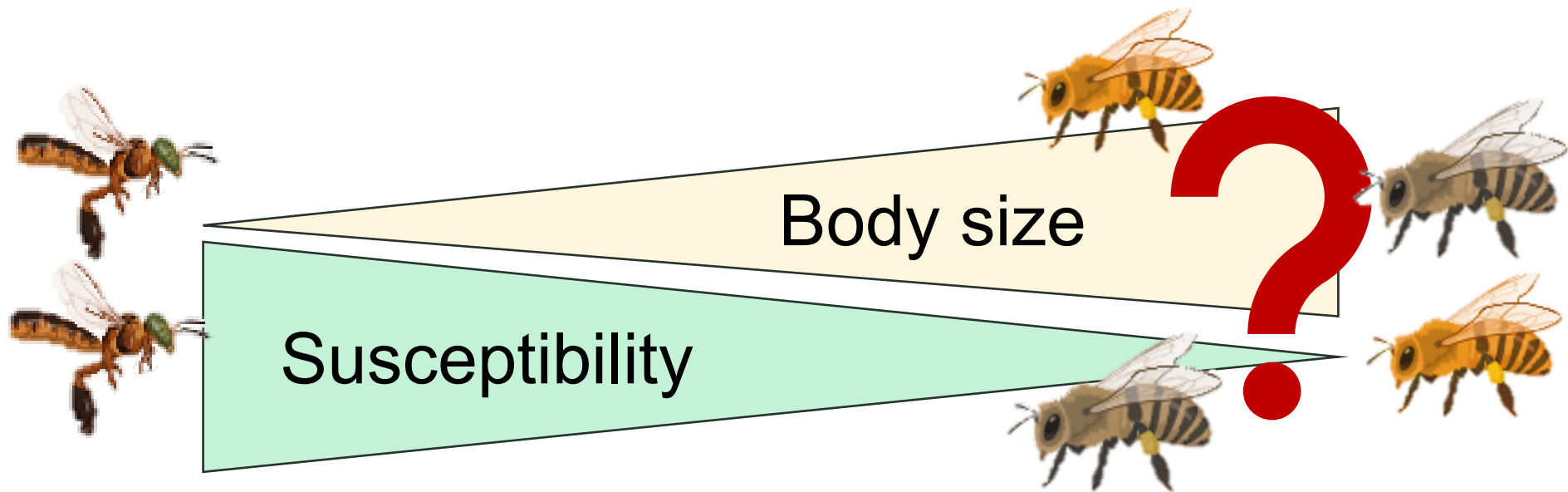
Discussion

Stingless bees exhibited greater susceptibility, likely due to higher sucrose consumption and increased exposure (*Thompson, 2003; Mobley & Gegeer, 2018*)



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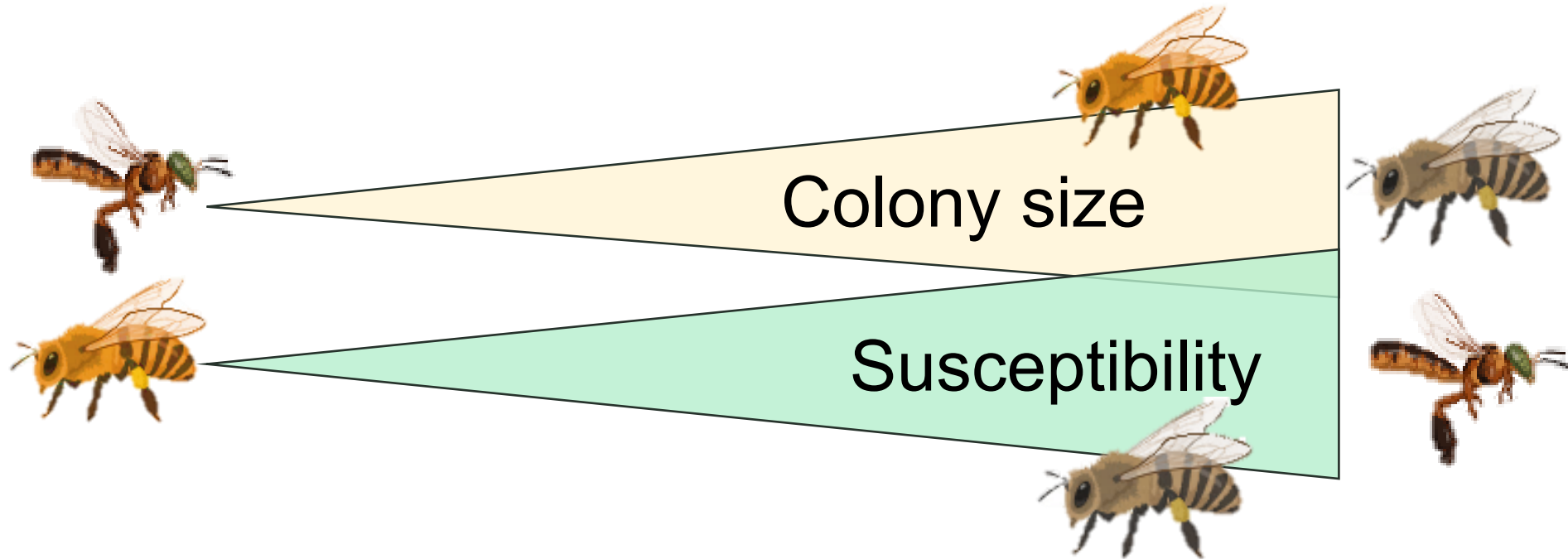


