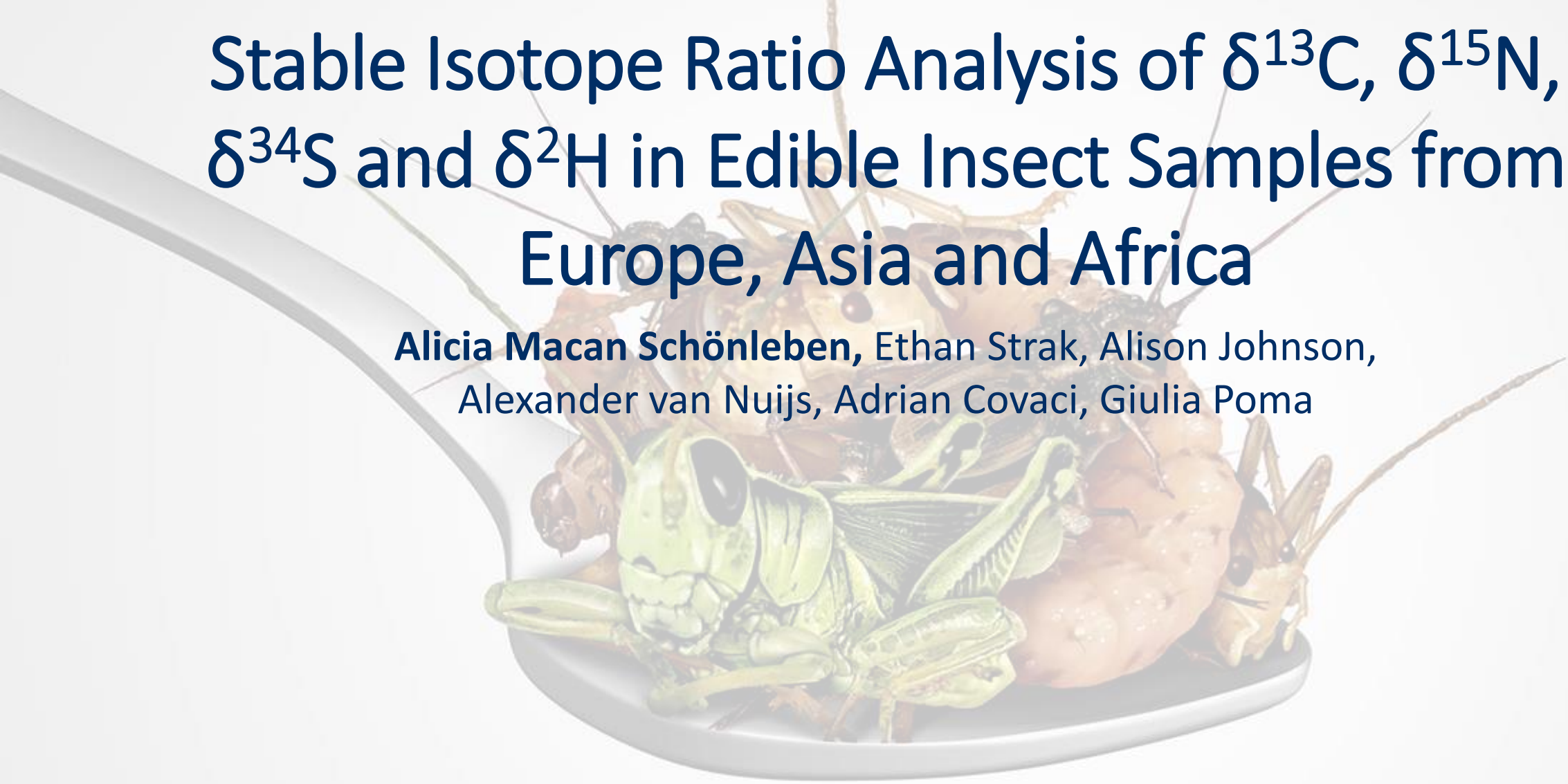
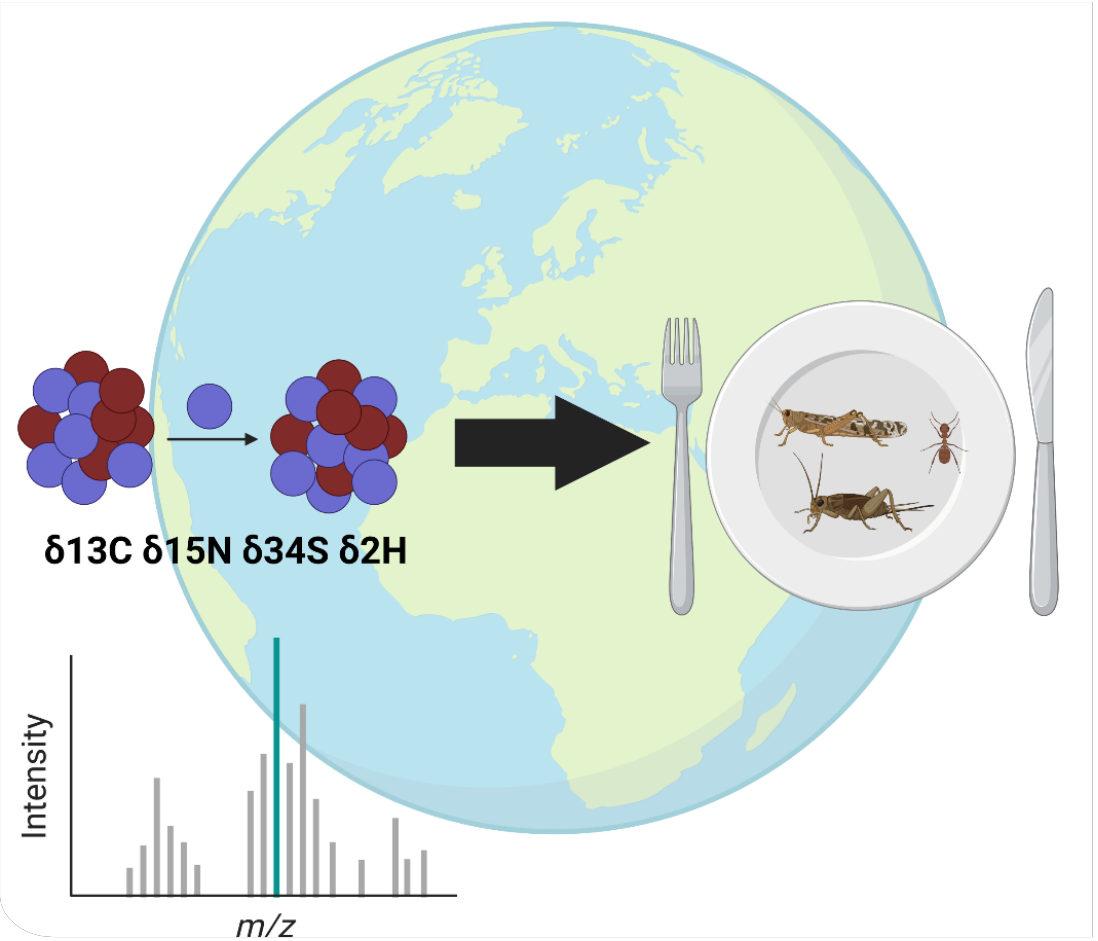
Stable Isotope Ratio Analysis of $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$ and $\delta^{2}H$ in Edible Insect Samples from Europe, Asia and Africa

Alicia Macan Schönleben, Ethan Strak, Alison Johnson,
Alexander van Nuijs, Adrian Covaci, Giulia Poma



Toxicological Centre, University of Antwerp
ISO-FOOD Symposium 2023

Outline



Outline

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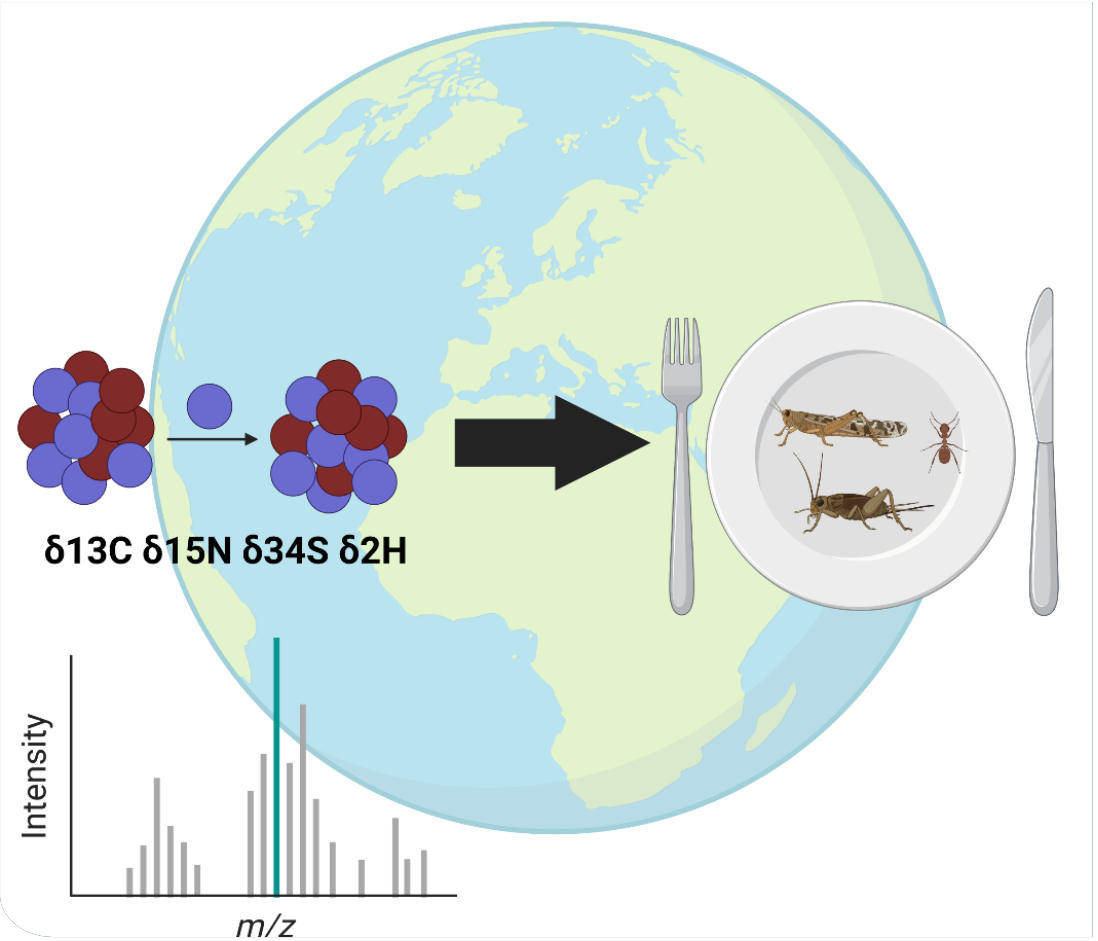

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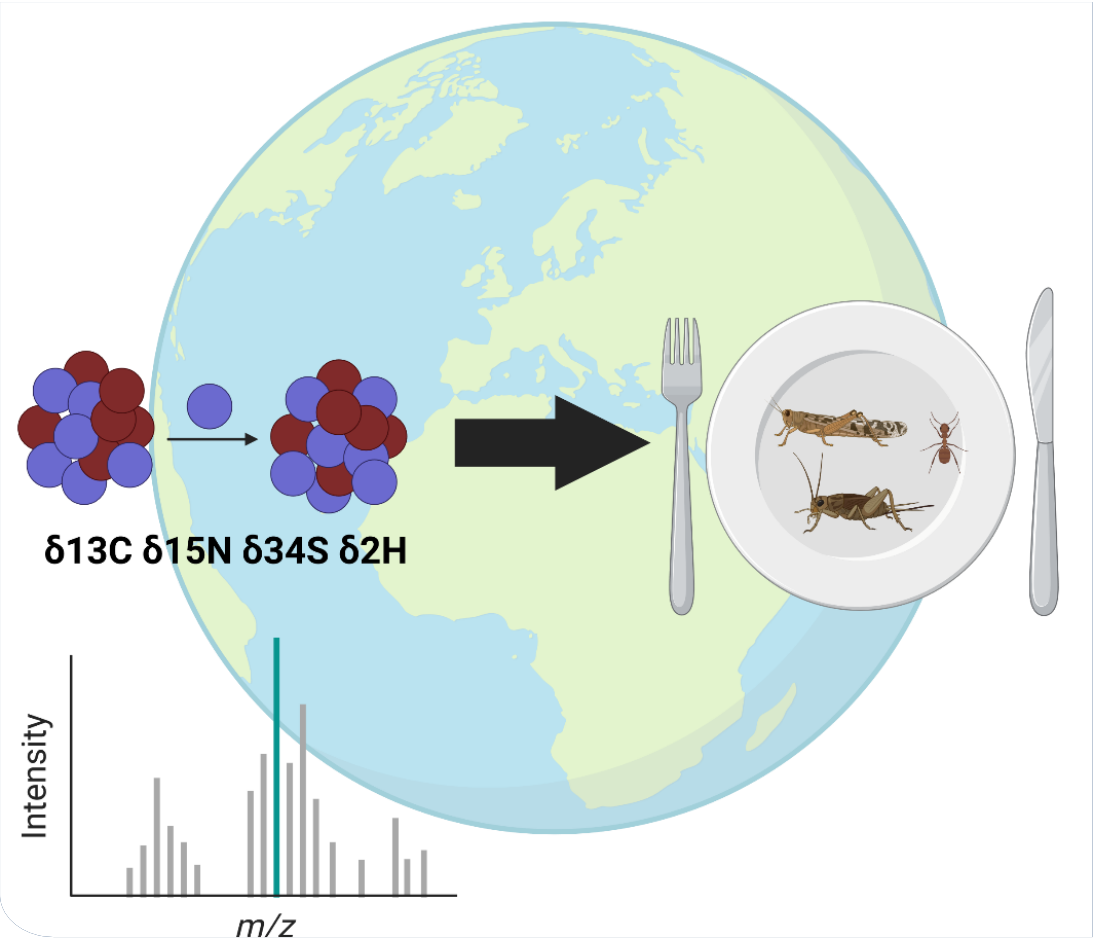

