Can the environmental impact of livestock feed be reduced by using waste-fed housefly larvae?

Hannah van Zanten - Animal Production Systems
Introduction

- Growing world population and developing countries → increase animal proteins

- Livestock pressure on environment
  - 70% of agricultural land
  - 15% of greenhouse gas emissions → feed

- Need for efficient production of livestock feed
  - Insects?

- Environmental benefits:
  - Replace ingredients with high impact
  - Not land intensive
  - Feed with organic waste streams
Aim

Explore if the environmental impact of livestock production can be reduced by using larvae of the common housefly fed with chicken manure and food waste as livestock feed including indirect consequences ‘waste’
Method: life cycle assessment

Assess environmental impact → LCA
1. Direct environmental impact of larvae meal production
2. Indirect environmental impact

Environmental impact per ton larvae meal
• Global warming potential (GWP): kg CO$_2$-eq
• Energy use (EU): MJ
• Land use (LU): m$^2$

Data from testing site: rearing place of 20 tons of larvae meal per day
Method: life cycle assessment

Step 1: Direct environmental impact of larvae meal
Method: life cycle assessment

Step 1: Direct environmental impact of larvae meal

- Egg feed
- Fly feed
- Larvae feed
- Water
- Energy

Diagram showing the life cycle of a fly with stages including egg, larva, and adult fly, along with the environmental impacts such as energy and water.
Method: life cycle assessment

Step 1: Direct environmental impact of larvae meal
Method: life cycle assessment

Step 1: Direct environmental impact of larvae meal

<table>
<thead>
<tr>
<th>Product</th>
<th>Amount</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>chicken manure:</td>
<td>11,079</td>
<td>GWP, EU, LU</td>
</tr>
<tr>
<td>food waste:</td>
<td>3,693</td>
<td>GWP, EU, LU</td>
</tr>
<tr>
<td>premix:</td>
<td>57</td>
<td>GWP, EU, LU</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td></td>
<td><strong>GWP, EU, LU</strong></td>
</tr>
</tbody>
</table>

**Product:**
- Egg feed
- Fly feed
- Larvae feed
- Water
- Energy
- Larvae meal

**Impact:** GWP, EU, LU
Method: life cycle assessment

Step 2: Indirect environmental impact
Method: life cycle assessment

Step 2: Indirect environmental impact
Method: life cycle assessment

Step 2: Indirect environmental impact
Method: life cycle assessment

Step 2: Indirect environmental impact
Results: life cycle assessment
Results 1: direct environmental impact of larvae meal

<table>
<thead>
<tr>
<th>Larvae meal</th>
<th>average</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWP</td>
<td>770</td>
<td>kg CO₂eq/ton</td>
</tr>
<tr>
<td>EU</td>
<td>9329</td>
<td>MJ/ton</td>
</tr>
<tr>
<td>LU</td>
<td>32</td>
<td>m²/ton</td>
</tr>
</tbody>
</table>
Results 1: processes of larvae meal

GWP kg CO₂-equivalent/ton larvae meal

- egg production
- larvae production
- building electricity
- building gas
Results 1: processes of larvae meal

![Graph showing MJ/ton larvae meal for different processes: egg production, larvae production, building electricity, and building gas. The building electricity process has the highest MJ/ton value, followed by larvae production and building gas, with egg production having the lowest value.](image)
Results 1: processes of larvae meal
Results 2: comparison livestock feed

**GWP feed**
kg CO₂-eq/ton feed

- Larvae meal
- Fishmeal
- SBM
Results 2: comparison livestock feed

![Bar chart showing GWP incl LUC (kg CO₂-eq/ton feed)]
Results 2: comparison livestock feed

![Bar chart showing EU feed MJ/ton feed for Larvae meal, Fishmeal, and SBM.]
Results 2: comparison livestock feed
Results 2: inclusion avoided feed

-998 CO$_2$eq

-5843 MJ

-1747 m$^2$
Results 2: total indirect

- **GWP kg CO$_2$-eq/ton larvae meal**: 1364 CO$_2$-eq
- **EU MJ/ton larvae meal**: 21342 MJ
- **LU m$^2$/ton larvae meal**: -1713 m$^2$
Can the environmental impact of livestock feed be reduced by using waste-fed housefly larvae?