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Stingless bees exhibited greater susceptibility, likely due to higher sucrose consumption and increased exposure (*Thompson, 2003; Mobley & Gegeer, 2018*)

Colony size partially accounted for the variation in susceptibility observed among eusocial bee species



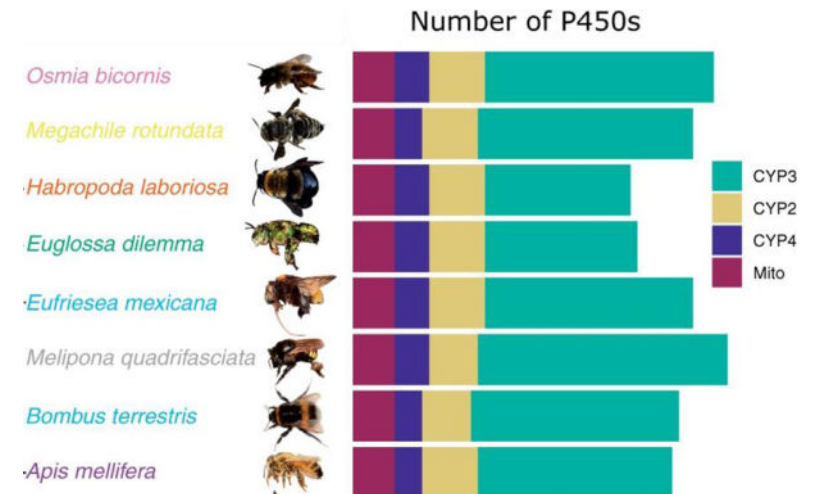
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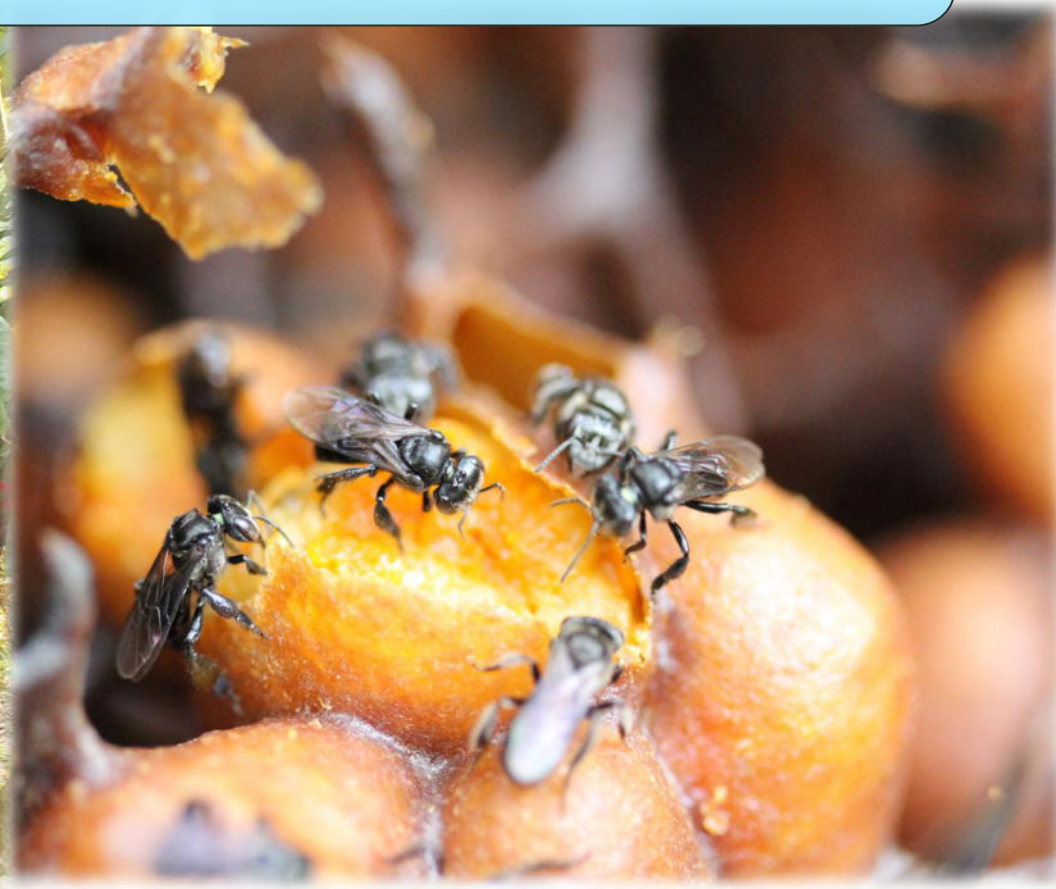
Our findings suggest that other mechanisms, such as species-specific detoxification, may have a stronger impact on agrochemical sensitivity