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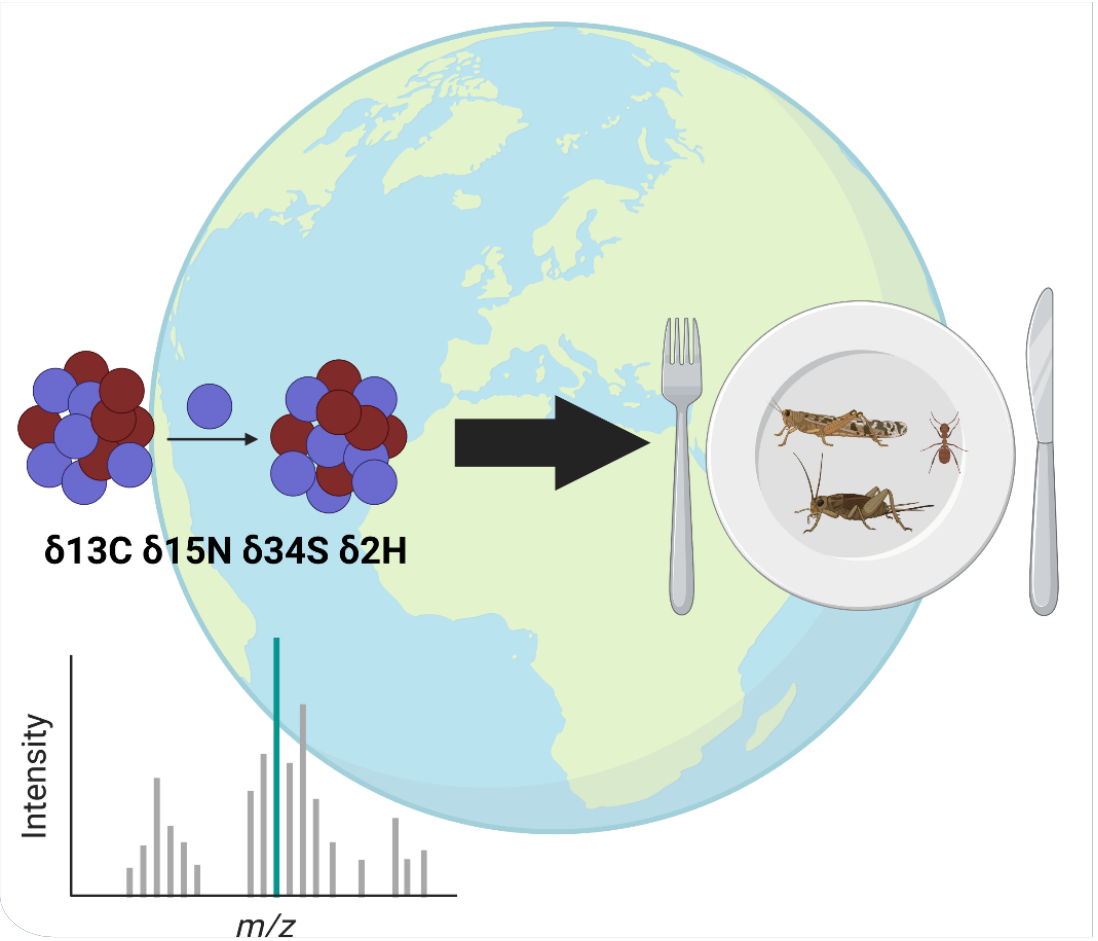
- Results



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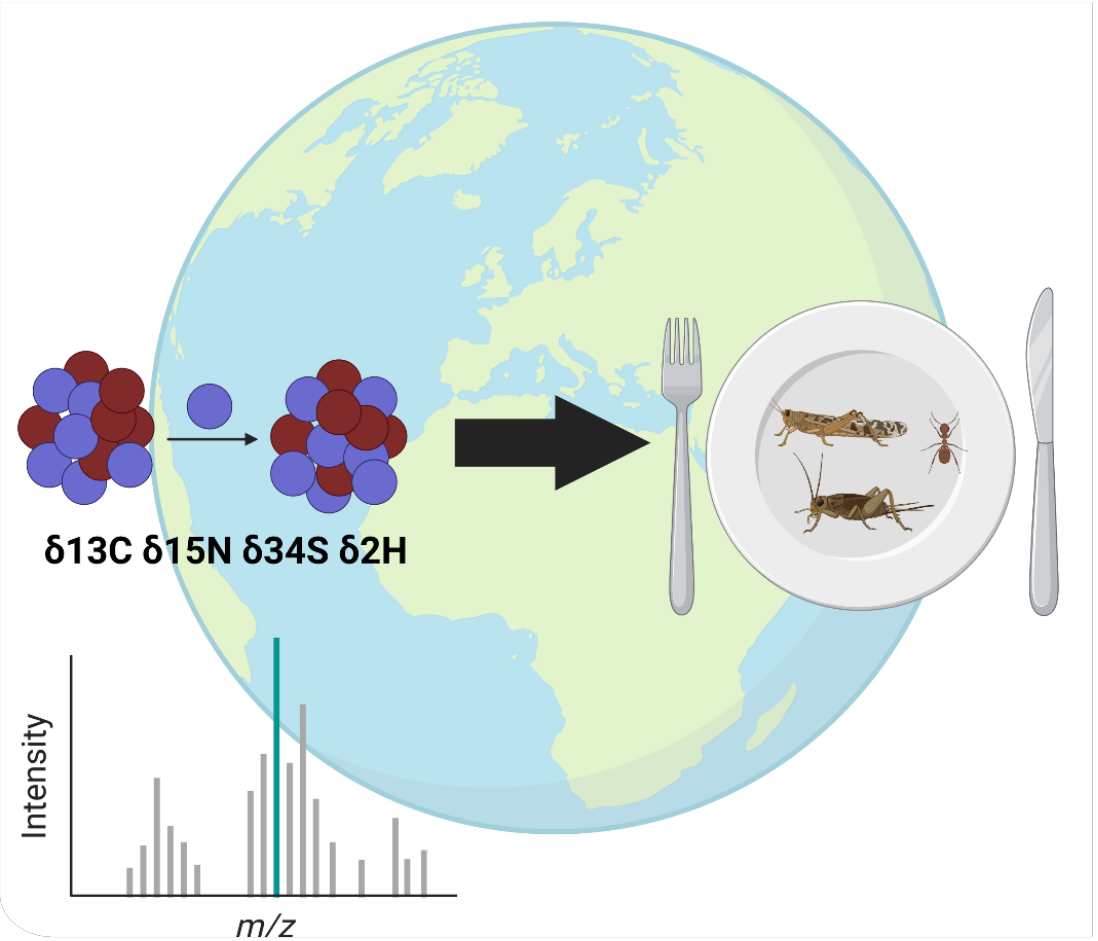

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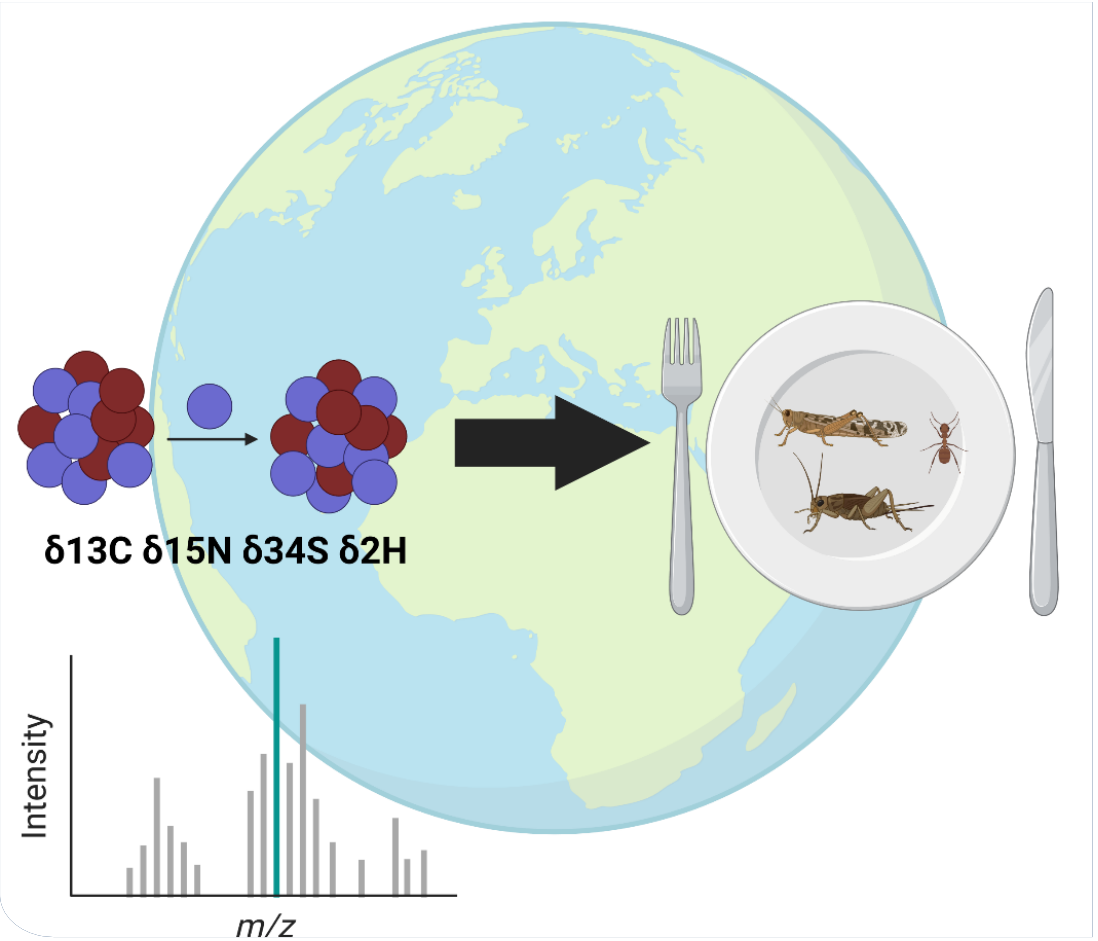
- Future perspectives



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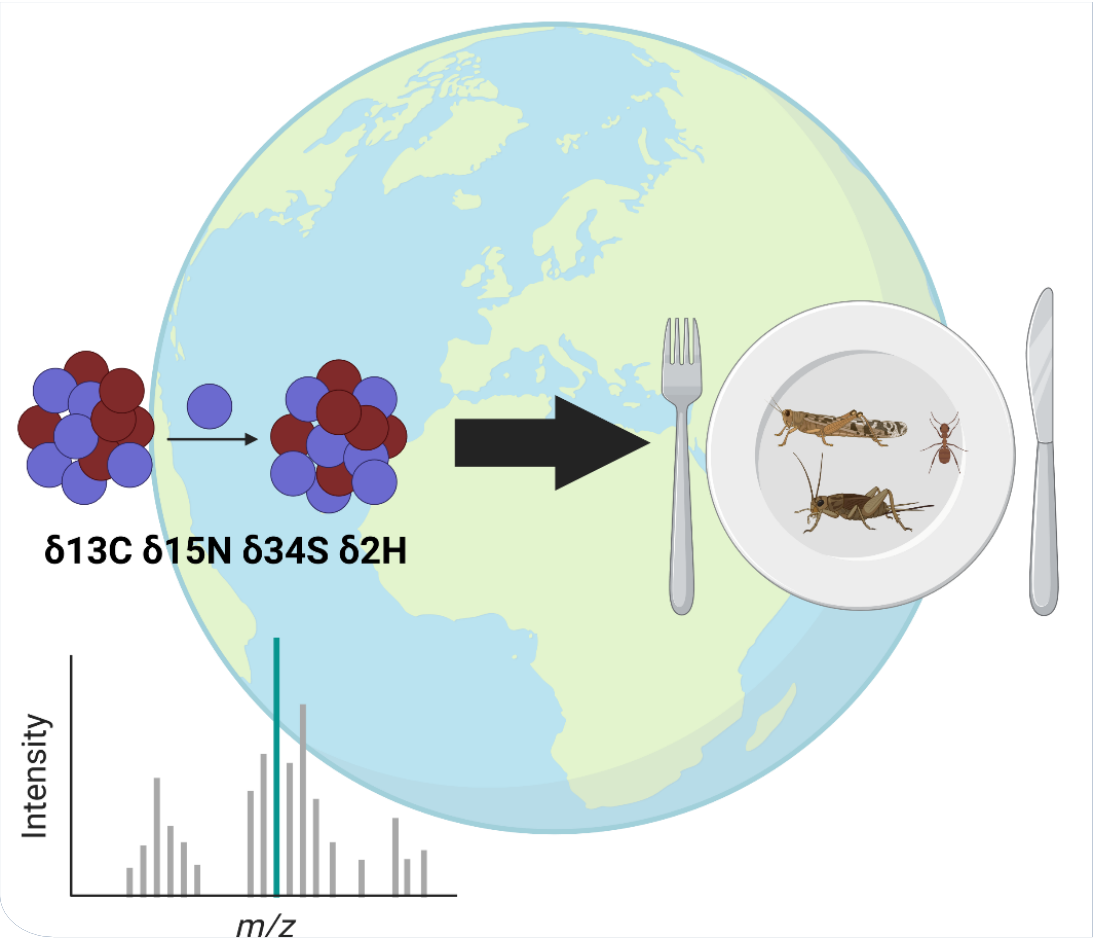
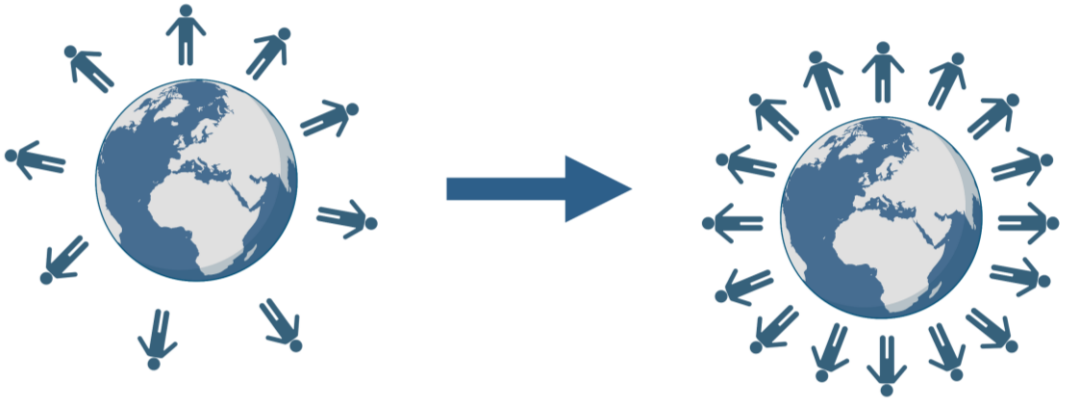
- Acknowledgements



Why insects?

Why insects?

