Sustainability constraints for insect protein meal production

Radu Popa
River Road Research
(Buffalo, NY)
Cultured insects

Honey bees

Silk moths

**Agriculture controllers** (predators, parasites, pollinators)  
(ladybugs, caterpillar parasite wasps, bees)

**Insects as food (FDA)**  
(mealworms, crickets, locusts)

**Insects as feed (AAFCO)**  
(*Hermetia illucens*; BSF)
General benefits of insects

- High diversity (taxonomy & physiology)
- Fast growth
- Less space and water to produce (per kg of protein)
- Simpler but efficient immunology (AMPs) (w. Cecropins and Defensins)
1,000 kg food waste
70-80% water

200-300 kg DW iMeal
13-14.5 % Protein
4-11 % Fat

40-75 kg pMeal
53-55 % Protein
8-12 % Fat
70 kg DW Frass
Land efficiency

Composting
1 mt/day  200-700 m²

Anaerobic digestion
1 mt/day  25 m²

BSF
1 mt/day  60 m²
4 acres for a city with 1 million people (@ 0.1 mt/person/year)
1 mt food waste =>
40-75 kg pMeal
70 kg DW frass
Effects of fish meal substitution with BSF pMeal Red Drum Diets (*Sciaenops ocellatus*)

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<th>Fish Meal:BSFM</th>
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Constrains to feed insects

1) Life cycle
2) Interaction w. other life forms
   War w. fungi; mycoinsecticides vs. cecropin-AMPs (Stomoxyn)
   Culture-specific parasites and pests
   Limited knowledge about BSF diseases
3) Physiology
   Heterotrophs => loss in CNP&E
   Compete for feeds with other farm animals
   Biomagnification of pesticides
4) Nutrition safety
   Food-safe insects compete with us for quality feeds
   Sloppy eaters are cheaper … but have limitations
5) Larvae feed quality
6) Protein & fats quality
7) Production costs
Larvae feed quality

Feed composition
Organic nitrogen, carbohydrates, fats, vitamins, mycotoxins,

Feed pre-processing
Refrigeration, Drying, Cooking, Fermentation.

Feed sources
Some feeds will never make it toward feeds (manure, sewage sludge; pesticide-contaminated)

Some feeds are of secondary/local interest (post-consumer food wastes; leafy vegetables; yard clippings; algae)

Industrial byproducts and commercial waste (fruit pulp, vegetable trimmings, whey, shelf-expired food, small-scale brewery and distillery waste)
Protein & fats quality

Fat content is very high and composition variable (lauric acid is high)

Digestibility
   Protein/melanin complex.
   (2 heating steps)
   Maillard rxn. materials?

Hazards
   Pathogens
   Microbial toxins
   Allergens

No industry standards for pMeal quality (feed sources and the drying method are the main causes of product variability)
Production costs

3.5-7.5 $/kg BSF meal

1.5-1.7 $/kg Fish meal

0.5-0.7 $/kg Soy meal
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Strategies to survive the ride

- Legislation (tipping fees & carbon credits)
- Automation
- Diversify revenue (tipping fees, frass, fats, treats, polymers, AMPs)
- Split the industry
  (eggs / larvae growing / biomass processing)
- High quality protein (solvent defatting, less denaturation)
- Low BSF protein addition to feeds
  (to temper soy antinutritional factors or for AMPs)
- Target specialized feed markets
  (e.g. predatory fish & customer-targeted feeds)
- BSF for waste reduction
  (pig manure, spoiled food waste, industrial organic wastes)
Thank you!

(any questions?)

Radu Popa (radu.o.popa@gmail.com)
River Road Research (Buffalo, NY)