(*Beadle et al., 2019; Darragh et al., 2021; Han et al., 2025*)



Conclusion

Considering wide use of neonicotinoids in Thailand, our data strongly indicate that stingless bee species may face severe pressure



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Considering wide use of neonicotinoids in Thailand, our data strongly indicate that stingless bee species may face severe pressure

Need to revise current risk assessment frameworks (*Barbosa et al., 2015; Boyle et al., 2019*); by include different bee species or extending exposure duration (*Wood et al., 2020*)



Conclusion

Considering wide use of neonicotinoids in Thailand, our data strongly indicate that stingless bee species may face severe pressure

Need to revise current risk assessment frameworks (*Barbosa et al., 2015; Boyle et al., 2019*); by include different bee species or extending exposure duration (*Wood et al., 2020*)

Political action required to reduce agrochemical usage and enhance sustainability (e.g., integrated pest management) (*Pretty, 2018; Möhring et al., 2020; Wyckhuys et al., 2024*)



Thank you

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vetsuisse-fakultät

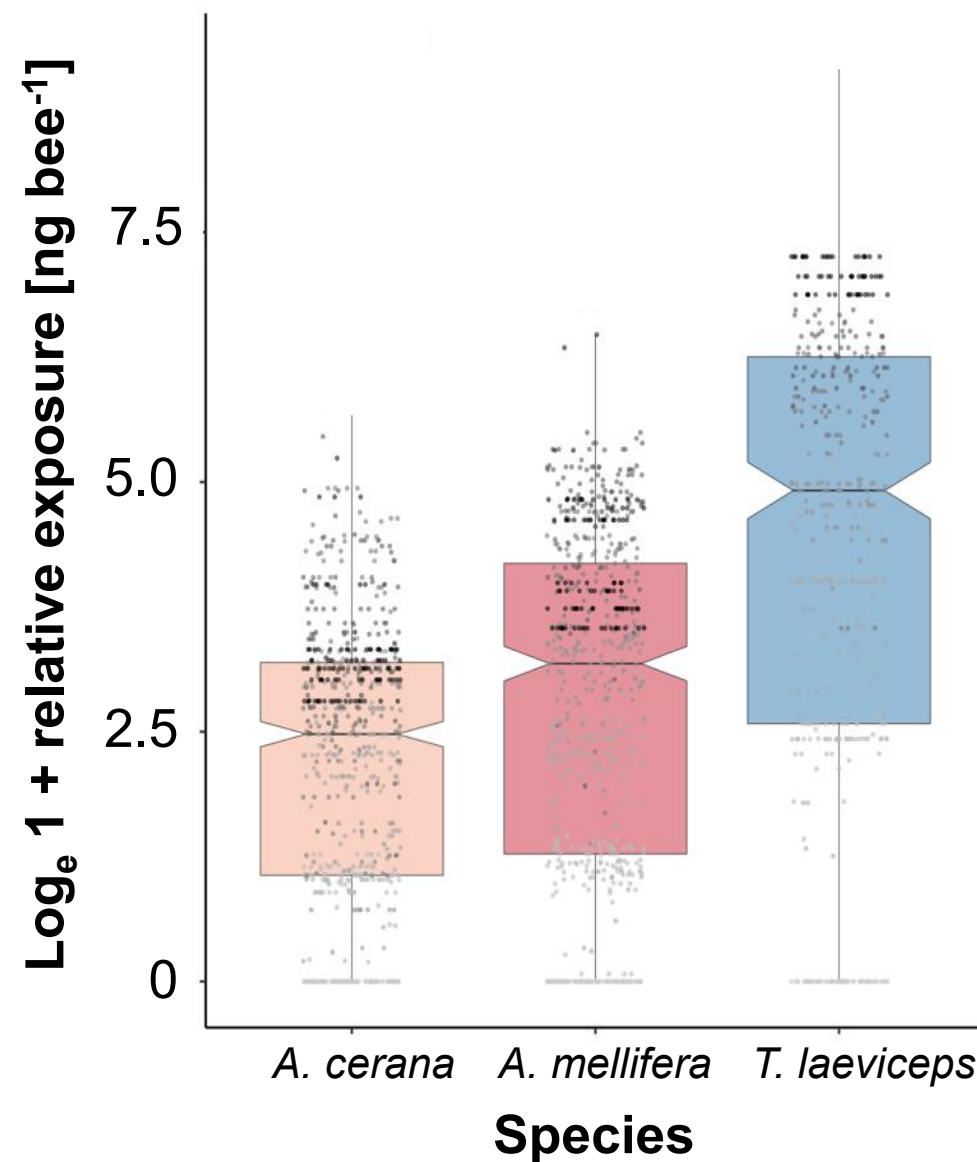
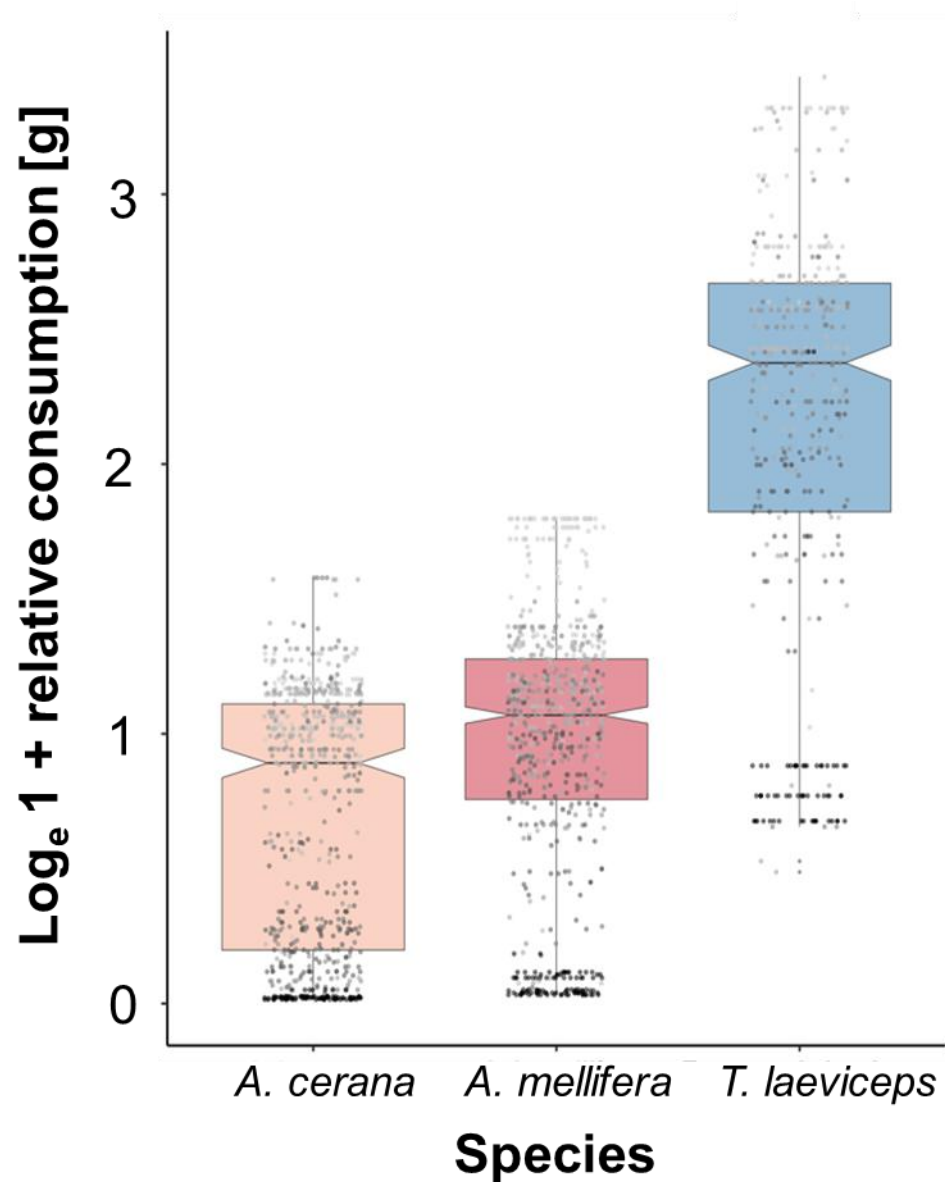