2020 **2050**



~10 billion people

→ 50% more food (and feed)

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2050

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If maintaining current food system
- → Significant increase in greenhouse gas emissions
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Climate change also contributes to food insecurity

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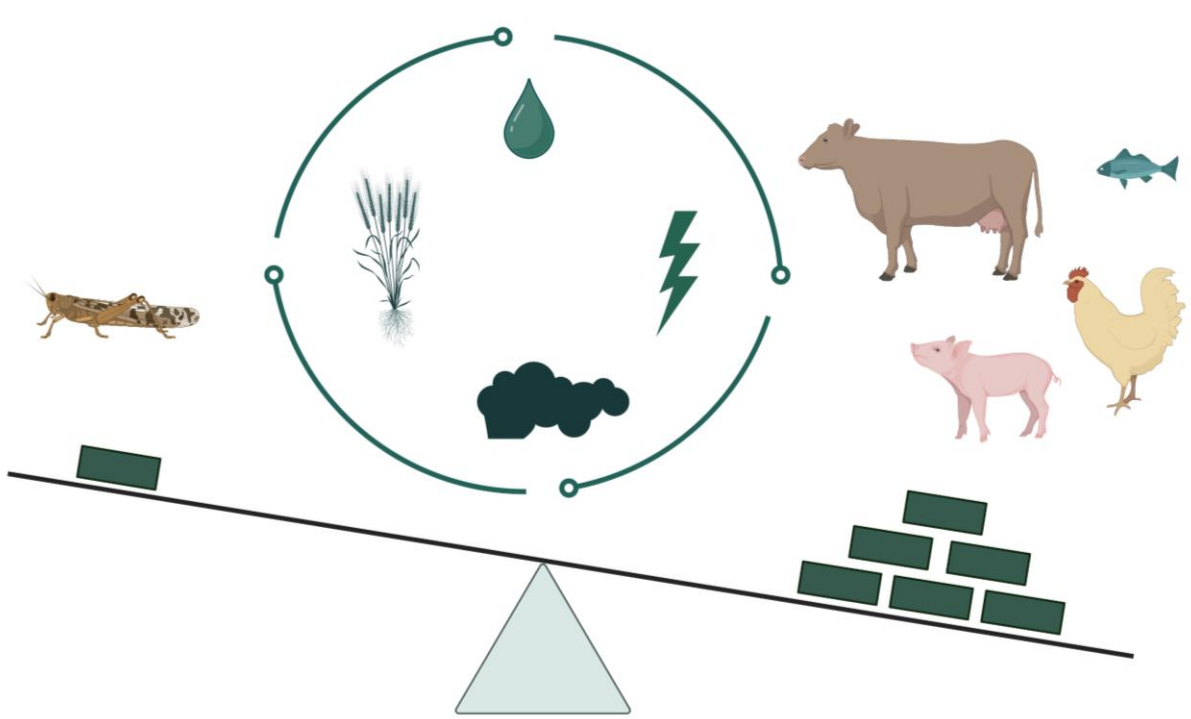
Climate change also contributes to food insecurity

Growing population and growing demand for food
→ in need for new protein sources

Why insects?

Why insects?

Insects are a sustainable and healthy protein alternative to conventional livestock products



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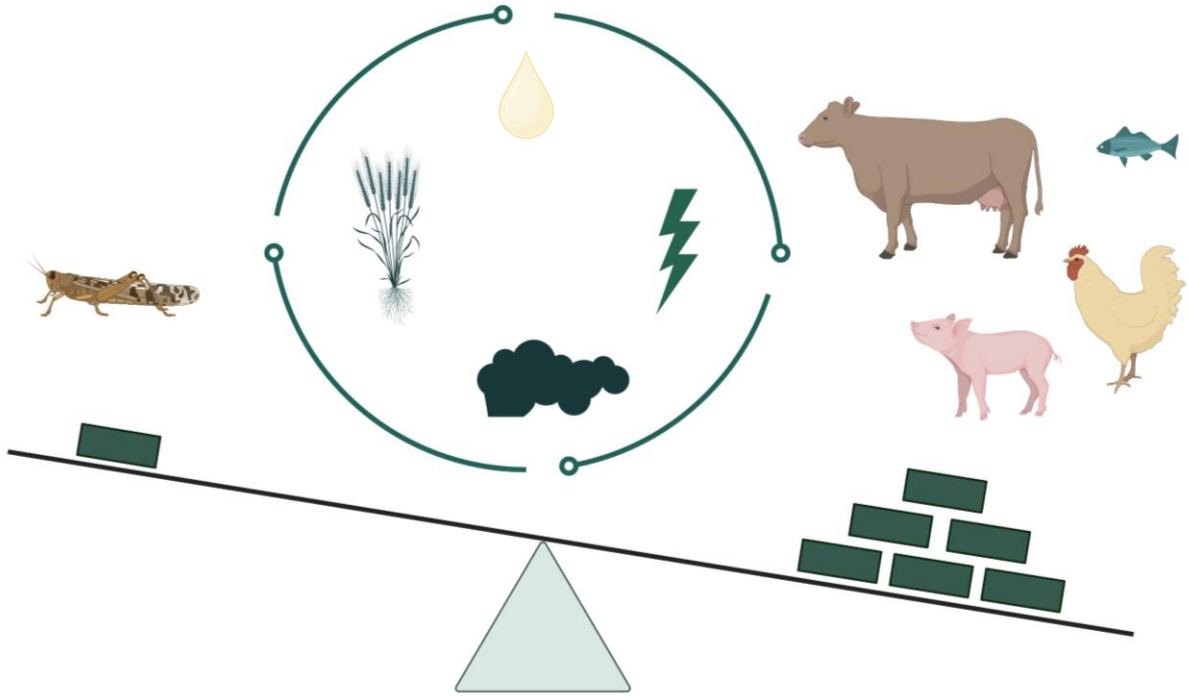

- Less food and water

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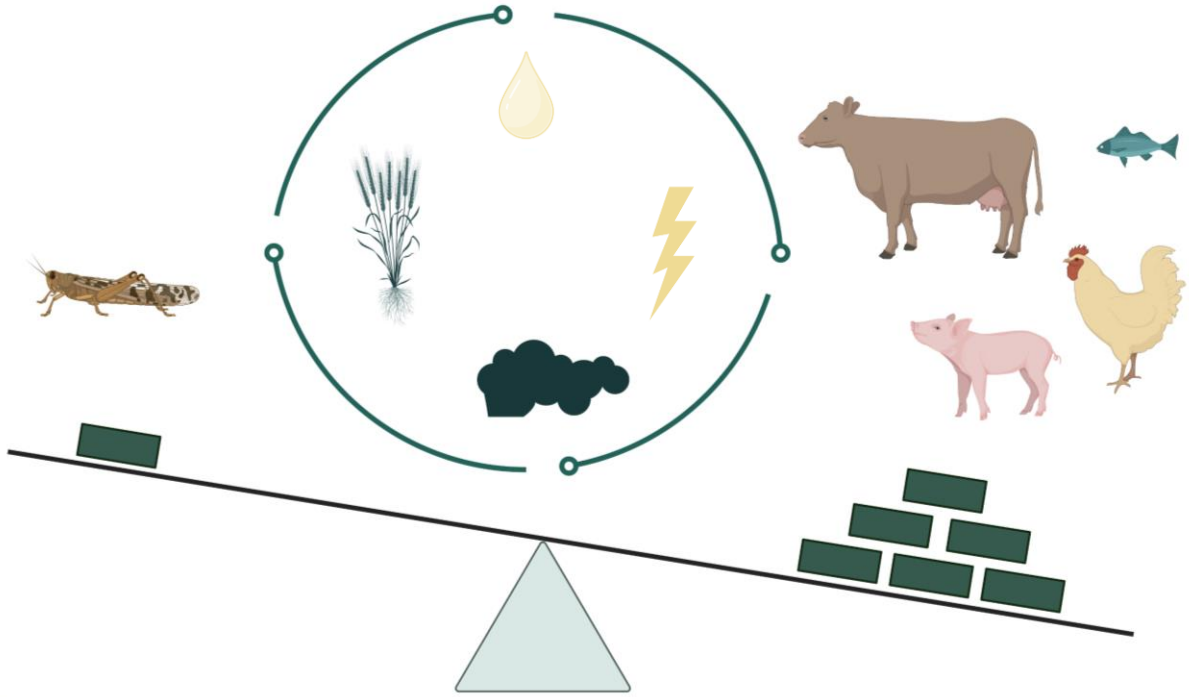

- Less food and water
- Less energy

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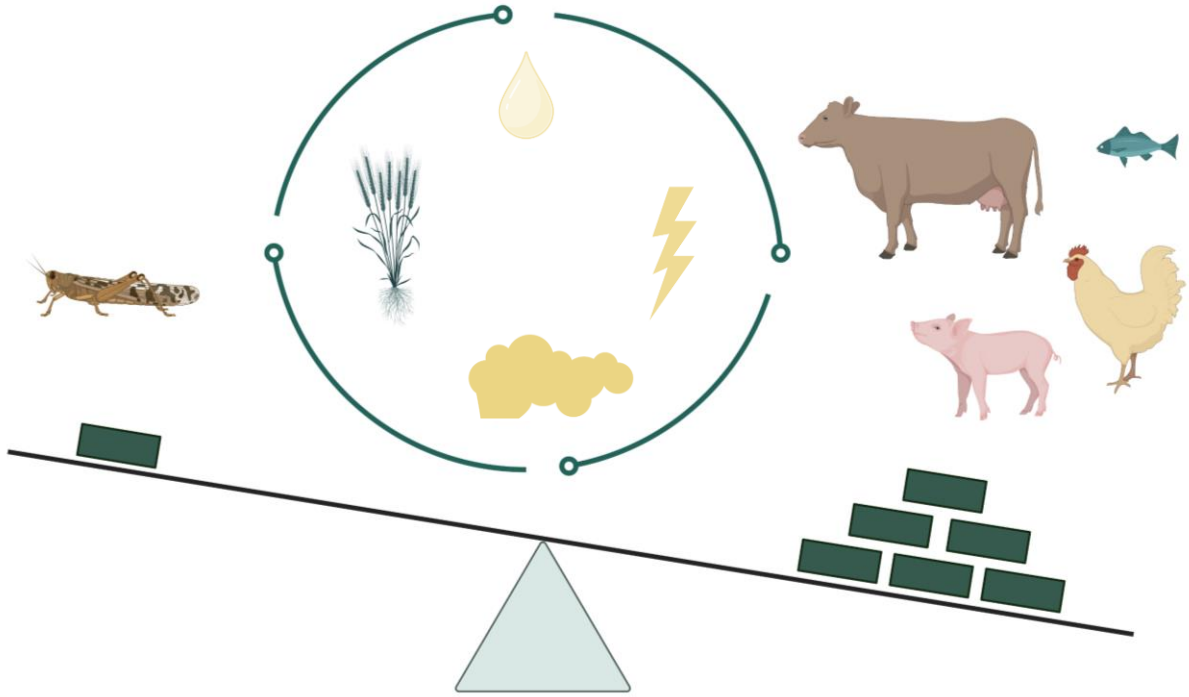

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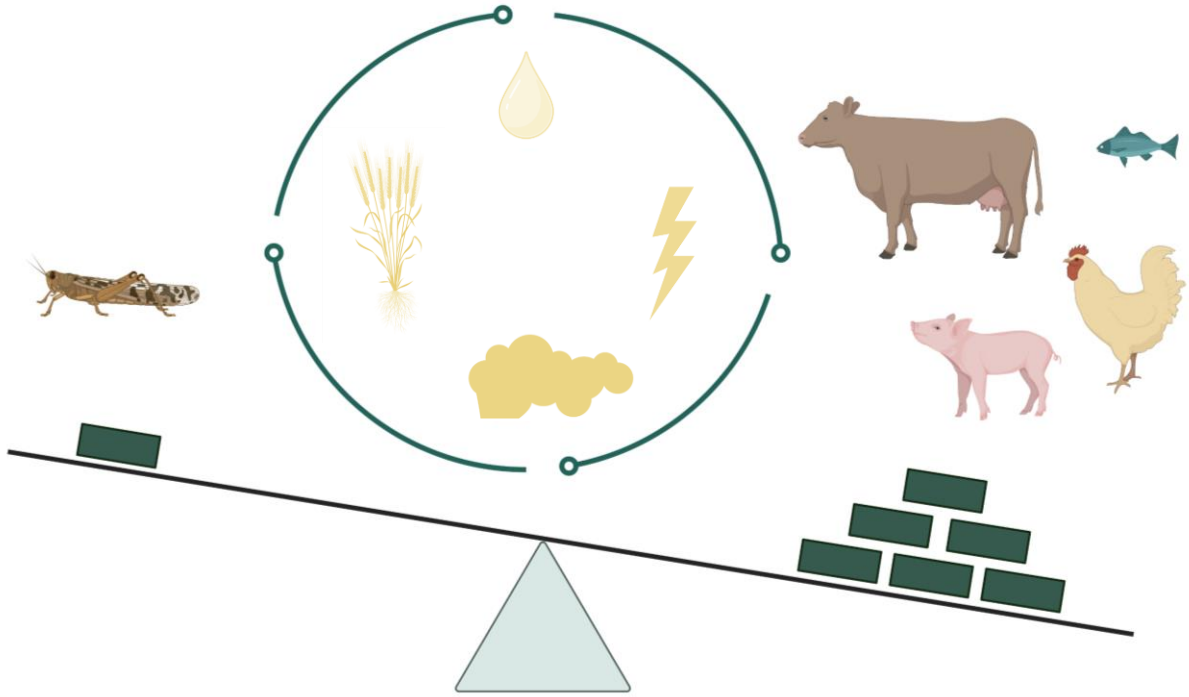

- Less food and water
- Less energy
- Less greenhouse gas emissions
- Less space

Why insects?