- LU will decrease
- GWP and EU?
  - Current situation
  - Decrease energy use

Waste: anaerobic digestion or larvae meal?

- Land and fossil fuels scarce
  - Fossil fuel replaced by sustainable sources
  - No other solution scarcity of land
Thank your for your attention!
Sensitivity analysis (direct)

- GWP: energy use (gas and electricity use) and feed for larvae,
- EU: electricity use of larvae production, followed by gas use for the total building.
- LU: production of feed for the larvae
Sensitivity analysis (indirect)

- GWP and EU: changes in anaerobic digestion.
  - methane production potential influencing the amount of energy assumed to be produced by anaerobic digestion.
  - the electricity factor used for greenhouse gas emissions which was merely determined by the mixer of electricity sources (in this case based on the Dutch situation).

- LU: production of SBM, and LU outcomes, therefore, were sensitive to changes in the relative replacement of SBM and fishmeal by larvae meal.
## Anaerobic digestion and manure

### GWP indirect impact larvae meal

<table>
<thead>
<tr>
<th>Source</th>
<th>kg CO₂-eq/ton larvae meal (incl LUC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larvae meal production</td>
<td>770</td>
</tr>
<tr>
<td>Exchange livestock feed</td>
<td>-1,768</td>
</tr>
<tr>
<td>Digestion larvae manure</td>
<td>-3,277</td>
</tr>
<tr>
<td>Digestate larvae manure</td>
<td>-355</td>
</tr>
<tr>
<td>Digestion foodwaste</td>
<td>3,954</td>
</tr>
<tr>
<td>Digestate foodwaste</td>
<td>895</td>
</tr>
<tr>
<td>Chicken manure</td>
<td>1,146</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,364</td>
</tr>
</tbody>
</table>
### EU indirect impact larvae meal

**MJ/ton larvae meal**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larvae meal production</td>
<td>9,329</td>
</tr>
<tr>
<td>Changes livestock feed</td>
<td>-15,172</td>
</tr>
<tr>
<td>Digestion larvae manure</td>
<td>-50,916</td>
</tr>
<tr>
<td>Digestate larvae manure</td>
<td>2,825</td>
</tr>
<tr>
<td>Digestion foodwaste</td>
<td>62,001</td>
</tr>
<tr>
<td>Digestate foodwaste</td>
<td>6,230</td>
</tr>
<tr>
<td>Chicken manure</td>
<td>7,045</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>21,342</td>
</tr>
</tbody>
</table>
## Anaerobic digestion and manure

### LU indirect impact larvae meal

\[ \text{m}^2/\text{ton larvae meal} \]

<table>
<thead>
<tr>
<th>Category</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larvae meal production</td>
<td>32</td>
</tr>
<tr>
<td>Changes livestock feed</td>
<td>-1,779</td>
</tr>
<tr>
<td>Digestion larvae manure</td>
<td>-27</td>
</tr>
<tr>
<td>Digestate larvae manure</td>
<td>-5</td>
</tr>
<tr>
<td>Digestion foodwaste</td>
<td>32</td>
</tr>
<tr>
<td>Digestate foodwaste</td>
<td>13</td>
</tr>
<tr>
<td>Chicken manure</td>
<td>22</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>-1,713</td>
</tr>
<tr>
<td></td>
<td>Larvae meal</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Dry matter</strong></td>
<td>88.0</td>
</tr>
<tr>
<td><strong>Crude protein</strong></td>
<td>47.9</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td>24.2</td>
</tr>
<tr>
<td><strong>Lysine</strong></td>
<td>32.6</td>
</tr>
<tr>
<td><strong>Methionine</strong></td>
<td>11.3</td>
</tr>
</tbody>
</table>
• Pupae will eclose into flies within 2 days.
• Feed of the flies: sugar, milk powder and egg powder. Flies are kept at a temperature of 25 degrees Celsius. Female flies start to lay eggs after 7 days in an oviposition substrate: milk powder, yeast, fiber, vegetable oil and vitamins.,
• Larvae are kept at a temperature of 27 degrees Celsius and are full grown after 5 days.
• Per 4 kilograms of substrate, one kilogram of larvae is produced.
• Harvesting of the larvae is performed by shutting off the ventilation, which makes the larvae crawl to the surface of the substrate when oxygen levels drop.
• Per day 65 ton of live larvae are produced resulting in 20 ton of larvae meal.