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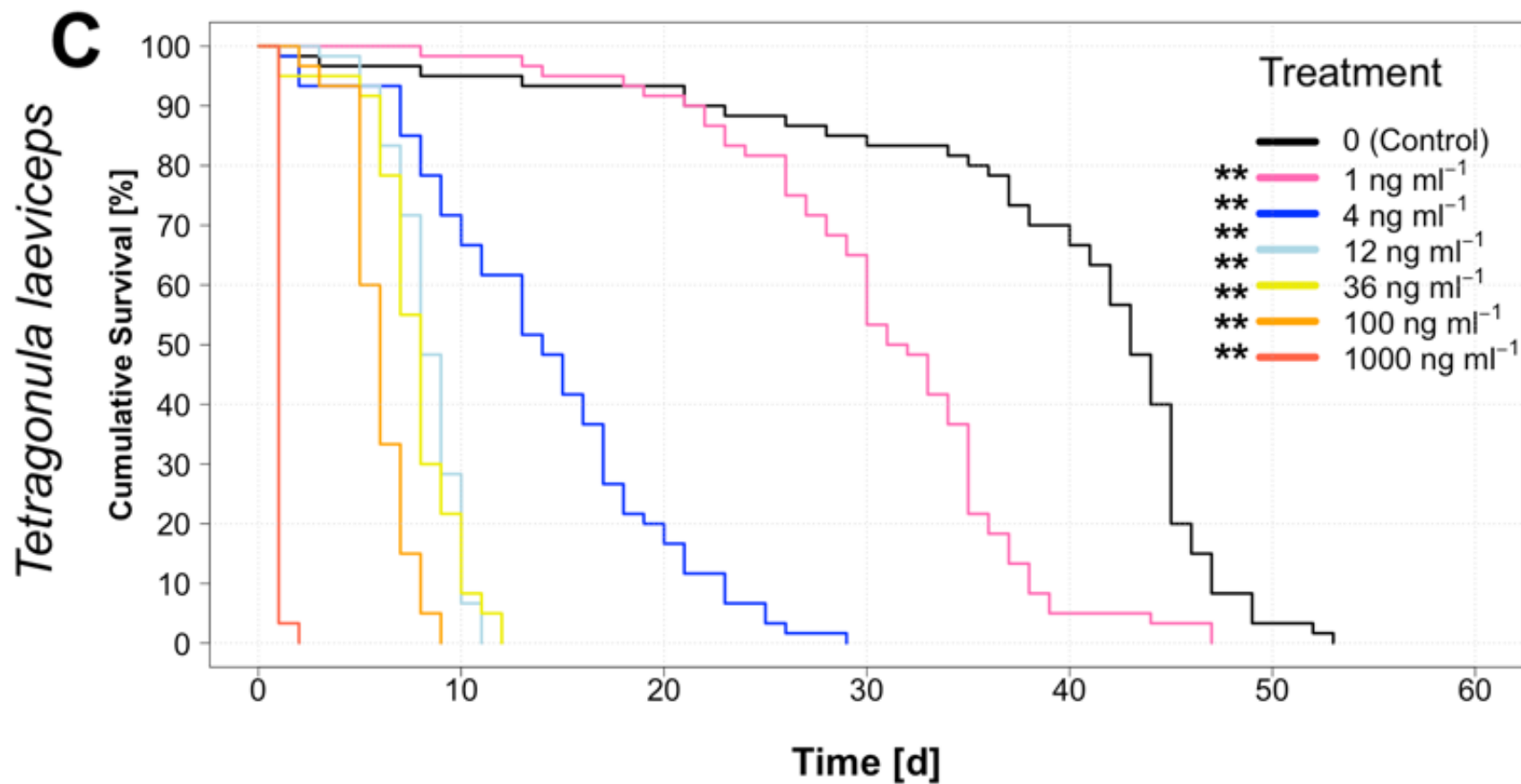
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Results: Consumption & exposure