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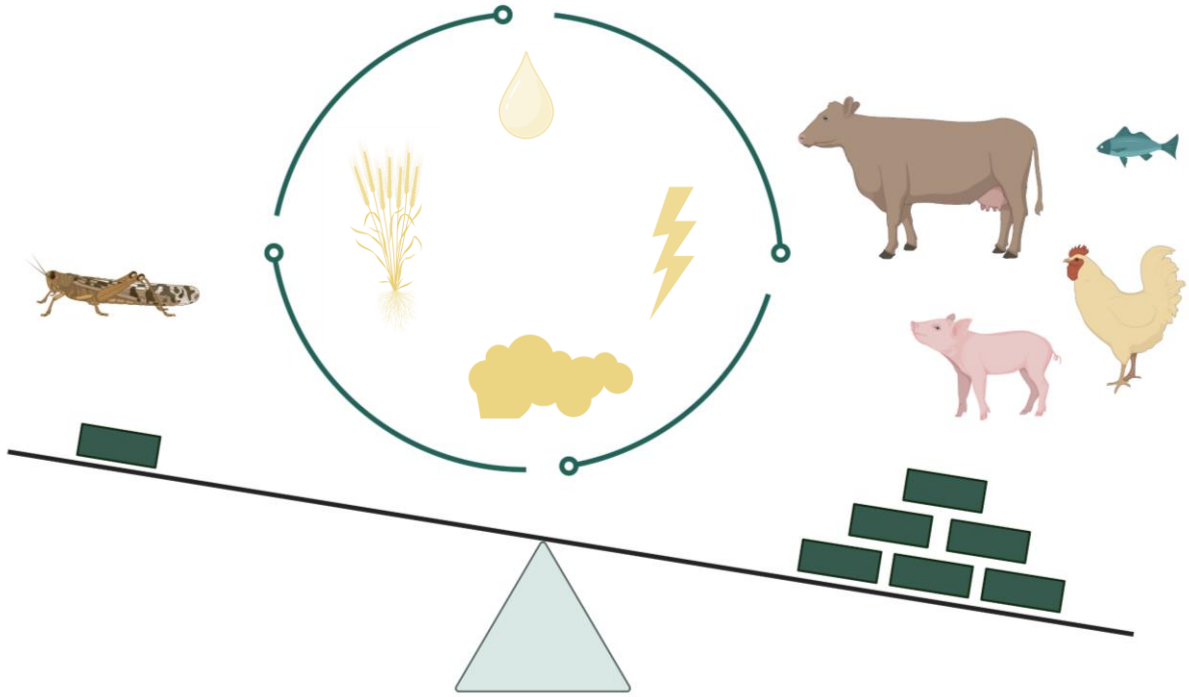

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- Additional nutritional value

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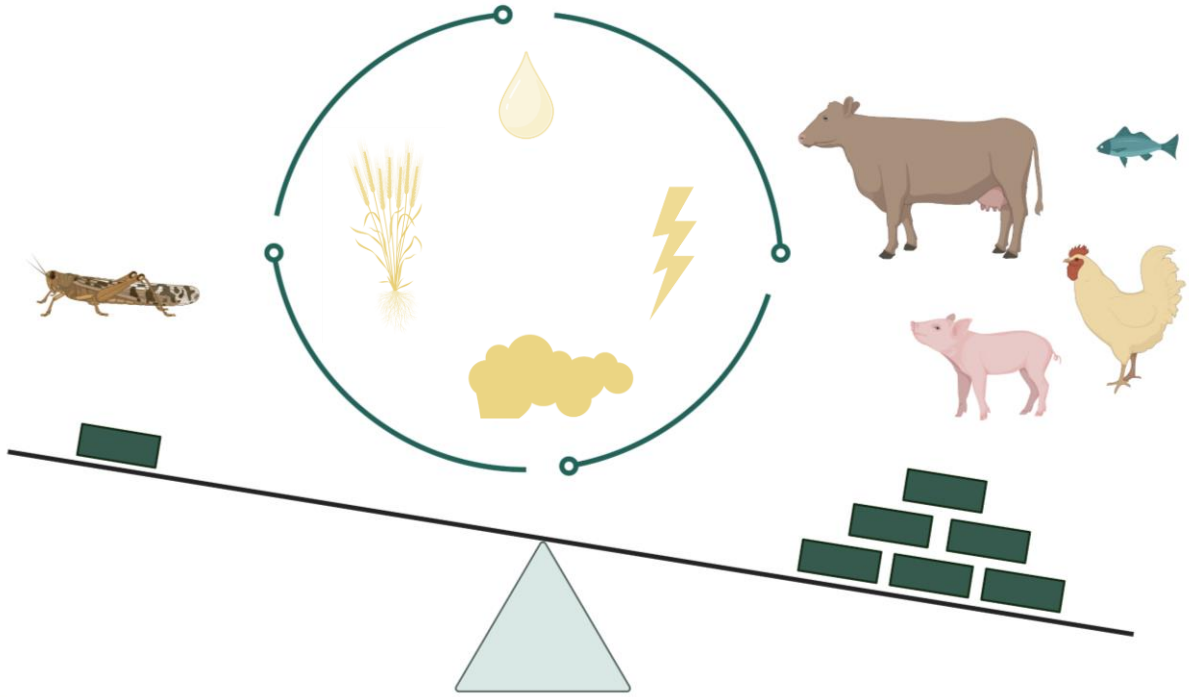

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- Additional nutritional value
- Consumed for centuries in many parts of the world

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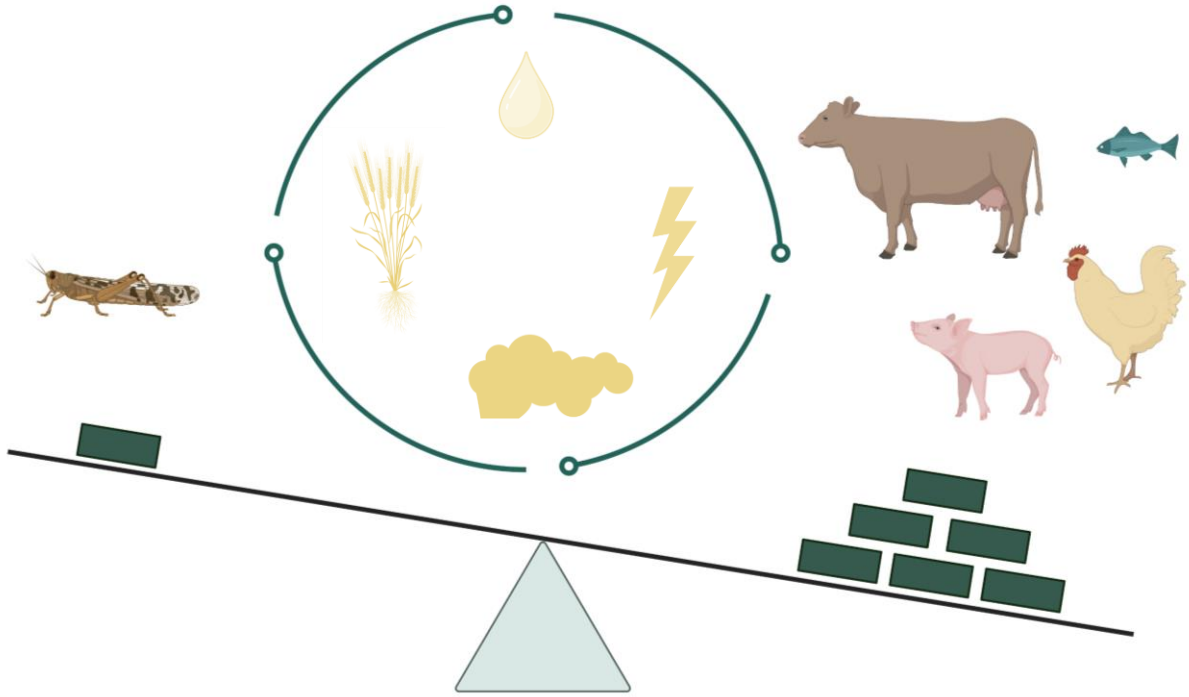

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Entering European market in recent years

History of consumption

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[1]https://ec.europa.eu/food/safety/novel-food_en

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Novel food regulation

„Food that had not been consumed to a significant degree by humans in the EU before 15 May 1997, when the first Regulation on novel food came into force.”[1]

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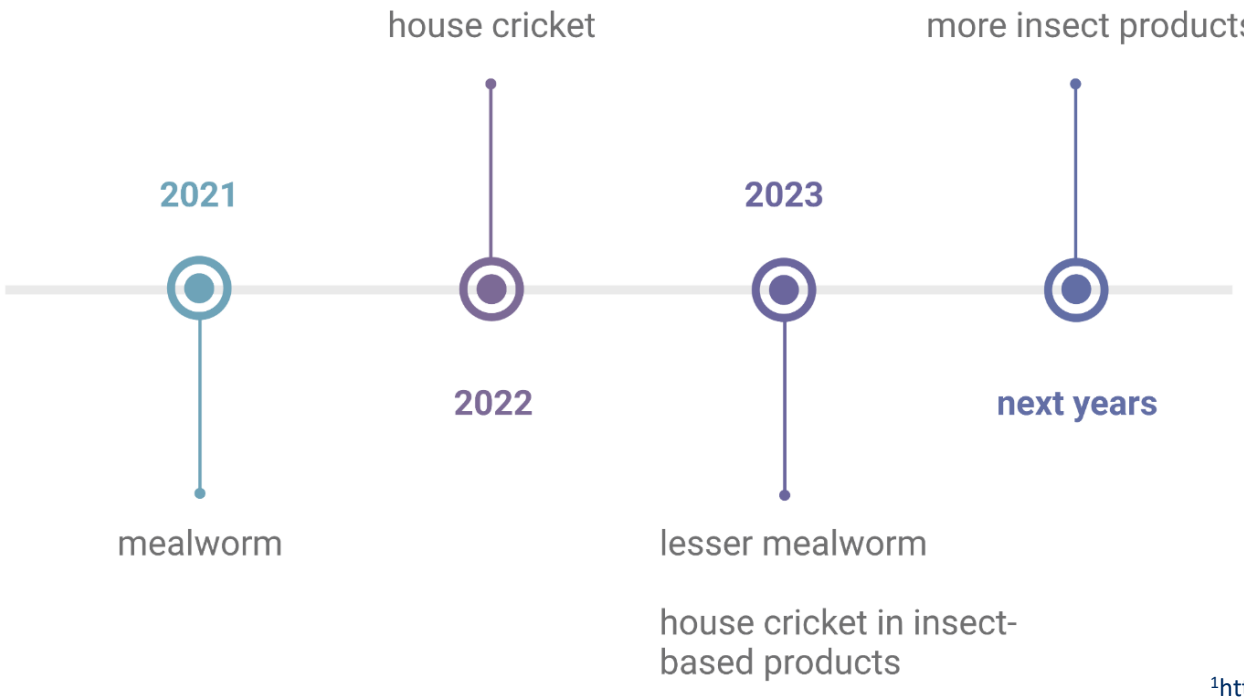

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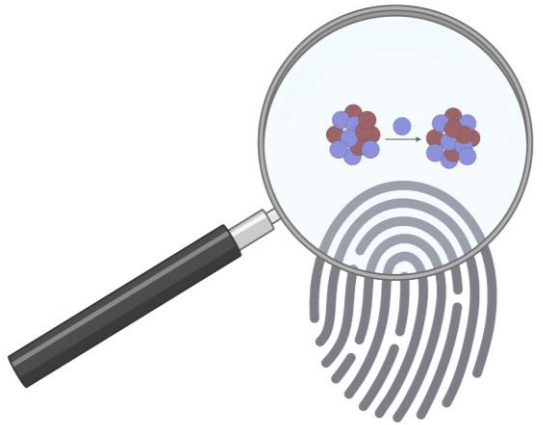
Stable isotope ratio analysis



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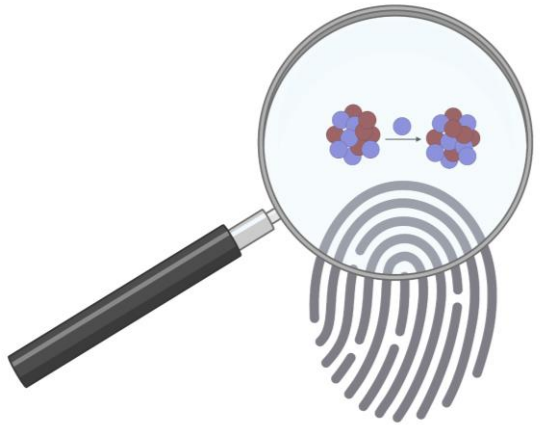


Materials have an “isotopic fingerprint”

Isotopic abundances are fixed

Subtle variations through chemical, physical, biological processes

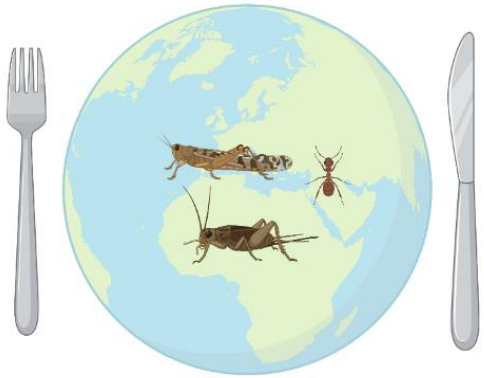
→ characteristic for history and origin of substance

Powerful tool in food authenticity and traceability

Datasets of isotope ratios need to be established

Samples

n=49



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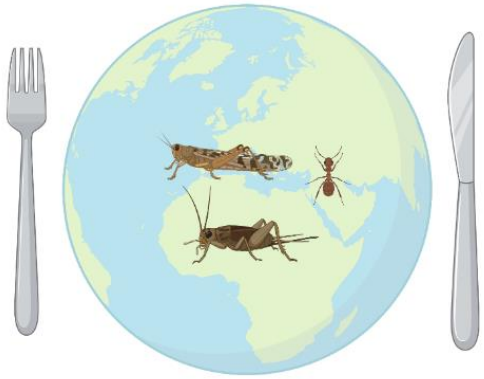

Origin

Africa:	Asia:	Europe:
- Nigeria	- Thailand	- Belgium
- Uganda	- China	- Netherlands
	- South Korea	- Austria
	- Japan	- UK

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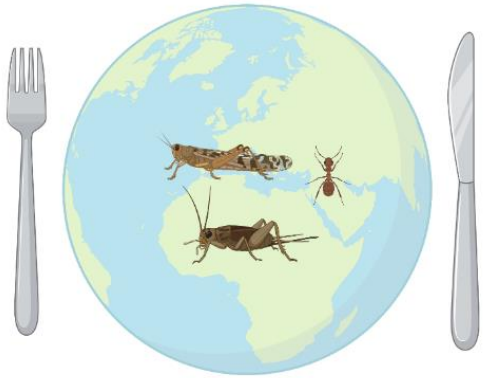

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Order

- Blattodea
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- Orthoptera
- Hymenoptera
- Hemiptera
- Trichoptera

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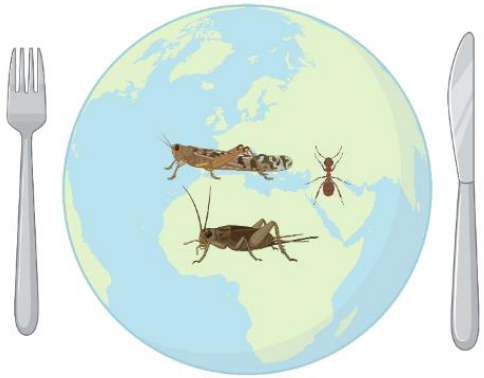

