A citizen science-based approach to promote circular economy in the context of a fast-growing insect industry

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Outline

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   • For schools
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Background

Advantages of insect farming over traditional livestock

• Low water consumption
• Less land use due to verticalization
• Lower GHG emissions
• Higher feed conversion efficiency
• Higher percentage of digestible bodymass
Background

Prospects for insect mass-rearing

• Currently mainly for aquaculture, growing market for pet food. Approval for poultry and pigs ahead.

• Annual production of >5 million tons of insect protein by 2030

• Black soldier fly market predictions:
  • Annual growth of 35%
  • Market volume >$ 3 billion by 2030

• Exponential increase on scientific publications
  • >240 publications on the black soldier fly in 2020, compared to only 17 publications in 2015
Background

Black soldier fly *(Hermetia illucens)*

- Can grow on e.g.:
  - Agro-industrial side streams
  - Food wastes
  - Animal manure
  - Human excrements
- High protein and fat content
- Rearing residues for fertilization

*Figure 1*: Larval nutrient composition. (Liland *et al.* 2017)

*Figure 2*: Life cycle in a lab-reared black soldier fly population.
Figure 3: Overview on the insect-related research topics of our working group.
Motivation for this project

Social acceptance of insects as feed and food

• No recent history of entomophagy in Europe
• Aversion towards insects spreads to “insect eating cultures”
• Emerging industry, products are still expensive
• Westerners prefer indirect insect consumption:
  • traditional livestock fed with insects
• Stigmatization due to association with waste management
Citizen Science

• Growing interest since the 1990s
  • Started in the field of biology, ecology, and conservation
  • Recent studies engage citizens to tackle socio-ecological questions: e.g. food losses and food wastes

• Valuable complement to hypothesis-driven research

• Generation of large datasets by including large groups of citizens

• **Crucial**: Scientific support & standardization for data acquisition
Workshops

What was the goal of this project?

Raise awareness about socio-ecological problems

Keywords: excessive soy farming, increasing fishmeal demand, environmental footprint of traditional livestock

Introduce people to the benefits of insect farming

Keywords: modularity, circular economy, investment opportunity

Highlight the benefits of insect-based food & feed

Keywords: nutrient content, bioconversion efficiency, useable biomass, ethics

Counteract prejudice against insects

Keywords: hands-on experiences, spread knowledge, independent work

Figure 4: Citizen Scientists setting up their rearing system.
How does it work?

Our initial requirements:
- Easy to handle
- Reusable & sustainable
- Low-cost

What we ended up with:
- Appealing & functional system
- Dismountable
- Easy to repair
- Total costs: approx. 33 €
  - Includes precision scale, tweezers, lab journal
- **Most important**: suitable for the rearing of larvae

Figure 5: Rearing system for black soldier fly larvae.
How does it work?

- **Inside**: plastic bucket
- **Outside**: wooden structure
- **Ideal substrate**:
  - vegetable kitchen waste
  - processed food wastes
  - Preferrably no meat
  - If well-balanced, low on odour
  - Approximate runtime 2-3 weeks depending on substrate

*Figure 6*: Exploded view of the rearing system.
How does it work?

- **Self-harvesting**: appropriately angled ramp for larval migration
- **Tightly sealable lid**: no unwanted escaping of larvae, net-covered holes for aeration
- **Drainage system**: hole at the bottom collects excess liquids in a detachable jar (can be used as fertilizer for plants = comparable to worm tea)

*Figure 7: Inner bucket with ramp for larval self-harvesting.*
Workshops

For schools
• Five classes (ages 13-18 years)
• Schools with different backgrounds and curricula
• >100 pupils

For public
• Four public workshops
• Multiple 1-on-1 trainings
• 28 three-week experiments by Citizen Scientists
• 3 control experiments under stable environmental conditions
• 3 control experiments under „household“ conditions
School workshops

Black Soldier Fly School Workshops as Means to Promote Circular Economy and Environmental Awareness

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Figure 8: Booklets containing information on organic waste statistics, insect rearing and instructions for the experiments.
School workshops

• Specifically tailored programm

• Elaborated together with teachers

• Lectures were streamlined with school curricula

• Pre-Workshop lecture vs. Post-Workshop lecture

• Independent research carried out by pupils

• Change in mindset observable between workshops
School workshops

Results

- All students stuck to the sampling scheme
- Good larval growth across all school experiments
- Mostly fruit wastes were used as feed

Figure 11: Overview on the different types and amounts of organic wastes used within the school experiments.

Figure 12: Larval biomass gain separated by school classes. The grey background represents the average biomass gain across all experiments (± standard error).
Public workshops

• Broad range of ages: 23 years to 72 years
• All backgrounds
• 64% female vs. 36% male participants
• Average duration of experiments: 23 ± 1.5 days
• Garden, balcony, kitchen, living room, basement
Public workshops

- Average survival: 93%
- Biomass gain:
  - Minimum: 515%
  - Maximum: 1962%
- Waste reduction index:
  - Minimum: 0.69
  - Maximum: 3.75

\[ WRI = \frac{D}{t} \times 100 \]
\[ D = \frac{W - R}{R} \]

\( W \)…total amount of organic material (feed amount)
\( t \)…duration of the experiment
\( R \)…residue after time \( t \)

High \( WRI \) = good reduction efficiency

Figure 13: Overview on the larval rearing success.
Public workshops

- High diversity in organic waste composition
  - 89 different products
- Large spread of total feed amounts
  - 197 – 854 g
Web application

Figure X: COHMILA web application for the exploration of Citizen Scientist experimental results.
Conclusion

• Citizen science is a helpful tool when applied accordingly
  • Scientific supervision & standardized data acquisition

• Industrially exploited insects in classrooms:
  • Provide hands-on experience
  • Low maintenance – high value
  • Easy to implement in school curricula

• Success for small-scale rearing system
  • Black soldier fly resilient and undemanding model organism
  • High survival, high efficiency, fast development stimulates interest
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