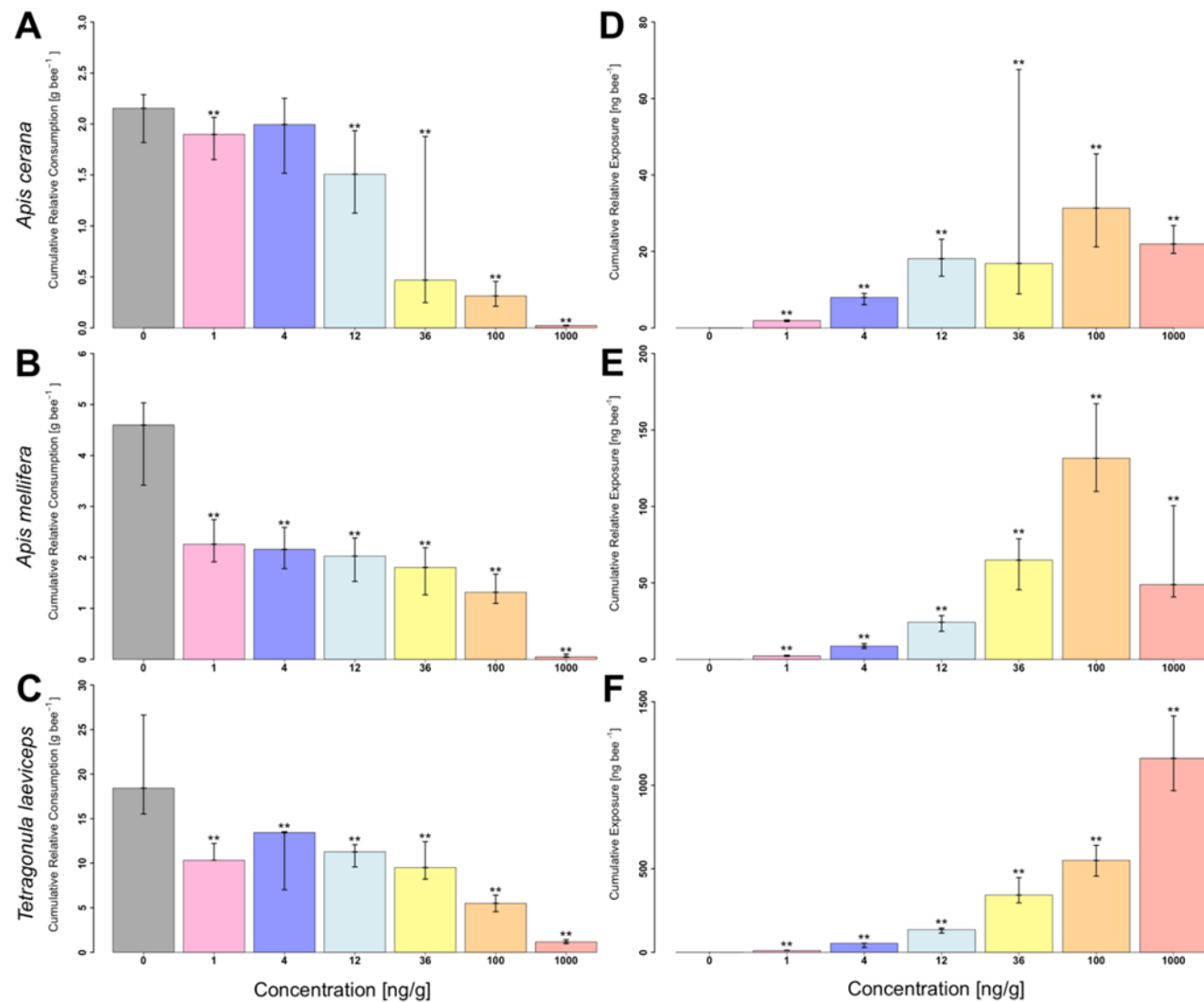
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Results: Survival (*Tetragonula laeviceps*)