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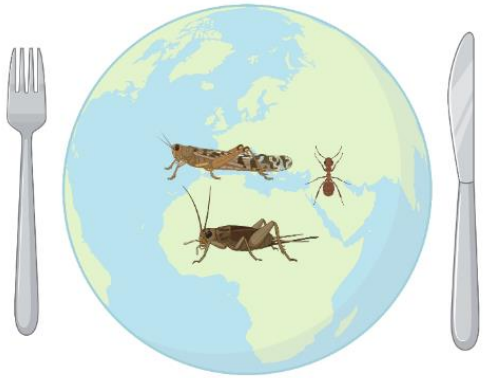

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→ Origin testing

→ Farmed vs wild

→ Testing for pesticide occurence (suspect screening data)

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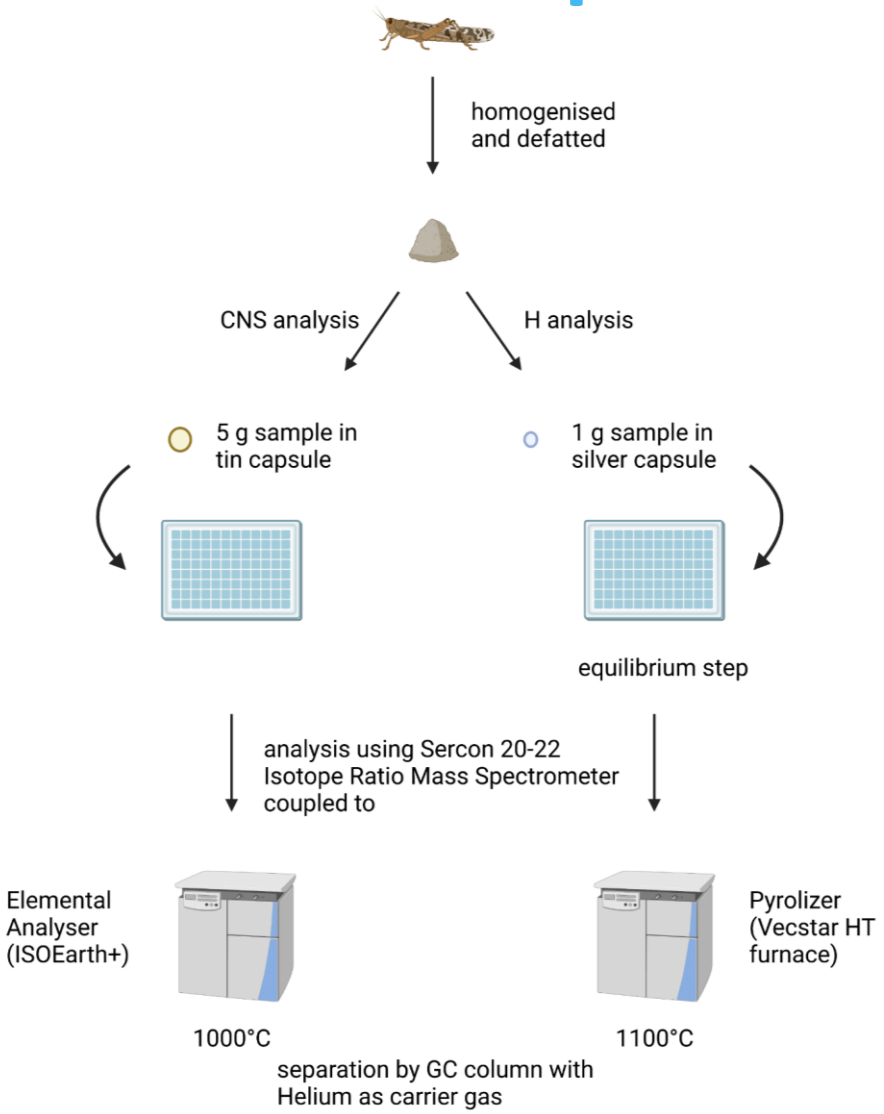

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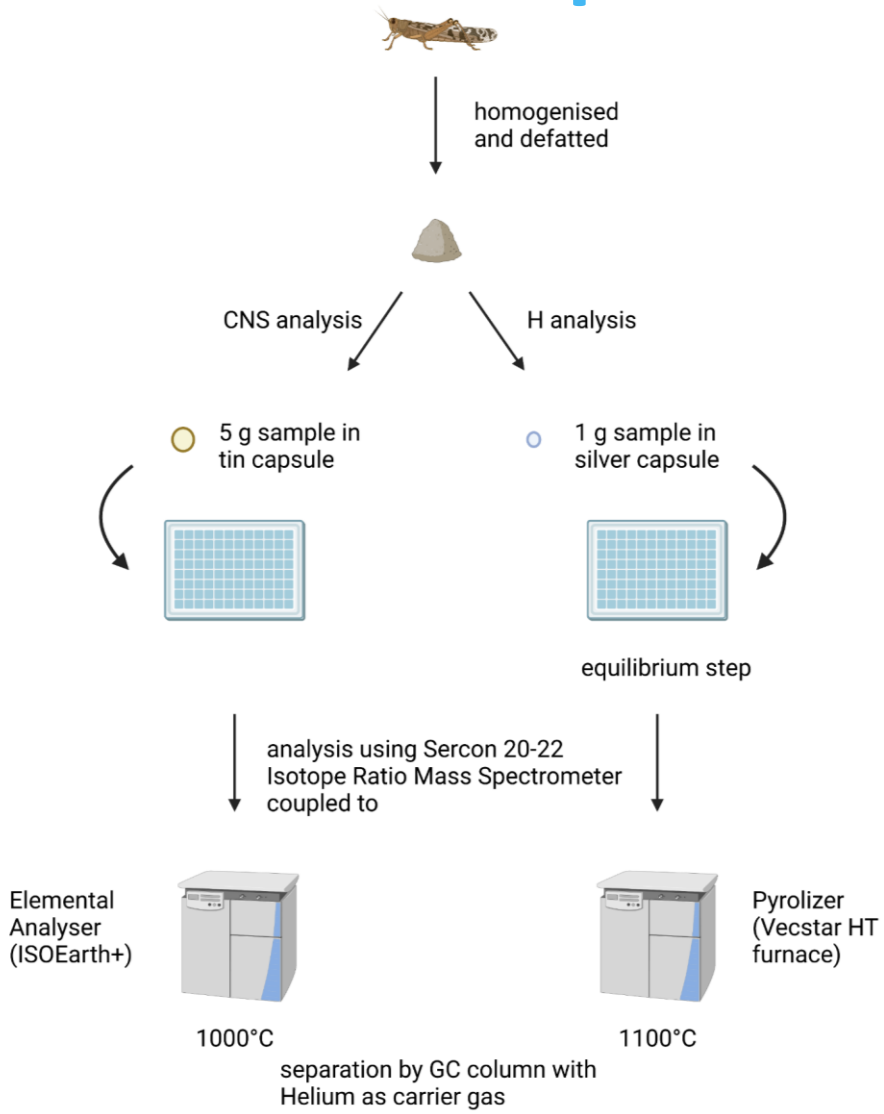


	dH	dC	dS	dN
International standard	V-SMOW	V-PDB	V-CDT	air
Maximum standard deviation	3.0‰	0.3‰	0.8‰	0.3‰

Reference materials: NIST 1577c and SCO463

In-house quality control

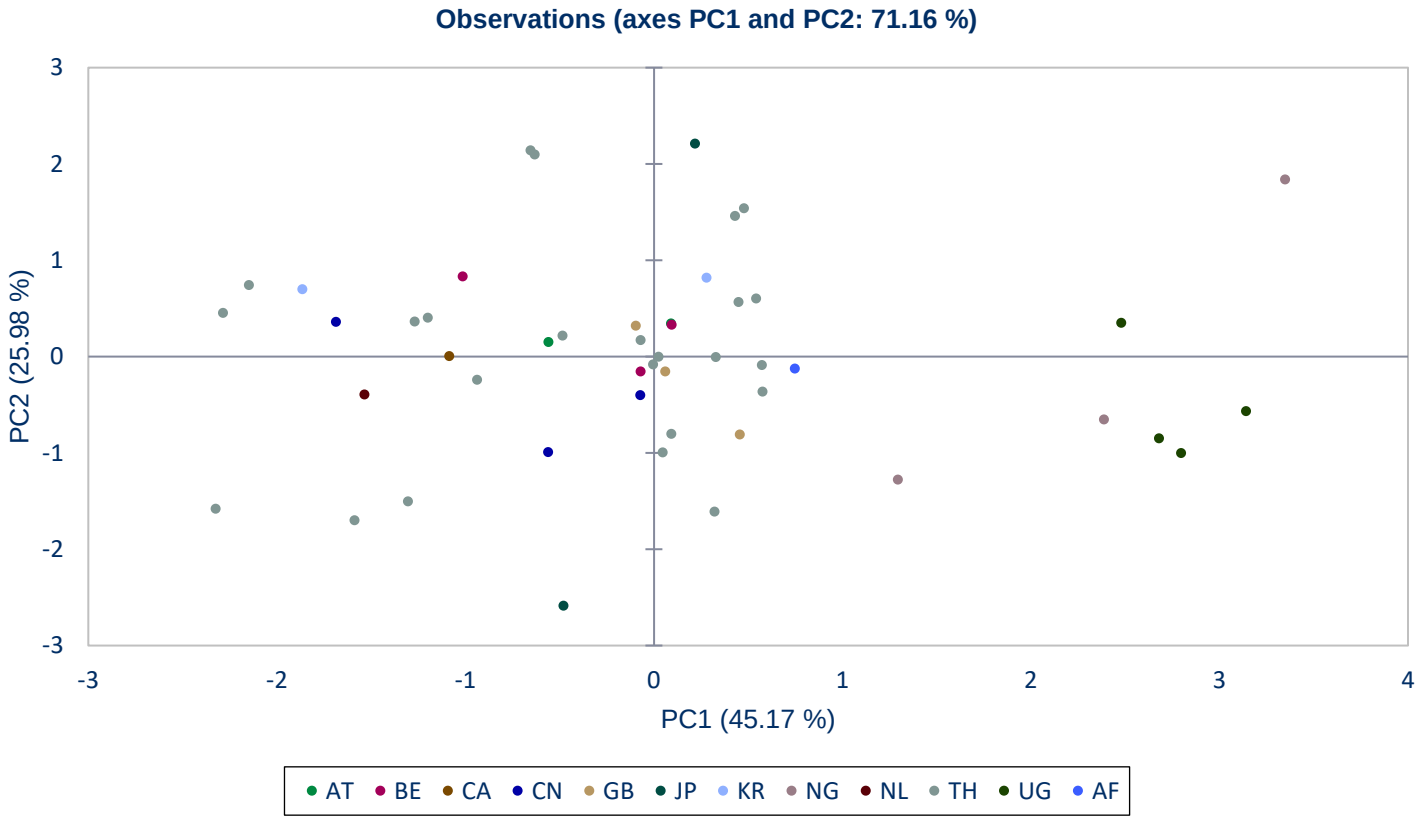
Re-processing with Calisto software

Statistical analysis using XLSTAT:

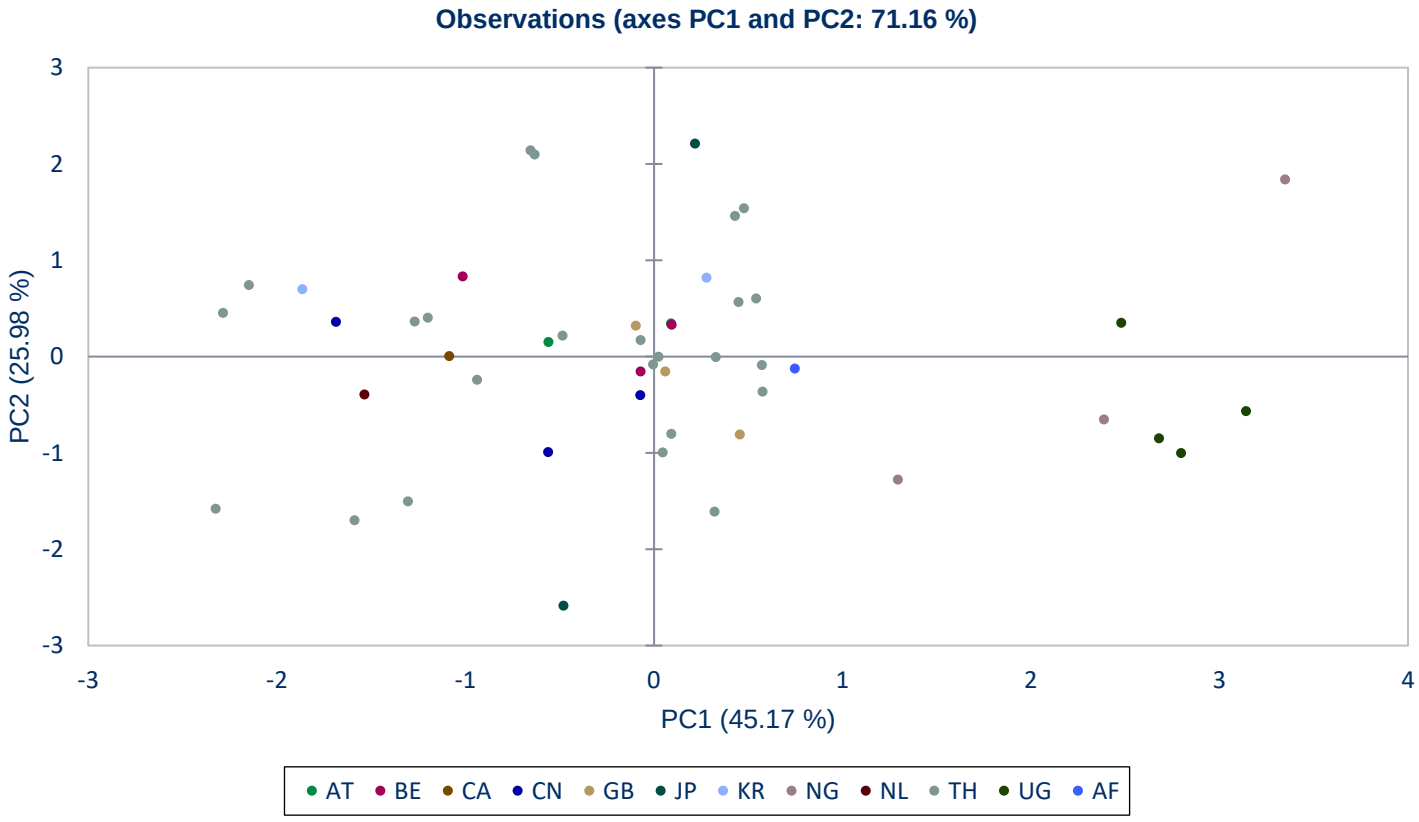
- Principal Component Analysis (PCA)
- One-way Analysis of Variance (ANOVA)
- Linear Discriminative Analysis (LDA)

Origin

Origin

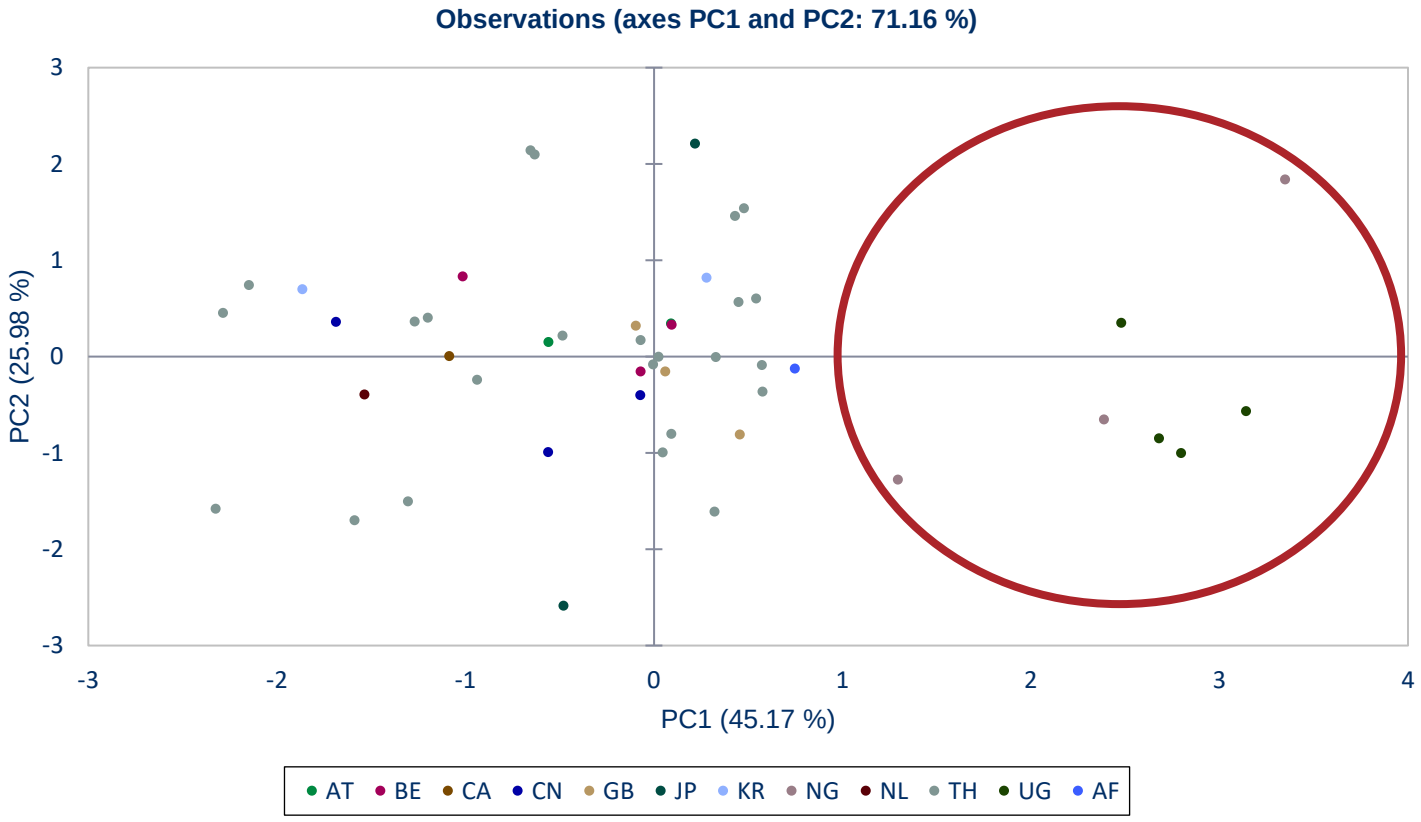

Observations (axes PC1 and PC2: 71.16 %)
PC2 (25.98 %)
PC1 (45.17 %)
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3
4
AT BE CA CN GB JP KR NG NL TH UG AF

Origin



No distinction between countries possible using PCA and LDA

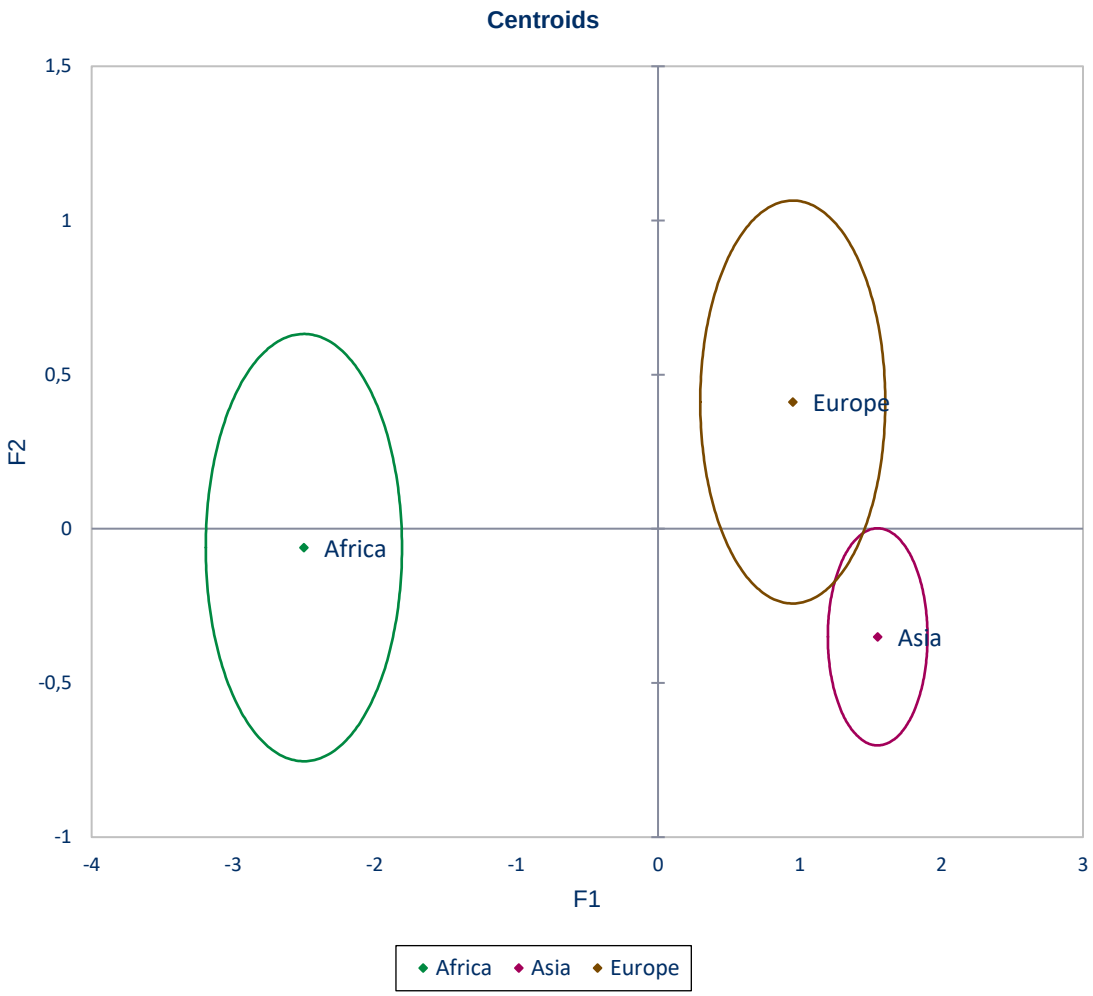
Origin



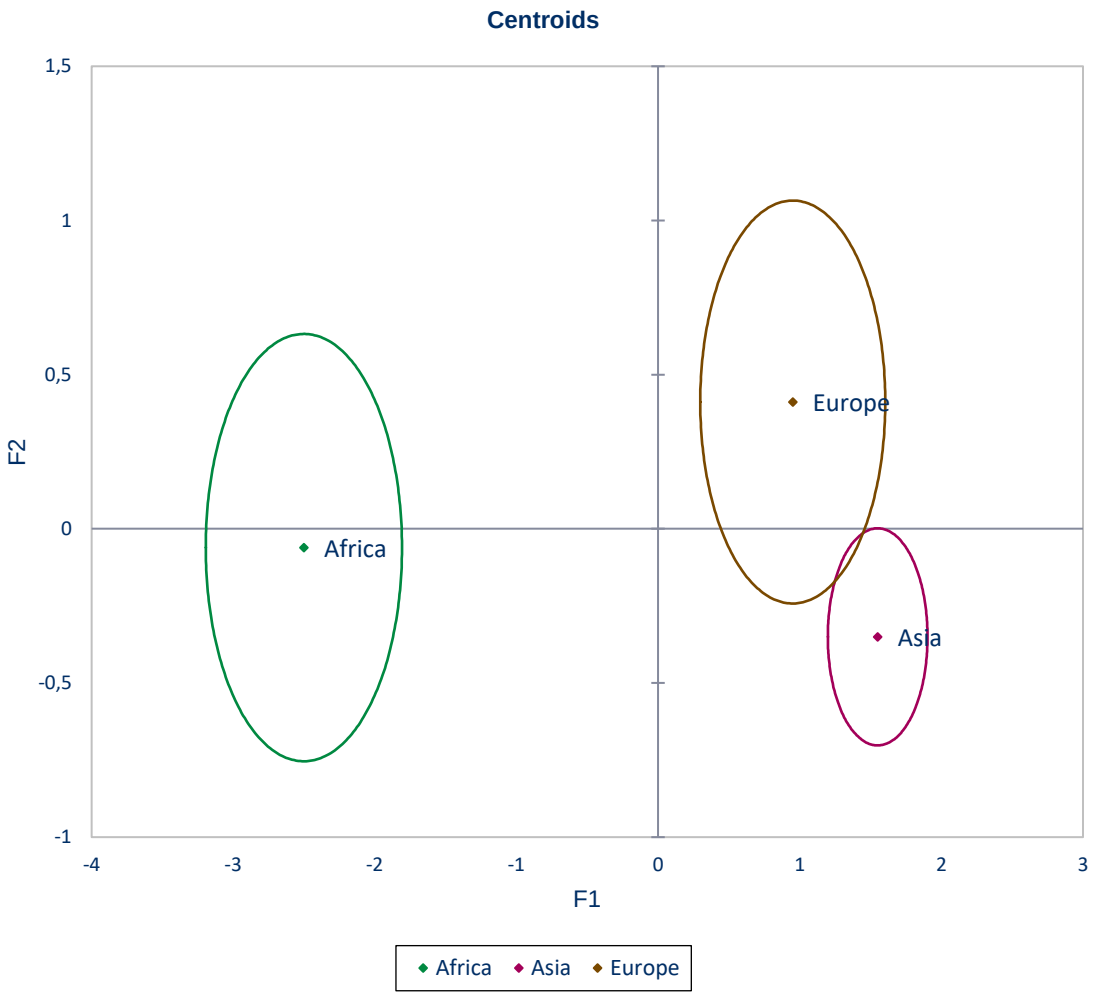
No distinction between countries possible using PCA and LDA

→ African samples showed distinct profile

Origin

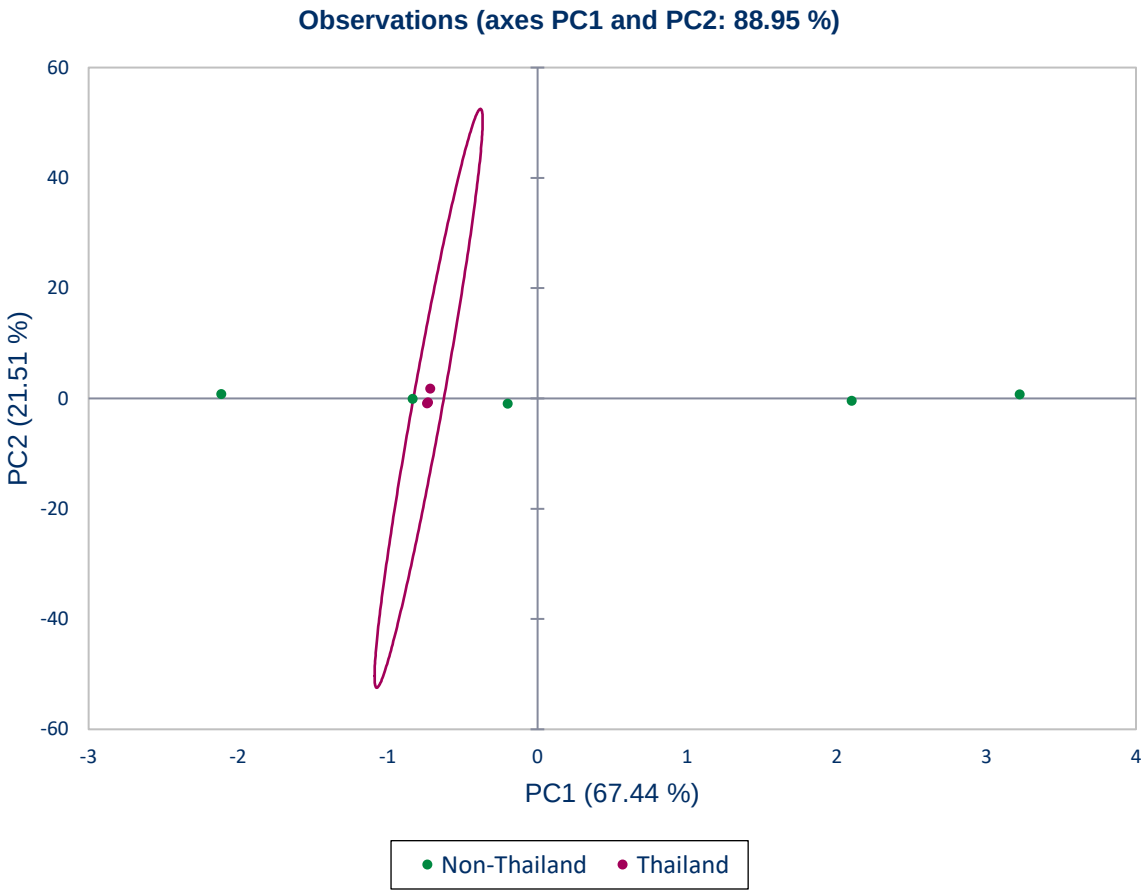

Centroids
1,5
1
0,5
0
-0,5
-1
F2
-4
-3
-2
-1
0
1
2
3
F1
Africa
Europe
Asia
Africa
Asia
Europe