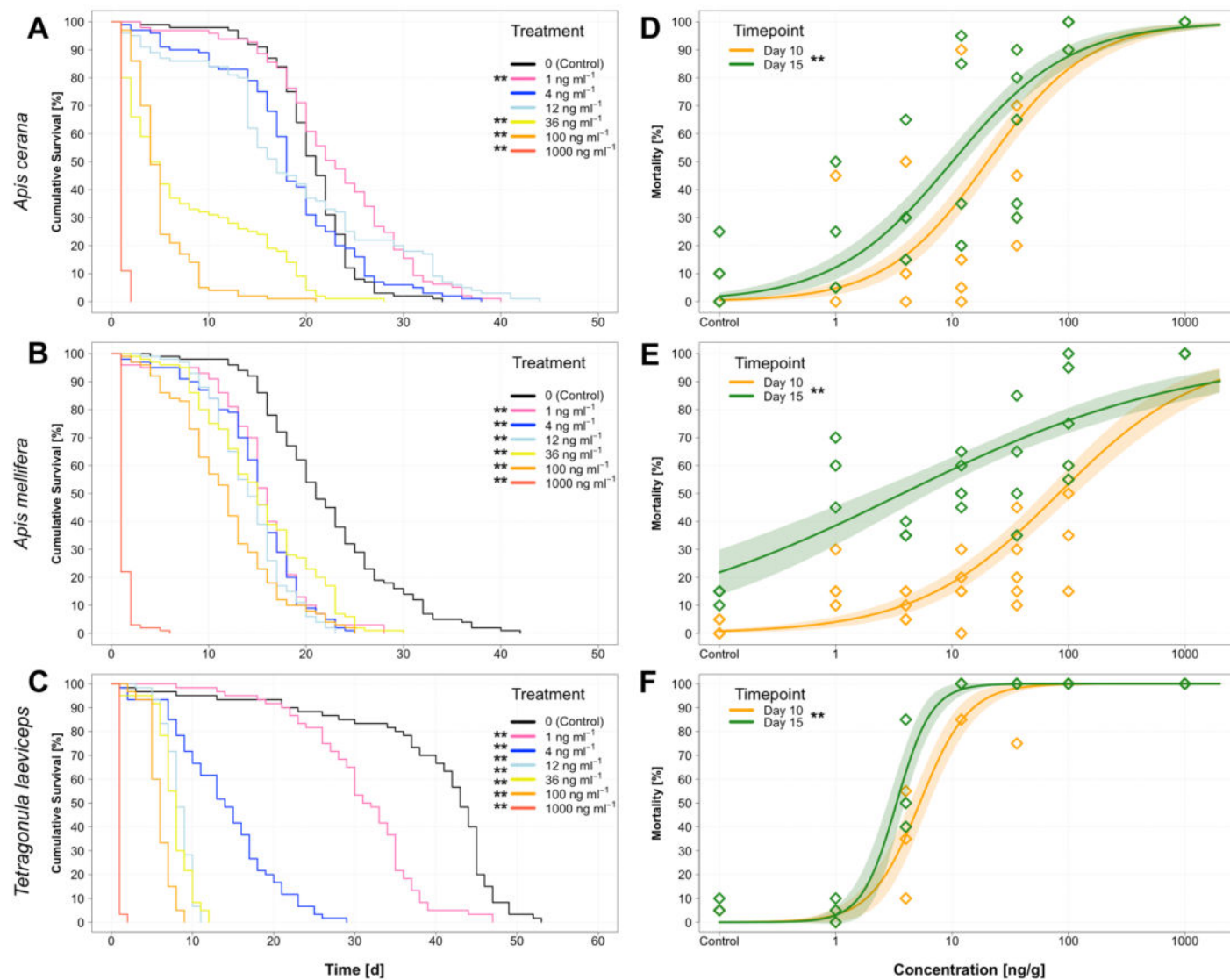
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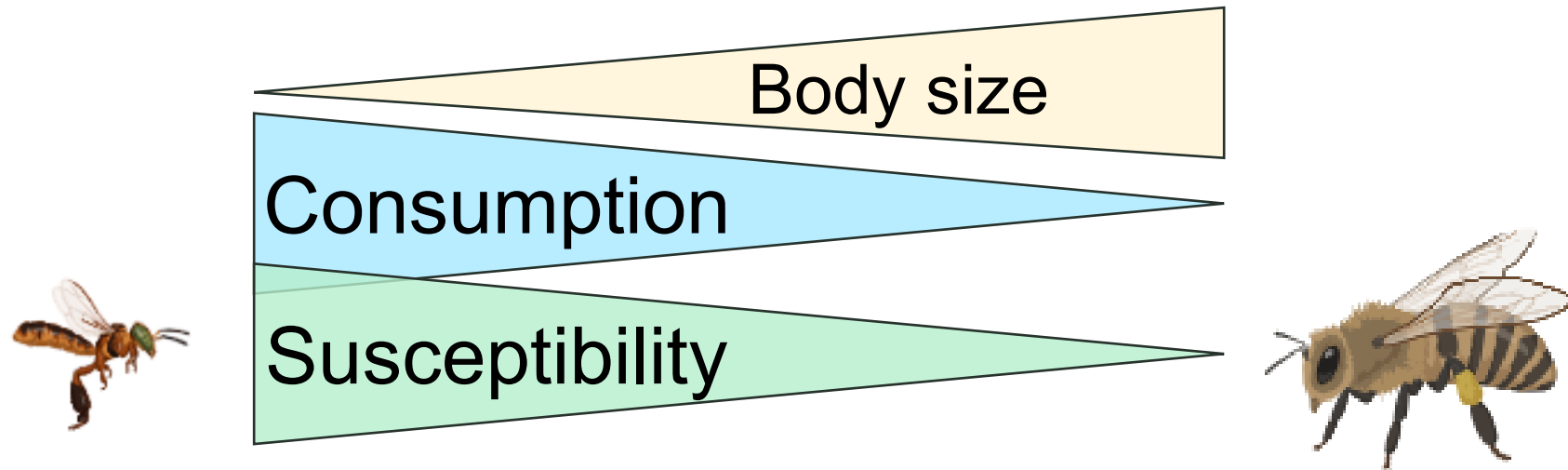


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Hypotheses

Hypothesis 1:

- Smaller bees are more susceptible due higher energetic demands, leading to greater consumption, and consequently increased neonicotinoid exposure



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Hypotheses

Hypothesis 2:

- Larger colony size increases susceptibility by enabling tolerance to individual loss, reflecting superorganism resilience (*Straub et al., 2015*).