Origin

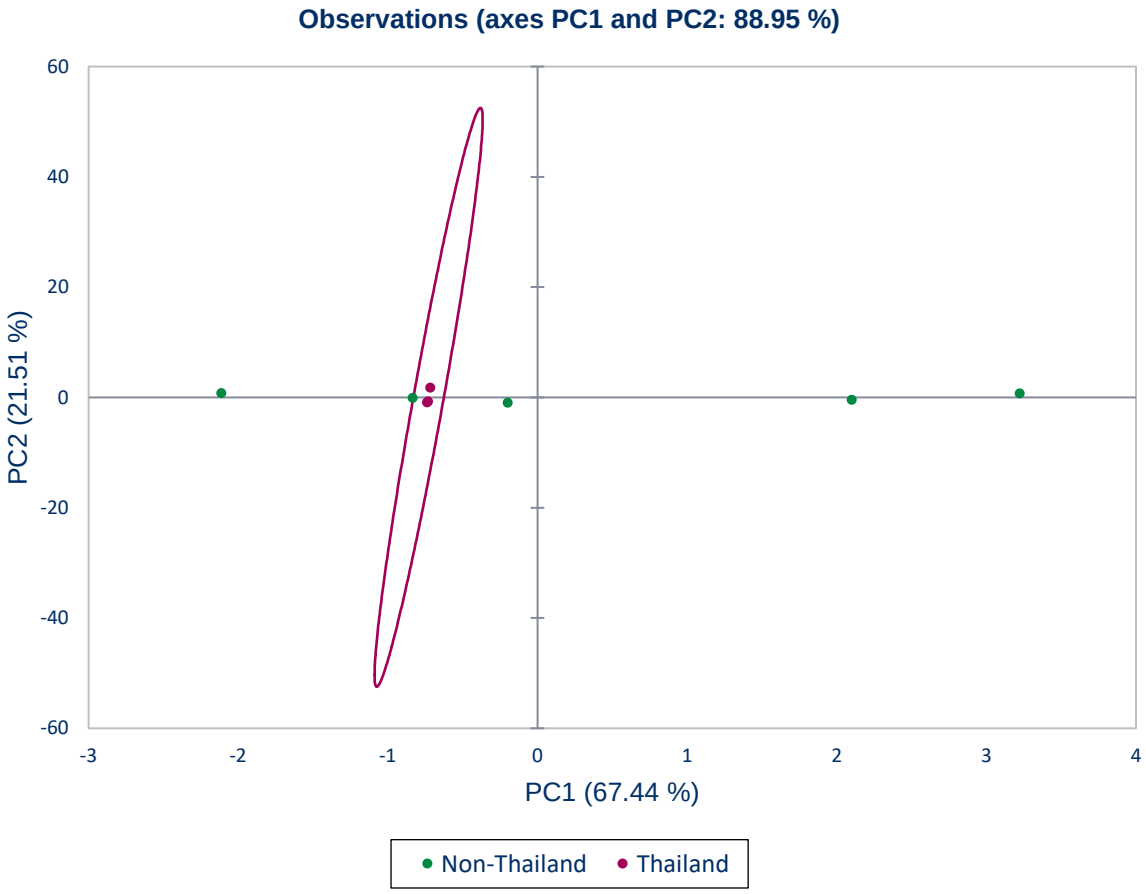


LDA was able to classify **96%** of samples with known origin separated by larger areas

Origin


Observations (axes PC1 and PC2: 88.95 %)
60
40
20
0
-20
-40
-60
PC2 (21.51 %)
-3
-2
-1
0
1
2
3
4
PC1 (67.44 %)
Non-Thailand
Thailand

Origin

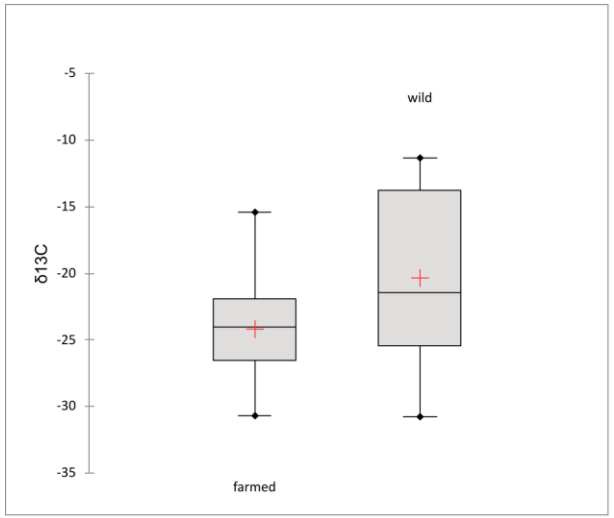


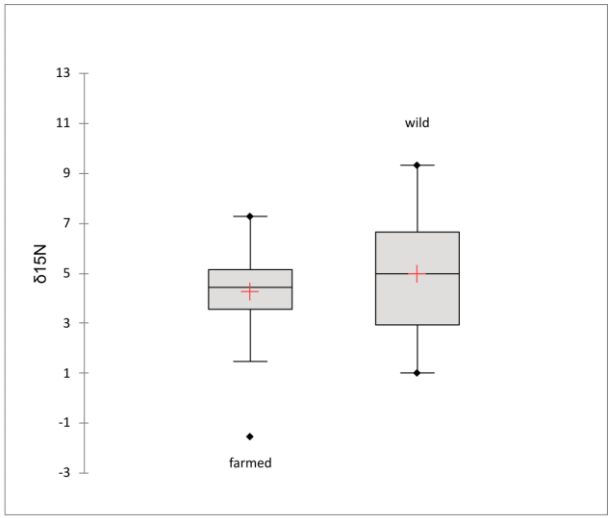
LDA was only able to classify 66% of samples with known origin

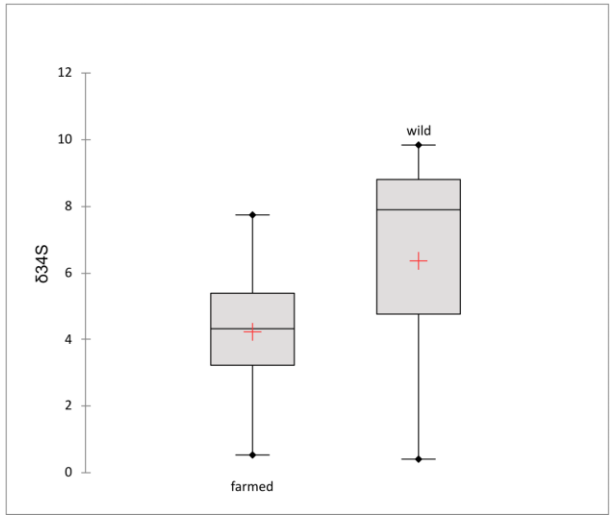
Per species, **90%** correct classification (mealworm, TH vs. non-TH)

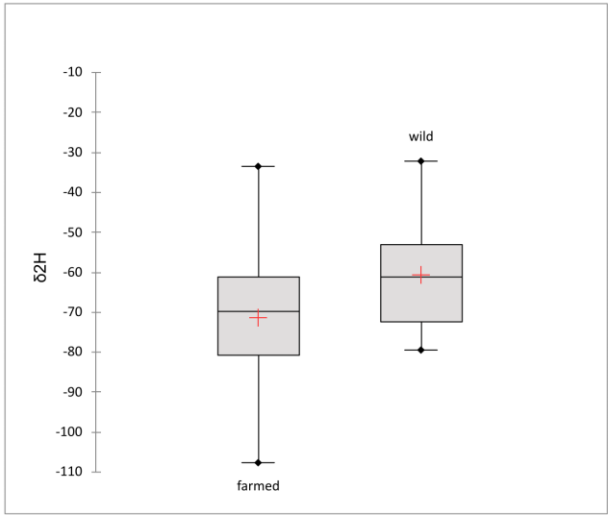
With PCA able to distinct as well

Farmed vs wild









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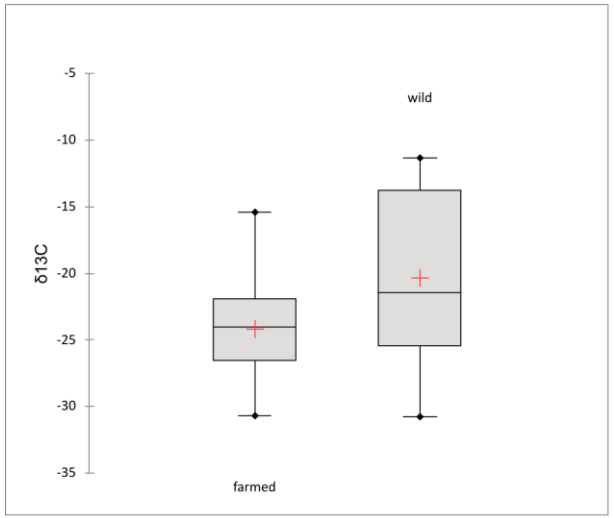
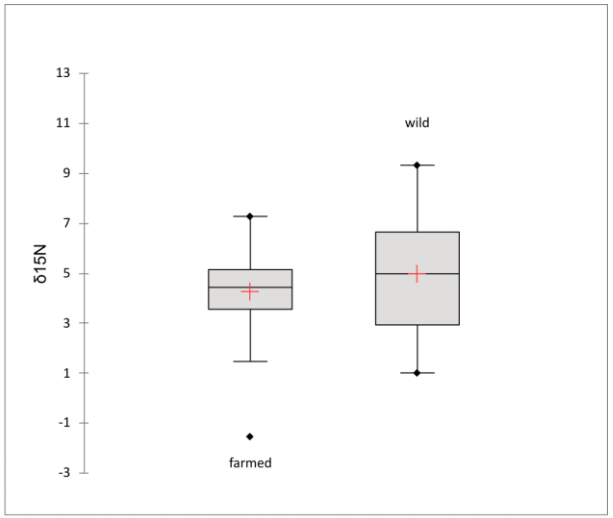
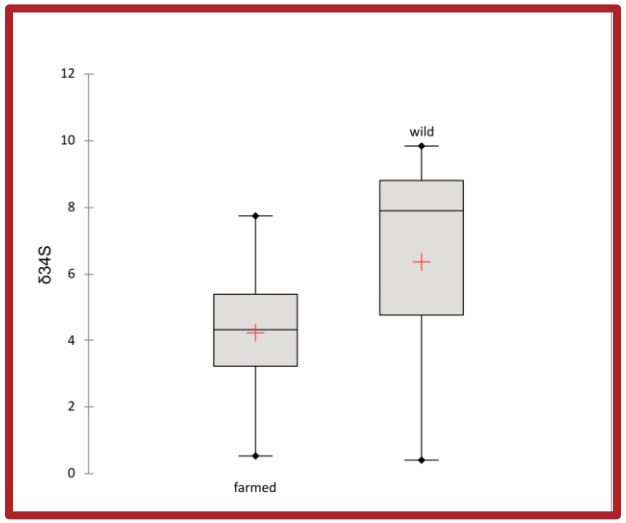
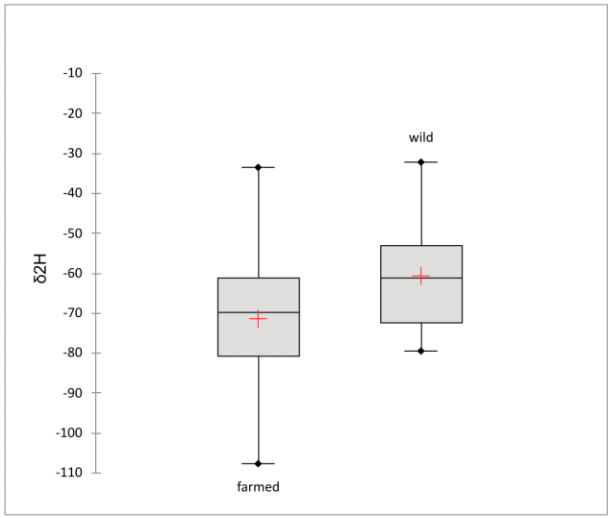


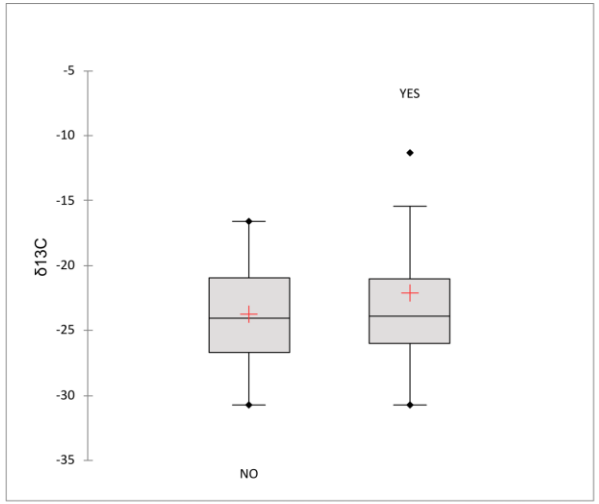


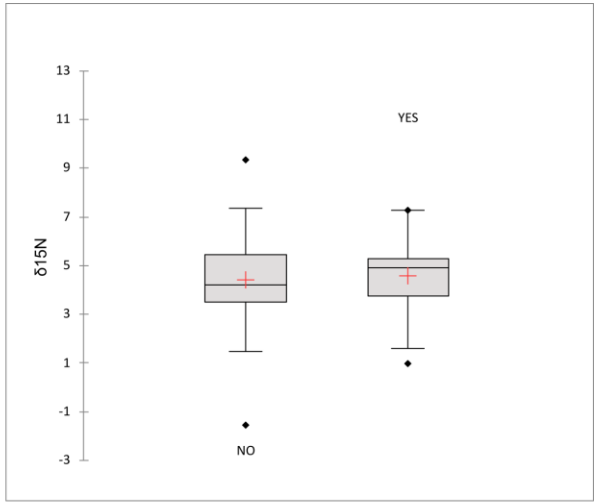


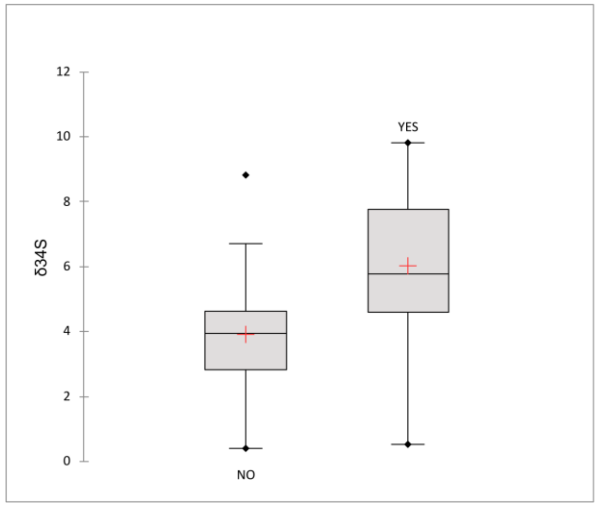


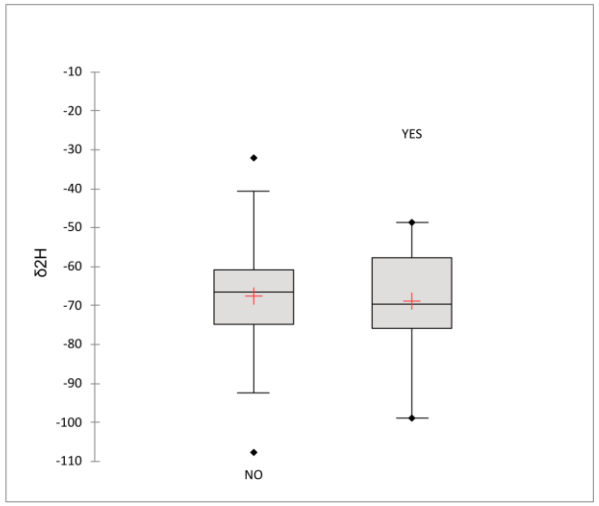
Heavier sulphur in wild insects compared to farmed insects

Pesticides

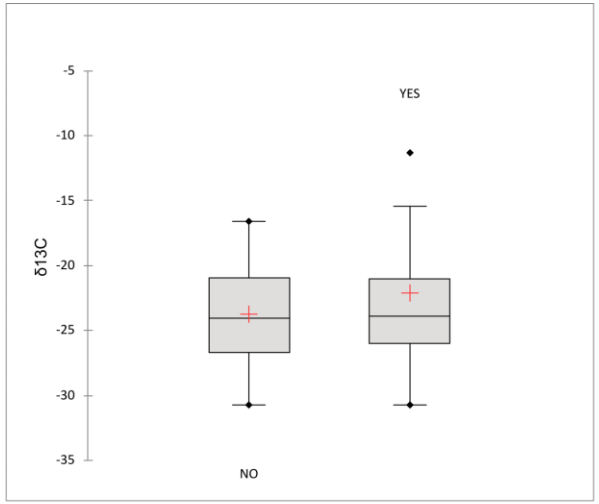

δ13C
-5
-10
-15
-20
-25
-30
-35
YES
NO

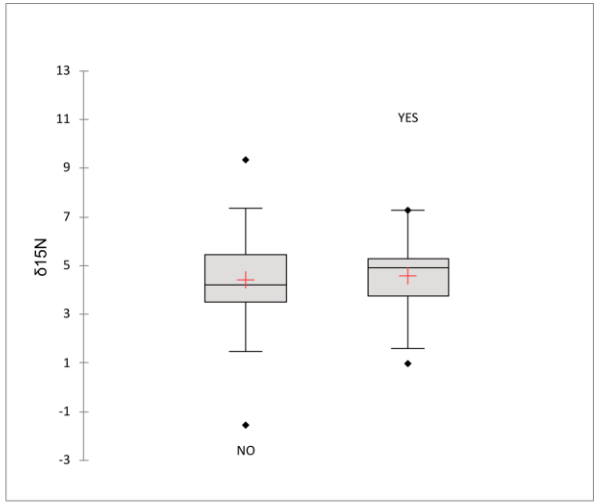

δ15N
13
11
9
7
5
3
1
-1
-3
YES
NO

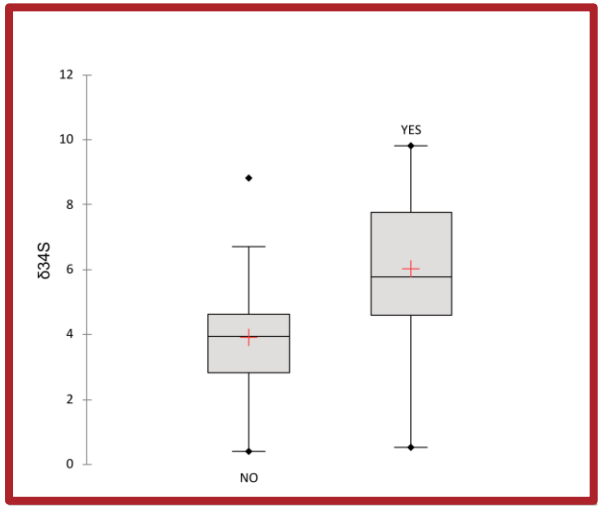

δ34S
12
10
8
6
4
2
0
YES
NO

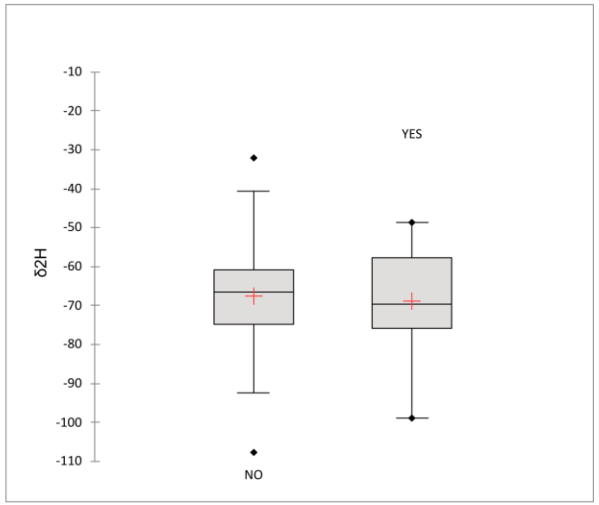

δ2H
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
YES
NO

Pesticides



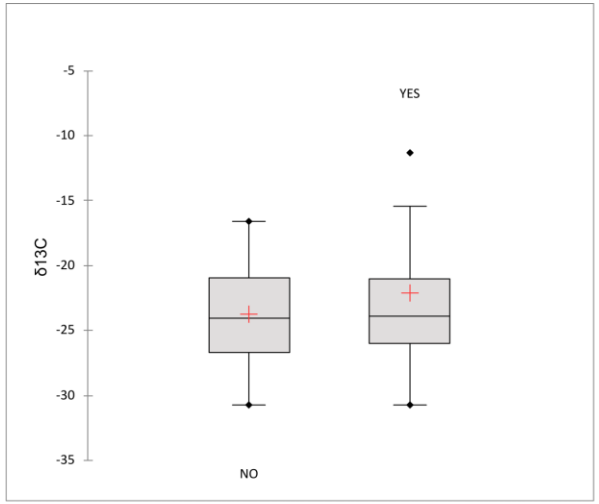


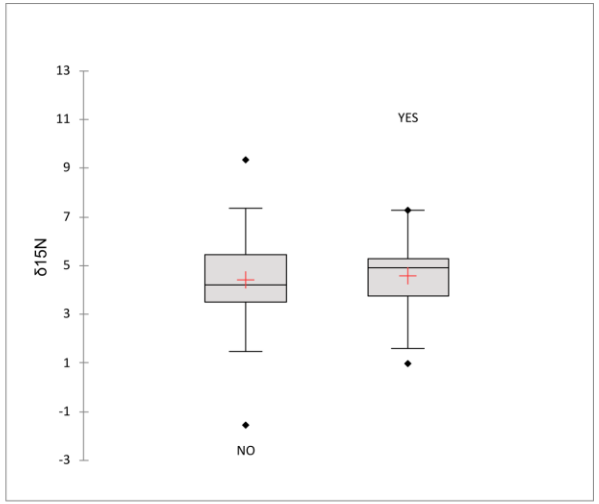


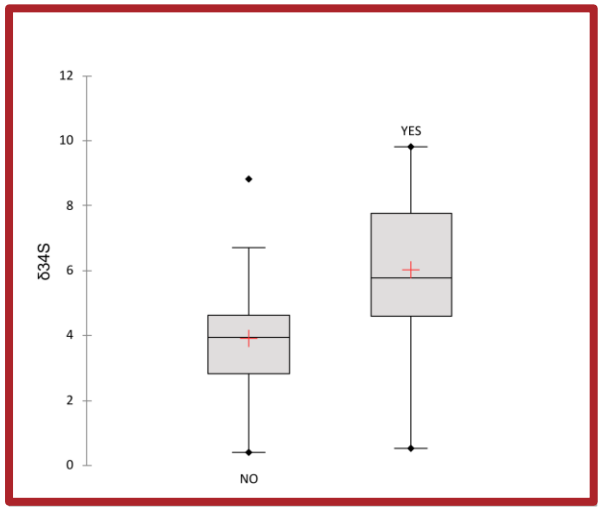


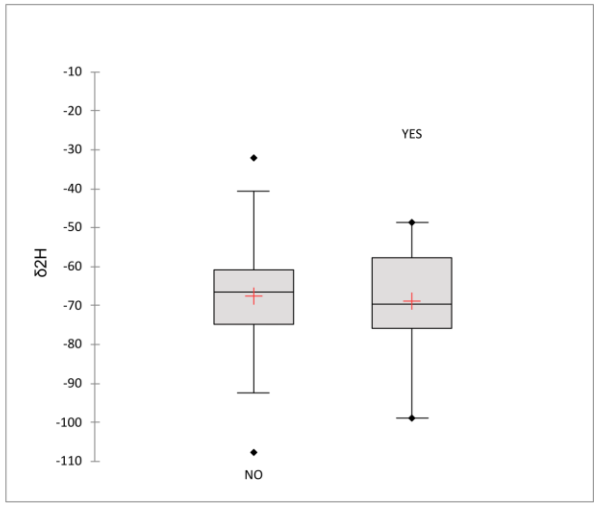
Heavier sulphur in samples containing pesticides compared to samples with no detected pesticides

Pesticides







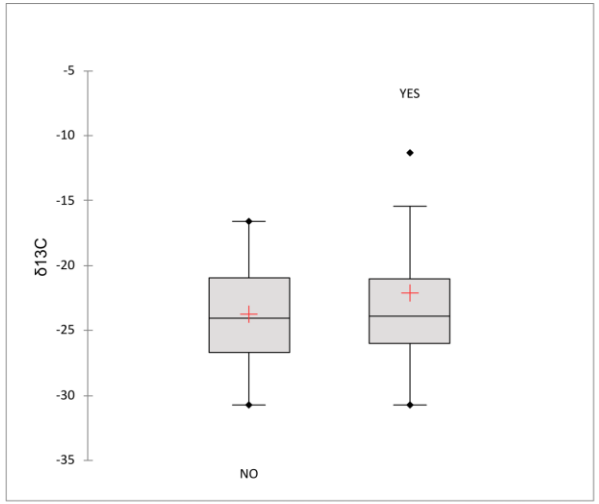


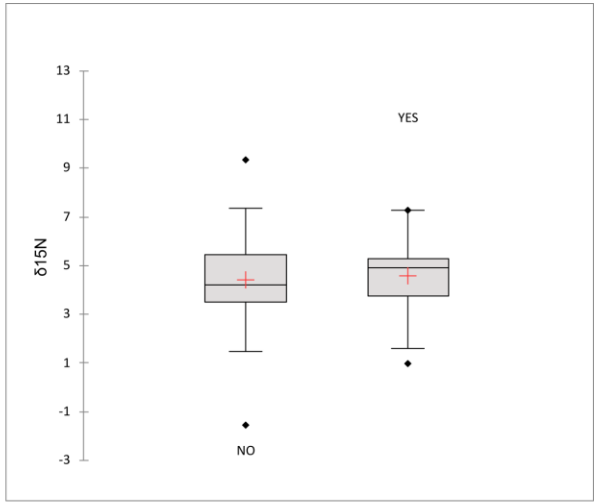
Heavier sulphur in samples containing pesticides compared to samples with no detected pesticides

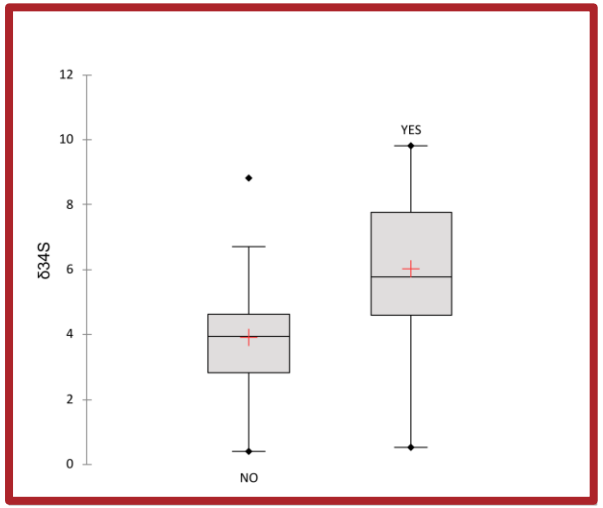
Sulphur composition seems most relevant

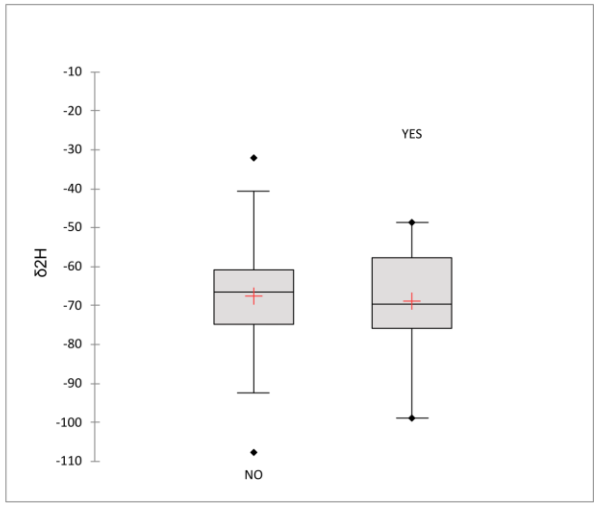
→ LDA only based on sulphur ratios

Pesticides









Heavier sulphur in samples containing pesticides compared to samples with no detected pesticides

Sulphur composition seems most relevant

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76% correct classification if sample contains pesticide or not

Discussion

- African samples have more distinct profile
- Not able to classify samples of known origin well according to countries but for regions
- Differences in sulphur composition for wild vs. farmed insects
- Differences in sulphur composition for pesticide containing samples

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Interesting for future edible insect market

→ organic vs. non-organic, EU vs. non-EU

Future perspectives

Findings can help provide framework for future investigations

- Origin
- Food safety and authenticity
- Pesticide occurrence

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- Origin
- Food safety and authenticity
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<u>BUT</u> bigger dataset necessary to confirm results

Acknowledgements

FoodTraNet

MARIE CURIE ACTIONS

University of Antwerp
Toxicological Centre

Food Forensics

Figures were prepared using Biorender

Thank you for your attention!

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